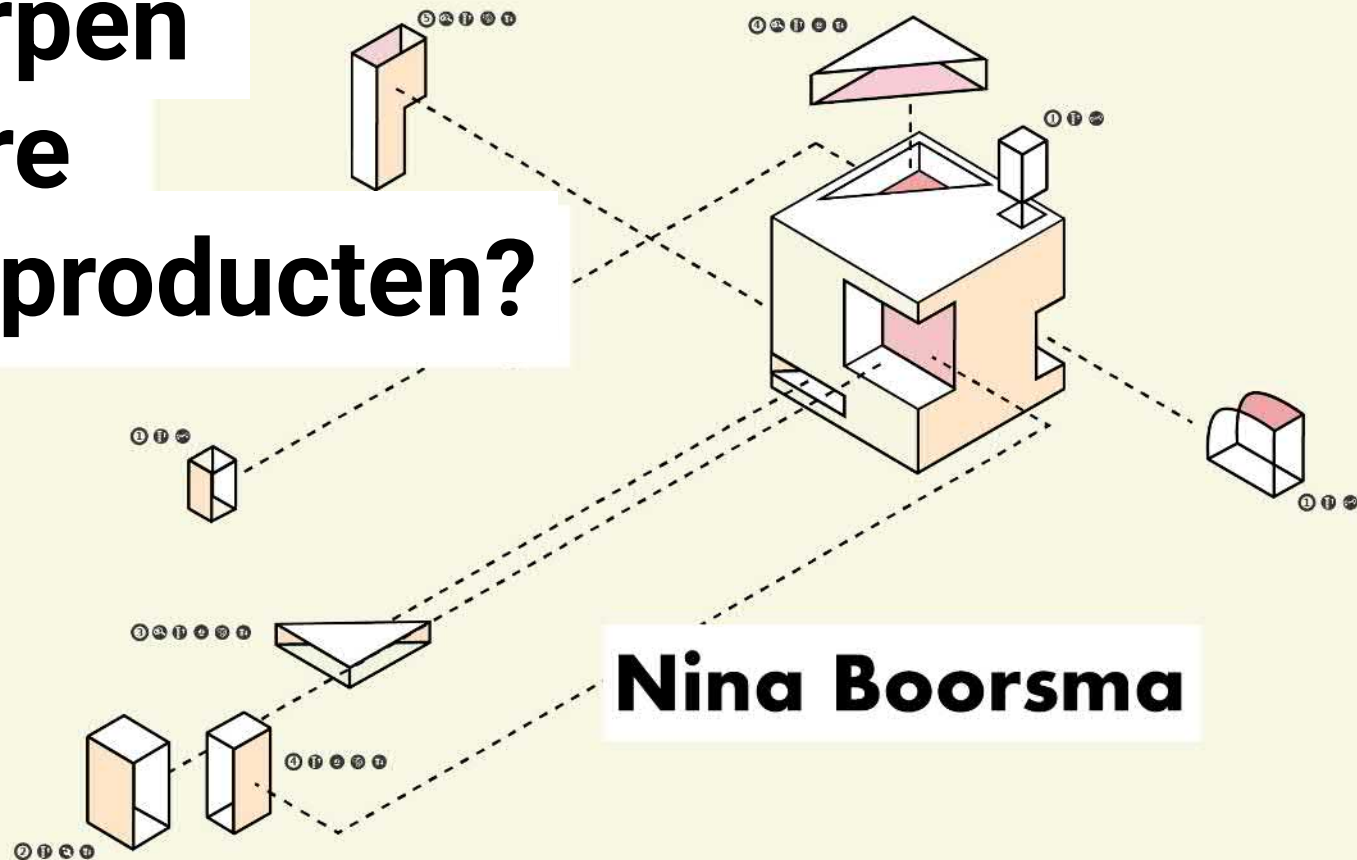
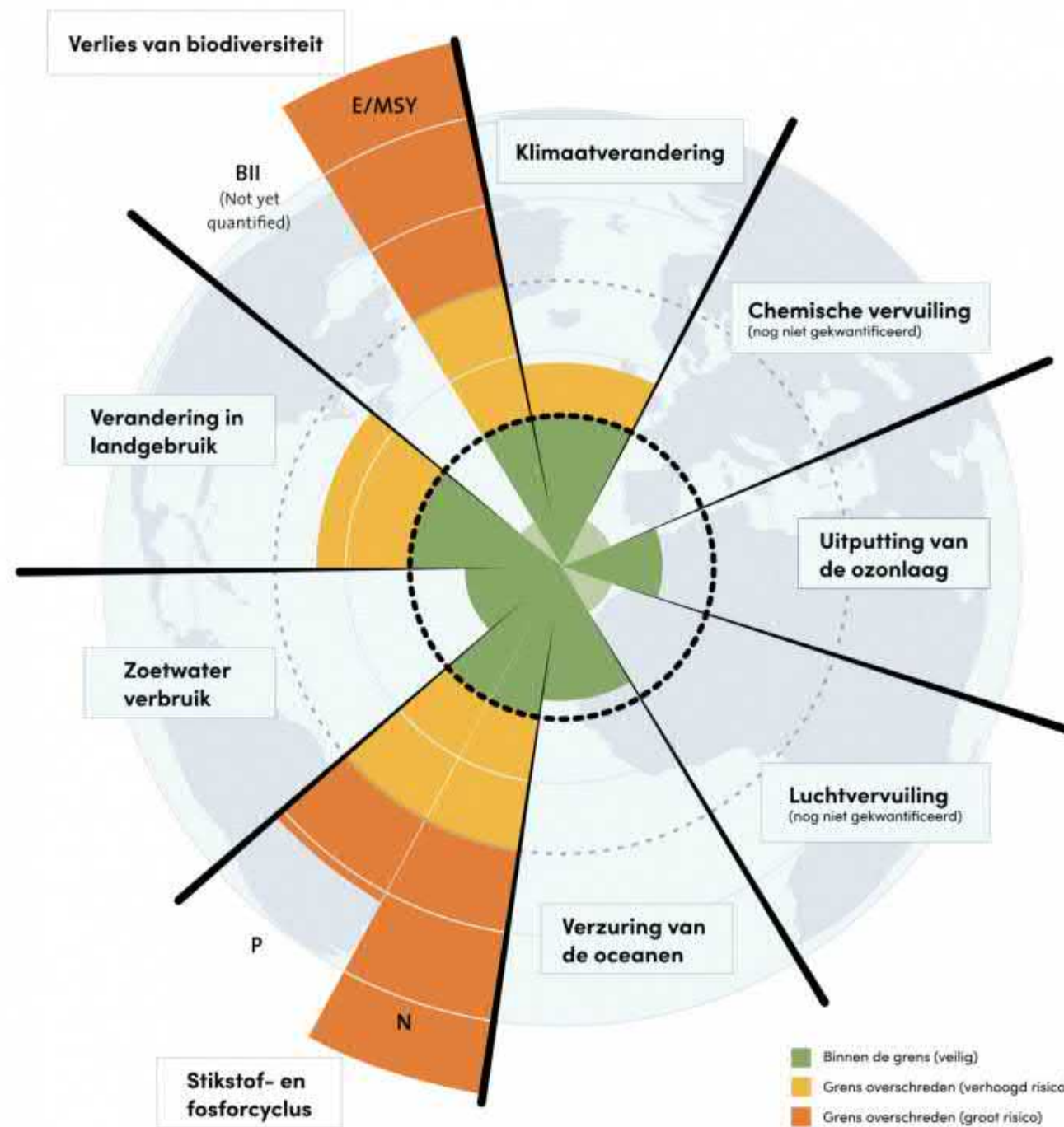


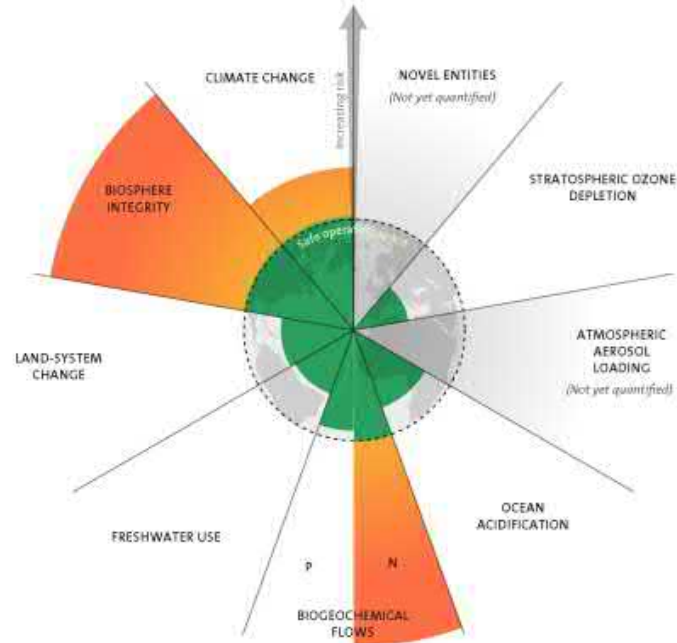
Hoe ontwerpen we circulaire industriële producten?



Nina Boorsma

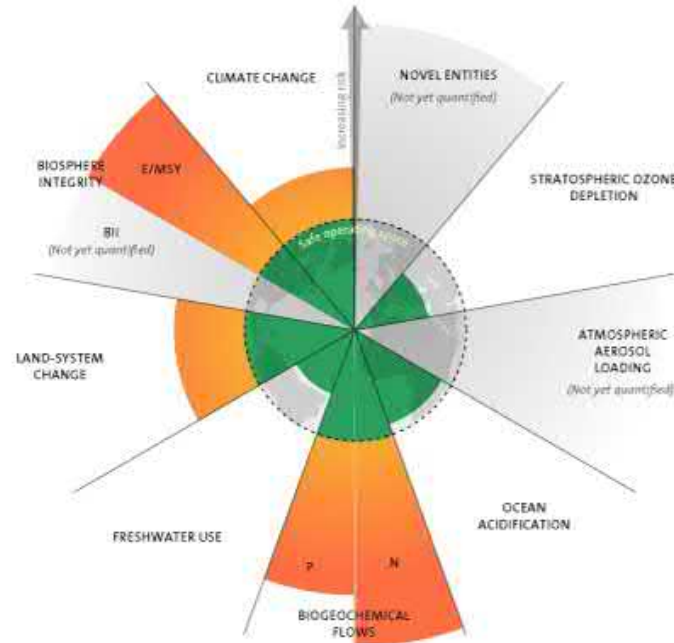


2009



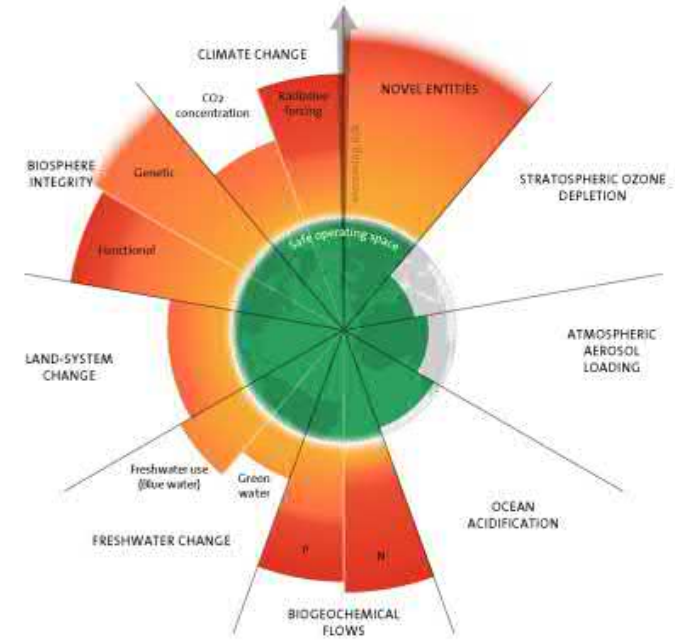
3 boundaries crossed

2015

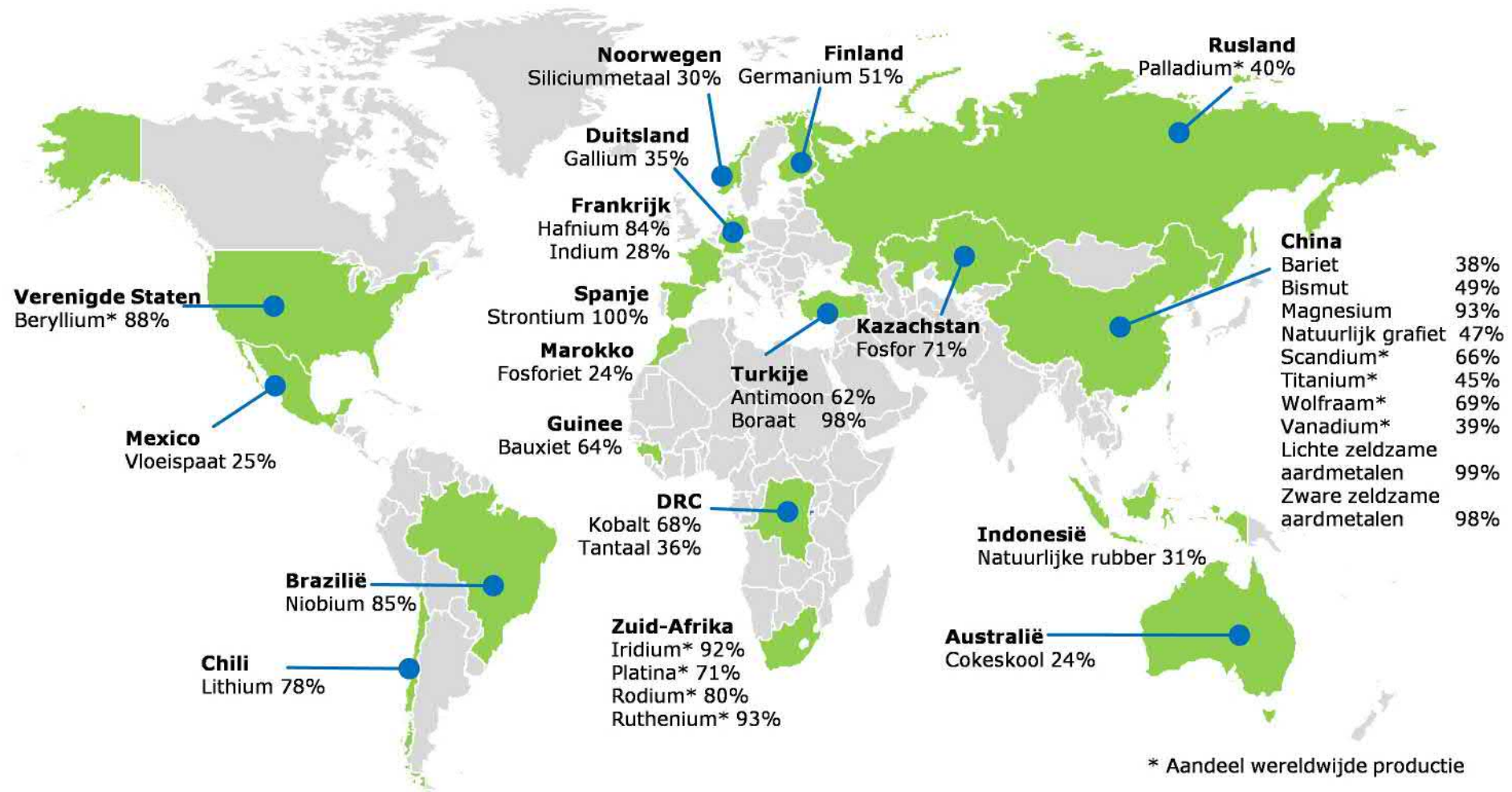


4 boundaries crossed

2023



6 boundaries crossed



Verordening kritieke grondstoffen

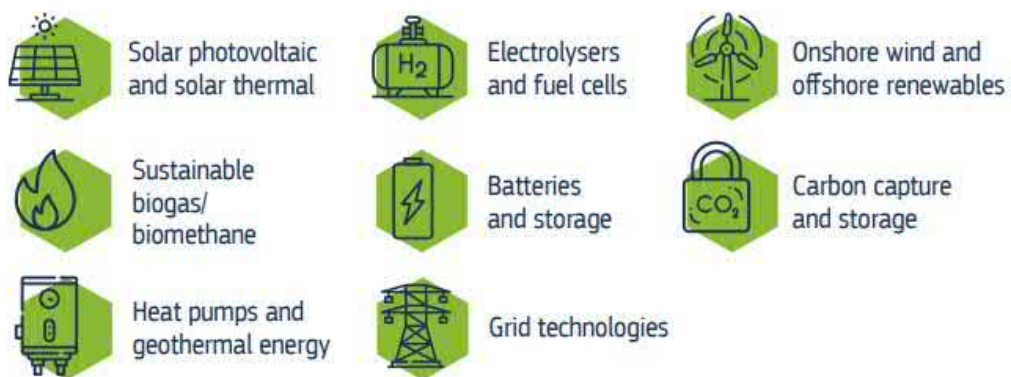
Ruimtevaart/ Defensie	Textiel	Elektronica	Mobiliteit/ Automobiel	Energie- intensieve industrie	Duurzame energie	Agrovoedings- industrie	Gezondheids- zorg	Digitaal	Bouwnijverheid	Detailhandel	Nabijheid/ sociale economie	Toerisme	Creatieve/ culturele sectoren
Antimoon	✓	✓		✓						✓			
Bariet				✓	✓			✓		✓			
Bauxiet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Beryllium	✓		✓	✓		✓			✓				
Bismut	✓		✓		✓			✓	✓	✓			
Boraat	✓		✓	✓	✓	✓	✓		✓	✓			
Kobalt	✓	✓	✓	✓	✓	✓			✓				
Cokeskolen				✓	✓	✓							
Vloeispaat					✓		✓				✓		
Gallium	✓		✓	✓		✓			✓	✓			
Germanium	✓		✓		✓	✓							
Hafnium	✓		✓		✓	✓			✓				
Indium	✓		✓			✓			✓				
Lithium	✓		✓	✓	✓	✓		✓	✓				
Magnesium	✓		✓	✓	✓				✓	✓			
Natuurlijk grafiet	✓		✓	✓	✓	✓			✓	✓			
Natuurlijke rubber	✓	✓		✓				✓					
Niobium	✓		✓	✓	✓			✓		✓			
Fosforiet					✓		✓						
Fosfor	✓				✓		✓						
Scandium	✓			✓		✓							
Siliciummetaal	✓	✓	✓	✓	✓	✓		✓		✓			

Benchmarks voor de Wet Kritieke Grondstoffen:
≥ 10% van het jaarlijkse verbruik in de EU voor winning
≥40% van het jaarlijkse verbruik in de EU voor verwerking
≥ 15% van het jaarlijkse verbruik in de EU voor recycling
≤ niet meer dan 65% van het jaarlijkse verbruik in de EU afkomstig uit één enkel derde land

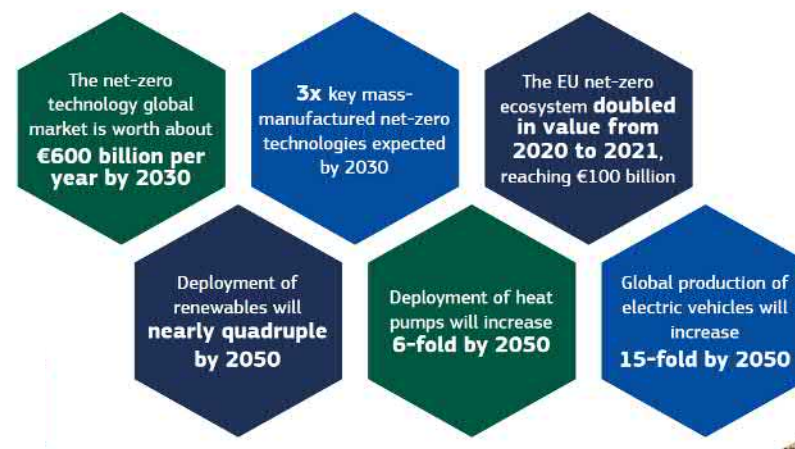
Verordening nettonulindustrie

Vergroten van het concurrentievermogen van de industrie met klimaatneutrale technologie.

Europese Commissie https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan/net-zero-industry-act_nl



NET-ZERO TECHNOLOGY TRENDS



[Net-Zero Industry Act](#)

1.Diversificatie van toeleveringsketens

2.Recycling en circulaire economie

3.Onderzoek naar vervangende materialen

4.Urban Mining en secundaire bronnen

5.Duurzame mijnbouwpraktijken

6.Technologische vooruitgang in extractie

7. Internationale samenwerking

8.Regelgevende initiatieven

9. Impact van de energietransitie

10.Geavanceerde materiaalwetenschap

Drie principes

van de circulaire economy

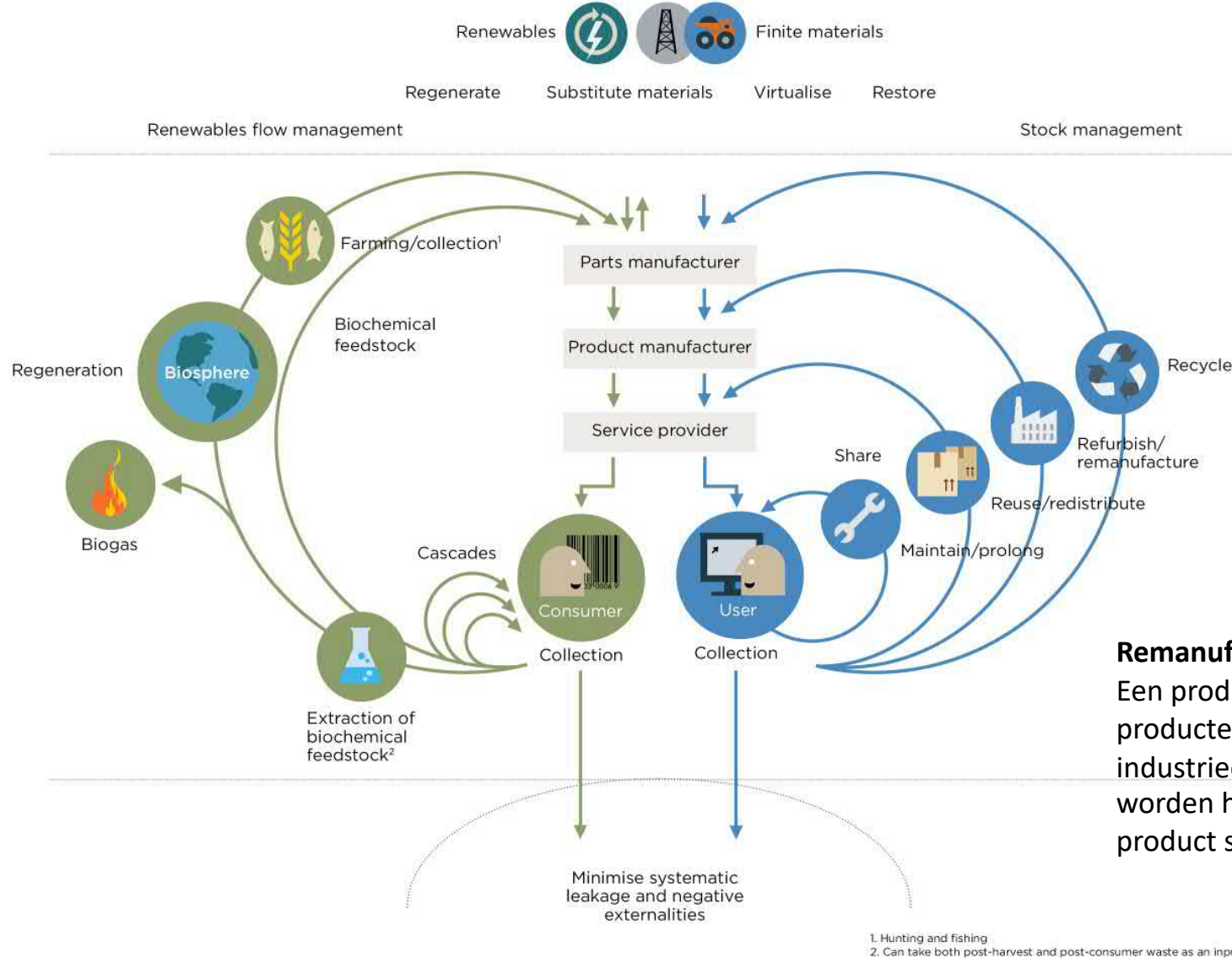
Afval en
vervuiling
eliminieren

Producten en
materialen
circuleren

De natuur
regenereren

“The problem, and the solution, start with design”

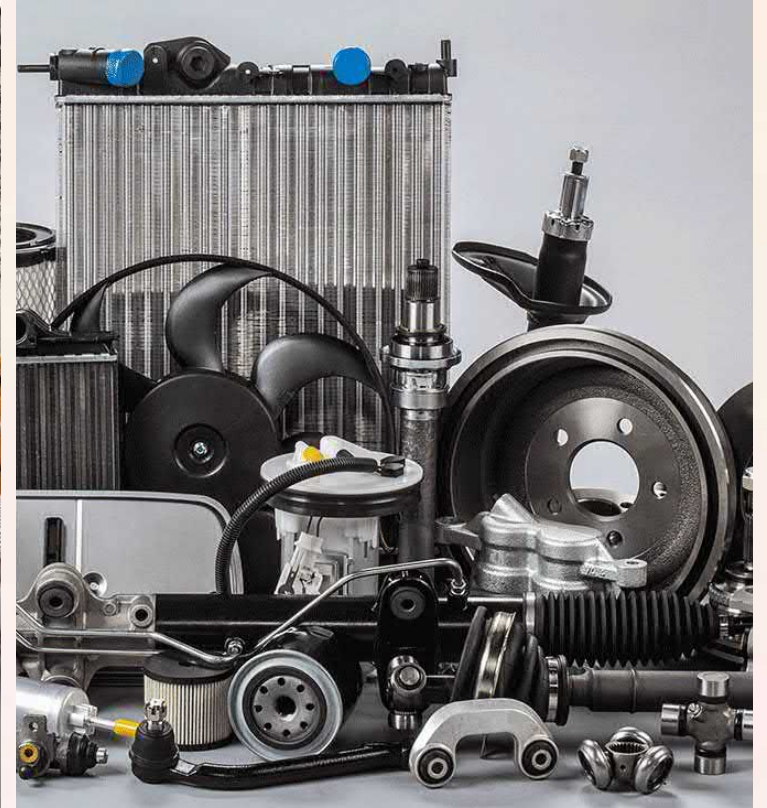
- Ellen MacArthur Foundation



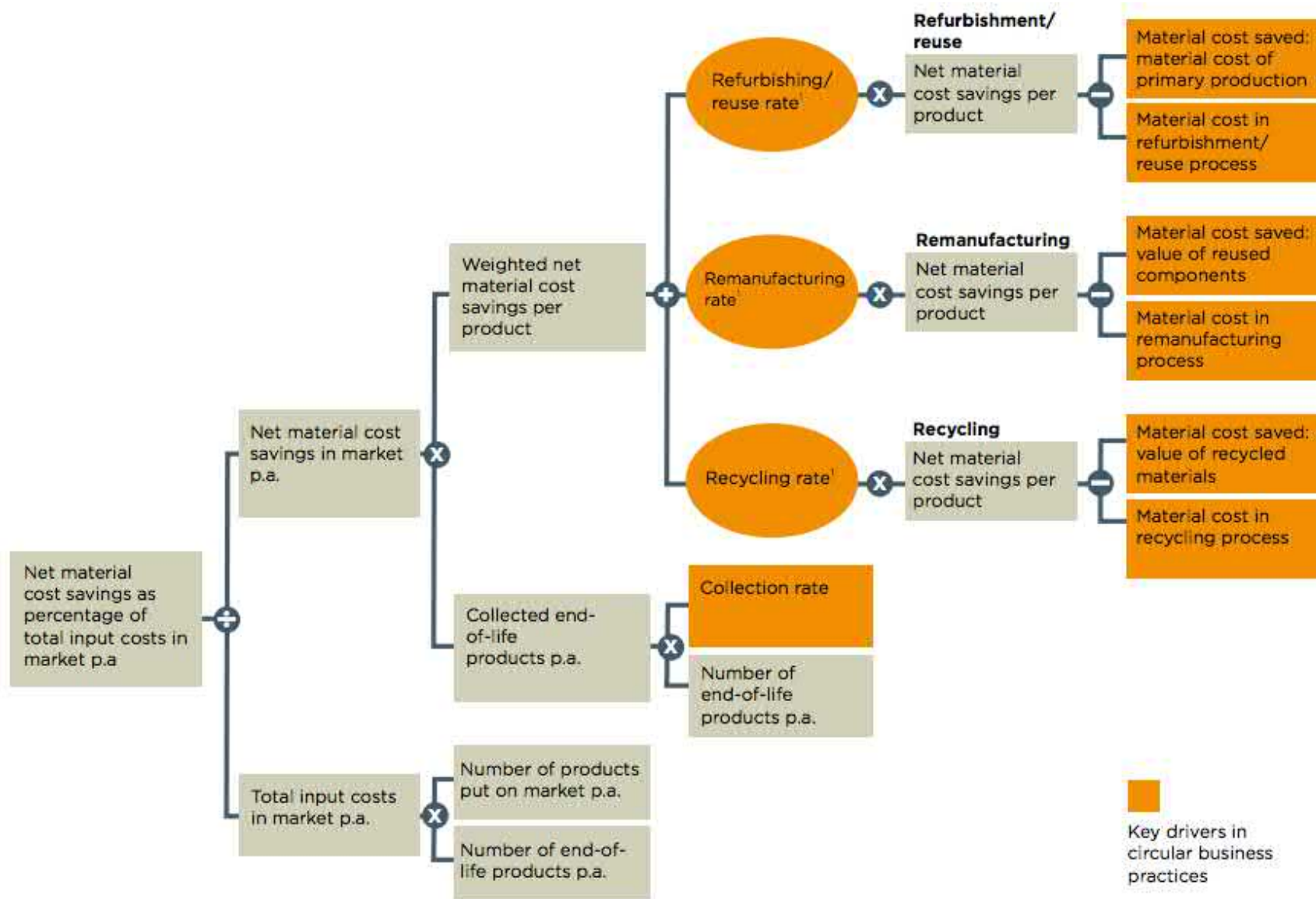
Remanufacturing

Een productieproces waarbij gebruikte producten een gestandaardiseerd industrieel proces doorlopen en worden hersteld tot de oorspronkelijke product specificatie.

Productvoorbeelden

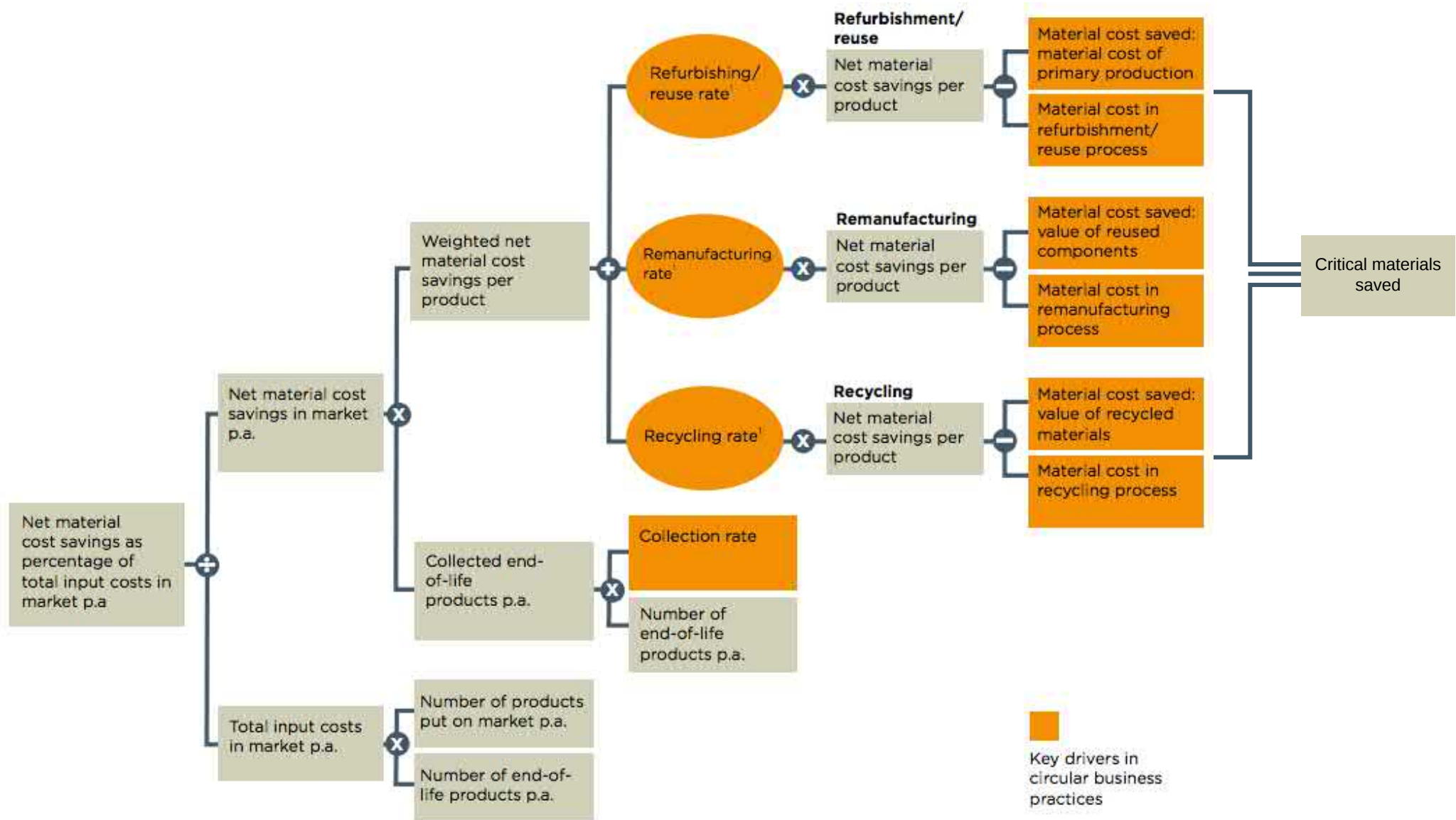






¹ Rates as percentage of collected products; add up to 100%

SOURCE: Ellen MacArthur Foundation circular economy team



¹ Rates as percentage of collected products; add up to 100%

SOURCE: Ellen MacArthur Foundation circular economy team

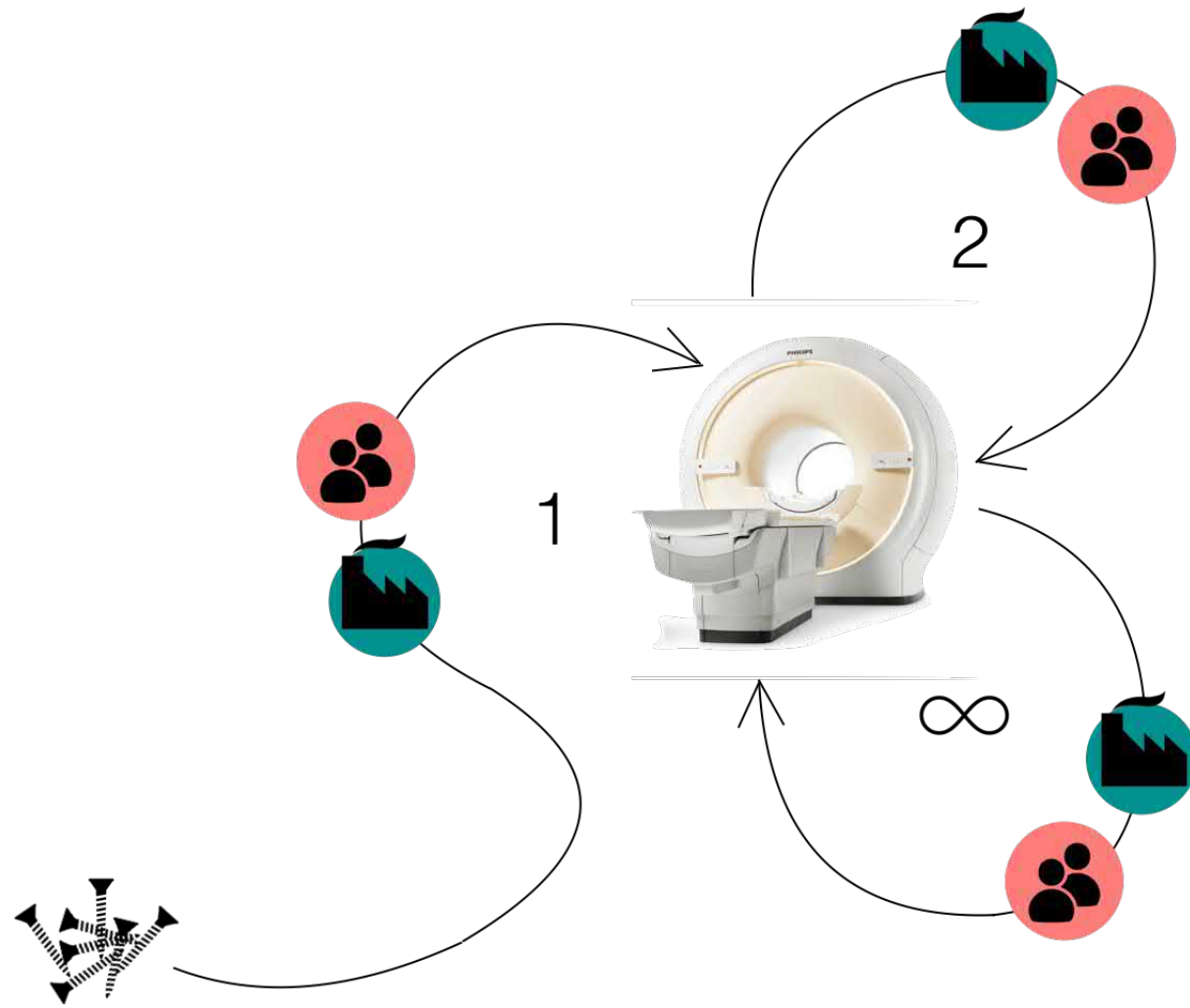
Casestudy: Medische systemen



Röntgen inspectiesystemen



Magnetic Resonance Imaging
(MRI)



Design guidelines



Design guidelines

Category

Part interfacing (1)

Concerns component level;
Assembly, Disassembly

Damage correction (2)

Concerns component level;
Repair, Replacement and
Refurbishment

Quality assurance (3)

Concerns performance level;
Testing and Inspection

Cleaning (4)

Concerns performance level

Design guidelines

1.2 Reduce total number of parts

1.3 Reduce quantity and variety of fasteners

1.4 Identify access points

1.5 Minimize number of joints

1.6 Use modular structure so that obsolescence occurs with rather than with entire product

1.7 Structure for ease of access to short life and prone to break down parts

1.8 Reduce tools required for disassembly

[...]

2.1 Structure to facilitate ease of upgrade of a product

[...]

2.2 Isolate expected damage to removable and replaceable parts .

[...]

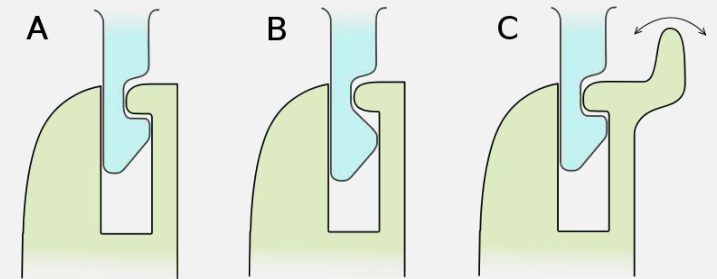
3.1 Clearly identify component load, limits, tolerances and adjustments

[...]

4.1 Arrange components so that all can be accessed for effective cleaning

4.2 Reduce/ eliminate redundant parts

[...]



Workshop



Sub modules

L-arm

C-arm

Patient table

System cabins

User interface

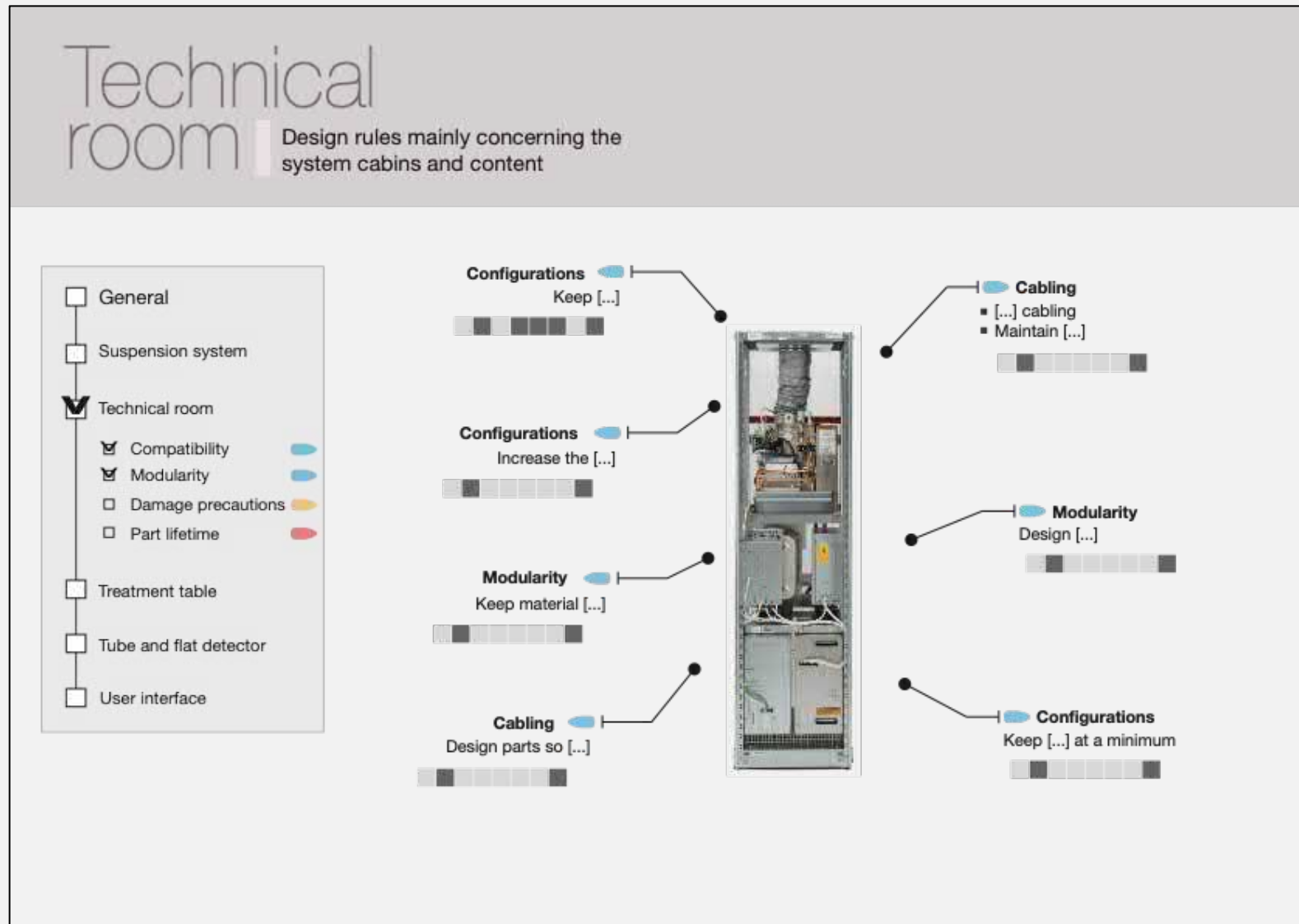
Flat detector

X-ray tube

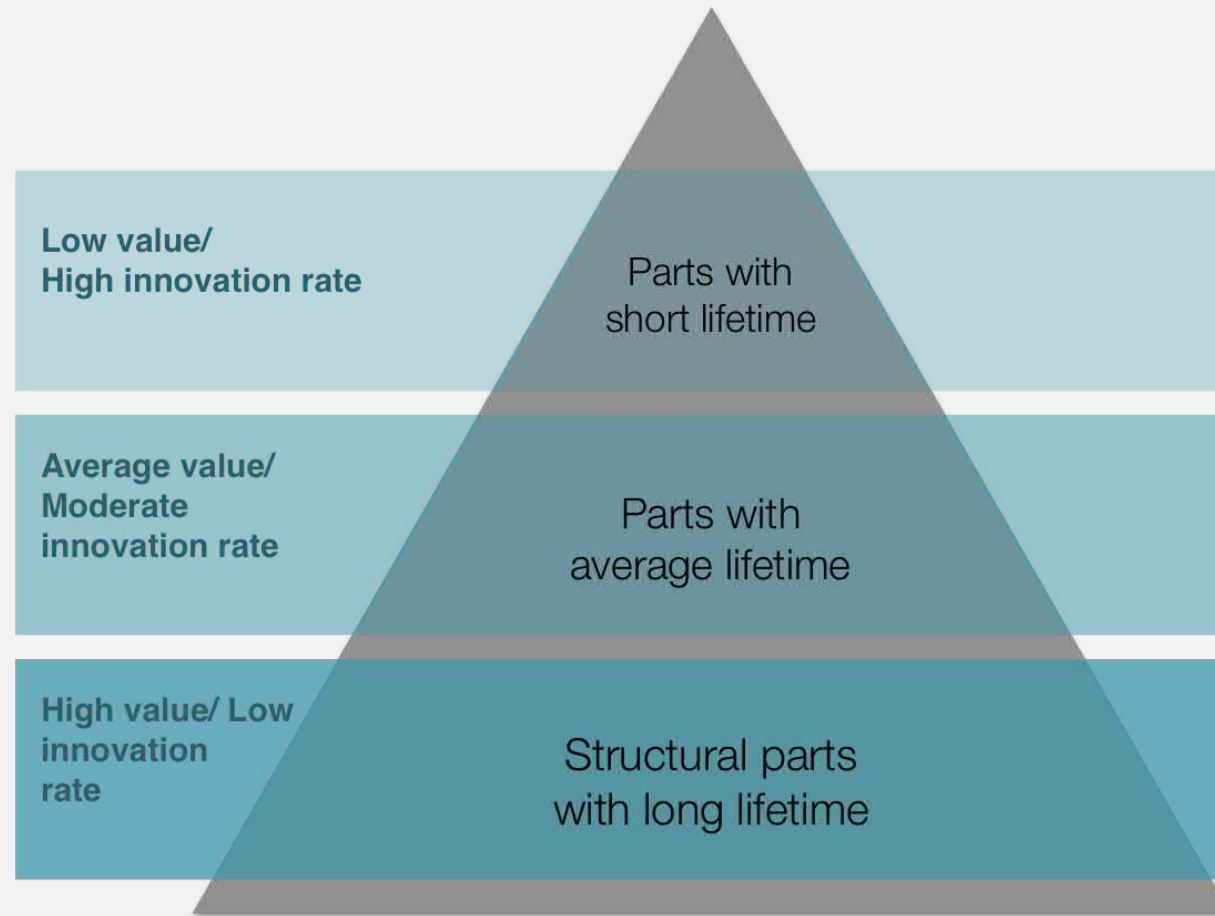
Design guidelines



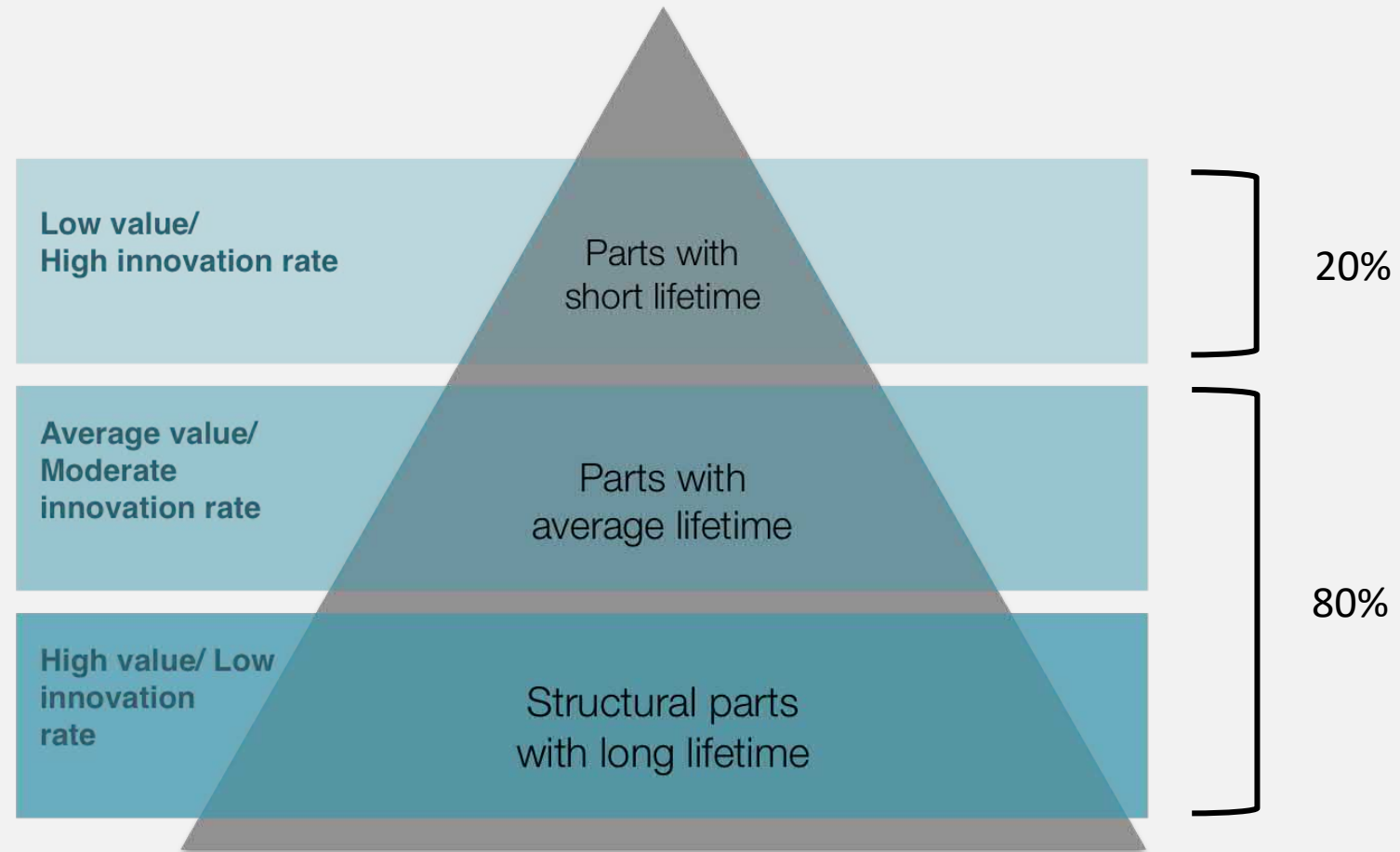
Design guidelines



Part lifetimes



Part lifetimes



S.W.O.T.

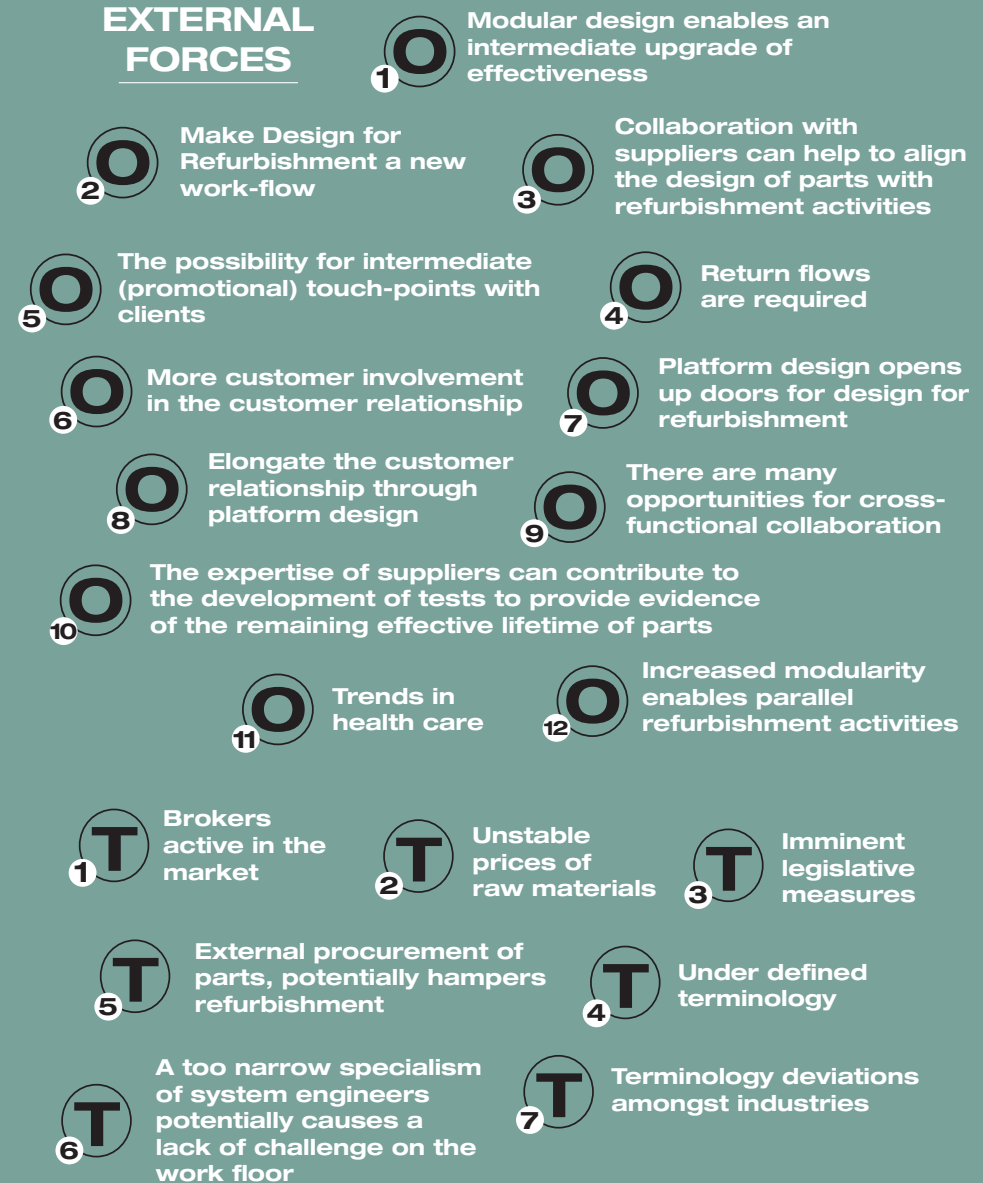
All chapters

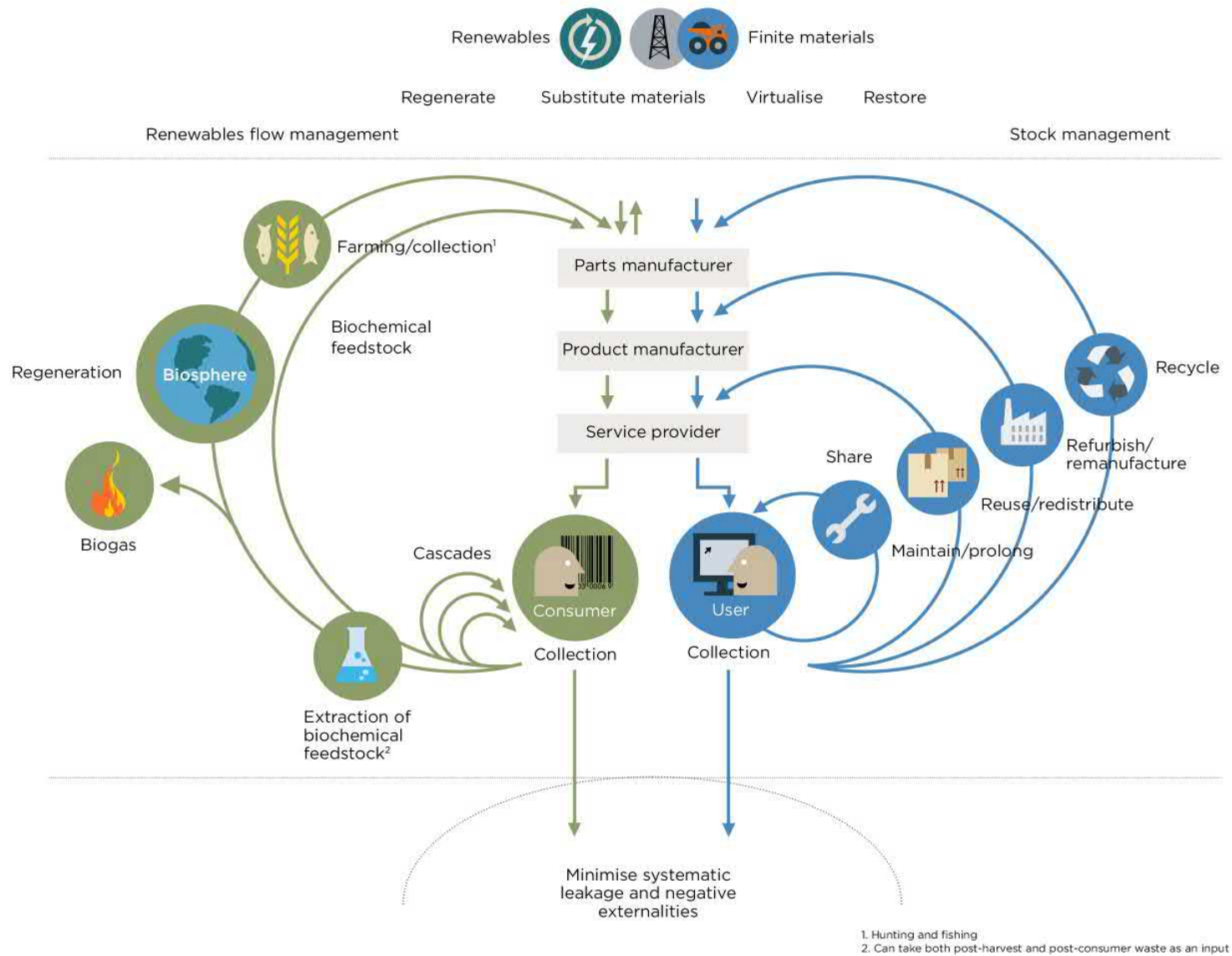
What the market and the company is concerned, the following strengths (S), weaknesses (W), opportunities (O) and threats (T) were found and clustered together below (some were shortened). This overview summarizes and concludes what was discussed in all chapters.

INTERNAL FORCES



EXTERNAL FORCES





Circular Product Readiness methode

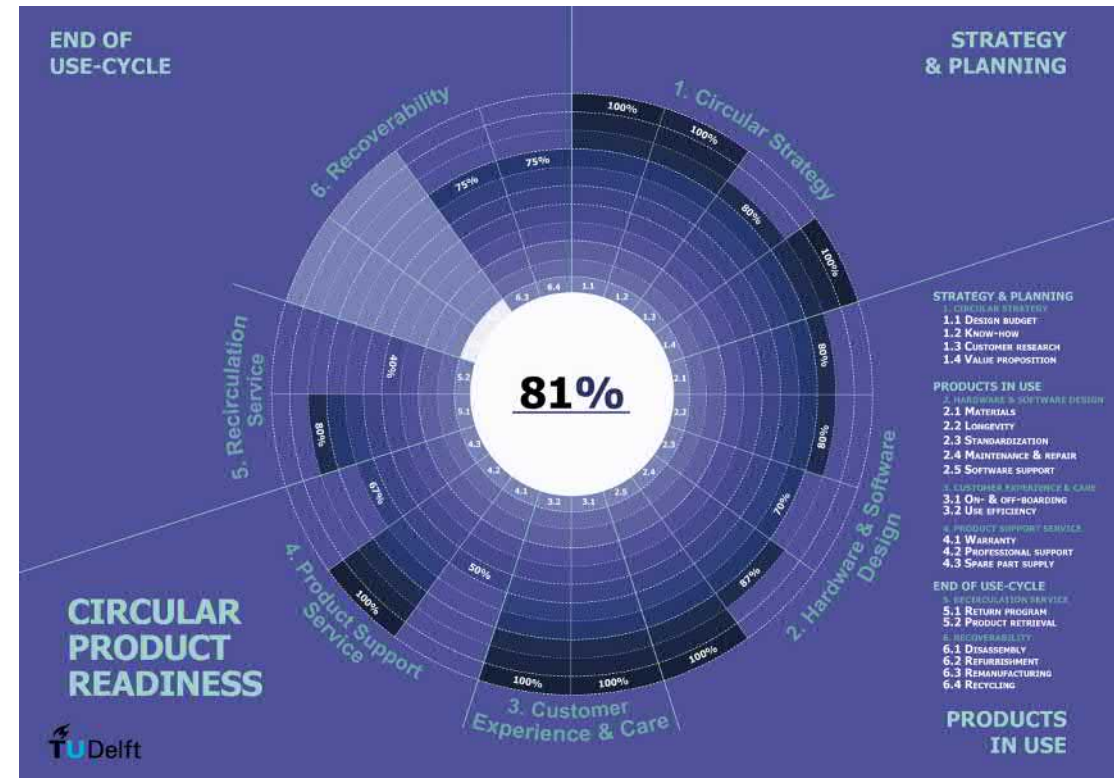
CIRCULAR PRODUCT READINESS

Een uitgebreide methode specifiek gericht op **ontwerpers**. De methode is de eerste indicator methode voor het beoordelen van circulair productontwerp op een **breed scala aan ontwerpaspecten**.

De methode maakt onderscheid tussen vier niveaus van gereedheid en toont zowel sterke punten van bedrijven als mogelijkheden voor verbetering.

De methode...

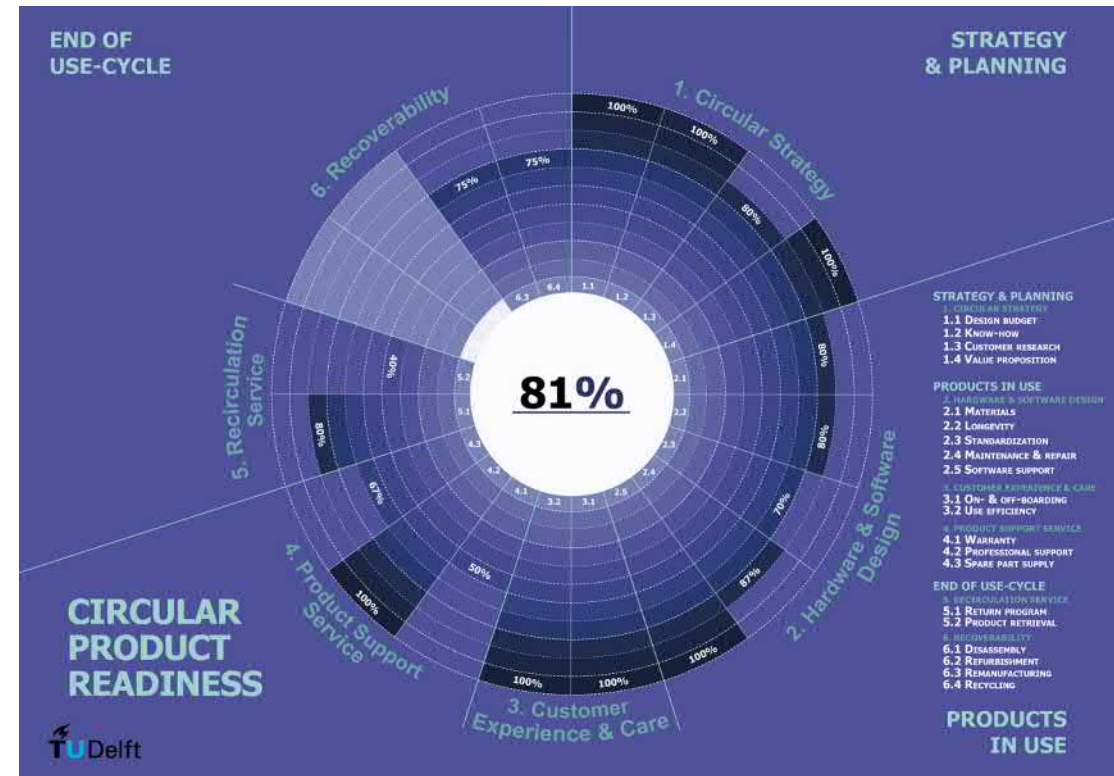
- Maakt gebruik van semantiek van productontwerp om ontwerpaspecten te evalueren
- Neemt de volledige levenscyclus in beschouwing
- Is ontwikkeld voor industrieel gebruik



Ontwikkeling van de methode

De ontwikkeling van de methode is gebaseerd op **literatuuronderzoek** en **kenniscoproductiesessies** met circulaire ontwerpexperts over onderwerpen als duurzaamheid, reparatie, remanufacturing en recycling.

De methode is geëvalueerd met **twee multinationals** die actief zijn in de witgoed- en auto-industrie.



THEMES

Indicators

1. STRATEGY AND PLANNING

- 1.1 Budget availability for circular product design
- 1.2 Access to circular design expertise
- 1.3 Customer research attuned to needs in all use-cycles
- 1.4 Circular value proposition design

2. HARDWARE AND SOFTWARE DESIGN

- 2.1 Materials
- 2.2 Longevity
- 2.3 Standardization across the product portfolio
- 2.4 Maintenance & repair
- 2.5 Hardware supports software updates

3. CUSTOMER EXPERIENCE AND CARE

- 3.1 User and product on- and offboarding
- 3.2 Product use-efficiency

4. PRODUCT SUPPORT SERVICE

- 4.1 Warranty
- 4.2 Professional support service for maintenance, repair and upgrades
- 4.3 Spare part supply

5. RECIRCULATION SERVICE

- 5.1 Product Return Program
- 5.2 Product Retrieval

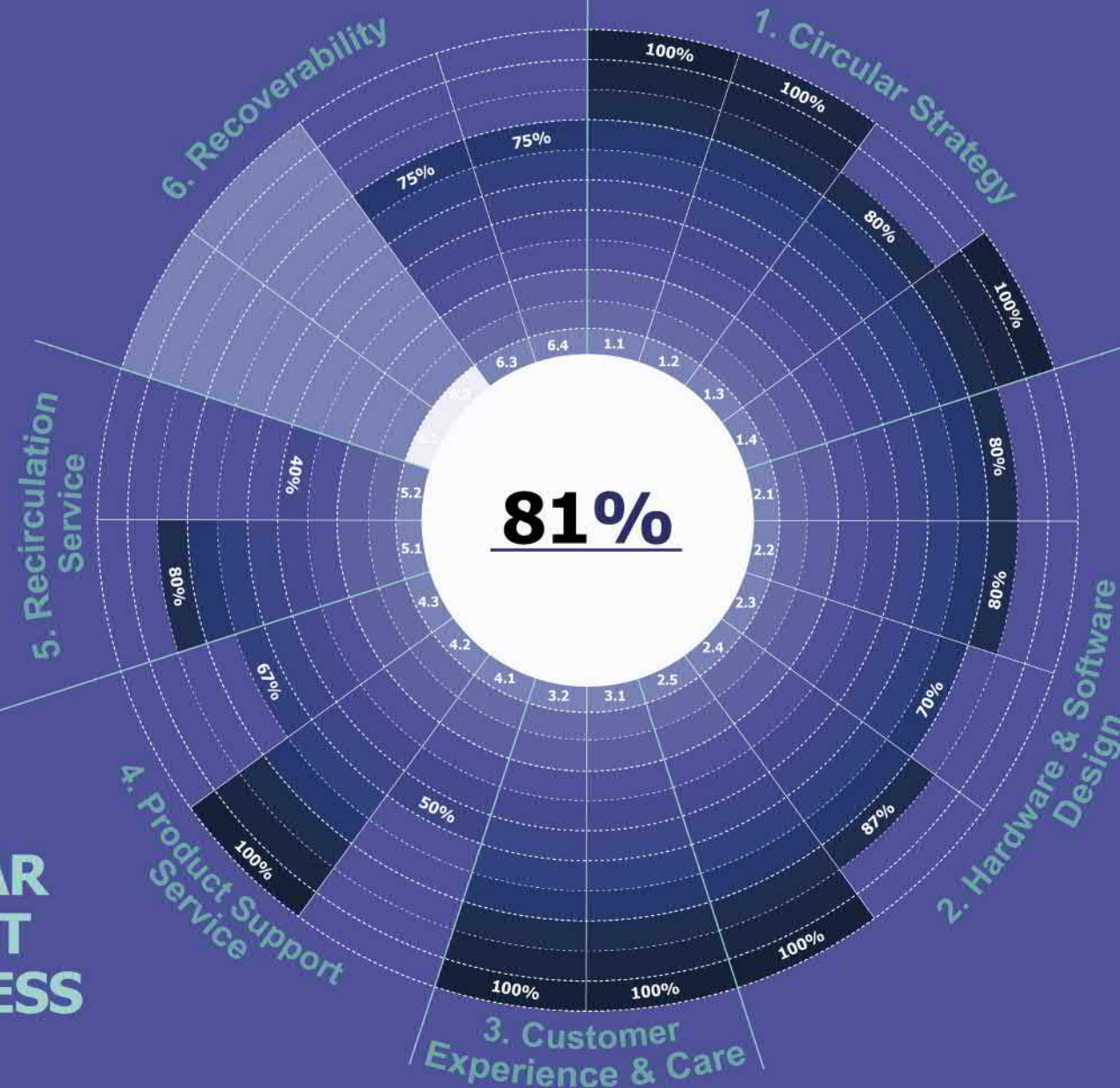
6. RECOVERABILITY

- 6.1 Disassembly
- 6.2 Refurbishment
- 6.3 Remanufacturing
- 6.4 Recycling

END OF
USE-CYCLE

STRATEGY
& PLANNING

CIRCULAR
PRODUCT
READINESS



STRATEGY & PLANNING

- 1. CIRCULAR STRATEGY
- 1.1 DESIGN BUDGET
- 1.2 KNOW-HOW
- 1.3 CUSTOMER RESEARCH
- 1.4 VALUE PROPOSITION

PRODUCTS IN USE

- 2. HARDWARE & SOFTWARE DESIGN
- 2.1 MATERIALS
- 2.2 LONGEVITY
- 2.3 STANDARDIZATION
- 2.4 MAINTENANCE & REPAIR
- 2.5 SOFTWARE SUPPORT
- 3. CUSTOMER EXPERIENCE & CARE
- 3.1 ON- & OFF-BOARDING
- 3.2 USE EFFICIENCY
- 4. PRODUCT SUPPORT SERVICE
- 4.1 WARRANTY
- 4.2 PROFESSIONAL SUPPORT
- 4.3 SPARE PART SUPPLY

END OF USE-CYCLE

- 5. RECIRCULATION SERVICE
- 5.1 RETURN PROGRAM
- 5.2 PRODUCT RETRIEVAL
- 6. RECOVERABILITY
- 6.1 DISASSEMBLY
- 6.2 REFURBISHMENT
- 6.3 REMANUFACTURING
- 6.4 RECYCLING

PRODUCTS
IN USE

CIRCULAR
PRODUCT
READINESS

gorenje group

ASKO
washing machine

R&D

16-11-2021

Company

Product

Owner

Date



European
Commission

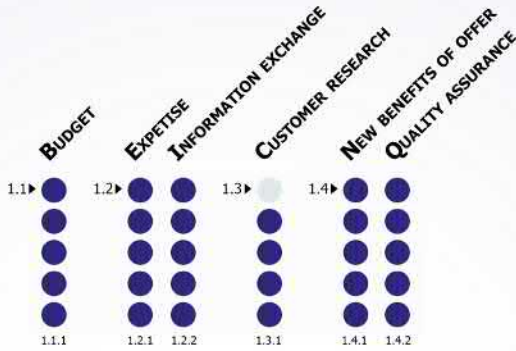
Horizon 2020
European Union funding
for Research & Innovation



Content development Nina Boorsma, Esra Polat & Prof. Dr. Conny Bakker
Design Nina Boorsma

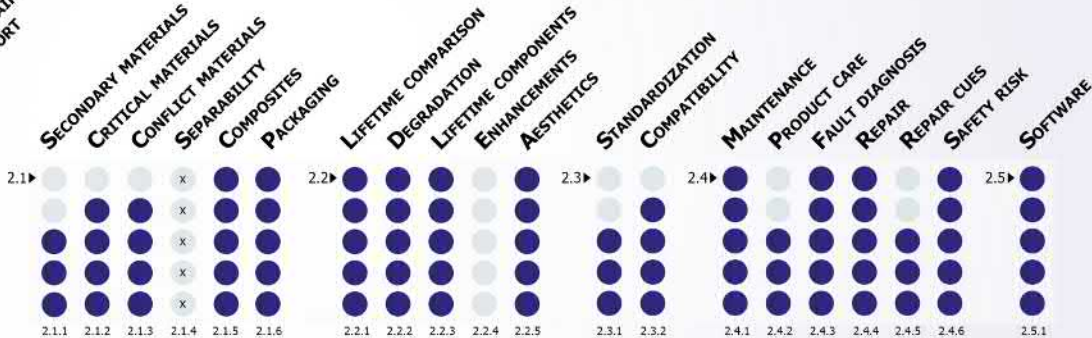
1. Circular
Strategy

95%



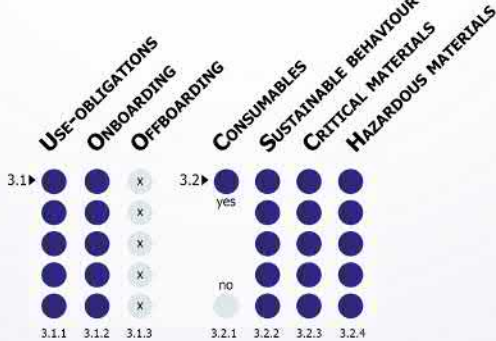
2. Hardware &
Software
Design

83%



3. Customer
Experience
& Care

100%



Average score
for a theme



Average score
for an indicator



0.2 points



Question is
out of scope

CIRCULAR PRODUCT READINESS

2022

1. STRATEGY & PLANNING

1.1 BUDGET AVAILABILITY FOR CIRCULAR PRODUCT DESIGN

- **1.1.1** Has your company made a budget available for circular design?

- ☐ Yes 1
- ☐ This is initiated 0.8
- ☐ This is planned 0.4
- ☐ This is not considered 0

1.2 ACCESS TO CIRCULAR DESIGN EXPERTISE

- **1.2.1** Does your company have access to circular design expertise?

This could be circular design expertise internally or from an external party, such as advisors, consultancies, etc.

- ☐ Yes, we have access to either internal and/ or external expertise 1
- ☐ We are in the process of acquiring (additional) expertise 0.8
- ☐ We are planning to acquire additional expertise 0.4
- ☐ No, we do not have access to circular design expertise 0
- ☐ N/A -

- **1.2.2** Does your company have channels to exchange product design information with stakeholders, like repair and remanufacturing technicians?

- ☐ Yes, we have access to either internal and/ or external expertise 1
- ☐ We are in the process of acquiring (additional) expertise 0.8
- ☐ We are planning to acquire additional expertise 0.4
- ☐ No, we do not have access to circular design expertise 0
- ☐ N/A -

1.3 CUSTOMER RESEARCH ATTUNED TO NEEDS IN ALL USE-CYCLES

- **1.3.1** To what extent are the needs of customers not only considered in the first use-cycle, but also in the subsequent use-cycles of the product?

- ☐ This is the norm 1
- ☐ This is initiated 0.8
- ☐ This is planned 0.4
- ☐ This is not considered 0
- ☐ N/A -

1.4 CIRCULAR VALUE PROPOSITION DESIGN

- **1.4.1** Does the circular value proposition and its related service and product offer new benefits to customers?

- ☐ Yes, there are new benefits to this circular value proposition 1
- ☐ We are in the process of adding new benefits 0.4
- ☐ No, there are no new benefits to this circular value proposition 0
- ☐ N/A -

- **1.4.2** To what extent does value proposition design support high product quality not only in the first use-cycle but also in subsequent use-cycles for the products?

- ☐ This is the norm 1
- ☐ This is initiated 0.8
- ☐ This is planned 0.4
- ☐ This is not considered 0

2. HARDWARE & SOFTWARE DESIGN

2.1 MATERIALS

- **2.1.1** What fraction of the material value, by cost price, consists of recycled and/ or reused materials calculated over all use-cycles?

This can be calculated using the following formula: (cost price of recycled and reused materials / cost price of materials in total) x 100%. For products with multiple use-cycles, the average of this fraction over the use-cycles can be calculated.

- ☐ 0% 0
- ☐ 1 - 19% 0.4
- ☐ 20 - 39 % 0.6
- ☐ 40 - 69% 0.8
- ☐ 70 - 100% 1

- **2.1.2** What amount of the material value, by cost price, consists of critical materials?

Critical materials for product designers are defined by Peck et al. (2015) as "elements from the periodic table of elements (metals/ rare earths) that may be at risk of price volatility and supply restrictions, they are often present in small quantities in technology products, substitution usually changes a product's properties and/ or performance." Examples of common critical materials to the EU are the following: Lithium, Beryllium, Magnesium, Scandium, Chromium, Cobalt, Gallium, and Germanium (Bauer et al. 2010).

- ☐ €0 1
- ☐ €0 - 0,09 0.8
- ☐ €0,1 - 0,19 0.6
- ☐ €0,2 - 0,4 0.4
- ☐ €0,4 0

- **2.1.3** What amount of the material value, by cost price, consists of conflict materials?

Conflict minerals refer to raw materials or minerals that come from a particular part of the world where conflict is occurring (i.e. those specifically associated with armed conflict, human rights abuses and corruption) that affect the mining and trading of those materials (Diemer et al. 2021). Examples of common conflict materials include the 3TG: tantalum, tin, tungsten, and gold.

- ☐ €0 1
- ☐ €0 - 0,09 0.8
- ☐ €0,1 - 0,19 0.6
- ☐ €0,2 - 0,4 0.4
- ☐ €0,4 0

- **2.1.4** Does the product contain easily separable biodegradable or compostable components?

- ☐ The product is fully biodegradable or compostable 1
- ☐ The product contains biodegradable and compostable components that are easy to separate 1
- ☐ The product contains biodegradable and compostable components that are hard to separate 0
- ☐ The product does not contain any biodegradable or compostable components -

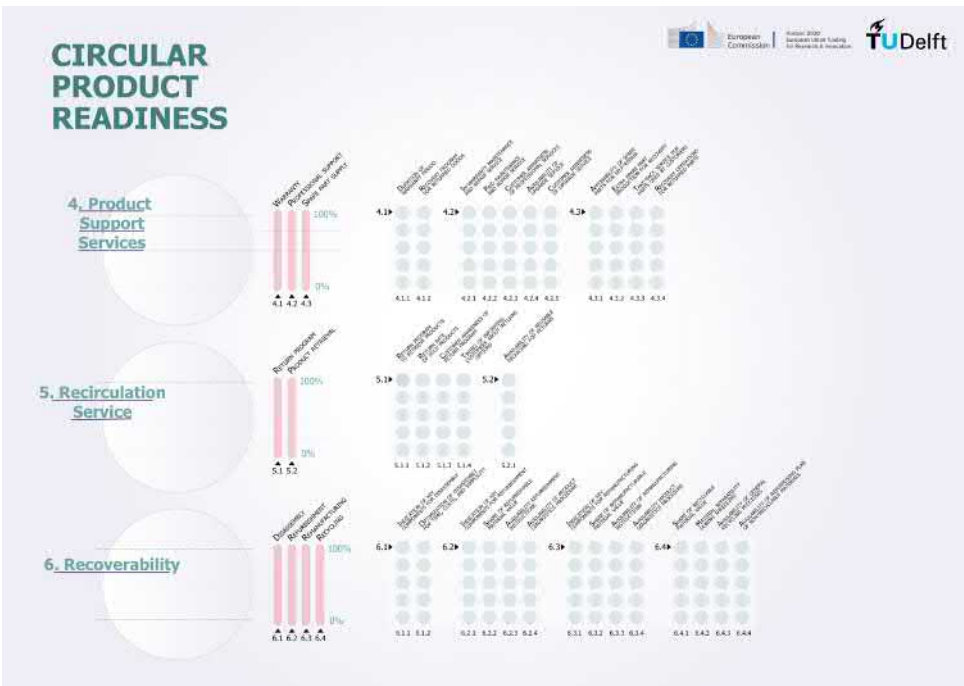
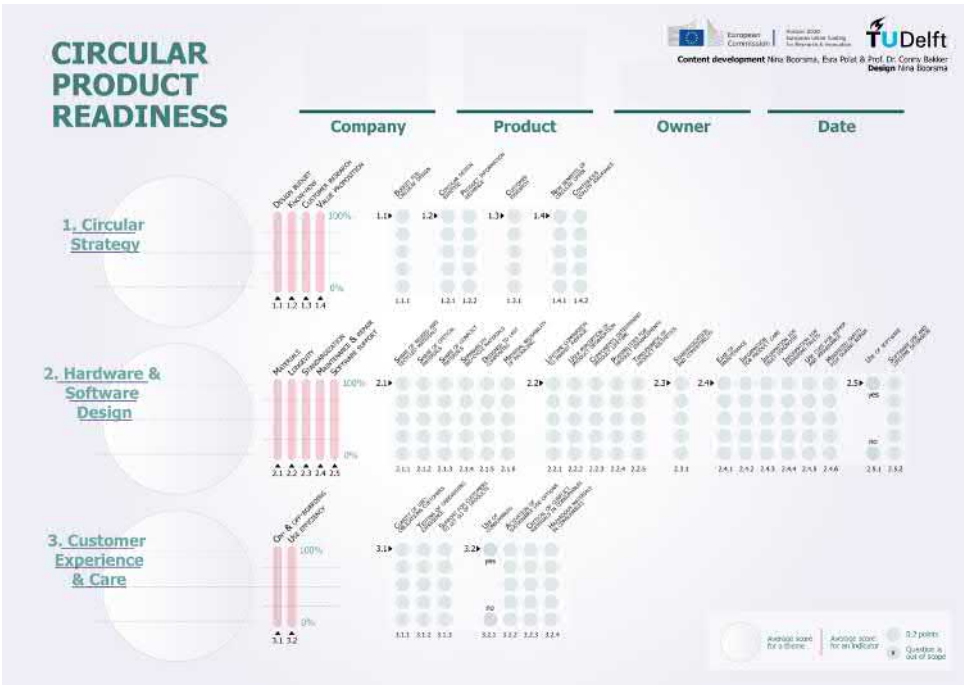
- **2.1.5** Does the product contain composite materials that are designed to last?

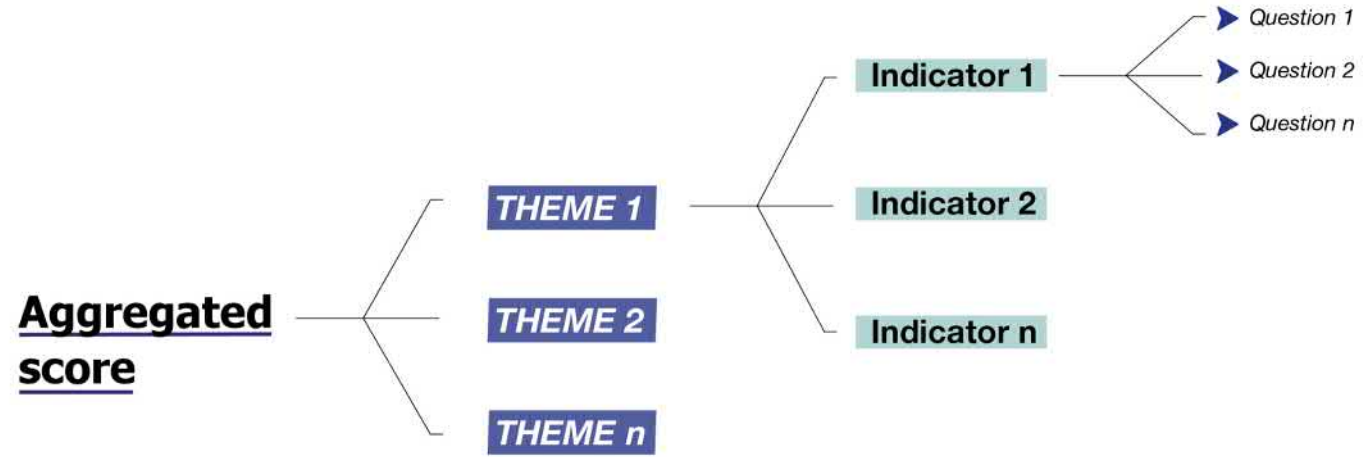
A composite material is a combination of two materials with different physical and chemical properties. Materials commonly used for composites are polymers, metals and ceramics.

- ☐ The composite materials used in this product are recyclable 1
- ☐ The product contains composite materials that are easy to separate and designed to last 0.6
- ☐ The product contains composite materials that are easy to separate, but not designed to last 0.2
- ☐ The product contains composite materials that are hard to separate 0
- ☐ No, the product does not contain any composite materials -

- **2.1.6** Does the product packaging consist of recyclable, biodegradable, or compostable materials?

- ☐ Yes, the packaging is fully recoverable 1
- ☐ The packaging is partly recoverable 0.8
- ☐ This is planned 0.4
- ☐ The packaging is not recoverable 0
- ☐ N/A -





Casestudy: Productieprinters

The gap

Design for Remanufacturing is uitgebreid bestudeerd, maar deze manier van ontwerpen wordt in de praktijk niet op grote schaal toegepast, hoewel bedrijven al tientallen jaren aan remanufacturing doen.

Hoofdonderzoeksvraag

Hoe kan strategisch ontwerp bijdragen aan de bredere implementatie van remanufacturing?

Hoofdonderzoeksvraag

Hoe kan strategisch ontwerp bijdragen aan de bredere implementatie van remanufacturing?

Een productieproces waarbij gebruikte producten een gestandaardiseerd industrieel proces doorlopen en worden hersteld tot de oorspronkelijke product specificatie.

Hoofdonderzoeksvraag

Hoe kan strategisch ontwerp bijdragen aan de bredere implementatie van remanufacturing?

Positioneert producten op de markt in relatie tot andere aanbiedingen van het bedrijf, rekening houdend met de behoeften van de markt en de langetermijndoelstellingen van het bedrijf.

Methode

Grondige casestudy

- Fabrikant van professionele productieprinters
- Lange geschiedenis in remanufacturing
- Op zoek naar manieren om Design for Remanufacturing te implementeren

Methode



Product design



Strategic design



New product development

First market release



Target segments



Segment parameters



Sales pitch

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch

Product design



Strategic design



New product development



Concept development



Product definition



Embodiment design

First market release



Target segments



Segment parameters



Sales pitch

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch

Product design



Strategic design



New product development



Concept development



Product definition



Embodiment design

First market release



Target segments



Segment parameters



Sales pitch

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch

Engineering requirements

Product design



Strategic design



New product development



Strategic vision



Product portfolio management



Product platform strategy



Product line strategy



Design brief

First market release



Target segments



Segment parameters



Sales pitch

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch

Product design



Strategic design



New product development



Strategic vision



Product portfolio management



Product platform strategy



Product line strategy



Design brief



First market release



Target segments



Segment parameters



Sales pitch

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch

Product design



Strategic design



New product development



Strategic vision



Product portfolio management



Product platform strategy



Product line strategy



Design brief

First market release



Target segments



Segment parameters



Sales pitch



Business case

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



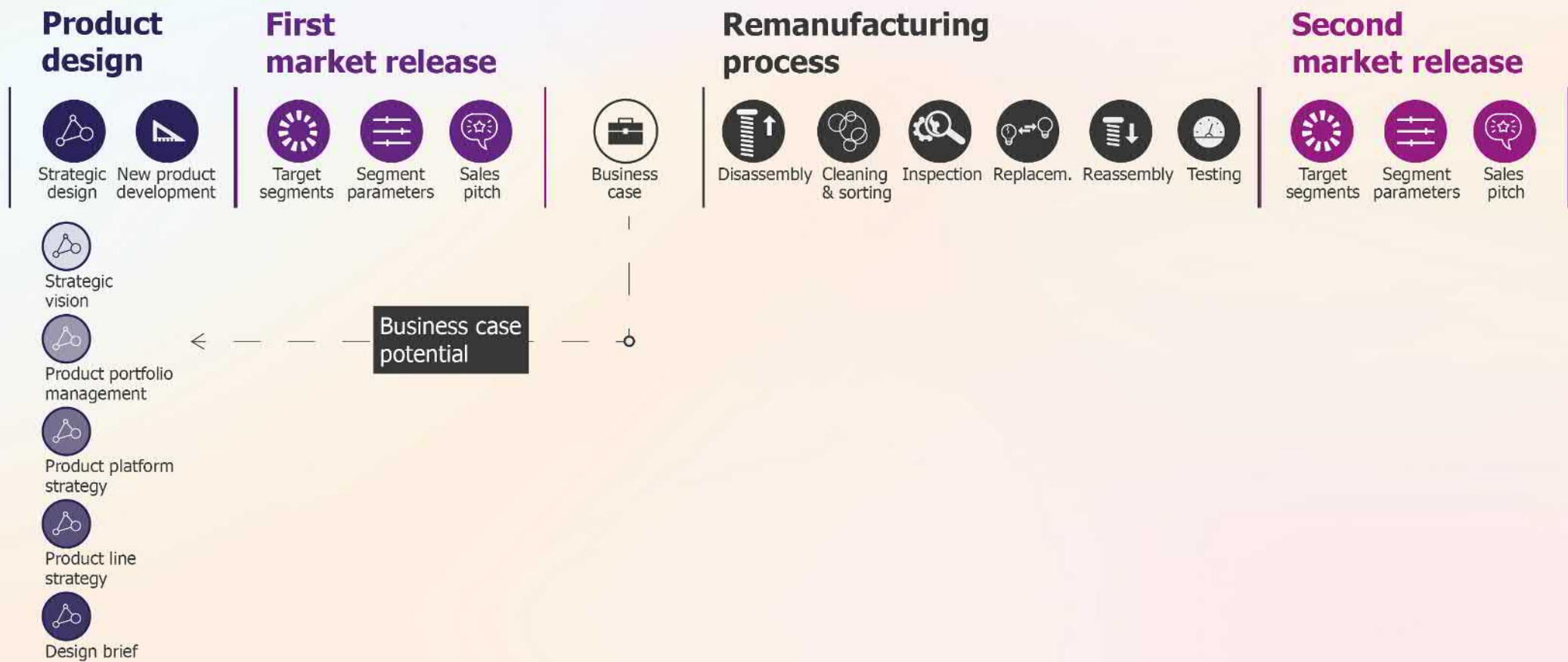
Target segments



Segment parameters



Sales pitch



Product design



Strategic design



New product development

First market release



Target segments



Segment parameters



Sales pitch



Business case

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch



Strategic vision



Product portfolio management



Product platform strategy



Product line strategy



Design brief



Identify critical parts

- High-value parts
- Software-related parts
- Safety-critical parts
- Procured parts
- Spare parts

Product design



Strategic design



New product development



Strategic vision



Product portfolio management



Product platform strategy



Product line strategy



Design brief

First market release



Target segments



Segment parameters



Sales pitch

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



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Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch

Product design



Strategic design



New product development

First market release



Target segments



Segment parameters



Sales pitch

Remanufacturing process



Disassembly



Cleaning & sorting



Inspection



Replacem.



Reassembly



Testing

Second market release



Target segments



Segment parameters



Sales pitch



Strategic vision



Product portfolio management



Product platform strategy



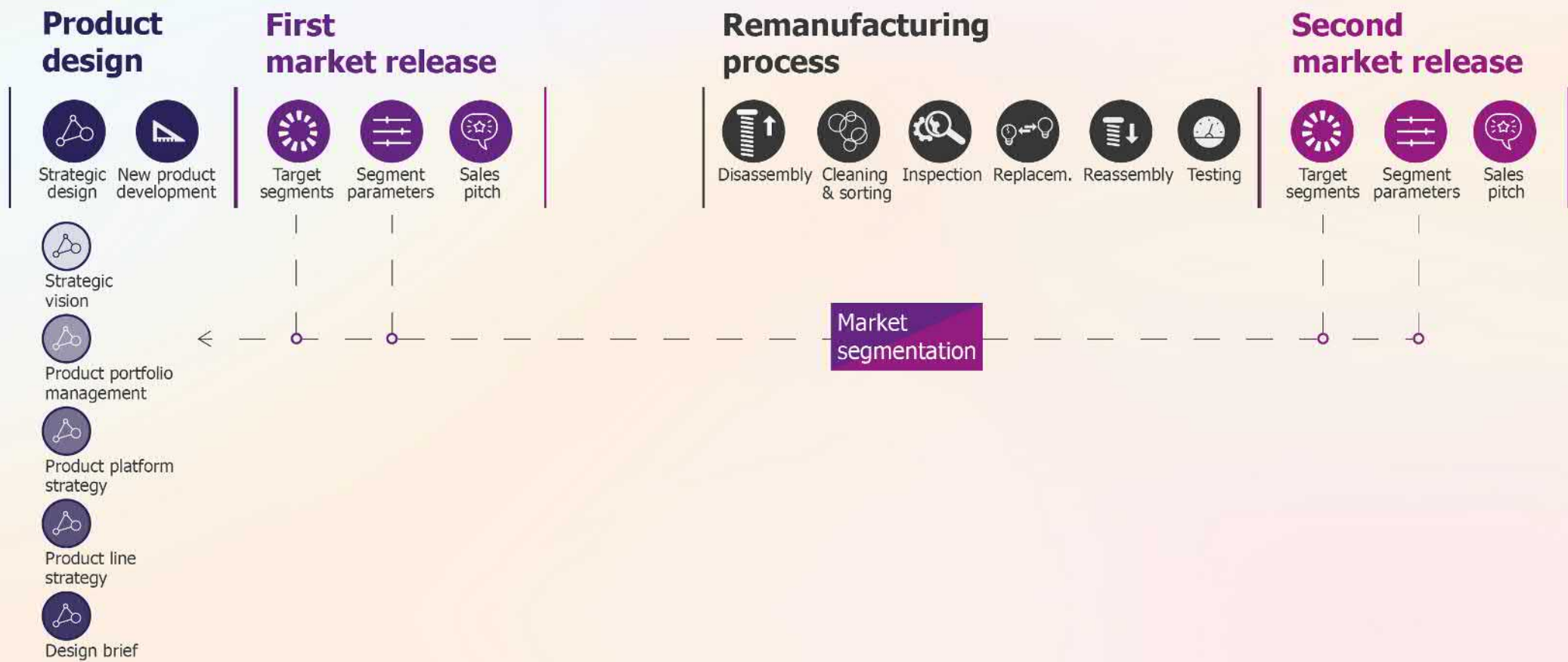
Product line strategy

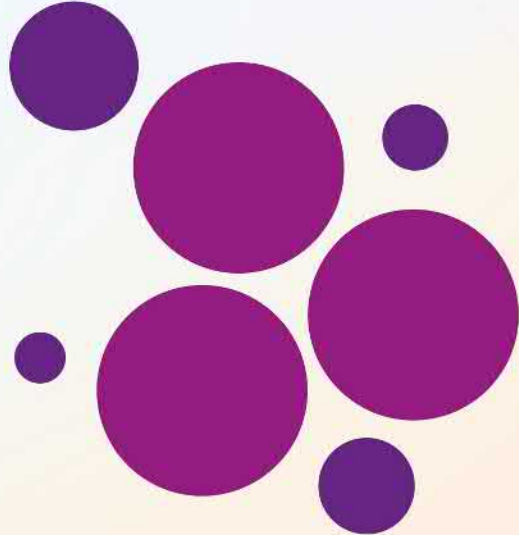


Design brief



Market segmentation





- Markets served with existing technology

➔ **Offer remanufactures products**

- Markets served with new technology

➔ **Offer new products**

Conclusies

We kunnen strategisch ontwerp gebruiken om remanufacturing om te vormen van een technische benadering aan het einde van de levensduur naar een strategisch bedrijfsmiddel.

Zo kun je..

- Meer mogelijkheden voor remanufacturing vinden
- Producten in de portfolio differentiëren
- Mogelijkheden voor ontwerpstandaardisatie vinden

De Circular Product Readiness methode kan helpen om dit op een holistische manier te bereiken. Dit alles brengt ons een stap dichterbij het ontwikkelen van geïntegreerde circulaire ontwerpstrategieën.

Bedankt voor uw aandacht!