
DAIKIN

Sustainability at Daikin
Driving Circular Design

Annex 65 Deep Dive – Task 5

DAIKIN

Agenda

1. Deep dive into how Daikin is embedding sustainability into product development
2. Case study: a full recyclability assessment of Daikin's Altherma 3 heat pump performed with Pezy Group
3. Q&A

EDC* Sustainability – 2 Pillars

Fusion 25

Offer new value for the environment and air to realize both contributions to a sustainable society and Group growth

Through products

Challenge to achieve carbon neutrality

- Power consumption reductions during product use
- Heat Pump Space and Water Heating business
- Refrigerant initiatives supporting the AC business
- Reduce greenhouse gas emissions in monozukuri (development and production) and offices, etc.
- Embrace new businesses aimed at a carbon neutral society
- Initiatives toward a circular economy

Through solutions

Promotion of solutions business connected with customers

- Establishment of owner-direct sales network, enhancements to sales proposal capabilities, expansion of service options by application and market, and improvements in business promotion functions
- Tackling the challenge of creating solution models balancing both energy efficiency performance and comfort
- In addition to growth of existing businesses, greater business expansion in Asia where market growth is anticipated

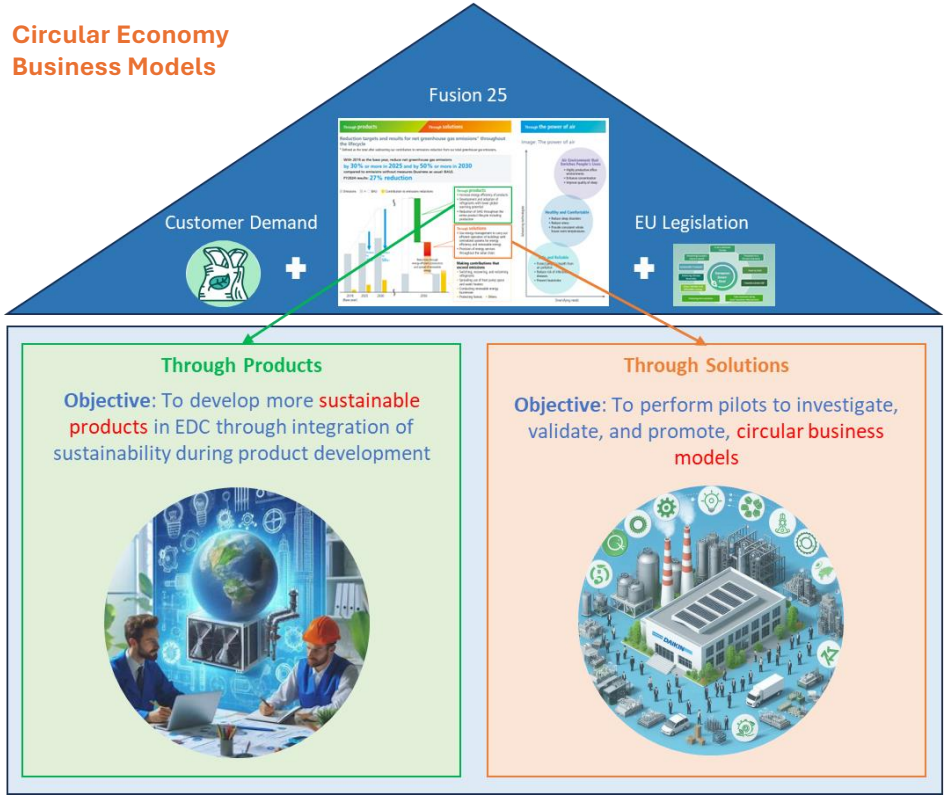
Through the power of air

Creating value with air

- Establishing a large-scale IAQ/Ventilation business
- Creation of IAQ/AE that enrich people's lives
- Pursuit of new value with air

Sustainable Product Development

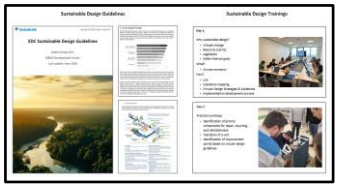
Circular Economy Business Models



* EDC: EMEA Development Centre

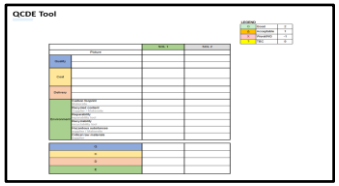
EDC Sustainability Actions Overview

1. Through Products – Sustainable Product Development

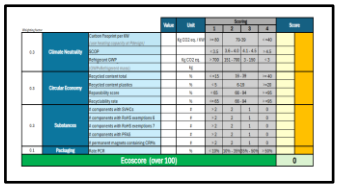


1. Knowledge Generation
Guidelines and Trainings

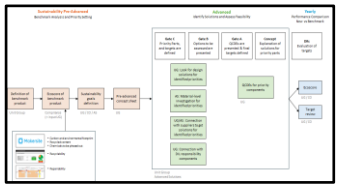
2. LCA Tool Implementation
Makersite



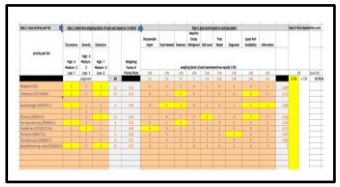
3. QCDE Tool Component Level Sustainability Assessment



4. Ecoscore Tool Unit Level Sustainability Assessment



5. Integration sustainability in DR cycle

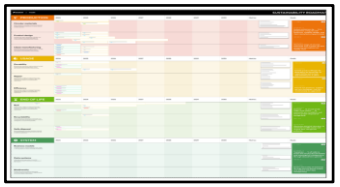


6. Repairability Calculation Tool

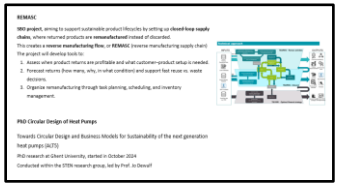
7. Recyclability Calculation Tool

8. Recyclability Assessment ALT3

2. Through Solutions – Circular Business Models



1. Roadmap Sustainability 2030



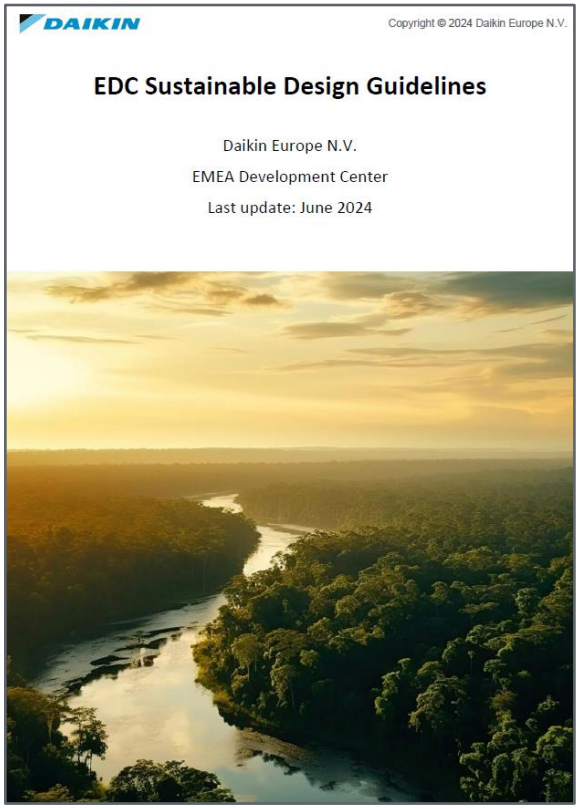
2. Research Projects

3. Condition Assessment EOL Units

4. Refurbishment Evaluation of Warranty and Transport Damages

1.1 Knowledge Generation

Sustainable Design Guidelines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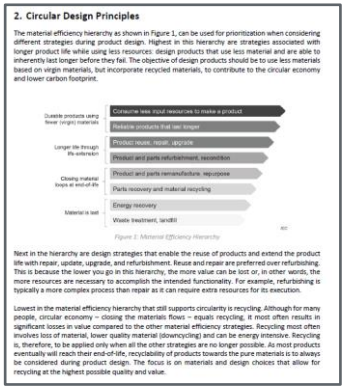
EDC Sustainable Design Guidelines

Daikin Europe N.V.

EMEA Development Center

Last update: June 2024


2. Circular Design Principles

The material efficiency hierarchy as shown in Figure 1, can be used for prioritization when considering different strategies during product design. Highest in this hierarchy are strategies associated with longer product life while using less resources: design products that use less material and are able to inherently last longer before they fail. The objective of design products should be to use less materials based on virgin materials, but incorporate recycled materials, to contribute to the circular economy and lower carbon footprint.

Consume less input resources to make a product

Redesign products that last longer

Product repair, repair, upgrade

Product and parts refurbishment, reconditon

Product and parts remanufacture, repurpose

Parts recovery and material recycling

Energy recovery

Waste treatment, landfill

Figure 1: Material Efficiency Hierarchy

Next in the hierarchy are design strategies that enable the reuse of products and extend the product life with repair, update, upgrade, and refurbishment. Reuse and repair are preferred over refurbishing. This is because the lower you go in this hierarchy, the more value can be lost or, in other words, the more resources are necessary to accomplish the intended functionality. For example, refurbishing is typically a more complex process than repair as it can require extra resources for its execution.

Lowest in the material efficiency hierarchy that still supports circularity is recycling. Although for many people, circular economy = closing the materials flows = equals recycling, it most often results in significant losses in value compared to the other material efficiency strategies. Recycling most often involves loss of material, lower quality material (downcycling) and can be energy intensive. Recycling is, therefore, to be applied only when all the other strategies are no longer possible. As most products eventually will reach their end-of-life, recyclability of products towards the pure materials is to always be considered during product design. The focus is on materials and design choices that allow for recycling at the highest possible quality and value.


2.2.Design for Recycling

When designing for increasing the ability of a product to have its materials recycled, first, the recycling process should be understood. In the case of heat pumps and refrigerators, generally, the recycling process would be like the one illustrated in Figure 3.

Figure 3: Example flowchart treatment process enabling separation. Source: Ecosystem asbl

Unloading

Storage

Partial dismantling of very large equipment

Equipment preparation

Decontamination

Shredding in a confined room

Suction of insulation foams

Treatment of insulation foams

Separation of non-ferrous metals (Eddy current)

Specific sorting

Sustainable Design Trainings

Day 1:

Why sustainable design?

- Climate change
- Resource scarcity
- Legislation
- Daikin internal goals

What?

- Circular economy

How?

- LCA
- Substance mapping
- Circular Design Strategies & Guidelines
- Implementation development process

Day 2:

Practical workshop

- Identification of priority components for repair, recycling, and refurbishment
- Teardown of a unit
- Identification of improvement points based on circular design guidelines

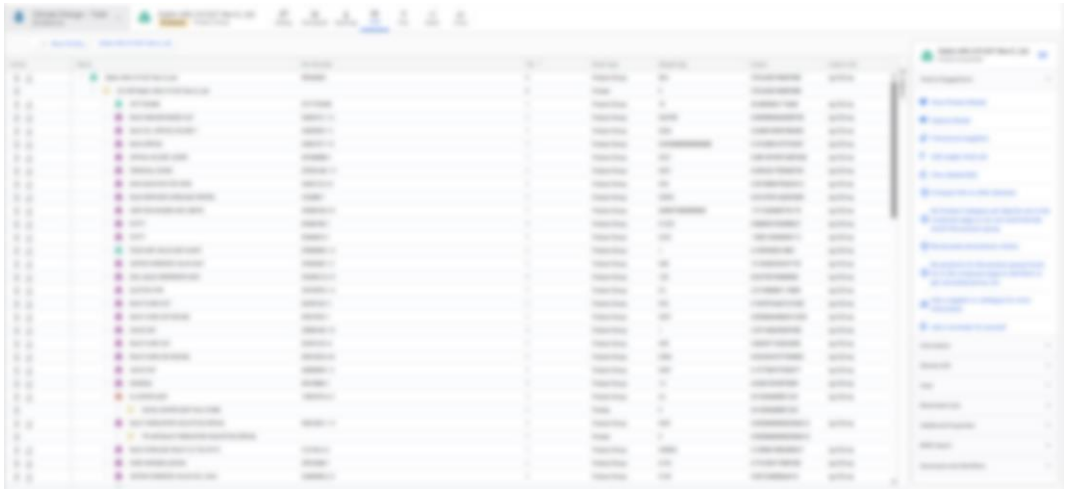
1.2 LCA Implementation

Makersite

→ Implementation of AI-driven LCA tool

→ Implementation with our SAP will allow to have Cradle-to-gate LCAs for all our products in SAP

→ LCA will be used in product development to reduce environmental impact



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1.3 QCDE Tool

→ Internal tool used to compare different solutions at component level based on **quality**, **cost, delivery** and newly added **sustainability** criteria

LEGEND		
O	Good	2
Δ	Acceptable	1
X	Worst/NG	-1
?	TBC	0

		SOL 1	SOL 2
Picture			
Quality			
Cost			
Delivery			
Environment	Carbon fooprint Makersite		
	Recycled content Supplier / Makersite		
	Reparability reparability tool		
	Recyclability recyclability tool		
	Hazardous substances supplier / Makersite		
	Critical raw materials supplier		

Each subcategory is evaluated using a symbol-based scoring system.

Q		
C		
D		
E		

A total score is calculated per solution and used as the decision basis for solution selection

1.4 Ecoscore Tool

→ **Product-level evaluation** to be integrated into the product development process

I. Benchmark analysis and priority setting

Goal: Identify hotspots for improvement in the new development

Workflow on benchmark product:

1. Define **priority components**
2. Conduct **component-level evaluation**
3. Analyze priority components of the **benchmark product**
4. Calculate the benchmark's **ecoscore**

Output: Clear hotspot areas to guide the focus of the new development

II. Ecoscore for the new development

- Calculate the ecoscore of the new development
- Compare performance **new vs. benchmark** to confirm improvement

1

Benchmark Product

Priority Components

	Carbon Neutrality	Circularity						Substances	
	Decarbonization	Recycled Content	Durability	Repair	Recyclability	Refurbishment	Reuse	Hazardous Chemicals	Critical Raw Materials
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Source:	Makersite	Makersite	Field claims Feedback installers	Field claims Feedback installers Disassembly workshop	Makersite	TBD	TBD	Makersite	CRM act

2

Overview Priority Components per focus Area

	Component	Focus areas			Responsible
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					

3

Priority Component 1	Benchmark	Target	New
Focus area 1			
Focus area 2			
Focus area 3			

Priority Component 2	Benchmark	Target	New
Focus area 1			
Focus area 2			

Priority Component 3	Benchmark	Target	New
Focus area 1			

Priority Component 4	Benchmark	Target	New
Focus area 1			
Focus area 2			
Focus area 3			

Priority Component 5	Benchmark	Target	New
Focus area 1			
Focus area 2			

4

ESPR requirements already covered

1. Carbon and environmental footprint
2. Durability & reliability
3. Possibility of remanufacturing
4. Reparability, Reusability & upgradability
5. Possibility of recycling & recovery of materials
6. Recycled content
7. Expected generation of waste materials
8. Presence of substances of concern
9. Energy use or energy efficiency
10. Possibility of maintenance and refurbishment

1.5. Integration of Sustainability in Development Process

→ Currently testing the procedure and tool in pilot projects

1.6. Repairability Calculation Tool

Based on EN 45554

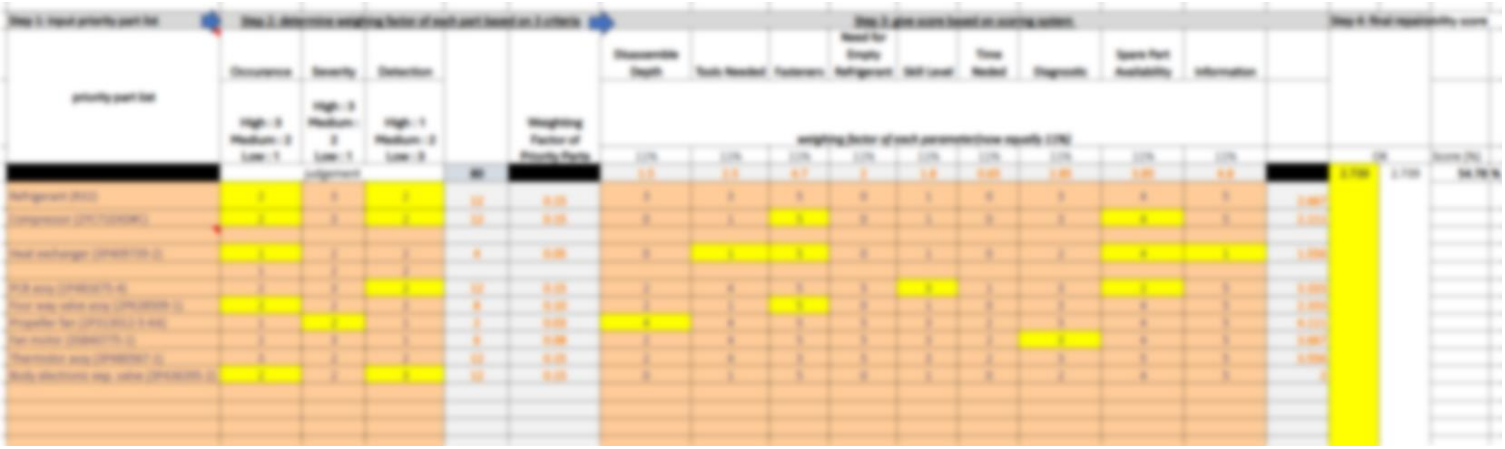
1. Define the **Priority Parts list** (first step in benchmark ecoscore)

2. Each part is evaluated on **three criteria** (score 1–3):

   - **Occurrence**: likelihood a defect occurs, or repair is needed
   - **Severity**: impact on unit operation or safety if a defect occurs
   - **Detection**: how easy it is to notice or detect a defect

3. Each part is then scored (score 0–5) on 9 parameters relevant to repairability assessment, including:

   - Depth of component accessibility
   - Tools required for removal
   - Fasteners involved
   - Refrigerant removal needed before replacement
   - Skill and time required
   - Diagnostic requirements
   - Spare part availability
   - Availability of instructions for replacement



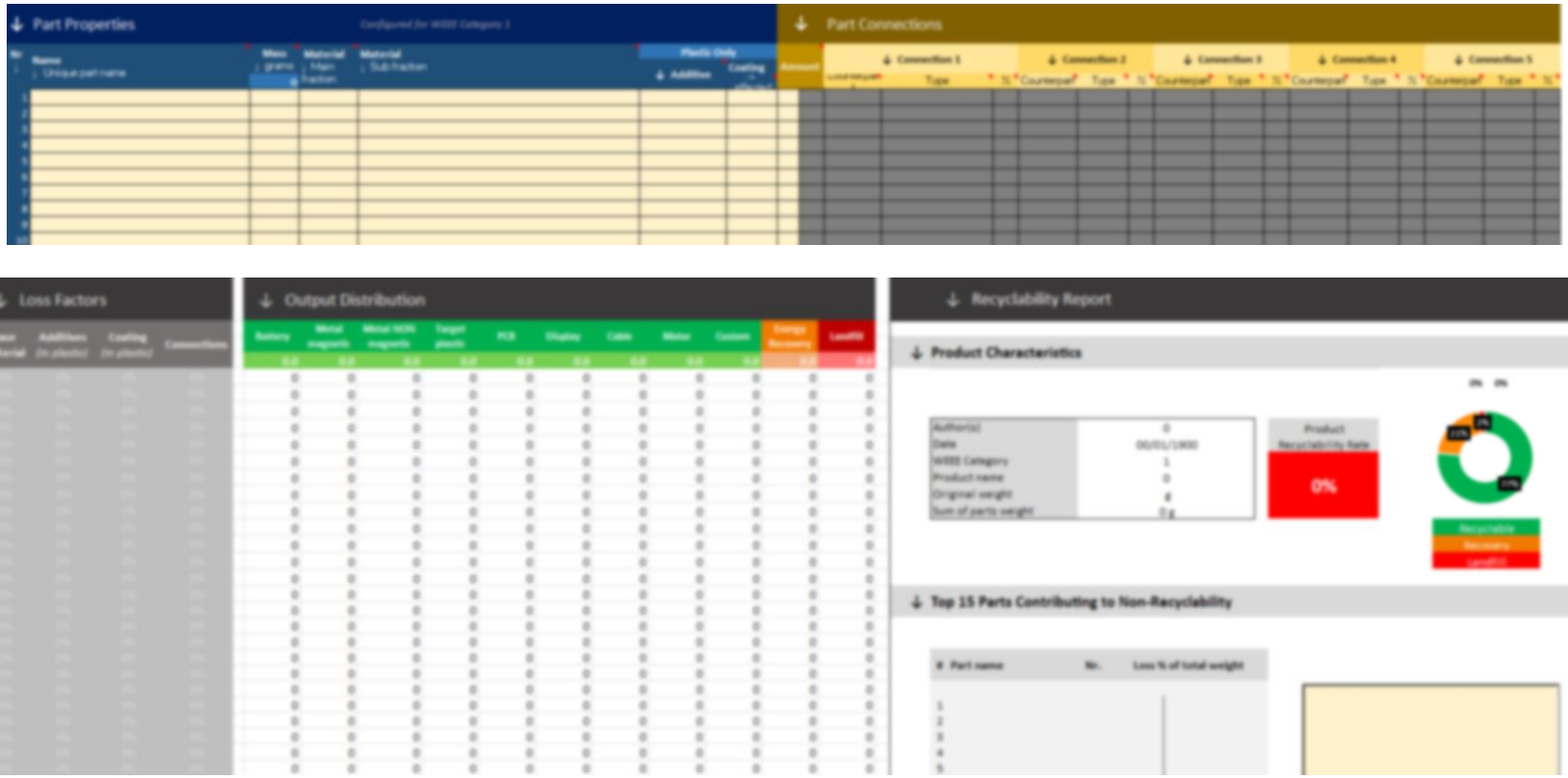
1.7. Recyclability Calculation Tool

An alternative for EN45555

Estimates the **recyclability rate** of EEE products using Western-European mechanical recycling assumptions

→ **Input:** Part name, weight, material fractions, additives, coatings and connection types

→ **Output:** Overall **recyclability (%)**, key **loss factors**, and top parts contributing to recyclability loss



1.8. Recyclability Assessment ALT3 – Case Study

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PEZY.

INGENIOUS PRODUCT DEVELOPERS

This is PEZY.

5	300+	PILOT FACTORY
Offices	Patents	In-House

100+	75	30
Clients	Specialists	Years

PEZY.

Design & Engineering Services.

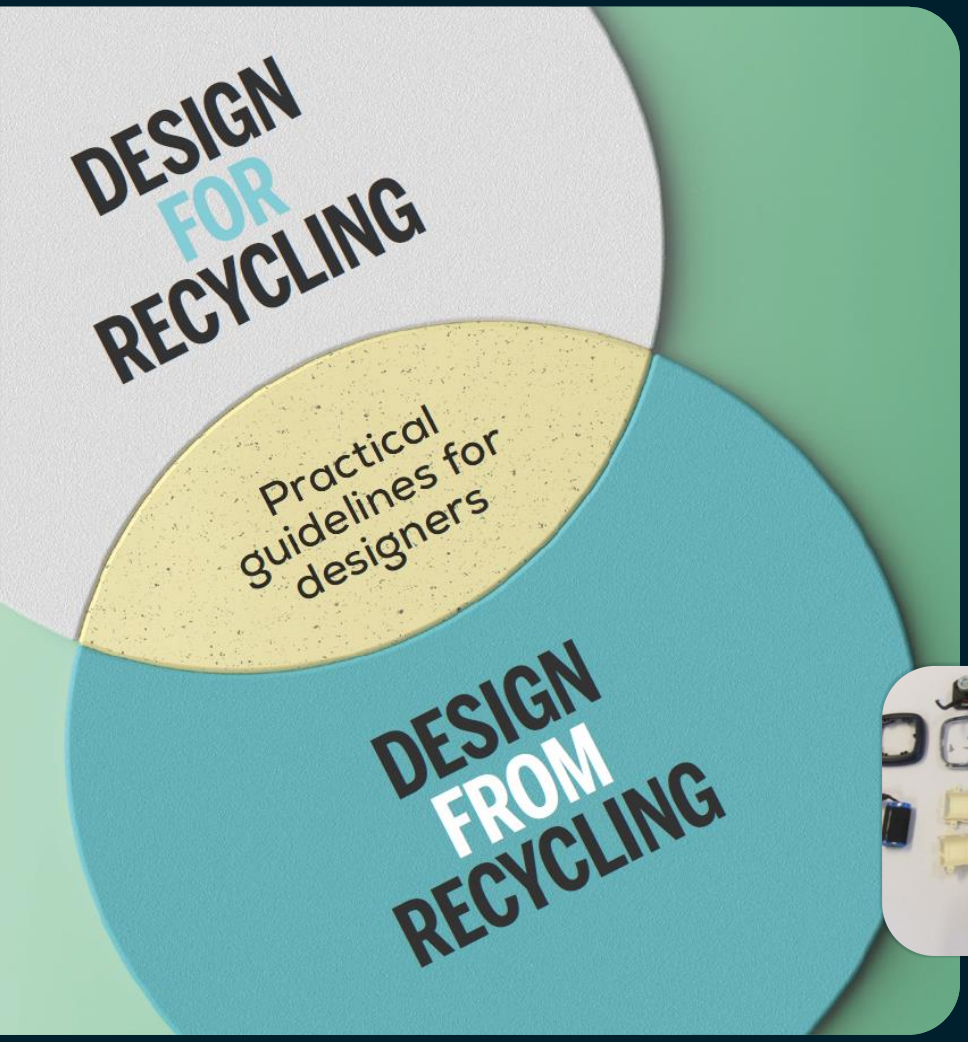
We bridge the gap between great ideas and running production.

DESIGNING THE RIGHT PRODUCT
This enables you to validate your proposition.

DEVELOPING THE PRODUCT RIGHT
This enables you to make it to market launch.

WE DEVELOP ‘NEW TO THE WORLD’ INNOVATIVE PRODUCTS

PEZY.



Circularity.

We bring circular design in practice by designing products "for" and "from" recycling. We developed a step-to-step methodology in a consortium, to stimulate a circular economy. Our proposition includes recycled material testing, disassembly & recyclability assessments.

PEZY.

1.8. Recyclability Assessment ALT3 – Case Study

Recyclability assessment of the Altherma 3 H MT ECH_2O heat pump, carried out with PEZY and in collaboration with recyclers.

PEZY a full-service product development agency offering design, engineering, and prototyping, based in the Netherlands.

Project Goal: I**dentify improvement opportunities in material choices, assembly, and end-of-life processing**

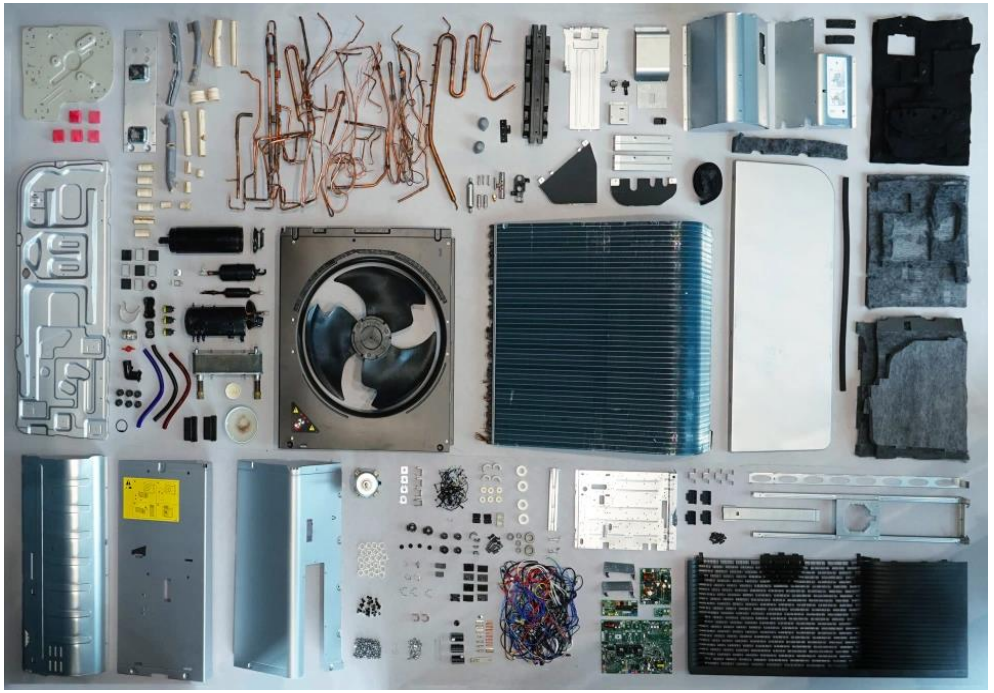
Project Objectives:

→ Evaluate the recyclability of ALT3's components

→ Establish a baseline recyclability rate of the product

→ Identify major non-yield* parts and propose design improvements

→ Explore opportunities to increase the recycling value and efficiency



* Non-yield parts refer to components of a product that cannot be effectively recycled or recovered during the recycling process. These parts often end up as waste, requiring disposal through energy recovery or landfill, rather than being converted back into usable materials.

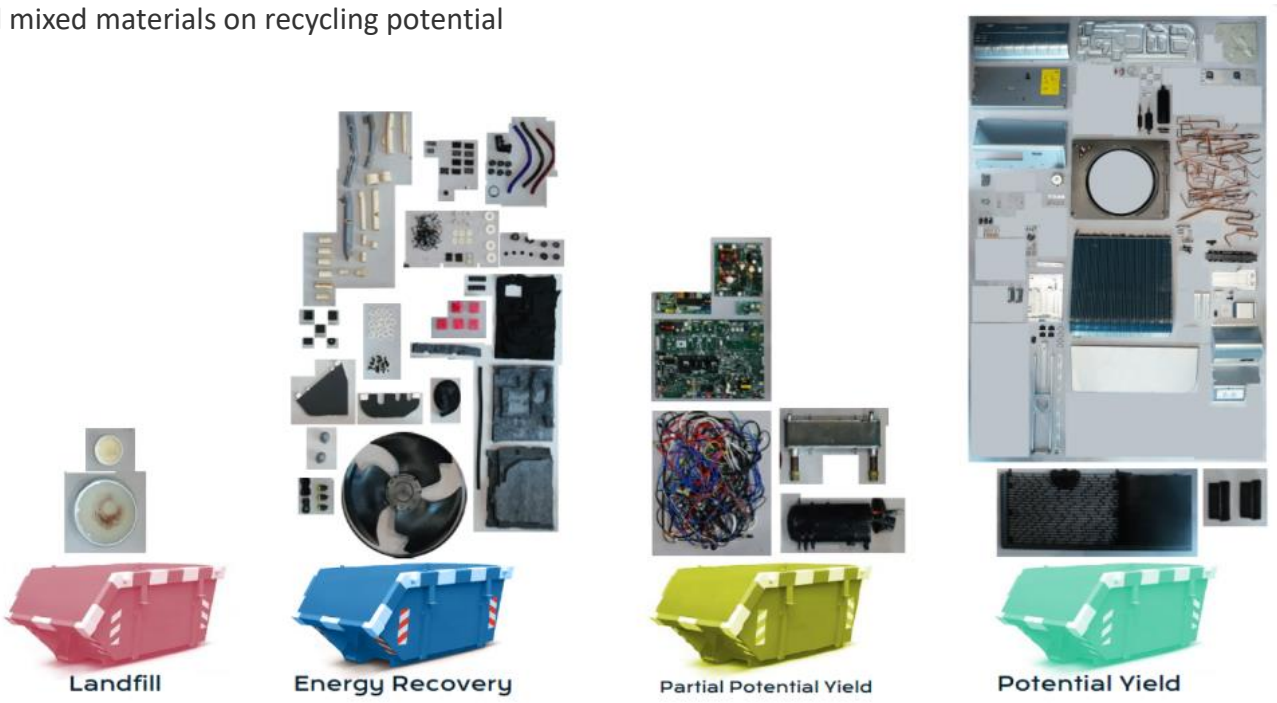
1.8.1. Methodology

The analysis started with a full disassembly of the unit to create a detailed BOM classifying each component by:

- Material
- Weight
- Connections

The parts were evaluated for **recycling**, **energy recovery,** and **landfill disposition**, focusing on:

- Ease of disassembly
- Material compatibility with existing recycling streams
- Impact of adhesives and mixed materials on recycling potential



1.8.2. Results and Key Findings

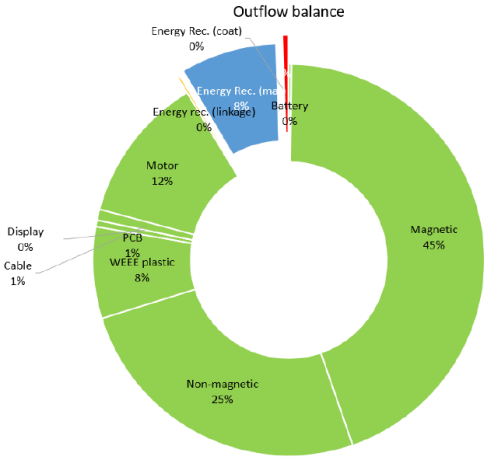
The heat pump comprises 70.1% metals and 29.9% non-metals, offering substantial potential for material recovery.

Major Non-Yield Hotspots:

→ Fan Assembly: Major avoidable loss driver*, with an impact of 2.1% of the total product's total recyclability rate.

→ PCB Cluster *(PCB, Cables, Accessories, & Copper Tubing)*: These electronic components pose challenges due to their mixed materials and attachment methods as well as being made of mainly plastics not commercially recyclable

→ Isolators *(Foams, Rubbers, & Fibers)*: Strong glue connections requires manual separation increasing recycling costs and waste



Total Yield:	91%

The total yield of the unit was approximately 91%, indicating that a significant portion of its materials can be effectively recovered and recycled, while 9% remains as non-yield or waste.

* Major avoidable loss driver refer to material that significantly reduces the overall recyclability, but the issue can be mitigated through a material substitution.

1.8.3. Outcomes

The project outlined actionable recommendations to improve recyclability:

→ **Material Substitution**: Favor metals or easily recyclable plastics for high-impact components (e.g. fan)

→ **Simplified Disassembly**: Design PCBs and cables as removable modules for easier separation, avoid PCB-to-Steel attachments

→ **Adhesive Alternatives**: Reduce the use of strong adhesives between foams and sheet metal walls

→ **Recycler Collaboration**: Involve recyclers in early design phases to align material choices with recycling infrastructure

Key Takeaways:

→ Thoughtful design is critical to advancing product recyclability

→ Material selection and assembly methods require further refinement

→ Optimizing recyclability enhances sustainability and meets growing market demand for sustainable products

2.1. Sustainability Roadmap

Overall Goal: Build the **circularity and sustainability strategy** for DENV, including KPIs, baseline values, targets, roadmap, and governance

→ Company-wide mapping of sustainability initiatives across all departments

→ Actions categorized into **Production**, **Use**, **End of Life**, and **Systems**

Gap analysis of existing KPIs to identify missing initiatives needed to meet company-level sustainability goals

Two main workstreams:

1.Mapping existing initiatives and metrics with baseline values and using them for the KPI gap analysis

2.Identifying barriers for each metric and defining potential future targets under different ambition levels and scenarios, plus actions needed to reach them

2.2. Research Projects

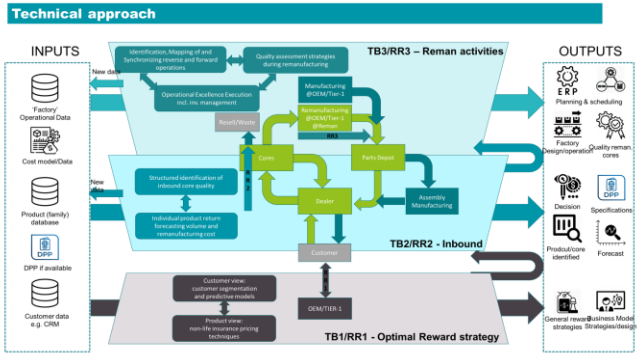
REMASC

SBO project, aiming to support sustainable product lifecycles by setting up **closed-loop supply chains**, where returned products are **remanufactured** instead of discarded.

This creates a **reverse manufacturing flow**, or **REMASC** (reverse manufacturing supply chain)

The project will develop tools to:

1. Assess when product returns are profitable and what customer–product setup is needed.
2. Forecast returns (how many, why, in what condition) and support fast reuse vs. waste decisions.
3. Organize remanufacturing through task planning, scheduling, and inventory management.



PhD Circular Design of Heat Pumps

Towards Circular Design and Business Models for Sustainability of the next generation heat pumps (ALT5)

PhD research at Ghent University, started in October 2024

Conducted within the STEN research group, led by Prof. Jo Dewulf

2.3/4. Pilots on Circular Business Models

Evaluation of refurbishment for warranty units and transport damages

→ Feasibility

→ Economic analysis

→ Environmental analysis

In depth analysis to assess condition of EOL units

→ Inventory of components leading to failure

→ Evaluation of components with potential for reuse

→ Preventive measures to prevent common failures from happening

→ Testing of components with potential for reuse

POC 1: Refurbishment of warranty units
Organize space to perform POC
Commitment of technical person
Creae template with investigation and outcomes to be included
1.Transport damages
Collection of transport damage units from 3R
Visual assessment to determine fesaibility of repair
Collect needed spare parts
Attempt repair of received units
Milestone check: if repair feasible, continue to next phase
Identify steps needed for refurbishment
Order needed spare parts
Perform refurbishment
Testing
Cost evaluation
Environmental evaluation
2. Warranty cases
Collection of warranty units from 3R
Visual assessment to determine fesaibility of repair
Collect needed spare parts
Attempt repair of received units
Milestone check: if repair feasible, continue to next phase
Identify steps needed for refurbishment
Order needed spare parts
Perform refurbishment
Testing
Cost evaluation
Environmental evaluation
POC 2: In-field units analysis
Organize space to perform POC
Collect units from Climatronix
Commitment of technical person
Create template with investigation and outcomes to be included
Assessment of delivered in field units
Summarize results
Define what components have potential for reuse
Identify parameters tha should be measured to know remaining lifetime
Investigate sensing technologies which could be used to measure
Cost evaluation
Environmental evaluation

Questions?

Thank you