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The transition from linear to circular

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SPORT INNOVATOR

www.sportinnovator.nl

Sportinnovator is an initiative from the Dutch government to accelerate innovations in sports

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NOC*NSF

TeamNL

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Brightlands
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Golden medal partners:

CHILL
empowering
tomorrow's
talent

Zuyd
Hogeschool
ZU
YD

UM
Maastricht University


Innovatie =
wetenschap x
ondernemerschap
brightlands.com

Connect this world with the world of sports and vice versa

Customers:

Sport Materials

- Sport equipment brands
- Sport associations

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What is the customers Problem?

- Upcoming EU Regulation (e.g. Digital Product Passport and Corporate Sustainability Reporting)
- Linear products, services and business models
- Lack of research facilities
- Lack of (executing) network
- Lack of Comprehensive Product Development Methodology and Knowledge

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What do our customers want?

Based on best practices (KNWU, Greenholds, Limburg Bike) and market demand (Shimano, Lazer, NABV, ISPO)

- **Accelerate** clear evidence based circular solutions for a Green identity
- Comply to (EU Green Deal) **regulations**
- Increase **revenues**
- **Performance** improvement
- **Increase** members

Do you experience similar challenges in your organization?

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What do we have to offer:

- **Circular product design**, engineering and materials knowledge
- **LCA's**. Measurement of **social, economic and environmental** impact.
- Connect to materials **network** partners/ eco-systems.
  - Consortium building
- High end material **R&D facilities**
- **Knowledge** of circular business models
- **Project management**

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Future Strategy?

What: Circular Product Design

By **2050**, the **EU aims for net-zero greenhouse gas (GHG) emissions**, necessitating an economic shift, with the **Circular Economy** at the forefront of solutions.

How: Regulation!

To achieve **net-zero GHG** the EU adopted the **Green Deal.** Validation of the objectives outlined in the Green Deal is carried out through **an EU Policy Framework (ESRS, DPP)**.

How: Change the Process

80% of environmental impact originates from product **Design Phase** decisions, emphasizing the need for implementing **Circular Strategies** to reduce the impact.

(Berwald et al., 2021; EU, 2023; EC, 2020; Johansson, 2002; McAloone & Bey, 2009)

Behind the regulation!

To achieve **net-zero GHG** the EU adopted the **Green Deal.** Validation of the objectives outlined in the Green Deal is carried out through **an EU Policy Framework (ESRS, DPP)**.

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ngineerin

What changes do we need to make to the current product development process to achieve this goal?

(Berwald et al., 2021; EU, 2023; EC, 2020; Johansson, 2002; McAloone & Bey, 2009)

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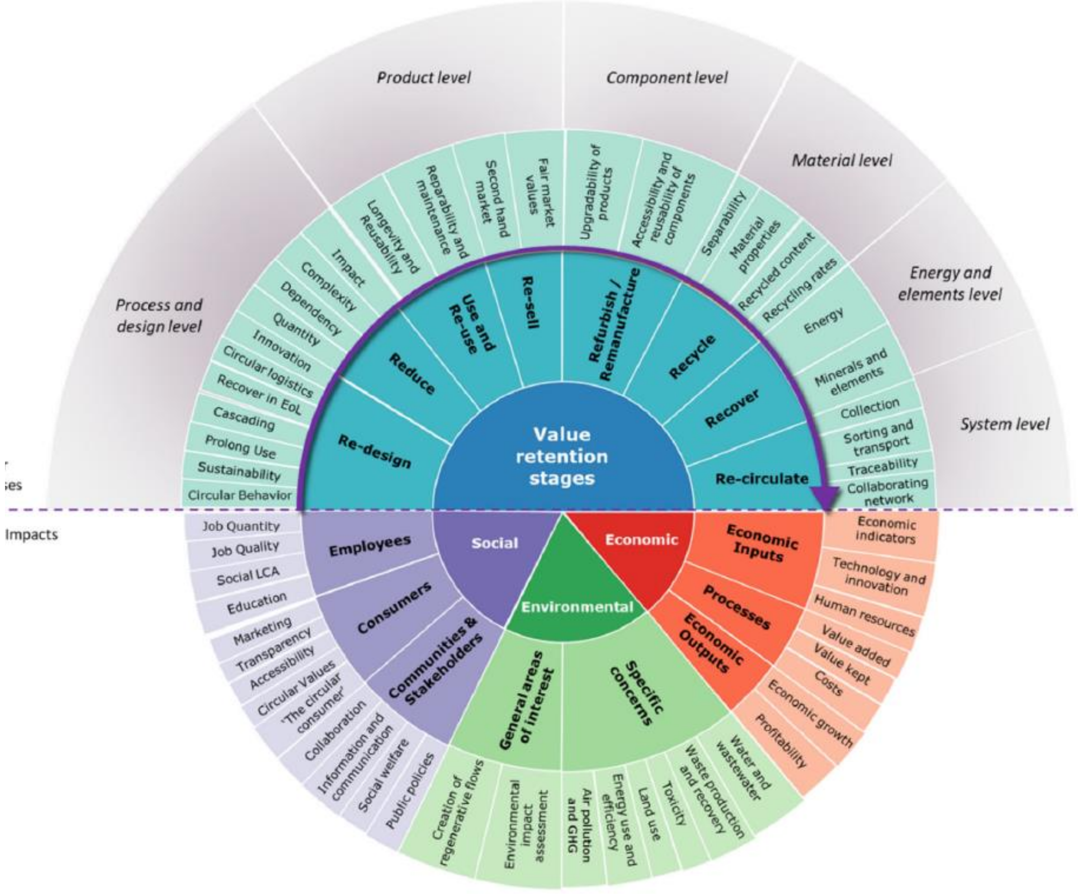
Circular Product Design

Circular Product Design	
Design for Product Integrity	Design for Recycling

Figure 1 Circular product design encompasses both design for product integrity (aimed at preventing and reversing obsolescence at a product and component level) and design for recycling (aimed at preventing and reversing obsolescence at a material level).

Design for Product Integrity		
Long use	Extended use	Recovery
Resisting Obsolescence: design approaches for long use	***Postponing Obsolescence: design approaches for extended use***	***Reversing Obsolescence: design approaches for recovery***
Design for Physical Durability	**Design for Maintenance**	**Design for Recontextualising**
Design for Emotional Durability	**Design for Upgrading**	**Design for Repair**
		Design for Refurbishment
		Design for Remanufacture

Figure 2 Typology of design approaches for product integrity.



(Den Hollander et al., 2017)

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Have you implemented any circular strategies so far – and if so, how?

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Example projects

- Olympic Handbike Mitch Valize
- 100% Limburg Bike
- Racket Orthese Sam Schröder
- Pole Vault scanner ESSX Rens Blom
- Greenholds
- Bio degradable Airsoft BB’s
- Bio degradable Golf Tees
- **Circulair Supply Chain Project**
- Circulair Product Design in Sport (PhD)
- Sustainable landing mats
- Network Events
- Monomaterial helmet

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Background: Greenholds Climbing holds

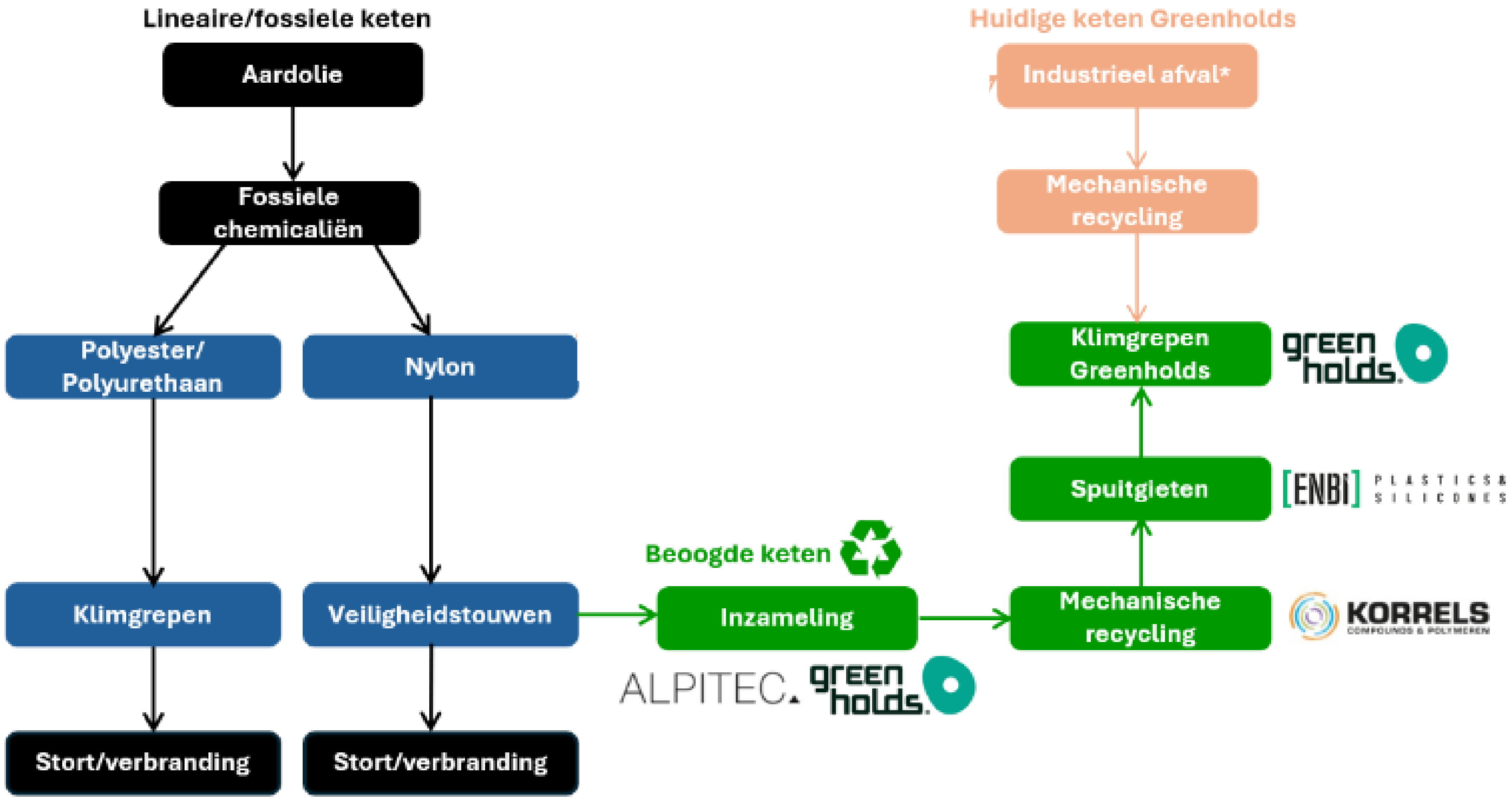
60 million climbing holds produced annually and rising:

Current Market standard: Thermosets Polyurethane & Polyester → waste 4 million holds annually

green holds

Greenholds: Thermoplastic Injection moulded from recycled Polyamide 6 Designed for Recycling

Circulair Chain Project



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Greenholds follows a DfR approach

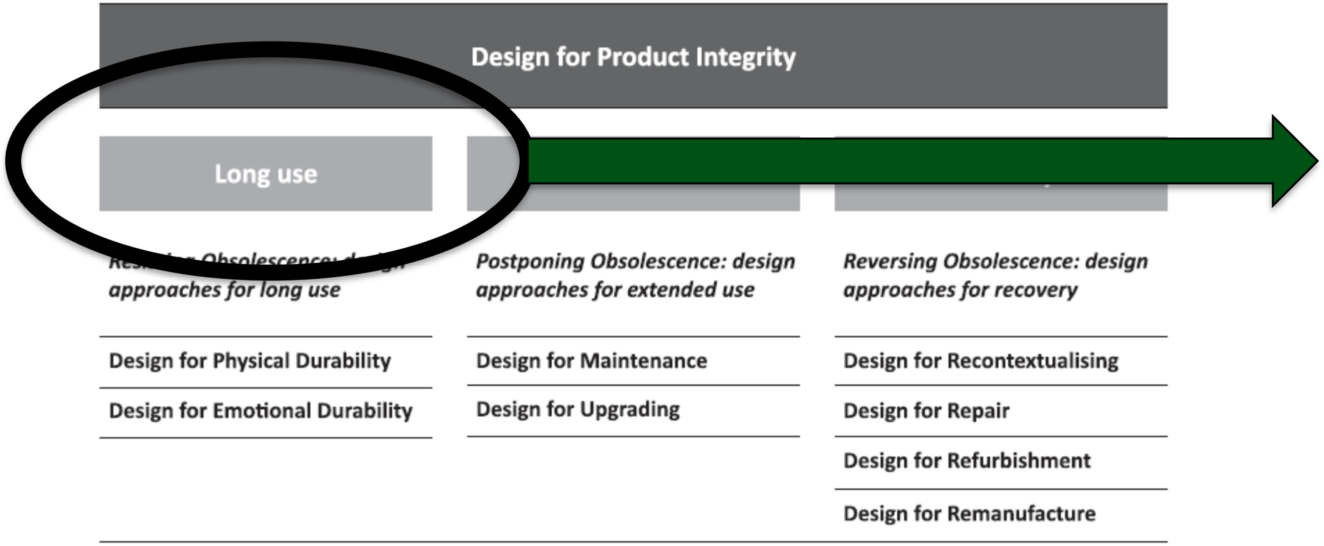

Figure 2 Typology of design approaches for product integrity.

Tests show that PA6 is three times more durable than PU and oneandhalf times more durable than UPR

(Den Hollander et al., 2017)

Goal & Research Question (option 1)

Goal: The goal of this study is to evaluate and compare the environmental impact and circularity performance of two types of climbing holds:

- 🧱 X: traditional holds manufactured from thermosetting plastics such as polyurethane (PU) and unsaturated polyester resin (UPR), which are currently dominant in the market;
- ♻️ Y: redesigned holds produced using recycled polyamide 6 (PA6) sourced from automotive waste and post-consumer climbing ropes, incorporating design for recycling principles.

RQ: *What is the difference in environmental impact and circularity performance between traditional climbing holds* ***(X)*** *made from thermosetting plastics and redesigned holds made from recycled content such as automotive waste and post-consumer climbing ropes* ***(Y)****?*

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Methodology

Aspect	Life Cycle Assessment (LCA)	ISO 59020 Circularity Assessment	Material Circularity Indicator (MCI)
Purpose	Assess environmental impacts	Measure circular performance using resource-related indicators	Score circularity of material flows in a single index
Focus	Environmental burdens (emissions, depletion, etc.)	Resource inflows/outflows; optional: energy, water, economics	Recycled input, product lifetime, recovery at end-of-life
Standards/ Tools	ISO 14040, ISO 14044 → ReCiPe 2016	ISO 59020:2024	Ellen MacArthur Foundation (2015)
Indicators	Midpoint and endpoint impact categories	Core: inflow/outflow quality; Optional: energy, water, economics	Single score (0–1) reflecting material circularity
Output	Environmental impact per functional unit	Multi-indicator profile of circularity performance	Circularity index supporting material flow decisions
Strength	Quantitative, comprehensive, standardized	Holistic, modular, adaptable to context	Easy-to-use, design-oriented, highly communicable
Limitations	Complex, assumption-sensitive, data-intensive	Still maturing, not yet widely applied in industry	Ignores emissions, toxicity, and critical material risks
Use in this study	Quantify impacts of UPR, PU, and PA6 climbing holds	Evaluate circularity performance across 11 scenarios	Compare scenarios on input/output balance and longevity

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Product Under Study & Functional Unit

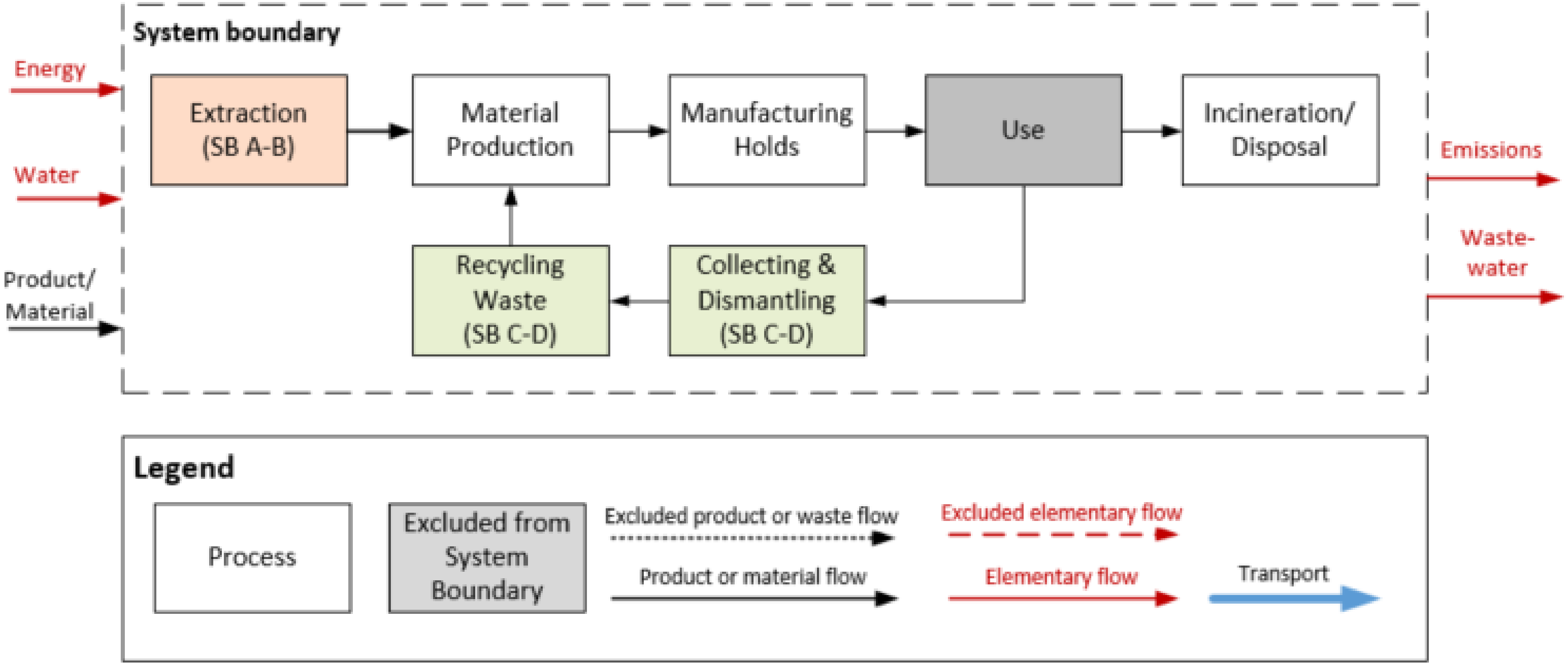
Product Under Study:

Name	Size	Mass	Main Location	Production	Main Material(s)
rPA6-AW (automotive)	M	242 g	Netherlands		Polyamide 6 (rPA6-AM)
rPA6-CR (climbing ropes)	M	242 g	Netherlands		Polyamide 6 (rPA6-CR)
PU Hold	M	442 g	Europe		Virgin Polyurethane (PU)
UPR Hold	M	1328 g	Europe		Virgin Unsaturated polyester resins (UPR)

Functional Unit:

The lifecycle of one medium-sized climbing hold (M), designed to withstand repeated loading and dynamic forces in accordance with NEN-EN 12572-3:2017 (ISO, 2017) for a lifetime of three years.

System Boundaries → cradle-to-grave



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System Boundary A: Thermoset Polyester Resin (UPR)

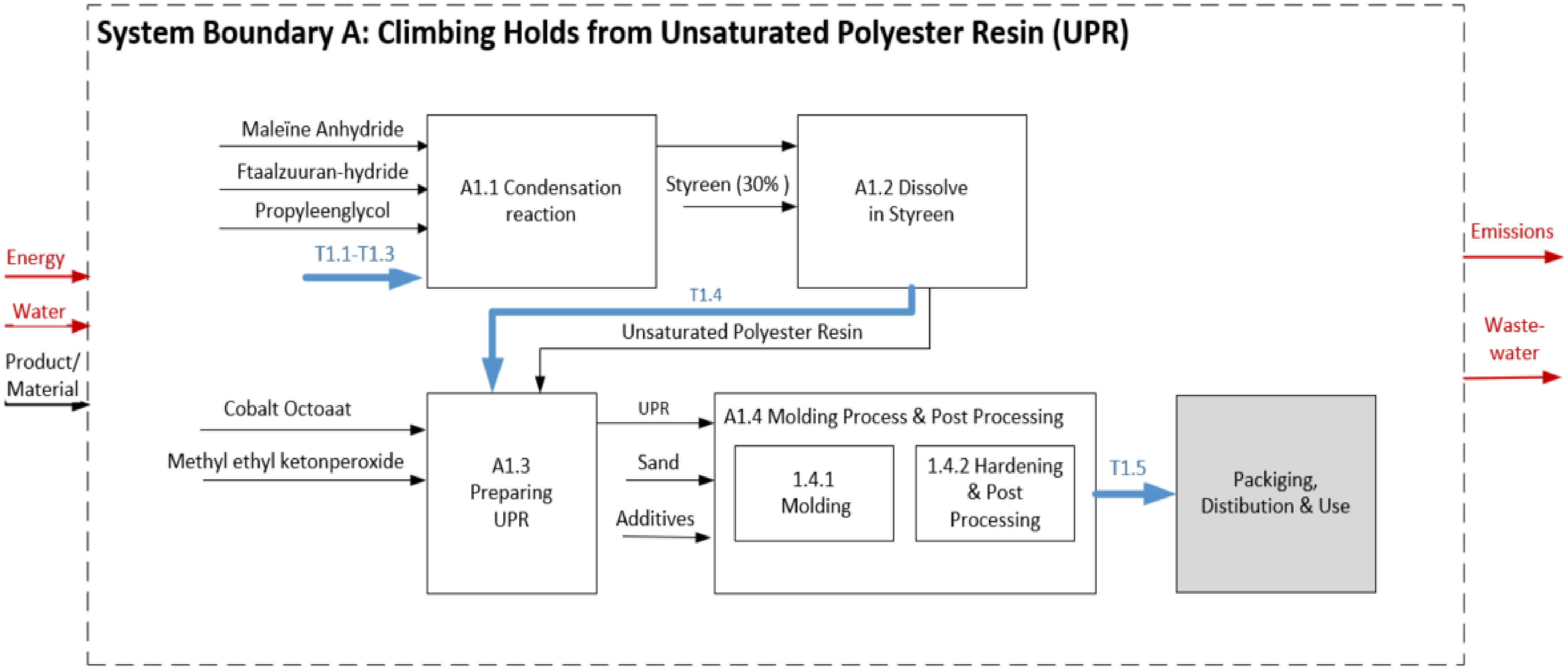

Figure 5 System boundary A of the production of climbing holds made from unsaturated polyester resin (UPR), including the synthesis, preparation, molding, and post-processing stages. Inputs such as raw materials, energy, and water are considered, along with emissions and wastewater outputs. Packaging, distribution, and use lie outside this boundary.

System Boundary B: Thermoset Polyurethane

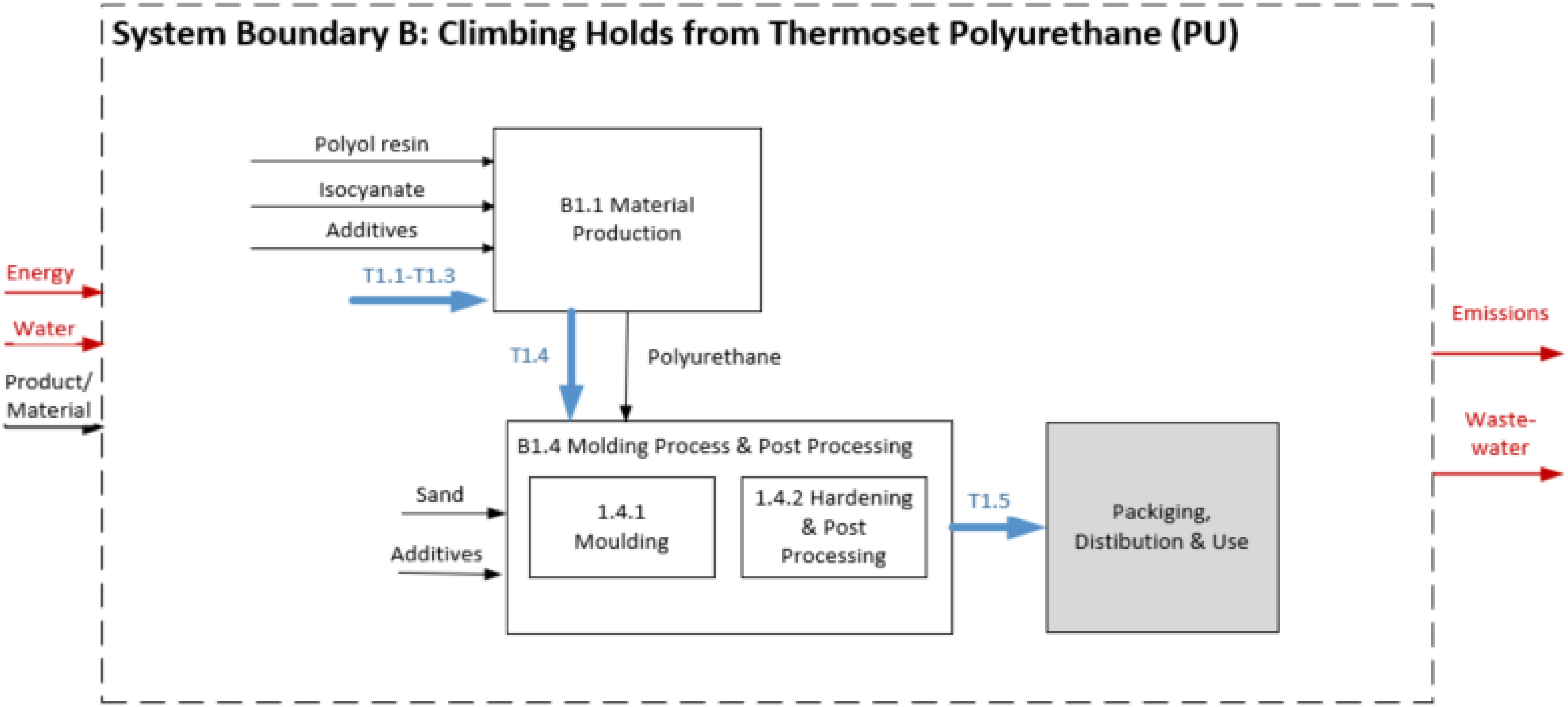

Figure 6 System boundary B of the production of climbing holds made from thermoset polyurethane (PU), covering material production, molding, and post-processing. The diagram includes all relevant inputs (e.g., polyol, isocyanate, additives) and outputs (emissions

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System Boundary C: Climbing Holds from Climbing Ropes

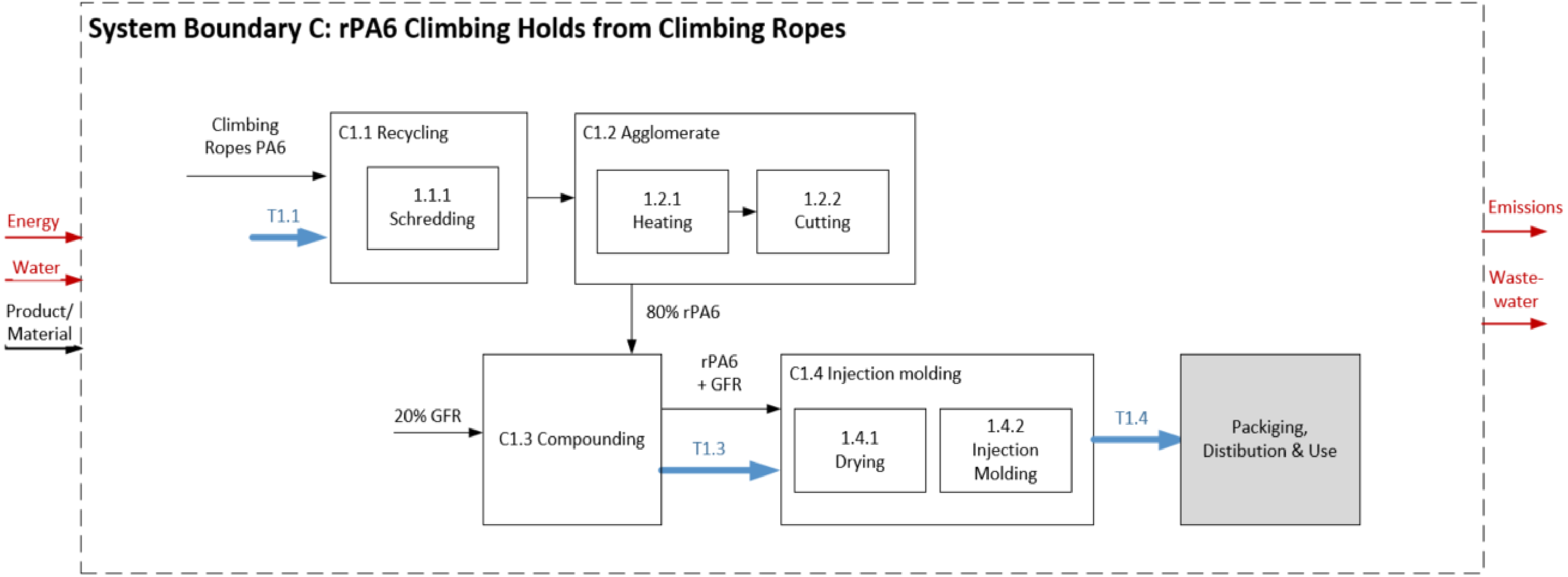

Figure 7 Overview of System Boundary C for PA6 Climbing Ropes Recycling for Climbing Holds Production. This figure shows the process of collecting climbing ropes from Alphitec's Customers, shredding and agglomerating them at Korrels, followed by compounding and injection molding, with an environmental impact com

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System Boundary D: Climbing Holds from Automotive Wa

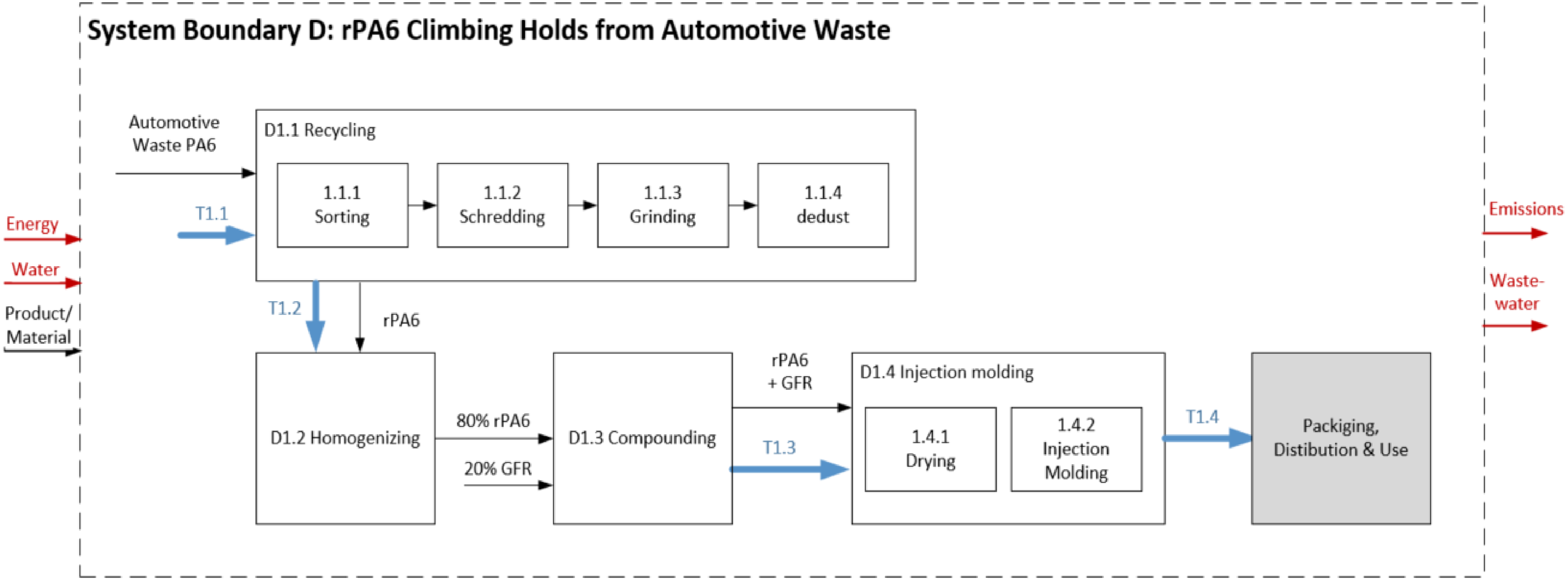

Figure 8 Overview of System Boundary D for PA6 Automotive Waste Recycling and Climbing Hold Production. This figure illustrates the process from collecting PA6 automotive waste, shredding into PA6 flakes, followed by homogenization, compounding with glass fibre,

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Translation in Scenario's

Key	Scenario	SB	Mass FU [kg]	Material	Lifetime [years]	Inflow	Outflow
A3I	1	A	1,328	URP	3	Virgin	Landfill
B3I	2	B	0,442	PU	3	Virgin	Landfill
C3I	3	C	0,242	PA-CR	3	Virgin	
D3I	4	D	0,242	PA-AW	3	Virgin	
C3R	5	C	0,242	PA-CR	3	Secondary	Recycling
D3R	6	D	0,242	PA-AW	3	Secondary	Recycling
A6I	7	A	1,328	URP	6	Virgin	Landfill
C6R	8	C	0,242	PA-CR	6	Secondary	Recycling
D6R	9	D	0,242	PA-AW	6	Secondary	Recycling
C9R	10	C	0,242	PA-CR	9	Secondary	Recycling
D9R	11	D	0,242	PA-AW	9	Secondary	Recycling

FU - LCA

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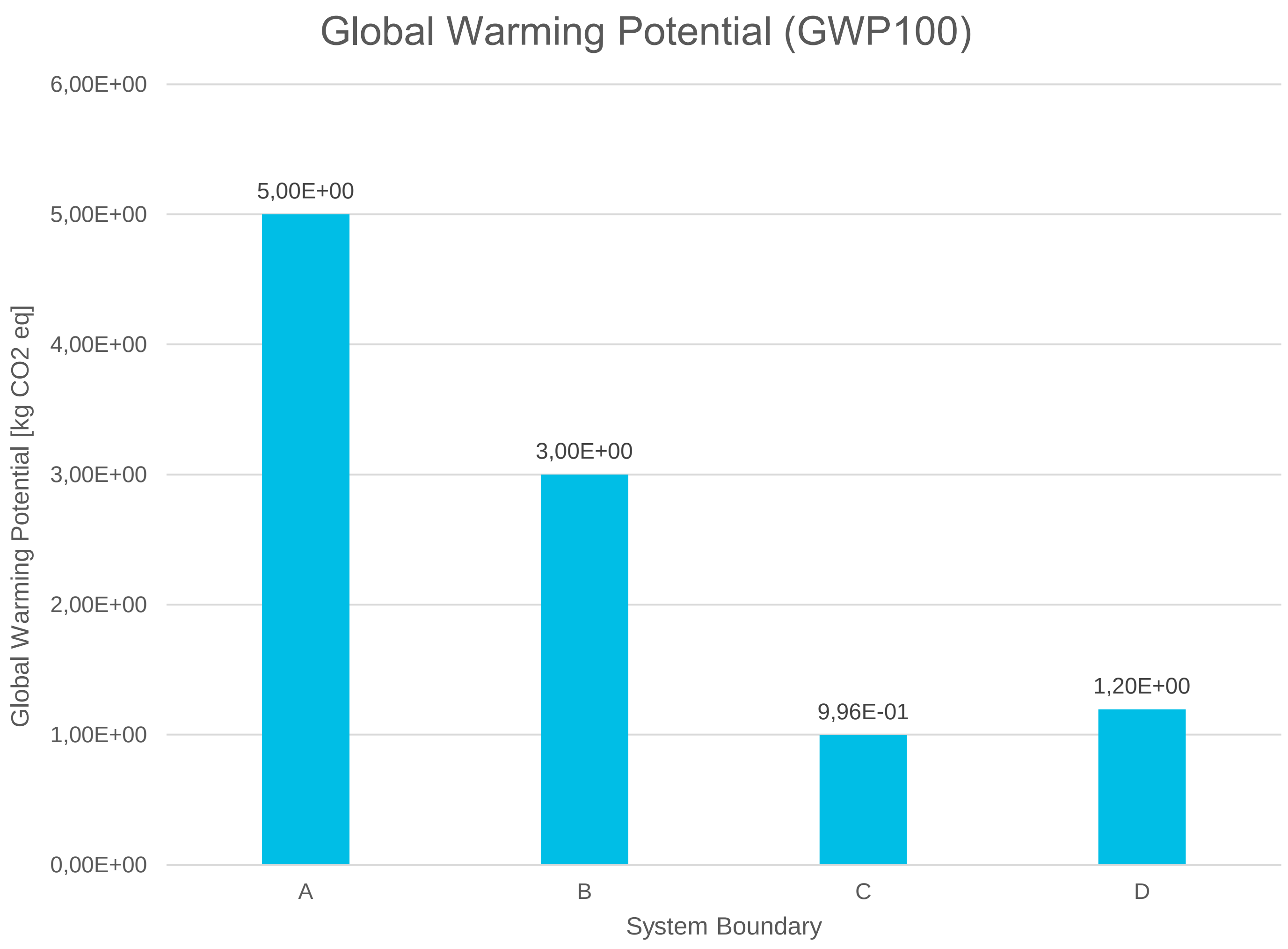
Results – GWP100



The Global Warming Potential (GWP100) decreases strongly from system boundary A (**5.00 kg CO_2-eq/FU**) to C (**0.996 kg CO_2-eq/FU**), with an average of **2.55 kg CO_2-eq/FU** and a standard deviation of **1.86**. This highlights clear differences in climate impact between the scenarios.

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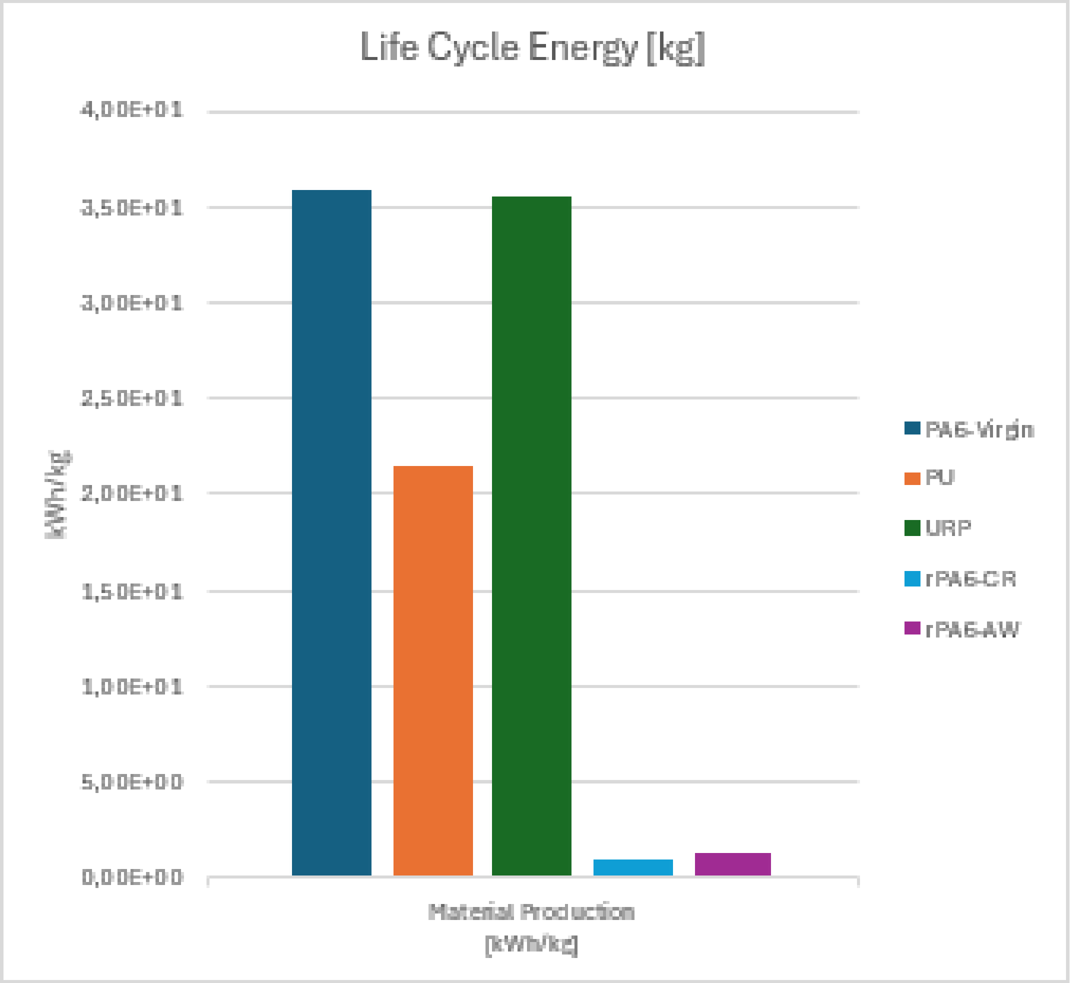
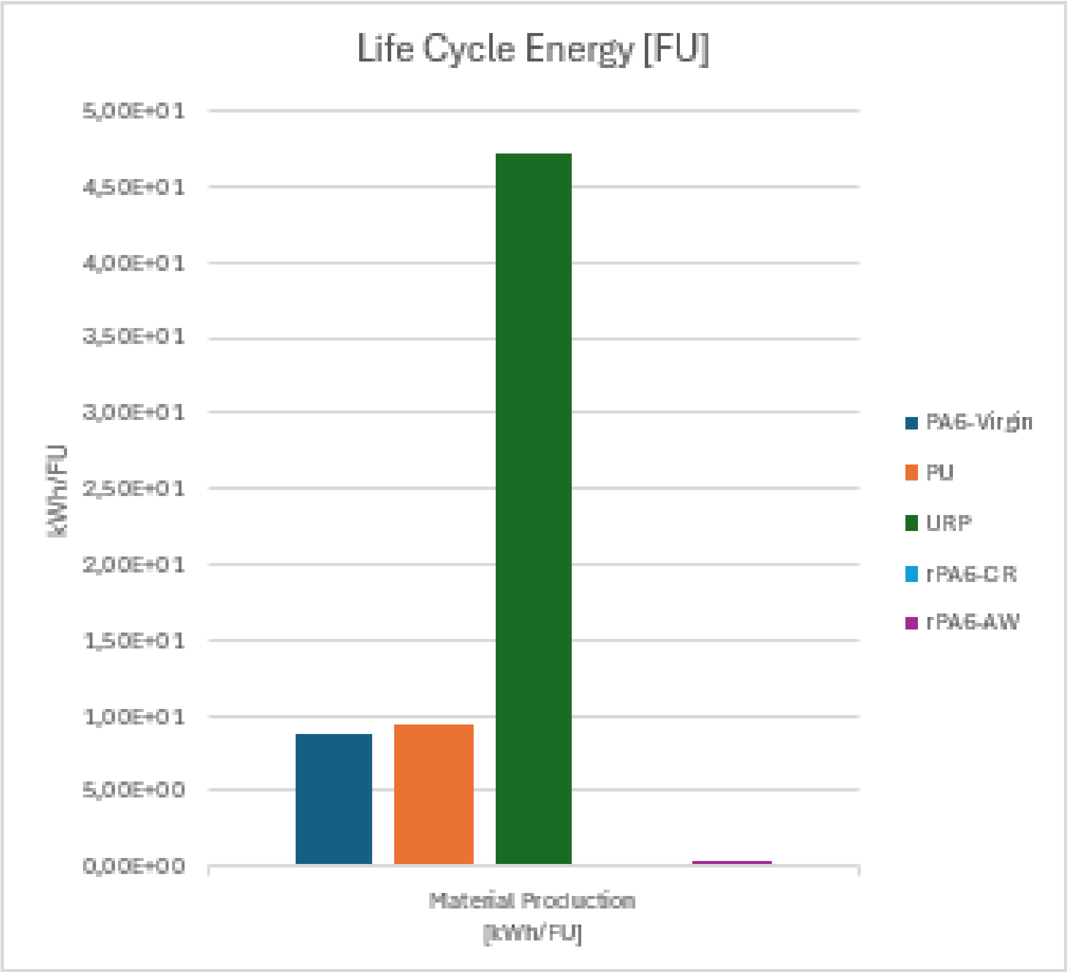
Results – Life Cycle Energy





This is an example of how sustainability is being measured under the ESRS framework.

How do you currently measure sustainability and circularity in your organization?

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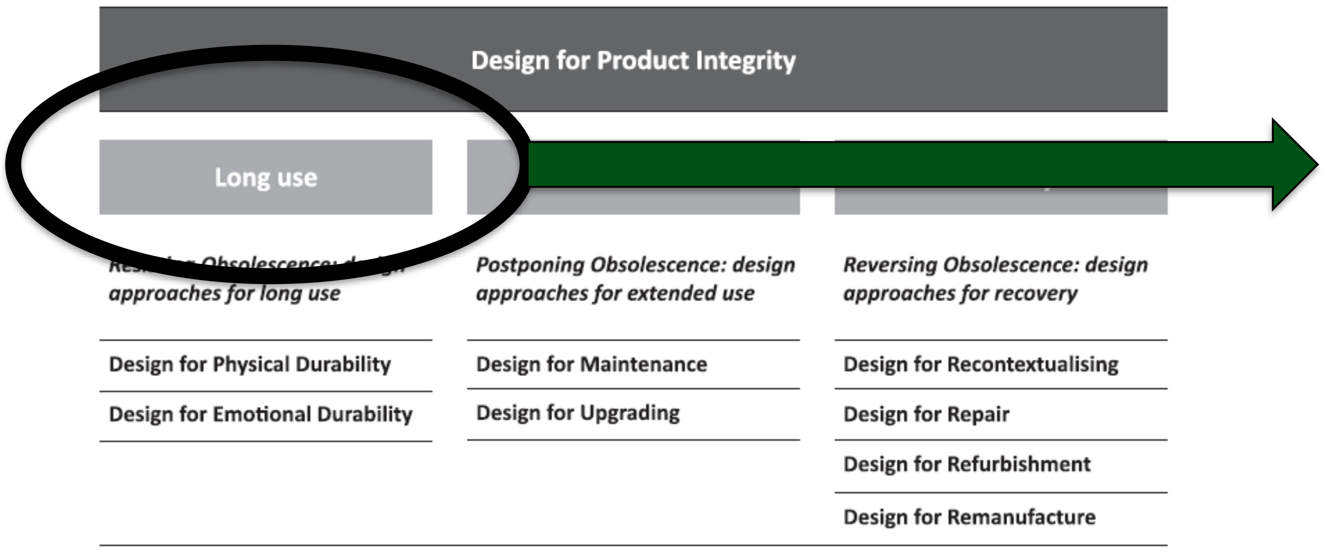

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C9R	10	C	0,242	PA-CR	9	Secondary	Recycling
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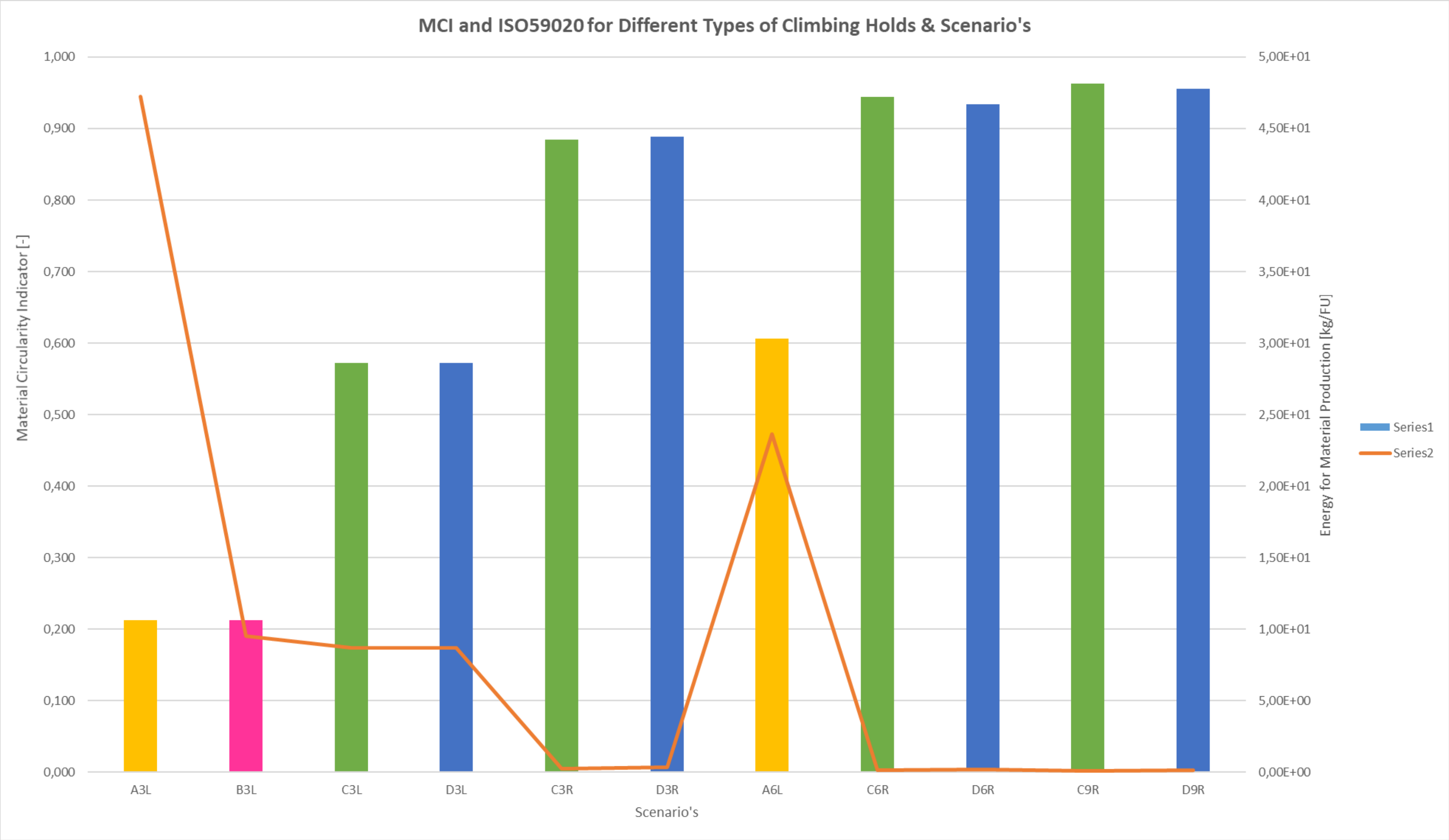
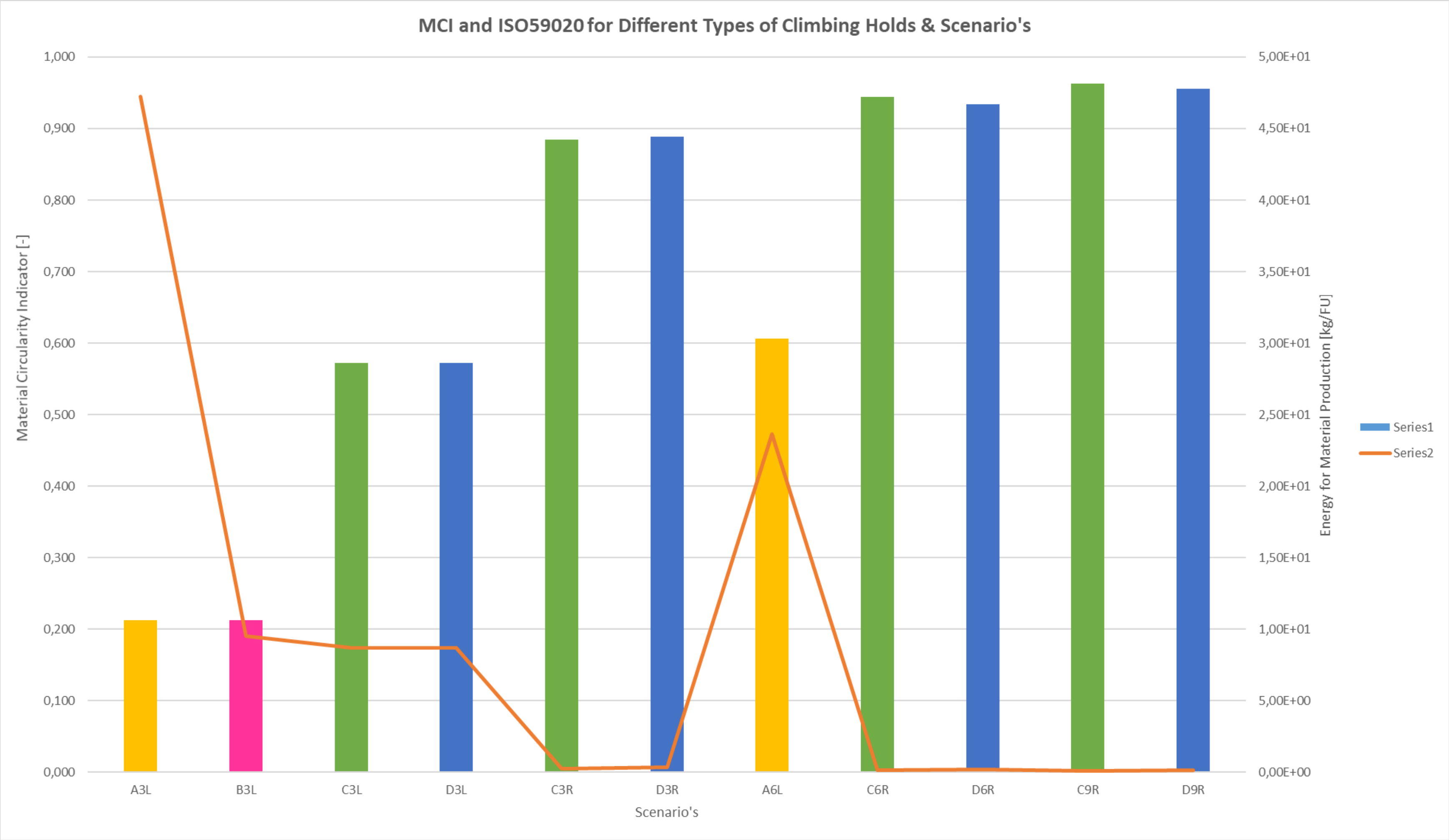
Results – Material Circularity Indicator (MCI) Trends (Left



- Scenarios C3R, C6R, D6R, C9R, and D9R show the highest **MCI values**, close to **0.95–0.98**, indicating these climbing holds are highly circular.
- Scenarios **A3l and B3l** have **very low MCI values (~0.2),** suggesting they are linear or poorly circular.
- Recycled scenarios (with "R" suffix) perform consistently better in circularity than "L" (Landfill) scenarios.

Results – Energy for Material Production (Right Y-axis,



- **A3I** has the **highest energy requirement (~47–48 kg/FU),** showing it is the most energy-intensive scenario.
- **C3R, C6R, D6R, C9R, D9R** require **almost zero energy**, likely because they use direct low-energy secondary inflow.
- **A6L** stands out with a moderate MCI (~0.4) but a peak in **energy demand (~22 kg/FU)** — suggesting a conflict between material recovery and energy intensity.

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The transition from linear to circular
What are your challenges?

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