LCA in a green environment

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Historical perspective

01

1969

Midwest Research Institute MRI

Harry E. TEASLEY, Jr. was managing the packaging function for The Coca-Cola

02

1970

resource and environmental profile analysis (REPA)

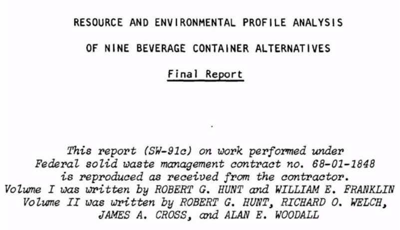
Proto-LCA

03

1975

EPA (USA)

About 15 REPAs


RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

OF NINE BEVERAGE CONTAINER ALTERNATIVES

<u>Final Report</u>

This report (SW-91c) on work performed under Federal solid waste management contract no. 68-01-1848 is reproduced as received from the contractor.
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Volume II was written by ROBERT G. HUNT, RICHARD O. WELCH, JAMES A. CROSS, and ALAN E. WOODALL

04

1990

Life Cycle Assessment

A Technical Framework for Life-Cycle Assessment, Smugglers Notch

05

1993

Birthday

Guidelines for Life-Cycle Assessment: A 'Code of Practice', Sesimbra

06

1997

Standardization

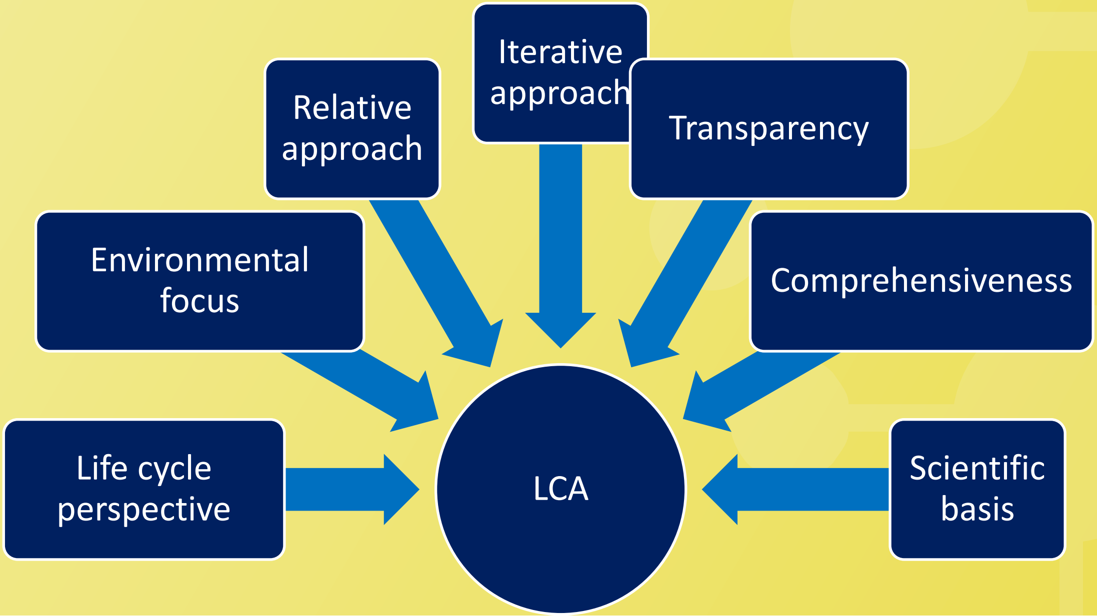
ISO 14040:1997 Environmental Management - Life Cycle Assessment - Principles and Framework - First Edition

Life Cycle Assessment

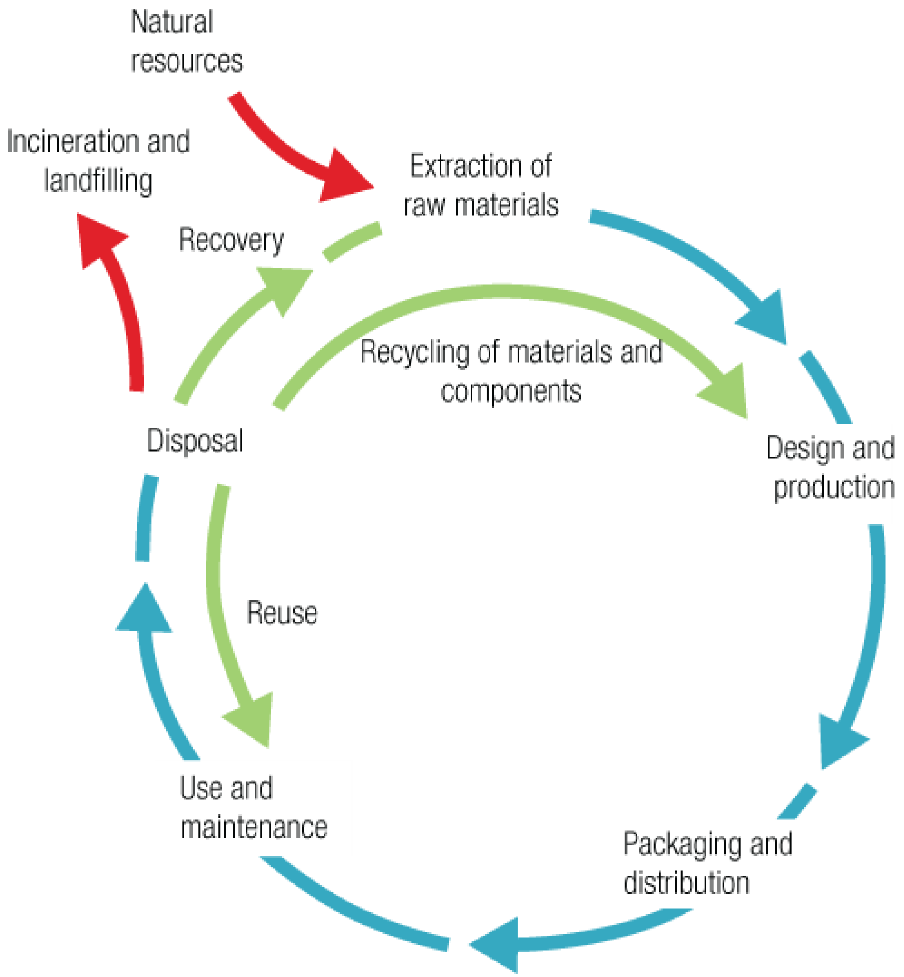
Life-Cycle Assessment is a process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and material uses and releases to the environment; and to identify and evaluate opportunities to affect environmental improvements. The assessment includes the entire life-cycle of the product, process, or activity, encompassing extracting and processing raw materials; manufacturing; transportation and distribution; use, re-use, maintenance; recycling, and final disposal (SETAC 1991).

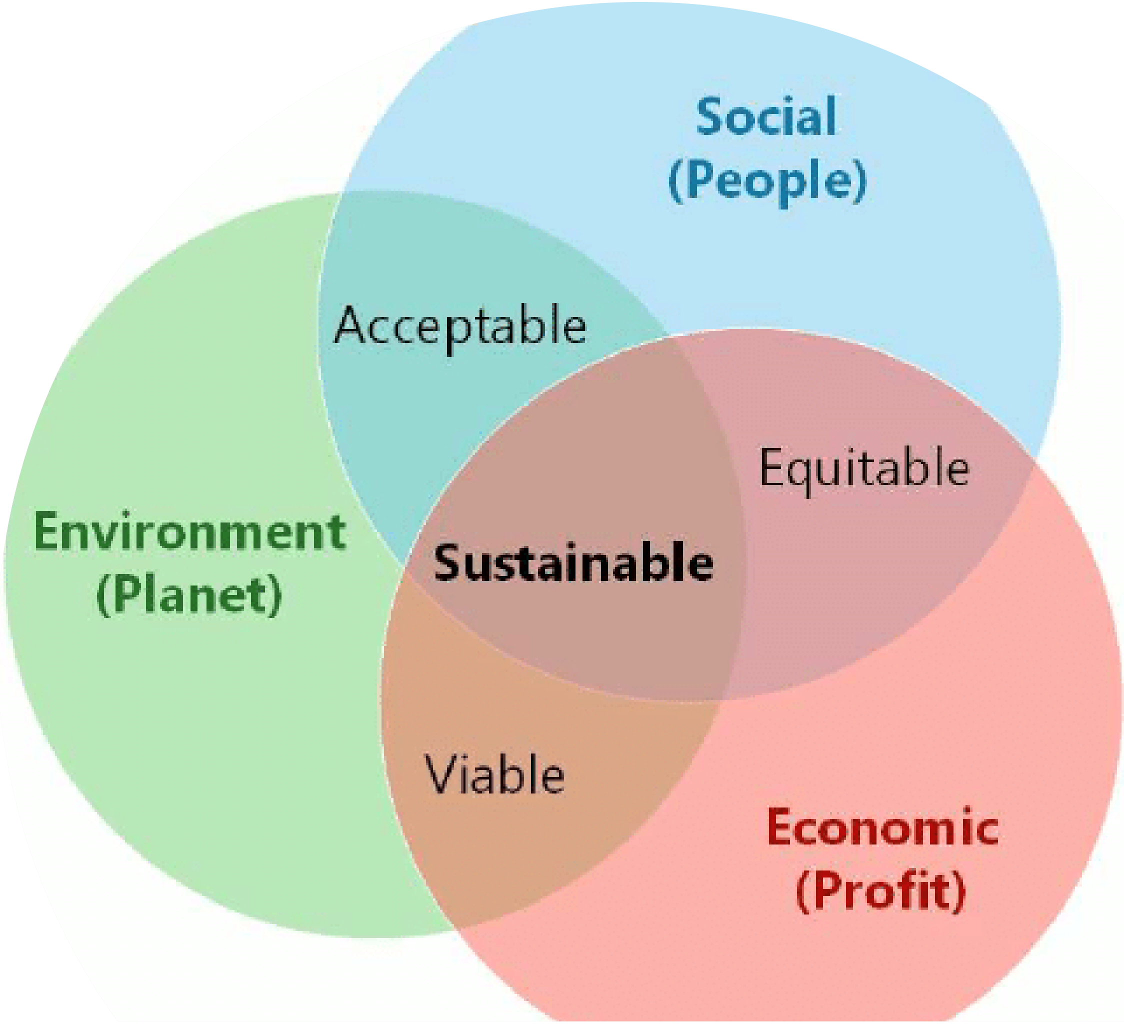
Guidelines for Life-Cycle Assessment: A "Code of Practice" EDITION 1 From the SETAC Workshop held at Sesimbra, Portugal 31 March - 3 April 1993;

Life Cycle Assessment



Life Cycle Thinking



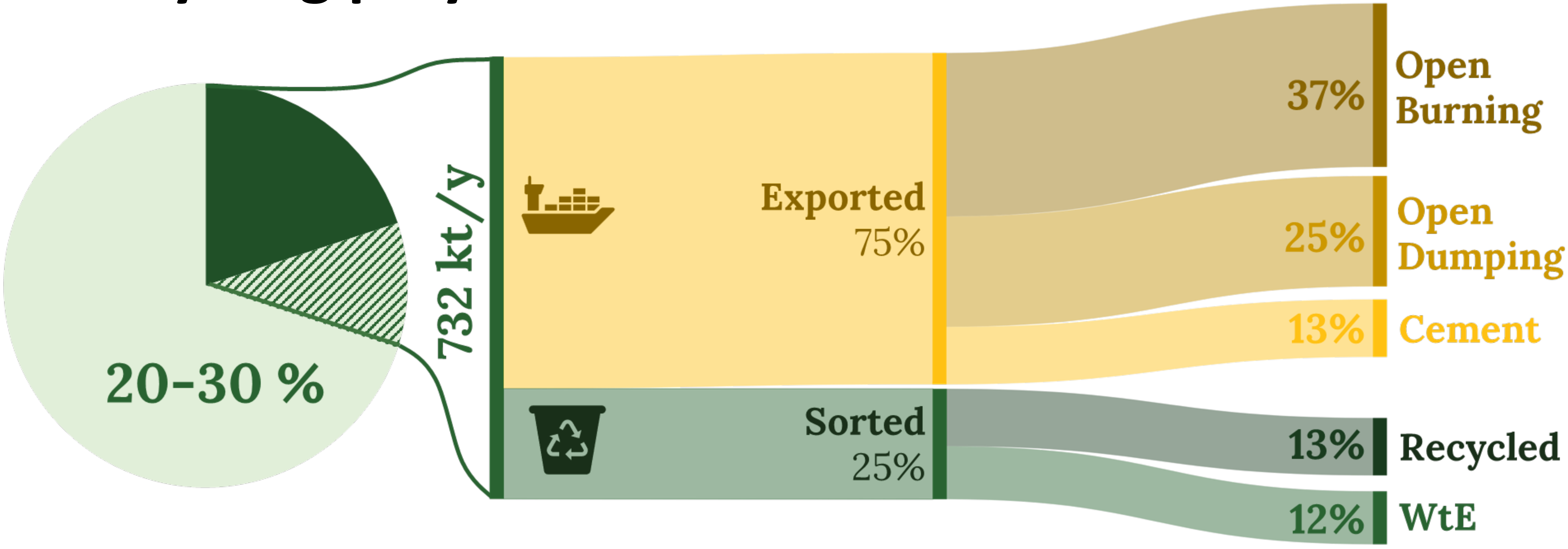


Why to do an LCA?

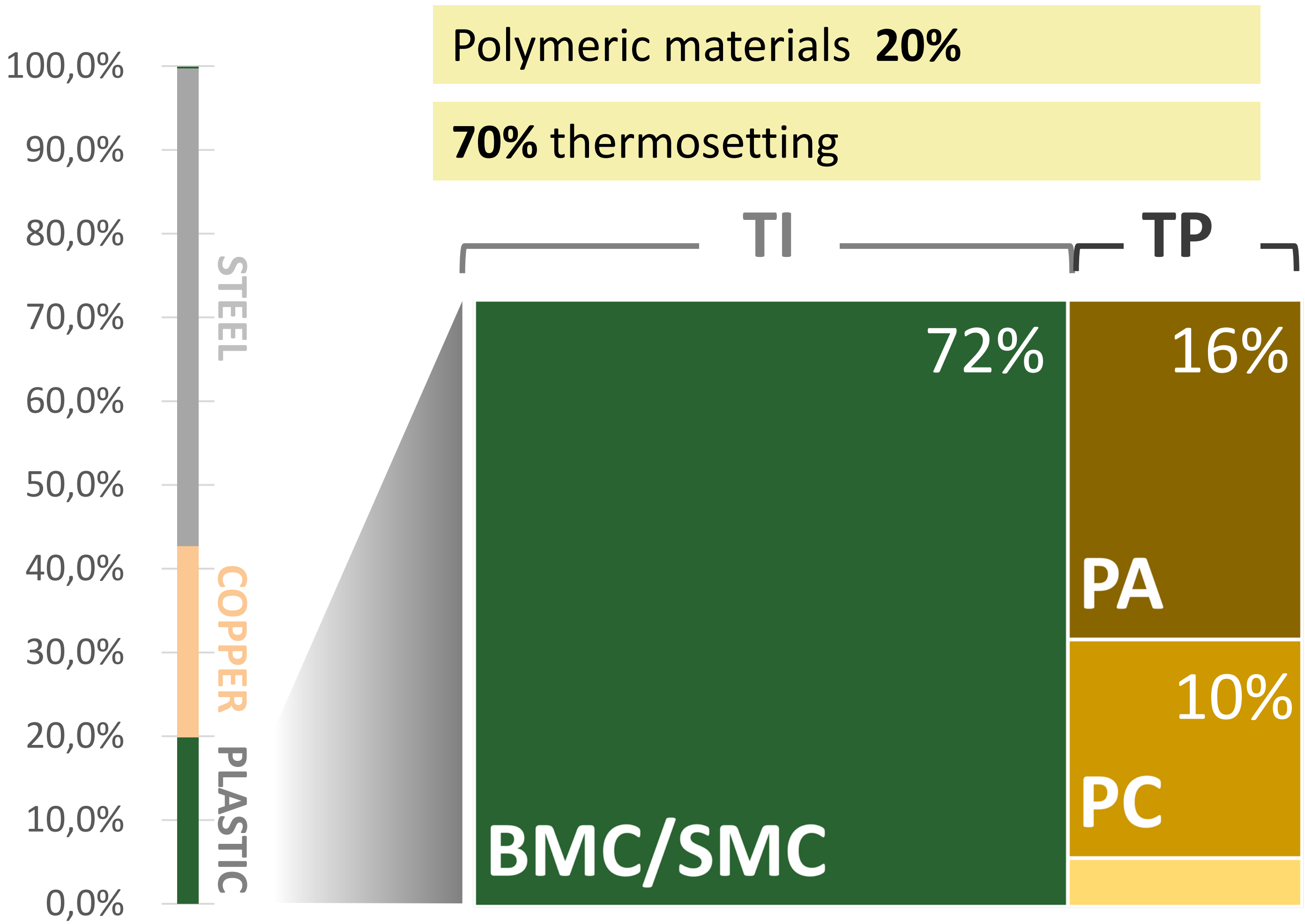
- to improve the environmental performance of products at various points in their life cycle
- informing decision-makers in industry, government or non-government organizations
- marketing (environmental product declaration)

Recycling polymers from WEEE

Recycling polymers from WEEE in EU



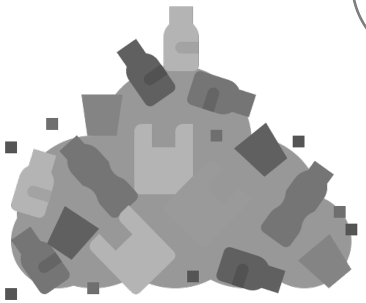
An industrial case study: Low-voltage circuit breaker



LCA of WEEP End-of-Life strategies

Functional Unit

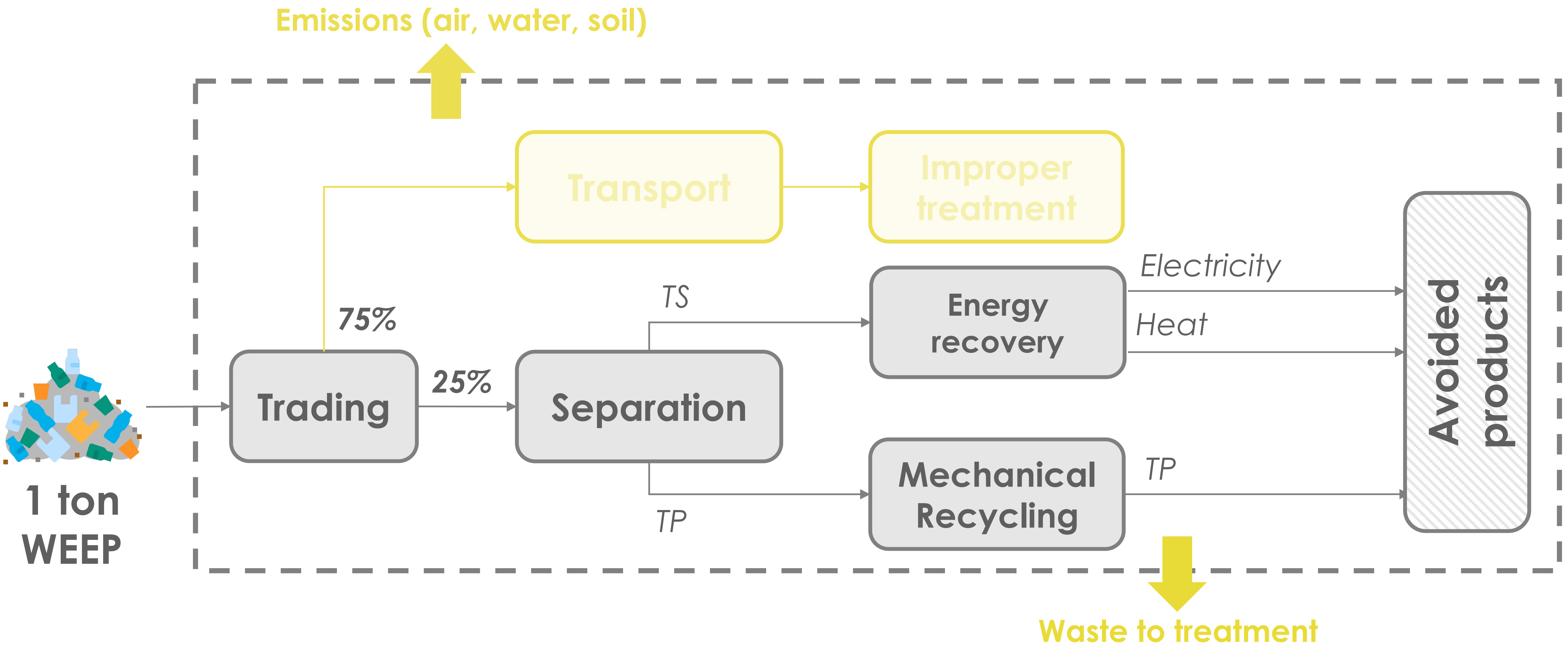
1 ton di WEEP



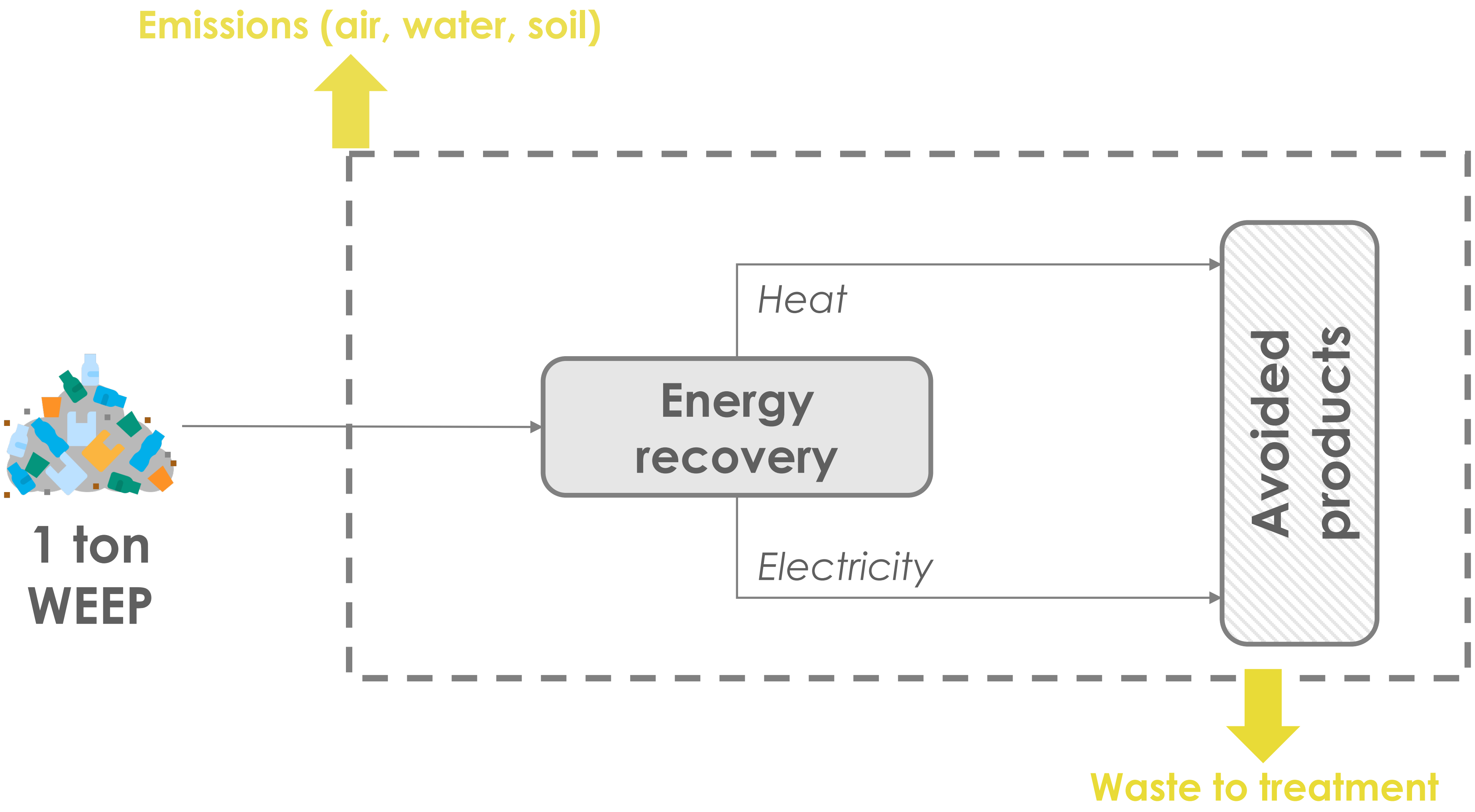
- Energy recovery
- Mechanical Recycling
- Pyrolysis

**WEEP = WEE Plastics*
TS thermo setting
TP thermoplastic

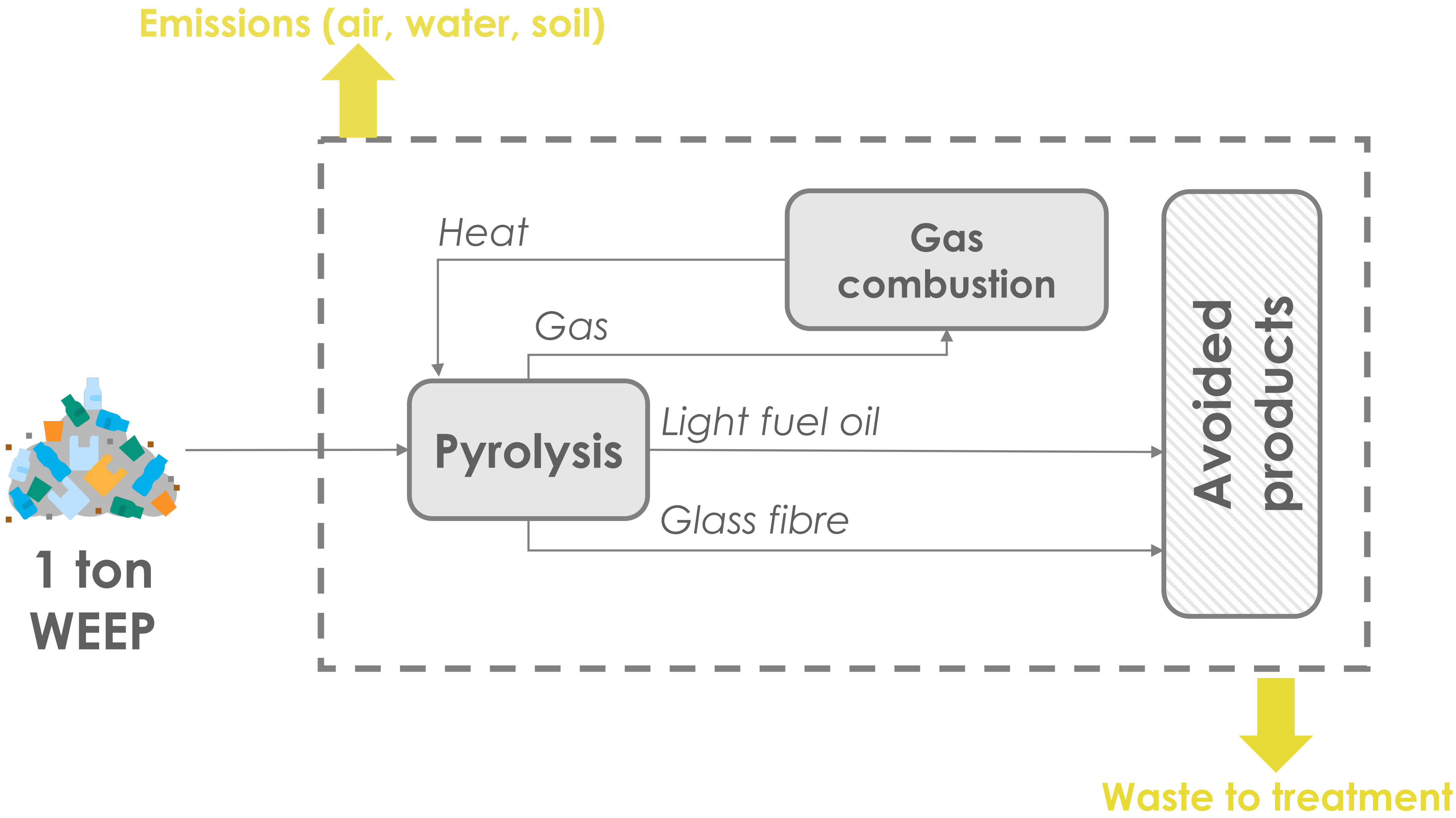
Present situation: scenario 1



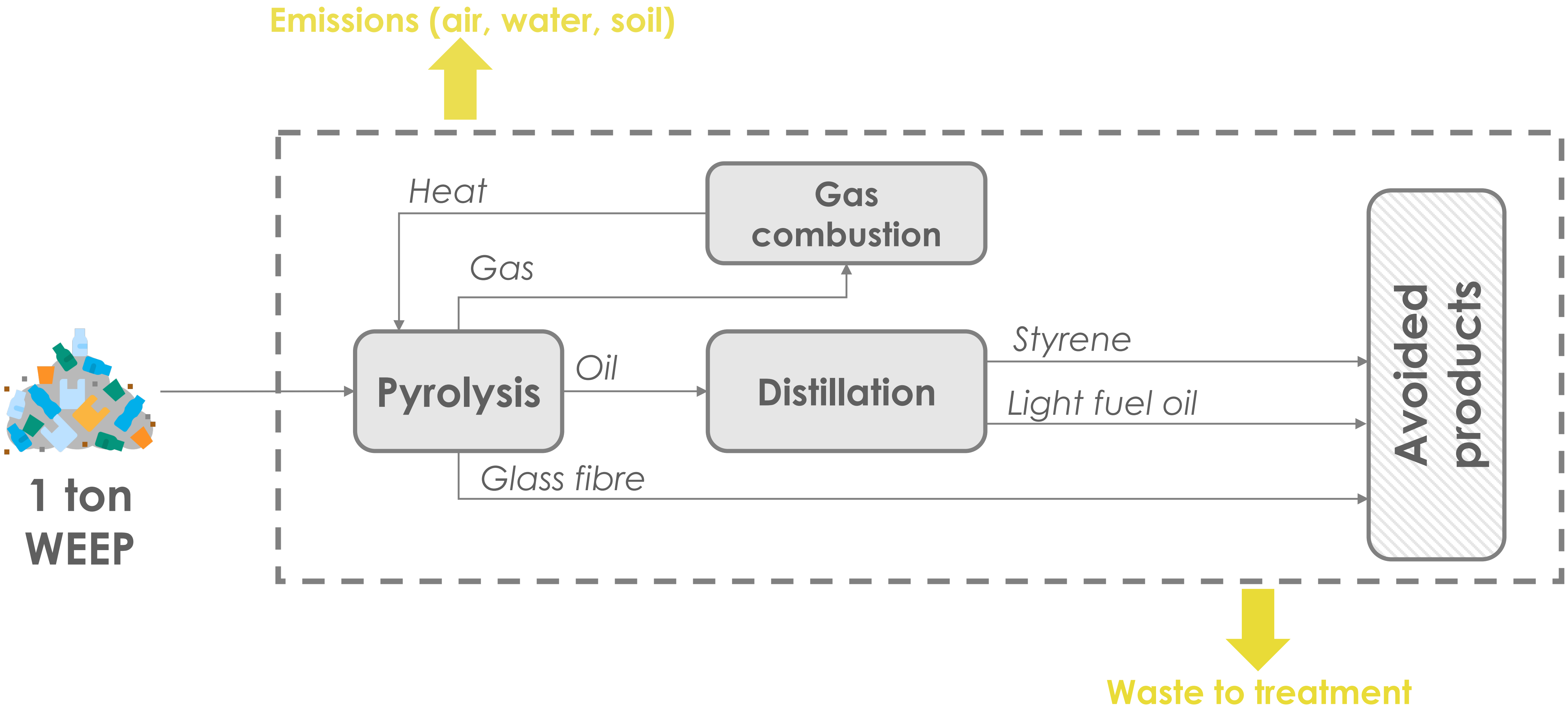
Energy Recovery: scenario 2



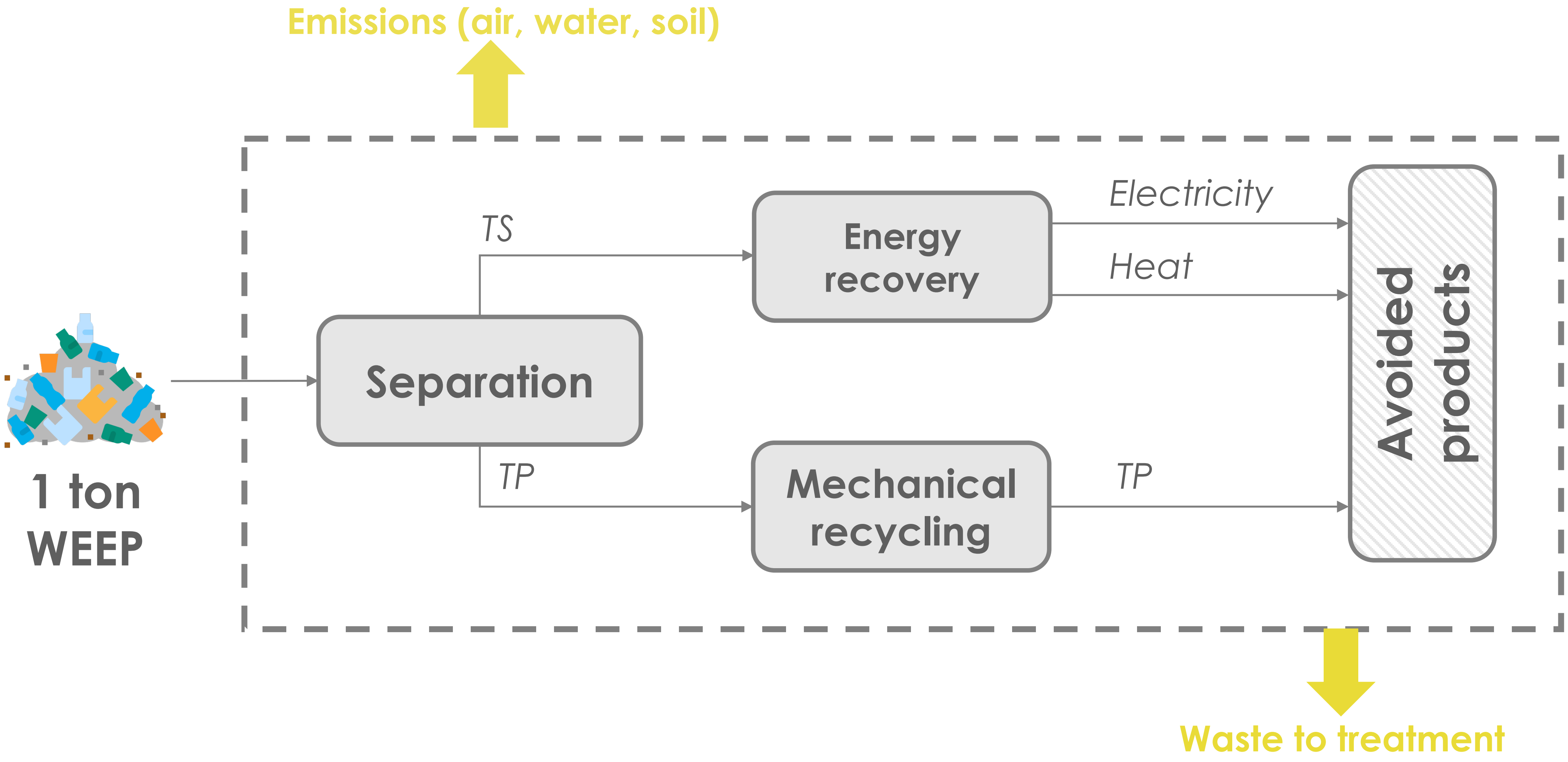
Pyrolysis – Waste to fuel: scenario 3



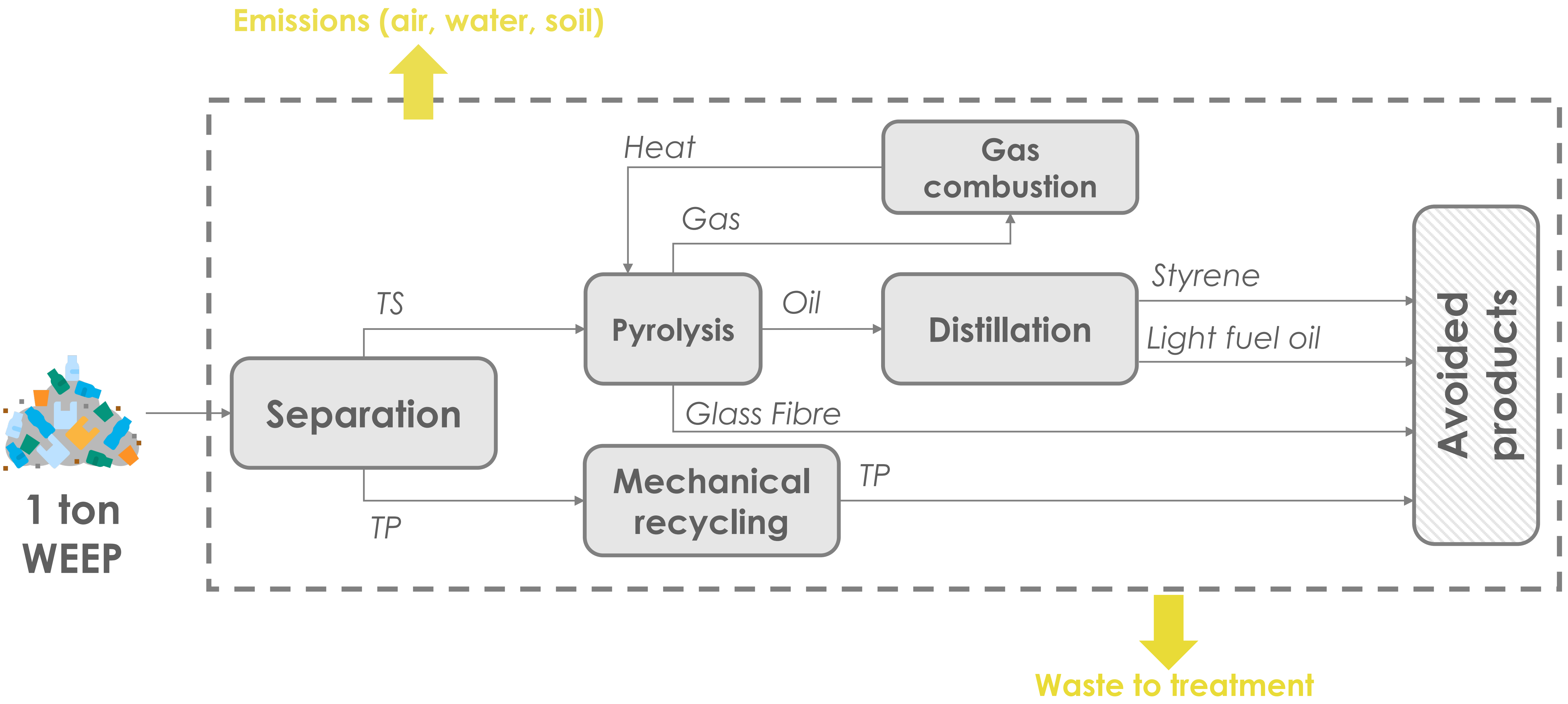
Pyrolysis – Waste to feedstock: scenario 4



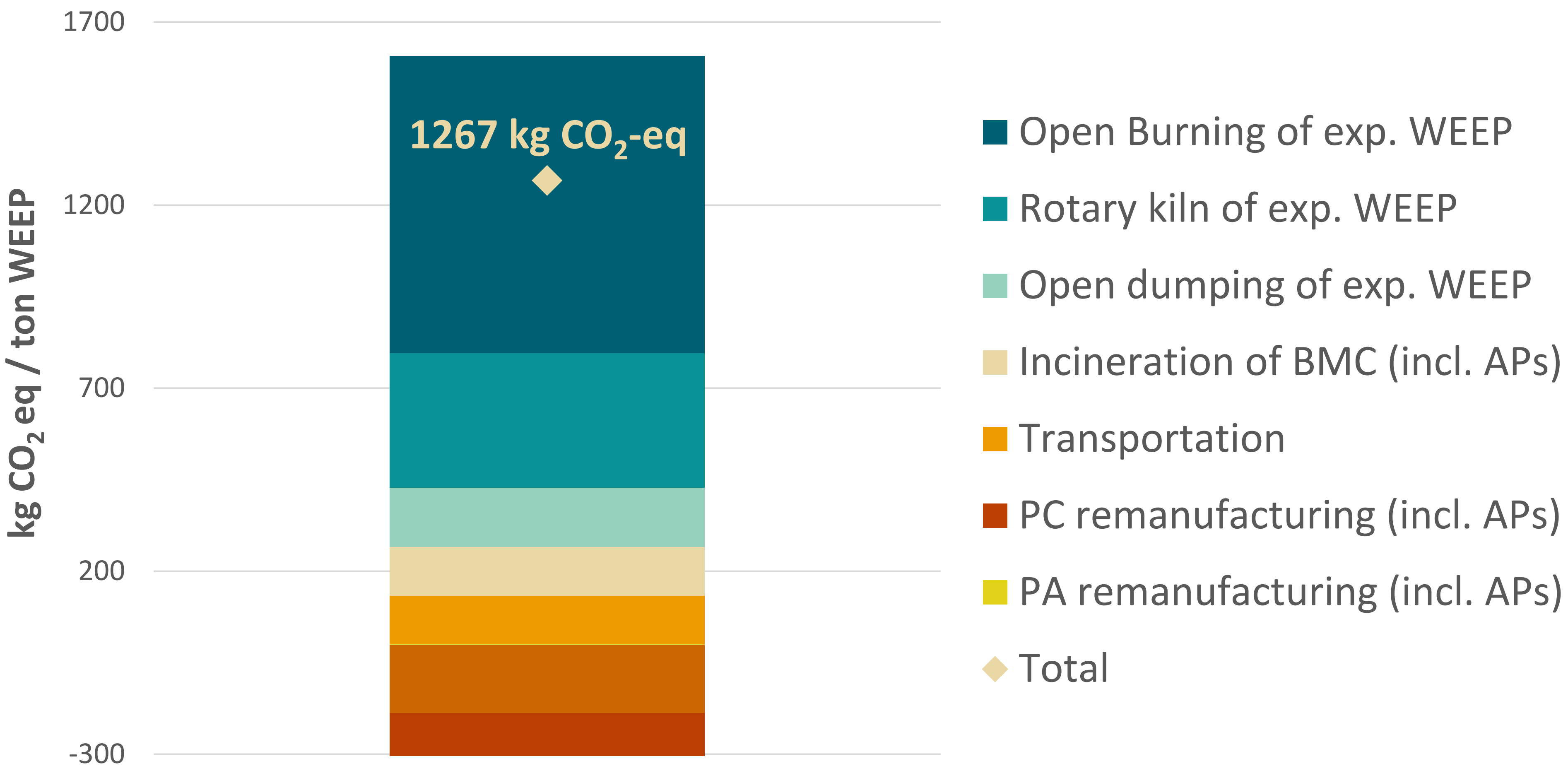
Mechanical recycling TP + energy recovery TS: scenario 5

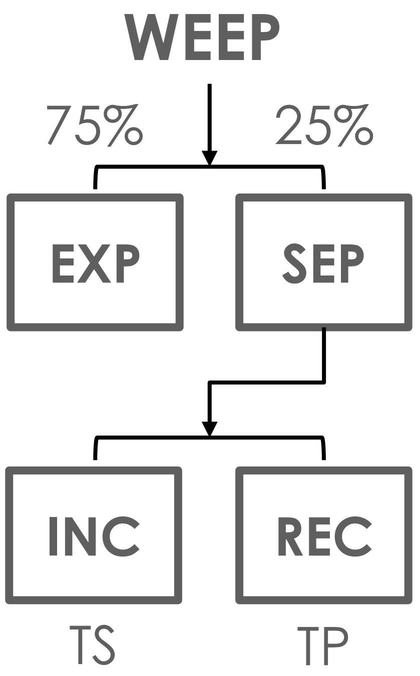


Mechanical recycling TP + pyrolysis TS: scenario 6

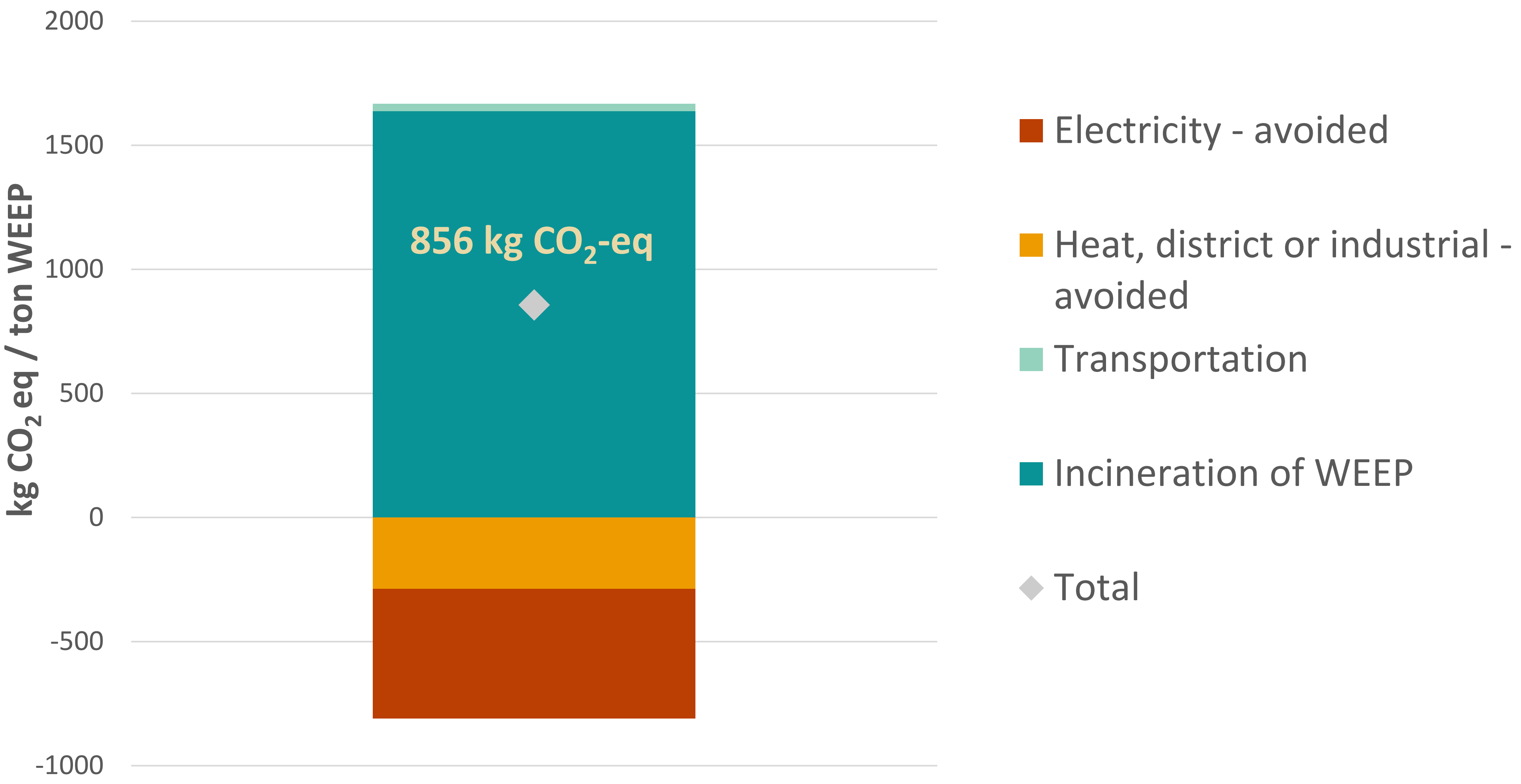


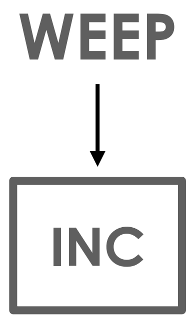
Climate change – Scenario 1 (present situation)



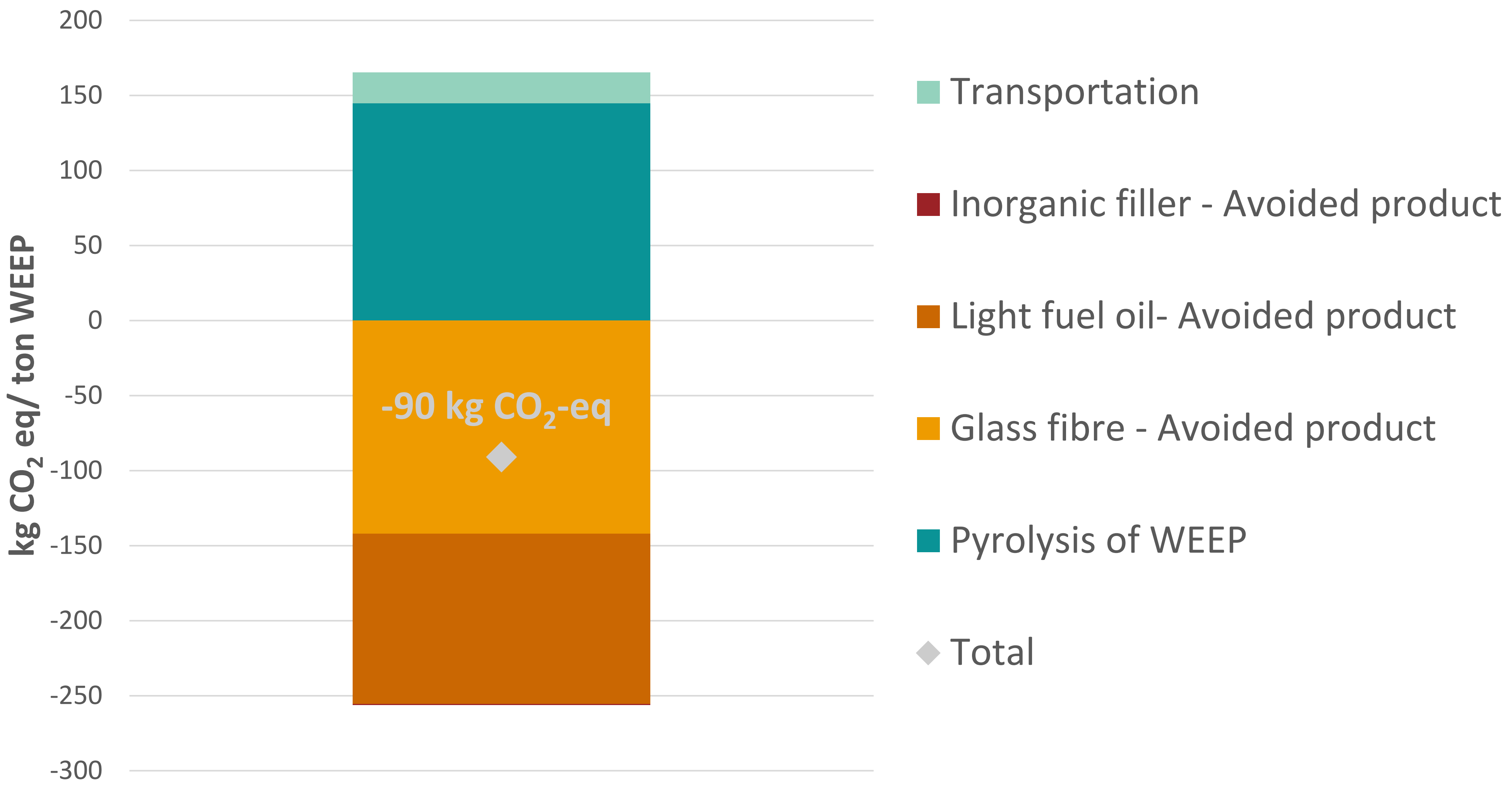


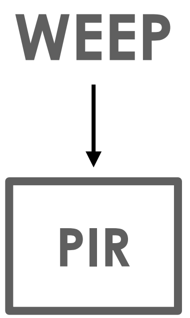
Climate change – Scenario 2



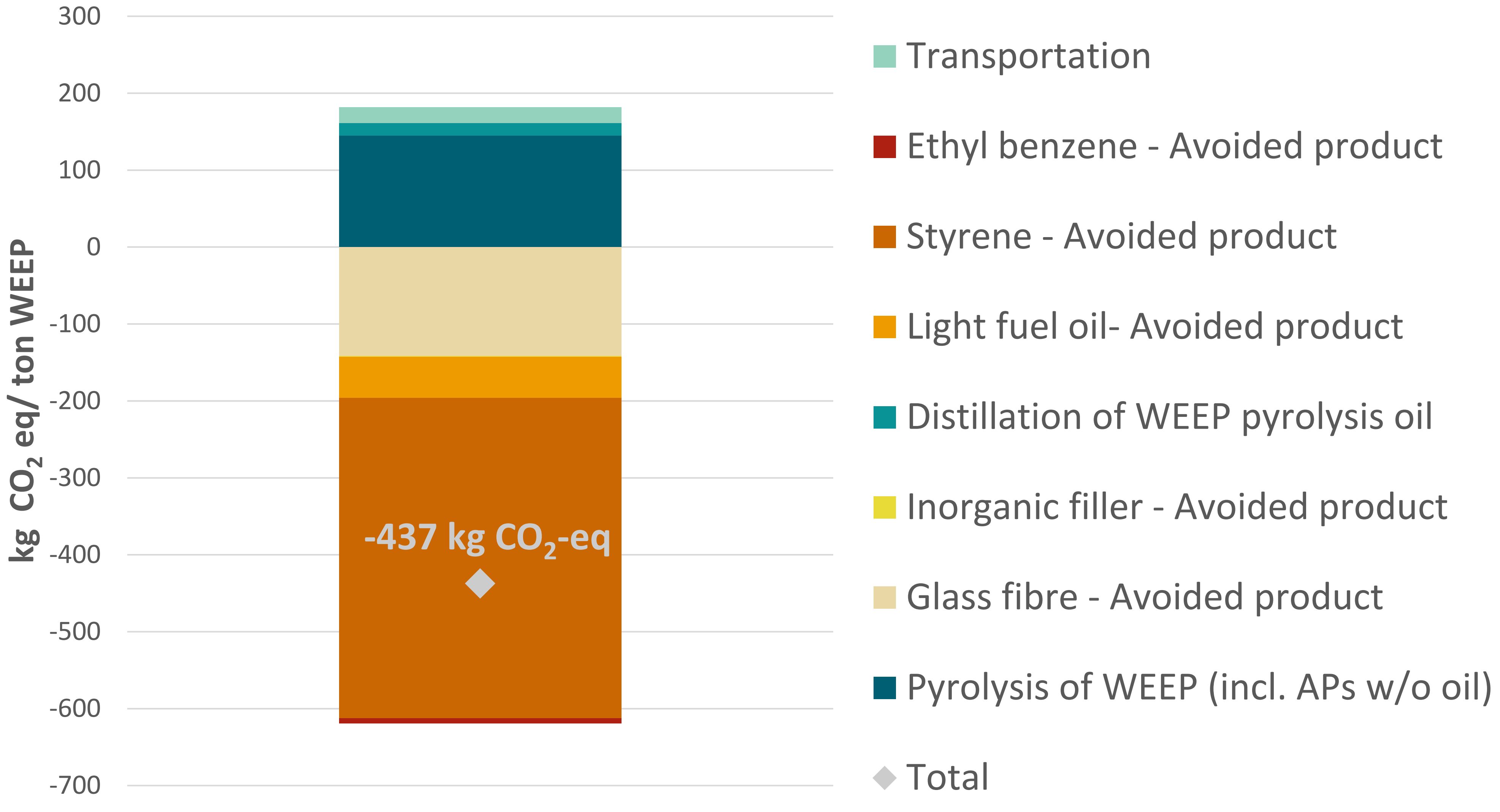


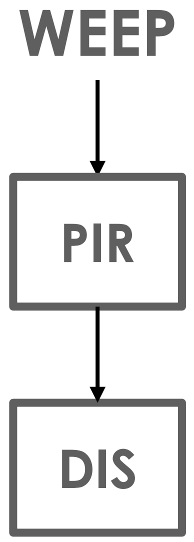
Climate change – Scenario 3



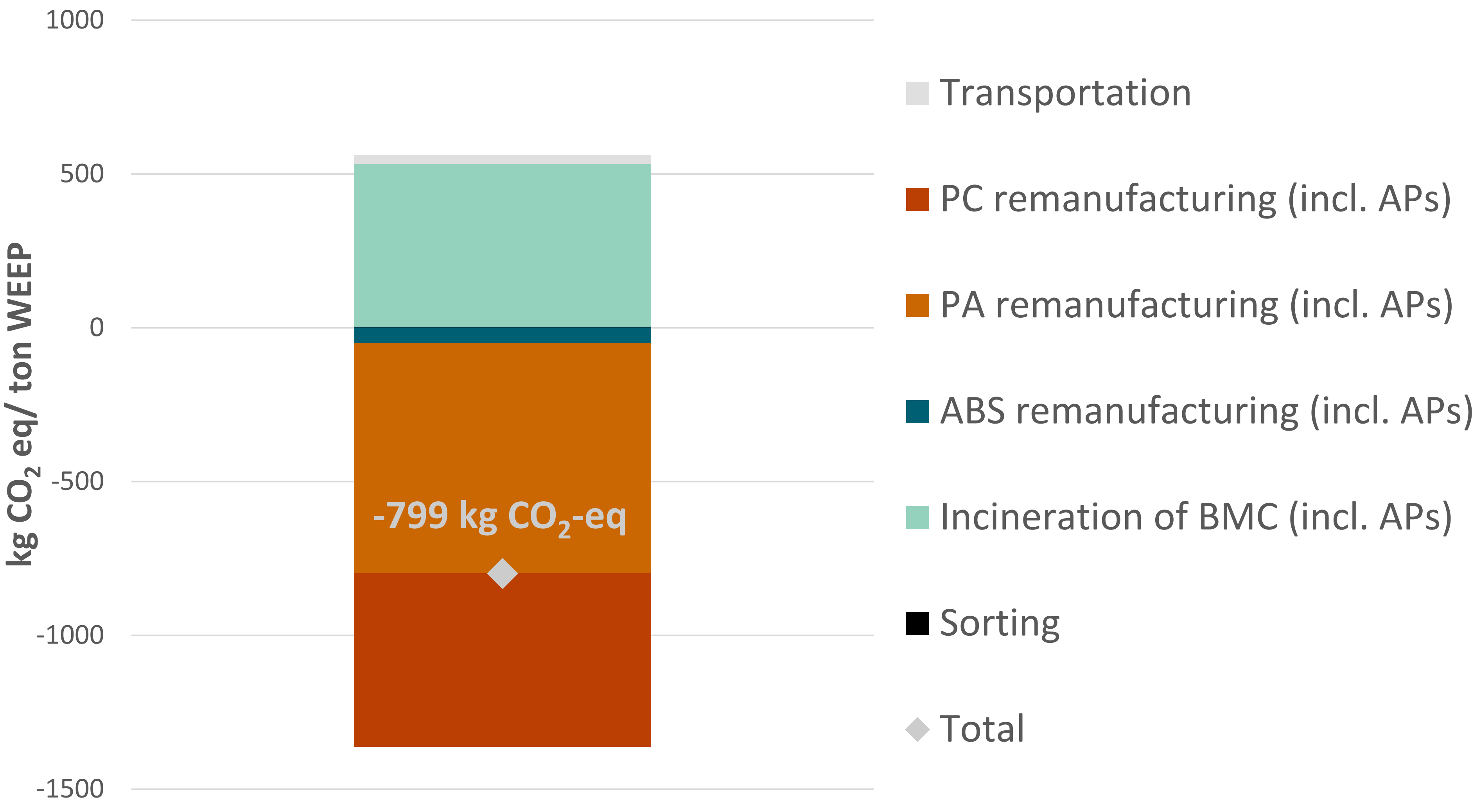


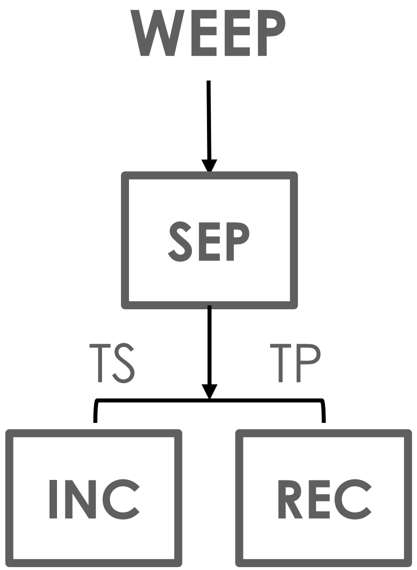
Climate change – Scenario 4



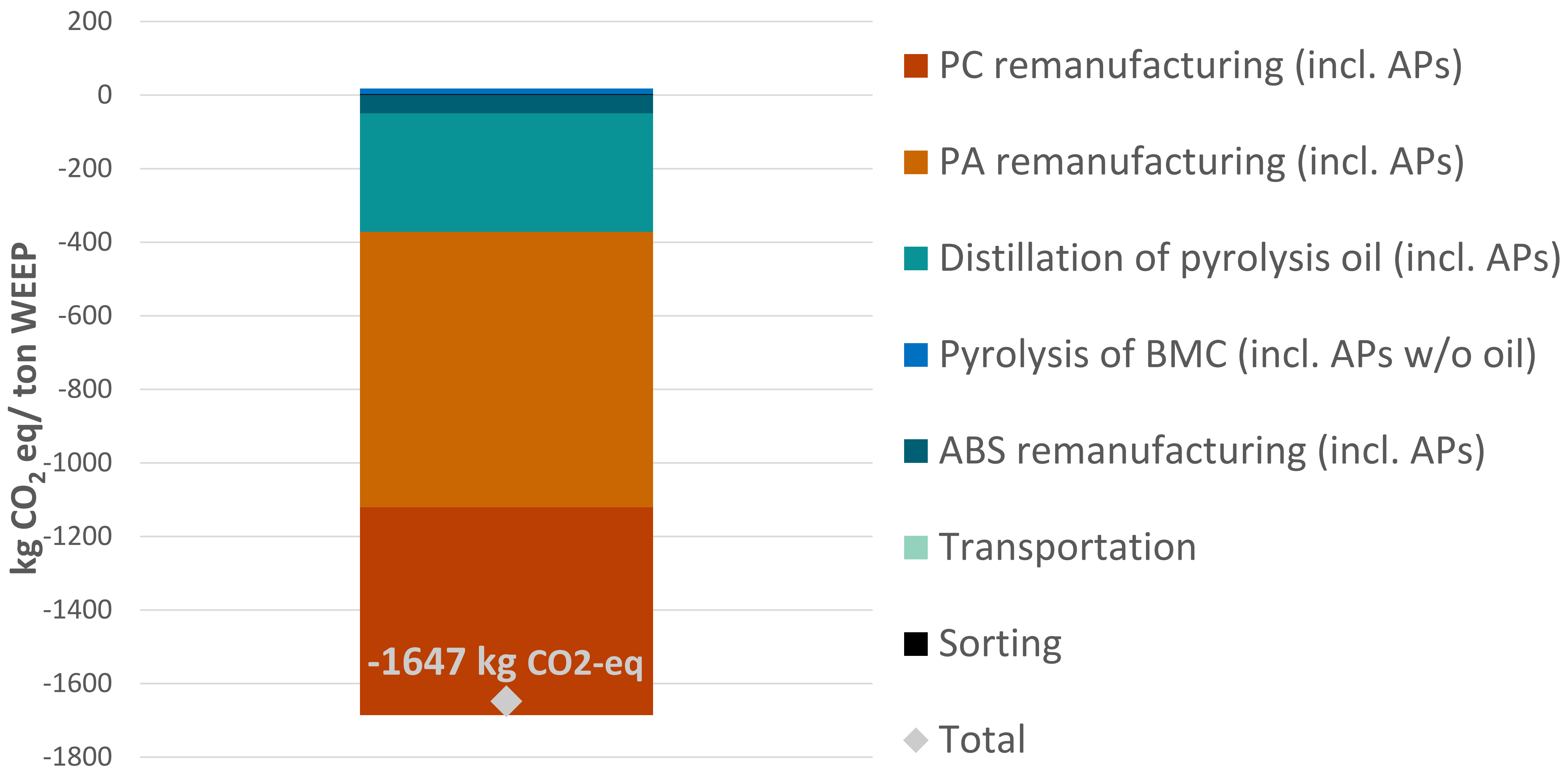


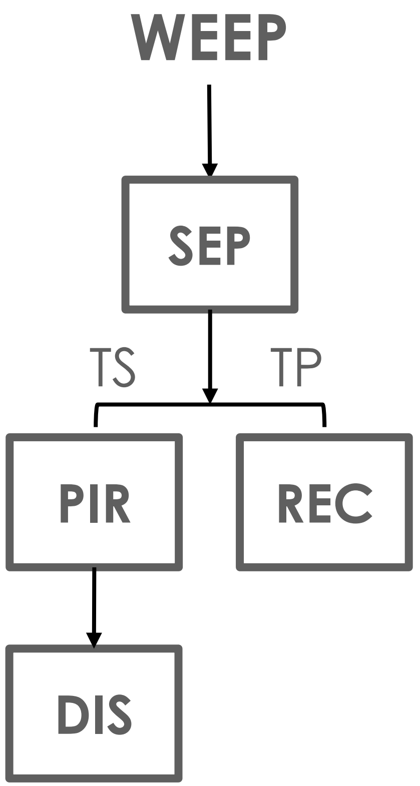
Climate change – Scenario 5





Climate change – Scenario 6





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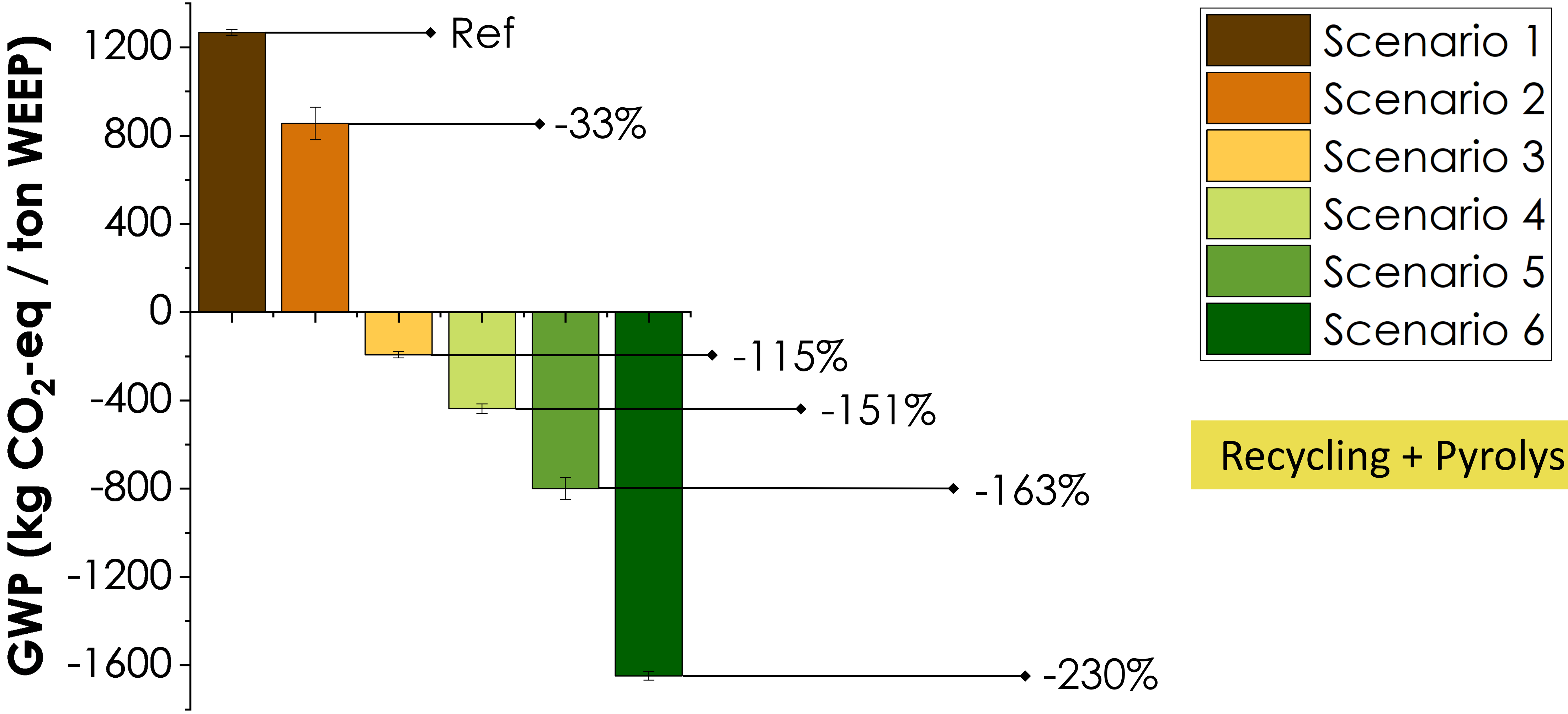
Climate change - Comparison



Recycling + Pyrolysis

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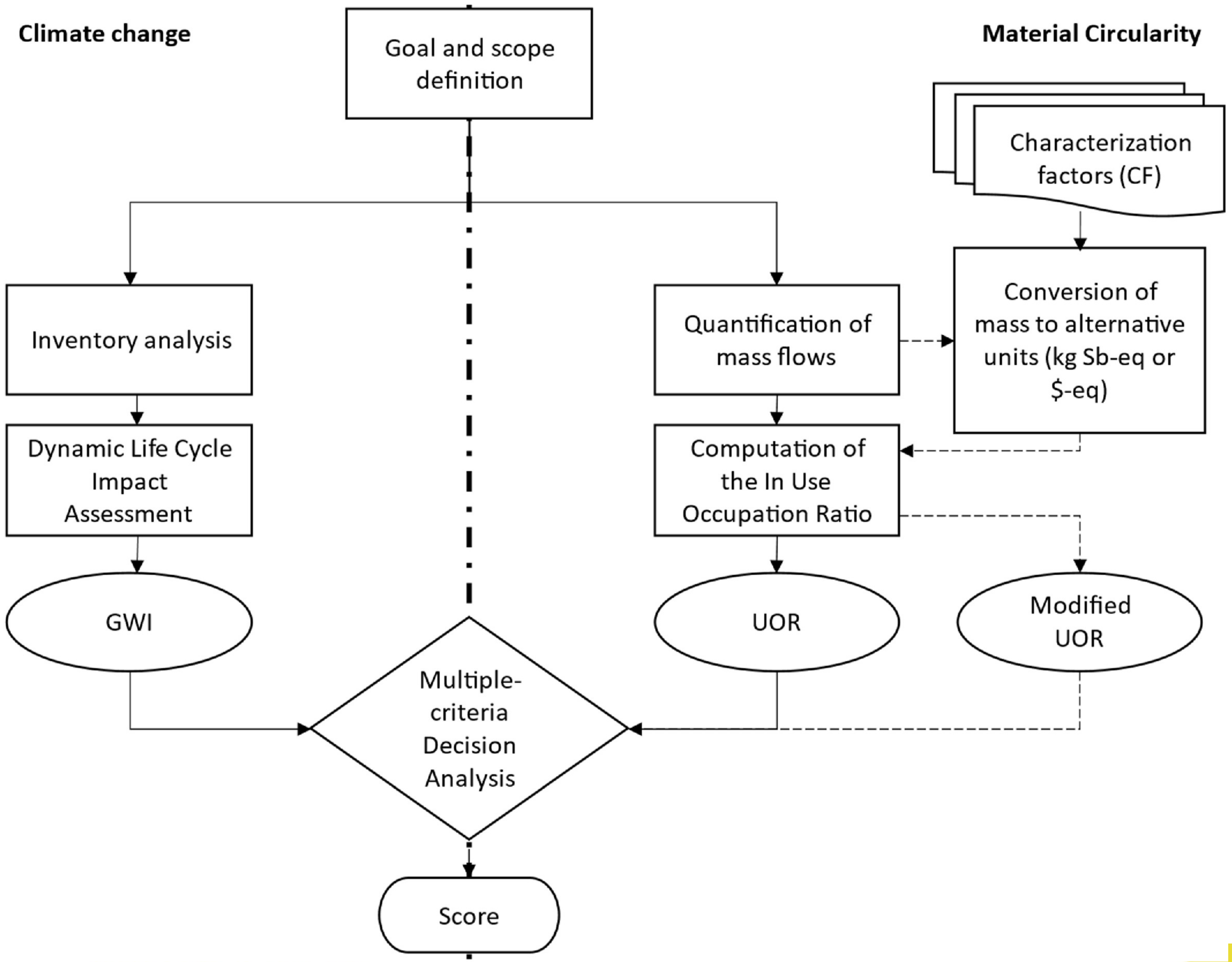
Circularity assessment: dynamic combination of material efficiency and LCA

Methodological framework

- Global Warming Impact (GWI) calculated using the dynamic LCA procedure
- Material circularity addressed by the in-use occupation ratio (UOR) and its modified versions (dotted lines)

Salvi A., Arosio V., Monzio Compagnoni L., Cubiña I., Scaccabarozzi G., Dotelli, Considering the environmental impact of circular strategies: A dynamic combination of material efficiency and LCA, J. Clean. Prod., 387, (2023) 10.1016/j.jclepro.2023.135850



In-Use Occupation Ratio

The underlying idea of the UOR is that materials are performing their function only during the use phase. Therefore, the longer materials stay in this phase (along the whole cascading of product cycles), the more useful for the society they are.

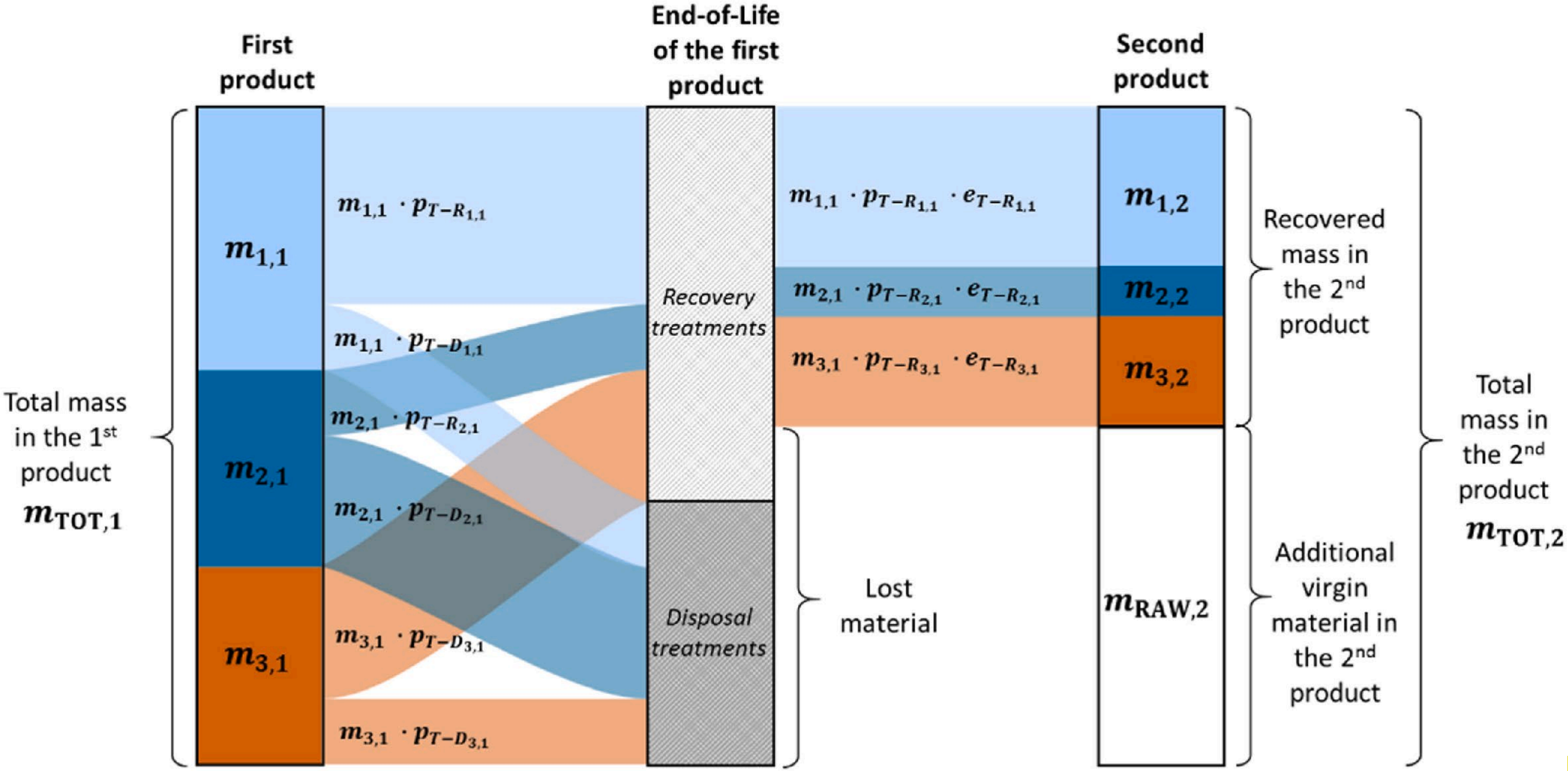
G. Moraga, S. Huysveld, S. de Meester, J. Dewulf, Development of circularity indicators based on the in-use occupation of materials
J. Clean. Prod., 279 (2021), 10.1016/j.jclepro.2020.123889

Dynamic LCA

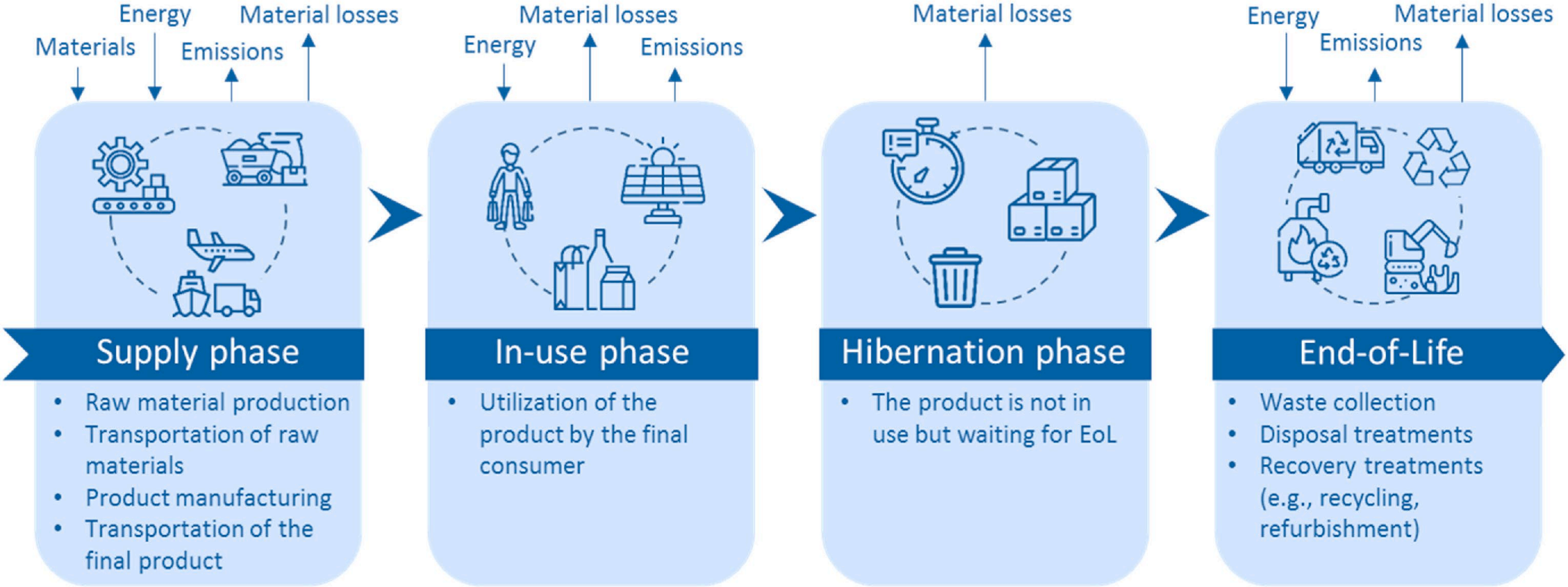
Dynamic LCA accounts for the timing of emissions in LCA using a dynamic inventory, which properly allocates each emission through time, and dynamic characterization factors. Dynamic characterization factors (DCFs) integrate the radiative forcing for each GHG over a time period included between the actual time of the emission and a selected time horizon.

A. Levasseur, P. Lesage, M. Margni, L. Deschěnes, R. Samson
Considering time in LCA: dynamic LCA and its application to global warming impact assessments, Environ. Sci. Technol., 44 (2010), pp. 3169-3174, 10.1021/ES9030003

Material flow from first to second product



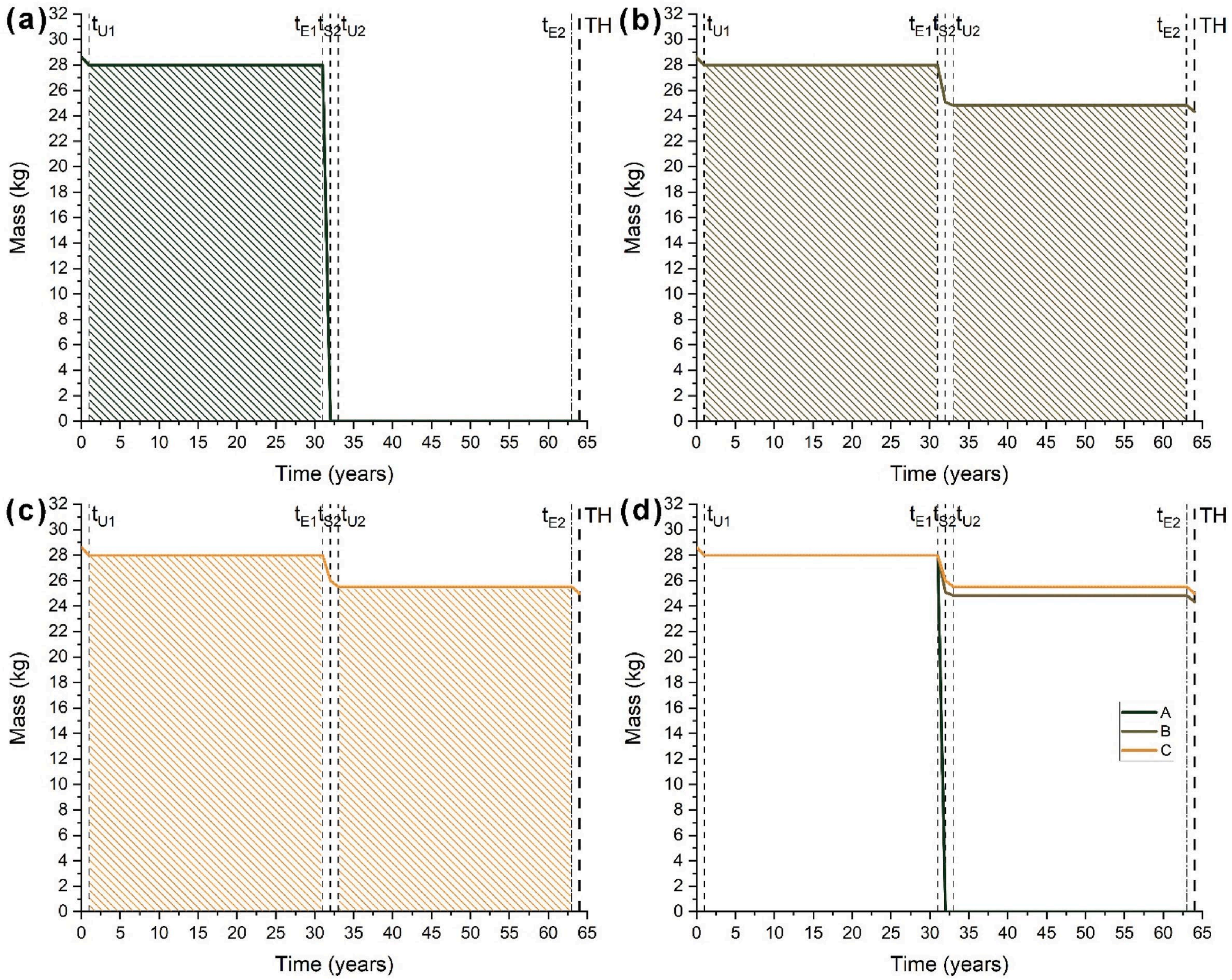
In-Use Occupation ratio and Life Cycle Phases

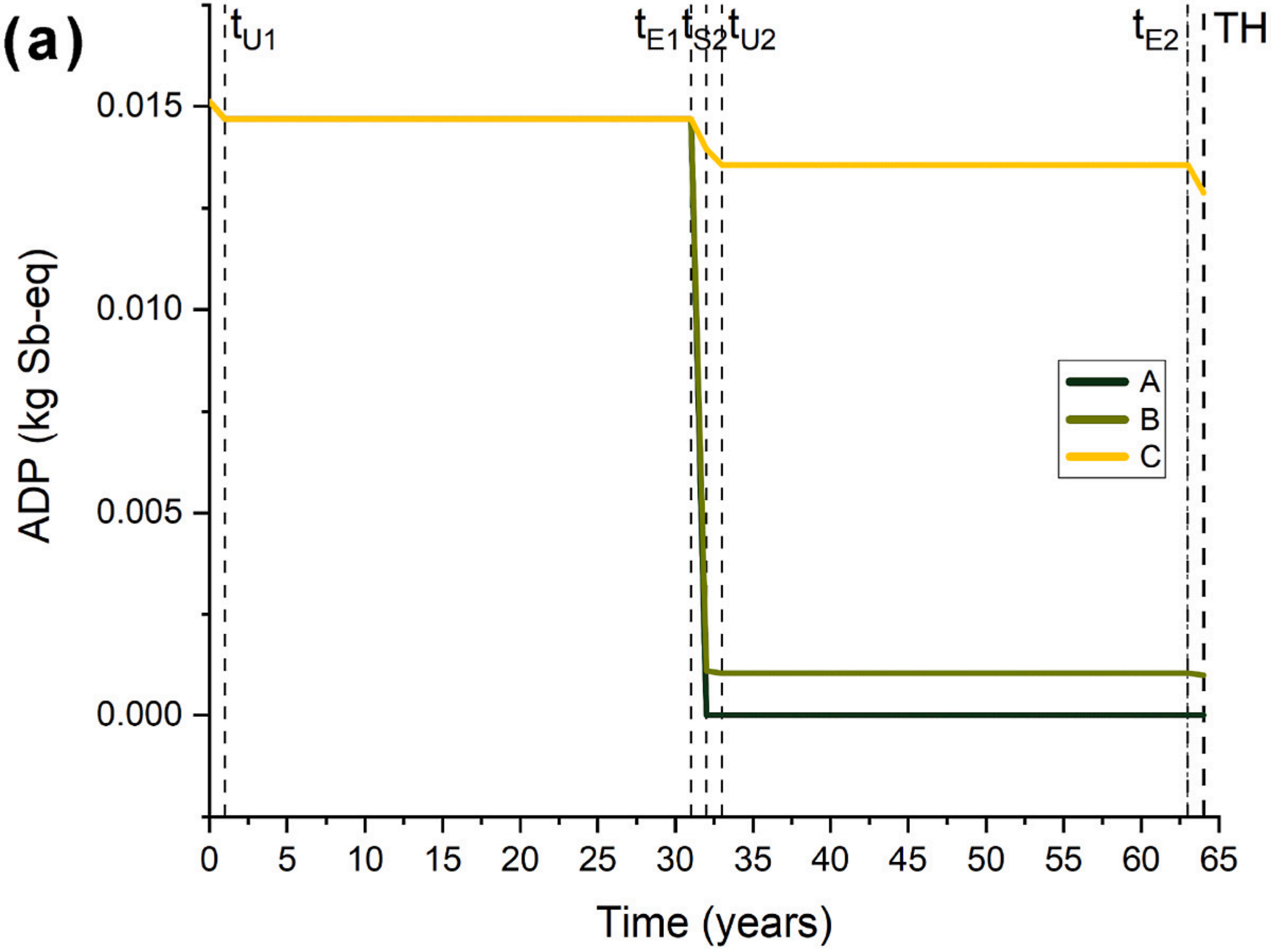


PV panels case study

- A fully linear model; no longer compliant with EU legislation — A
- Downcycling scenario: recycling of glass from the module and part of the copper from the cables — B
- most of the materials, including those present with a low concentration (but with a high value), are recovered with satisfactory efficiencies — C

UOR plots for (a) scenario A, (b) scenario B, (c) scenario C. A comparison of the three is given in (d), where the difference between scenarios B and C is appreciable. The total mass is plotted in the graphs, given by the sum of the masses of the individual materials present in the solar PV panel. The variables $t_{S,j}$, $t_{U,j}$, and $t_{E,j}$ refer respectively the time of supply, use, and end-of-life in the j-th life-cycle.

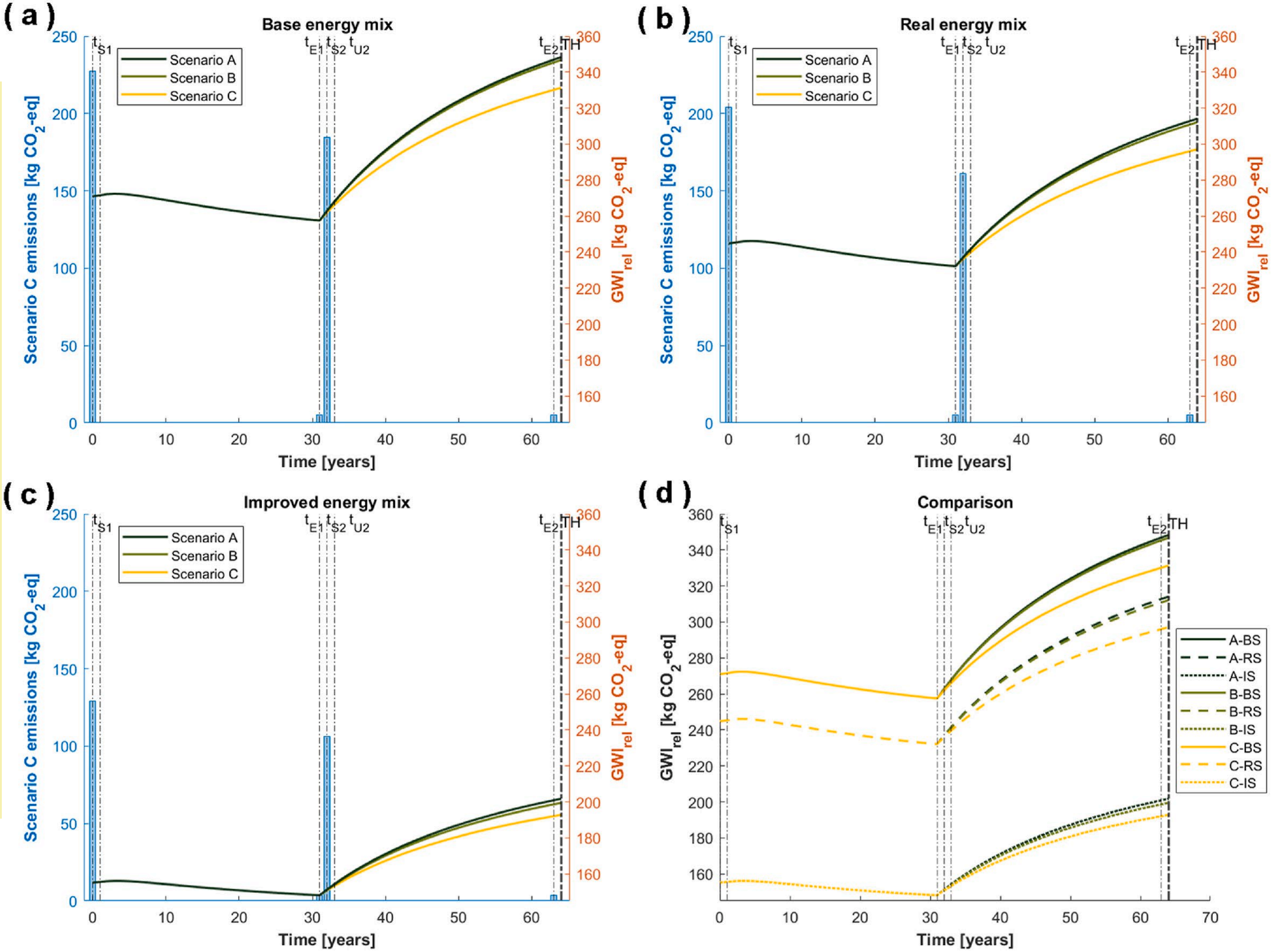




(a) Abiotic Depletion Potential (ADP) UOR plot for the three EoL scenarios.

(b) Economic Value (EV) UOR for the three EoL scenarios.

Relative global warming impact along time for the three EoL and energy mix scenarios: Base mix (a), Real mix (b), Improved mix (c). A comparison of the nine cases is shown in (d). The value at t = TH represents the GWI of each case. In plots (a), (b), and (c), the left axis refers to the bar plot, representing the punctual emissions released at a specific time. The relative GWI is plotted on the right axis, which is magnified in the section from 145 to 360 for sake of visualization.



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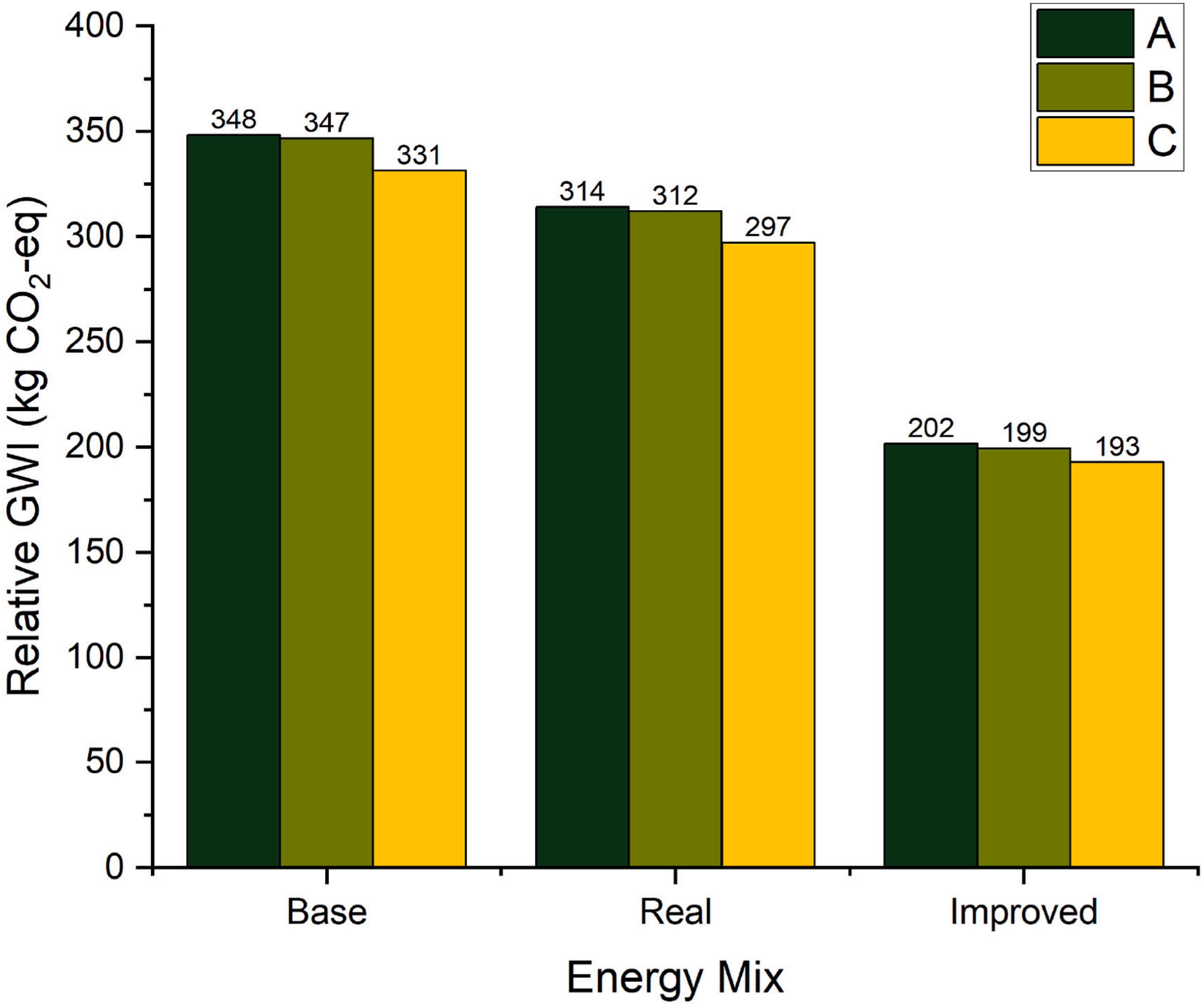
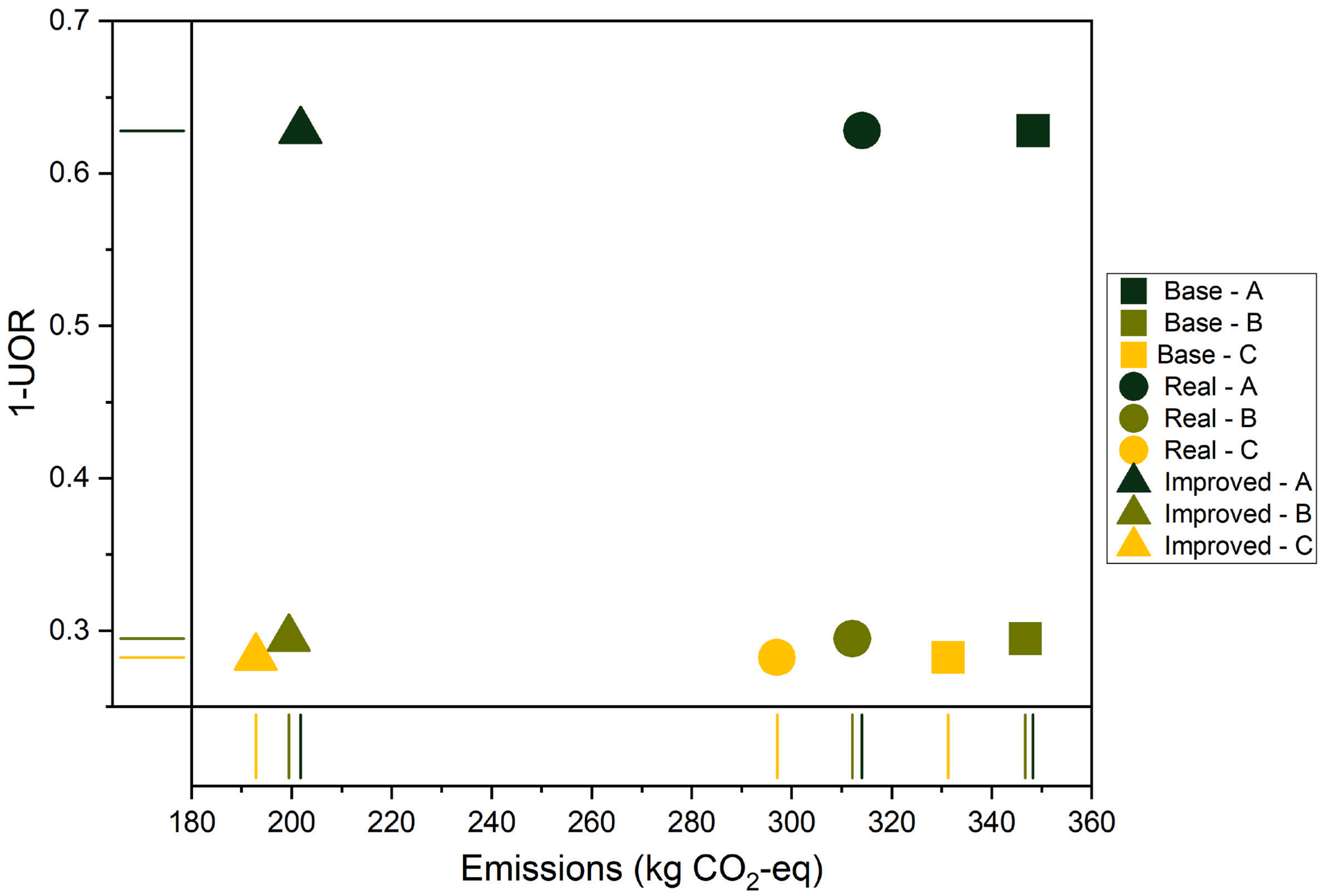
Global warming impact of the nine scenarios expressed in kg CO_2-eq.



Two-dimensional comparison of the nine cases. The y-axes plots (1-UOR) instead of UOR to facilitate data visualization, maintaining the “the lower the better” hierarchy valid for the emissions plotted on the x-axis.



Thank You

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MATERIALS FOR ENERGY AND ENVIRONMENT

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