RETHINK WASTE

RETHINKING MUNICIPAL TARIFF SYSTEMS
TO IMPROVE URBAN WASTE GOVERNANCE

C.2 & C3.2
Evaluation of KPIs before the implementation of KAYT campaigns. Presentation of baseline intra-comparison

Focus group workshop 1st December 2021, Sant Just Desvern

David Font Vivanco, PhD

2.-0 LCA consultants

Introduction: relation to application form

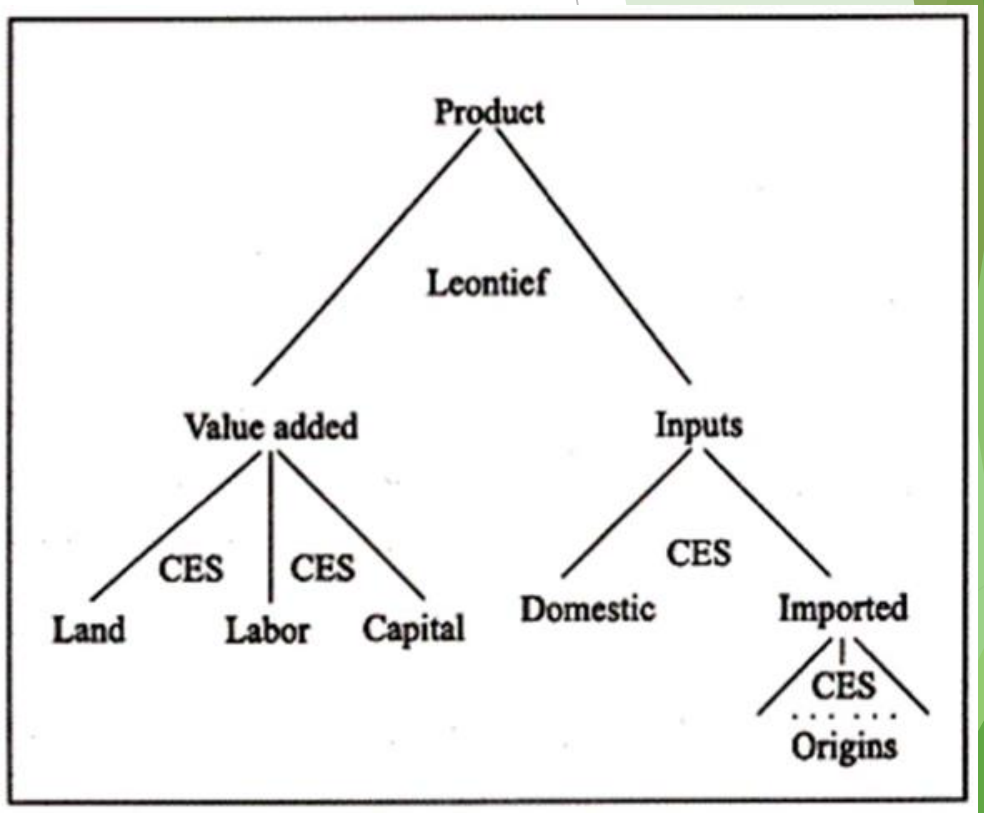
- **Action C.2:** Environmental footprint analysis
  - **Deliverable N.4:** LCA goal & scope document and testbed areas' baselines
- **Action C.3.2:** Socio-economic analysis
  - **Deliverable N.4:** Life Cycle Costing report of PAYT-KAYT
- In short, the **environmental life cycle assessment** and **life cycle costing** of the baselines (**before KAYT**) of Sant Just Desvern, Bassano, Varese, and Bitetto.

Introduction: Life cycle assessment (LCA)

- **Environmental footprint**: The direct (e.g., use emissions) and indirect (e.g., other [direct] emissions during the life cycle) environmental consequences of a given product.
- **Life cycle**: From raw material acquisition through production, use, end-of-life treatment, recycling and final disposal.
- **Life Cycle Assessment (LCA)**: Method to calculate environmental footprints of products.
- **Relevant LCA standards**: ISO 14040:2006 and ISO 14044:2006.

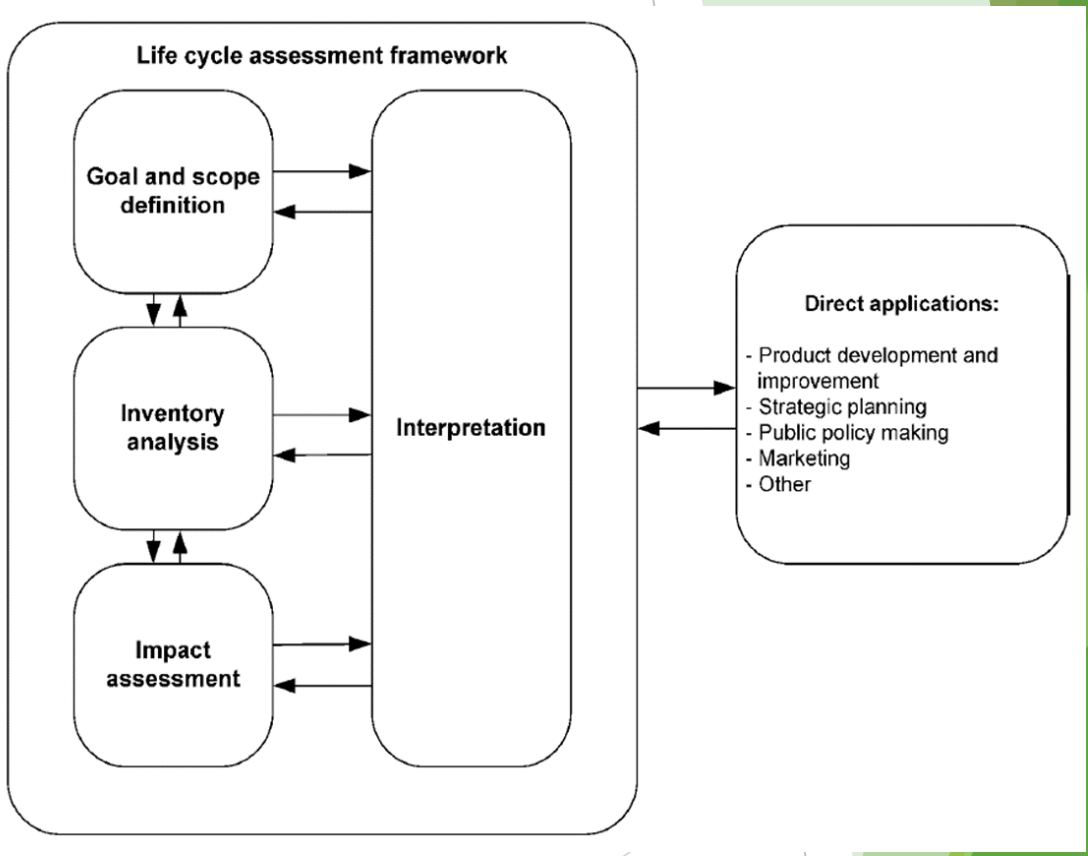
Introduction: Life cycle costing (LCC)

- **Value added**: «Services» provided by factors of production (labor, capital, etc.) which raise the unit price of a product (X) relative to the cost per unit of intermediate goods used up in the production of X.
- **Life cycle cost**: The direct (by seller) and indirect (by upstream suppliers) value added associated with a product. This is also the theoretical retail price of a product.
- **No international LCC standards**: Relevant standards are the ISO 15686-5, IEC 60300-3-3:2005, and EN 15643-4:20012.
- **Environmental LCC** is consistent with LCA following SETAC's code of practice.



Introduction: joint LCA-LCC modelling

- **LCA and LCC can be modelled simultaneously within the same framework.** LCA yields the "environmental cost" and LCC yields the "economic cost" of a given final demand.
- **"Dual" goal**: looking at both environmental and economic consequences.
- **Inventory analysis**: Same economic relationships with both environmental (e.g. air emissions) and economic extensions (value added).
- **Impact assessment**: Use of both environmental and economic characterisation factors.



Goal and scope

- **Goal:** to evaluate the life-cycle environmental and economic performance of the current municipal waste management systems in the four pilot areas and use the results to inform structural and strategic choices (-> Consequential LCA)
- **Scope:** collection and treatment of household municipal unsorted, organic, light packaging, paper & cardboard, and glass waste until final disposal in the pilot's area.
- **Allocation procedure**: product substitution.
  - **Substitution potential** = secondary material amount * conversion efficiency * intersubstitutability ratio * market elasticity (=1) (Vadenbo et al. 2017)
- **Impact assessment**: Stepwise2006 (17 environmental impacts, focus on fossil-based global warming) + economic costs.

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Life cycle inventory

- **Model structure**
  - **Foreground system (primary data)**
    - Parameterised input data (inputs that change in the short term, 453 parameters)
      - Waste collected by waste fraction
      - Number of containers by waste fraction and type of container
      - Distances by waste fraction and type of truck
      - Waste characterisations by material and waste fraction
      - Intersubstitutability ratios by material
      - Collection and treatment costs and revenues by fraction and cost type
  - **Background system (secondary data)**
    - Fixed inventories (model calibration)
      - Regionalisation whenever possible (electricity mix, waste treatment, etc.)
    - Hybrid LCA-IO background: administrative activities included via costs
    - Ecoinvent + EXIOBASE hybrid + literature

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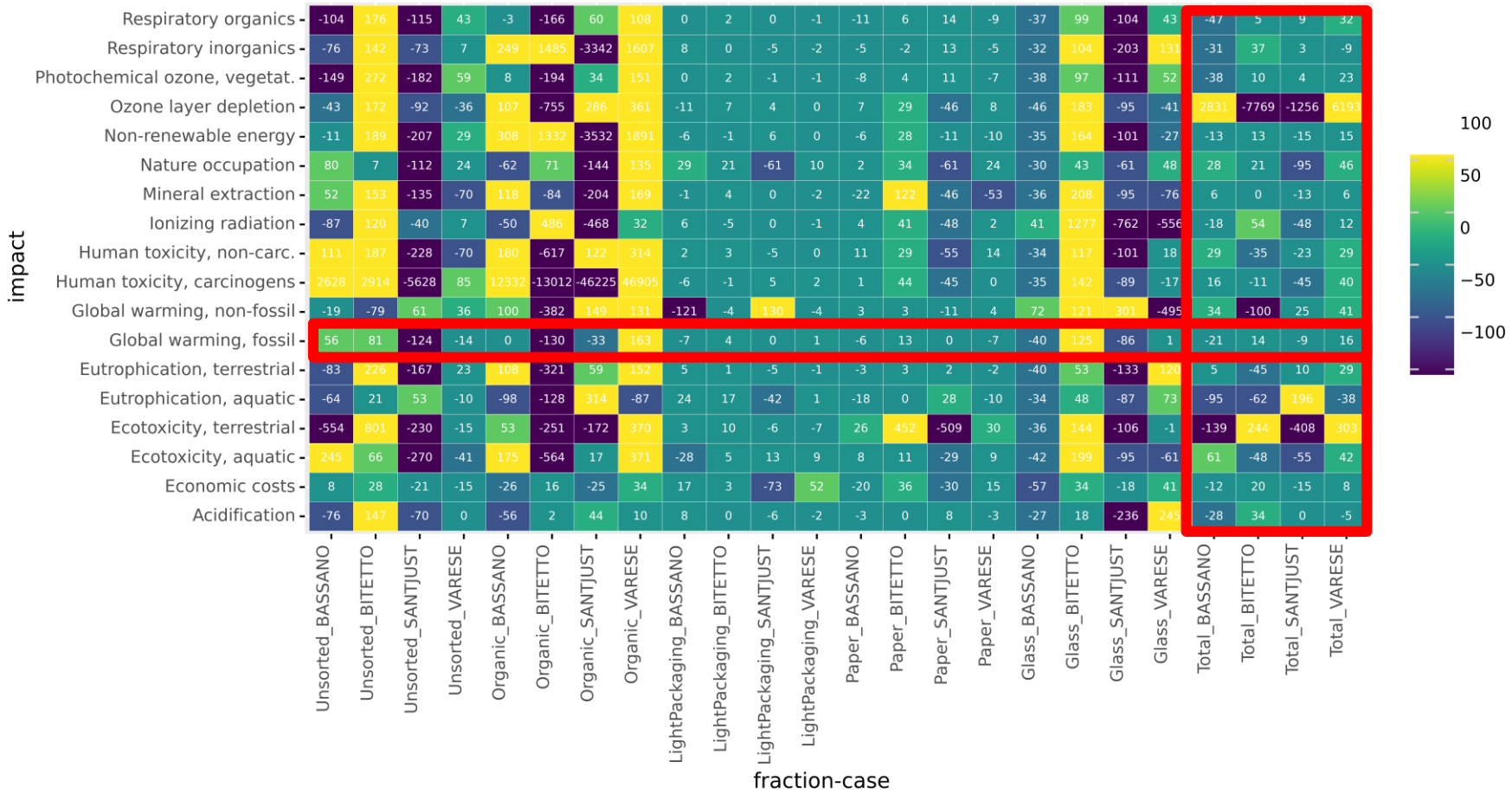
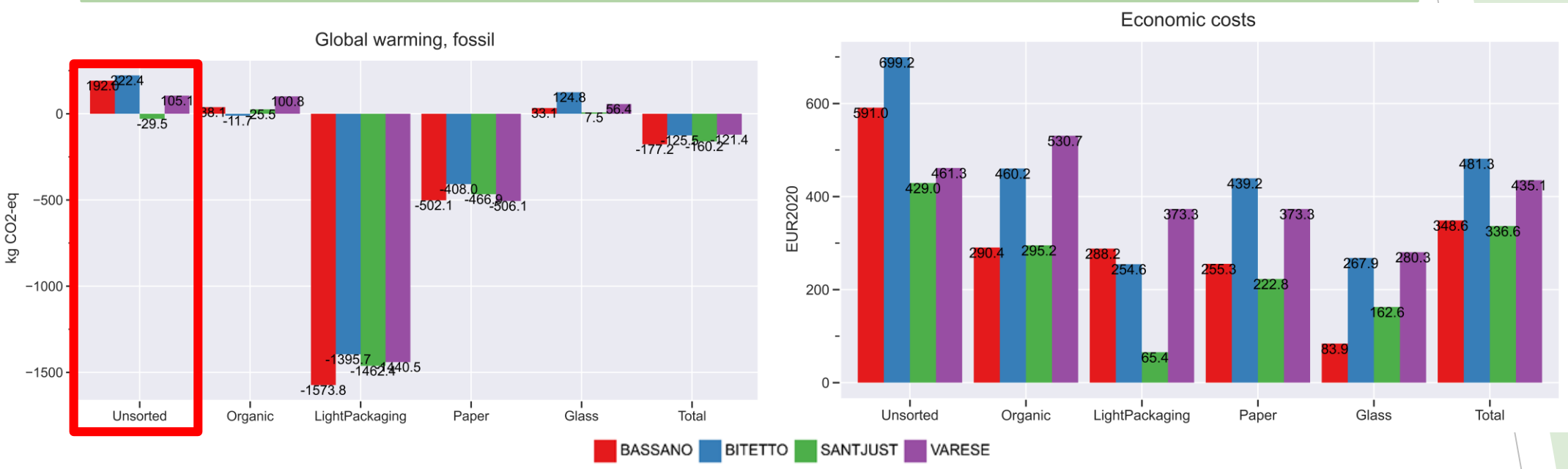
Life

Baseline results: unitary results summary



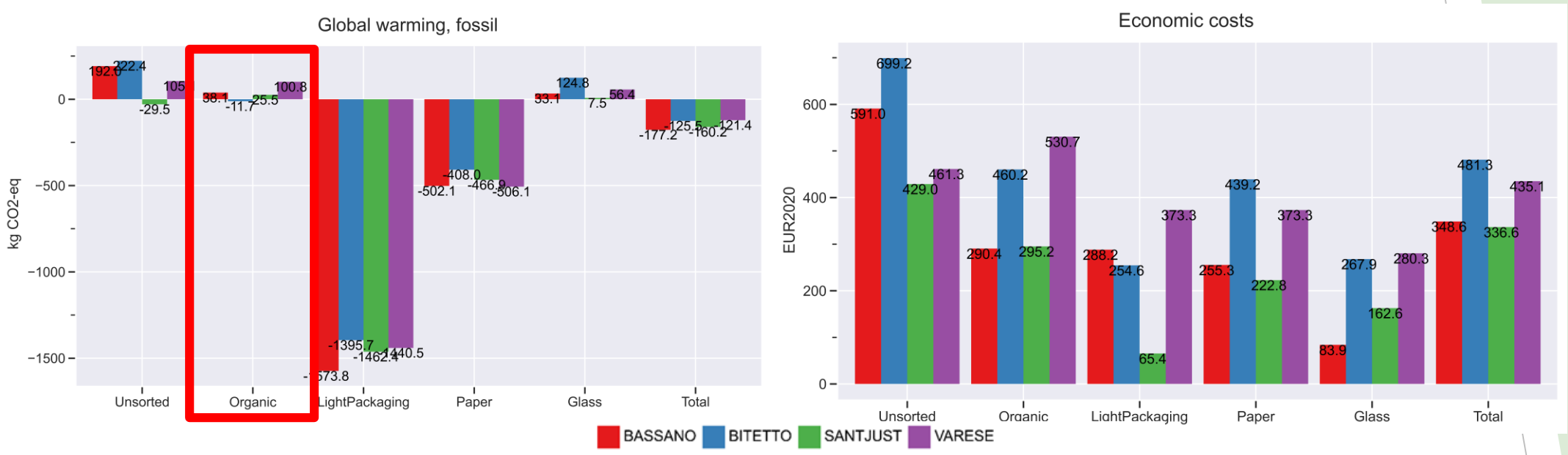
- **Total waste best (across impacts):** Sant Just (8/18), Bassano & Bitetto (5/18), Varese (0/18).
- **Global warming best (across fractions):** Sant Just (unsorted, glass), Bassano (light packaging), Varese (paper & cardboard), Bitetto (organic).

Baseline results: unitary (per ton) results summary



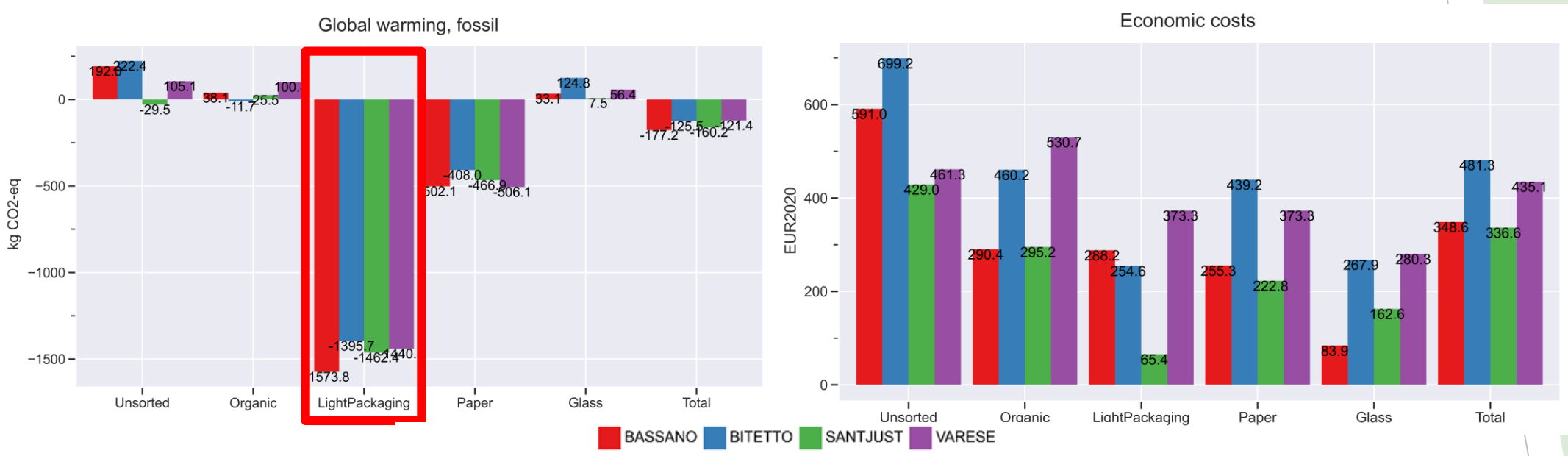
- **Global warming**
  - **Unsorted**
    - **Sant Just** -> plenty of recoverable materials + mechanical-biological treatment
    - **Bitetto** -> all landfilled

Baseline results: unitary (per ton) results summary



- **Global warming**
  - **Organic**
    - **Bitetto** -> high share of organic matter + quality compost + surplus of biogas sold
    - **Varese** -> anaerobic digestion + little surplus electricity + no surplus of biogas
    - Sant Just -> low share of organic matter + mechanical treatment

Baseline results: unitary (per ton) results summary



- **Global warming**
  - **Light packaging**
    - **Bassano** -> highest share of PET, HDPE, LDPE, and aluminium
    - **Bitetto** -> high share of recoverable materials + high container volume + high administrative costs
    - Sant Just -> low share of recoverable materials + low container volume + low administrative costs

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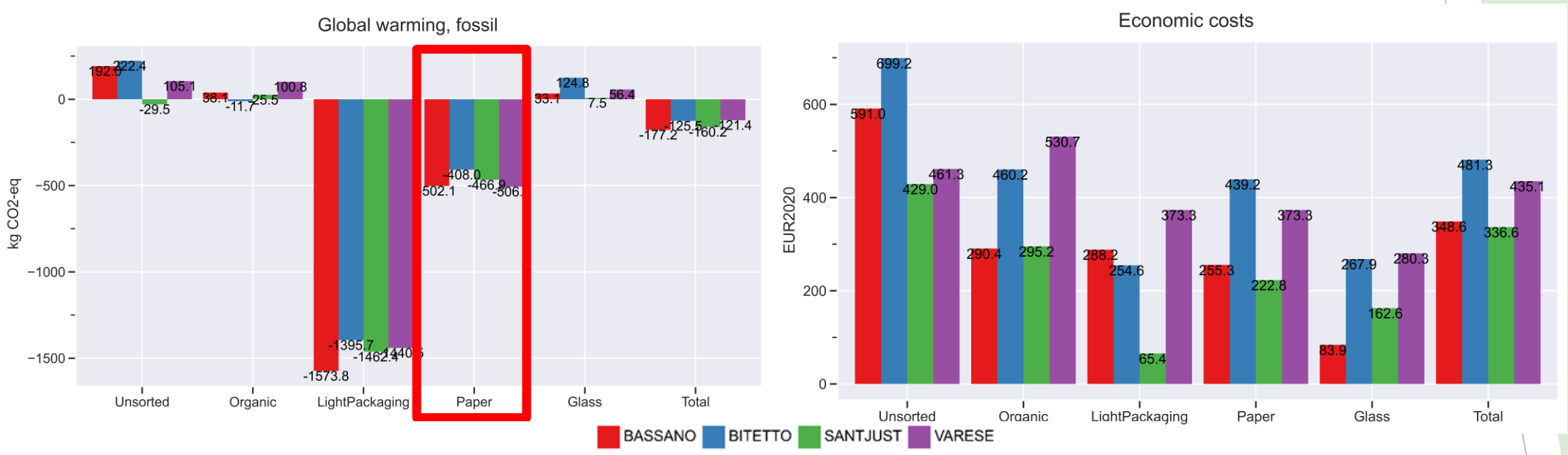
Baseline results: unitary (per ton) results summary



- **Global warming**
  - **Paper and cardboard**
    - **Varese** -> highest share of paper & cardboard
    - **Bitetto** -> high share of paper & cardboard + high administrative costs

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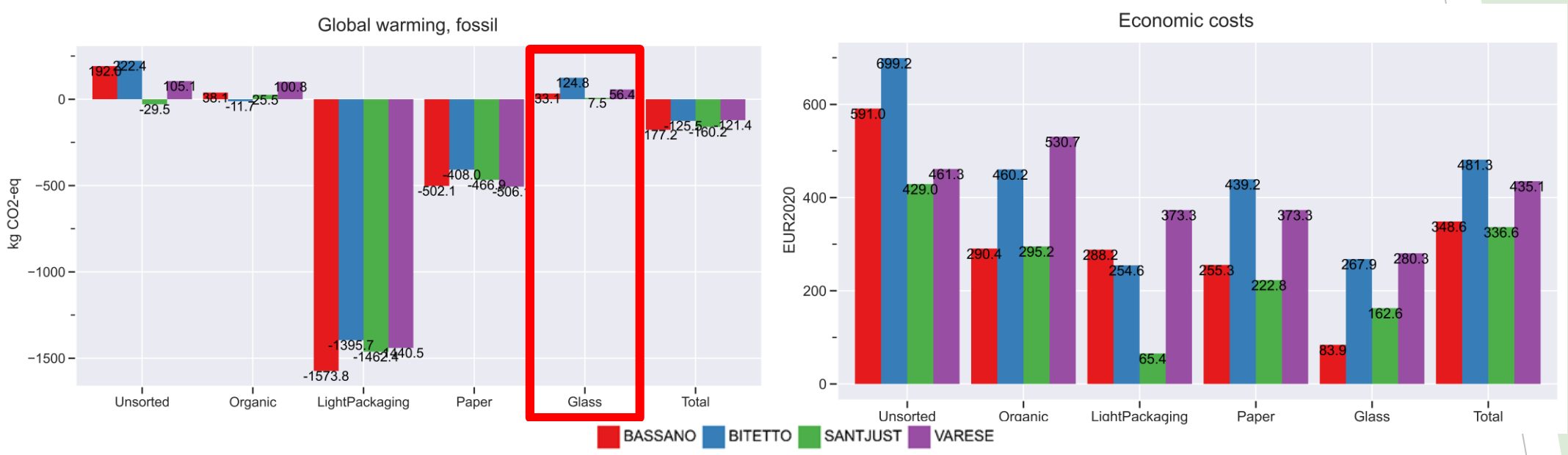
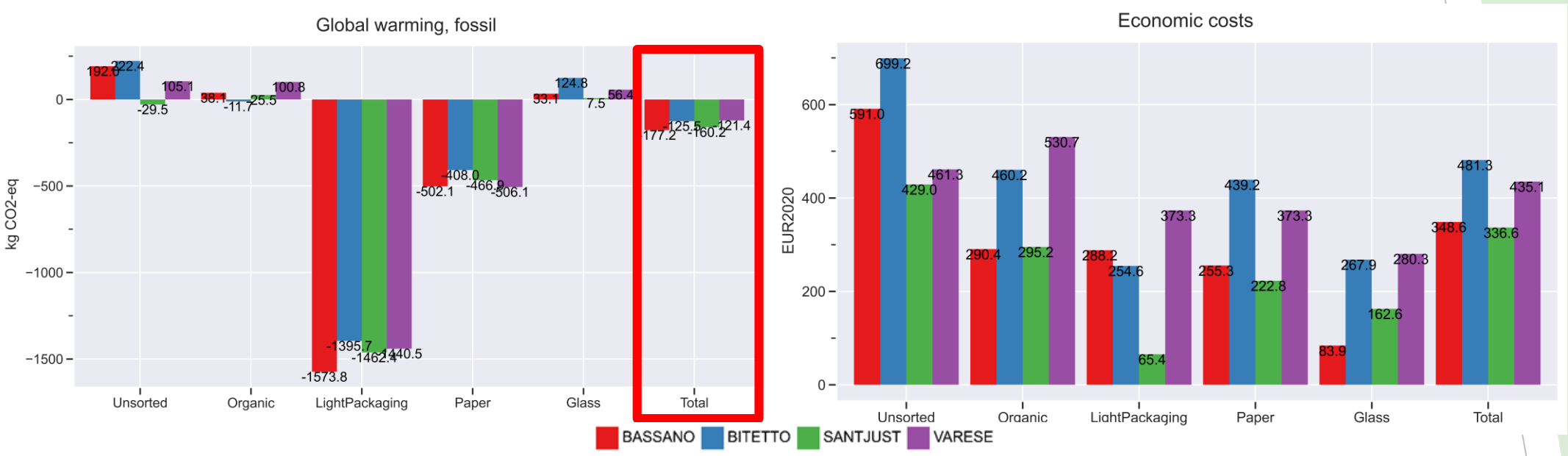
Baseline results: unitary (per ton) results summary



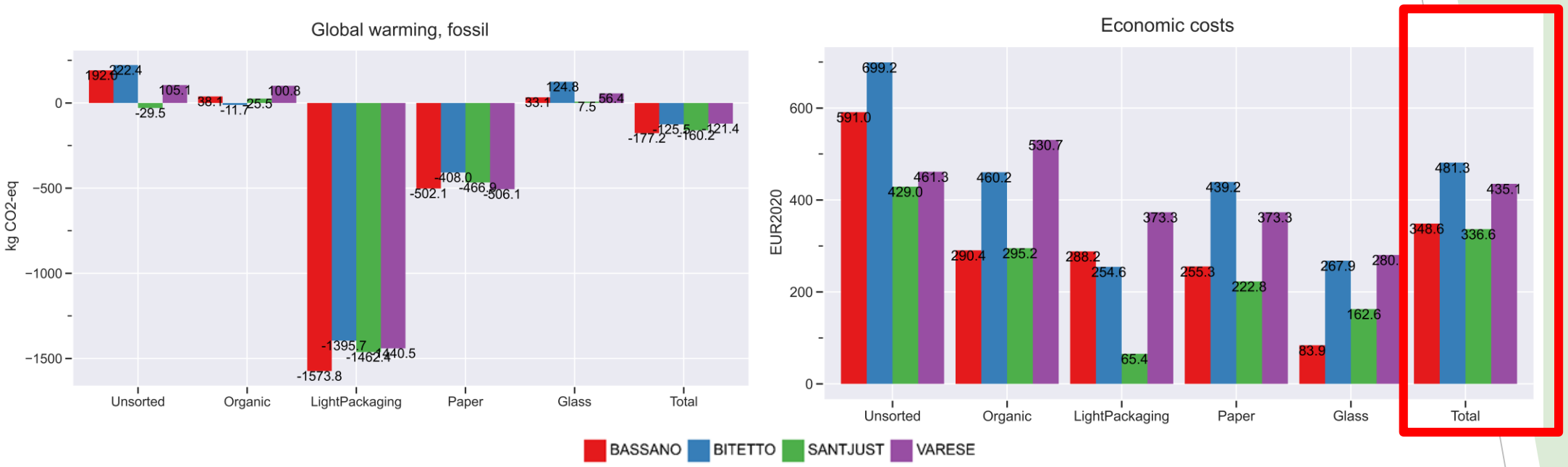
- **Global warming**
  - **Glass**
    - **Sant Just** -> low container volume + low administrative costs
    - **Bitetto** -> high container volume (.98 l/kg vs .15-.69 l/kg) + high administrative costs

Baseline results: unitary (per ton) results summary



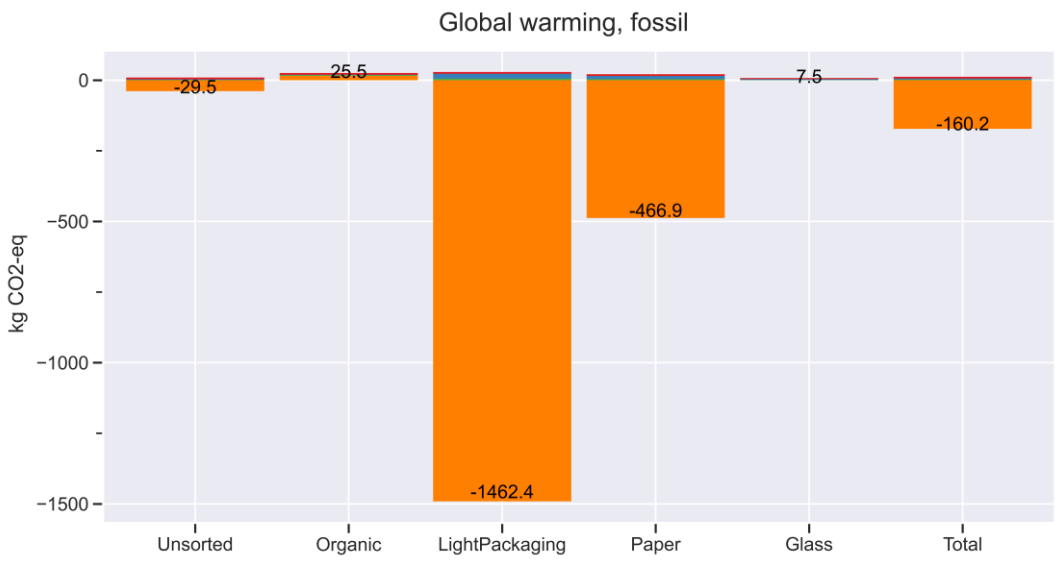
- **Global warming**
  - **Total**
    - **Bassano** -> low unsorted & organic absolute amount
    - **Varese** -> high unsorted & organic absolute amount

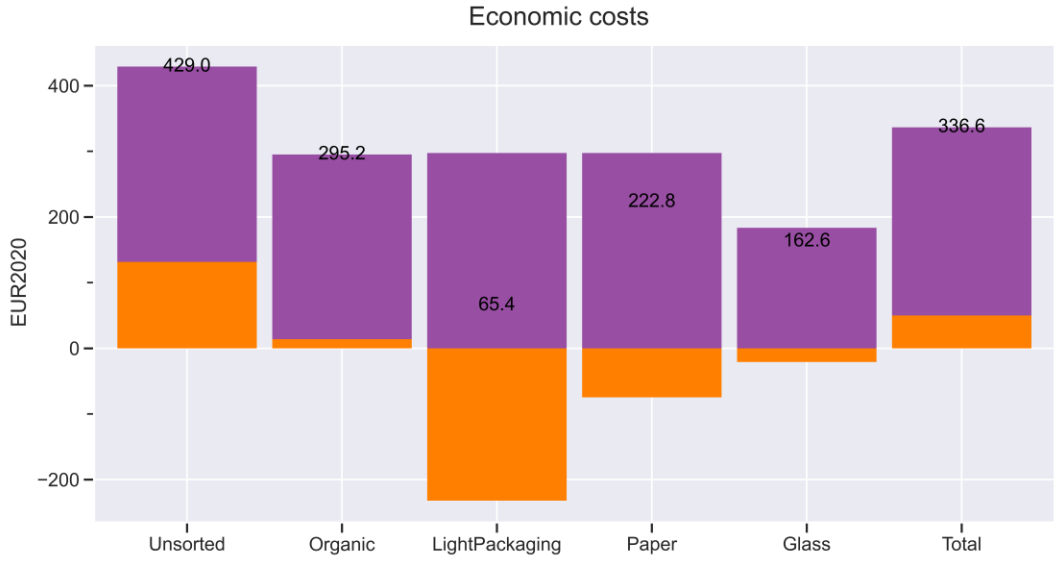
Baseline results: unitary (per ton) results summary



- **Economic costs**
  - **Total**
    - **Sant Just** -> high treatment revenues from secondary materials + low collection costs
    - **Bitetto** -> low treatment revenues + high collection costs

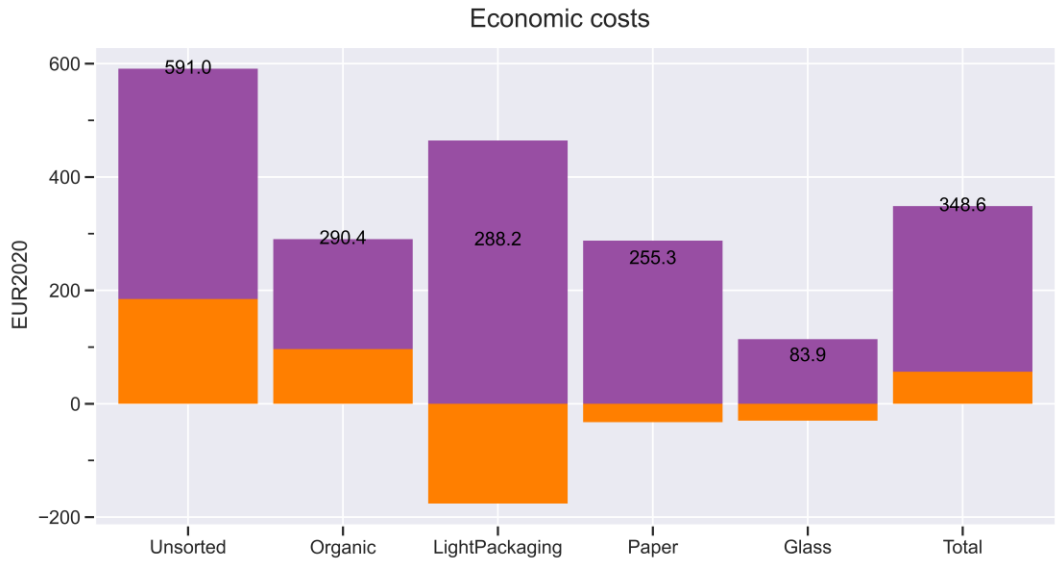
Baseline results: unitary (per ton) results by stage





Sant Just Desvern

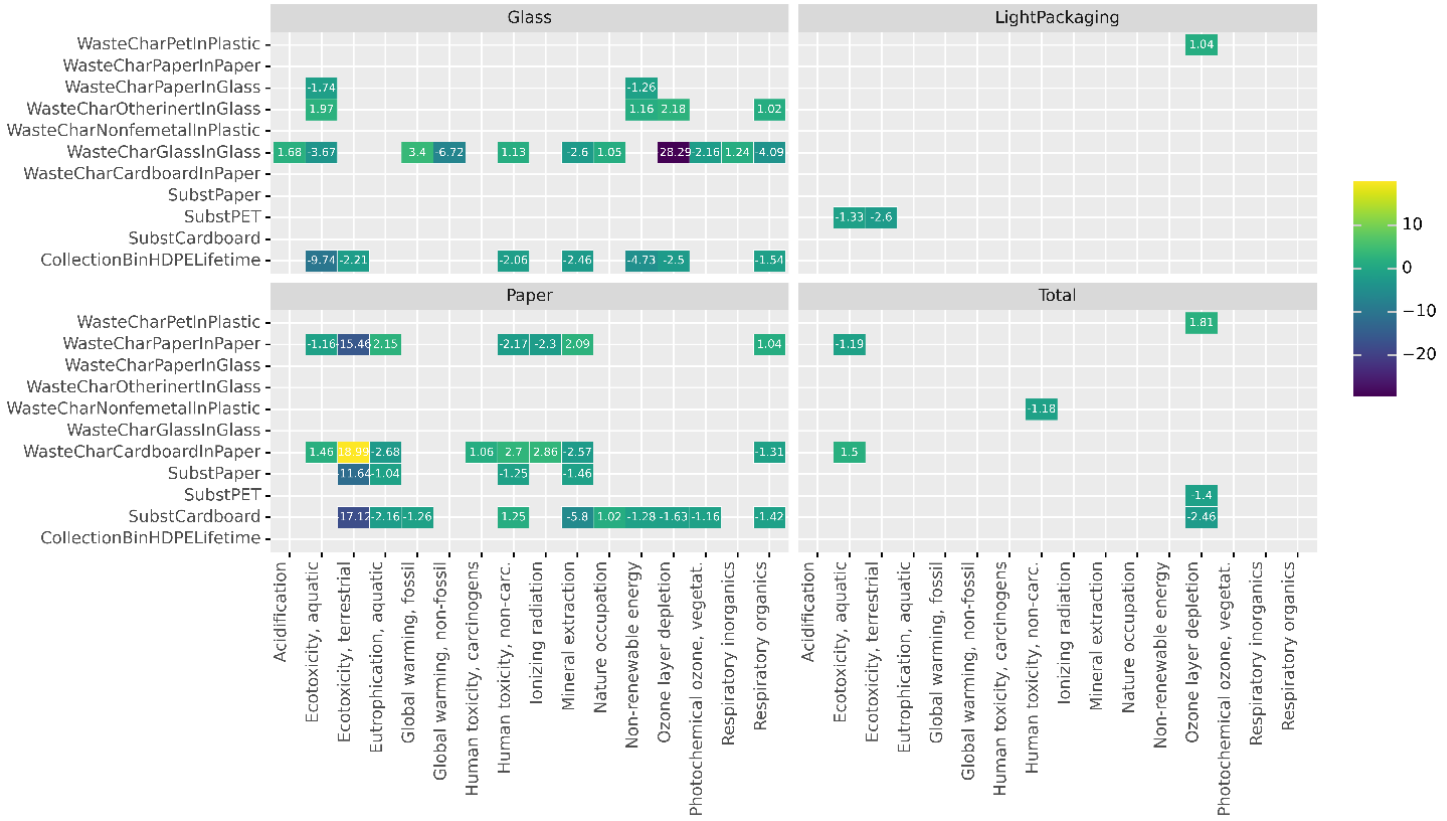
- Environmental impacts generally dominated by treatment
- Economic costs highly influenced by collection system and secondary material revenues



Bassano

Baseline results: sensitivity analysis

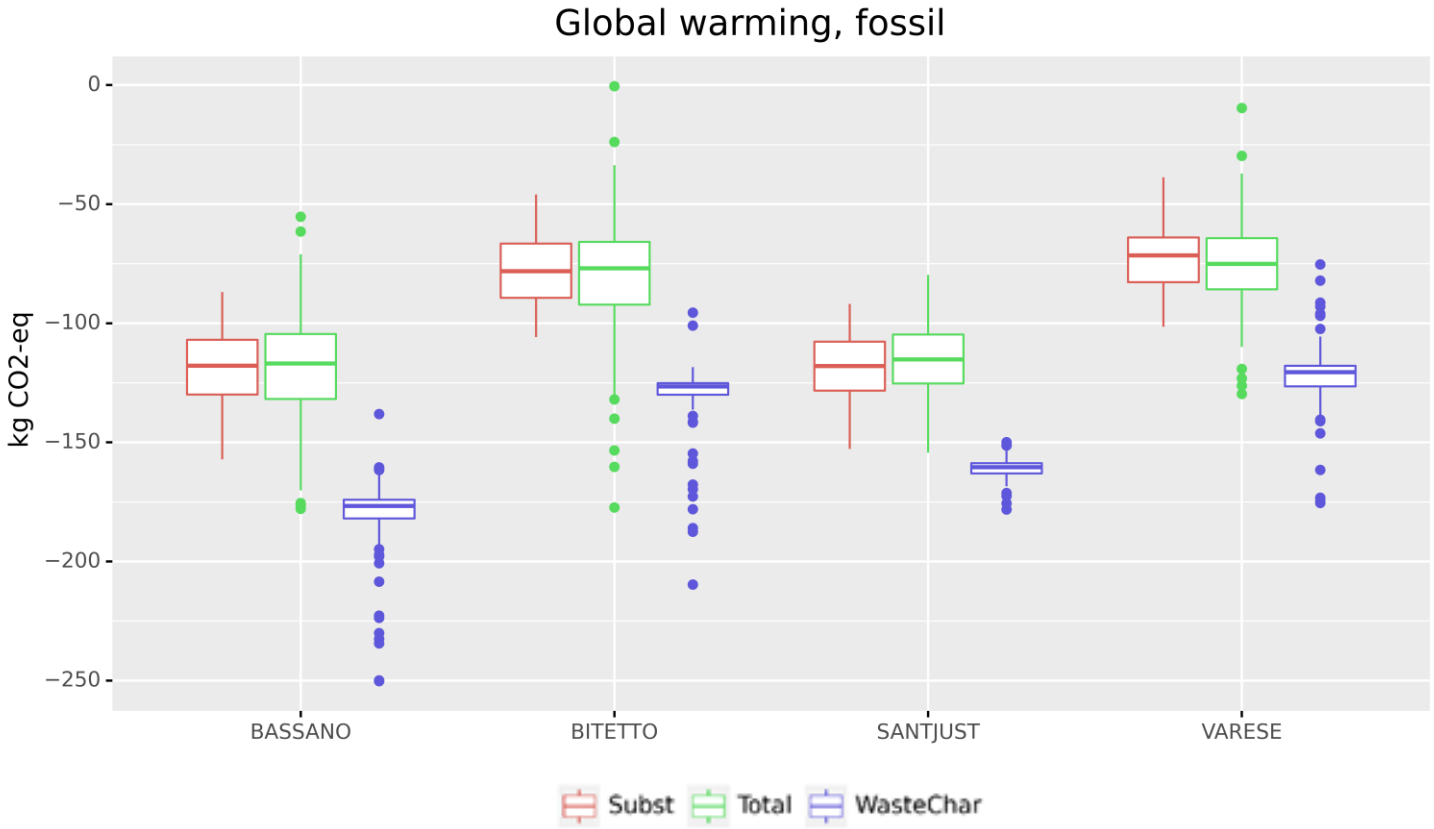
Regression coefficients higher than 1, Bassano. Parameter correlation for waste characterisation and waste collected.



- Parameter correlation as suggested by Wei (2015) for waste characterisation and waste collected
- **Key parameters across pilots**
  - **Intersubstitutability:** cardboard, paper, PET, & LDPE
  - **Waste characterisations:** Al & PET in light packaging, paper & cardboard in P/C

Baseline results: uncertainty analysis

Results for total waste, only variance in highly-sensitive parameters. Ranges with uniform distributions, 150 runs. Parameter correlation for waste characterisation and waste collected.



- **Input variance:** alternative waste characterisations, intersubstitutability ranges from Viau (2020).
- **Intersubstitutability uncertainty drives total output uncertainty**.

Interpretation

- Data quality, completeness, and consistency checks together with sensitivity, and uncertainty analyses **validate the robustness of results**.

- **Lack of similar studies to compare results**
  - Sant Just Desvern: **AMB (2020)** reports 123 (vs -160) kg CO2 eq. per ton of total waste and -401 (vs 7.5) for glass, 190 (vs -467) for P/C, and -375 (vs -1,462) kg CO2 eq. per ton for packaging. Differences: additional fractions, attributional (APOS) approach, ReCiPe 2016 (+ indirect effects).
  - Bassano, Varese, Bitetto: 67-192 (vs -177 - -121) kg CO2 eq. per ton for total waste and 134 (vs -11 - 100) for glass, 53 (vs 33-125) for organic, 19 (vs -506 - -408) for P/C, and 7 (vs -1,574 - -1,396) kg of CO2 eq. per ton of for packaging (**De Feo et al., 2019**). Differences: attributional (APOS) approach, ReCiPe 2016 (+ indirect effects).

- Bassano and Sant Just Desvern achieve the **best carbon footprint economic efficiency** (-.51 and -.48 kg CO2 eq./ton per EUR spent), while Varese and Bitetto achieve the worst (-.28 and -.26 kg CO2 eq. per EUR spent).

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Interpretation

- Door-to-door schemes achieve high quality waste streams, yet **this potential is not fully exploited** due to:
  - No recovery of secondary materials from unsorted waste, e.g. PET (2-4%), PE (4-11%), Al (1-2%), paper (1-5%), cardboard (2-3%).
  - Landfilling of unsorted waste.
  - Full methanisation of quality organic waste.
  - Organic waste treatment technologies?
- Sant Just Desvern is limited by the waste quality imposed by the (open) street container scheme, yet the treatment pathways yield substantial environmental credits.
- While intersubstitutability ratios are highly influential, they are exogenous and outside the scope of waste management authorities. **Efforts should focus on improving waste characterisation parameters**.
- **KAYT emerges as a potentially cost-efficient way to influence key parameters behind the environmental performance of municipal solid waste management**.

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Thank you for your attention

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References

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Life