# Sustainable supply chains in a circular economy

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# Overview

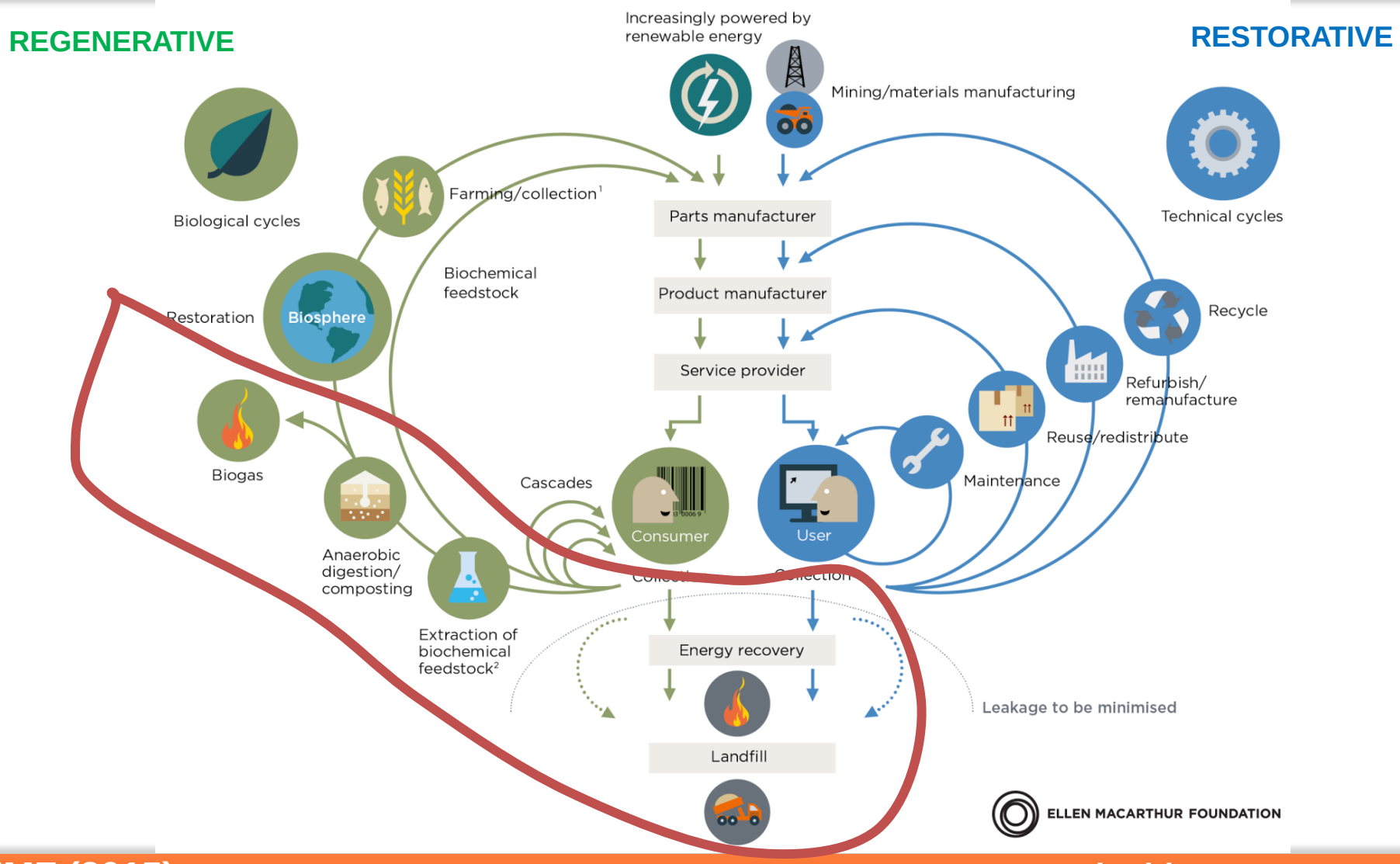
- Introduction
- Systems approach and life cycle thinking
- “Circularity” vs “sustainability”
- Illustrative examples
  - Food waste
  - Energy-using appliances
  - Packaging
- Conclusions

# Circular economy

- Regenerative and restorative by design
- Keep products and resources in use as long as possible
- Extract the maximum value while in use
- Recover and regenerate products and resources at the end of life

EMF (2015)

# Circular economy




EMF (2015)

# Sustainable supply chain

- Economically viable
- Environmentally benign
- Socially beneficial

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# Systems approach and life cycle thinking

# Sustainable supply chain in a circular economy

- Regenerative and restorative by design
- Keep products and resources in use as long as possible
- Extract the maximum value while in use
- Recover and regenerate products and resources at the end of life

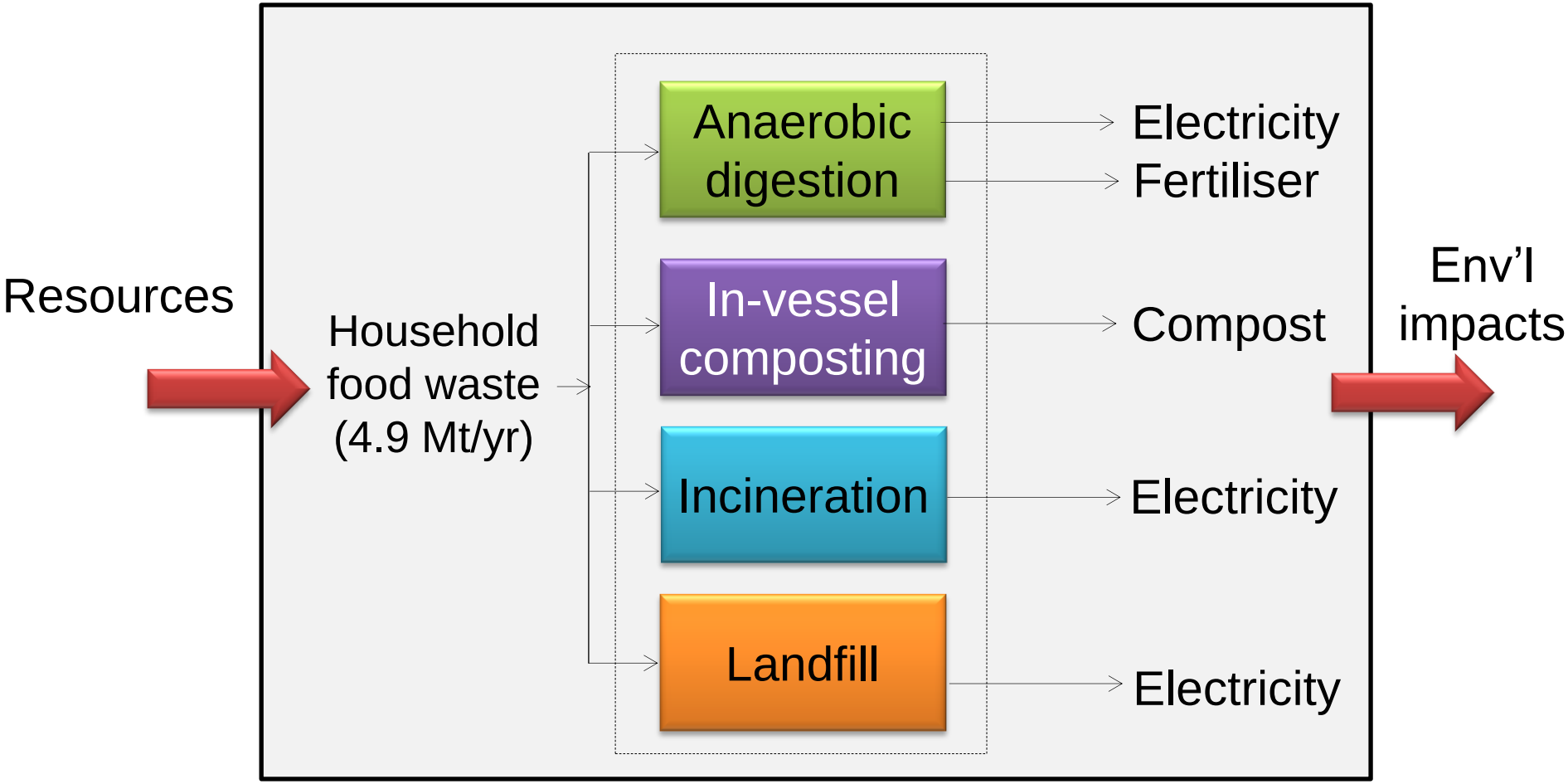
EMF (2015)

# Food waste

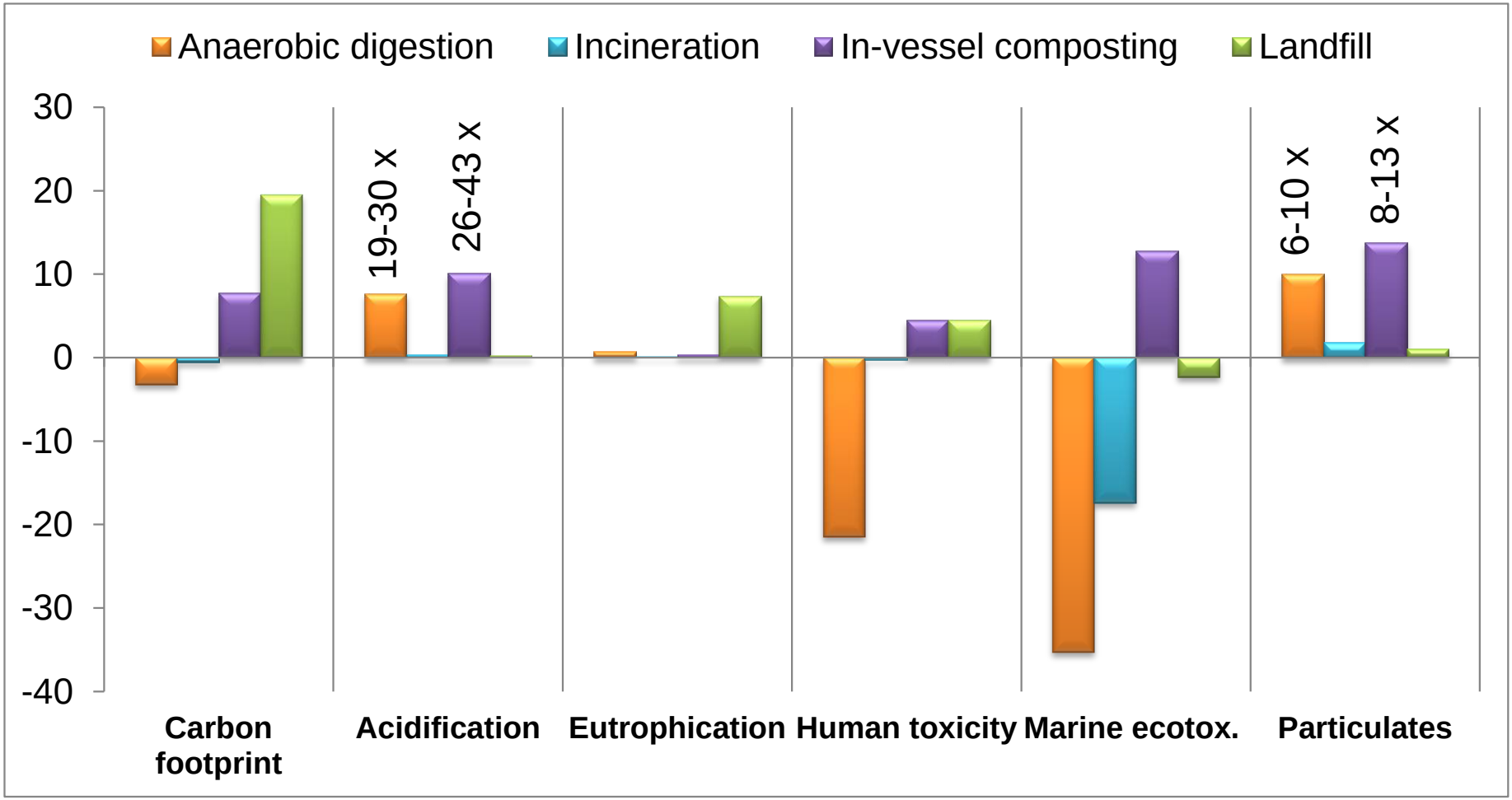
## To digest, compost, burn or bury?

7.3 Mt/yr of household food waste generated in the UK of which 4.9 Mt is managed

# Resource recovery from food waste



# Environmental impacts (per tonne)



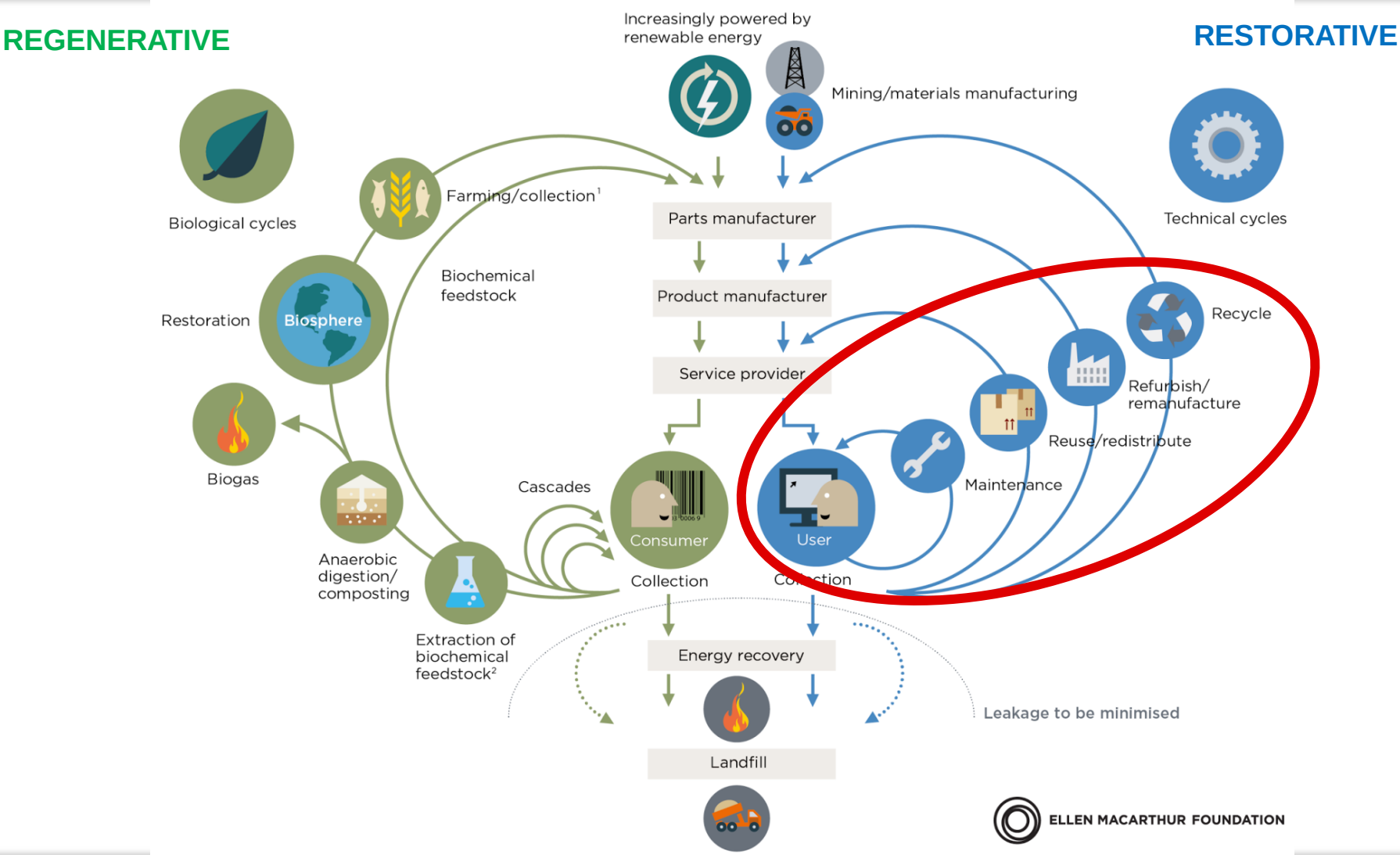

Not to scale

Slorach et al. ,Sci.Tot. Env. 693 (2019) 133516.

# Summary

- In-vessel composting is the worst option for most impacts
  - In this case “circular” does not translate into “sustainable”
- Anaerobic digestion is the best option for the carbon footprint and most other impacts
- However, it has much higher acidification and particulates (PM10)
- Much greater benefits would be achieved through waste prevention (several orders of magnitude)

# Restorative




EMF (2015)

# Circular economy concept

- Regenerative and restorative by design
- Keep products in use as long as possible
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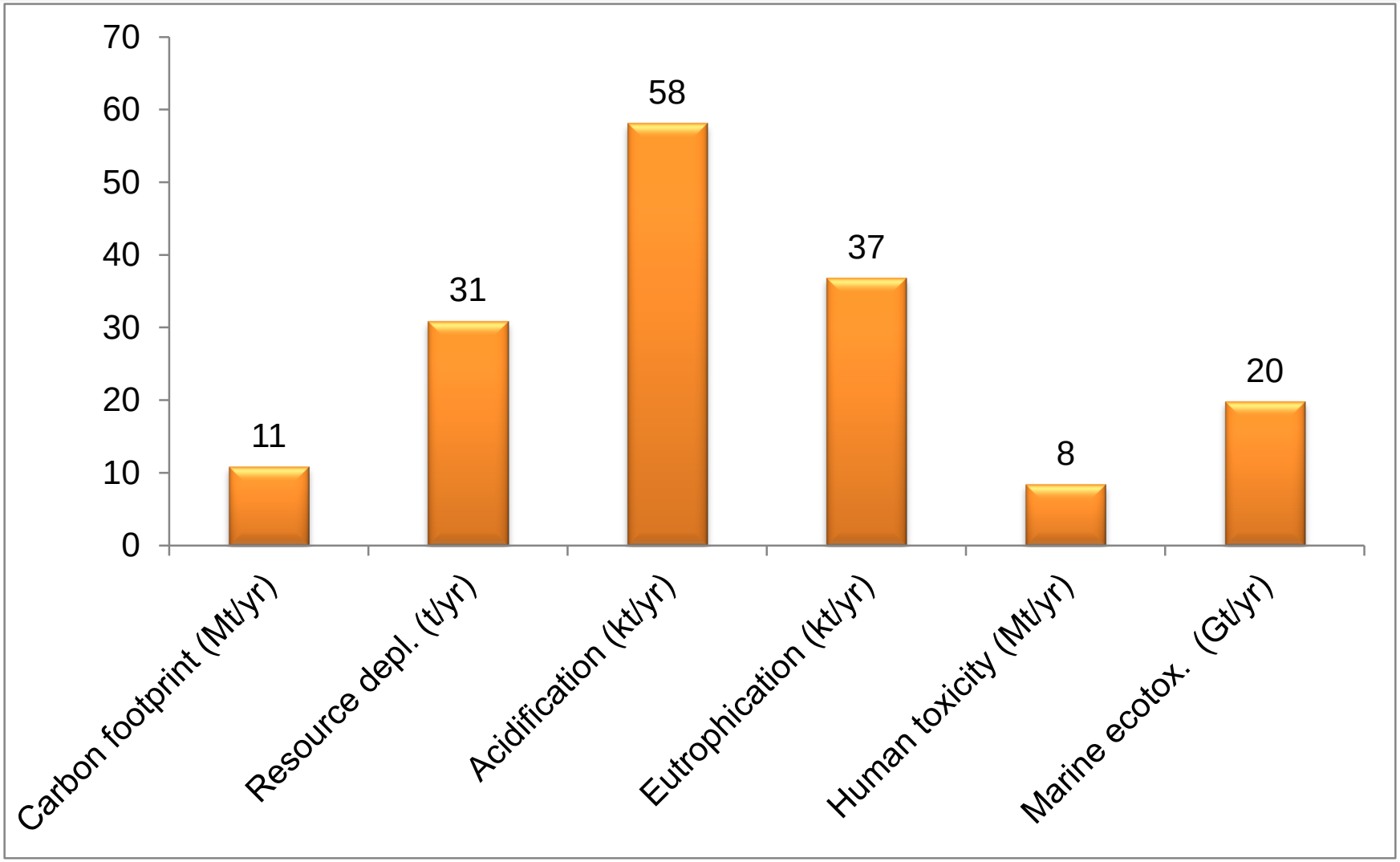
# Restorative by design

## Vacuum cleaners

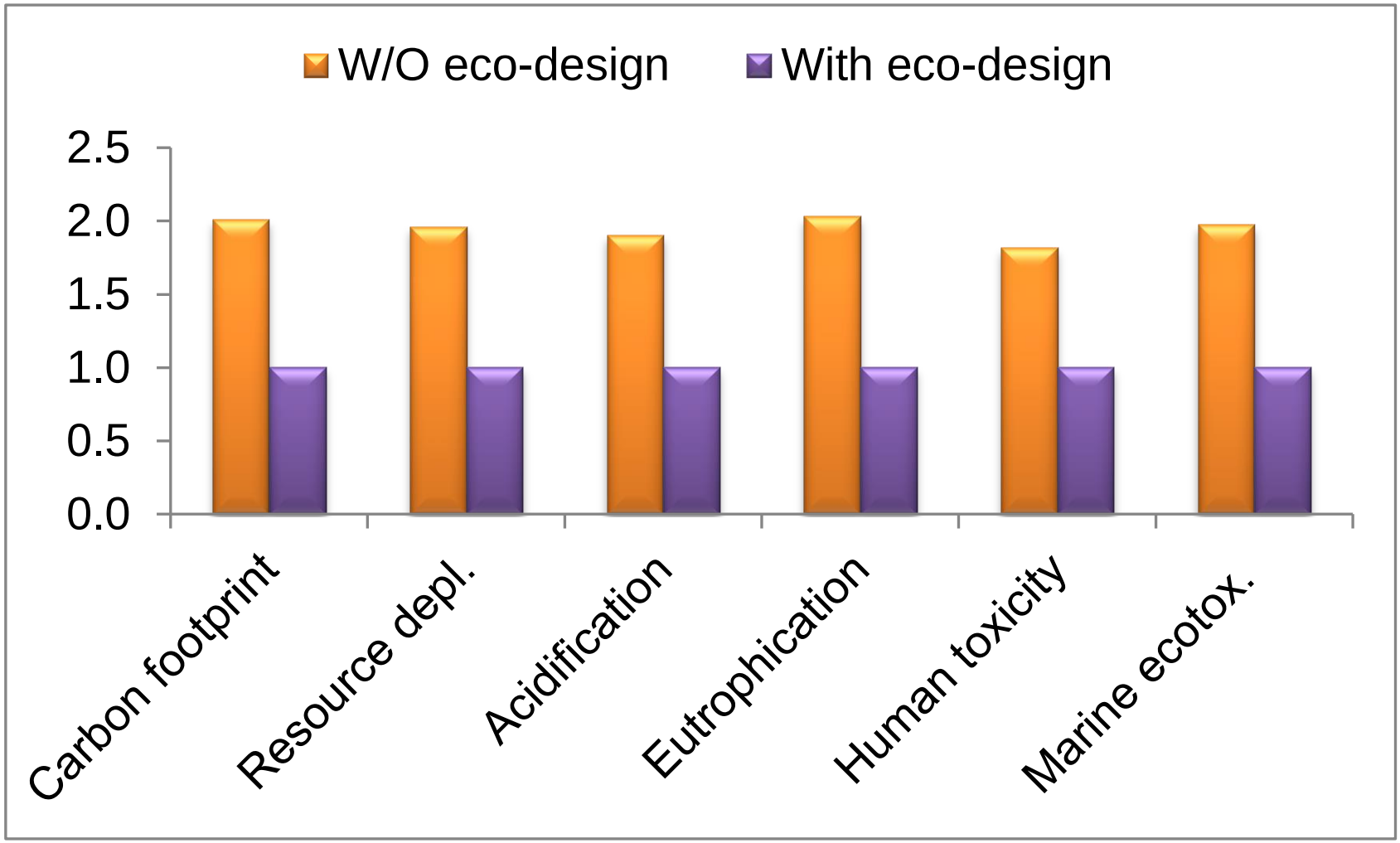
200 M vacuum cleaners are in use in the EU, with 45 M sold annually

# Annual impacts in the EU




Gallego-Schmid et al., Sci.Tot. Env. (2016) 559 192-203.

# Eco-design: Improving energy efficiency

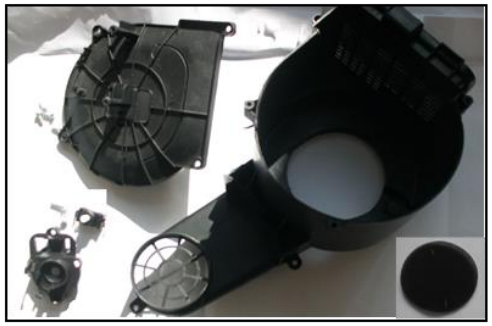



Gallego-Schmid et al., Sci.Tot. Env. (2016) 559 192-203.

# Eco-design: Improving material efficiency


Dust cup

Interior casing



Accessories


Exterior casing

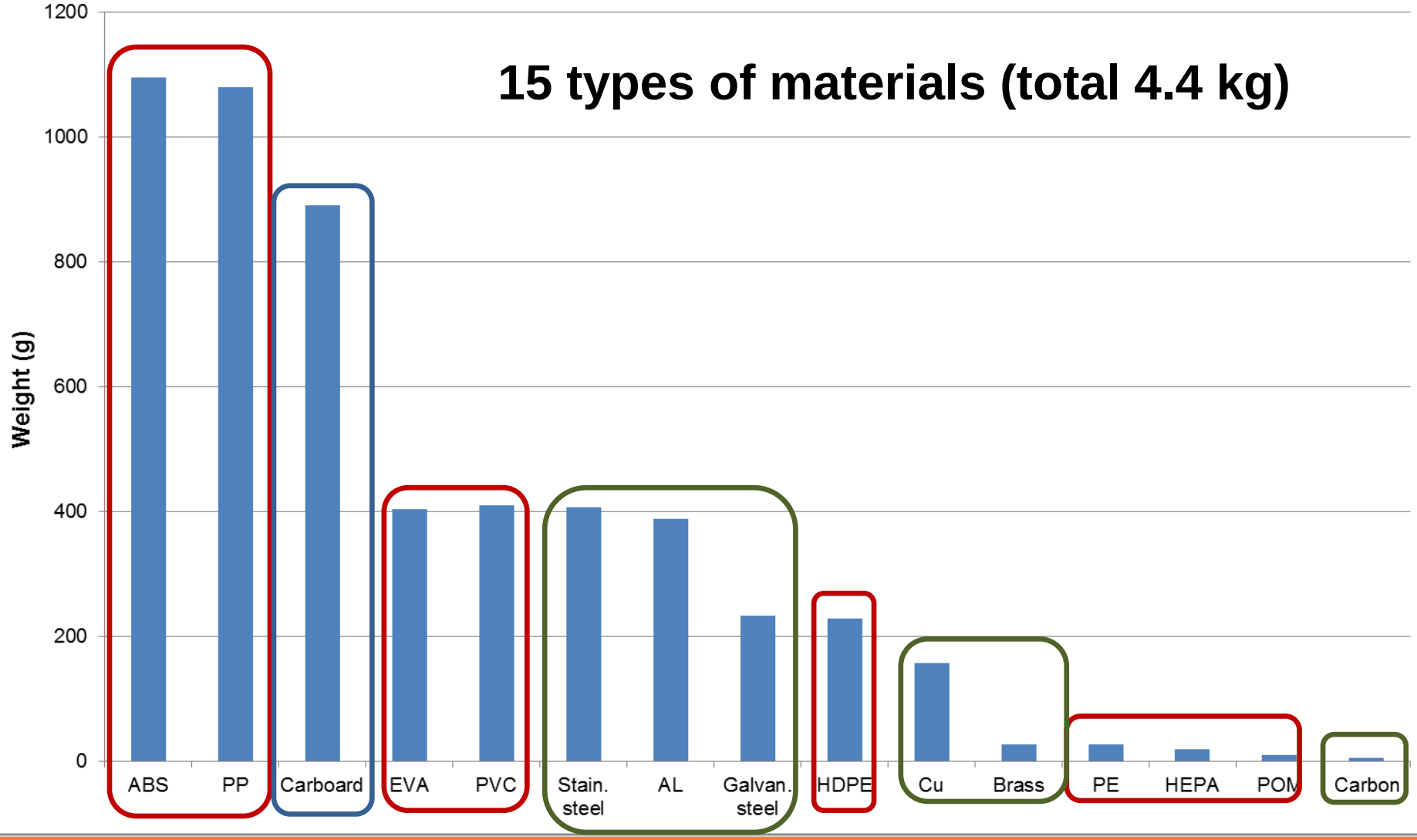
Cord rewind mec.

Motor

# Disassembly analysis

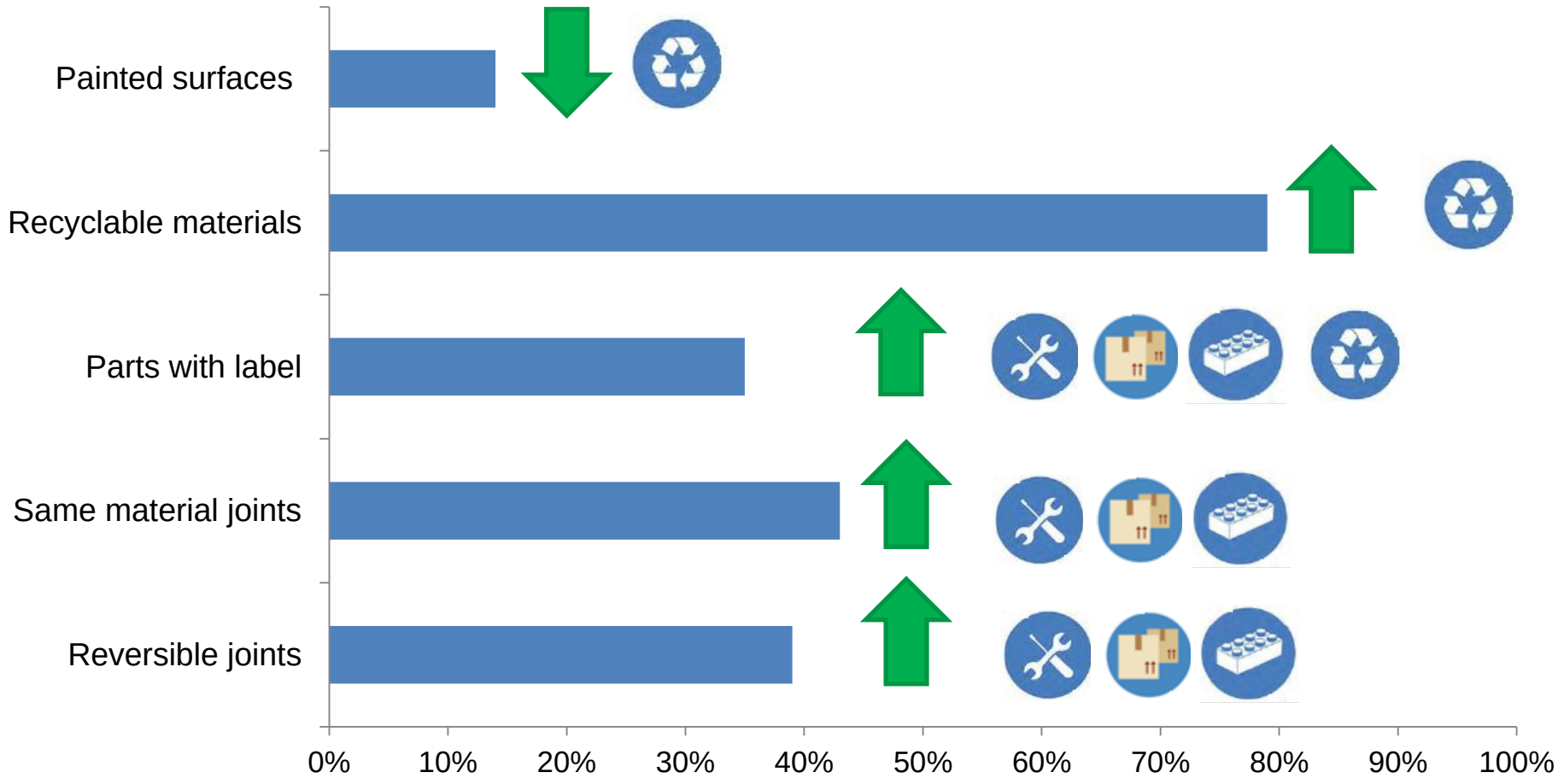
| Product disassembly characterisation | Outcomes |
|---|---|
| Total number of pieces | 150 |
| Pieces theoretically not required | 41 |
| Number of task repetitions | 313 |
| Number of tool manipulations | 116 |
| Number of non-value-added tasks | 104 |

# Materials in a vacuum cleaner




Mendoza et al., J. Ind. Ecol. (2017) 526-544.

# Eco-design: Improving circularity



# CE in practice for vacuum cleaners

Miele

Long lasting product (20 years)

dyson

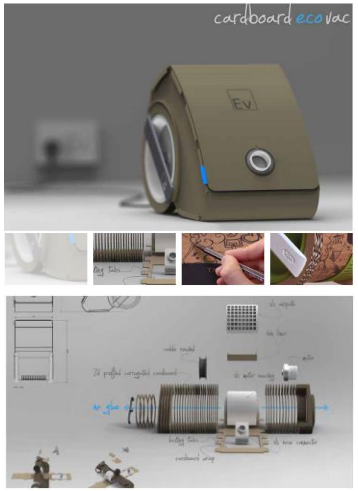

Recyclability
Size reduction


Second-hand products
Take-back systems

Cambridge Consultants


Sustainable materials
Easily replaceable components

vax




Recycled content
Low-impact materials
Easy disassembly

Electrolux


Plastics from the sea
High recyclability
Availability of spares
Reverse supply chain

# Circular economy concept

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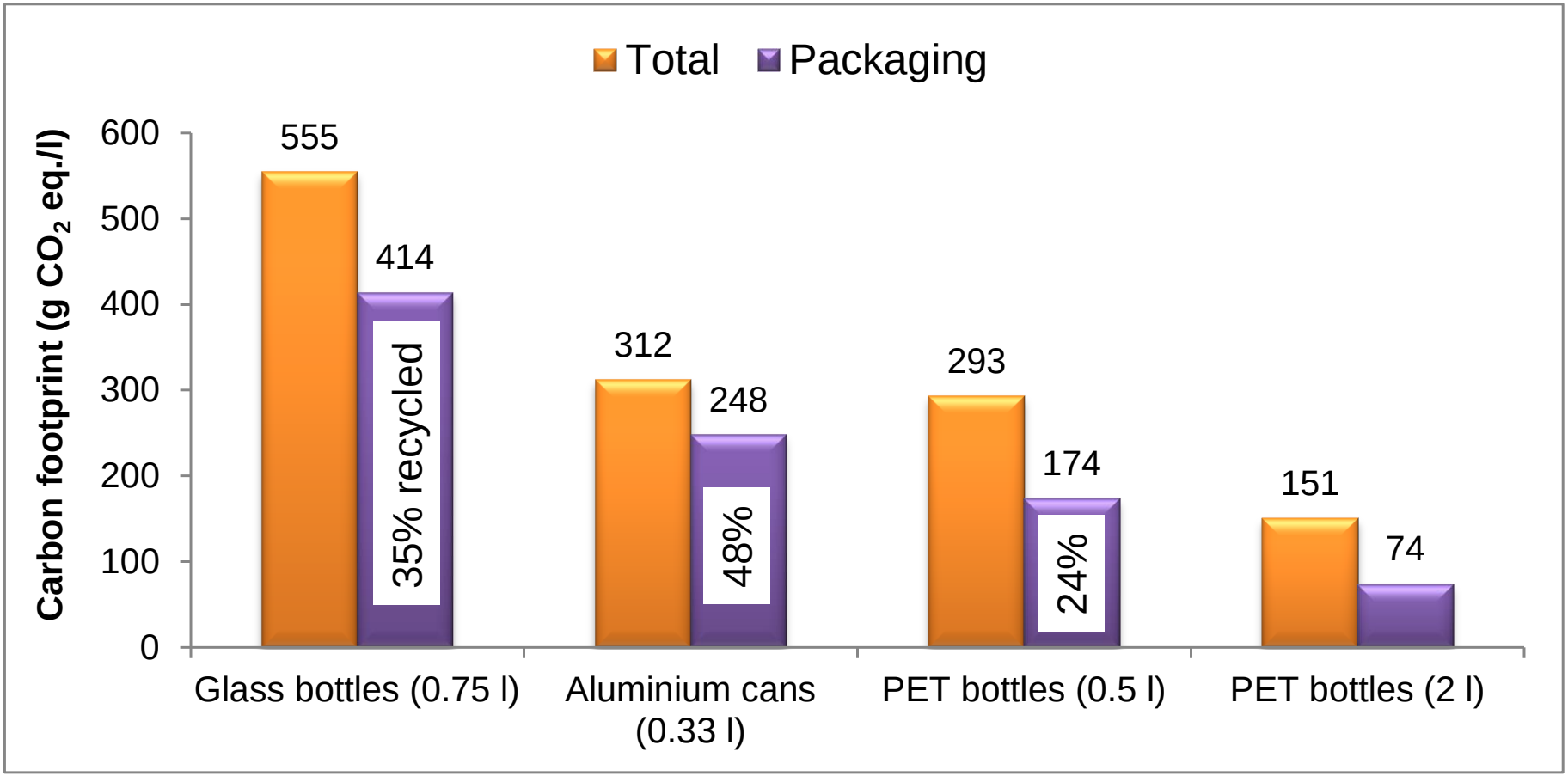
# Reuse or recycle?

## Fizzy drinks packaging

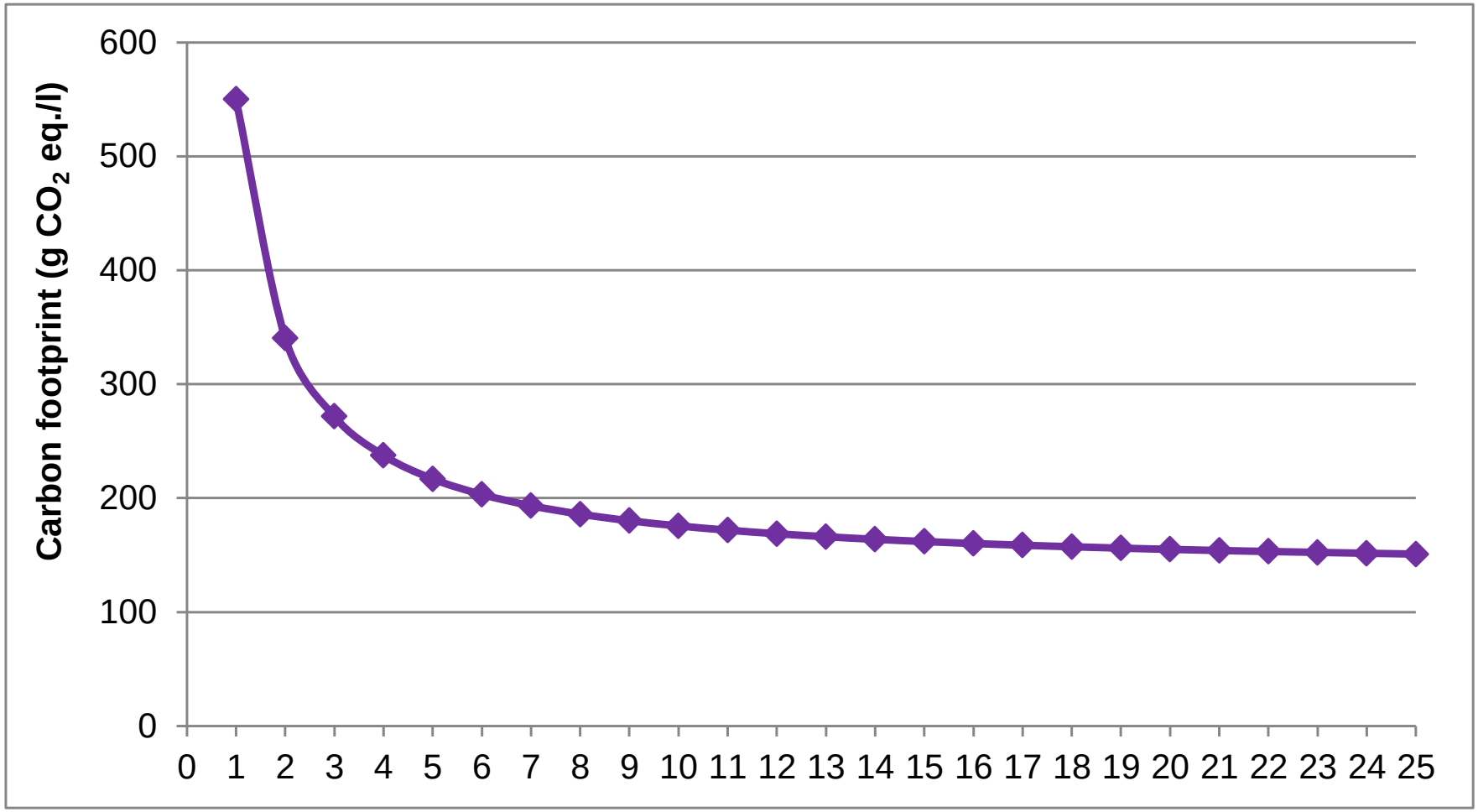

1.5 Mt $CO_2$ eq./yr emitted from the UK fizzy drinks sector

13% of the GHG emissions from the whole F&D sector

# Carbon footprint of fizzy drinks

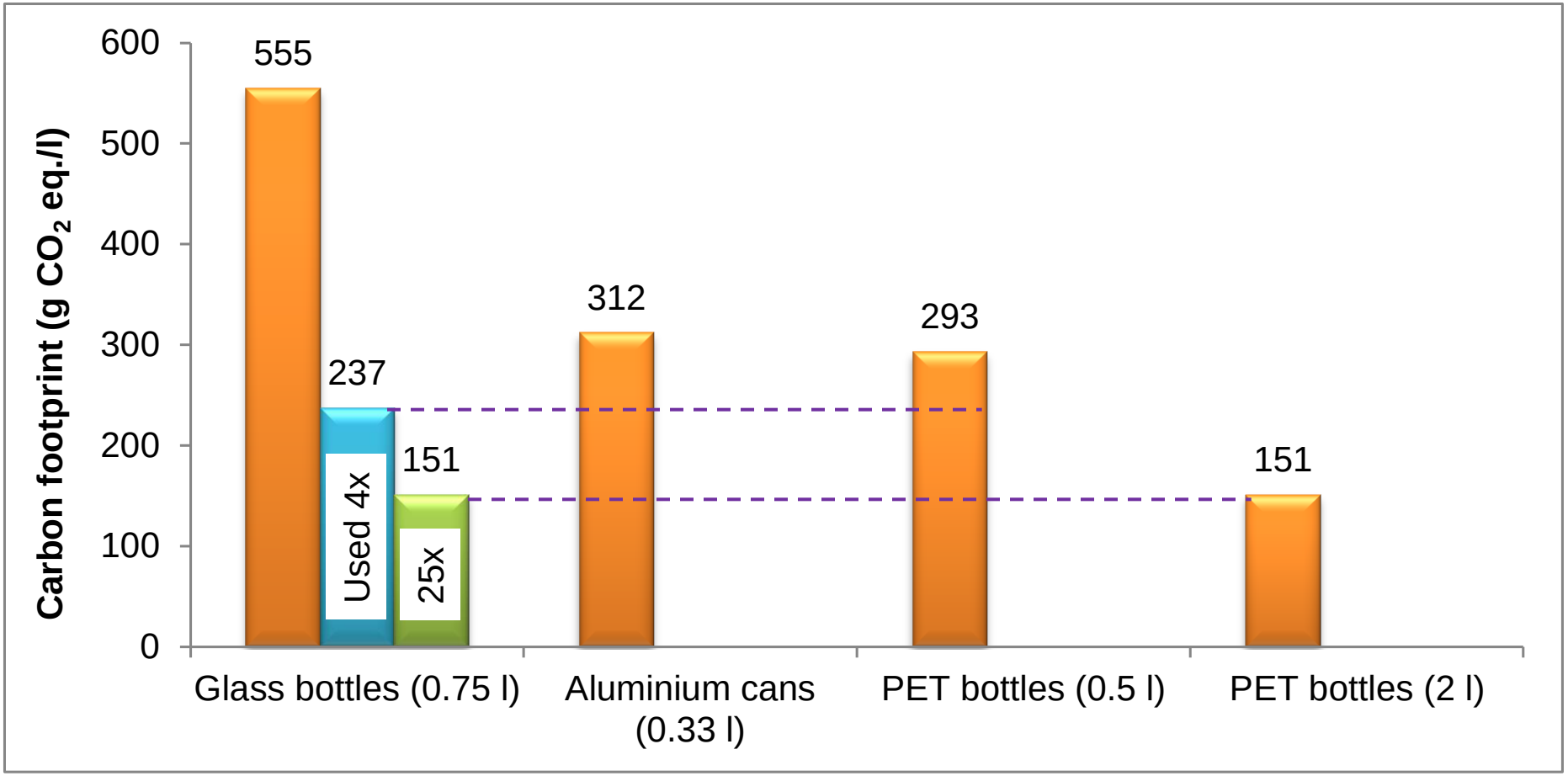


# Reusing glass bottles

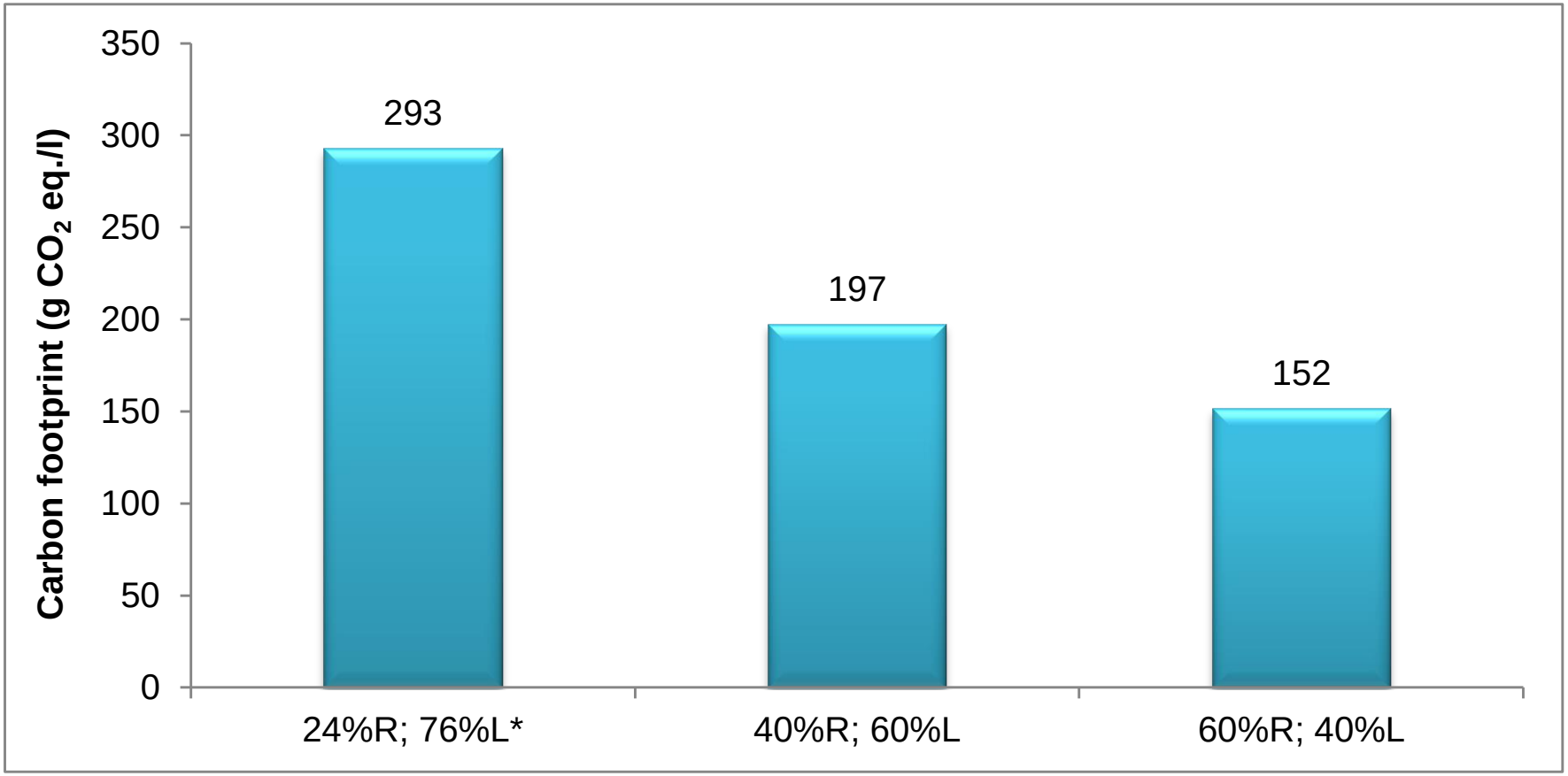



Amienyo and Azapagic, Int. J. LCA (2013) 18 77–92

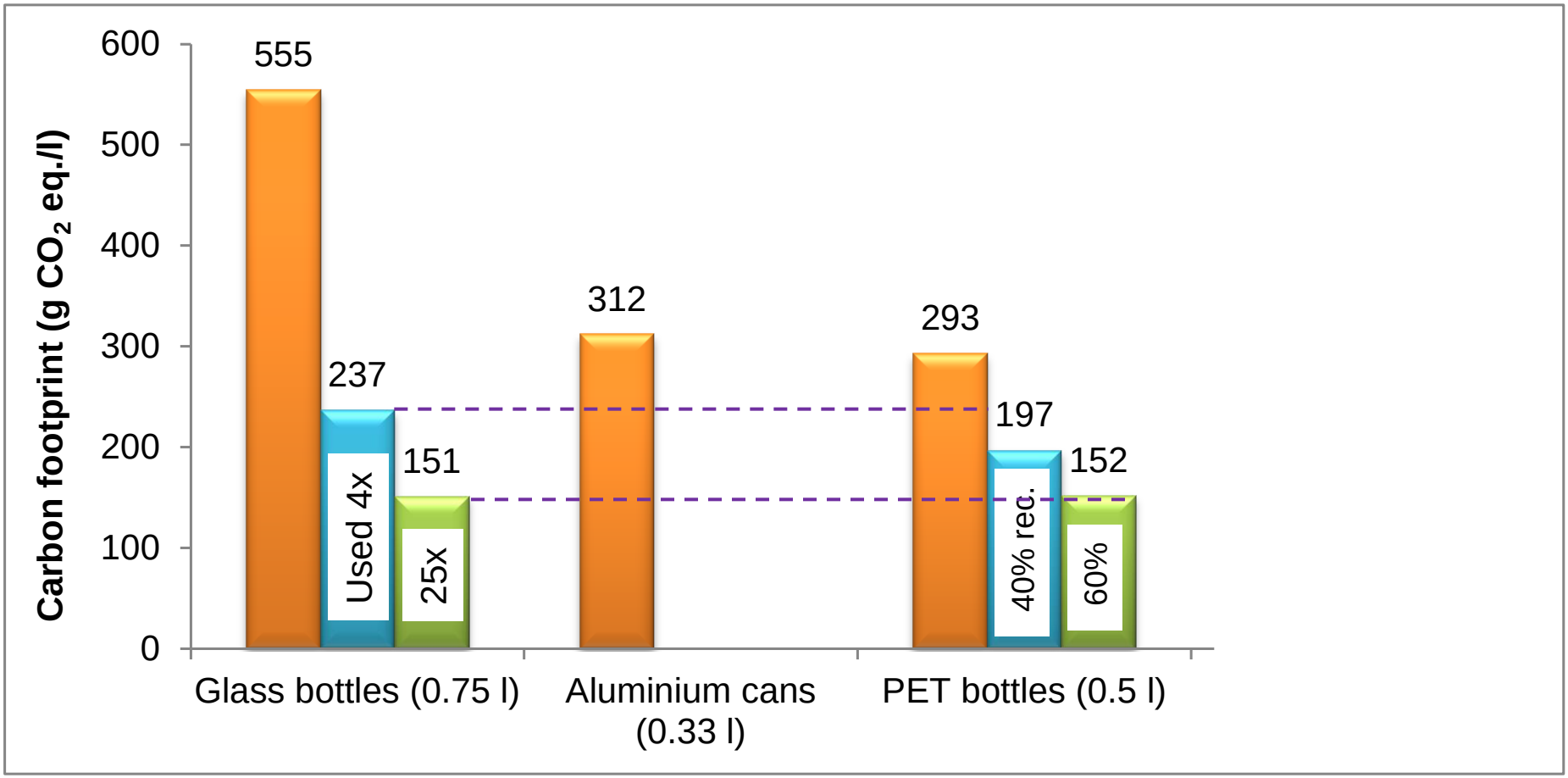
# Reuse or recycle?



# Recycling PET bottles (0.5 l)



# Reuse or recycle?



# Summary

- It pays to reuse glass bottles
- Benefits ‘fizzle out’ beyond 3-4 times
- Reusing glass 7 times comparable to recycling 40% of plastic bottles
- Larger plastic packaging still better than glass used 25 times

# Single-use plastics:

# To ban or not to ban?

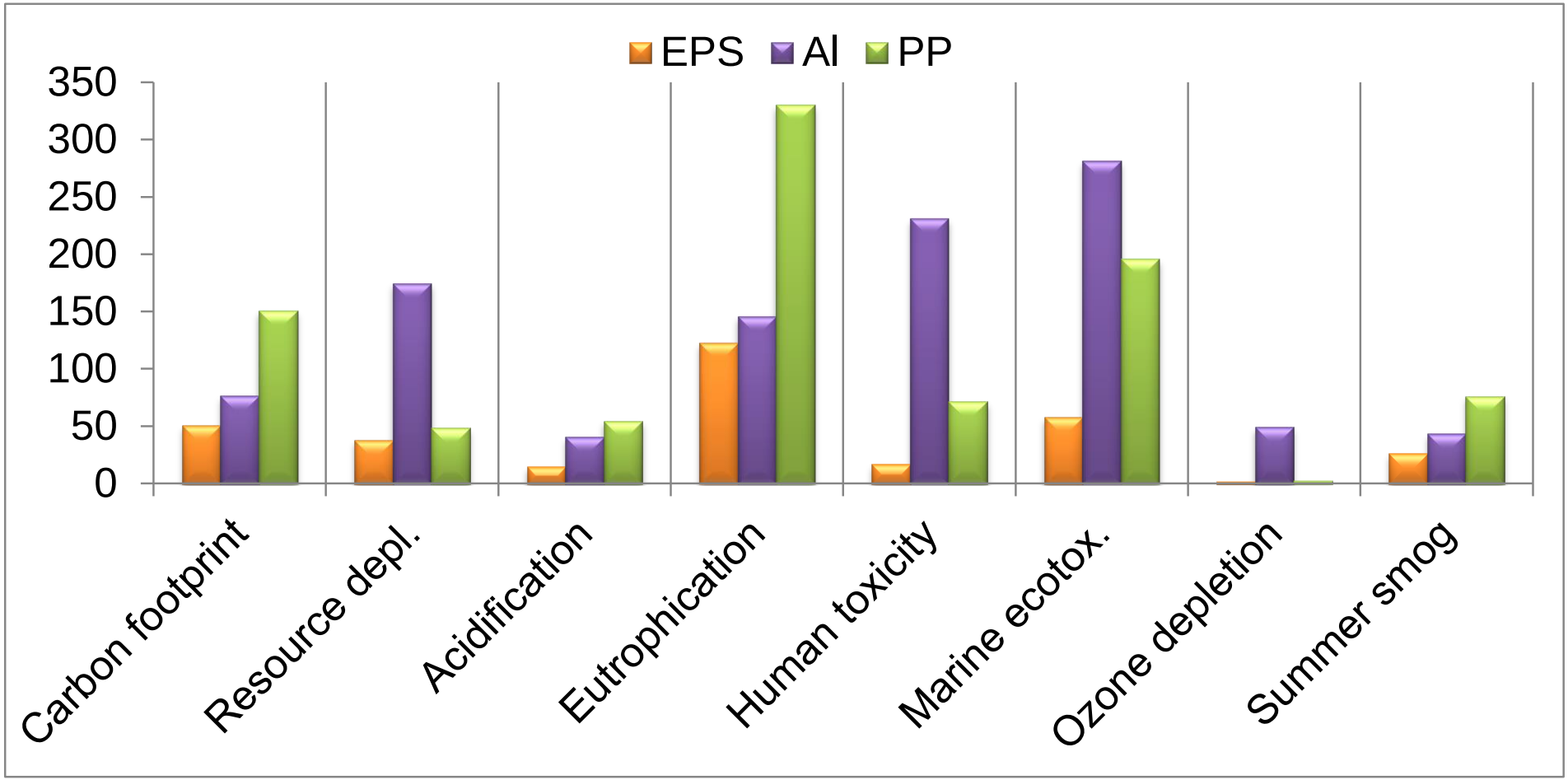
# Food containers: Single-use vs reusable

500-850 million units/yr used and disposed in the EU

# End-of-life management (EU28)

- Polypropylene
  - 11% recycled, 44% incinerated and 45% landfilled
- Aluminium
  - 54% recycled and 46% landfilled
- Extruded polystyrene
  - 50% landfilled and 50% incinerated

# Life cycle impacts of single-use containers

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# Life cycle impacts of single-use containers

- EPS
  - 7% to 28 times lower impacts than aluminium
  - 25% to six times lower than polypropylene

- Less EPS needed than PP and less energy used than for aluminium

# Single-use vs reusable container

**Number of uses of reusable PP containers needed to equal the impacts of single-use containers**

| **Impact** |  **vs**  |  **vs**  |
|---|---|---|
| Carbon footprint | 18 | 11 |
| Resource depl. | 208 | 3 |
| Acidification | 29 | 8 |
| Eutrophication | 18 | 14 |
| Human toxicity | 37 | 2 |
| Marine ecotox. | 24 | 4 |
| Ozone depletion | 27 | 1 |
| Summer smog | 16 | 9 |

# Summary

- Single-use, non-recyclable EPS has the lowest life cycle environmental impacts
- Single-use polypropylene container is the worst option for most impacts
- Reusable PP container needs to be reused 16-208 times to match the single-use EPS container
- Recycling of EPS is technically possible but costly
- In this case, “circular” does not translate into “sustainable”

# Conclusions

- Most supply chains are not designed for a circular economy
- We still need to understand better when “circular” is “sustainable”
- The systems and life cycle approaches are essential
- Implementation of CE will be challenging but is achievable
  - Drivers are increasing
  - Methods and evaluation tools are available
  - Technologies are developing (slowly)
- More success stories are needed to stimulate the uptake
- Legislation will need to get tougher

# Acknowledgements


- Alejandro Gallego Schmid
- David Amienyo
- Harish Jeswani
- Joan Fernandez Mendoza
- Peter Slorach
- Rosa Cuéllar-Franca

- EPSRC

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