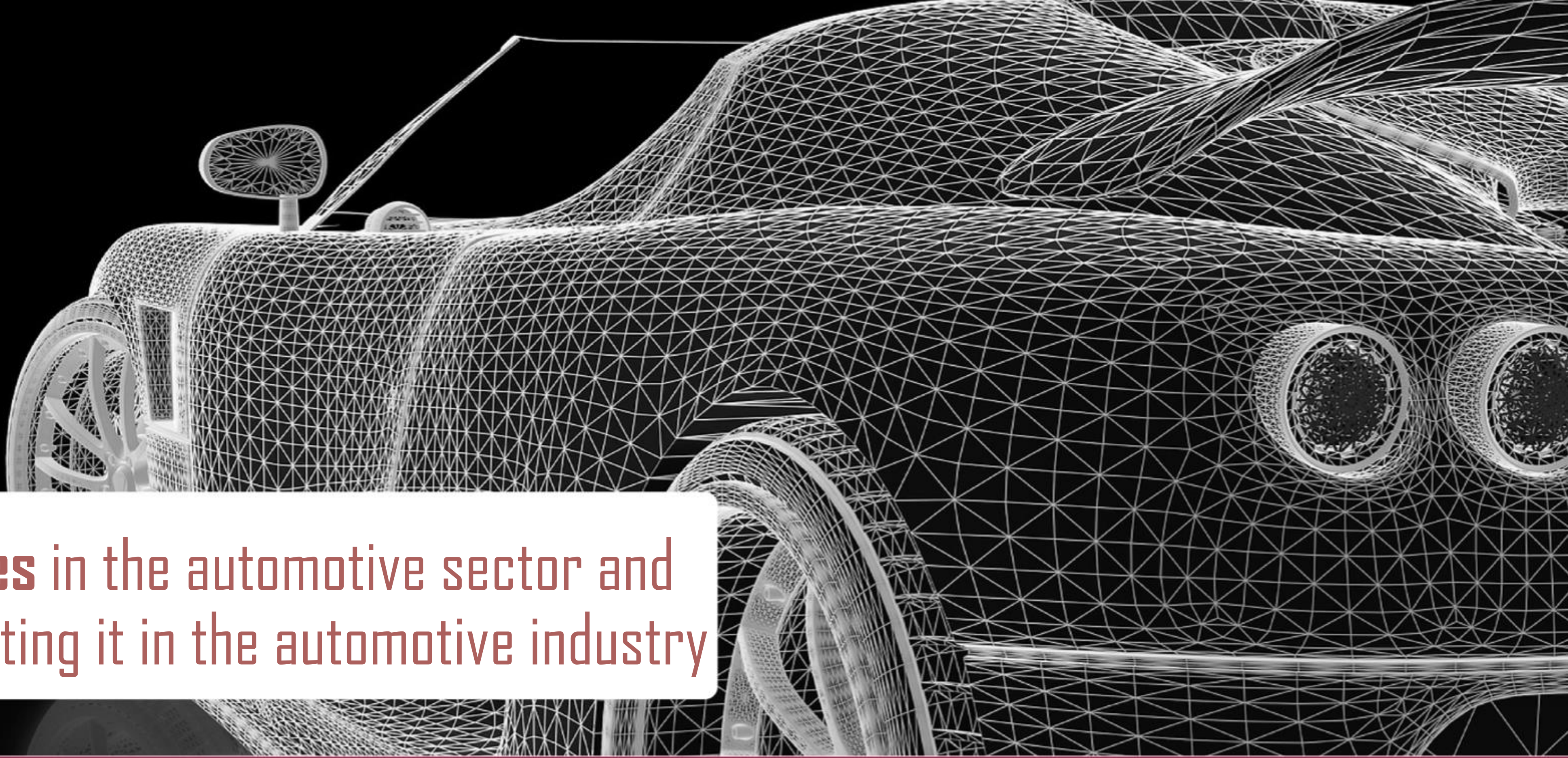


Circularity **challenges** in the automotive sector and **strategies** for integrating it in the automotive industry

Life Cycle Assessment (LCA) and its application to the automotive sector

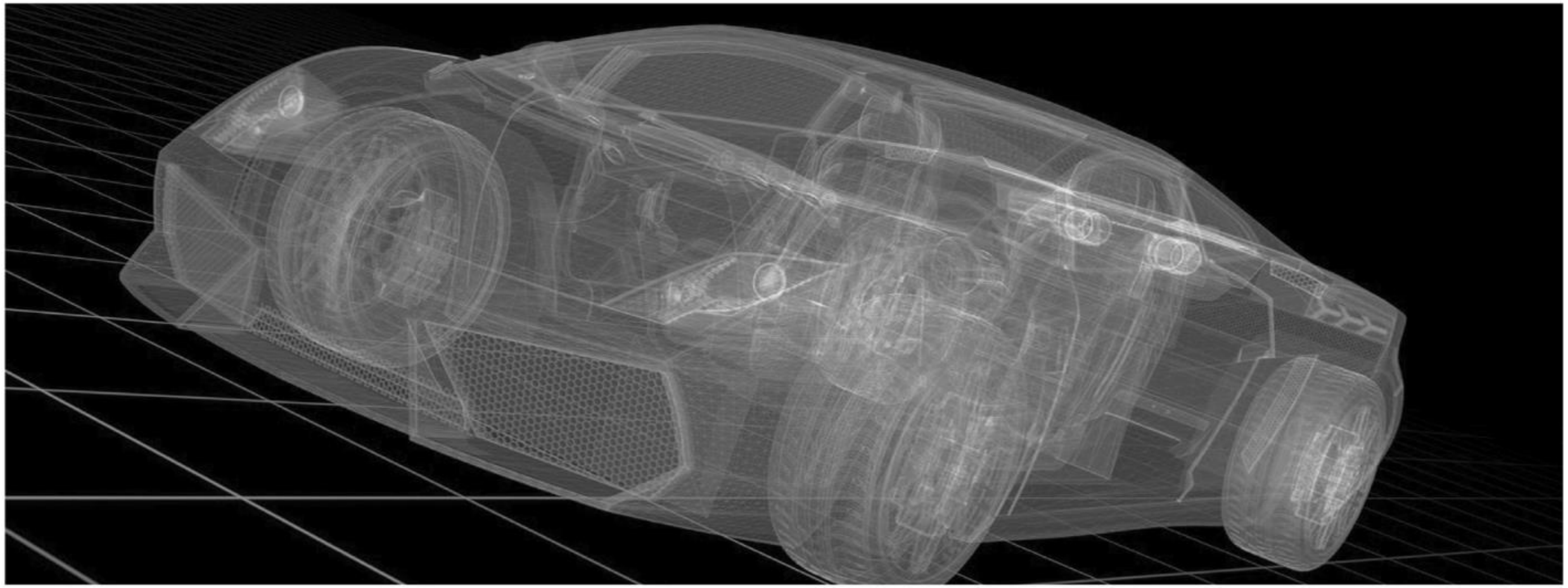
Dr. T.N. (Tom) Ligthart, TNO & Ximena Franco-Villegas – Global Factor.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grand agreement number 101007011

Contents

- Contextual Framework:
  - Circular Economy and Net-Zero
  - Main trends
  - General challenges in the automotive industry
  - Main strategies for the automotive industry
- Circularity in the Automotive industry: Facts and Figures, MCI.
- Take away messages

Contextual Framework



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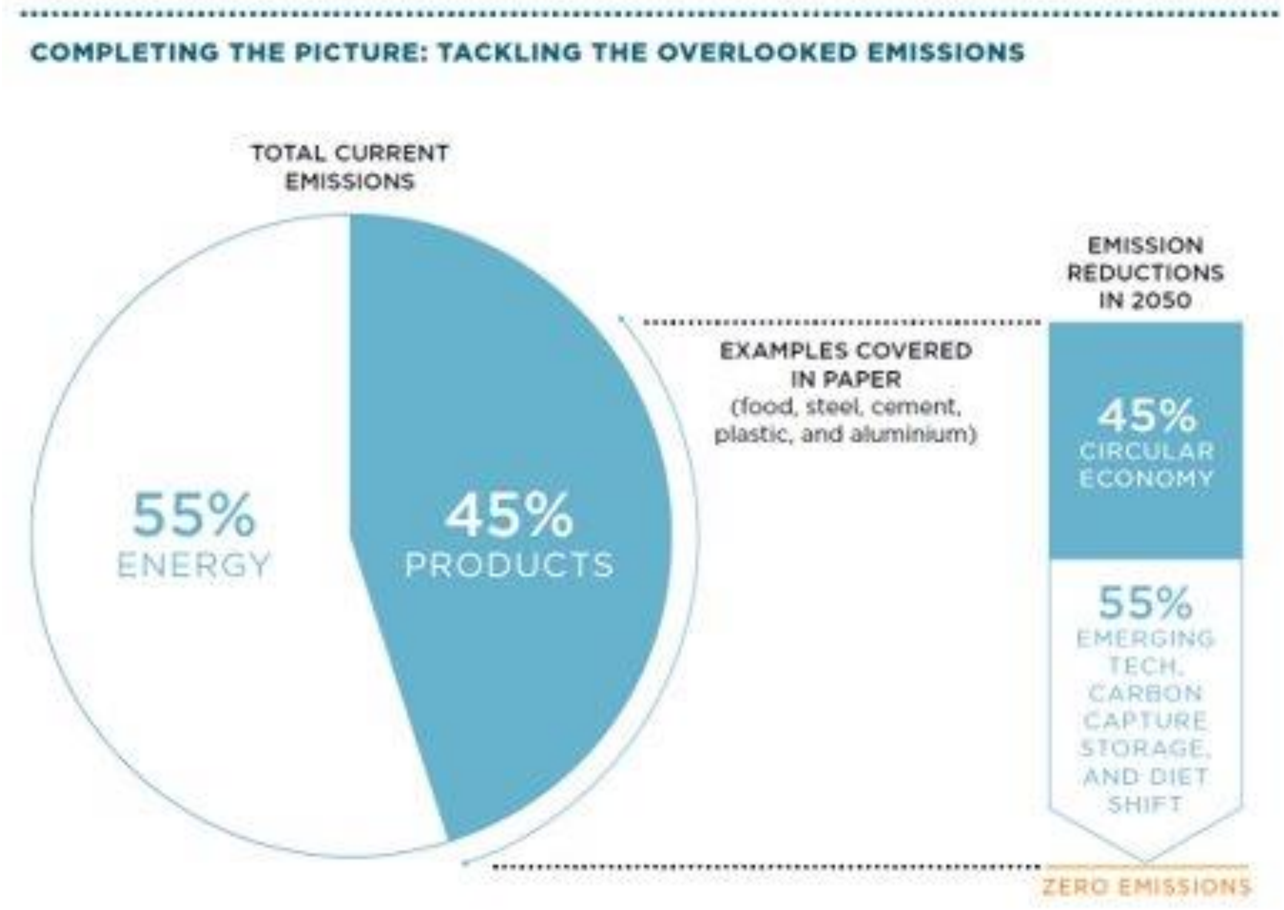
Circularity challenges in the automotive sector and strategies for integrating it in the automotive industry

Efforts to combat climate change have focused primarily on addressing 55% of global GHG emissions through:

- Transitioning to renewable energy
- Energy efficiency measures

Measures 45% remaining

Important to meet Net-Zero emissions by 2050 .



Ellen MacArthur Foundation + Material Economics: Completing the Picture: How the Circular Economy Tackles Climate Change (2019)

Main **trends** of the automotive sector - 2022

More than 50% of vehicles on the market by 2030 will have some form of electrification

- Electrification
- Autonomy
- Connectivity
- Mobility services

Significant increase in the semiconductor content of manufactured vehicles

The automotive semiconductor market (and its consequent use of materials) will quadruple over the next twenty years

Sources: KPMG, 2022 *(Vulnerable supply – Automotive industry insights).*

Main **Current challenges** of the automotive sector

- High dependence on the supply chain
  - e.g. microchip shortage
- Material shortages and Geopolitical uncertainty
  - High dependence of the automotive industry on raw materials from countries currently in conflict (Russia and Ukraine)
- Global health risks (pandemics)
- Increasing stringent environmental regulations with decarbonisation targets
- Scarcity in the labor market

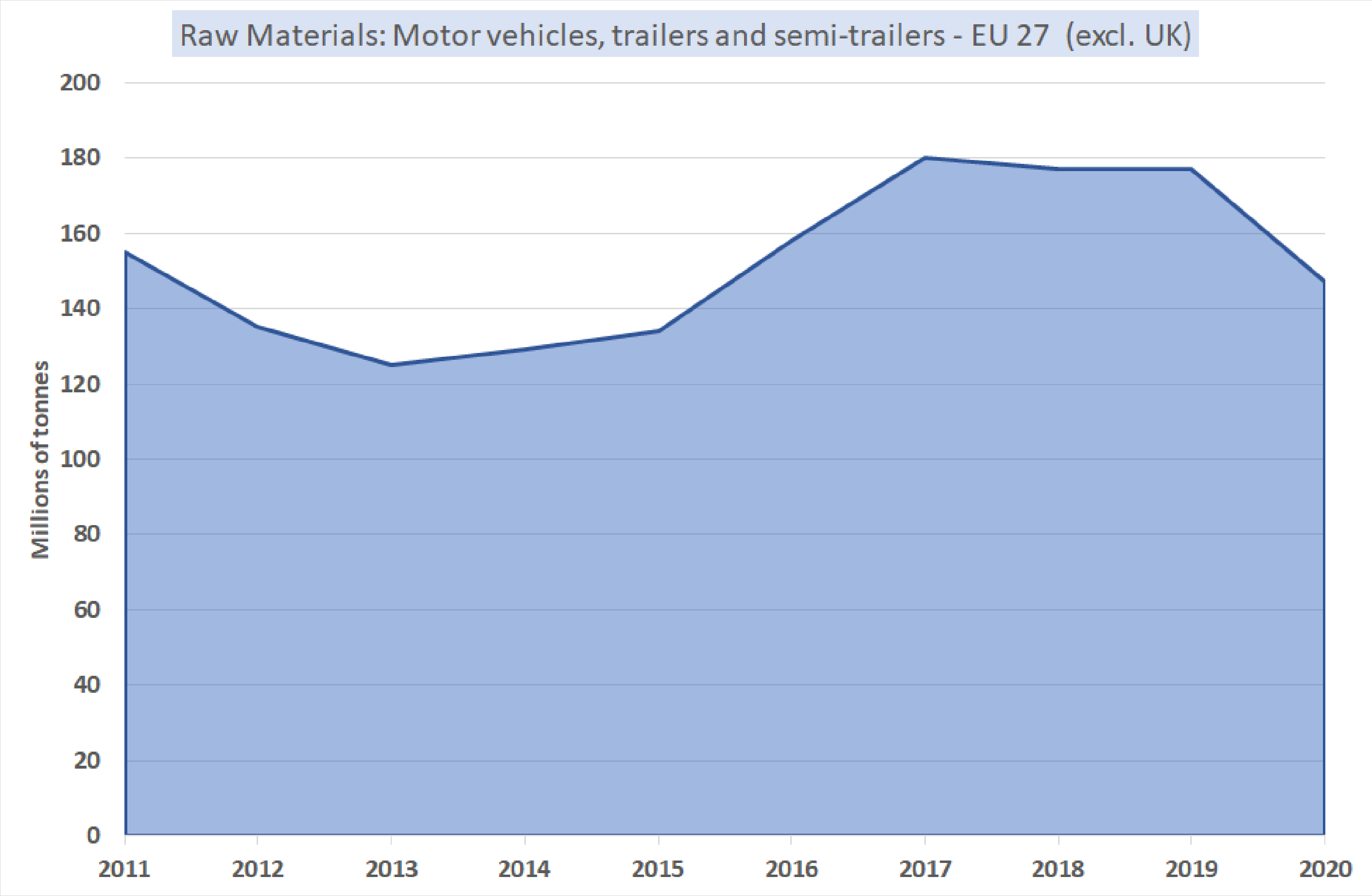
High vulnerability of the global automotive supply chain

Sources: Own elaboration and KPMG, 2022 *(Vulnerable supply – Automotive industry insights).*

Strategies for integrating **circularity** in the automotive industry

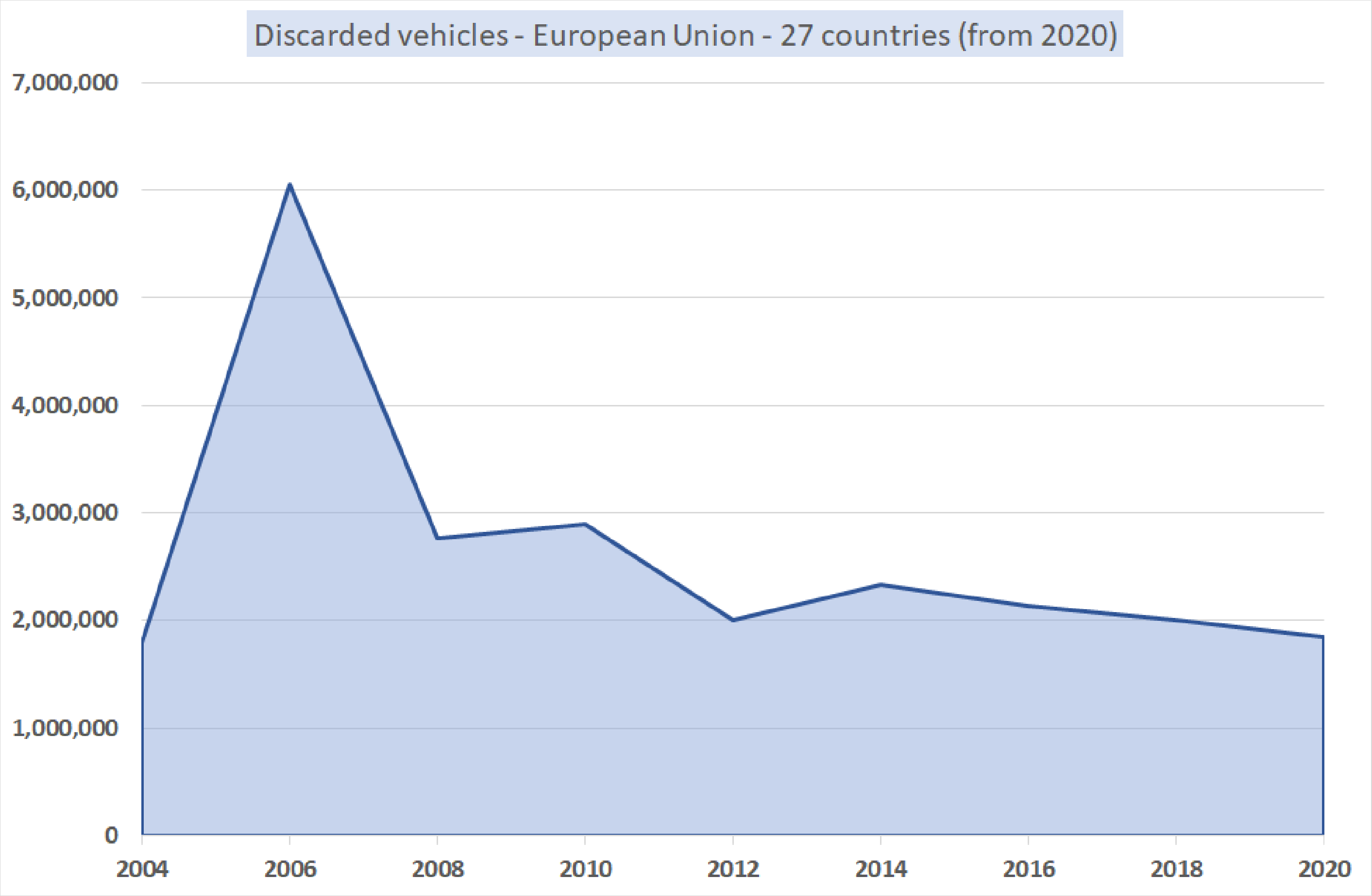
1. New models of collaboration between value chain players: between the automotive, semiconductor and computer industries.
2. Regionalizing and optimising the supply chain
3. Ensuring supply chain diversity:
   - review and reconfigure the relationship with suppliers, especially when it comes to critical raw materials
   - rethink a company's purchasing and sourcing strategy
4. Complying with regulations and ensuring transparency
   - To meet decarbonization targets, CE must be incorporated throughout the supply chain to ensure the availability of materials through the "Rs“ implementation.

Raw material consumption in the automotive sector (EU27)



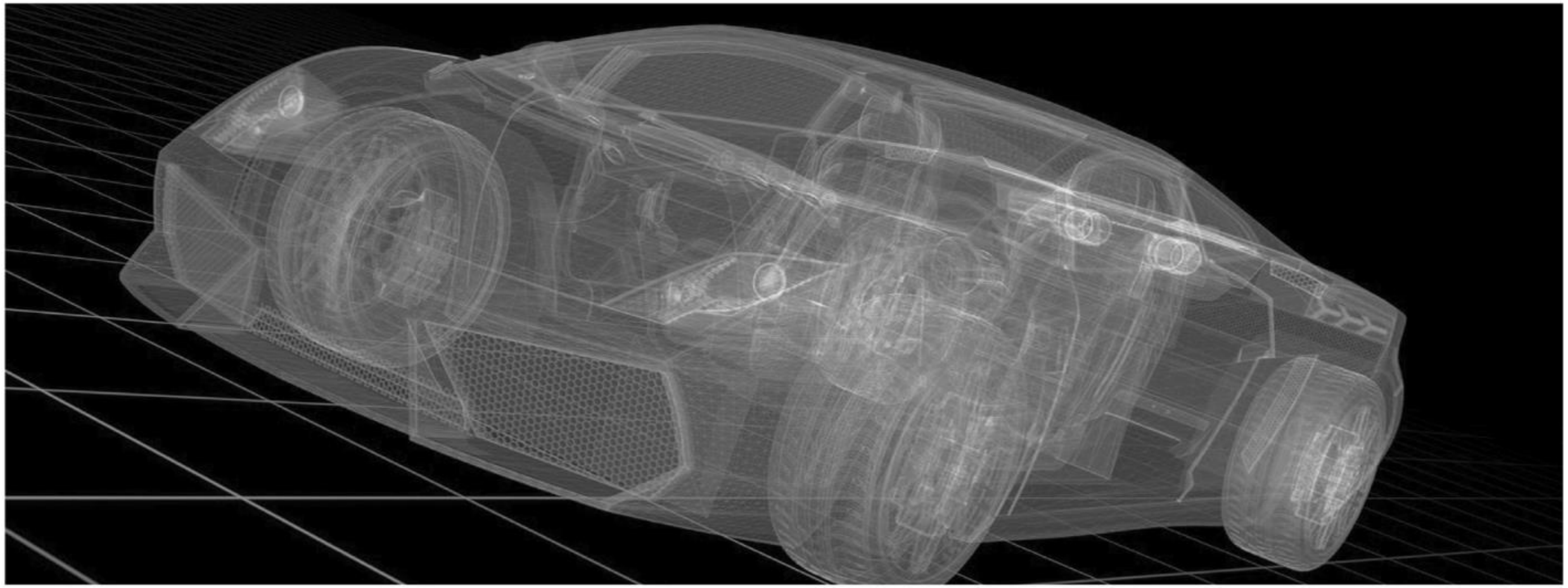
Source: Eurostat

Millions of vehicles are discarded each year in the EU – a potential leak



Source: Eurostat

Circularity in the Automotive industry: Facts and Figures, MCI.



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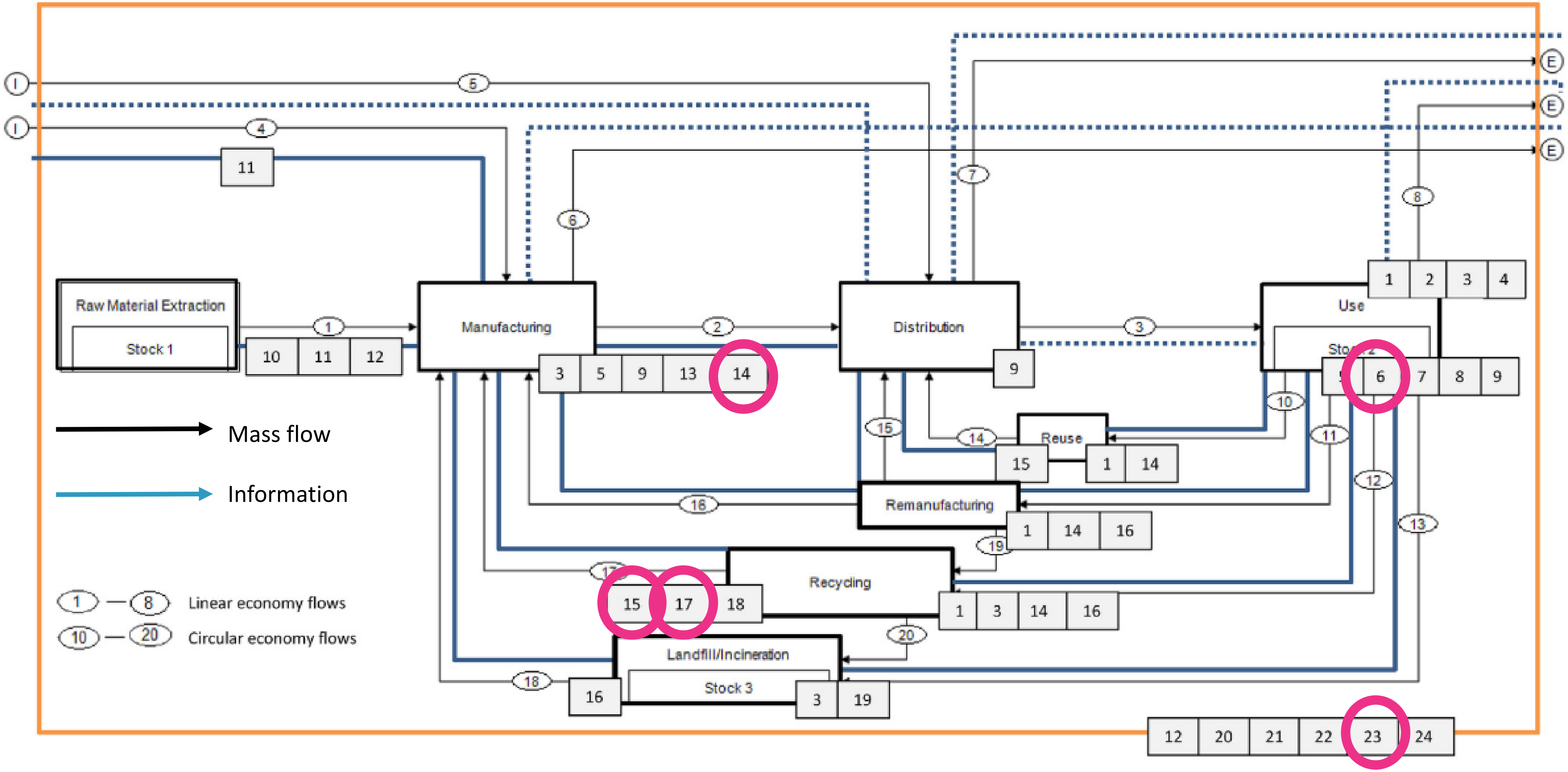
Elements of the Circular Economy

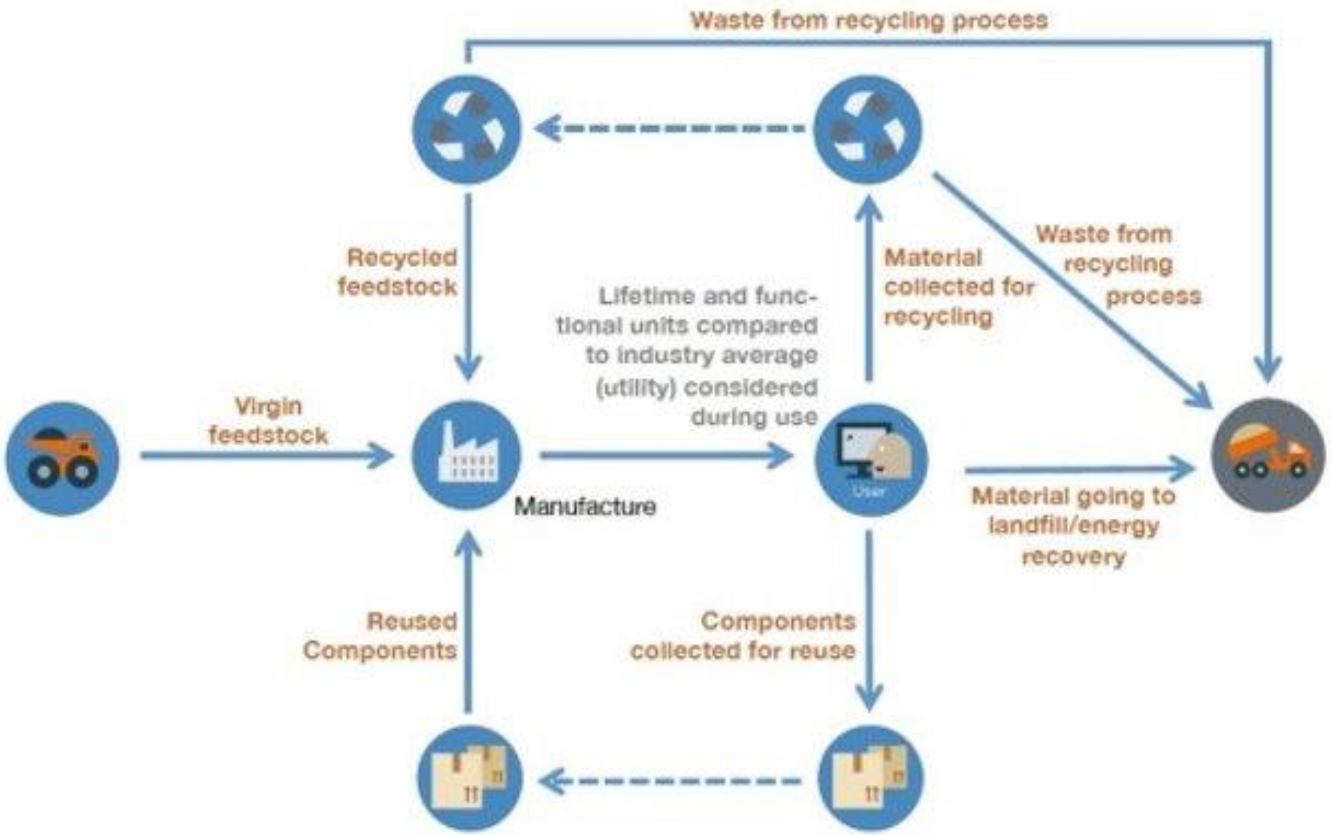
- **Multitude of CE metrics available**
- i) resource efficiency cluster of indicators
- ii) materials stocks and flows cluste r
- iii) product-centric cluster
- 6 Potential for recycling – remanufacturing
- 14 Input of secondary materials
- 15 Reuse, remanufacturing, ease of recycling, 17 recycling efficiency
- 23 System stability



A. Parchomenko et al. / Journal of Cleaner Production 210 (2019) 200e216

BEVSIM & Circularity: the Material Circularity Indicator (MCI)

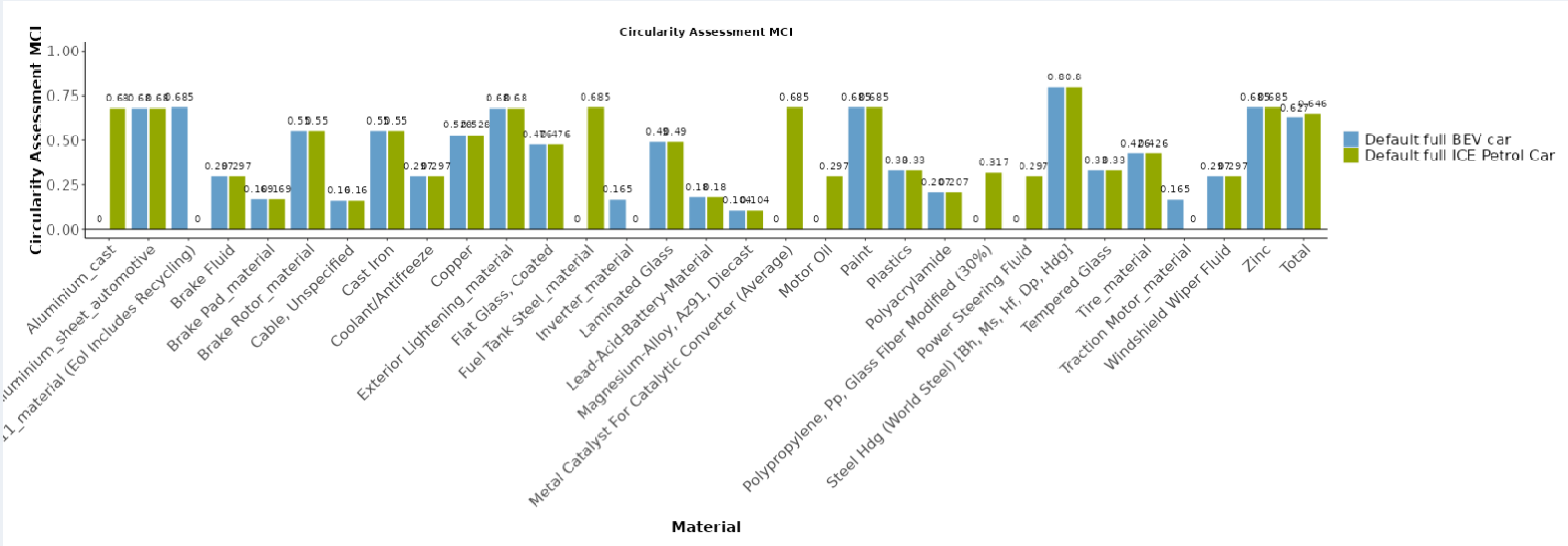
- The Material Circularity Indicator (MCI) was developed by The Ellen MacArthur Foundation and Granta Design. The MCI measures the circularity, from 0 to 1, of material flows for selected products.
- The MCI considers the amount of virgin feedstock, recycling efficiency and unrecoverable waste, while considering the time and intensity of product use.



Source: BEVSIM

MCI for BEV and ICE vehicle

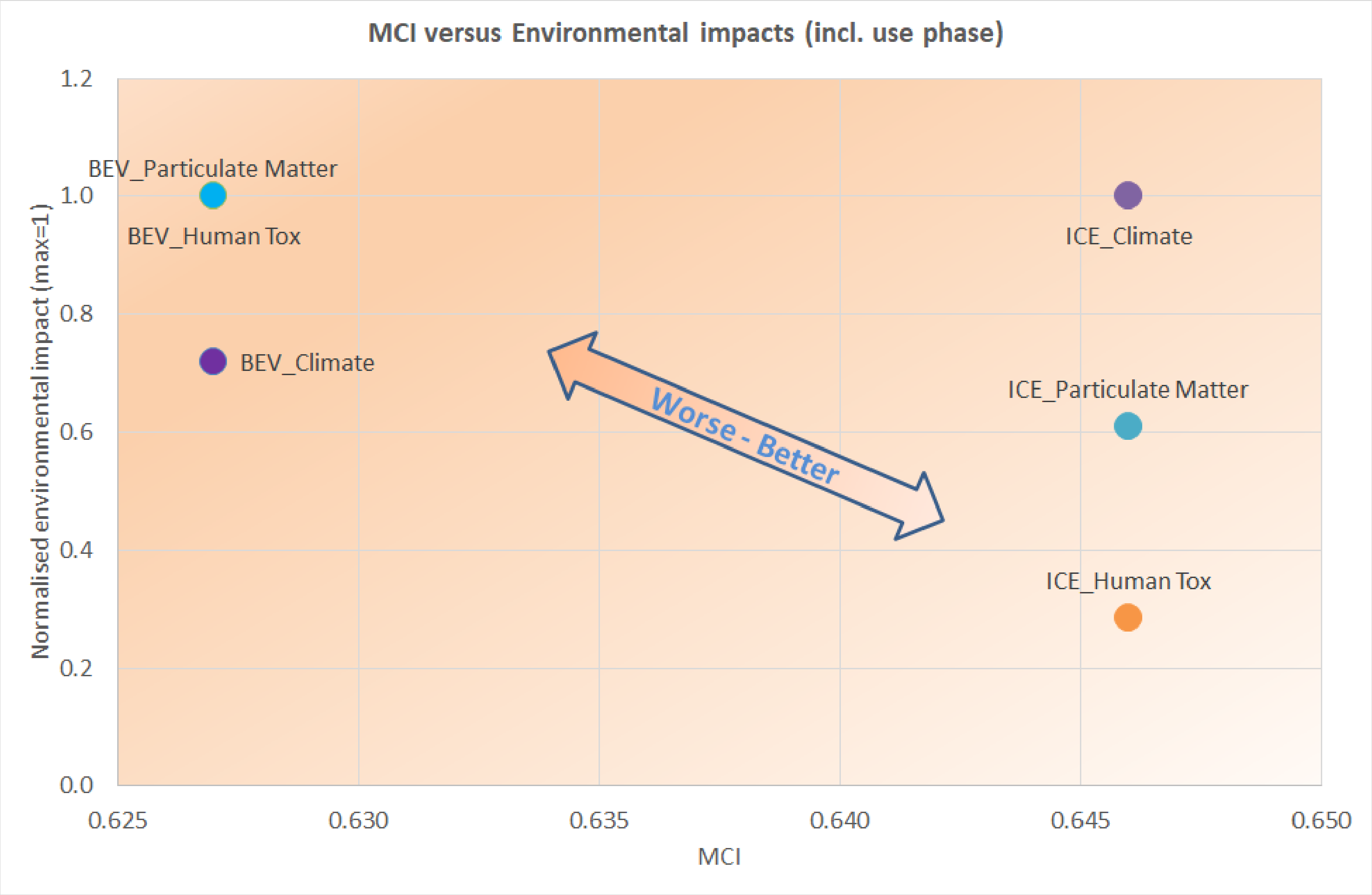
- The vehicle with petrol engine and BEV do not really differ in circularity. High metal recycling efficiency is a cause



Source: BEVSIM

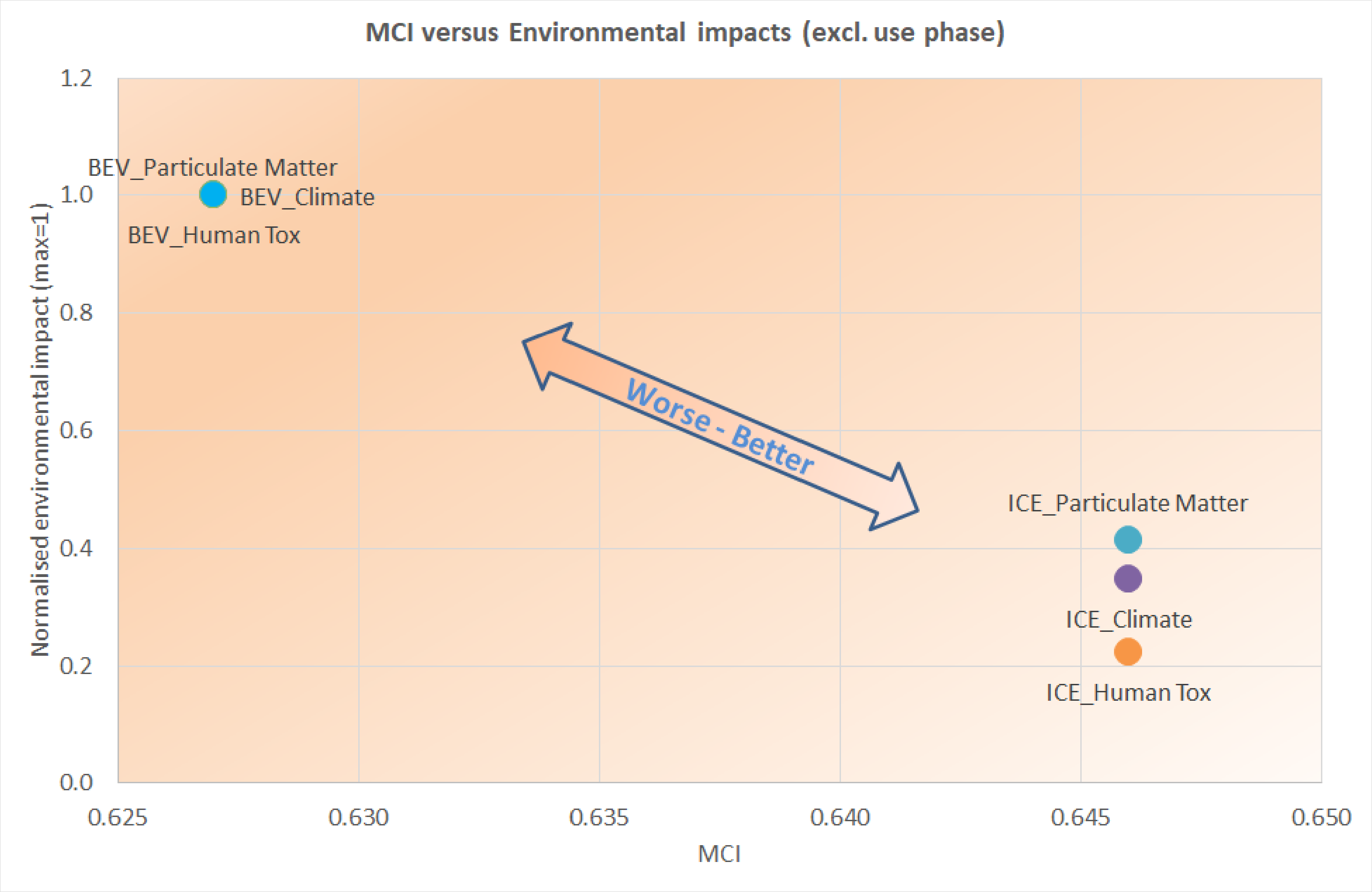
Trade-offs MCI versus environmental impacts

- MCI and LCA from cradle to grave (incl. use phase)
- MCI of BEV (0.627) and ICE (0.646) not significantly different
- Climate change ICE (lower score) is better as BEV uses grey electricity
- On the contrary BEV has better performance on Human toxicity and Particulate Matter Formation
- EXPLAIN



Source: BEVSIM

- MCI and LCA from cradle to grave (**excl. use phase**)
- MCI of BEV and ICE not significantly different
- ICE has better performance on all three impacts
- EXPLAIN



- The CFF tries to accommodate both by covering the recycled content at the input side and recyclability at EoL
- The CFF considers the change in material quality (Q primary, Q secondary in, Q secondary out) between cycles
- Both material as sector specific values for A, R1, R2
- Factor A shares the recycling burdens and benefits between the connected life cycles (default 0.2 or 0.5)
- Factor B shares energy recovery burdens and benefits among connected life cycles (default 0)

PEF: THE CIRCULAR FOOTPRINT FORMULA

A Allocation factor of burdens and benefits (jointly: "credits") between supplier and user of recycled materials.

CFF IS A COMBINATION OF "MATERIAL + ENERGY + DISPOSAL"

LCI virgin material and pre-processing

LCI secondary material

LCI material recycling minus credit avoided

Material $$(1-R_1)E_V + R_1 \times \left(AE_{recycled} + (1-A)E_V \times \frac{Q_{Sin}}{Q_p}\right) + (1-A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$$

Energy $$(1-B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$$

Disposal $$(1-R_2-R_3) \times E_D$$

LCI material recycling minus credit avoided

LCI of the disposal of remaining waste

B Allocation factor of energy recovery processes. It applies both to burdens and benefits.

R1 Proportion of material in the input to the production that has been recycled from a previous system.
R2 Proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.
R3 Proportion of the material in the product that is used for energy recovery at EoL.

Take away messages

- The automotive Circular Economy (CE) should pay special attention to critical raw materials (CRM) as semiconductors and battery systems become more and more important;
- CE indicators are still under development and not always include the energy input needed to make systems more circular, CFF does;
- Better circularity is not always better environmental performance, even when focusing on waste treatment technologies;
- Longer service life, design-for-recycling and design-for-remanufacturing/refurbishment will increase circularity.
- The circularity measures should consider regeneration and restoration, making ecosystem services visible for value chains; these services are fundamental to the availability of materials.

THANK YOU!

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