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Modular parametric LCA models for standardized aluminium alloys

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Goal

The aim is to develop a parameterized life cycle assessment model that allows the identification of ecologically relevant parameters for alloy and pre-product production and emphasizes on their influence on the ecological footprint.

Problem definition

Aluminum offers great potential for lightweighting, which can reduce the CO₂ footprint of products during their use phase. There is a growing global demand for primary aluminum alloys and their production is associated with a high global warming potential. For the majority of alloys available on the market, there are insufficient data sets to assess the environmental impact of aluminum alloys and their semi-finished products.

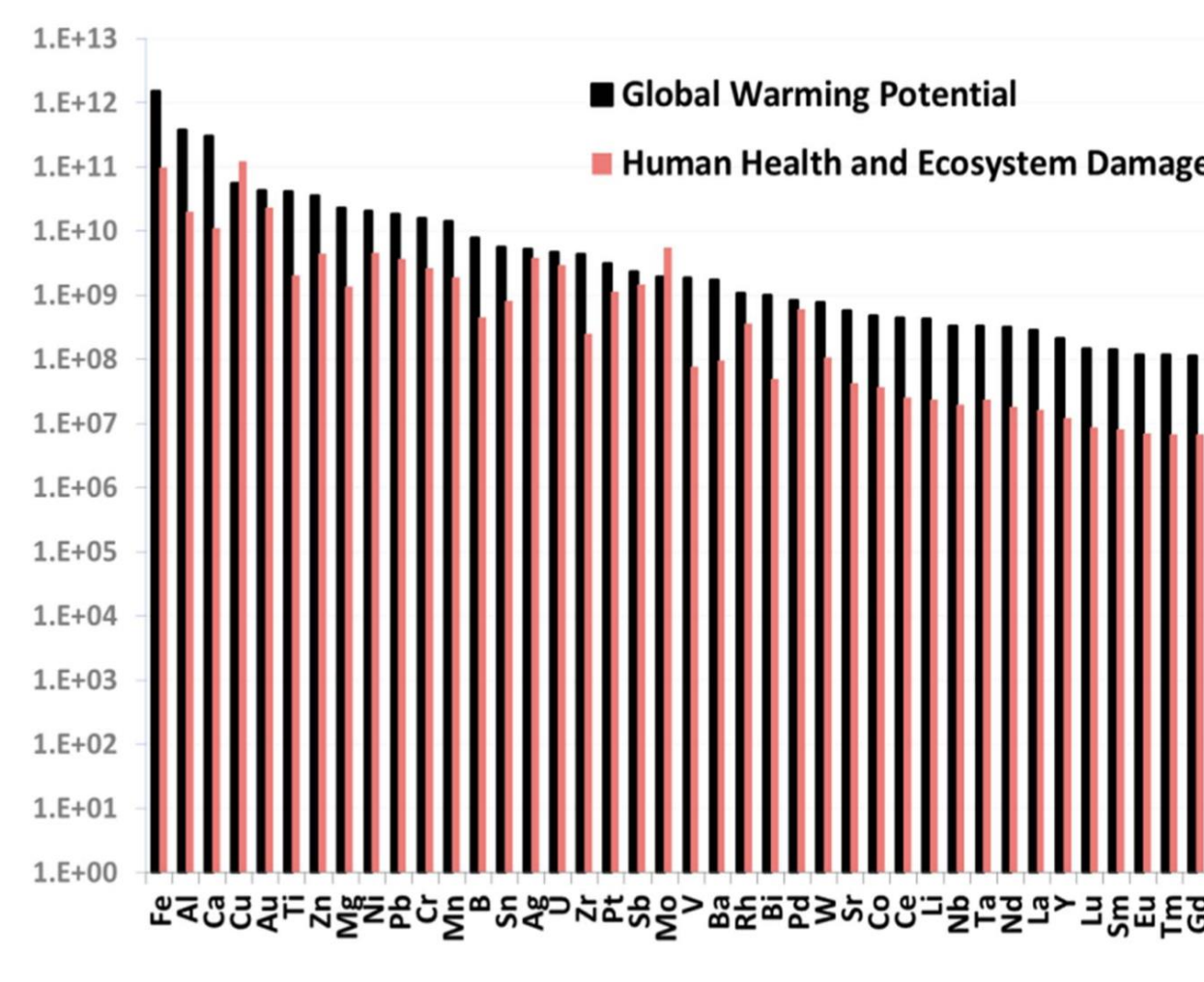


Figure 1: Environmental impacts of different metallic materials [1]

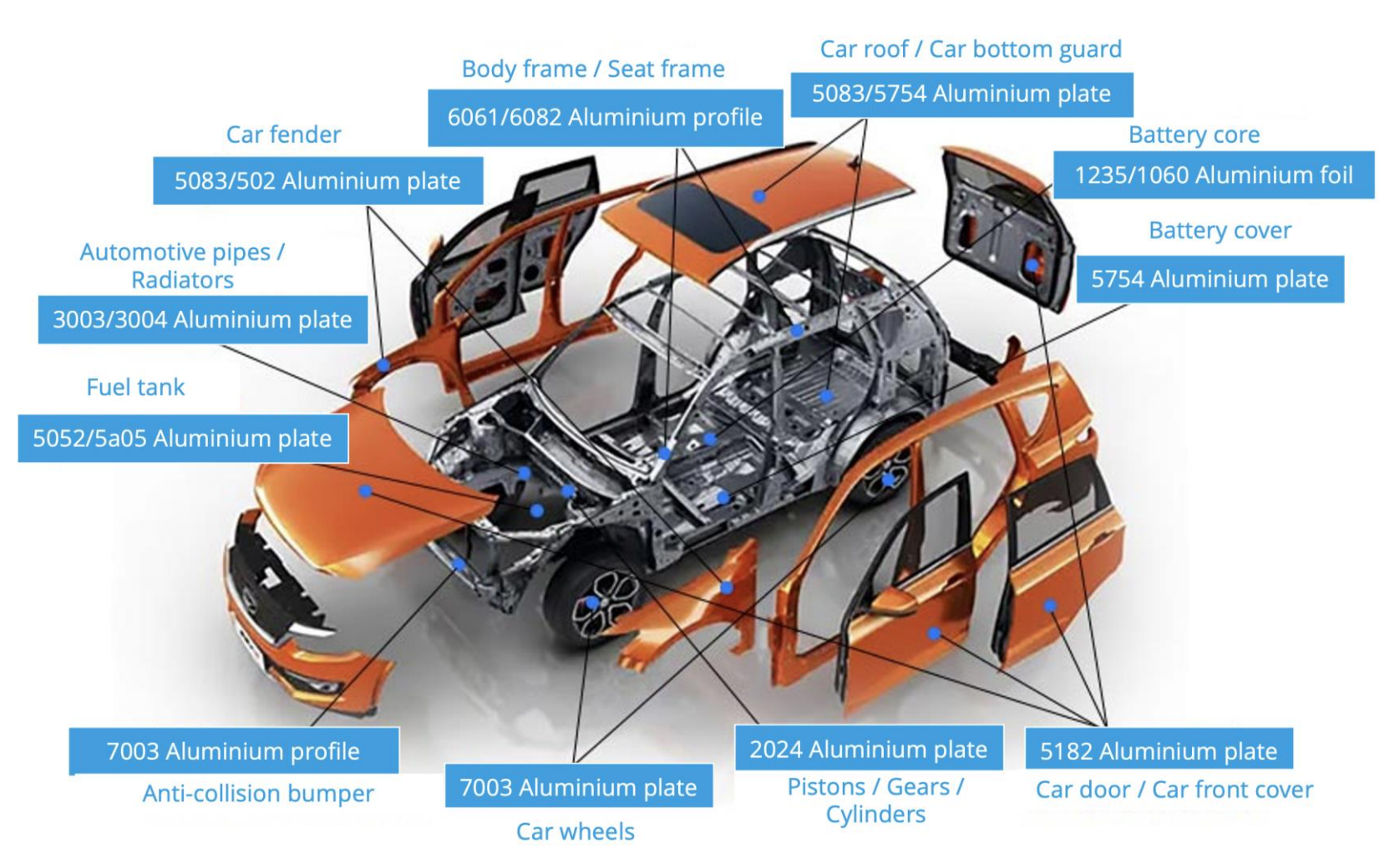


Figure 2: Application of different aluminium alloys in the automobile [2]

Parameterized LCA model

Goal & Scope

- System boundaries:
 - Modelling: Gate-to-gate
 - Accounting: Cradle-to-gate
- Geographical scope: Europe
- Power mix: Hydro power
- Neglection of: Transport routes, auxiliary and operating materials

Reference
Semi-finished aluminium
alloy product : 1kg

Life Cycle Inventory

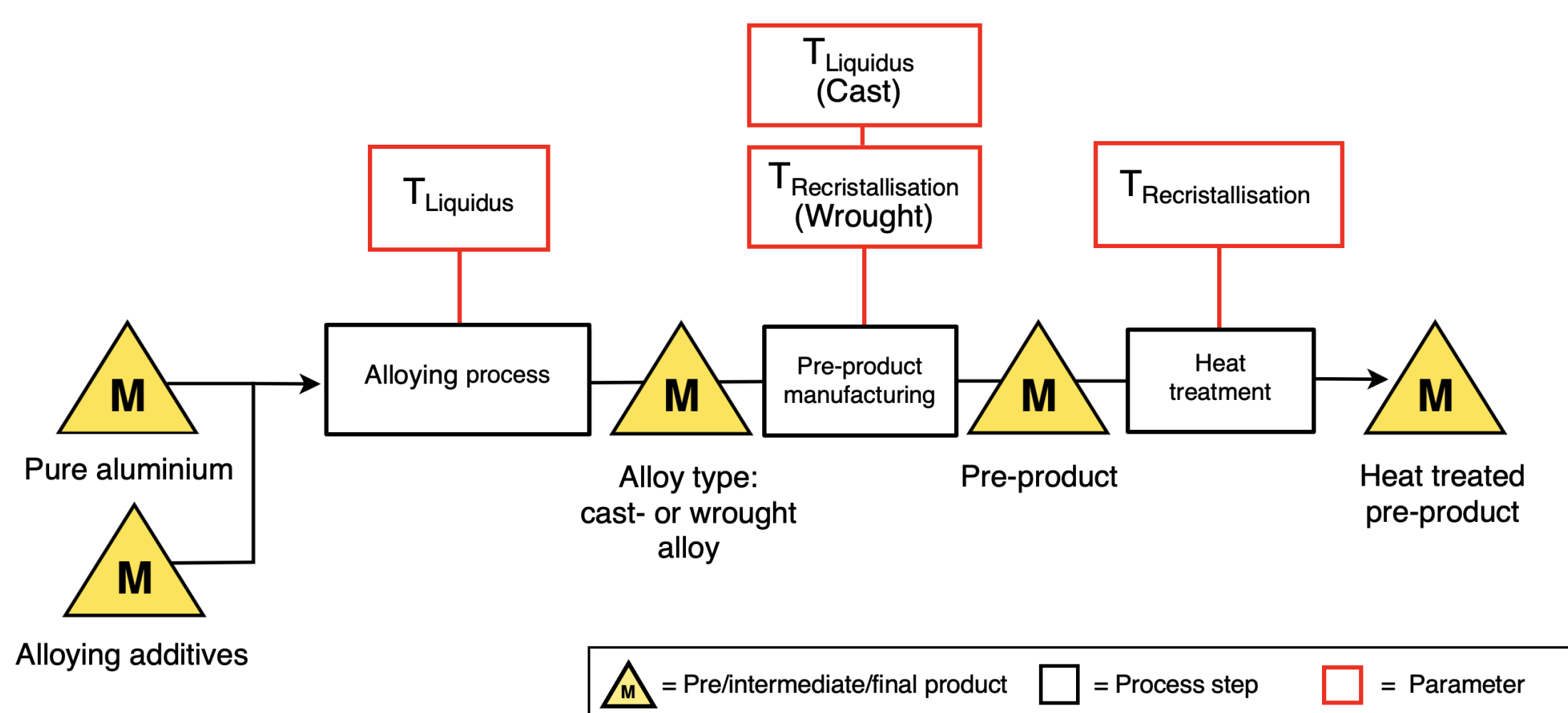


Figure 4: Process chain representation of the manufacturing process of aluminium precursors

- Main energy consumer: Thermal processes (furnaces)
- Type of energy: Electrical energy

Life Cycle Impact Assessment

| Settings | Select |
|---------------------------------|--|
| Impact category | Climate Change |
| Characterisation factor | Global Warming Potential (GWP) |
| Unit | kgCO ₂ eq |
| LCIA Method | Environmental Footprint (Mid-point indicator) |
| Normalization and weighting set | PEF standard weighting and normalization factors |

Table 1: Settings for impact assessment in the openLCA software

Cast Product

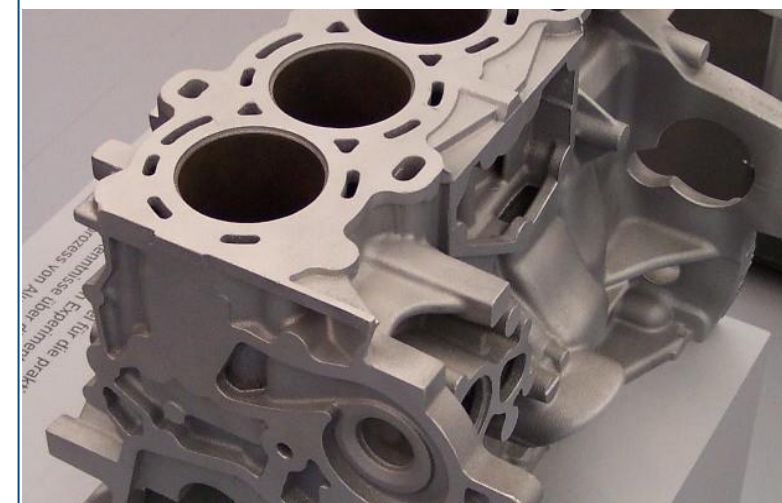
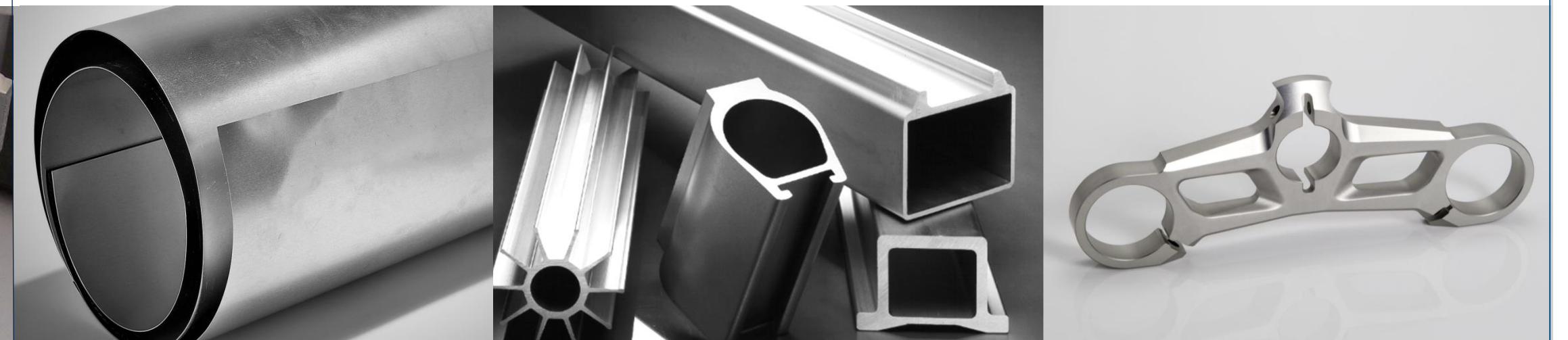


Figure 3: Cast and wrought aluminium products [3,4,5,6]

Wrought Product



Interpretation

Dependence of the global warming potential (GWP) on:

- GWP value of alloying elements (AE): ↑ Magnesium (Mg), ↓ Silicon (Si)
- Thermal characteristic values of AE's ($T_{Liquidus}$, $T_{Recrystallisation}$): ↑ Mg, ↓ Si
- Processing method
- Deformation factor
- Temperature and duration of heat treatment
- Other factors: power mix, secondary material

Results

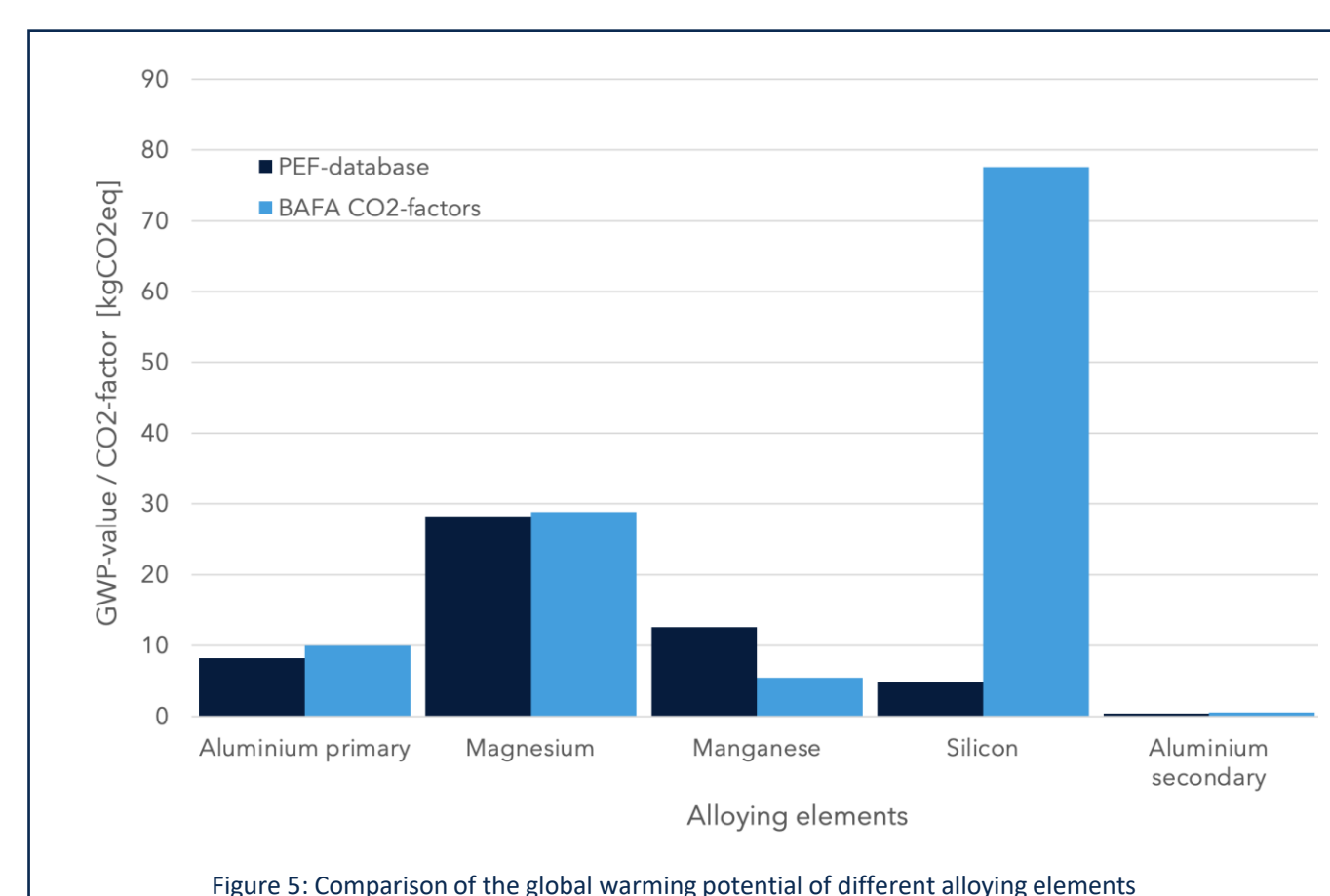


Figure 5: Comparison of the global warming potential of different alloying elements

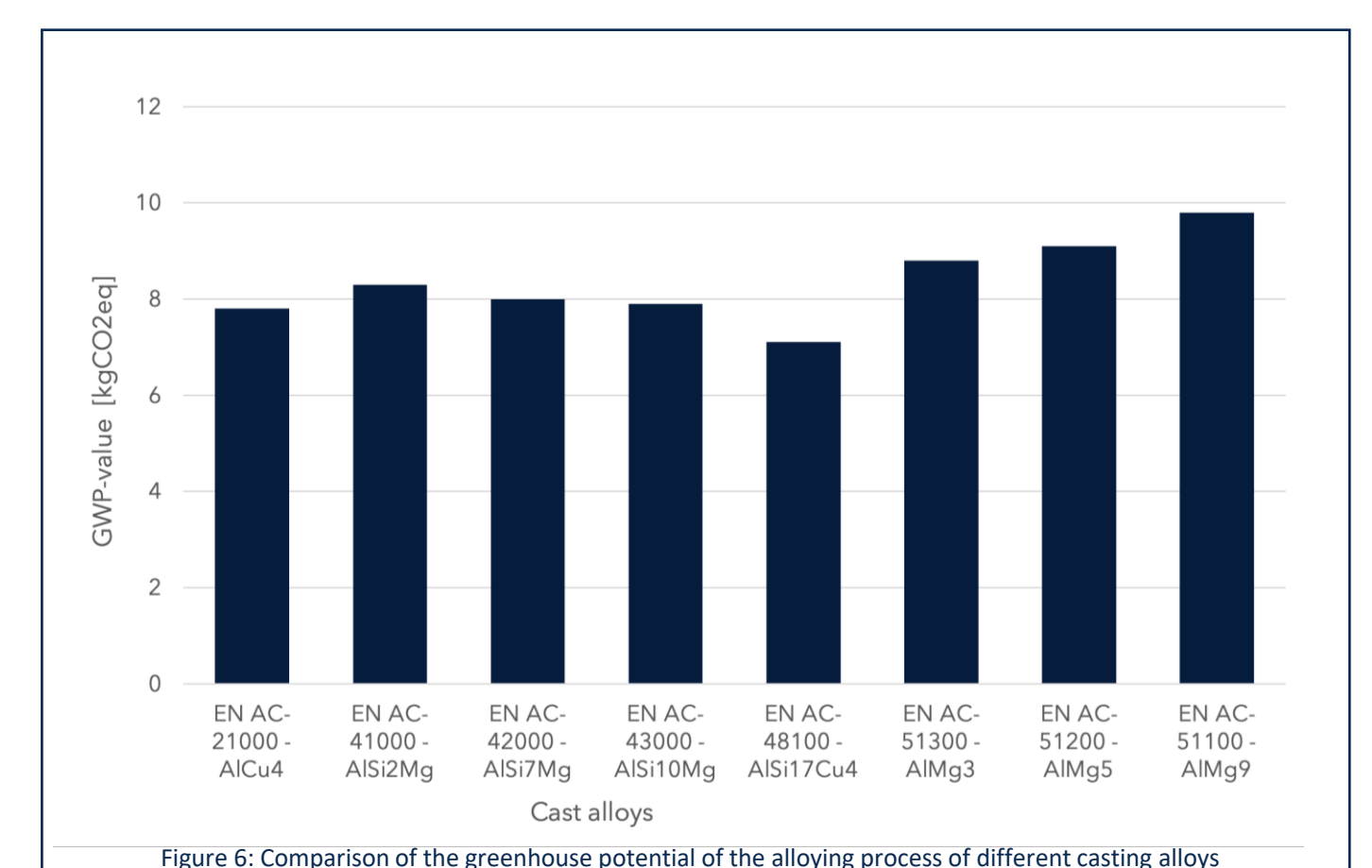


Figure 6: Comparison of the greenhouse potential of the alloying process of different casting alloys

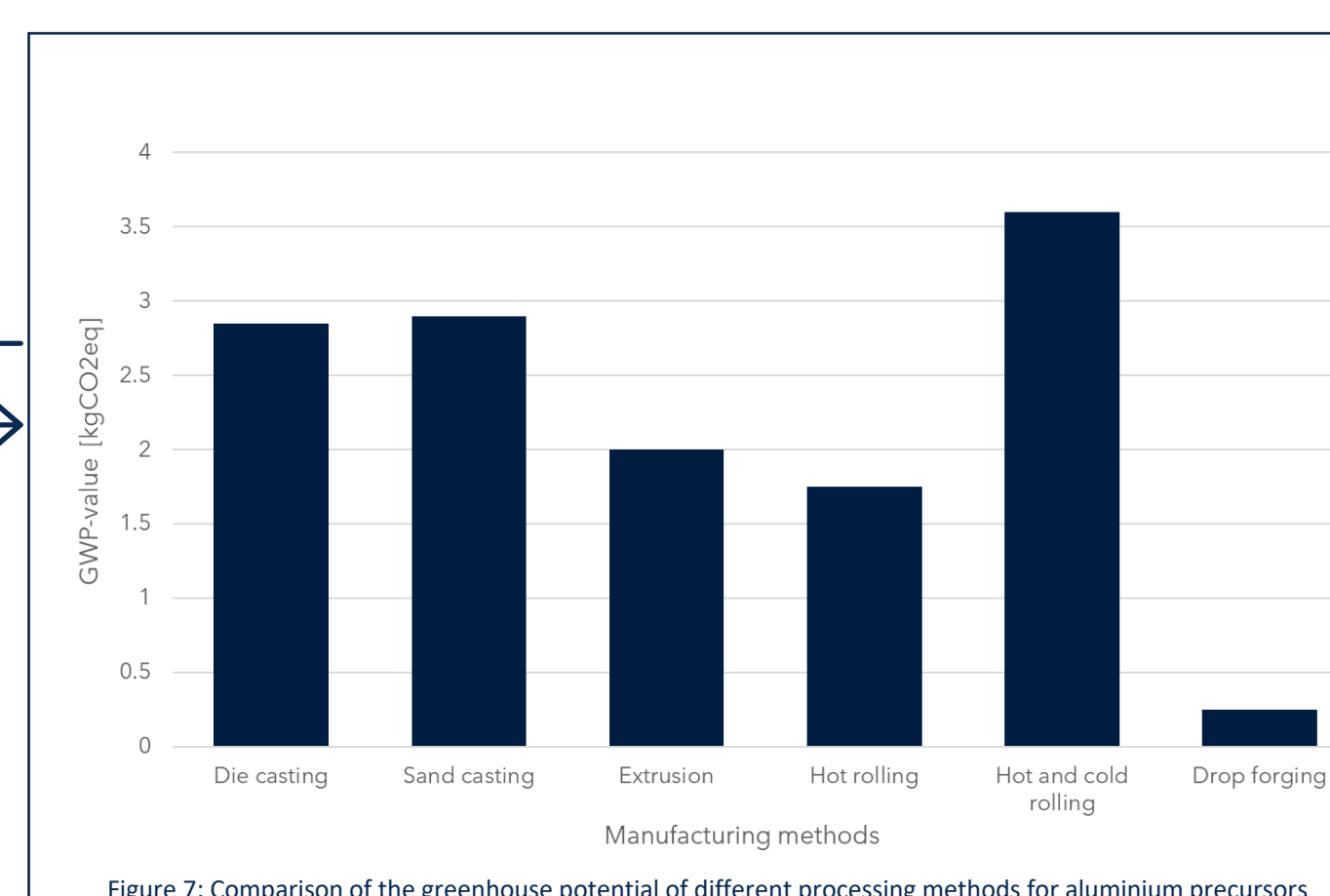


Figure 7: Comparison of the greenhouse potential of different processing methods for aluminium precursors

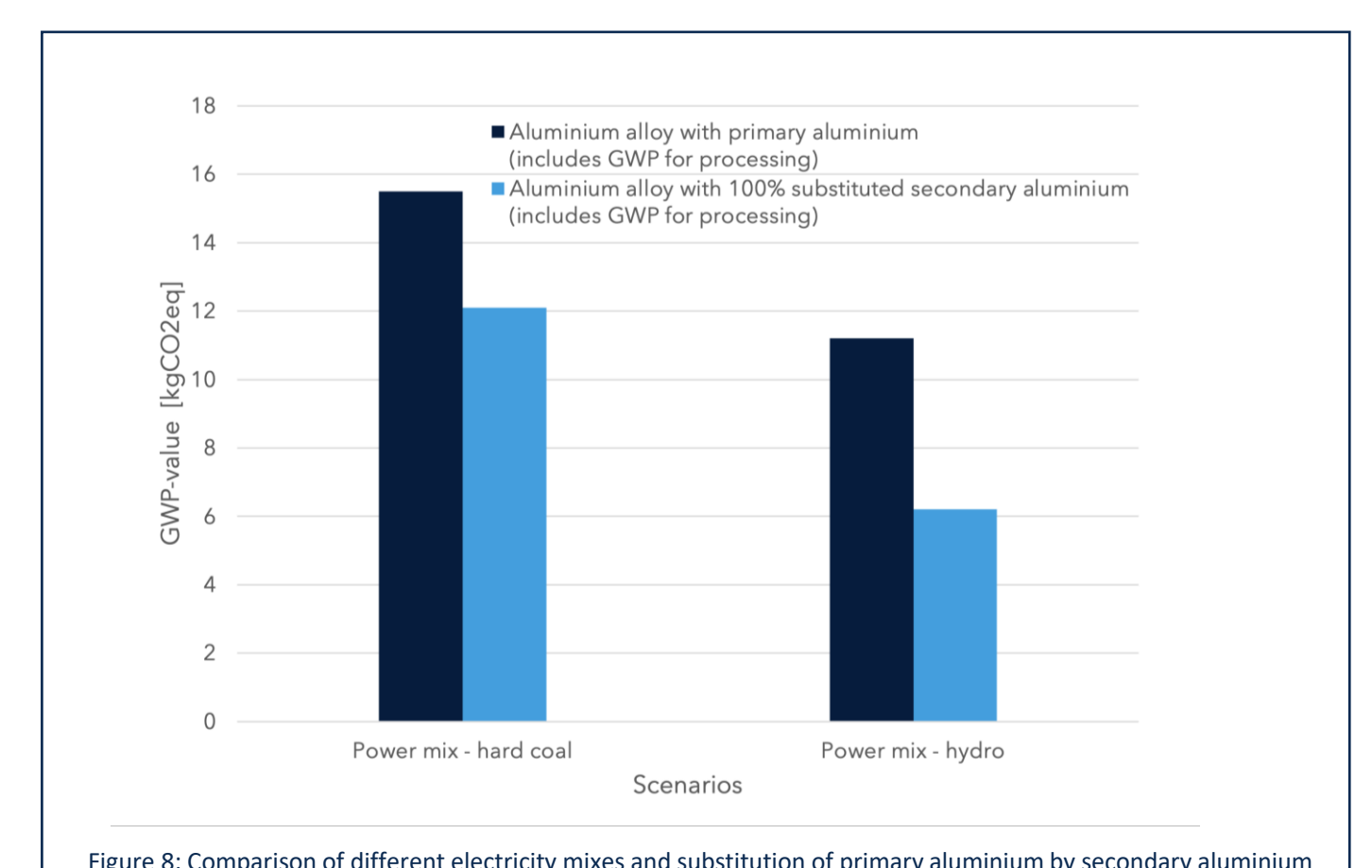


Figure 8: Comparison of different electricity mixes and substitution of primary aluminium by secondary aluminium

Conclusion

- Adding Si lowers the GWP, adding Mg increases the GWP
- Choice of furnace type, electricity mix and use of secondary materials are far more important than the choice of alloy, semi-finished product type or heat treatment
- GWP from alloying and processing > 5% of total life cycle of aluminium products

References

- Life cycle assessment of metals: a scientific synthesis, at: [10.1371/journal.pone.0101298](https://doi.org/10.1371/journal.pone.0101298)
- Aluminum Alloys in Automotive, Chalco Aluminum, at: <https://www.chalcoaluminum.com/application/aluminum-automotive/>
- Wikipedia Motorblock, at: <https://de.wikipedia.org/wiki/Motorblock>
- Aluminium Bleche, at: <https://www.diorama-shop.de/Metall-Bleche-Profil/Aluminium-Bleche/Aluminium-Bleche-weich-500-x-1000-mm-Staerke-0-2-mm-257.html>
- Gesamverband deutscher Aluminiumindustrie: Broschüre „Der Werkstoff Aluminium“, at: https://alu-am-bau.ch/wp-content/uploads/2014/03/04_Der-Werkstoff-Aluminium.pdf
- Aluminium Schmiedeteile, at: <https://www.impol-group.de/produkte/schmiedeteile/>

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