How Energy Transition Reshapes Ecodesign Of Automotive Components In Battery Electric Vehicles? Retrospective Vs. Prospective Life Cycle Assessment

Carlos Hernandez, Carla Rodrigues and Fausto Freire

Univ Coimbra, ADAI, Department of Mechanical Engineering, Rua Luís Reis Santos, Pólo II, Coimbra, 3030-788, Portugal

MOTIVATION

The use of lightweight materials is a widely adopted for designing automotive components. However, the effectiveness of lightweighting for battery electric vehicles (BEVs) depends on the electricity grid mix consumed during the use phase. The ongoing energy transition demands a dynamic assessment to capture how evolving electricity grid mixes influence the ecodesign of automotive components.

GOAL AND SCOPE DEFINITION

A life cycle assessment (LCA) is performed to evaluate the environmental impacts of a prototype automobile interior door handle. The following alternatives are assessed and compared:

- **(PP-novel).** Prototype made of a novel polymer composite;
- **(PP-HF40).** Polypropylene with 40 % hemp fiber;
- **(N6-GF40).** Nylon 6 with 40 % glass fiber;
- **(N66-CF20).** Nylon 66 with 20 % carbon fiber;
- **(N66-GF/CF).** Nylon 66 with 20 % glass fiber/10 % carbon fiber.

Life-cycle model

- **Cradle-to-gate:** The functional unit is defined as the production of one automobile interior door handle.
- **Cradle-to-use:** The functional unit is defined as an automobile interior door handle used throughout a lifetime distance of 250 000 km in 15 years.

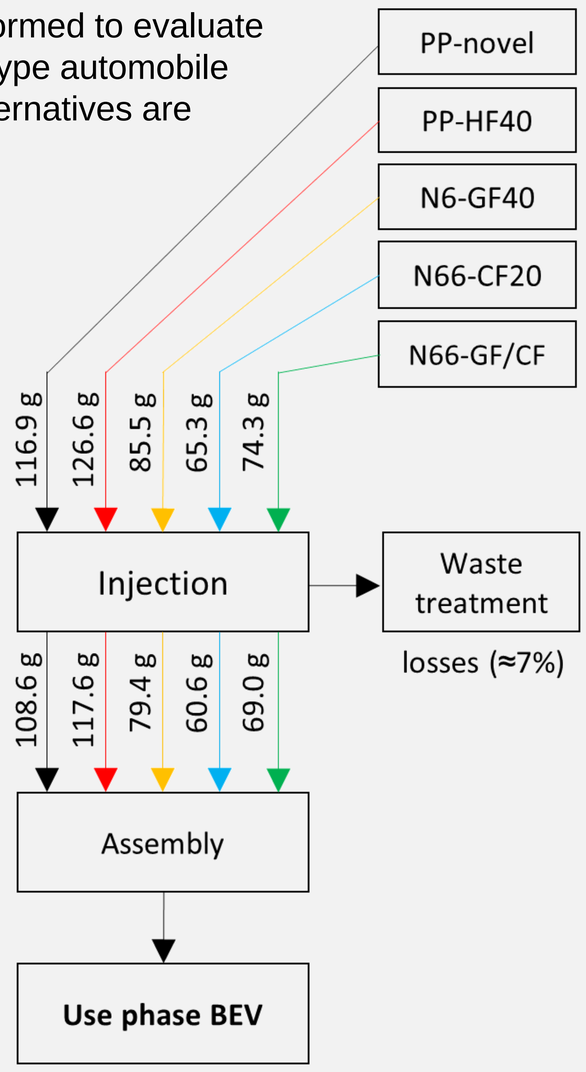


Figure 1. System boundaries

USE PHASE MODEL

The use phase encompasses a well-to-wheel approach based on Kim et al. (2015). The weight-induced energy consumption is analysed for Poland (fossil-grid) and Portugal (renewable-grid), using two approaches:

- **Retrospective** based on the market electricity generation datasets in the ecoinvent 3.11 database.
- **Prospective** based on dynamic forecasted electricity generation pathways from Ember (2022) mapped and processed to align with the electricity generation datasets in the ecoinvent using Brightway2.

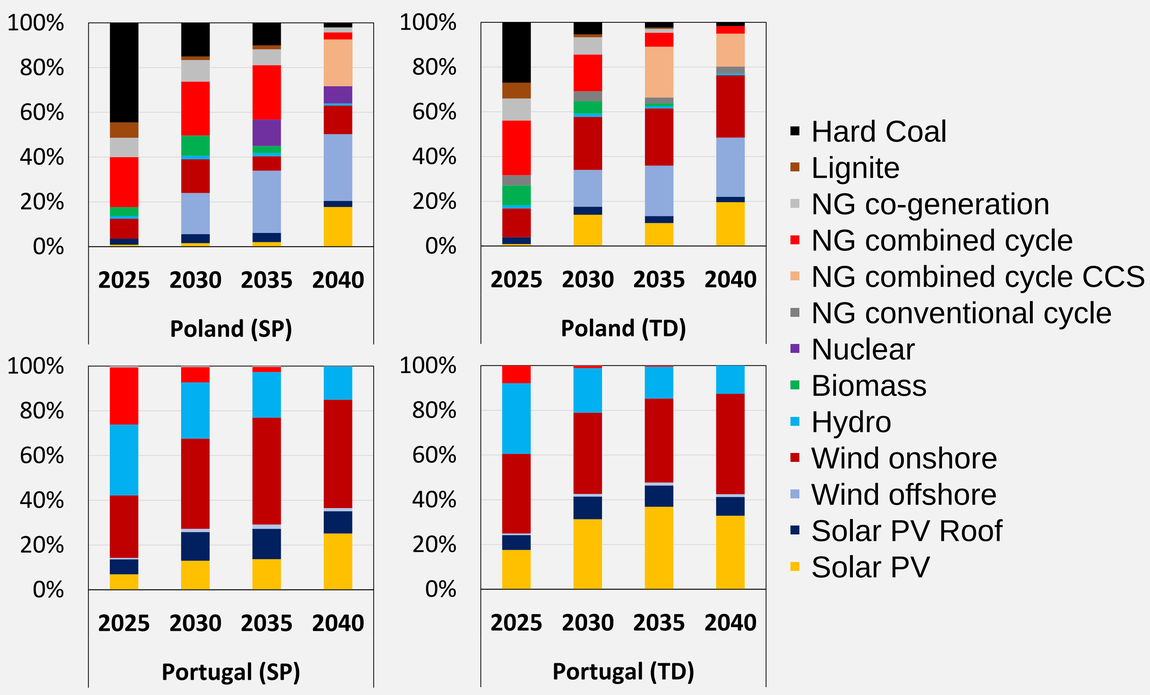


Figure 2. Forecasted pathways: **stated policy** (SP); **technology-driven** (TD).

CRADLE-TO-GATE IMPACTS

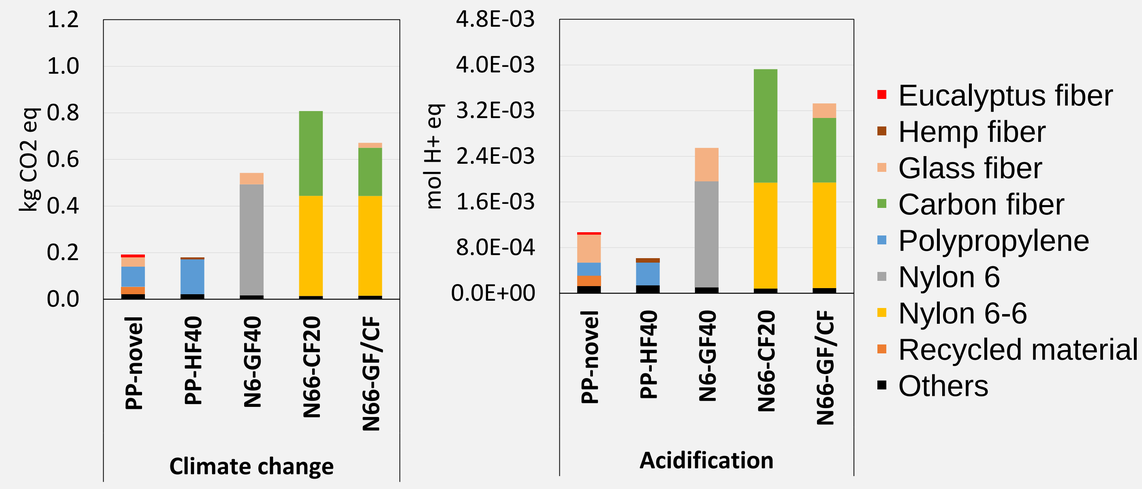
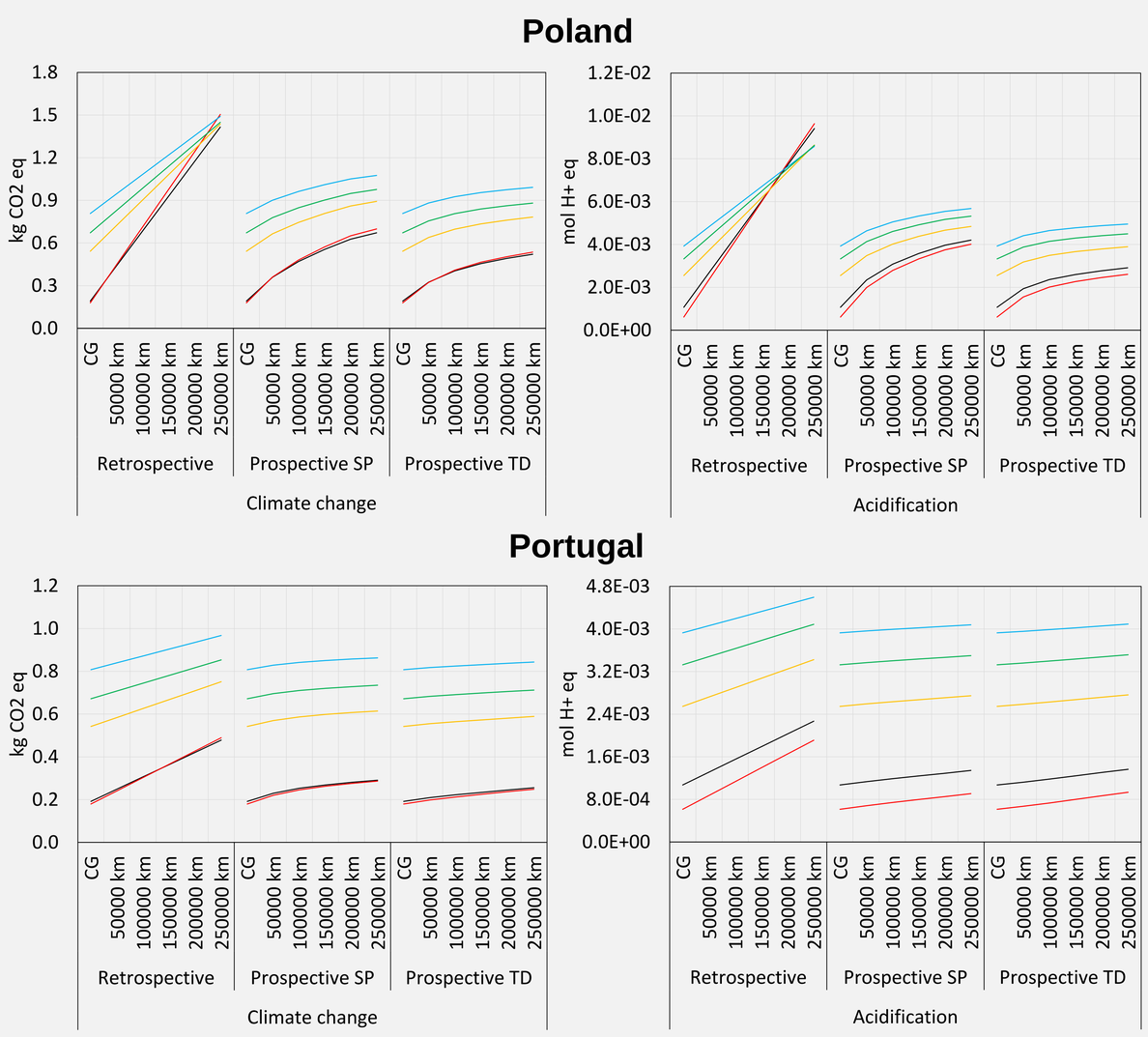


Figure 3. Cradle-to-gate impacts of one automobile interior door handle.

CRADLE-TO-USE IMPACTS



(—) PP-novel, (—) PP-HF40, (—) N6-GF40, (—) N66-CF20, (—) N66-GF/CF.

Figure 4. Cradle-to-use impacts of one automobile interior door handle throughout a lifetime distance of 250 000 km in 15 years .

CONCLUSIONS

- The results shows that energy transitions influences the comparison of automotive components used in BEVs, especially in electricity grids with high dependence of fossil-sources.
- The energy transition promotes the adoption of ecodesign alternatives with lower cradle-to-gate impacts (e.g., polymer biocomposites), rather than traditional lightweighting solutions.
- Using a retrospective approach with constant electricity generation data overestimate the environmental impacts of automotive components used in BEVs.

Acknowledgments

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References

Ember. (2022). New Generation - Technical Report Building a clean European electricity system by 2035. https://ember-energy.org/latest-insights/new-generation/european-clean-power-pathways-explorer-data-tool/

Kim, H. C., Wallington, T. J., Sullivan, J. L., & Keoleian, G. A. (2015). Life Cycle Assessment of Vehicle Lightweighting: Novel Mathematical Methods to Estimate Use-Phase Fuel Consumption. Environmental Science & Technology, 49(16), 10209–10216. https://doi.org/10.1021/ACS.EST.5B01655/SUPPL_FILE/ES5B01655_SI_001.PDF