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Sustainability in Vehicle Repair and Replacement

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Building upon the existing AZT and Allianz SE study: "Repair or Replace - Investigating the relative GHG emissions of repairing or replacing damaged vehicle parts" focused on the VW iD.3 (BEV-Battery Electric Vehicle), this study broadens the scope of application to include an Internal Combustion Vehicle (ICV).

Key Points for Improvement and Extended Exploration

The most important points for the improvements and extended study are the expansion of the vehicle group and the inclusion of various damage scenarios. In addition to the BEV VW iD.3, which had already been investigated, we wanted to have a direct comparison with an ICV. The VW Golf 8 was identified as a suitable vehicle.

The study includes various damage locations such as the front bumper, windshield and front door. Nevertheless, the focus lies on the damage to the underbody. It was important to find out whether different damage levels have an influence. This study specifies three damage levels ranging from minor scratches to severe structural damage, to fully assess the corresponding repair or replacement decision.

Motivation and Objectives of the Study

Given the growing popularity of BEVs and their impact on the automotive industry, it's crucial to evaluate whether BEVs promote environmentally friendly repair and replacement practices. This study aims to provide valuable insights and stimulate further research that can help automotive manufacturers, service providers and policy makers to shape future strategies for vehicle maintenance, resource management and sustainability.

Framework Conditions of the Study

The Lifecycle Assessment (LCA) methodology is a fundamental component of this study. By analysing the environmental footprint of repair and replacement decisions, we aim to provide a comprehensive understanding of sustainability within the automotive industry. Our calculations are based on the openLCA software. Our flowchart shows the framework of our study and the areas examined and included.

Another important point was the goal and scope setting. The key points among these were:

- The product and service development and improvement as the intended application of the result.
- Setting good comparable functional units.
- Defining suitable system boundaries such as the time horizon and the geographic location. We looked at the current situation and the assumption was made that the repair and replacement is taking place in Germany.
- Setting the most important impact categories such as the climate change (CO2 equivalents) and the global warming potential (GWP 100).

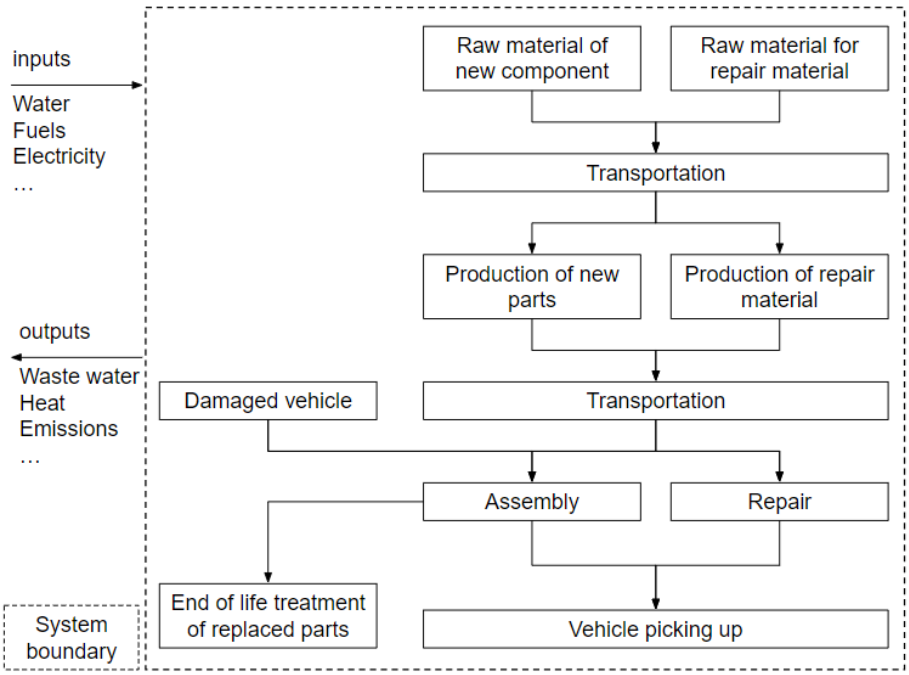

Figure 1: General Flowchart; source: own illustration

Due to the already existing study with the VW iD.3 as functional unit, it was obvious to adopt it and expand it with a comparable combustion engine. The strong selling VW iD.3 and the Golf 8 are both placed in the C-segment and have enough similarities such as shape and proportions to conduct the study.

At the beginning of our study, various expectations and hypotheses were also drawn up to be able to evaluate them afterwards:

- Repair in general has lower environmental impact than replacement parts.
- Repair or replacement BEV parts have a lower environmental impact than ICV except from battery change.
- Battery damage has a decisive influence on the environmental impact result.

Investigated Damage Scenarios

In line with the scope of this comprehensive study, a variety of damage scenarios are considered, each corresponding to different types of insurance claims. This approach helped us to better study the environmental impact of repair and replacement decisions.

- Front Bumper: Typical scenario for third-party liability insurance claims.
- Windshield: Typical scenario for partial comprehensive motor insurance claims.
- Front Door: Typical scenario for fully comprehensive motor insurance claims.
- Underbody: A scenario of remarkable relevance for BEV insurance claims, and now one of many scenarios explored in the study.

The figure illustrates our damage scenario for the front door, windshield and front bumper:

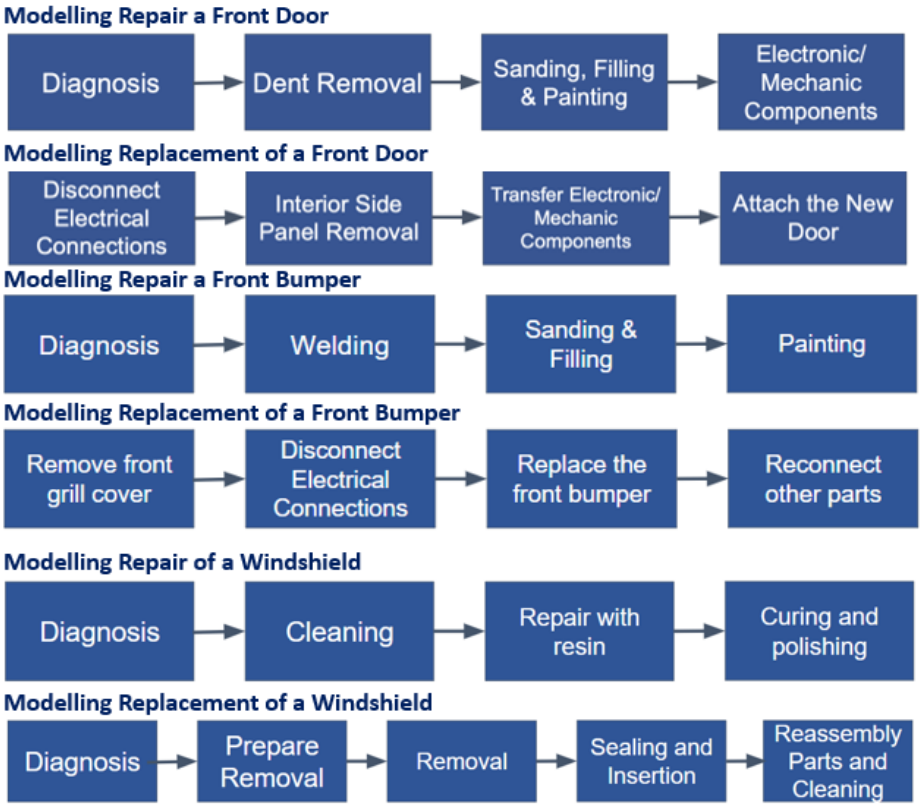

Figure 2: Modelling repair and replacement of a front door, a front bumper and a windshield; source: own illustration

It immediately became clear that the differences here were not of great significance. The focus was placed on the underbody, especially the area between the wheels. We were lucky to have very detailed information from Mr. Belingardi from DIMEAS (Department of Mechanical and Aerospace Engineering) and his team for the battery part. They disassembled and analysed the entire battery complex in great detail. It was now possible to make various assumptions and calculations for materials and different dimensions and convert them to the ICV.

Comprehensive Study Results

The findings of this comprehensive study encompass a wide range of repair or replace decisions for different levels of damage, considering both BEV and ICV models.

1. Minor Damage

- BEV: Scratches on the battery protection plate - Technically, no repair is needed.
- ICV: Scratches on the exhaust system - Technically, no repair is needed.
- It is important to consider manufacturer specifications, especially when there is no protection plate.

2. Medium Damage

- BEV: Medium dents on the battery protection plate - Repair or replace is possible.
- ICV: Medium dents on the catalytic converter - Replacement is needed.
- ICV's environmental footprint increases due to precious metals in the catalytic converter, while the BEV's footprint can be further decreased by repairing the plate.

3. Severe Damage

- BEV: Partial intrusion (1/3) into the vehicle battery - Repair or replace is possible.
- ICV: Severe damage to the exhaust system - Replacement is needed. Even with partial battery replacement, the BEV footprint is greatly increased.

Results, Interpretation and Conclusion

The following Figures 3, 4 and 5 are representing a short overview of our main results:

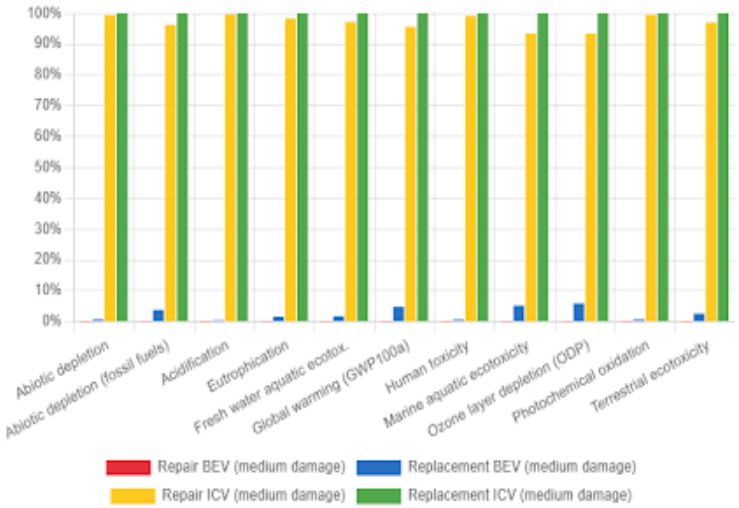

Figure 3: Medium damage LCIA result in all categories; source: own illustration and openLCA

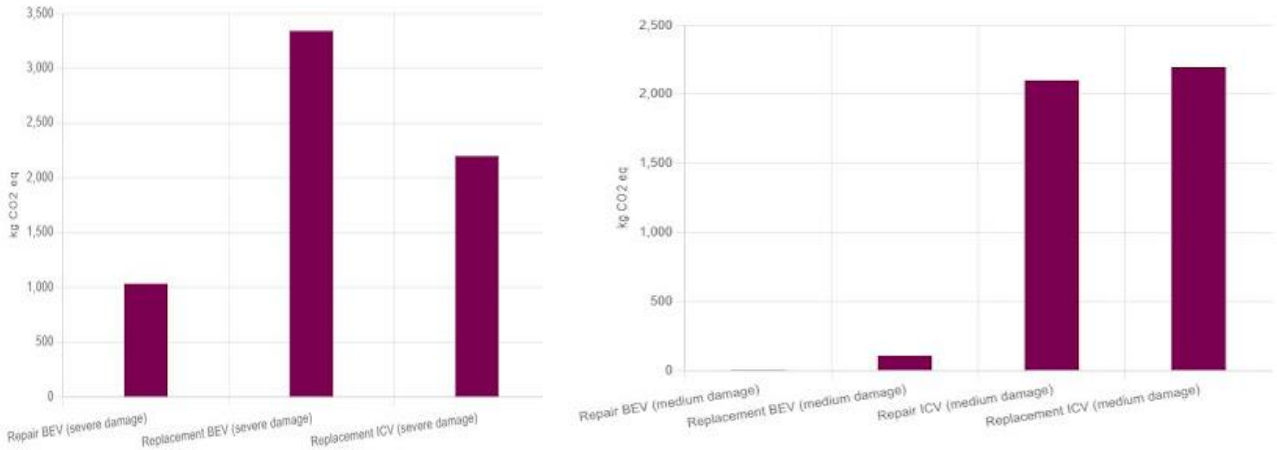

Figure 4: Severe and medium damage LCIA results on GWP100; source: own illustration and openLCA

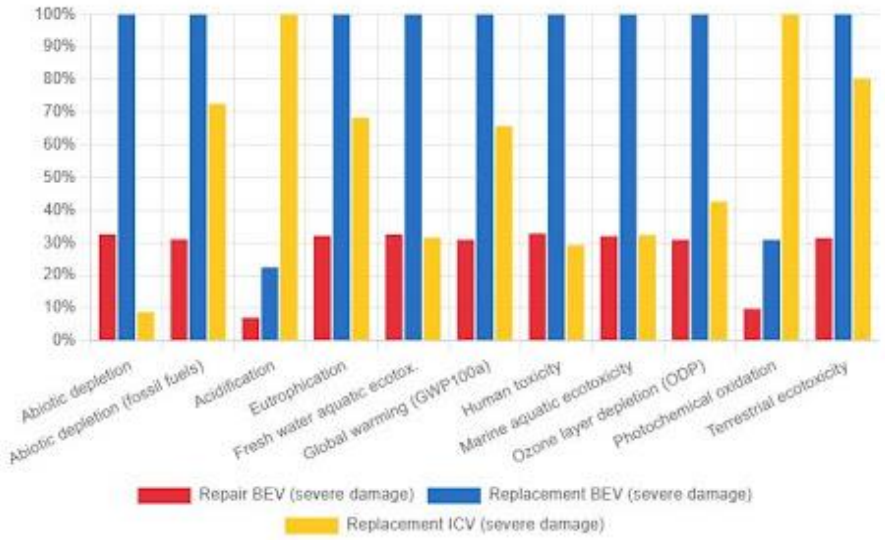

Figure 5: Severe damage LCIA Result in all categories; source: own illustration and openLCA

The conclusions drawn from the LCA results considering the hypotheses presented earlier:

- When there is no substantial difference in components, the environmental impact of repairing or replacing damage in BEVs and ICVs is comparable.
- Batteries play a crucial role, significantly influencing the environmental impact in the context of repairs and replacements for BEVs.
- Overall, the environmental impact is consistently lower for repairs compared to replacements in both BEVs and ICVs when repairs are feasible.

Finally, the LCA findings highlight a significant environmental impact when replacing vehicle battery modules compared to the more sustainable repair practice. While environmental concerns are crucial, consumer choices in the automotive industry are shaped by a complex dynamic of factors including price, safety, social influence, vehicle condition, warranty coverage, resale value, and regulatory incentives.