

Generalization of Truck Disassembly Process Models for Reused Parts Production and Environmental Impact Assessment

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Reused parts play an important role in reducing environmental impact in the automotive circular economy. While the environmental benefits of reused parts have been evaluated for passenger cars and light trucks, they remain insufficiently understood for long-haul trucks. Although prior studies have analyzed truck disassembly processes, these studies have focused on a single vehicle model each, and generalizing the disassembly process across vehicle types remains a challenge. This study aims to construct a generalized disassembly process model applicable across multiple truck types, thereby improving the validity of disassembly process data, and to apply the model to evaluate the environmental impact of truck disassembly.

To generalize the model across vehicle types, disassembly tasks were classified into elemental categories and grouped into 8 major process stages based on the system involved (e.g., powertrain, cabin, front/rear axle). The consistency of this grouping was verified using a Design Structure Matrix (DSM), which examines whether the precedence relationships among grouped processes are consistent with those of external processes. Conditional branches were introduced to account for variations in process configuration depending on how the removed cabin was subsequently resold; for example, when the cabin was disassembled for individual door sales, it was removed on its own, whereas when the cabin was resold intact, it was removed together with the frame by gas-cutting the joint so that the frame could also be reused. In the latter case, a cab-mount arch reinstallation process was additionally required.

The generalized model was applied to evaluate GHG emissions for each major process stage across three truck models (two heavy-duty, one light-duty). The results showed that heavy-duty trucks tended to emit more GHG than the light-duty truck overall. Notably, GHG emissions in rear axle-related parts removal were markedly higher for one heavy-duty truck, attributable to corrosion-induced fastener seizure between the rear axle and air suspension, which required extended removal time using a gas burner and a heavy-duty air impact wrench.

This study presents a framework for quantifying the environmental impact of truck disassembly and demonstrates that vehicle condition, in addition to process structure, can affect disassembly-related GHG emissions. Future work includes expanding the dataset across additional vehicle types and facilities to verify whether this tendency reflects a structural characteristic or an individual vehicle condition.

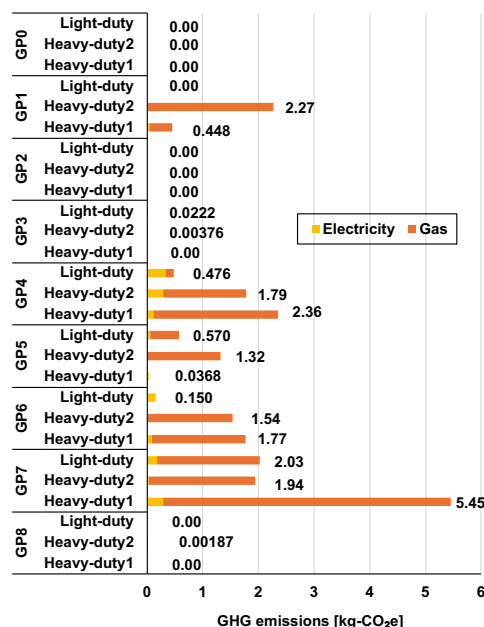


Fig.1 GHG Emissions by Major Process Stage for Three Truck Types