
3M Science. Applied to Life.™
LCA of Car Paint Repair Systems
A Comparative Assessment
March 2026
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Executive Summary

The global automotive collision repair industry is experiencing ongoing growth, which coincides with rising environmental concerns and stricter regulations. This is leading the market to transition toward more sustainable working practices.

This study focuses on technologies that are used to apply sprayable coatings to vehicles in the collision repair industry. In this context, 3M Company has developed a new car paint coating system and has commissioned Sphera to conduct a Life Cycle Assessment (LCA) study to comparatively assess 3M's Performance Spray Gun and the 3M Paint Preparation System (PPS™) system with representative competing technologies as well as to identify the main drivers of potential environmental impacts.

The study evaluates three distinct spray gun setups used in the automotive collision repair industry

- Setup #1 = 3M™ vented cup (single use) + metal spray gun
- Setup #2 = reusable cup + metal spray gun (plus single use mixing cup and cone filter)
- Setup #3 = PPS™ 2.0 spray cup system + 3M™ Performance Spray Gun

This report is based on a critically reviewed LCA and serves to address stakeholders of the automotive collision repair industry with an interest in better understanding the environmental impact from associated products and processes.

The results of the study highlight that booth operation is the primary contributor to potential environmental impacts across all setups, driven mainly by thermal energy consumption. Life cycle results for Climate Change are similar for all three setups. Considerable emissions of volatile organic compounds (VOC) during paint/coating application and cleaning dominate the impact category *Photochemical Ozone Formation*.

Setup #1: Demonstrates 4.3% lower Climate Change results compared to Setup #2, but 1.3% higher greenhouse gas (GHG) emissions than setup #3. Emissions from paint application dominate results for *Photochemical Ozone Formation*.

Setup #2: Has the highest GHG emissions among the three setups. Paint application is the largest contributor. Impacts for *Photochemical Ozone Formation* are significantly higher compared to Setup #1 and Setup #3. Intensive cleaning requirements for the reusable cups drive up results.

Setup #3: Has the lowest GHG emissions, approximately 1% lower than Setup #1 and 5.6% less than Setup #2, due to optimized design, improved paint transfer efficiency, and efficient solvent use. Moreover, the 3M™ Performance Spray Gun system has significantly lower VOC emissions than setup#2.

1. Context & Importance

1.1. The Automotive Collision Repair Industry

The global automotive collision repair industry is growing rapidly, supported by a considerable market, driven by rising vehicle ownership and the resulting increased demand for repair services. The industry is experiencing significant innovation resulting from advances in technologies, material, and repair processes. Modern vehicles are becoming more complex, featuring advanced materials and requiring specialized repair processes and technical expertise. Repair shops are increasingly adapting advanced technologies and tools, such as paintless dent repair and augmented reality for diagnostics, to boost their efficiency and maintain the quality of their services.

The global collision repair industry is influenced by multiple stakeholders driving growth through continuous innovation. These key players are strongly focusing on customer experience and prioritizing sustainable practice to limit their environmental impacts.

Additionally, the industry is significantly impacted by environmental regulations. The regulations concern paint and solvent VOC emissions, waste disposal and energy efficiency. Companies must adopt the appropriate repair processes and use better materials to comply with environmental regulations.

Due to these factors, the market is transitioning toward more sustainable practices. Repair shops are focusing on lowering their carbon footprint, reducing VOC emissions and waste, and using sustainable materials. These facilities are increasingly adopting lower impact operations such as using environmentally safe paints and using energy efficient technologies to meet the environmental regulations.

1.2. What is Life Cycle Assessment

Life Cycle Assessment (LCA) is defined by ISO 14040 as the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. LCA quantifies all relevant emissions and resources consumed and the related environmental and health impacts and resource depletion issues that are associated with any goods or services. These assessments thereby help to identify environmental hotspots, avoid resolving one environmental problem while creating others, and compare the environmental performance of products that provide the same function. LCA is a powerful decision support tool that helps making consumption and production more sustainable.

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2. Goal & Scope of the Study

2.1. Goal of the Study

The objective of the study is to comparatively assess 3M's Performance Spray Gun and the 3M PPS™ 2.0 system with commonly used competing setups. Moreover, 3M would like to understand hot spots and main drivers for the related potential environmental impacts. Another goal of the study is to understand the influence of single use (disposable) paint cups in comparison to reusable cups and related setups on the potential environmental impacts.

The results are intended to support comparative assertions between the setups analysed and to be disclosed to the public. Intended audiences include interested stakeholders of the automotive collision repair industry.

2.2. Scope of the Study

The setup includes a spray gun, a cup/reservoir for the paint (or other liquid coating) to be applied, paint, energy for paint application, and solvents for cleaning the equipment. In the context of this report, paint may refer to paint or other sprayable coating used as part of the collision repair process

The study evaluates three distinct spray gun setups used in the automotive collision repair industry

- **Setup#1 = 3M™ vented cup (single use) + metal spray gun**
- **Setup #2 = reusable cup + metal spray gun (plus single use mixing cup and cone filter)**
- **Setup #3 = PPS™ 2.0 spray cup system + 3M™ Performance Spray Gun**

Detailed description of the setups is provided in Annex B.

In this study, the functional unit[1] is defined as: *Covering 1m² of a vehicle in the context of repairing damaged car surfaces including painting replacement panels.*

System boundaries include production, distribution and disposal (end of life) of spray guns and cups as well as the production and application of the car paint, including VOC emissions. Booth operation and cleaning of reusable parts are also considered.

The present study is a cradle-to-grave LCA including all relevant life cycle stages, as shown in Figure 2-1.

[1] The functional unit is the quantified performance of a product system to be used as a reference unit, and meaningful comparisons can only be made if products fulfil the same function.

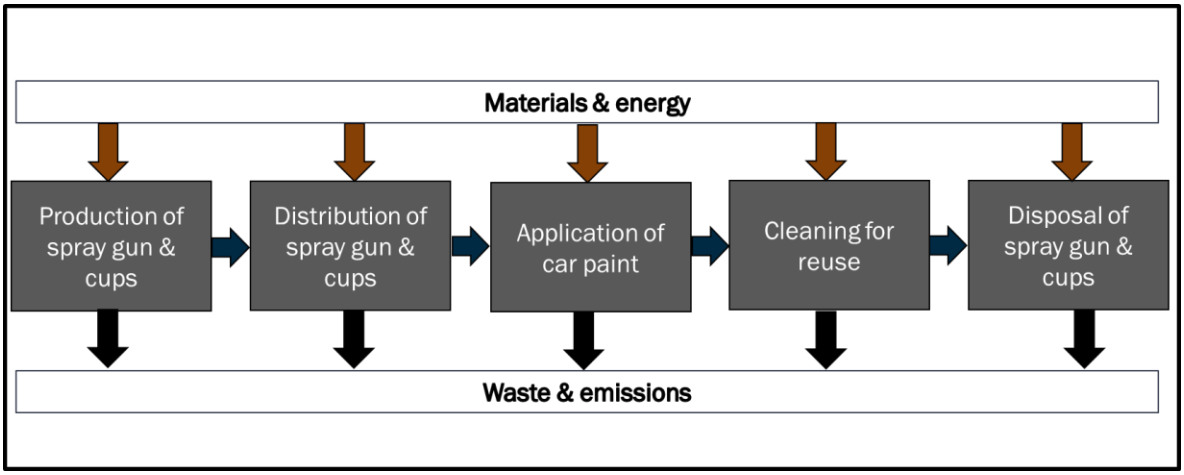


Figure 2-1 System boundaries

The 3M products are assembled in Poland. For the purposes of the LCA, use and disposal of the product take place in Europe. Results of this study refer to the year 2023.

While the full LCA study included a broad selection of impact categories, this Whitepaper focuses on

- ***Climate change, Total***
- ***Photochemical Ozone Formation***
- ***Resource Use, Fossils***

Climate Change, Total and *Resource Use, Fossils* are relevant due to high energy consumption of the spray booth. *Photochemical Ozone Formation* reflects the health effects of solvents and VOC emissions, which play an important part for paint systems.

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3. Key Findings

This section shows the potential environmental impacts for these life cycle stages:

- Cup & Gun: manufacturing and disposal of spray gun and cup system
- Paint application: primer, base coat, clear coat & energy for application with spray gun
- Cleaning: solvents used for cleaning gun and cup. Cup cleaning is only relevant for the reusable cup of setup#2
- Booth operation: thermal and electrical energy. Automotive repair spray booths are generally equipped with ventilation systems but typically lack dedicated VOC exhaust gas abatement (e.g., thermal oxidation).

3.1. Results for Setup #1: 3M™ Vented Cup + Metal Spray Gun

The result for Climate Change is 40.73 kg CO_2 equivalents per 1 m² of treated surface. Total results are dominated by the booth operation, which is significantly more important than the other life cycle stages

The result for Photochemical Ozone Formation is 0.21 kg NMVOC equivalents per 1m² of treated surface. Impacts are driven by cleaning solvents and by solvent-based paints.

The results for Resource Use, Fossil is 684.30 MJ per 1m² of treated surface. Total results are dominated by the booth operation.

Results for setup#1 are shown in Figure 3-1.

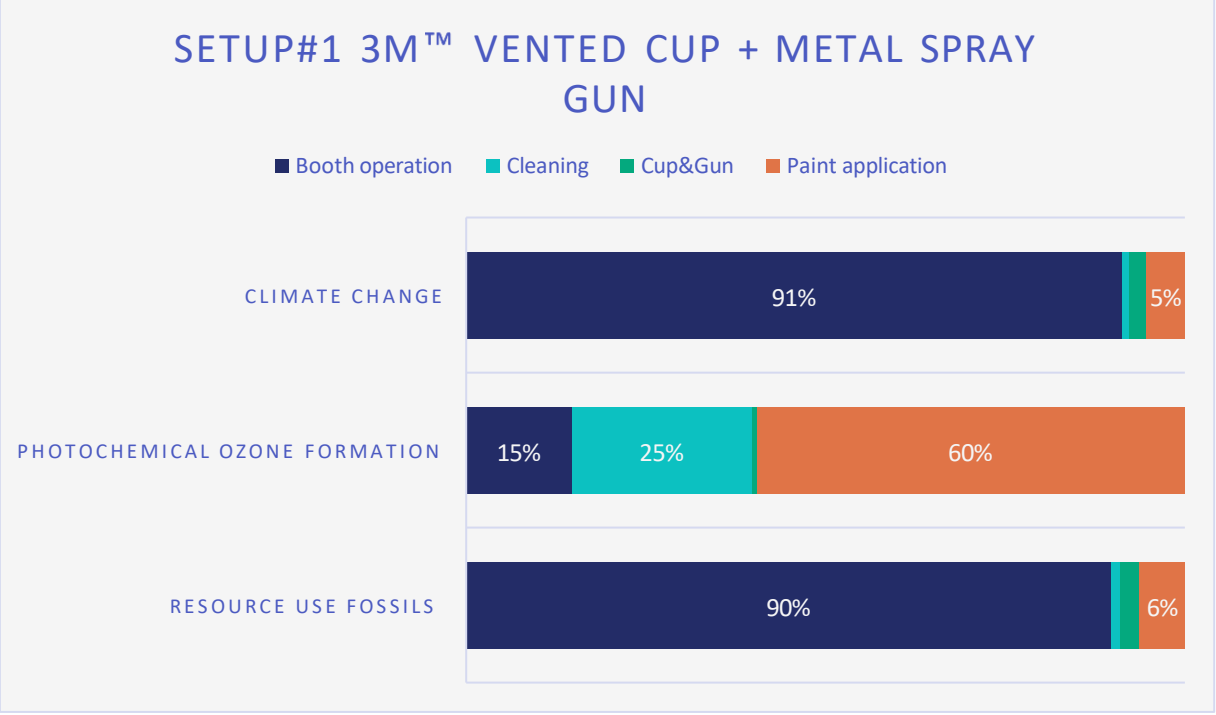


Figure 3-1: Results for Setup #1 - 3M™ Vented Cup + Metal Spray Gun

3.2. Results for Setup #2: Reusable Cup + Metal Spray Gun

The result for Climate Change is 42.60 kg CO_2 equivalents per 1 m² of treated surface. Similarly to the Setup #1 baseline scenario, total results are dominated by the booth operation, which is significantly more important than the other life cycle stages.

The result for Photochemical Ozone Formation is 0.54 kg NMVOC equivalents, per 1 m² of treated surface. Impacts are driven by VOC emissions from cup and gun cleaning, and by solvent-based paints.

The results for Resource Use, Fossils is 730.90 MJ, per 1 m² of treated surface. Impacts are dominated by booth operation.

Results for Setup #2 are shown in Figure 3-2.

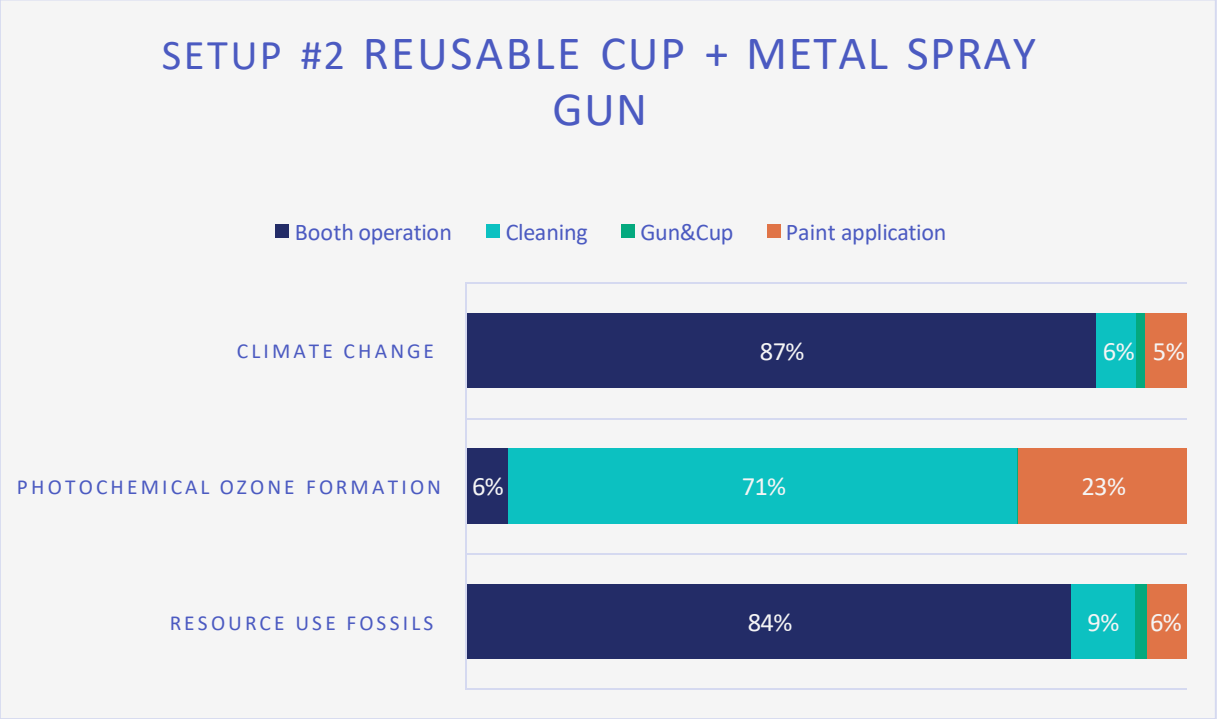


Figure 3-2: Results for Setup #2 - Reusable Cup + Metal Spray Gun

3.3. Results for Setup #3: PPS™ 2.0 Spray Cup + 3M™ Performance Spray Gun

The result for Climate Change is 40.20 kg CO_2 equivalents per 1 m² of treated surface. Total results are dominated by booth operation, which is significantly more important than the other life cycle stages

The result for Photochemical Ozone Formation, human health is 0.18 kg NMVOC equivalents per 1m² of treated surface. Unlike Setup #2, impacts are mainly driven by solvent-based paints.

The results for Resource Use, Fossils is 670.35 MJ per 1 m² of treated surface. Impacts are dominated by booth operation.

Results for Setup #3 are shown in Figure 3-3.

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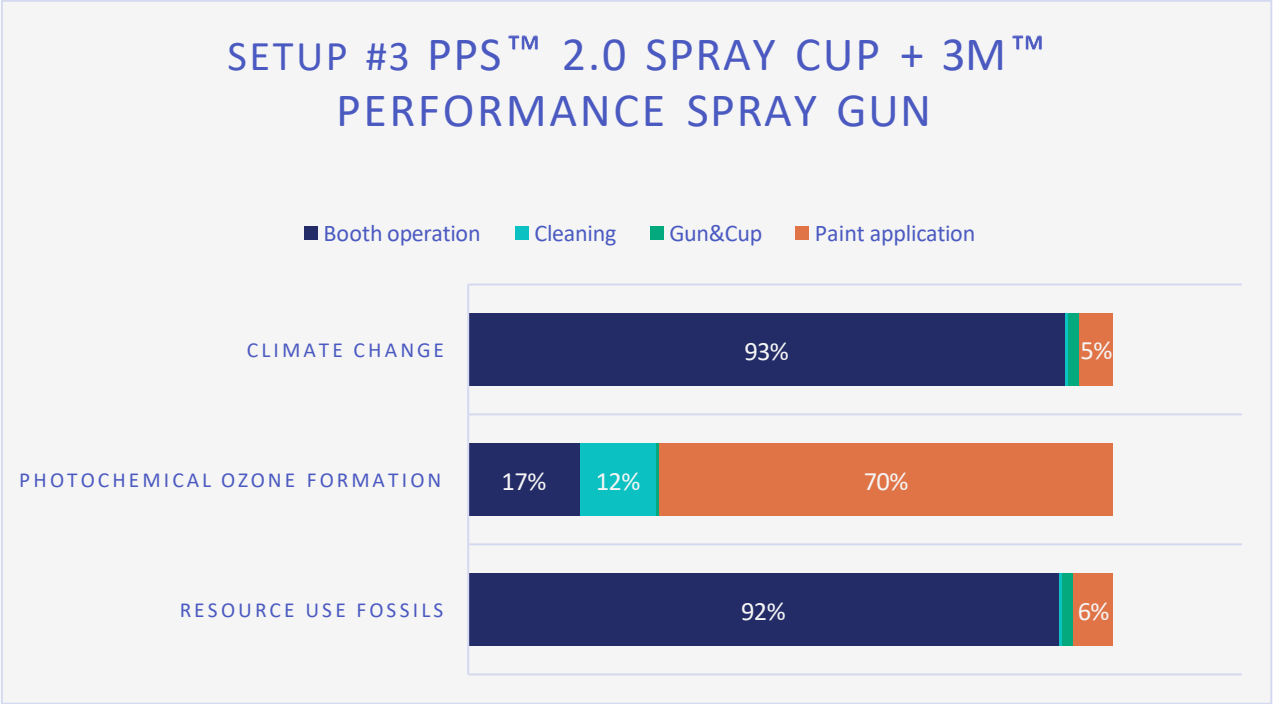


Figure 3-3: Results for Setup #3 - PPS™ 2.0 Spray Cup + 3M™ Performance Spray Gun

3.4. Comparison of the results

For *Climate Change*, Setup #2 has 4.4% higher results than Setup #1. Setup #3 has 1.3% lower results than Setup #1 and 5.6% less than Setup #2. These are very moderate differences.

For *Photochemical Ozone Formation,* Setup #2 has 155% higher results than Setup #1. Setup #3 has 15.2% lower results than Setup #1 and 66.8% less than Setup #2. Setup #1 and Setup #3 have significantly lower results for this impact category than Setup #2.

For Resource Use, Fossils, Setup #2 has 6.4% higher results than Setup #1. Setup #3 has 2.0% lower results than Setup #1 and 8.3% less than Setup #2.

Figure 3-4 shows the results comparison of the 3 Setups.

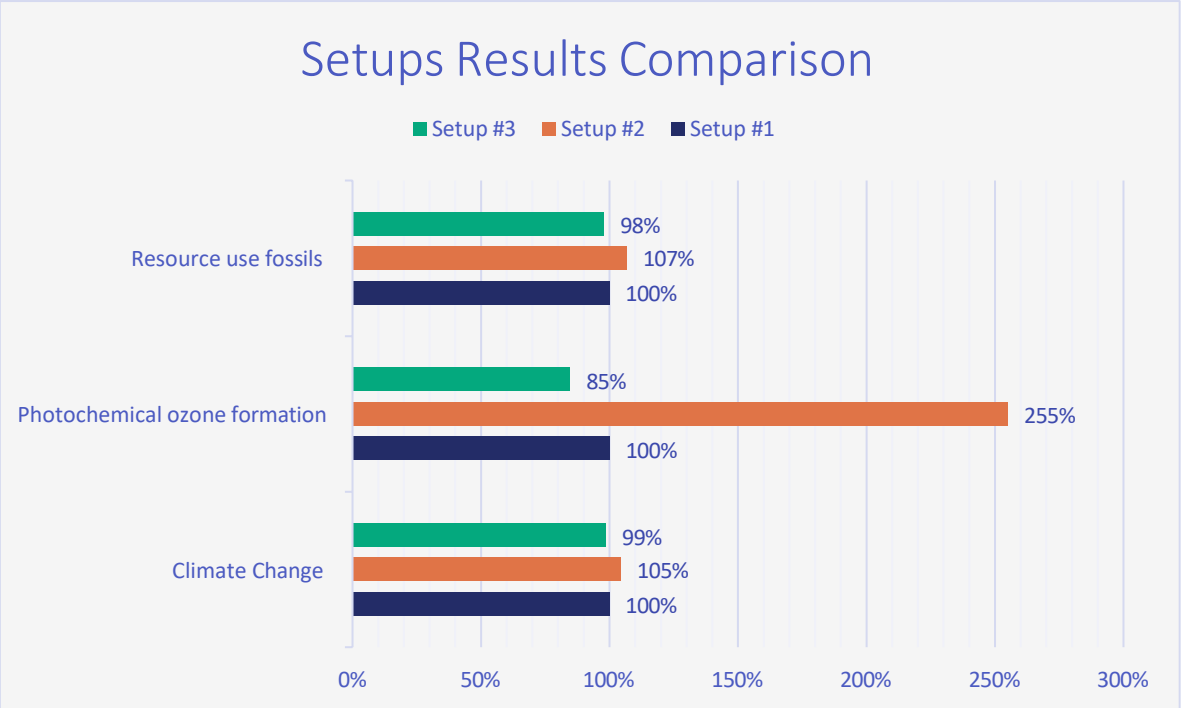


Figure 3-4 Comparison of Results

3.5. Identification of Relevant Findings

Setup #1 demonstrated 4.3% lower CO_2 equivalent emissions compared to setup #2, but 1.3% higher emissions than setup #3. All three calculations produce comparable results, and the small differences are within the expected uncertainty range. However, without the booth operation, Climate Change results would be 44.7% lower for setup#3 (and 34.7% lower for setup#1) compared to setup#2.

Emissions from paint application dominate results for *Photochemical Ozone Formation*, primarily due to high VOC emission release during paint spraying and solvent-based cleaning. Single-use vented cups contributed additional plastic waste, but their impact was less relevant compared to the emissions from the paint application process. Single-use cups contribute 2% to the Climate Change results for setup #1.

Setup #2 had the highest CO_2 equivalent emissions among the three setups. Booth operation remained the largest contributor, partly driven by inefficiencies in paint transfer and high energy demands in the spray booth. Impacts for *Photochemical Ozone Formation* are significantly higher compared to Setup #1 and Setup #3. This is due to the intensive cleaning of both the reusable cup and spray gun which further elevated VOC emissions

Setup #3 had the lowest CO_2 equivalent emissions by a very small margin. The primary hotspot was booth operation, though its optimized design reduced VOC emissions and improved transfer efficiency, lowering the overall *Climate Change* impact. Setup #3 further optimized material use through lightweight, reusable liners, while Setup #1 relied heavily on single-use vented cups, and Setup#2 required disposable mixing cups and filters resulting in lower secondary impacts compared to the other setups.

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For all setups, the spray gun itself has a negligible impact, because it is used so often over an extended period of time (3,000 uses per lifetime).

Booth operation dominates *Climate Change, Total* and *Resource Use, Fossils* for all the 3 setups due to high thermal energy consumption. Especially the curing requires a high temperature (60 to 80°C) to accelerate the hardening of the coating.

3.6. Conclusions

The results of the study highlight that booth operation (use phase) is the primary contributor to environmental impacts across all systems, driven mainly by thermal energy consumption. Considerable VOC emissions during paint application and cleaning contribute to the impact category Photochemical Ozone Formation.

Setup #1 produced the highest plastic waste, followed by Setup #2. Setup #3 had the lowest waste generation due to reusable and lightweight components.

While reusable components can reduce single-use plastic waste, their performance depends strongly on operational parameters, particularly cleaning intensity, solvent consumption, and the resulting VOC emissions.

In this assessment, the production of single-use components (e.g., vented cups, liners, and filter lids) was a minor contributor to results in all setups. The relative contribution to total *Climate Change* results is approximately 1%. For setup #2, production of disposable mixing cups and reusable components added to the environmental footprint.

However, the solvent-based cleaning contributed heavily to VOC emissions and hazardous waste. Setup #2 was the most affected, with extensive cleaning of both the reusable cup and spray gun. Setup #2 also requires disposable mixing cups and filters. The production of these disposable components added to the environmental footprint. Setup #3 showed improved efficiency, resulting in lower emissions from cleaning.

3.7. Recommendations

To reduce life cycle impacts of the repair process, it is recommended to improve paint transfer efficiency, optimize booth energy use, and incorporate recycled content in the cups. 3M could continue investing in technologies and training to improve paint transfer efficiency, reduce material waste and minimize VOC emissions. The use of recycled content in disposable plastic components can lower the environmental footprint. Moreover, in future studies, primary data for booth operation should be used.

4. Implications & Benefits

The LCA study provides an understanding of the product environmental performance along the entire life cycle. It highlights environmental hotspots that cannot be identified when only focusing on a single process step or the carbon footprint alone.

It also helps enable informed decision-making during the product development stage. By understanding how each process step contributes to the environmental performance of the product, actions that lead to meaningful process optimization and better environmental performance can be prioritized.

It is recommended to engage with stakeholders, including suppliers and customers, to promote sustainable practices and innovations across the collision repair industry. Additionally, 3M could establish a continuous improvement program to regularly update and refine LCA models based on the latest data and technological developments and ensure compliance with evolving environmental regulations and standards to maintain market competitiveness and sustainability leadership.

For repair shops and repair network, the LCA findings identify the key environmental drivers within relevant processes and help them focus on adapting the right measures to reduce their environmental impacts. The results can also support sustainability related reporting requirement, such as internal environmental performance accounting, customer reporting requests, and broader ESG or decarbonization initiatives, by providing transparent and standardized insights.

The LCA study performed for the car paint repair systems reflects 3M's commitment to sustainability. In 2024, 3M's near-term GHG emissions targets were validated by the Science Based Targets initiative (SBTi) and classified scope 1 and 2 targets as in line with a 1.5ºC trajectory. The company is committed to reducing absolute scope 1 and 2 GHG emissions 52.6% by 2030 and reducing absolute scope 3 GHG emissions 42% by 2030[2].

The LCA study also aligns with the company's "math, path, and plan" strategy for GHG emission reduction. This strategy focuses on working across the supply chain to reduce emissions and improve the efficiency of manufacturing equipment and processes. The LCA results enables the prioritization of the most impactful improvement strategies, assessment of the actual benefits from process and technology enhancements, and the targeting of supplier and sourcing initiatives that yield the most significant reductions in Scope 3 emissions.

By underpinning these strategic initiatives with product-level, life-cycle data, the LCA enhances the connection between the company's climate strategy and its operational and product decisions, facilitating a more focused and effective emissions reduction approach. .

[2] 3M, "Climate," *Our Global Impact – Sustainability*, available at: https://www.3m.com/3M/en_US/sustainability-us/climate/

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5. Methodology Transparency

5.1. Life Cycle Assessment

The study follows a cradle-to-grave Life Cycle Assessment (LCA) approach, adhering to ISO 14044 standards, and reports the results and conclusions of the LCA completely, accurately and without bias to the intended audience. The LCA was conducted by Sphera (https://sphera.com/).

The LCA model was created using Sphera's LCA FE Software and MLC database (CUP 2025.1).

Impact assessment is based on the EF 3.1 methods, which are part of the EU's Product Environmental Footprint initiative.

A critical review was conducted in accordance with ISO/TS 14071 by a review panel consisting of three members. The Critical Review Statement can be found in the Annex A of the LCA full report.

5.2. Additional Information

Further information is available in the full LCA report and can be accessed through the following:
→Provide a link to the full technical report for experts

3M's sustainability report (published in 2025) can be found here:

https://www.3m.com/3M/en_US/sustainability-us/climate/

Annex A: Product Carbon Footprint

Carbon footprints presented in the Annex refer to only those components produced by 3M™.

It is important to note that their relative contribution to total footprints of the car repair process is small (cup system) or even negligible (3M Performance Spray Gun).

Carbon footprint results were calculated using the method „EF3.1 *Climate change, total*". All products were modelled using primary data for the manufacturing, except for the PSG handle.

For the purposes of the study, three paint layers (primer, base, clear) were applied, which means that one use cycle represents the application of one layer. In the case of setup#1, three vented cups would be required for one paint repair.

A1. Setup#1: Carbon Footprint Results

Parts are produced primarily in Austria and Poland, final assembly and packaging takes place in Poland. All parts are single use parts. The reported carbon footprint and mass of the packaging refer to the mass of packaging per one cup assembly. The machined PPS™ adapter connects the fluid inlet of the metal spray gun with the vented cup.

The disposal scenario assumes a recycling rate of 20% for the cup, 40.7% for the stretch film and 82.5% for the carton, whereas the rest is either incinerated or landfilled. As this refers to an average European scenario, a 50/50 split between incineration and landfill is assumed.

Description	Item	Carbon footprint [kg CO_2 eq.]	Mass [g]	Use cycles
Vented Cup system including raw materials, manufacturing and upstream transport	Cup with label	0.118	40.7	1
	Lid	0.054	18.1	1
	Filter	0.001	0.15	1
	Plug	0.008	2.2	1
	Vent ring	0.008	1.35	1
Vented Cup Packaging	Carton + Stretch film	0.004	8.63	50 cups per packaging
Disposal of cup and packaging		0.080		
PPS™ Adapter		1.059	80	3000

A.2 Setup#3 Carbon Footprint Results

The PPS™ 2.0 cup system is produced primarily in Austria and Poland, final assembly and packaging takes place in Poland. The cup system is produced using 100% virgin plastic. The 3M Performance

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spray gun handle and atomizing head are produced in the United States of America. Liner, lid, plug and locking ring are single use parts. The 3M™ Performance spray gun (PSG) and PPS™ 2.0 outer cup can be used multiple times. The reported carbon footprint and mass of the packaging refer to the mass of packaging per one cup.

The disposal scenario exclusively refers to the single use parts and assumes a recycling rate of 40.7% for the stretch film and 82.5% for the carton, whereas the rest is either incinerated or landfilled. As this refers to an average European scenario, a 50/50 split between incineration and landfill is assumed.

The carbon footprint of the 3M™ PSG handle is based on a simplified model, which only considers the main materials (steel, aluminium, polymers) and excludes assembly and upstream transport.

Description	Item	Carbon footprint [kg CO_2 eq.]	Mass [g]	Use cycles
Performance Spray Gun	PSG handle	1.530	264.63	3000
	3M Gravity Atomizing Head	0.105	22.62	20
PPS™ cup system	Reusable (outer) cup with label	0.162	44.8	50
	Lid	0.107	16.5	1
	Filter	0.005	0.44	1
	Plug	0.006	2.2	1
	Locking ring	0.024	9.55	1
	Liner	0.025	8.7	1
PPS™ Cup Packaging	Carton + stretch film	0.004	7.28	1
Disposal of single use components	incineration/landfill/recycling	0.060		

Annex B: Setup Description

Annex B provides detailed description of evaluated three spray gun setups.

B1. Setup #1 = 3M™ vented cup (single use) + metal spray gun

The metal spray gun consists of numerous metals and some plastic parts. For this study, samples of some readily available metal spray guns that are commonly used within the collision repair industry by painters and technicians alike were disassembled to model an average metal spray gun. Figure 5-1 shows the spray guns analysed.



Figure 5-1: Metal spray guns DeVilbiss TEKNA® Prolite and Anest Iwata

The cup system for Setup #1 is the 3M vented cup, as shown in Figure 5-2. No separate mixing cup is required. To convert the metal spray gun over to accept the 3M vented cup, a stainless-steel adaptor is provided, which is attached to the (typically) threaded fluid inlet of the metal spray gun.

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Figure 5-2: 3M™ vented cup (single use)

B2. Setup #2 = reusable cup + metal spray gun

For Setup #2, the metal spray gun analysed was identical to the metal spray gun described for setup#1. The paint cup/spray gun reservoir is a reusable metal or plastic cup as shown in Figure 5-3. These cups are attached directly to the spray gun and no adapter is required.



Figure 5-3: Reusable cups of the traditional systems

The paint is mixed in a disposable mixing cup, which is shown in Figure 5-4 and then filtered through a disposable filter which is also shown in Figure 5-4.



Figure 5-4: Single use mixing cup with filter

The spray gun and the reusable cup need to be cleaned with solvents.

B3. Setup #3 = PPS™ 2.0 spray cup system + 3M™ Performance Spray Gun

The 3M™ Performance Spray Gun consists mainly of durable light-weight plastic parts and is shown in Figure 5-5.



Figure 5-5 3M™ PSG (Performance Spray Gun)

No separate mixing cup or filter is required as the spray gun is designed to work with the 3M™ PPS™ product.

The 3M™ Performance Spray Gun integrates seamlessly with the 3M™ PPS™ Series 2.0 Spray Cup System. The PPS™ cup system consists of a reusable cup and disposable liner and filter lid. The paint or sprayable coating is mixed directly in the inner liner. Figure 5-6 shows the components of PPS™ system.

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Figure 5-6: 3M™ PPS™ reusable cup (left) with disposable liner (right) and disposable lid with filter (bottom right)

Similarly to the cleaning process for the metal spray gun, solvents are used to clean the atomizing head of the 3M™ Performance Spray Gun between uses.

B4. Booth operation

The paint application takes place in a temperature-controlled booth as shown in Figure 5-7. The process involves four key modes: Spray Mode, where paint is sprayed onto the vehicle with controlled air pressure and temperature, with fresh air heated and filtered before entering the booth and overspray exhausted; Flash Mode, which increases booth temperature to release solvents from the paint before the next coat or final cure, with duration depending on paint type and application method; Cure Mode, where paint is cured at up to 200°F (93°C) with air recirculated and heated to maintain the preset temperature; and Cool Down, where the booth and heating unit cool down automatically after curing, ensuring safe handling. Automotive repair spray booths are generally equipped with ventilation systems but typically lack dedicated VOC exhaust gas abatement (e.g., thermal oxidation).



Figure 5-7: Paint application