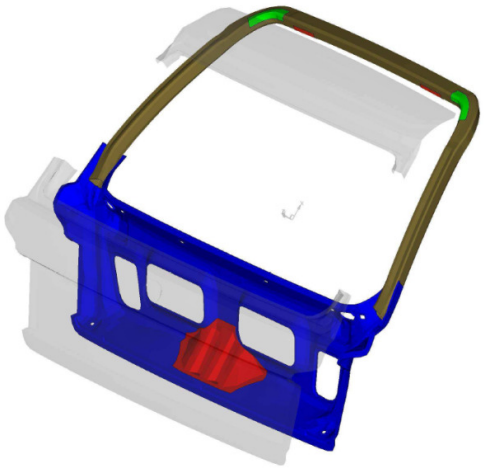


BACKGROUND

At a North American Great Designs in Steel Conference (GDIS), General Motors and the Massachusetts Institute of Technology (MIT) presented research comparing lightweight materials for a liftgate closure panel, evaluating functional performance, mass and cost. Their study compared a mild steel liftgate from a compact 2-door vehicle (baseline or reference) with three alternative designs, fabricated from Advanced High-Strength Steel (AHSS) aluminium and SMC composite. The AHSS design included hydroformed tubes, the aluminium design was completely stamped and the SMC design was molded. Each design passed the performance criteria. The materials, equivalent mass savings and the associated cost for mass reduction are summarized in Table 1:

Table 1: GM/MIT Lift Gate Study Mass Savings Results and Associated Cost

	Total Mass (kg)	Mass Savings (kg)	Cost Difference	Δ $ / Δ kg
Baseline	12.32	---	---	---
Steel	7.81	4.51	$ -3.15	**
Aluminum	6.77	5.55	$ 28.54	5.14
Composite	8.05	4.27	$ 3.15	0.74

LIFE CYCLE ASSESSMENT PARAMETERS

A vehicle Life Cycle Assessment was conducted for each liftgate material/design, using the latest UCSB GHG Materials Comparison Model, featuring updated life cycle inventory (LCI) data for steel and aluminium. The mass of each lift gate design was substituted for the mass of the mild steel liftgate (our baseline). Secondary mass reduction is considered at 30%. The vehicle powertrain for the liftgate LCA is an internal combustion engine with an estimated lifetime mileage of 200,000 km and fuel consumption ratings of 7.0 L/100km or 33.6 mpg, typical for a compact car. All evaluations included consequential system expansion, which includes optimized recycling rates (alpha = 0.1), and thus favors materials with high manufacturing emissions. Finally, we use a HYZEM driving cycle which is a composite of aggressive urban-rural driving behaviour.

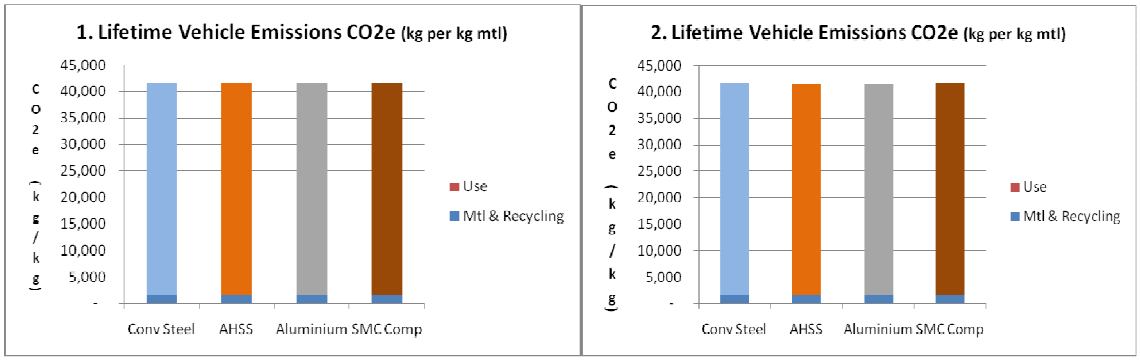
The following tables and graphs show the LCA results: For Table 1, the powertrain is not resized, to simulate reality involving small component weight reductions; in Table 2, the powertrain is re-sized for equivalent vehicle performance, favouring light weight materials.

Table 1: GM Liftgate Study: Compact Car, ICE-G, 7L/100km, VCW 1260 kg, Hyzem, 200,000 km, Recycling - alpha = 0.1, no powertrain adjustments

		In kg of CO2eq			
Liftgate Material	Mass	Material	Recycling	Use	Vehicle Life Cycle
Conv Steel	12.32 kg	2,713	(1,135)	40,103	41,681
AHSS	7.81 kg	2,691	(1,125)	40,053	41,619
Aluminium	6.77 kg	2,786	(1,193)	40,041	41,634
SMC Comp	8.05 kg	2,778	(1,114)	40,055	41,719

Table 2: GM Liftgate Study: Compact Car, ICE-G, 7L/100km, VCW 1260 kg, Hyzem, 200,000 km, Recycling – alpha = 0.1; Powertrain re-sized for equivalent performance

Liftgate Material	In kg of CO2eq				
	Mass	Material	Recycling	Use	Vehicle Life Cycle
Conv Steel	12.32 kg	2,713	(1,135)	40,103	41,681
AHSS	7.81 kg	2,691	(1,125)	40,009	41,575
Aluminium	6.77 kg	2,786	(1,193)	39,987	41,581
SMC Comp	8.05 kg	2,778	(1,114)	40,014	41,678



CONCLUSIONS

1. ***AHSS is the only material and design option that resulted in mass, cost and emission savings in all life cycle phases, compared to the baseline design.***

2. Life Cycle Assessment is required to fully evaluate the effect of materials substitution on vehicle emissions, to avoid unintended consequences. This study confirms that the lowest mass design (Aluminium) does not achieve the lowest vehicle life emissions.

3. The AHSS liftgate design results in lower vehicle emissions and cost savings = US$3.15 per kg. In comparison, there is no benefit to use aluminium for the additional 1 kg of weight savings; life cycle emissions are higher, and there is a cost penalty = US$5.14 per kg.

4. In this particular study, the SMC design is heavier than the AHSS design, with increased costs and emissions.

5. Mass reduction on a small part contributes very little to overall vehicle emissions reduction, but is optimized with powertrain re-sizing for equivalent performance. Investment in alternative powertrains may be a better long-term solution.