alumobility

Last Mile Delivery Vehicle Project

Last Mile Delivery Vehicle Value Proposition + Scope

Show advantages of Aluminum Intensive Vehicle (AIV) design for Last Mile Delivery Vehicles

Show how aluminum light-weighting benefits battery electric LMDVs

Showcase the role aluminum can play for the industry

The Alumobility LMDV case study shows light-weighting benefits for delivery vehicles

Develop AIV LMDV that meets requirements of the market relative to Steel ICE benchmark & Steel BEV

Key Requirements: optimized size and weight of payload, mileage range, durability, driver ergonomics for driving and delivering

- Benchmark data studies
- Business case and Life Cycle Assessment
- Vehicle Package CAD Layout
- Design renderings, concept visuals, ergonomic studies

Last Mile Delivery Vehicle (LMDV)

Ecommerce Logistics

Order
Customer
Orders
Online

Ship Request
Remote DC /
Manufacturer

Regional DC

Middle Mile
Shipped to Local DC

Last Mile
Delivery to home / office

Avg. Speed: *12 miles/h*
19 km/h

Avg. Daily Distance: *57 miles*
92 km

Click-to-Ship

Ship to Deliver

The final vehicles used to delivery packages to their final customer.

Vehicle Assumptions

Aluminum BEV

COMPARED TO

Steel ICE + BEV

For the same gross vehicle weight and duty cycle, a lightweight **AIV requires less battery capacity and less motor power** to achieve the same performance.

AIV has more payload capacity as compared to steel.
BEV gives bigger volume versus ICE.

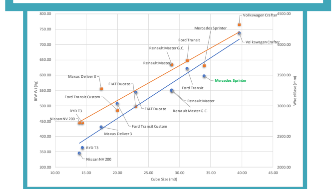
Energy consumption is improved at GVW and even better in real life operation (from fully laden to unladen).

LMDV: Benchmark Analysis — Efficiency Metrics

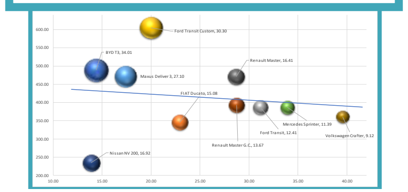
- Compared benchmark vehicles across systems
- Normalized weight to size using cube size of vehicle

Mercedes Sprinter and **Volkswagen Crafter** were the most efficient and were used as **Baseline Vehicles**

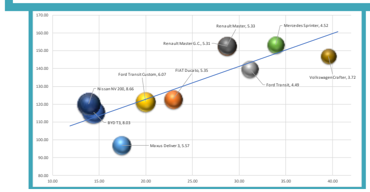
BIW Wt Cube Size, Wheelbase vs Cube Size

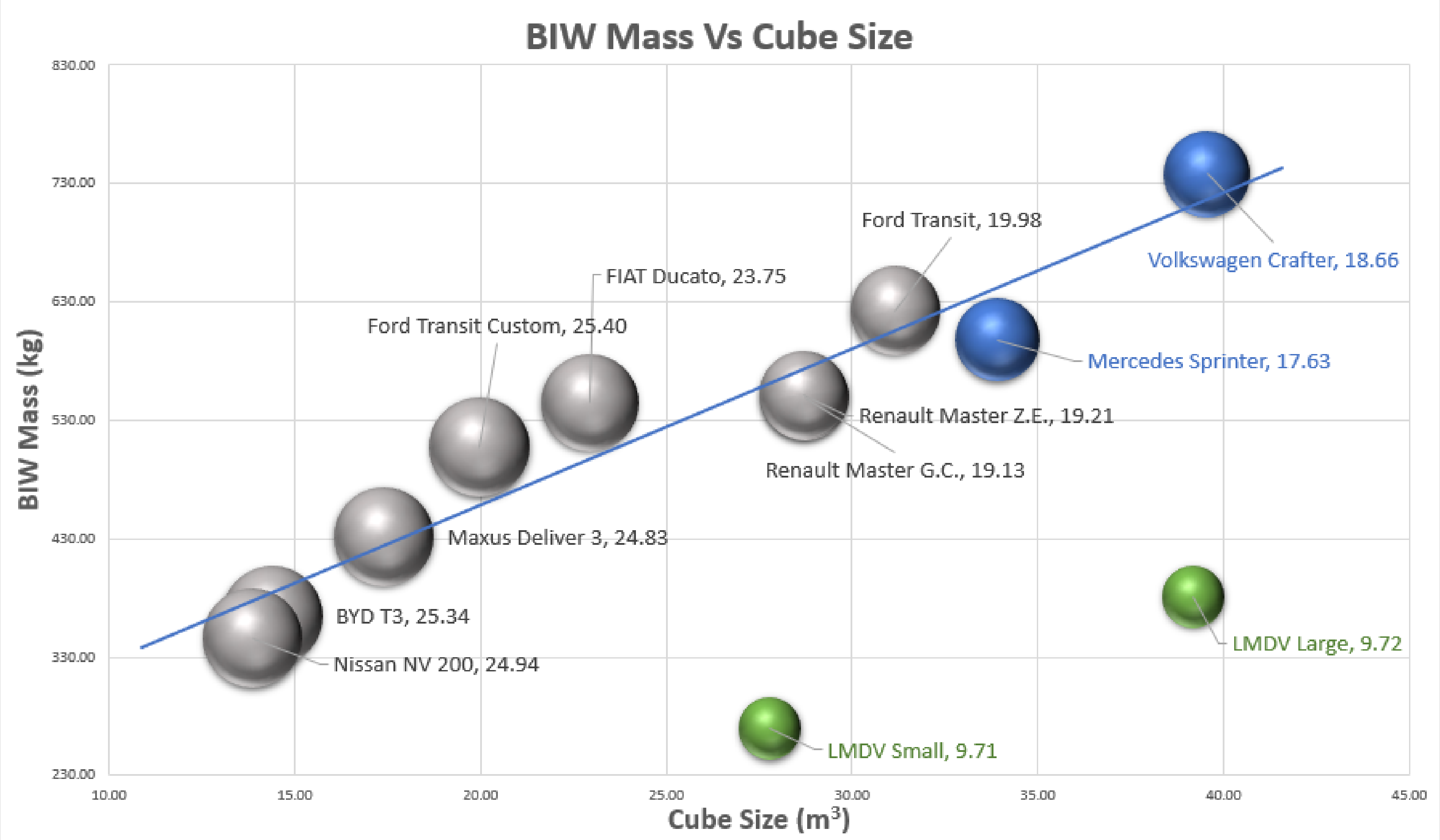


Total Powertrain Wt vs Cube Size *(bubble area = wt/cube)*

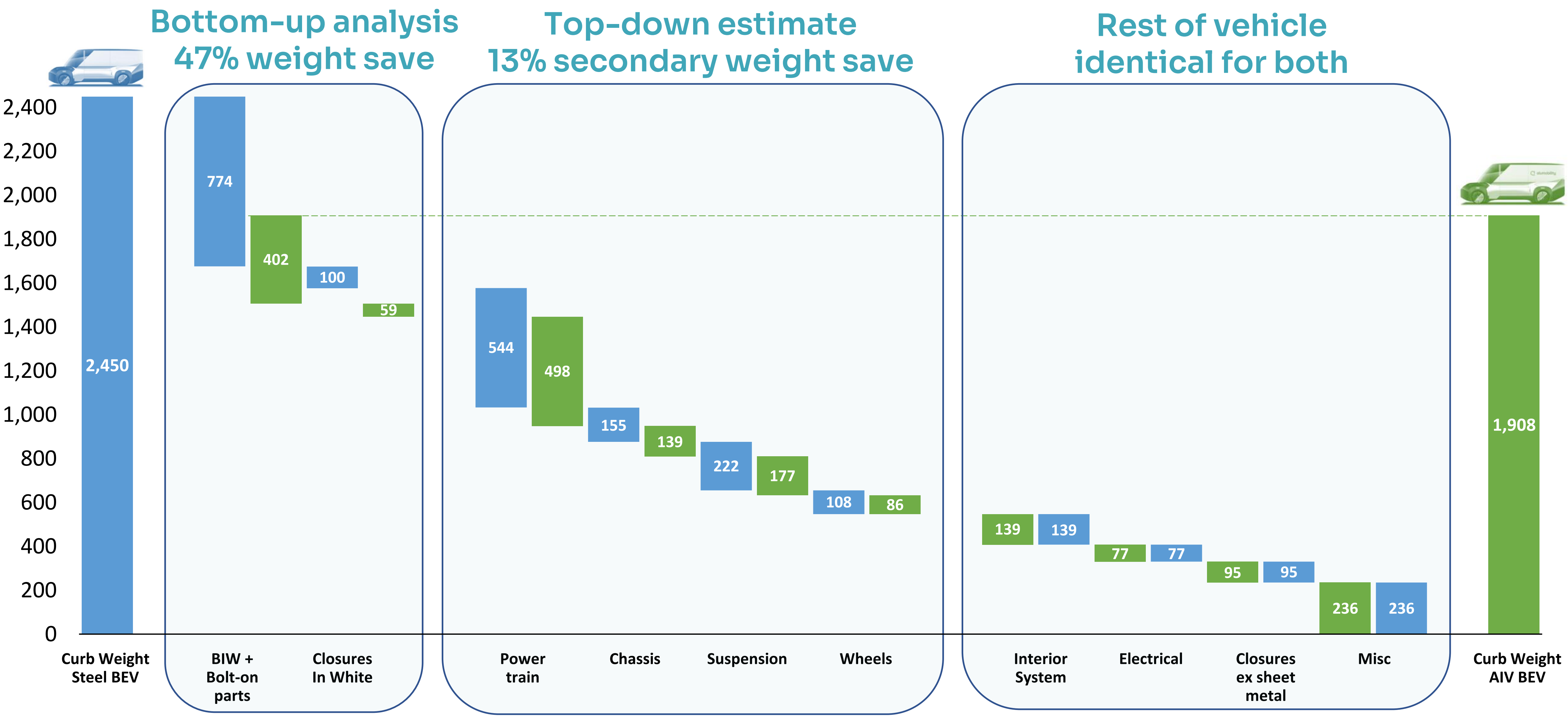


Total Closure in White vs Cube Size *(bubble area = wt/cube)*





LMDV Weight Walk: Steel BEV vs AIV BEV – 22%



Benchmark Battery & Motor Optimization

LMDV: FASTSim

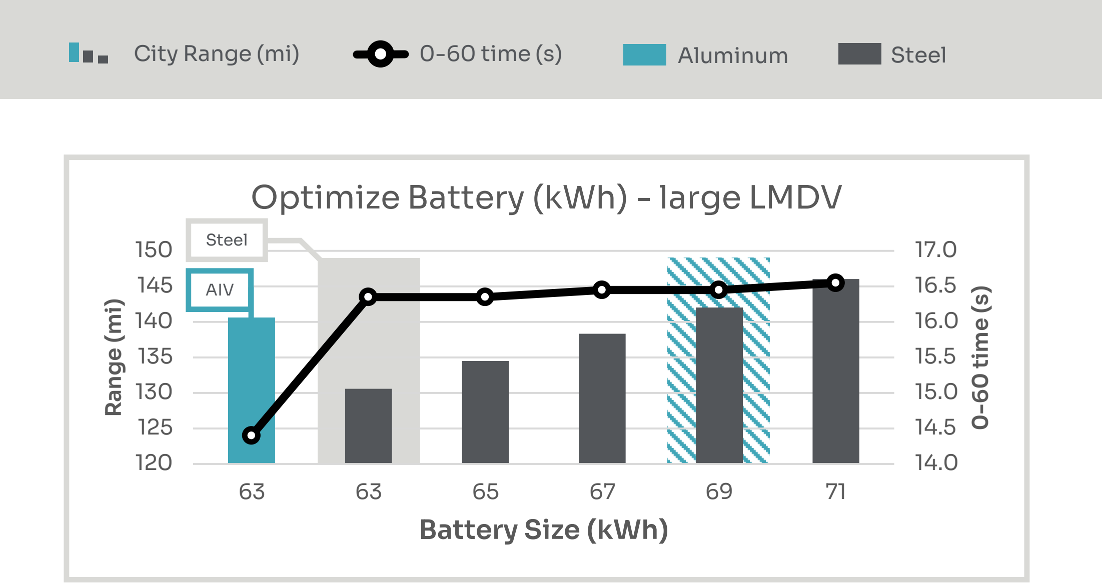
- After designing the AIV-LMDVs, the vehicles weights were calculated as if they used steel ("steel-LMDV")
- The steel-LMDV models were calculated with various battery sizes and motor powers to find comparable range and acceleration to the AIV-LMDVs

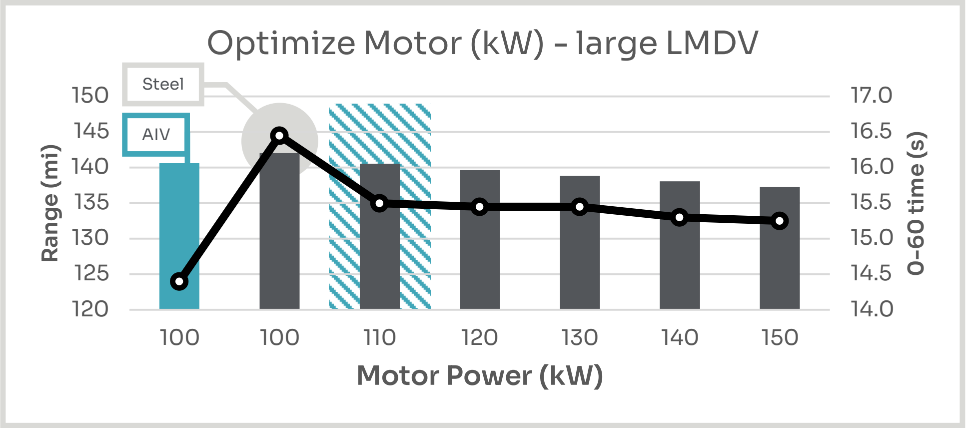
Steel Comparable Performance to AIV

→ **Higher weights reduce vehicle range and 0-60mph acceleration time**

→ **Leading to secondary weight and cost increases for the steel-LMDVs**

	AIV →	Steel
Battery Size (kWh)	63	69
Motor Power (kW)	100	110





Summary

Business cases and life cycle assessment

Aluminum BEV

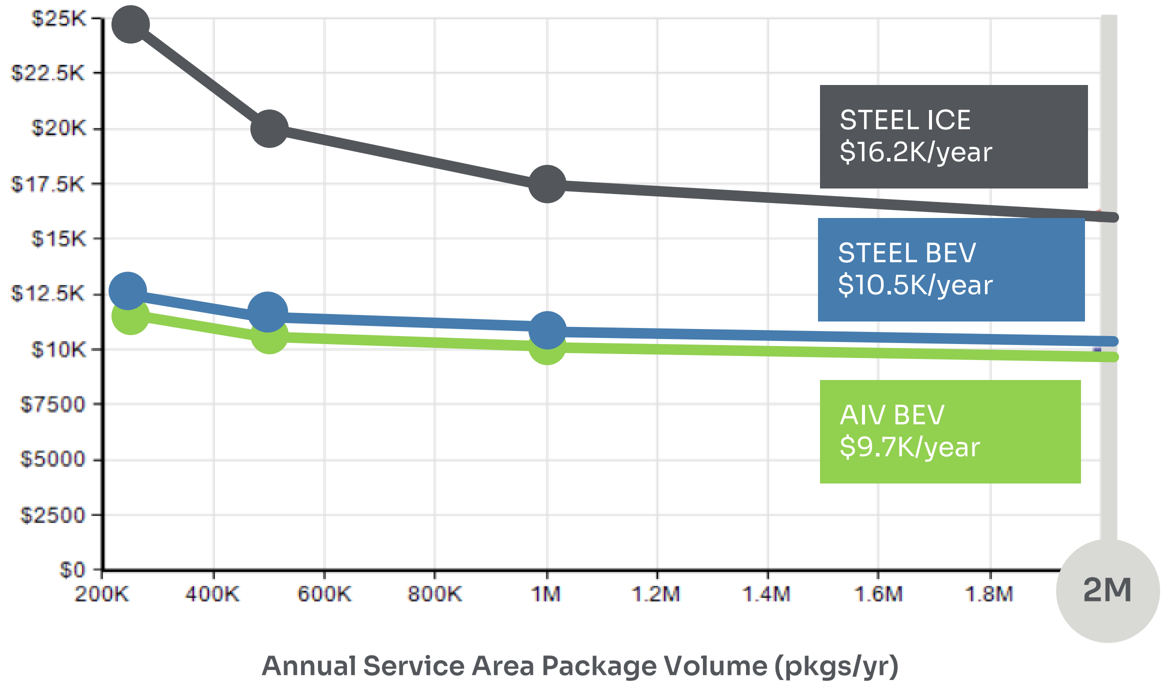
COMPARED TO

Steel ICE + BEV

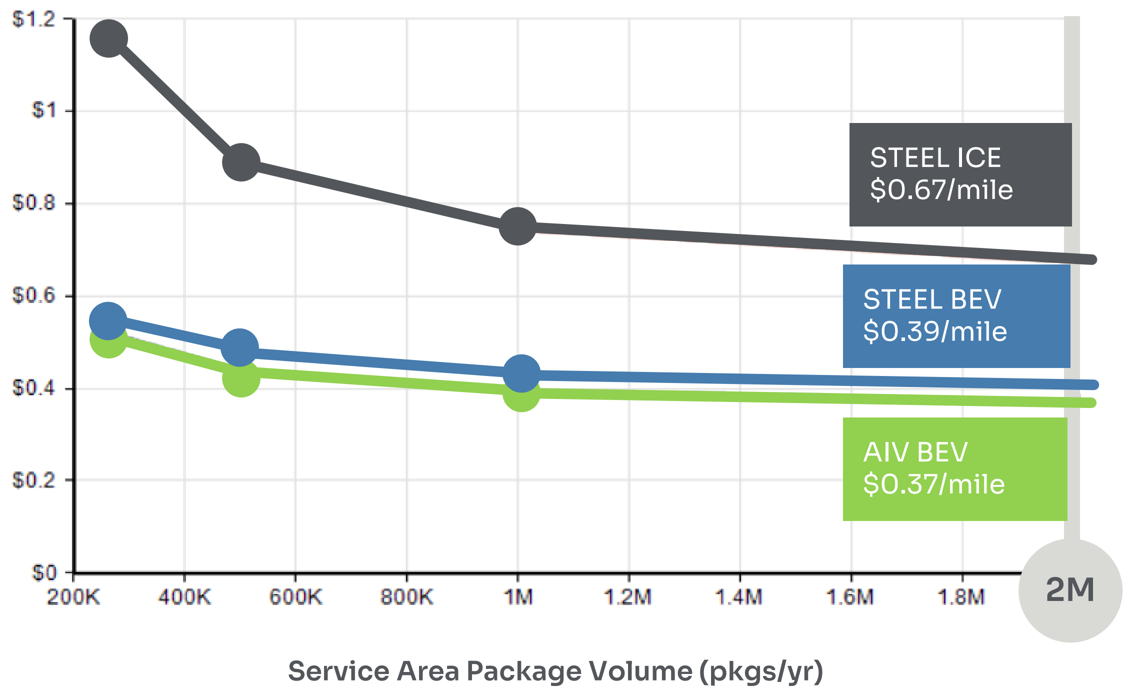
AIV BEV	Steel BEV	Steel ICE
Energy Consumption (100 miles)		
46 kWh	50 kWh	68kWhe
Curb Weight		
1,908kg	2,450	2,321kg
Battery Capacity		
63kWh	69 kWh	n.a. (ICE)

Total Cost of Ownership

Vehicle Annualized Operating Cost (ex labor) [$/year]



Total Cost Per Operating Distance (ex. labor) [$/mile]



BEVs Operate at Similar Specific Cost Levels Across Scale with NO Crossover Point

Key Drivers of Cost Differences

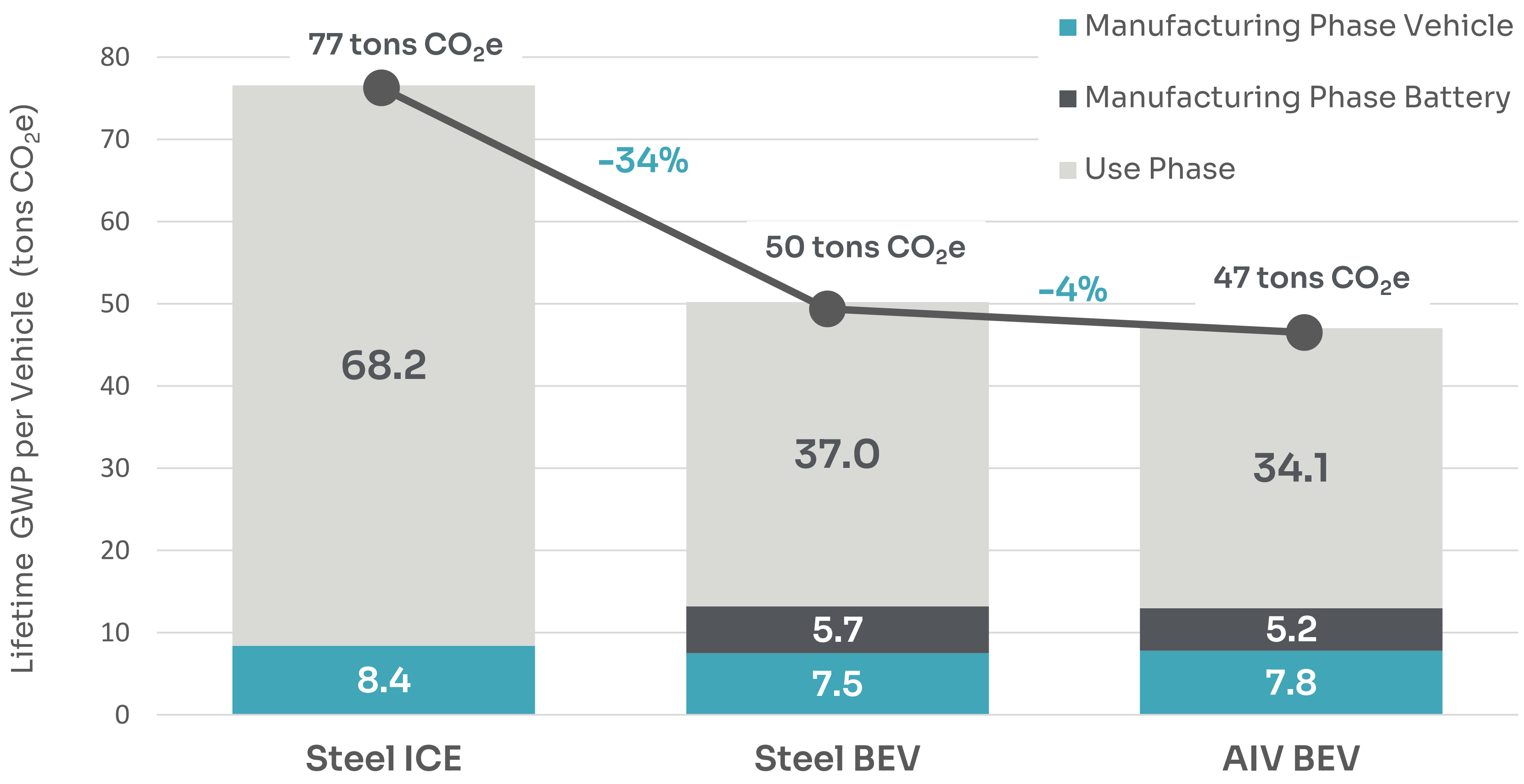
Net Fuel / Electricity Costs

Planned Maintenance

Sustainability

Full Lifecycle CO_2e Emissions

Significant reduction in lifetime emissions when switching from ICE to BEV at current best practice for manufacturing phase = 50% primary metal / 50% pre-consumer scrap



Assumptions
"Today's best practice"

50% primary metal / 50% Scrap

Driving distance –
200k km (124 k mile)

Al CO2 footprint[1] :
Primary: 8.51 kg CO2e / kg
Recycled: 0.51 kg CO2e / kg

Steel CO2 footprint[2] :
Primary: 2.08 kg CO2e / kg
Recycled: 0.48 kg CO2e / kg

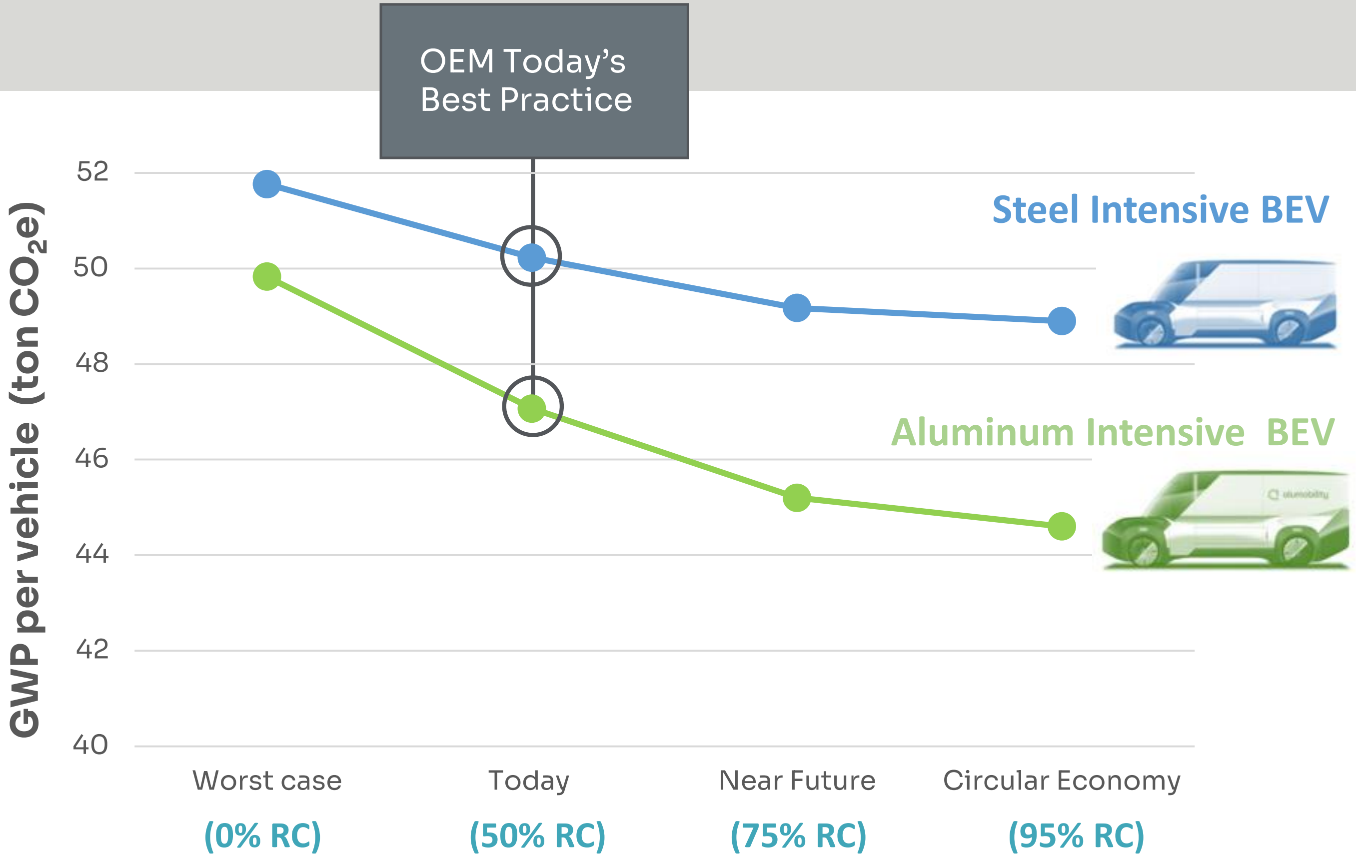
Grid Mix: U.S. 2019

[1] Aluminum Association – LCA Report of semi-fabricated products 2022. [2] World Steel Association – LCI report 2017
Disclaimer – Preliminary results. ISO compliant Third Party critical review in progress and results are subject to change.

Sustainability

LCA of Steel vs AIV BEVs

Increasing recycling rates will further improve lifetime emissions advantage of aluminum intensive vehicles over steel



Worst Case: 100% Primary Metal

- No EoL Credits

Today: Current OEM Best Practice

- 50% Primary / 50% Pre-Consumer Scrap

Near Future: Start using EoL Scrap

- 25% Primary Metal
- 50% Pre-Consumer Scrap
- 25% EoL Scrap

Circular Economy: Steady-State

- 5% Primary Metal
- 50% Pre-Consumer
- 45% Post-Consumer Scrap

LMDV Value Proposition

	AIV BEV	Steel BEV	Steel ICE	% Improvement	
				vs Steel BEV	vs Steel ICE
Cost/Mile	**$0.37/mile**	$0.39/mile	$0.67/mile	**5%**	**45%**
Vehicle Cost of Operation	**$9.7K/year**	$10.5/year	$16.1K/year	**8%**	**39%**
Maintenance Cost (year/vehicle)	**$3200**	$3200	$5300	**=**	**40%**
Curb weight (kg)	**1908 kg**	2450 kg	2321 kg	**22%**	**17%**
Payload by volume	**15.4 m^3**	15.4 m^3	14.5 m^3	**=**	**6%**
0-60 (half loaded)	**14.4 sec**	15 sec	15.5s	**4 %**	**7%**
LCA GWP (200k km)	**47 tons CO2e**	50 tons CO2e	78 tons CO2e	**6%**	**40%**
Battery Size (kWh)	**63 kWh**	69 kWh	—	**10 %**	**n.a.**
Motor Size (kW)	**100 kW**	110 kWh	—	**11 %**	**n.a.**

Assuming 2 million packages per year

LMDV Project Conclusions

AIV BEV Advantages

- LMDVs are ideally suited for lightweighting with aluminum
  - Large, flat panels allow for a 47% mass save
- LMDVs benefit more from lightweighting than other vehicles
  - AIV saves 8% of energy consumption
- For OEMs, lightweighting pays for itself
  - Cost savings in battery outweighs material cost
- For LMDV fleet operators, reduced cost
  - AIV gives 45% cost save vs steel ICE and 5% vs steel BEV
- For the environment, lower lifetime carbon emissions
  - Already in the manufacturing phase