Fuel Economy with Aluminum

The road to fuel efficiency is enabled by Aluminum. Aluminum technology will support an additional 1.5 – 2.0 mpg save.

Todd Summe
Chief Research & Development Officer,
Novelis Inc
The Aluminum Transportation Group

120+ Association Member Companies
Nearly 700,000 jobs supported
$3B invested since 2013
Aluminum Content in North American Light Vehicles 2016 to 2028, Ducker Worldwide, 2017
Increase in Total Aluminum Content for Light Vehicles


63%

** THEN 2012 **

- High volume sheet applications mainly hang-on parts.

** PRIMARY APPLICATIONS: **

- Heat Exchangers, Wheels, Engine Blocks and Heads, Hoods and Decklids

** NICHE APPLICATIONS: **

- Aluminum body, doors, bumpers and crash systems.

** NOW 2020 **

- Demonstrated in high volume for BIW applications.

** APPLICATIONS: **

- ** Status Quo:** Heat Exchangers, Wheels, Engine Blocks and Heads, Hoods, Decklids, Bodyside

- ** Conversion Underway:** Doors (25% of Market by 2020)

- ** Demonstrated Next Step:** High Volume Aluminum body (6% of Market by 2020)
The 2015 Ford F-150 Changed the Game

**Market Share**
- Market Leadership Expanded\(^1\)

**Consumer Price**
- Reported New Model Price Increase\(^2\)
- $395

**Curb Weight**
- Aluminum intensive body with steel frame\(^1\)
- 700 lb

**Fuel Economy**
- Up to 19% better fuel economy\(^1\) (3-5 mpg\(^3\))

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1. Ford’s Use of Aluminum in the F-Series Truck Program By George Luckey, Ford Motor Company, Presented at the Aluminum USA Conference, Oct 25-26, 2017 Nashville TN
Jaguar I-PACE

- **Lb**: 802 lb Body with doors
- **Al**: 91.5% Aluminum Body Content by Wt.
- **Mi**: 234 mile range on a single charge.
- **EV**: Battery box is primarily 6xxx aluminum construction
<table>
<thead>
<tr>
<th>Production Vehicle</th>
<th>Closures</th>
<th>BIW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Al Application</td>
<td>Component Weight Reduction</td>
</tr>
<tr>
<td>2012 Range Rover¹,²</td>
<td>Doors, Hood, Fender, Bodyside</td>
<td>est. 40%</td>
</tr>
<tr>
<td>2014 Cadillac CTS³</td>
<td>Hood, Doors</td>
<td>est. 30%</td>
</tr>
<tr>
<td>2015 Ford F150⁴</td>
<td>Hood, Fenders, Bodyside, Doors</td>
<td>39%</td>
</tr>
<tr>
<td>2015 Cadillac CT6⁵</td>
<td>Hood, Bodyside, Doors, Decklid, Roof</td>
<td>39%</td>
</tr>
<tr>
<td>2019 Chevrolet Silverado⁶</td>
<td>Hood, Doors, Tailgate</td>
<td>36%</td>
</tr>
</tbody>
</table>

1. Bad Nauheim – The all new Range Rover – L405
3. A2MAC1 comparing ATS steel doors to CTS aluminum doors
5. EuroCarBody 2015 – Cadillac CT6 – Car body benchmarking data summary
6. A2MAC1 comparing 2014 to 2019

**Automakers continue to refine aluminum designs.**
The road ahead is enabled by Aluminum

- Global Vehicle Platforms with Regional Regulations supported by the aluminum industry
- Ridesharing and Autonomy supported by the aluminum advantages
- Mixed Powertrain challenges supported by the aluminum advantages
Lightweighting is a key enabler for mixed powertrain platforms

Batteries add weight and will remain heavy:

Even as cost and energy density improves – batteries will continue to weigh 880-1,300 lb in the near to midterm.\(^1\) Lightweighting of structure can help to offset battery weight and cost.

Platform Sharing Adds Weight:

ICE, Hybrid and BEV platform sharing will drive weight addition through due to design trade offs ... structure lightweighting can help to offset weight penalty.

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New Ultra High Strength Aluminum (UHSAL) Rises to the Challenge

Both Sheet and Extrusion product forms rise to the challenge with new UHSAL grades.
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Both Sheet and Extrusion product forms rise to the challenge with new UHSAL grades.
Aluminum Intensive Architectures enabled by Ultra High Strength Aluminum (UHSAL)

ATG Silverado Lightweighting Study, EDAG, 2017
New High Strength Aluminum (UHSAL) Application Map
Ultra High Strength Aluminum (UHSAL): Next steps with BIW

1. High Strength 7xxx Aluminum Alloys: Design and Business Case for Automotive Applications, Bad Nauheim, April 2019
2. Does not include possible cumulative secondary weight savings such as engine reduction

<table>
<thead>
<tr>
<th>Component</th>
<th>Value-in-Use1,2 ($/lb-saved)</th>
<th>Weight1 (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>2.5-3 $/lb-saved</td>
<td>10</td>
</tr>
<tr>
<td>7xxx 1st Gen</td>
<td>1.5-2.5 $/lb-saved</td>
<td>5</td>
</tr>
<tr>
<td>7xxx 2nd Gen</td>
<td>2-3 $/lb-saved</td>
<td>2</td>
</tr>
<tr>
<td>B Pillar</td>
<td>46%</td>
<td>2</td>
</tr>
<tr>
<td>Rocker Reinforcement</td>
<td>48%</td>
<td>2</td>
</tr>
<tr>
<td>A Pillar</td>
<td>45%</td>
<td>2</td>
</tr>
<tr>
<td>Roof Rail</td>
<td>47%</td>
<td>2</td>
</tr>
<tr>
<td>Door Beam</td>
<td>46%</td>
<td>2</td>
</tr>
</tbody>
</table>

1. High Strength 7xxx Aluminum Alloys: Design and Business Case for Automotive Applications, Bad Nauheim, April 2019
2. Does not include possible cumulative secondary weight savings such as engine reduction
Key Enablers to Increasing Aluminum Value-in-Use

Joining
- Resistance Spot Welding
- Remote Laser Welding
- Multi-Material Joining

Forming
- Hot Forming
- Roll Forming
- Textures & Lubes

Recycling
- Closed Loop
- Open Loop
- End of Life

Tailored Performance
- Continuous Casting
- Tailor Rolling & Welded Blanks
- Optimized Extrusion Design
- Multi-alloy Sheet

20-40% Value Improvement
Aluminum Continuous Casting will play an important role across the industry by 2035

Continuous Casting opens new possibilities for transformational alloys, CO₂ footprint, and production efficiency for UHSAL alloys

1.5X

Strength increase new UHSAL 3rd Gen alloys enabled by continuous casting

Significant efficiency improvement for UHSAL alloys
Recycling Aluminum is a key enabler for the future

70-80% of recycle content for new high recycle content grades

100% of production scrap can be returned to the same material in a closed loop

> 90% of aluminum parts are recycled at vehicles’ end of life

1. Automotive Aluminum Recycling Rate Study, Sean Kelly, Diran Apelian, CR3 Center for Resources Recovery & Recycling
Putting it all together.

Less is more: “Lower” Value-In-Use enables broader use

Key Drivers of Value

- Design
- Advanced Alloys (UHSAL)
- Continuous Casting
- Recycling

Value-in-Use on component level ($/lb-saved)


2025-2035: value improvement of 20-40% from strength improvement and key enablers.
Aluminum technology will support an additional 1.5 – 2.0 mpg save ...

... economically and sustainably.