MEETING FUEL ECONOMY & EMISSIONS REGULATIONS WITH ALUMINUM

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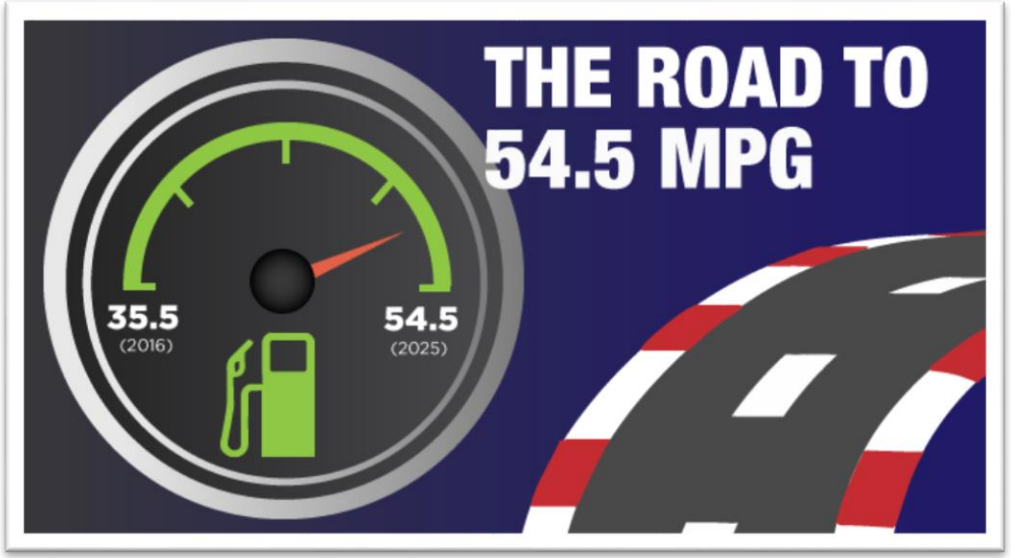
DISCUSSION AGENDA

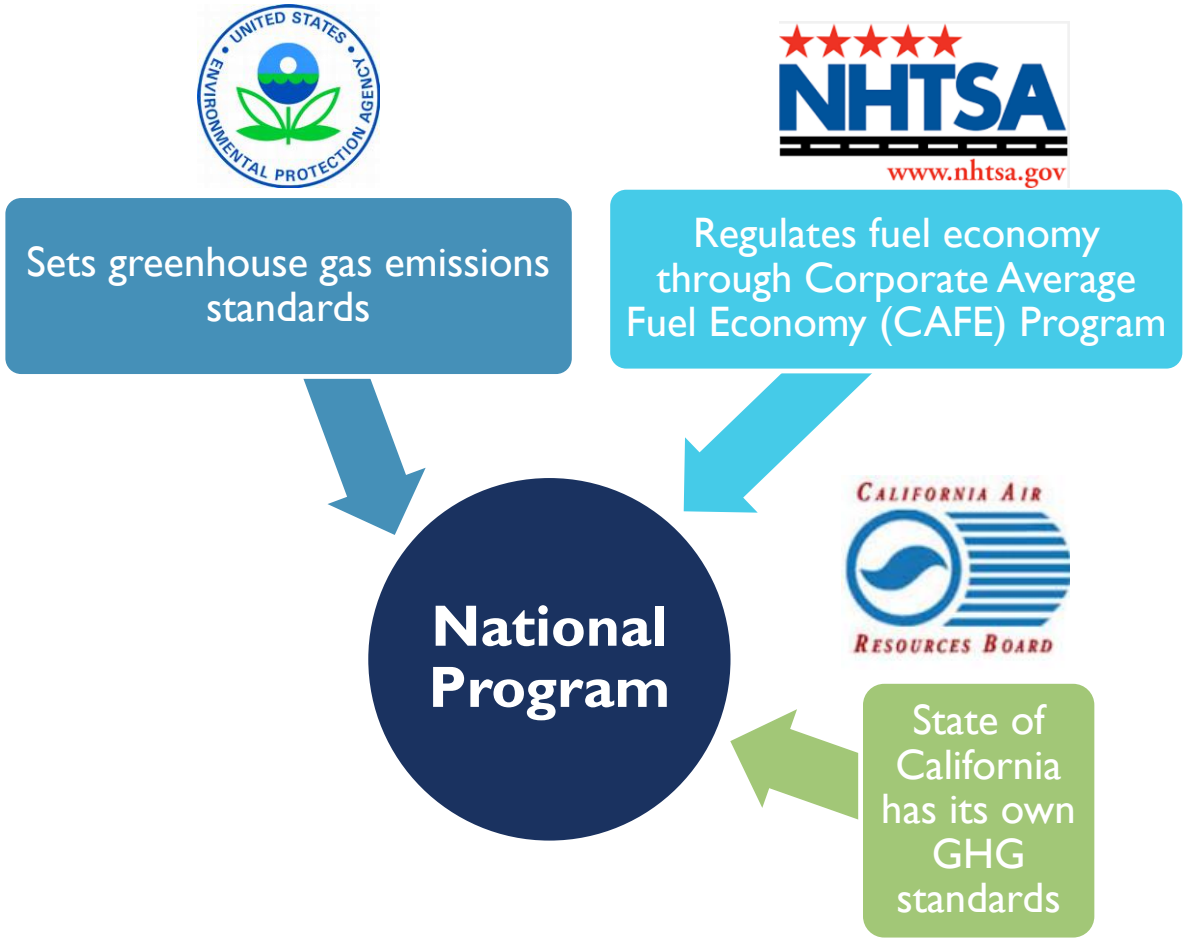
- **What is CAFE?**
- **The Role of Automotive Aluminum**
- **Continuous Improvement**
- **Questions**



CORPORATE AVERAGE FUEL ECONOMY (CAFE)

OVERVIEW

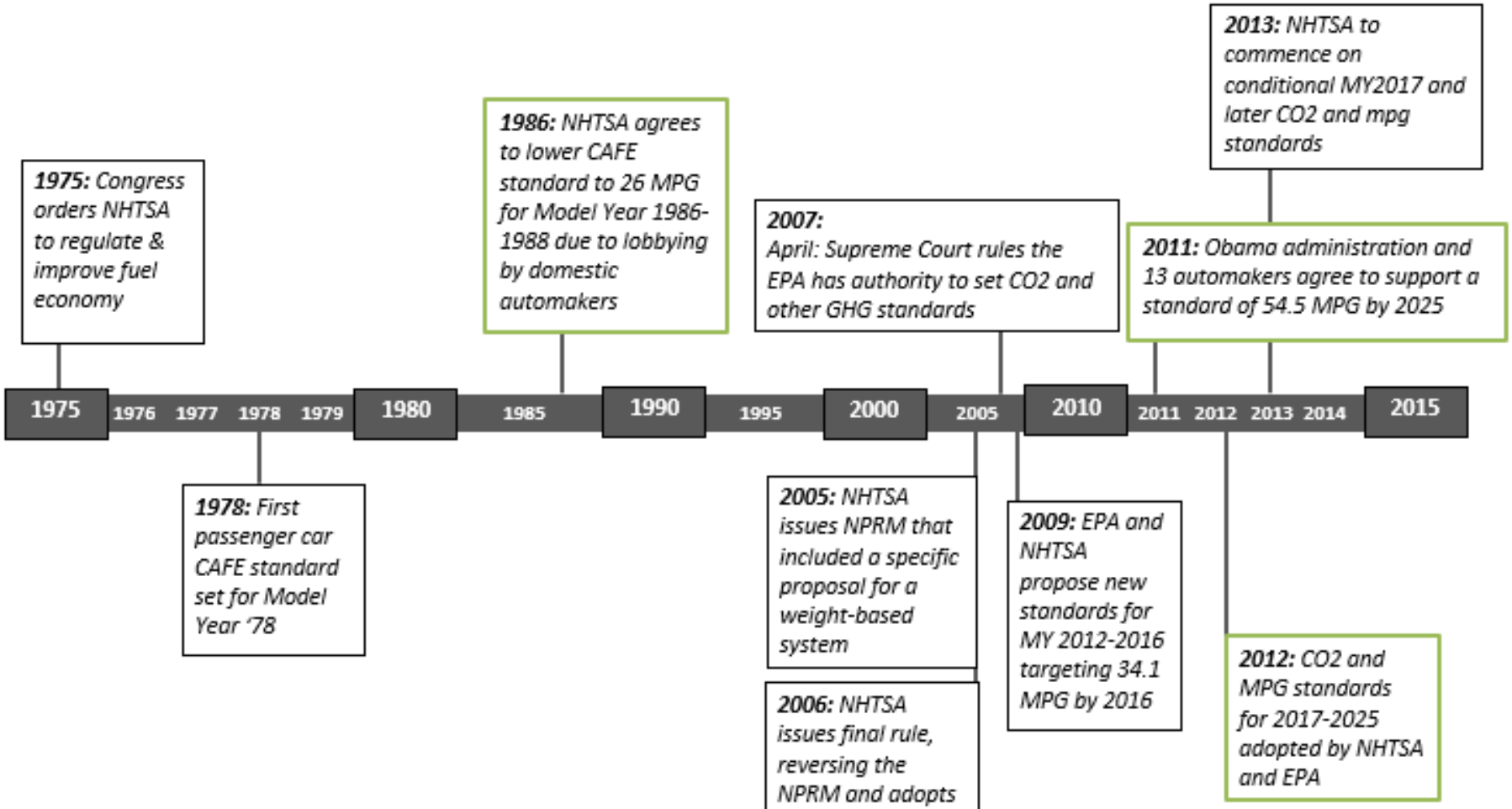
- The National Program to reduce **greenhouse gas emissions**
- **Improvements in fuel economy** for light-duty cars and trucks directly proportionate to reductions in CO2
- Program often referred to collectively as CAFE. **CAFE is only a portion of the standard.**



OPEC OIL EMBARGO

- Members of OAPEC proclaimed **oil embargo in Oct. 1973** against Canada, Japan, the Netherlands, the United Kingdom and United States
- Embargo **raised price of oil by 70 percent,** cut production by 5 percent and add'l **5 percent cut in production** monthly until economic and political objectives were met.
- Peace talks ended embargo in **March 1974**

HISTORY



Source: Edmunds.com

MIDTERM REVIEW

- Initial rule included regulatory commitment to conduct a Midterm evaluation in 2017
- EPA will reexamine the GHG standards for model years 2022-2025
- NHTSA will review fuel economy standards based on the best available technical research information
- Could elect to reduce, maintain or even increase the currently agreed to standard

CAFE OVER THE YEARS

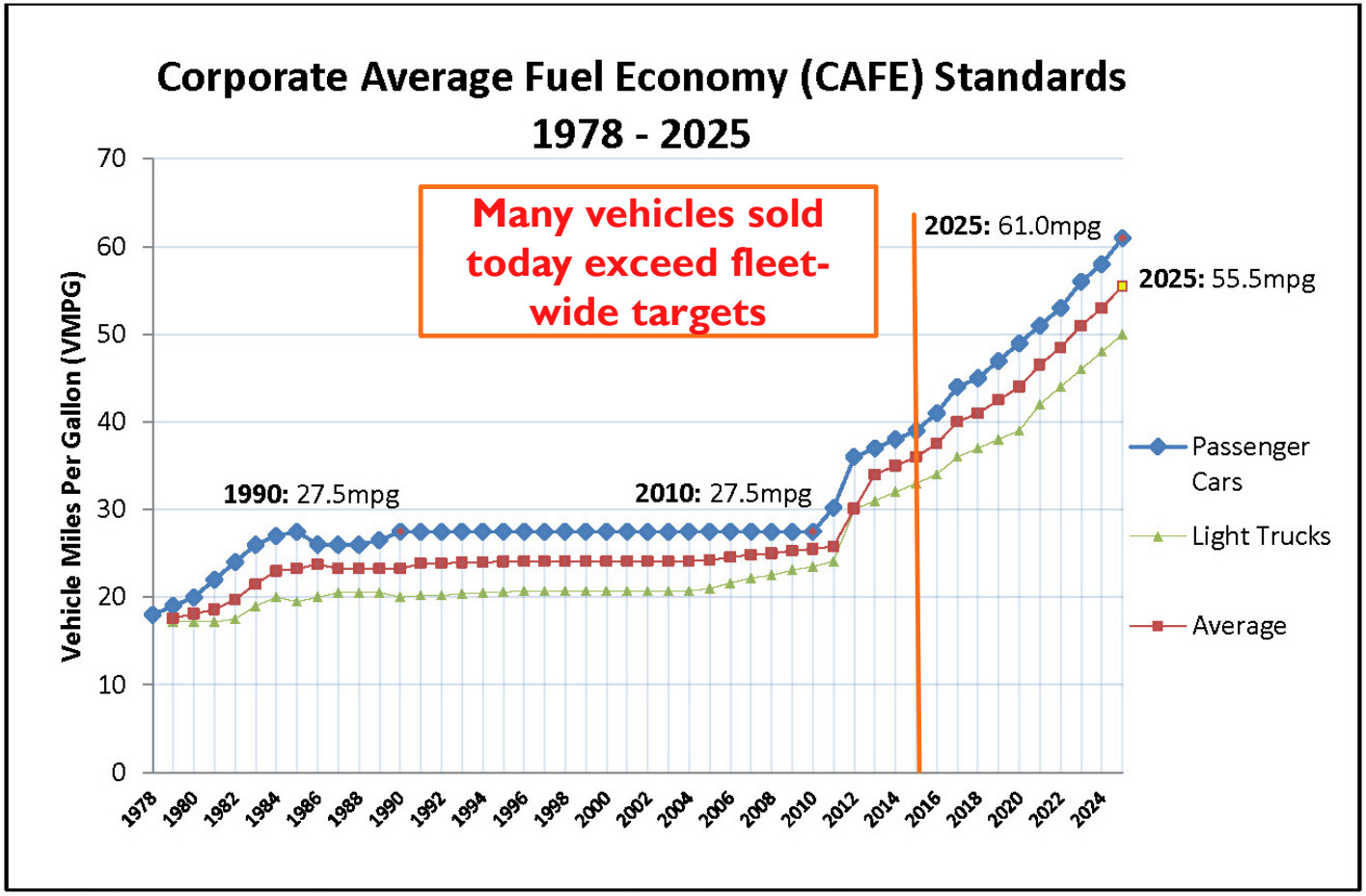
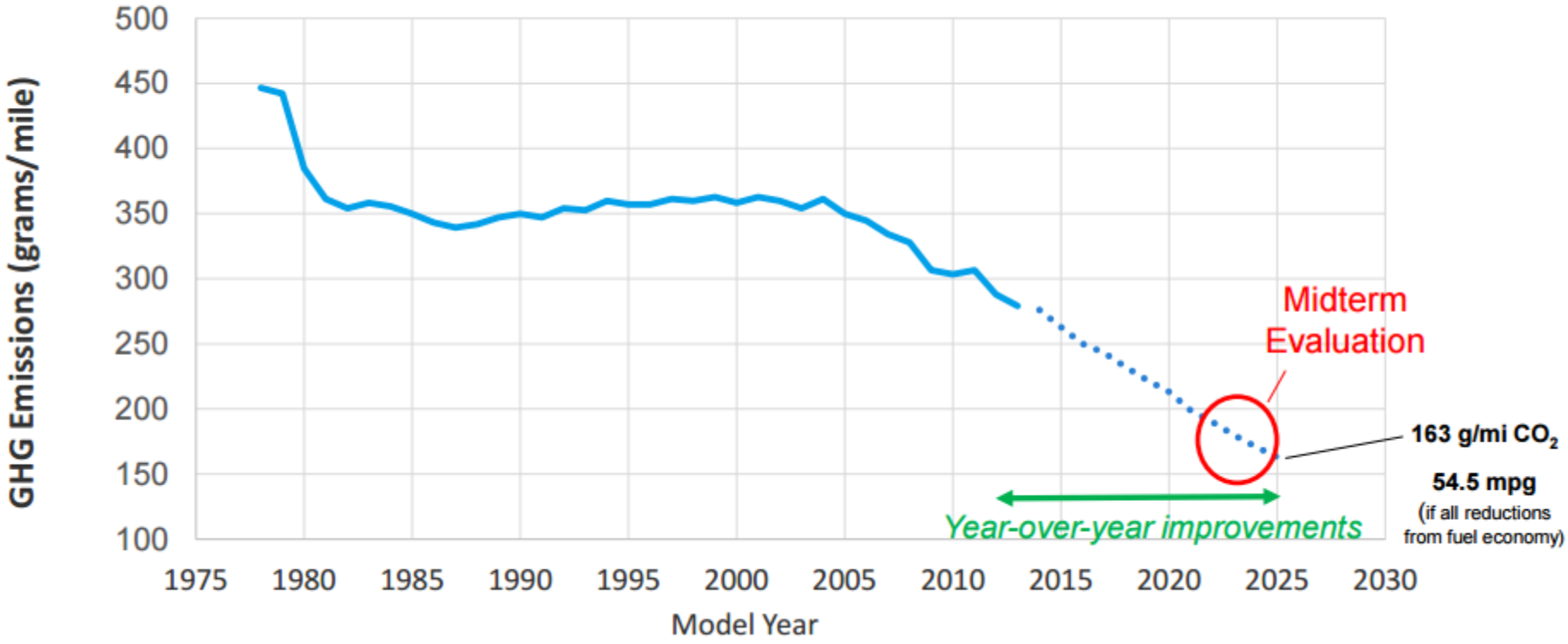


Fig. a | Data Source: (Anderson, Terry , 2011) Graph Credit: Fernando Arias

EMISSIONS DECREASES OVER THE YEARS



MEETING FUEL ECONOMY/EMISSIONS STANDARDS

- **Advanced engine technologies (diesel, hybrid, electric)**
- **Efficient transmissions (CVT, 8-speed)**
- **Aerodynamic designs**
- **Mass reduction: Increased use of advanced aluminum alloys**
- **Credits (two types)**
  - **Off-cycle**
  - **CAFE**

DUCKER WORLDWIDE AUTOMAKER SURVEY

- **2015: Highest growth year**
  - First high-volume automotive body and structure (F-150 pickup)
  - Sheet and extrusions – body, closures
- **By 2020: multiple OEM will have more than one aluminum-intensive body and multiple aluminum-intensive closure programs**

Source: 2015, Ducker Worldwide

THE ROLE OF AUTOMOTIVE ALUMINUM

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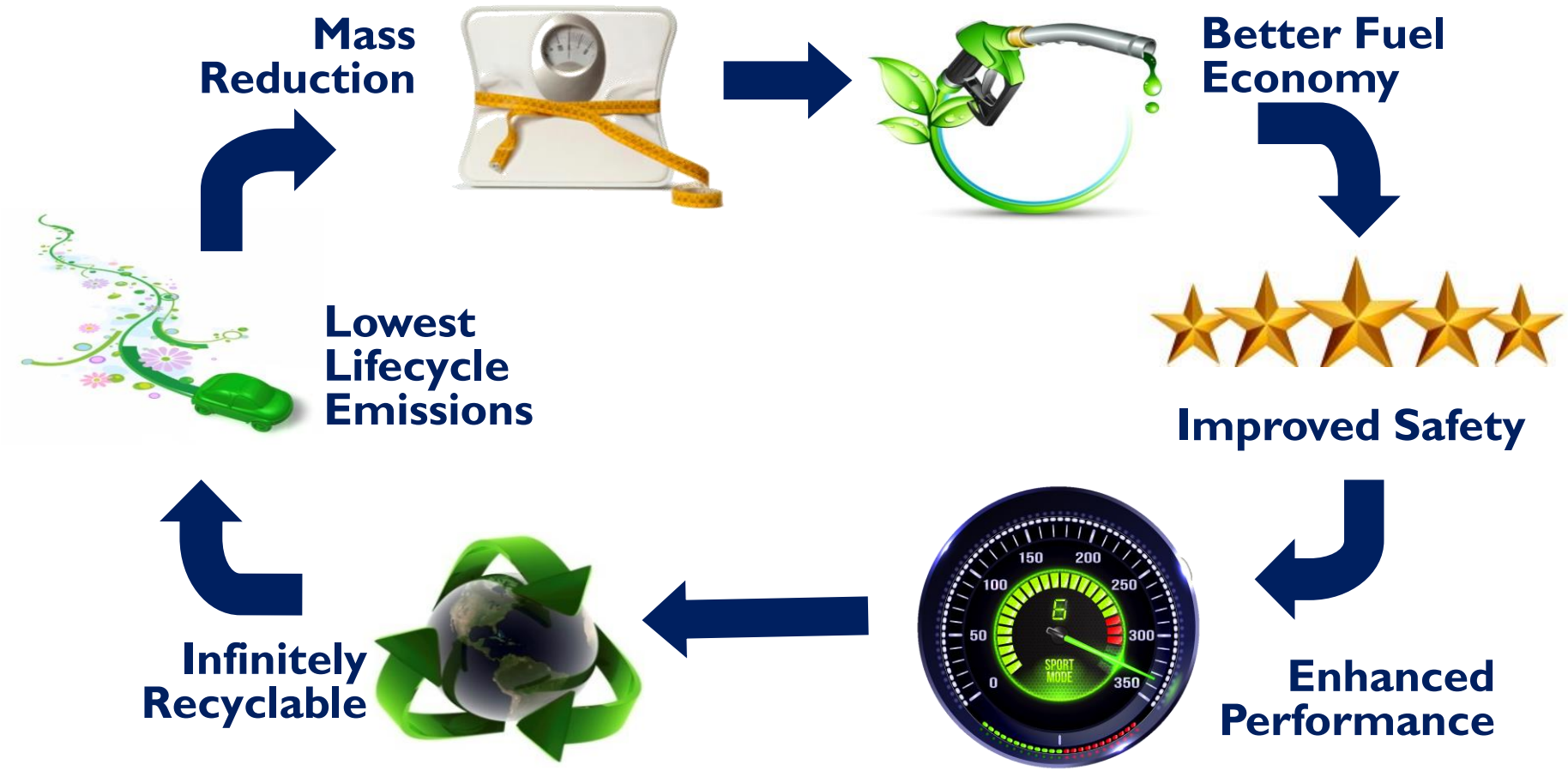
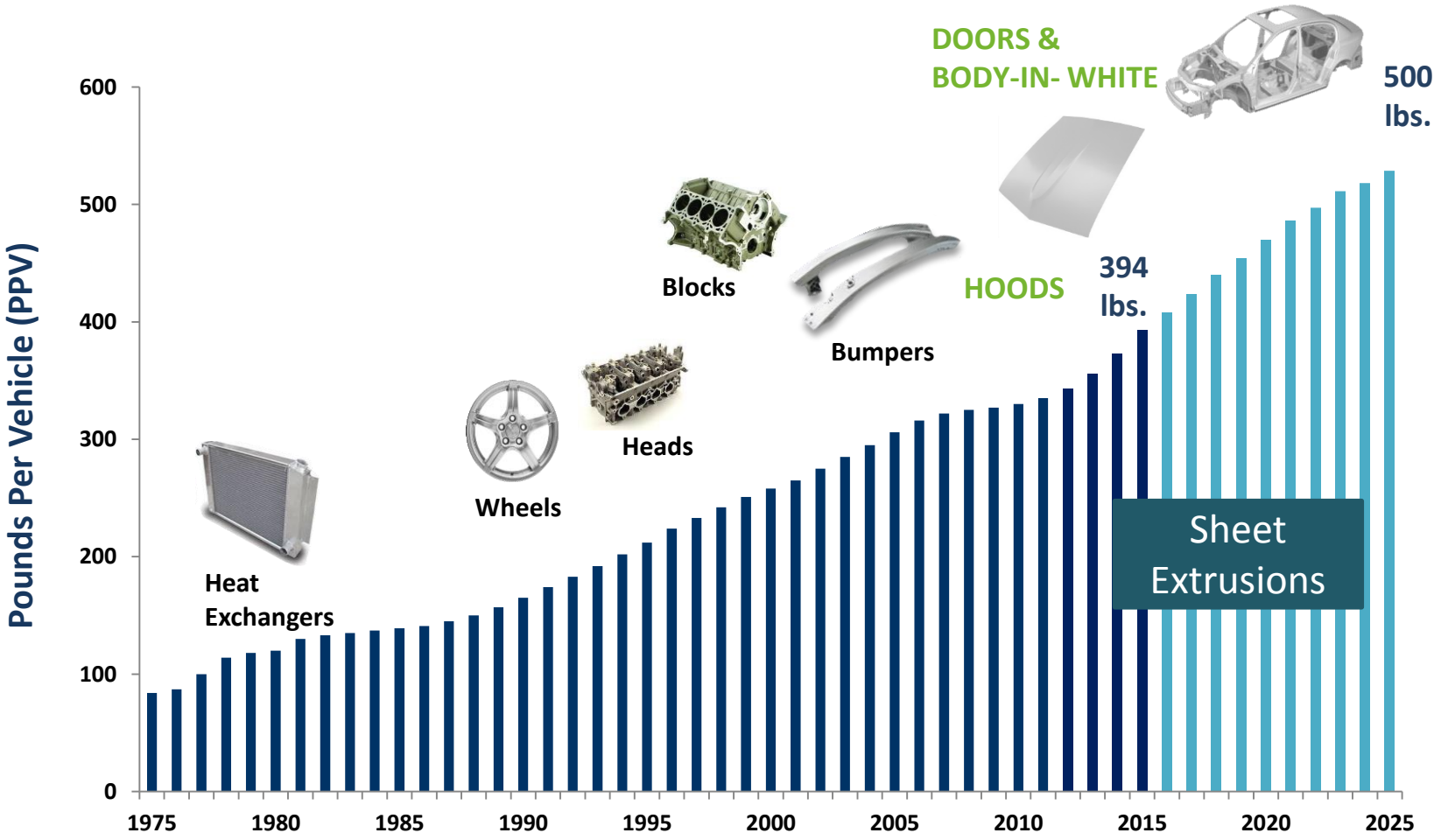
THE VIRTUOUS CYCLE



Source: USGS Minerals Yearbook 2014

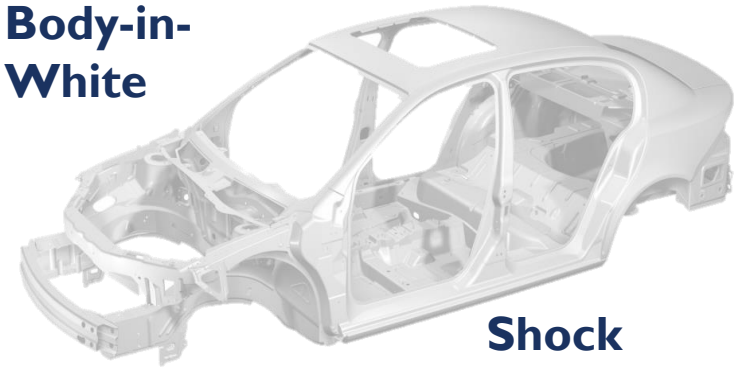
1975-2025: 50 YEARS OF ALUMINUM GROWTH



Source: Ducker Worldwide

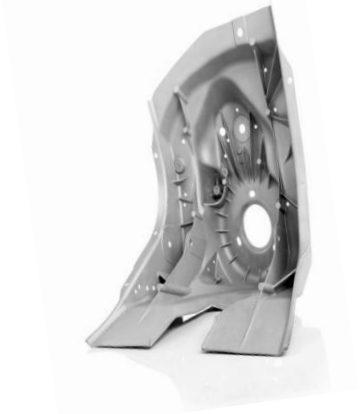
ALUMINUM BODY COMPONENTS

Body-in-White



Bumper Beams

Shock Towers



Fenders

Deck

Door outer

Door outer

Hood

Door and other closure inners

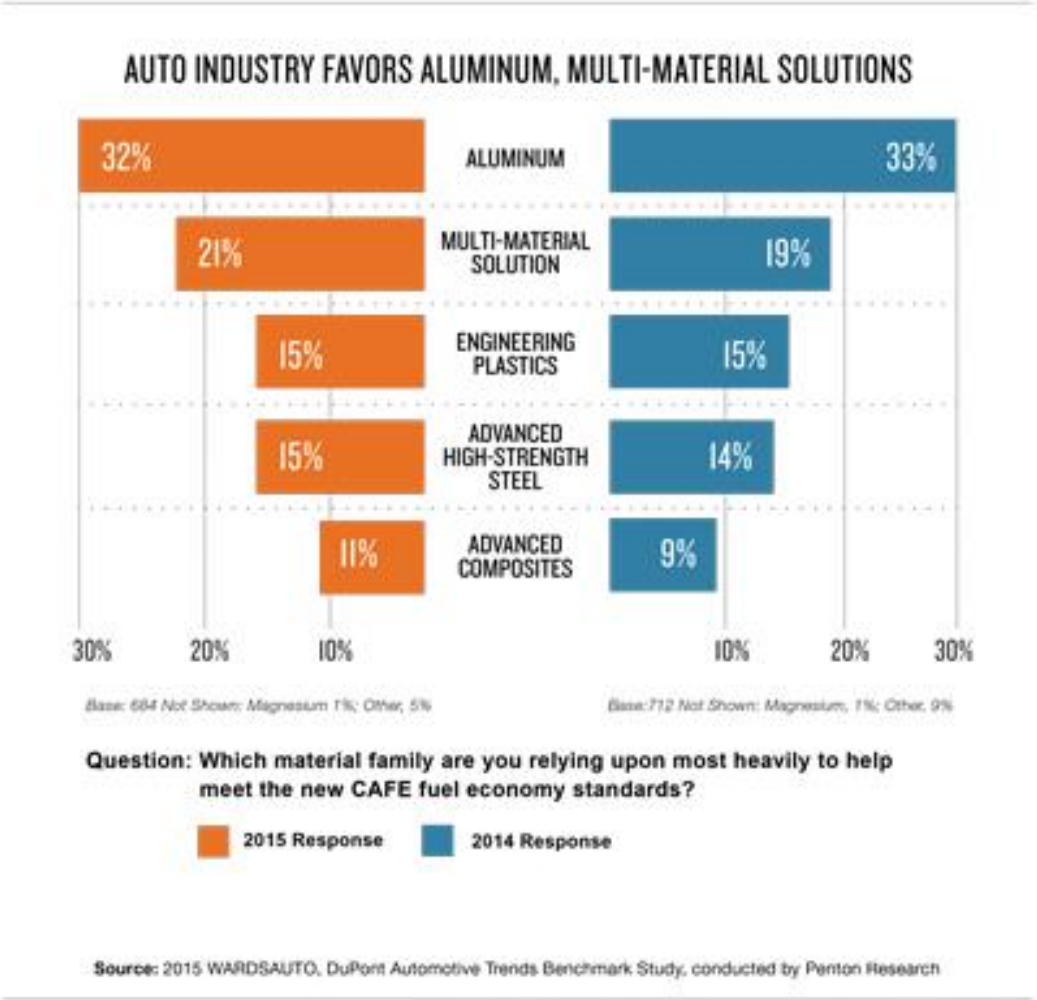
NATIONAL ACADEMY OF SCIENCES STUDY

- **Aluminum is essential to meeting 2025 fuel economy & emissions standards**
- **Estimate of mass reduction needs now 12% (from 7% in earlier study)**
- **More confidence that aluminum use is consistent with current and future safety objectives**

Source: 2015, The National Academy of Sciences

WARDSAUTO/DUPONT AUTO TRENDS STUDY

- **Aluminum favored among designers and engineers to help meet 2025 fuel economy and emissions targets**



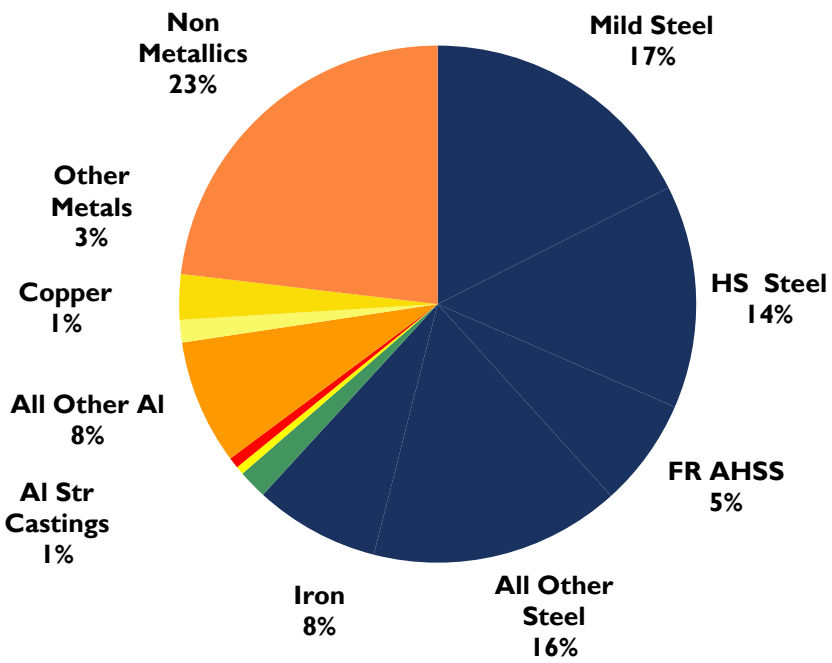
ALUMINUM FILLS KEY REQUIREMENTS

What Automakers Want:

1. **Weight reduction**
2. **Fuel economy/CO_2 gains (regulatory compliance)**
3. **Safety**
4. **Affordability**
5. **Performance**
   - 0-60; handling; ride; noise, vibration, harshness (NVH); braking, etc.
   - Payload, towing capacity

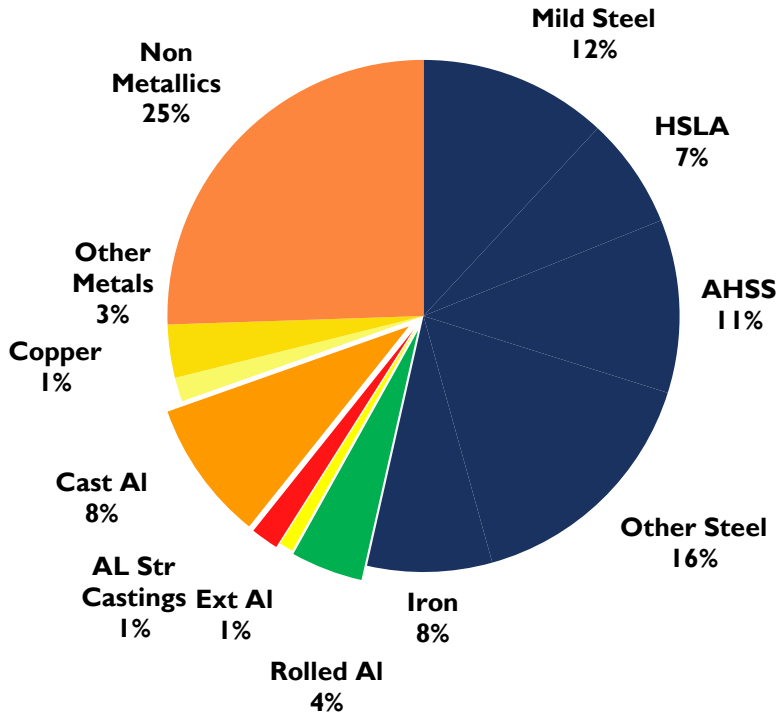
AUTOMOTIVE MATERIAL MIX SHIFT - LIGHTER

2015



Aluminum: 10%
3700 lbs.

2025



Aluminum: 13%
3427 lbs.

MASS REDUCTION WITH ALUMINUM

- **1.0 lb. of aluminum replaces 1.6 lbs. of steel**
  - Body: -40% mass
  - Curb mass: Up to -12%
- **Improved fuel economy**
  - 10% achievable
- **Reduced life-cycle CO_2 emissions**
  - 20% achievable
- **Improved safety**
  - Without downsizing
  - Increase crush space without increasing weight
  - Reduce kinetic energy
- **Cost advantage compared to other fuel economy improvement technologies**

MULTI-MATERIAL VEHICLES: THE NEW NORMAL

ALUMINUM-INTENSIVE VEHICLES

Body-in-White and Closures

MEETING STANDARDS IN THE REAL-WORLD

2015 Ford F-150

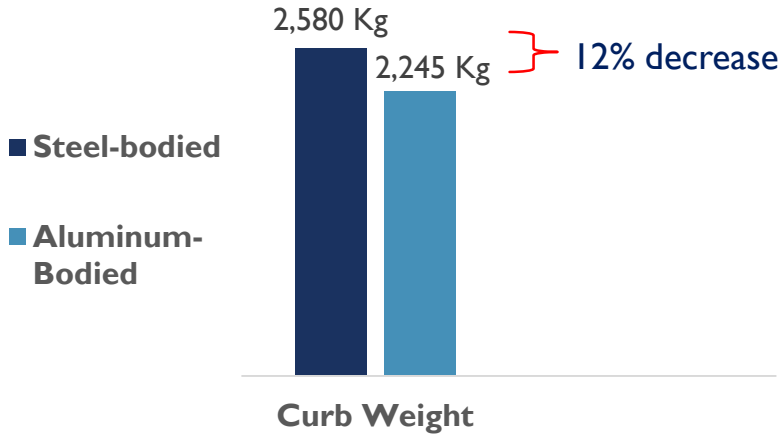
- **EPA: Ford F-150 already meeting 2024 standards**
- **Ducker Worldwide: By 2020, multiple OEMs will have more than one aluminum-intensive body and multiple aluminum-intensive closure programs**

BENCHMARK: FORD F-150

1. Weight Reduction

- 320+ Kg (12%) of curb mass shaved with help of aluminum
- Majority of curb mass reduction achieved via aluminum body-in-white and closures

  Body: - 250 Kg (39%)



Source: Ford Motor Company

BENCHMARK: FORD F-150

2. Fuel Economy/CO_2

- Highest EPA-estimated fuel economy ratings of any full-size gas-powered pickup in America. (19 city/26 hwy/22 combined)**
- Aluminum-bodied Ford F-150 named "Best Environmental Performance" for achieving "the highest level of protection for the environment throughout its life-cycle."***

*Source: EPA
**Source: Ford Motor Company
***Source: Automotive Science Group

BENCHMARK: FORD F-150

3. **Safety**
   - Improvement in every category for aluminum-bodied model
   - 5-star safety rating from the National Highway Traffic and Safety Administration

Year/Make/Model	Overall	Frontal Crash	Side Crash	Rollover
2015 Ford F-150 4x4	★★★★★	★★★★★	★★★★★	★★★★☆
2014 Ford F-150 4x4	★★★★☆	★★★★☆	★★★★★	★★★☆☆

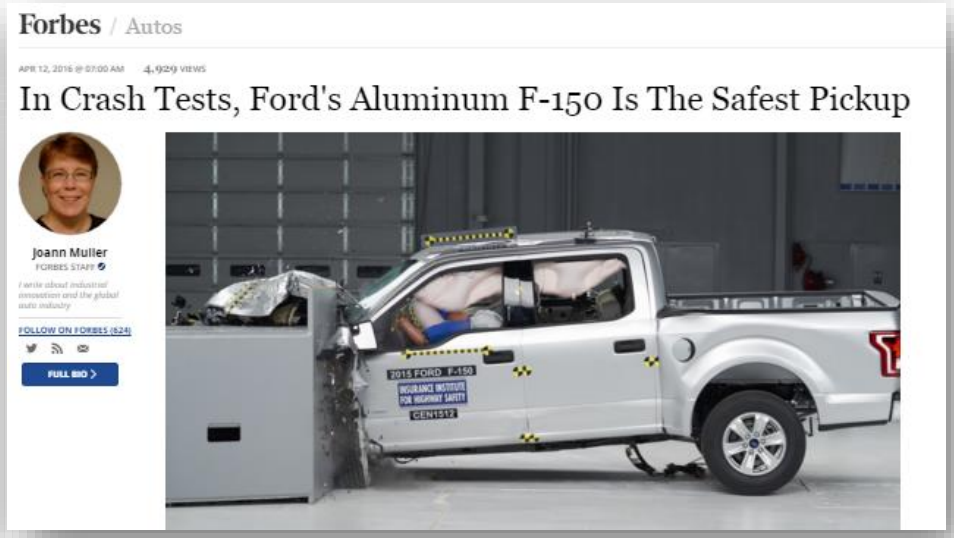
Source: safercar.gov

BENCHMARK: FORD F-150

3. Safety (cont.)

- 2016 F-150 SuperCab named **"IIHS Top Safety Pick"** in April 2016
- Only full-size pickup awarded a "good" rating in all categories

IIHS
Insurance Institute for Highway Safety



BENCHMARK: FORD F-150

4. **Consumer Affordability**

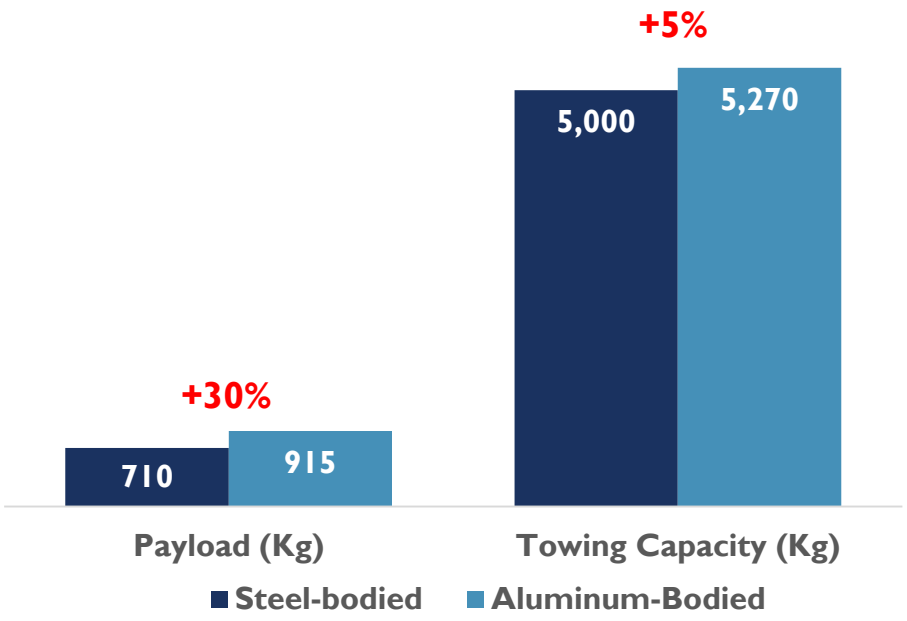
- 2015 base model just $395 more than the 2014 version, despite array of new equipment and technology.
- MSRP increase typical when launching complete redesign.

Source: Ford Motor Company

BENCHMARK: FORD F-150

5. Performance

- Mass reduction = increase load-carrying performance



Based on F-150 SuperCrew Cab with 3.5 L Ecoboost engine and 6.5 ft. bed

Source: Ford Motor Company

CONTINUOUS IMPROVEMENT

ALUMINUM POISED TO MEET 2025 DEMAND

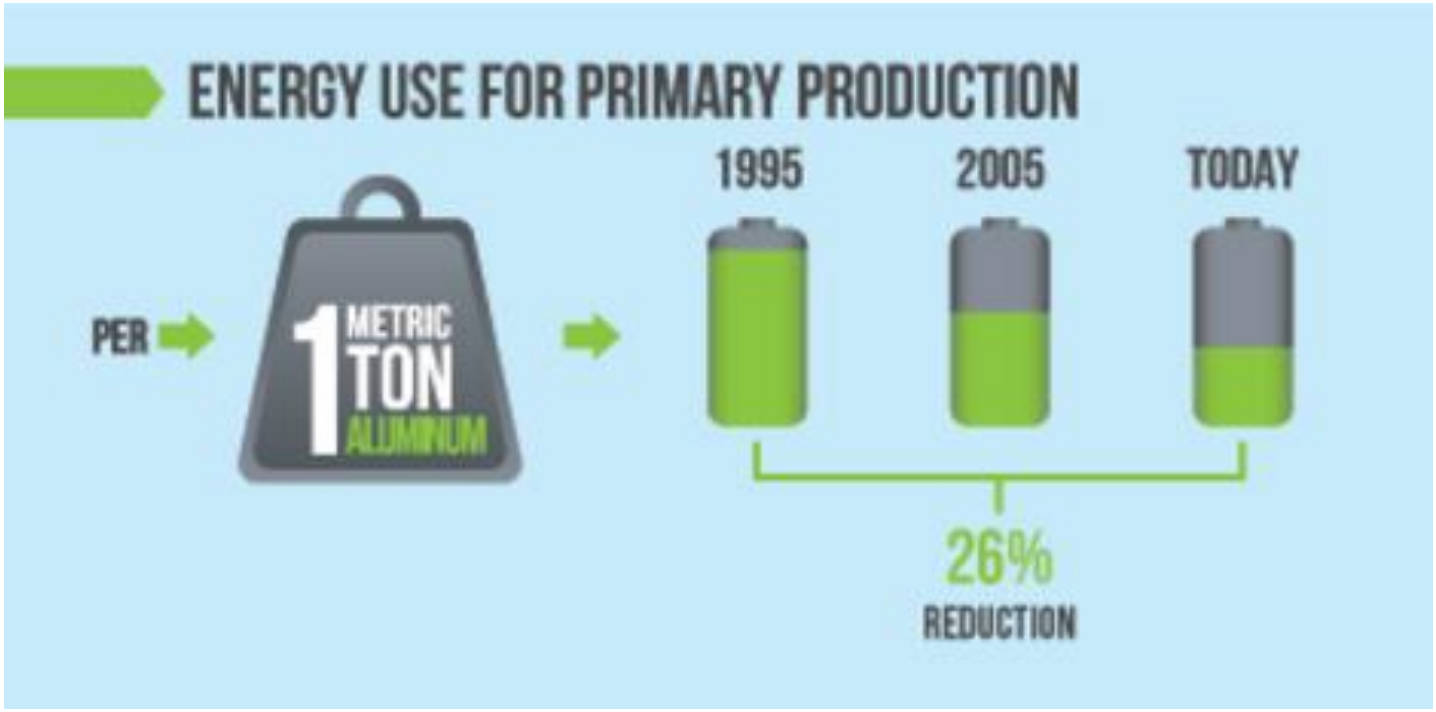
NAFTA Aluminum Rolling Capacity (Sheet and Plate)

		Total S&P	Body Sheet*
2015	Demand	10.6 B lbs.	1.1 B lbs.
	Total Capacity	12.6 B lbs.	
	Domestic	11.3 B lbs.	1.5 B lbs.
	Imports	1.3 B lbs.	-
2025	Demand	13.1 B lbs.	3.7 B lbs.
	Opportunity	+0.5 B lbs.	+2.1 B lbs.

* Unique cold rolling, finishing, HT, coating

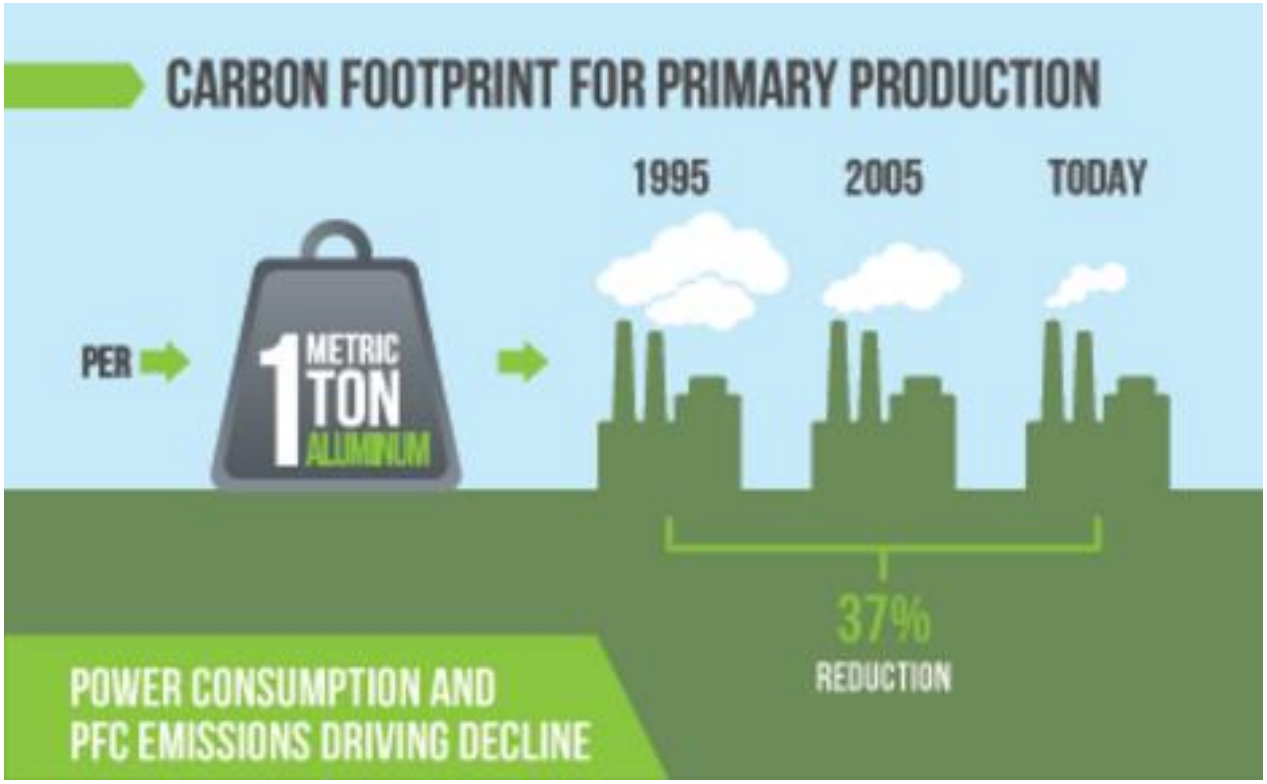
Sources: Harbor, Ducker Worldwide

DECREASED ENERGY USE



Sources: Aluminum Association

REDUCED CARBON FOOTPRINT



Sources: Aluminum Association

U.S. DOE OAK RIDGE NATIONAL LAB

- **Aluminum-intensive vehicles offer lowest life cycle energy (↓ 20%) and CO_2 impact (↓ 17%) vs. modern steel vehicles**
- **Use phase contributes over 90% of life cycle impacts**
- **Steel vehicle's higher use phase energy and CO_2 cancels out production phase advantage**

Source: 2014, Oak Ridge National Laboratory

ALCOA MICROMILL™ TECHNOLOGY

Industry Breakthrough

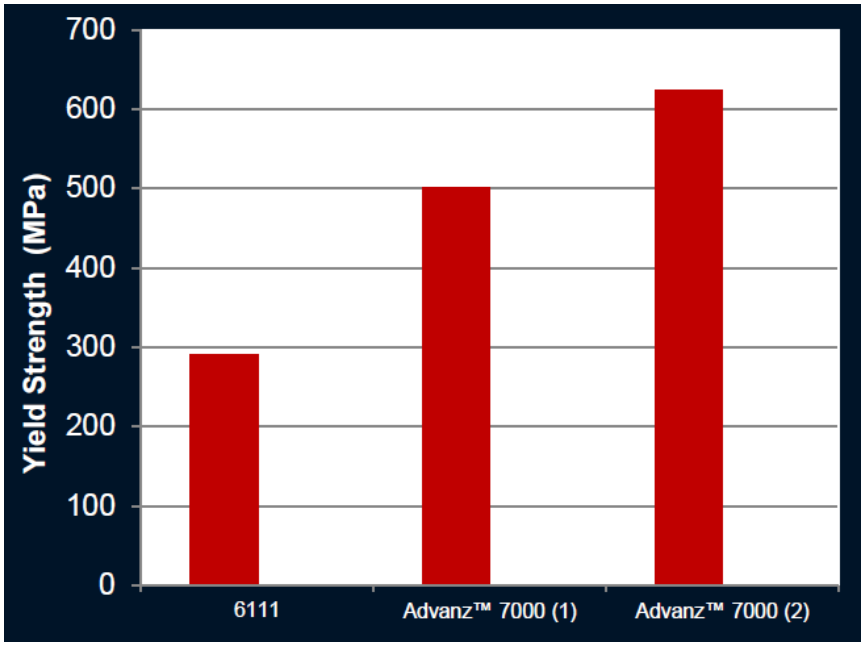
✓ 20 min. vs. 20 days ✓ 40% more formable ✓ 30% stronger than incumbent

Source: Alcoa Inc.

NOVELIS ADVANZ 7000-SERIES

Advanz 7000-series

- Designed for unsurpassed vehicle lightweighting and passenger safety
- Yield Strengths above 500 Mpa; above 600 Mpa in development
- Good elevated temperature formability
- Gauge Range of 1 mm - 3.0 mm



Source: Novelis

PRODUCTION PROVEN: HIGH-VOLUME JOINING SOLUTIONS

Download

bit.ly/atgjoining

Chapters:

- Introduction to Joining
- Fusion welding
- Arc welding
- Beam welding
- Resistance welding
- Brazing
- Solid state welding
- Mechanical joining
- Adhesive joining
- Hybrid joining techniques
- Joining of dissimilar materials

SUMMARY

IN SUMMARY

	Metric	Source
Shift to aluminum is accelerating	**500 PPV by 2025**	**Ducker**
Aluminum is safe	★★★★★	**NHTSA**
Saves more weight than steel	**25% vs. 15%**	**ORNL**
Cost effective; offers greatest ROI		**EDAG**
Lowest life cycle carbon footprint	**Energy:↓ 20%** **CO_2: ↓ 17%**	**ORNL**

QUESTIONS