GHG Standards for Light-duty Vehicles
Review of EPA’s Technical Assessment
and Role of Engineering Plastics for Mass Reduction

Kevin Bolon, Ph.D.
National Vehicle and Fuel Emissions Laboratory
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

12th Annual Auto EPCON, Society of Plastics Engineers, Troy MI
May 2, 2017
Overview

- How the EPA GHG Standards Work
- Industry Progress-to-Date
- What Might the 2025 Time-Frame Look Like
  – EPA assessment (thus far)
- What Comes Next
How the EPA standards work
Footprint-based CO₂ Target Curves for Trucks – “The Standards”

[separate footprint curve for Cars]

As Sales Shift, OEMs Standards automatically adjust

With a shift from cars to SUVs & trucks, the OEM’s standard becomes less stringent
So What is the 2025 EPA Standard?

Projections for Model Year 2025 Fleet CO2 Compliance Target
Fuel Prices/Fleet Mix Affect EPA’s PROJECTION of 2025 Standard

<table>
<thead>
<tr>
<th></th>
<th>2012 Projection</th>
<th>Summer 2016 Projection</th>
<th>Fall 2016 Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Price</strong></td>
<td>$3.87</td>
<td>$2.95</td>
<td>$2.97</td>
</tr>
<tr>
<td>($/gallon)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Car/truck mix</strong></td>
<td>67/33%</td>
<td>52/48%</td>
<td>53/47%</td>
</tr>
<tr>
<td><strong>2025 Fleet CO₂</strong></td>
<td>163</td>
<td>175</td>
<td>173</td>
</tr>
<tr>
<td><strong>Compliance Level</strong></td>
<td>(g/mi, 2-cycle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MPG-e</strong></td>
<td>54.5</td>
<td>50.8</td>
<td>51.4</td>
</tr>
<tr>
<td>(2-cycle)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These are industry compliance values. For consumers, the 2025 average real-world value is ~ 36 MPG.
Progress-to-Date and Contribution of Mass Reduction
Vehicle CO₂ Emissions at Record Low –
every major vehicle category improving

**MY2015**: 358 g/mi CO₂ (24.8 mpg)
**MY 2016 Projected**: 25.6 mpg

Truck SUVs highest % improvement since 2004, up 33%
Pickups improved most in past year, up 0.8 mpg to 18.8 mpg
Automakers Adopting a Wide Array of Technologies at Rapid Rates

- **GDI** use on nearly half of all vehicles (up from 3% in MY2008), with Mazda at 100%, 6 more OEMs above 75%

- ~20% fleet use **7+ speed transmissions**, led by Mercedes, BMW, and Fiat-Chrysler

- >20% fleet use **CVTs**, led by Subaru, Nissan, and Honda
Early Years of Program Producing Positive Results

Industry Outperforming Standards

7 Years of Sales Increases Thru 2016
First Time in 100 Years

U.S. Environmental Protection Agency – OAR-OTAQ
What Happens to the Over Compliance?

GHG Program is a **Multi-Year Program**, multiple layers of flexibility for OEMs

- No single year determines compliance.
- Program includes emissions banking and trading
- **Credits last at least 5 model years**, and early credits last longer.
- **Debits can be carried forward for 3 model years.**
- Today, the bank is **280 Million Megagrams CO2**
  - What’s a Megagram?
  - 280M worth about **80 grams CO2/mile** for the entire U.S. fleet
  - Would allow the MY2015 fleet to comply with EPA standards through 2019, if all firms participated fully in credit trading
  - Through MY2015, 12 OEMs involved in credit trading

U.S. Environmental Protection Agency – OAR-OTAQ
Advanced Gasoline Vehicles can Take the Industry Much Further … many vehicles already meet future targets

Vehicle Production that Meets or Exceeds MY2020 CO₂ Targets

With fleet averaging, in any given model year, only about 50% of vehicles would need to meet/exceed their target, depending on sales volumes.
What might 2025 look like: EPA technical assessment (thus far)
EPA’s Assessments are Informed by a Wide Range of Information

- Technical research performed by EPA
  - Benchmarking testing of **30 vehicles** across wide range of powertrains & segments (with more to come)
  - Published more than **30 peer-reviewed papers and technical reports**
  - Vehicle simulation modeling, cost teardown studies, mass reduction feasibility/cost studies, manufacturer “learning by doing” costs, research on consumer issues, economic inputs, others

- Extensive reviews of the literature
  - **100’s of reports/papers** from the literature published since 2012, including major studies such as the 2015 National Academy of Sciences report

- Stakeholder outreach & collaboration
  - Hundreds of meetings with automakers, suppliers, NGOs, consumer groups, labor, states/local governments, others
  - Collaboration with NHTSA, CARB, DOE, Transport & Environment Canada
EPA Most Recent Assessment –
Standards can be Met Mostly with Advanced Gasoline Technologies

Cost estimate of $875/vehicle
- Advanced engines and transmissions
- Vehicle light-weighting
  - 7% Average Mass Reduction from MY2015
- Improved aerodynamics
- More efficient accessories
- Low rolling resistance tires
- Stop-start technology
- Mild hybrid (e.g., 48 volt systems)
- Small levels of strong HEV, EV, PHEV

Fuel Savings Offsets Cost increase
- Net lifetime savings of $1,650
<table>
<thead>
<tr>
<th>Study Source</th>
<th>Vehicle Type</th>
<th>Baseline Year</th>
<th>Body Structure</th>
<th>Towing Capacity</th>
<th>Optimization Levels</th>
<th>Materials Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHTSA/EDAG</td>
<td>Midsize Car</td>
<td>2012</td>
<td>Unibody</td>
<td></td>
<td>3G Optimization</td>
<td>AHSS body structure with Al Closure</td>
</tr>
<tr>
<td>ARB</td>
<td>Midsize CUV</td>
<td>2012</td>
<td>Unibody</td>
<td>Towing 1000-3500 lbs</td>
<td></td>
<td>Al intensive design</td>
</tr>
<tr>
<td>DOE/Ford/Magna</td>
<td>Midsize car</td>
<td>2015</td>
<td>Unibody</td>
<td></td>
<td>2G Optimization; Secondary Mass</td>
<td>HSS body structure with limited use of Al closure</td>
</tr>
<tr>
<td>EPA/FEV</td>
<td>Midsize CUV</td>
<td>2012</td>
<td>Unibody</td>
<td>Towing 1000-3500 lbs</td>
<td></td>
<td>Al intensive and HSS frame</td>
</tr>
<tr>
<td>Transport Canada</td>
<td>Light Duty Pickup Truck</td>
<td>2015</td>
<td>Body on Frame</td>
<td>Towing up to 12,000 lbs</td>
<td>3G Optimization</td>
<td>AHSS frame with Al/AHSS cab structure and closure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2016</td>
<td>Body on Frame</td>
<td>Towing up to 12,000 lbs</td>
<td></td>
<td>AHSS frame with Al/AHSS cab structure and closure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2015</td>
<td>Body on Frame</td>
<td>Towing up to 12,000 lbs</td>
<td>2G Optimization; Secondary Mass</td>
<td>Al intensive and HSS frame</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mass impact of meeting IIHS Small Overlap</td>
</tr>
</tbody>
</table>

U.S. Environmental Protection Agency – OAR-OTAQ
Mass Reduction Cost Curves
(costs for mass reduction applied to typical 2008-vintage designs)

<table>
<thead>
<tr>
<th>Unibody Vehicles</th>
<th>Cost per pound</th>
<th>Cost per vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$/lb</td>
<td>$/vehicle</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Body-on-Frame Vehicles</th>
<th>Cost per pound</th>
<th>Cost per vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$/lb</td>
<td>$/vehicle</td>
</tr>
</tbody>
</table>
Mass Reduction and Cost Savings

Passenger Cars and CUVs

Cost savings
- opportunities only available at lower levels of mass reduction
- very limited for vehicles starting with >2% mass reduction

Estimated Total Costs depend on Both:
- Starting Mass Reduction
- Total Mass Reduction Applied (%)

Total Costs, Min ~ Max
- $0
- $2
- $4
- $6
- $8
- $10
- $12
- $14
- $16
- $18
- $20

Pickup Trucks

Cost savings
- opportunities for Pickup Trucks are more limited than for Passenger Cars/CUVs

EPA estimates 2.0% average mass reduction is already in current fleet

U.S. Environmental Protection Agency – OAR-OTAQ
Material Composition – EPA/FEV Silverado Mass Reduction Study

Scope of Study:
- Baseline: 2011 Silverado 1500, Crew Cab, 4x4
- Contractor: FEV w/Subcontractors EDAG, Munro, etc.

Boundary Conditions
- Maintain function and performance (including payload and towing capacities)
- No degradation in safety from the baseline vehicle
- Capable of being mass produced in the 2020-2025 timeframe (450,000/yr)
EPA/FEV Silverado Study – Plastic Content by System

Plastics Content

<table>
<thead>
<tr>
<th>System</th>
<th>Baseline</th>
<th>Lightweighted</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>13.9 (6%)</td>
<td>18.9 (9%)</td>
<td>5.0kg</td>
</tr>
<tr>
<td>Transmission</td>
<td>6.9 (5%)</td>
<td>7.7 (7%)</td>
<td>0.8kg</td>
</tr>
<tr>
<td>Body System - A</td>
<td>7.1 (53%)</td>
<td>6.4 (51%)</td>
<td>-0.7kg</td>
</tr>
<tr>
<td>Body System - B</td>
<td>47.0 (19%)</td>
<td>49.6 (23%)</td>
<td>2.6kg</td>
</tr>
<tr>
<td>Body System - C</td>
<td>22.9 (57%)</td>
<td>20.8 (54%)</td>
<td>-2.1kg</td>
</tr>
<tr>
<td>Body System - D</td>
<td>2.2 (4%)</td>
<td>2.1 (4%)</td>
<td>-0.1kg</td>
</tr>
<tr>
<td>Suspension</td>
<td>1.7 (1%)</td>
<td>21.9 (10%)</td>
<td>20.2kg</td>
</tr>
<tr>
<td>Driveline</td>
<td>0.2 (0%)</td>
<td>0.2 (0%)</td>
<td>0.0kg</td>
</tr>
<tr>
<td>Brake</td>
<td>2.5 (3%)</td>
<td>4.9 (9%)</td>
<td>2.4kg</td>
</tr>
<tr>
<td>Exhaust System</td>
<td>0.0 (0%)</td>
<td>0.0 (0%)</td>
<td>0.0kg</td>
</tr>
<tr>
<td>Fuel System</td>
<td>15.5 (59%)</td>
<td>16.1 (65%)</td>
<td>0.6kg</td>
</tr>
<tr>
<td>Steering Gear</td>
<td>0.7 (2%)</td>
<td>0.6 (3%)</td>
<td>0.0kg</td>
</tr>
<tr>
<td>Climate Control</td>
<td>8.3 (41%)</td>
<td>6.4 (35%)</td>
<td>-1.9kg</td>
</tr>
<tr>
<td>Info, Gage &amp; Warning Device</td>
<td>1.1 (72%)</td>
<td>1.1 (83%)</td>
<td>0.0kg</td>
</tr>
<tr>
<td>Electrical Power Supply</td>
<td>0.0 (0%)</td>
<td>2.0 (25%)</td>
<td>1.9kg</td>
</tr>
<tr>
<td>Infotainment</td>
<td>1.7 (99%)</td>
<td>2.4 (89%)</td>
<td>0.7kg</td>
</tr>
<tr>
<td>Lighting System</td>
<td>6.4 (67%)</td>
<td>6.0 (65%)</td>
<td>-0.4kg</td>
</tr>
<tr>
<td>Electrical</td>
<td>11.2 (33%)</td>
<td>8.7 (34%)</td>
<td>-2.5kg</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>149.5</strong></td>
<td><strong>175.9</strong></td>
<td><strong>26.4</strong></td>
</tr>
</tbody>
</table>

Plastic in System, kg (% of system mass)
## Metal to Plastic

### Valve Cover

<table>
<thead>
<tr>
<th>System</th>
<th>Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Valve Cover</td>
</tr>
<tr>
<td>Component Mass Saving %</td>
<td>44%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>1.16 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>$6.06</td>
</tr>
<tr>
<td>Value</td>
<td>5.22 $/kg (cost save)</td>
</tr>
</tbody>
</table>

[Base Technology]
Material: Aluminum
Application: Silverado

[New Technology]
Material: Polyamide
Application: Chrysler 4.7L V8 Ford Duratec 2.0L
### Metal to Plastic

#### Front Engine Cover

<table>
<thead>
<tr>
<th>System</th>
<th>Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Front Cover</td>
</tr>
<tr>
<td>Component Mass Saving %</td>
<td>32%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>0.42 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>-$2.44</td>
</tr>
<tr>
<td>Value</td>
<td>-5.88 $/kg (cost increase)</td>
</tr>
</tbody>
</table>

**[Base Technology]**
- Material: Aluminum
- Application: Silverado

**[New Technology]**
- Material: Polyamide
- Application: GM 4.3L Vortec
## Metal to Plastic

### Oil Pick-up Tube

<table>
<thead>
<tr>
<th>System</th>
<th>Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Oil Pick-up Tube</td>
</tr>
<tr>
<td>Component Mass Saving %</td>
<td>25.5%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>0.07 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>-$0.33</td>
</tr>
<tr>
<td>Value</td>
<td>-4.48 $/kg (cost increase)</td>
</tr>
</tbody>
</table>

**[Base Technology]**  
Material: Steel  
Application: Silverado

**[New Technology]**  
Material: Polyamide  
Application: BMW 2.0L Diesel
### Metal to Plastic

#### Passenger Airbag Housing

<table>
<thead>
<tr>
<th>System</th>
<th>Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Passenger Airbag Housing</td>
</tr>
<tr>
<td>Component Mass Saving %</td>
<td>15.4%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>0.62 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>$0.99</td>
</tr>
<tr>
<td>Value</td>
<td>1.60 $/kg (cost save)</td>
</tr>
</tbody>
</table>

**[Base Technology]**
- **Material:** Steel
- **Application:** Silverado

**[New Technology]**
- **Material:** PA6 GF40
- **Application:** Ford Explorer
## Metal to Plastic

### Rear Leaf Spring

<table>
<thead>
<tr>
<th>System</th>
<th>Infotainment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Rear Leaf Spring</td>
</tr>
<tr>
<td>Component Mass Saving %</td>
<td>56.2%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>35.7 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>-$113.47</td>
</tr>
<tr>
<td>Value</td>
<td>-3.17 $/kg (cost increase)</td>
</tr>
</tbody>
</table>

**[Base Technology]**
- **Material:** Steel
- **Application:** Silverado
- **Weight:** 26.2kg

**[New Technology]**
- **Material:** Glass fiber reinforced plastic
- **Application:** Sprinter
- **Weight:** 10.5kg

---

U.S. Environmental Protection Agency – OAR-OTAQ
## Engineered Plastics to Lightweight Engineered Plastics

### Intake Manifold

<table>
<thead>
<tr>
<th>System</th>
<th>Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Intake Manifold</td>
</tr>
<tr>
<td>Component Mass Saving %</td>
<td>4.6%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>0.28 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>-$0.81</td>
</tr>
<tr>
<td>Value</td>
<td>-2.93 $/kg (cost increase)</td>
</tr>
</tbody>
</table>

**[Base Technology]**
- Material: PA66 GF20
- Application: Silverado

**[New Technology]**
- Material: PA66 GF20 with 5% Glass Bubbles
- Application: Various exterior components and mouldings
PolyOne used on all class “A” surface plastic parts

- Center Console Trim
- Front and Rear Seat Trim
- Door Trim
- Kick Panels
- A&B Pillar Trim
- Instrument Panel Trim

MuCell used on non-class “A” surface plastic parts:

- Engine Air Intake Components
- Radiator Fan Shroud and Blades

<table>
<thead>
<tr>
<th>System</th>
<th>Interior Trim and Ornamentation (Body System C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Mass Saving %</td>
<td>--%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>2.06 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>$6.84</td>
</tr>
<tr>
<td>Value</td>
<td>3.32 $/kg (cost save)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Air Filter Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Mass Saving %</td>
<td>15%</td>
</tr>
<tr>
<td>Mass Saving</td>
<td>0.66 kg</td>
</tr>
<tr>
<td>Cost Saving</td>
<td>$0.27</td>
</tr>
<tr>
<td>Value</td>
<td>0.40 $/kg (cost save)</td>
</tr>
</tbody>
</table>
What could aggressive application of technology look like?

EPA could have included even more technology:

- Water injection for knock mitigation – BMW
- Variable Compression Ratio – Nissan
- Electric supercharging – Valeo, Eaton, Audi
- 48 volt P2 hybrids – near strong HEV effectiveness at lower cost
- Lean-burn operation – several manufacturers are investigating
- Delphi-Tula Dynamic Skip Fire Cylinder Deactivation System
- Increased thermal management (e.g., waste heat recovery – as used in HD Rule)
- Additional friction reduction:
  - Cam and crank roller bearings
  - Plasma Vapor Deposition (PVD) cylinder coating – already in production
- Ball-based Continuously Variable Transmissions (Dana)

Auto Industry 3rd largest sector for global R&D investment

> $100 Billion/year, >$270 Million/day

Source: Booz & Co.

Thompson Reuters lists Fuel Economy among the 5 “hottest areas” of automotive innovation

- based on assessment of publications/inventions/patent filings

U.S. Environmental Protection Agency – OAR-OTAQ
Sample of Recent Innovations in Engineered Plastics from the Trade Press

**Sabic**
- Structural foaming IP carrier
- Plastic-metal hybrids


**LANXESS**
- Continuous fiber thermoplastic brake pedal
- PA6 oil pans


**Teijin**
- Improved chemical hardening of plastic glazing


**Elring Klinger**
- Hybrid cross-car beam

![Elring Klinger Innovations](https://www.elringklinger.de/en/products-technologies/original-equipment/lightweight-plastic-components-car-body#ui-id-1)

**Solvay**
- Heat performance PA66

What comes next?
March 15, 2017 - EPA Administrator Pruitt issued a Notice announcing he will reconsider the EPA Final Determination published in January 2017:

“… EPA has concluded that it is appropriate to reconsider its Final Determination in order to allow additional consultation and coordination with NHTSA in support of a national harmonized program.”

“In accord with the schedule set forth in EPA’s regulations, the EPA intends to make a new Final Determination regarding the appropriateness of the MY 2022-2025 GHG standards no later than April 1, 2018.”
Component benchmarking efficiency maps:
• MY2016 Mazda CX-9 2.5 liter GDI-turbo-charged w/ 6-speed AT
• MY2016 Honda Civic 1.5 liter GDI-turbo-charged 10.6:1 w/ CVT

Vehicle level benchmarking:
• MY2016 Acura ILX w/dual-clutch transmission with torque converter
• MY2017 Ford F150 w/10 speed AT
• MY2016 Chevy Malibu w/1.5 liter GDI-turbo-charged w/ 6-speed AT

Demonstration and Modeling:
• Demonstration of cooled EGR on a modified European Mazda 2.0 liter GDI-naturally-aspirated 14:1 CR engine
• GTPower modeling of a MY2012 PSA 1.6 liter GDI-turbo-charged engine with cooled EGR and an advanced turbo
• GTPower modeling of a MY2016 Honda Civic 1.5 liter GDI-turbo-charged 10.6:1 CR engine
• ALPHA model comparison of several CVTs
• ALPHA modeling of all vehicles included in above component and vehicle benchmarking
Additional EPA Work Underway in Many Areas

- **Technology cost teardowns with FEV**: modern GDI turbo-downsized engine, advanced diesel engine, CVT
- Updates to OMEGA *cost-effectiveness optimization model* and ALPHA *full vehicle simulation model*
- Ongoing work to evaluate the *willingness to pay (WTP) for vehicle attributes* (e.g., power, fuel economy, size, etc).
  - Our review of 50+ papers from the last 20 years found very wide variation in these WTP values. Ongoing work evaluates what factors may contribute to this variation.
- **Ongoing evaluation of automotive reviews of MY2015 vehicle fuel efficient technologies**
  - Building upon EPA’s study of MY2014 vehicles, we continue to find that positive evaluations for all technologies (70%) exceed negative evaluations of the technologies (18%)
- **Ongoing work to evaluate the vehicle miles traveled (VMT) rebound effect**
- Collaboration with Transport and Environment/Climate Change Canada on *mass reduction* and *aerodynamics*
- Continued evaluation of the vehicle fleet each year to assess technologies, emissions, and compliance – supporting EPA’s forthcoming *MY2016 Manufacturer GHG Performance Report* and *2017 CO2/Fuel Economy Trends Report*
Appendix
Global Passenger Car CO2 Standards

Source: International Council for Clean Transportation.

U.S. Environmental Protection Agency – OAR-OTAQ
2025 CO2 Standard is a Function of Car & Truck Production Volume and Vehicle Footprint

**Passenger Car Target** \( (g/\text{mi}) = (3.26 \times \text{footprint}) \) \(- 3.2 \)
- for vehicle footprints \( >41 \) and \( < 56 \) square feet

**Light-Truck Target** \( (g/\text{mi}) = (3.58 \times \text{footprint}) \) \(+12.5 \)
- for vehicle footprints \( >41 \) and \( < 74 \) square feet

For each individual company the Car & Truck standards are a function of the \# vehicles produced & each vehicle’s footprint.
Compliance Determination with Credit Banking and Trading

• Assist manufacturer planning and phase-in of GHG-reducing technologies, consistent with typical redesign cycles

• Unlimited credit transfer across car and truck fleets

• Unlimited credit trading between manufacturers

• 5-year credit carry-forward, with one-time early credit carry forward of CO₂ credits
  • MY 2010 and later credits can be carried forward to MY 2021

• 3-year credit carry-back
EPA Sponsored Light Duty Pickup Truck Lightweighting Study - Project Methodology

Finger Print Baseline Technology

1. Measure
2. Record
4. Analyze

Teardown and Idea Generation

5. Evaluate
6. Generate

Mass-Reduction and Cost Optimization Process

7. Estimate
8. Score
9. Select

Detailed Mass-Reduction Feasibility and Cost Analysis

10. Calculate
11. Analyze
# Key Mass Reduction Studies Considered in MTE

<table>
<thead>
<tr>
<th>Agency</th>
<th>Description</th>
<th>Completion Date</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pass Car/CUV Studies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><a href="http://avr.illinois.edu/pdf/TechnicalCostModel40and45PercentWeightSavings.pdf">http://avr.illinois.edu/pdf/TechnicalCostModel40and45PercentWeightSavings.pdf</a> [13]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SAE papers include:2015-01-0405<del>0409,2015-01-1238</del>1240,2015-01-1613~1616</td>
</tr>
<tr>
<td><strong>Light Duty Truck Studies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>2011 Silverado 1500</td>
<td>2015</td>
<td>Final Report, Peer Review and SAE Paper [16] [17]</td>
</tr>
<tr>
<td>Transport Canada</td>
<td>IIHS small overlap mass add on LDT (EPA)</td>
<td>2015</td>
<td>Final Report and Peer Review [18] [19]</td>
</tr>
</tbody>
</table>

EPA technical information available to all stakeholders/public

Wide range of peer-reviewed publications and presentations:

- Technical papers, including SAE papers and EPA reports
- Conference presentations
- Modeling workshop

+ more ...
Case Study: 2017 Honda CRV 1.5 liter AWD

- Best-selling SUV in U.S.
- AWD versions make up 2/3 of sales
- **Advanced Gasoline Technology:**
  - Turbocharged GDI 1.5 liter I4 engine
  - Continuously variable transmission
  - No electrification
- Could already meet* 2022 target
  - 5 years ahead
- Within 4 mpg of 2025 target
  - *With 8 years to go

*Illustrative example only. EPA estimated real-world fuel economy targets from CO₂ compliance targets, assuming A/C credits and 5 g/mi off-cycle credits