Passenger Vehicle Technology: U.S. CAFE and GHG standards

John German

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Philosophy of CAFE/GHG Standards

Technology agnostic – sets *performance* goals

Let the most cost effective technologies win

Does not drive any specific technology

Exception: CA ZEV Mandate
Strong driver for BEV/PHEV sales
Overview of U.S. Passenger Vehicle Fuel Economy and GHG Standards
Background: 2016 US Car and Truck Standards

- Separate CO\(_2\)-indexed car and truck standards (with separate slopes)
  - By statute (EPCA 1975, EISA 2007), NHTSA must set separate attribute-based car, truck standards
  - Assuming no shifts in fleet composition and no trading → -24% gCO\(_2\)/mile from 2008-2016
    - Cars and trucks would reduce gCO\(_2\)/mile by 23% and 26%, respectively, from 2008 to 2016.
    - Excluding 10.6 gCO\(_2\)/mile from AC credits, CO\(_2\) reductions are 19% (cars) and 21% (truck)

The equivalent lines for CAFE standards are slightly sloped (i.e., not perfectly linear) in fuel economy (mpg) space; note that EPA assumes some sales shift toward smaller car/trucks in 2016 timeframe in their analysis; in MY2012, 2WD SUVs shift from light truck to car category; the right y-axis is rated fuel economy after 10.6 g/mile A/C credits are utilized.
2017 and 2025 US Car and Light-Truck Standards

Greenhouse Gas Emissions (gCO2e/mile)
Footprint (Sq. Ft)

2017 L-T
2017 Cars
2025 L-T
2025 Cars

1 Sq. meter = 10.764 Sq. feet
Comparison of passenger vehicle GHG standards

EU 2011: 135
EU 2020: 95
US 2011: 217
US 2025: 109
Japan 2010: 127
Japan 2020: 105
China 2010: 180
China 2015: 167

Annual reduction rate %
4.8%
4.2%
3.8%
1.9%

US (2011-2025)
China (2010-2020)
EU (2011-2020)
Japan (2010-2020)

[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
A size-based standard fully captures benefits of lightweighting

- **Size-based design:**
  - Efficiency: 11-14 g CO₂/km benefit
  - Lightweighting: 7-8 g CO₂/km *actual* benefit

- **Mass-based design:**
  - Efficiency: 11-14 g CO₂/km benefit
  - Lightweighting: only 2-3 g CO₂/km *compliance* benefit

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2016 and 2021 US Car and Light-Truck Standards

Annual % increase

Footprint (sq. ft.)

Car - 2016 to 2021
LDT - 2016 to 2021
LDT - 2012 to 2016
Car - 2012 to 2016

1 Sq. meter = 10.764 Sq. feet
Air Conditioning Credits

- CO$_2$ credits given based upon the GWP of the air conditioning refrigerant
  - Continuous incentive for better refrigerants without mandates or artificial deadlines
  - Allows manufacturers to consider both GWP and A/C system efficiency when choosing refrigerant
- CAFE and CO$_2$ credits for improved air conditioning efficiency
Off-Cycle Credits

- **Off-cycle** credits are a great concept
  - Can increase the total fuel and CO2 savings and reduce the cost to comply

- But to be effective, credits must:
  - Properly reflect actual in-use reductions
  - Be verifiable
  - Avoid duplicating on-cycle benefits

- Credits that are artificial and do not produce comparable in-use reductions severely undermine the effectiveness and credibility of the standards.
## Off-Cycle Credits

### Table II-22 Off-cycle Technologies and Credits and Equivalent Fuel Consumption Improvement Values for Cars and Light Trucks

<table>
<thead>
<tr>
<th>Technology</th>
<th>Adjustments for Cars</th>
<th>Adjustments for Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$g/mi$</td>
<td>$gallons/mi$</td>
</tr>
<tr>
<td><em>High Efficiency Exterior Lights</em> (at 100 watt savings)</td>
<td>1.0</td>
<td>0.000113</td>
</tr>
<tr>
<td>*Waste Heat Recovery (at 100W)</td>
<td>0.7</td>
<td>0.000079</td>
</tr>
<tr>
<td><em>Solar Panels (based on a 75 watt solar panel)</em>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Battery Charging Only</td>
<td>3.3</td>
<td>0.000372</td>
</tr>
<tr>
<td>Active Cabin Ventilation and Battery Charging</td>
<td>2.5</td>
<td>0.000282</td>
</tr>
<tr>
<td>*Active Aerodynamic Improvements (for a 3% aerodynamic drag or Cd reduction)</td>
<td>0.6</td>
<td>0.000068</td>
</tr>
<tr>
<td>Engine Idle Start-Stop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>w/ heater circulation system#</td>
<td>2.5</td>
<td>0.000282</td>
</tr>
<tr>
<td>w/o heater circulation system</td>
<td>1.5</td>
<td>0.000169</td>
</tr>
<tr>
<td>Active Transmission Warm-Up</td>
<td>1.5</td>
<td>0.000169</td>
</tr>
<tr>
<td>Active Engine Warm-up</td>
<td>1.5</td>
<td>0.000169</td>
</tr>
<tr>
<td>Solar/Thermal Control</td>
<td>Up to 3.0</td>
<td>0.000338</td>
</tr>
</tbody>
</table>

*Starts 2014 for CO2, 2017 for FE

*OEMs can apply for higher credits than listed and can apply for other off-cycle credits

*Total off-cycle credits capped at 10 g/mi

Source: Greenpeace US rule summary, September 6, 2012
EV, FCV, CNG Credits (CO$_2$ only)

- 0 g/miCO$_2$ rating for EVs, PHEVs, FCVs
  - Per-company sales cap of 200,000 to 600,000 applies to MYs 2022-2025

- Multiple vehicle credits:

<table>
<thead>
<tr>
<th>Year</th>
<th>EV/FCV multiplier</th>
<th>PHEV/CNG multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-16</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2017</td>
<td>2</td>
<td>1.6</td>
</tr>
<tr>
<td>2018</td>
<td>2</td>
<td>1.6</td>
</tr>
<tr>
<td>2019</td>
<td>2</td>
<td>1.6</td>
</tr>
<tr>
<td>2020</td>
<td>1.75</td>
<td>1.45</td>
</tr>
<tr>
<td>2021</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>2022-25</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Credits will be given for vehicles mandated by ZEV
- ICCT supports EV credits, but they should not be used to weaken the benefits of the standards
Pickup Truck Technology Credits

- Pickup trucks performing 15% better than their applicable CO2 target receive a 10 g/mi credit (0.0011 gal/mi)
  - Expires after 2021
- Those performing 20% better than their target receive a 20 g/mi credit (0.0023 gal/mi)
  - Credits continue for 5 years even if FE does not improve after year qualified
- These are artificial credits that reduce the benefits of the standards
  - Especially a concern due to the lower improvements required from light trucks
Credits (maximum):
- A/C refrigerant: 13.8 gCO2/mi for cars; 16.4 for LDT (No use of AC credits = 54.5 mpg)
- A/C efficiency: 5 g/mi (.000563 gal/mi) for cars; 8 g/mi (.000810 gal/mi) for LDT
- Off-cycle: 10 g/mi (.001125) for cars and LDT
- Pickup: 20 g/mi (.002250) for pickup trucks only
- EV: Zero upstream + multiple credits (assumed 5% market share for cars and 1% for LDT)
Mid Term Evaluation

- EPA committed to a midterm evaluation of the 2022-2025 standards
- Coordinating with NHTSA and CARB
- Timing:
  - EPA talking with stakeholders now and throughout the process
  - Technical Assessment Report for public comment by November 2017
  - EPA final determination by April 2018
- Transparent
Mid Term Evaluation

MY 2017 - MY 2025

EPA Standards final unless changed by rulemaking

MY 2017-2021 Final

MY 2022-2025 Augural

Joint Technical Assessment Report
(draft no later than November 15, 2017)
Banked Credits
### 2012 Performance by Credit Type

- Another snapshot of 2012 performance
- Shows ~10 g/mi over-compliance as measured by EPA’s program
  - ~6-7 g/mi if FFV credits are excluded
- A/C credits are large contributor

#### Total Net Credits for the 2012 Model Year Fleet, by Credit Source

<table>
<thead>
<tr>
<th>Credit Source</th>
<th>Credits (Mg)</th>
<th>Grams/Mile Equivalent</th>
<th>Percent of Total 2012 Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleet Average</td>
<td>1,812,926</td>
<td>0.8</td>
<td>7%</td>
</tr>
<tr>
<td>E85 Flexible Fuel Vehicles</td>
<td>8,245,611</td>
<td>3.2</td>
<td>33%</td>
</tr>
<tr>
<td>Air Conditioning (Improved Efficiency &amp; Refrigerant Leakage)</td>
<td>15,518,434</td>
<td>6.0</td>
<td>62%</td>
</tr>
<tr>
<td>Off-Cycle</td>
<td>5,822</td>
<td>0.0</td>
<td>0%</td>
</tr>
<tr>
<td>Methane and Nitrous Oxide Deficits</td>
<td>(556,869)</td>
<td>(0.2)</td>
<td>-2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25,025,930</strong></td>
<td><strong>9.8</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
### Status of Manufacturers at the Conclusion of the 2012 Model Year

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Credits from 2009-2011 Model Years (Mg)</th>
<th>Total Credits from 2012 Model Year (Mg)</th>
<th>Net Credits Carried Forward to 2013 Model Year (Mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toyota</td>
<td>86,105,835</td>
<td>13,163,009</td>
<td>99,268,844</td>
</tr>
<tr>
<td>Honda</td>
<td>35,425,108</td>
<td>7,851,257</td>
<td>43,276,365</td>
</tr>
<tr>
<td>General Motors</td>
<td>24,564,829</td>
<td>2,874,504</td>
<td>27,439,333</td>
</tr>
<tr>
<td>Ford</td>
<td>15,296,436</td>
<td>4,333,951</td>
<td>19,630,387</td>
</tr>
<tr>
<td>Nissan</td>
<td>17,631,200</td>
<td>(979,937)</td>
<td>16,651,263</td>
</tr>
<tr>
<td>Chrysler</td>
<td>9,610,207</td>
<td>(1,892,184)</td>
<td>7,718,023</td>
</tr>
<tr>
<td>Subaru</td>
<td>5,755,171</td>
<td>543,316</td>
<td>6,298,487</td>
</tr>
<tr>
<td>Mazda</td>
<td>5,482,642</td>
<td>734,887</td>
<td>6,217,529</td>
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<tr>
<td>Volkswagen</td>
<td>6,441,405</td>
<td>(502,495)</td>
<td>5,938,910</td>
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<tr>
<td>Mitsubishi</td>
<td>1,449,336</td>
<td>57,837</td>
<td>1,507,173</td>
</tr>
<tr>
<td>Suzuki</td>
<td>876,650</td>
<td>(127,699)</td>
<td>748,951</td>
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<tr>
<td>BMW</td>
<td>884,903</td>
<td>(291,272)</td>
<td>593,631</td>
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<tr>
<td>Volvo</td>
<td>740,358</td>
<td>(175,195)</td>
<td>565,163</td>
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<tr>
<td>Porsche</td>
<td>-</td>
<td>198,348</td>
<td>198,348</td>
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<tr>
<td>Mercedes-Benz</td>
<td>428,044</td>
<td>(320,782)</td>
<td>107,262</td>
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<tr>
<td>Fisker</td>
<td>-</td>
<td>46,694</td>
<td>46,694</td>
</tr>
<tr>
<td>Ferrari</td>
<td>90,000</td>
<td>(64,277)</td>
<td>25,723</td>
</tr>
<tr>
<td>Tesla*</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jaguar Land Rover</td>
<td>-</td>
<td>(424,032)</td>
<td>(424,032)</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>210,782,124</strong></td>
<td><strong>25,025,930</strong></td>
<td><strong>235,808,054</strong></td>
</tr>
</tbody>
</table>

* Tesla generated credits in the 2010-2012 model years, but sold all of them. Thus they have a net balance of zero at the end of the 2012 model year. See Sections 2 and 3.1.1.
Table 3.1.1-1: Reported Fleet Average Credit Detail for Manufacturers with Primary Program Fleets, 2012 Model Year

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Car</th>
<th>Trunk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO$_2$ Standard (g/mi)</td>
<td>Average (g/mi)</td>
<td>Production Volume (Mg)</td>
</tr>
<tr>
<td>BMW</td>
<td>269</td>
<td>277</td>
<td>191,154</td>
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<tr>
<td></td>
<td>336</td>
<td>363</td>
<td>65,856</td>
</tr>
<tr>
<td></td>
<td>257,010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrysler</td>
<td>277</td>
<td>287</td>
<td>538,887</td>
</tr>
<tr>
<td></td>
<td>345</td>
<td>363</td>
<td>994,996</td>
</tr>
<tr>
<td></td>
<td>1,533,883</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferrari</td>
<td>276</td>
<td>494</td>
<td>1,510</td>
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<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1,510</td>
<td></td>
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</tr>
<tr>
<td>Fisker</td>
<td>315</td>
<td>146</td>
<td>46,694</td>
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<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1,415</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td>265</td>
<td>252</td>
<td>1,052,721</td>
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<tr>
<td></td>
<td>364</td>
<td>364</td>
<td>701,602</td>
</tr>
<tr>
<td></td>
<td>1,754,323</td>
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<tr>
<td>General Motors</td>
<td>272</td>
<td>272</td>
<td>1,449,244</td>
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<td></td>
<td>369</td>
<td>374</td>
<td>915,130</td>
</tr>
<tr>
<td></td>
<td>2,364,374</td>
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<td>Honda</td>
<td>263</td>
<td>237</td>
<td>1,047,165</td>
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<tr>
<td></td>
<td>333</td>
<td>320</td>
<td>493,414</td>
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<td>1,540,579</td>
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<td>Jaguar-Land</td>
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<td></td>
<td>316</td>
<td>303</td>
<td>9,086</td>
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<td></td>
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<tr>
<td>Mazda</td>
<td>259</td>
<td>241</td>
<td>213,308</td>
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<td>323</td>
<td>324</td>
<td>65,696</td>
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<td>279,004</td>
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<td>298</td>
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<td>335</td>
<td>368</td>
<td>61,343</td>
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<td>224,590</td>
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<td>Mitsubishi</td>
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<td>262</td>
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<td>307</td>
<td>283</td>
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<td>64,467</td>
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<td>258</td>
<td>896,278</td>
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<td>337</td>
<td>367</td>
<td>331,886</td>
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<td>1,228,164</td>
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<td>Subaru</td>
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<td>257</td>
<td>106,152</td>
</tr>
<tr>
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<td>309</td>
<td>296</td>
<td>163,860</td>
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<td>270,012</td>
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<td></td>
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<td>267</td>
<td>25,266</td>
</tr>
<tr>
<td></td>
<td>325</td>
<td>361</td>
<td>5,997</td>
</tr>
<tr>
<td></td>
<td>31,263</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tesla</td>
<td>303</td>
<td>-</td>
<td>2,952</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2,952</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toyota</td>
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<td>221</td>
<td>1,298,021</td>
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<td></td>
<td>342</td>
<td>345</td>
<td>722,227</td>
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<td>Volkswagen</td>
<td>263</td>
<td>273</td>
<td>500,690</td>
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<td>327</td>
<td>330</td>
<td>64,882</td>
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<td>565,572</td>
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<tr>
<td>Volvo</td>
<td>272</td>
<td>297</td>
<td>52,375</td>
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<tr>
<td></td>
<td>325</td>
<td>343</td>
<td>19,432</td>
</tr>
<tr>
<td></td>
<td>71,807</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7,592,312</td>
<td>17,197,318</td>
<td>4,627,947</td>
</tr>
<tr>
<td></td>
<td>12,220,260</td>
<td></td>
<td>10,359,568</td>
</tr>
</tbody>
</table>

Note: This table shows only the inputs and results of the fleet average credit calculation. It does not include credits from air conditioning or other programs and does not completely represent either the cumulative performance of a manufacturer in the 2012 model year or their final status at the end of the model year.
Technology Deployment Spurred by Fuel Economy Standards
The Real Technology Breakthrough

Computers

- Computer design, computer simulations, and on-vehicle computer controls are revolutionizing vehicles and powertrains
- Especially important for lightweight materials
  - Optimize hundreds of parts – size and material
  - Capture secondary weight – and cost – reductions
- The high losses in the internal combustion engine are an opportunity for improvement
- Also reducing size and cost of hybrid system
Example of Technology Upgrade: High-Selling Passenger Cars 2010 to 2014
Accelerating Technology Introduction in the U.S. is driven by Fuel Economy Regulation

<table>
<thead>
<tr>
<th>Year</th>
<th>GDI</th>
<th>Turbo</th>
<th>VVT</th>
<th>Stop/Start</th>
<th>Hybrid</th>
<th>6 speed</th>
<th>7+ speed</th>
<th>CVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>-</td>
<td>4%</td>
<td>44%</td>
<td>-</td>
<td>0.9%</td>
<td>5%</td>
<td>0.4%</td>
<td>2%</td>
</tr>
<tr>
<td>2005</td>
<td>-</td>
<td>2%</td>
<td>49%</td>
<td>-</td>
<td>1.9%</td>
<td>6%</td>
<td>0.4%</td>
<td>3%</td>
</tr>
<tr>
<td>2006</td>
<td>-</td>
<td>3%</td>
<td>58%</td>
<td>-</td>
<td>1.5%</td>
<td>12%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>2007</td>
<td>-</td>
<td>4%</td>
<td>63%</td>
<td>-</td>
<td>3.2%</td>
<td>16%</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>2008</td>
<td>3%</td>
<td>4%</td>
<td>63%</td>
<td>-</td>
<td>3.3%</td>
<td>19%</td>
<td>3%</td>
<td>11%</td>
</tr>
<tr>
<td>2009</td>
<td>4%</td>
<td>4%</td>
<td>79%</td>
<td>-</td>
<td>2.9%</td>
<td>19%</td>
<td>3%</td>
<td>11%</td>
</tr>
<tr>
<td>2010</td>
<td>9%</td>
<td>4%</td>
<td>92%</td>
<td>-</td>
<td>5.5%</td>
<td>33%</td>
<td>3%</td>
<td>14%</td>
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<tr>
<td>2011</td>
<td>18%</td>
<td>8%</td>
<td>95%</td>
<td>-</td>
<td>3.4%</td>
<td>54%</td>
<td>5%</td>
<td>12%</td>
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<tr>
<td>2012</td>
<td>28%</td>
<td>10%</td>
<td>98%</td>
<td>0.9%</td>
<td>4.6%</td>
<td>58%</td>
<td>6%</td>
<td>15%</td>
</tr>
<tr>
<td>2013</td>
<td>37%</td>
<td>15%</td>
<td>98%</td>
<td>3.0%</td>
<td>5.3%</td>
<td>60%</td>
<td>8%</td>
<td>18%</td>
</tr>
<tr>
<td>2014</td>
<td>42%</td>
<td>19%</td>
<td>98%</td>
<td>6.2%</td>
<td>6.0%</td>
<td>59%</td>
<td>9%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Source: 2014 EPA Fuel Economy Trends Report – **Cars only**
GDI: Gasoline Direct Injection
CVT: Continuously Variable Transmission – includes hybrid sales
VVT: Variable Valve Timing
Weight Reduction in 2015 Ford F150

The largest selling vehicle in the US

Weight reduction: 318 kg, 14%
Engine downsize: 3.5L to 2.7L

First use of aluminum body in high volume production vehicle

95% of body– Aluminum
77% of frame– HSS

Source: http://www.ford.com/trucks/f150/2015/
Turbo Dedicated EGR Engines

- Highly dilute, low temperature combustion
- ~1% H₂ by volume in the intake
- Advanced ignition systems required
- ~40% brake thermal efficiency (similar to diesel)
- PSA 2018 introduction

Christopher Chadwell, Dr. Terry Alger, Raphael Gukelberger, Jacob Zuehl – Southwest Research Institute, A DEMONSTRATION OF DEDICATED-EGR ON A 2.0 L GDI ENGINE, SAE 2014-01-1190
EPA projected Hybrid/EV penetration needed to meet 2025 GHG standards

<table>
<thead>
<tr>
<th></th>
<th>2021</th>
<th>2025</th>
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<tr>
<td>12v stop/start</td>
<td>8%</td>
<td>15%</td>
</tr>
<tr>
<td>Mild hybrid</td>
<td>7%</td>
<td>26%</td>
</tr>
<tr>
<td>Full hybrid</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>PHEV</td>
<td>&lt; 0.5%</td>
<td>&lt; 0.5%</td>
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<tr>
<td>BEV</td>
<td>1%</td>
<td>2%</td>
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</table>
Benefits and Costs
Projected Benefit on Light-duty Vehicle Oil Consumption

- Business As Usual (pre-rules)
- LD GHG (2012-2016)
- LD GHG (2017-2025)
Oil Reduction Impacts of Combined MY 2012-2025 GHG/CAFE standards

Fuel Saved

- 2.1 MBPD in 2025
- 3.2 MBPD in 2030
- 4.8 MBPD in 2040
MYs 2012-2025 GHG Rules: Primary Costs & Benefits

$Billions of 2010 dollars

- New Technology Costs
- Maintenance Costs
- Pre-Tax Fuel Savings

- $325 billion
- $1.7 trillion

- $0
- $200
- $400
- $600
- $800
- $1,000
- $1,200
- $1,400
- $1,600
- $1,800
MY 2025 Vehicle Meeting the 2025 GHG Standard versus the 2011 Standard

![Bar chart comparing new technology costs, maintenance costs, and retail fuel savings for MY 2025 vehicles meeting the 2025 GHG standard versus the 2011 standard. The chart shows that retail fuel savings are significantly higher than new technology costs and maintenance costs.]
“Absolutely, …fuel efficiency is the number one reason to buy….This is fantastic, this is why we feel so good that we have worked together to have regulations in line with what our customers really do want.”

Alan Mulally, CEO of Ford
September 18, 2012

“This standard is 14 years out. If you start giving up on projects that are 14 years out, we might as well choose another occupation.”

Sergio Marchionne, CEO of Fiat-Chrysler
February 4, 2012
Real World
FE Label Adjustments

• CAFE values are unadjusted test results

• FE labels are discounted:
  • The higher the FE, the larger the discount
  • Current vehicles around 23% on average
  • 2025 vehicles around 26% on average

• 2025 average of 45.2 mpg on the test cycle = average combined FE label value of 33.3 mpg
The gap between EU ‘real-world’ and type-approval CO2 emissions is increasing!!

[natural text]

Build year / Fleet composition year / Launch year / Test year

[natural text]
Conclusion
Summary of US CAFE/GHG Requirements

- Future US standards will make stringency comparable to the rest of the world
- Footprint-based standard and A/C refrigerant incentives much better than approaches used elsewhere in world
- Off-cycle credits potentially good, but only if they are properly constructed and validated
- Pickup and EV credits are artificial and reduce the benefits from the rule
- Smaller changes to the light truck footprint curve increase the incentive to reclassify cars as trucks and to make light trucks larger
Vehicle Fuel Efficiency Initiatives gaining traction globally

- Cost-effective technologies to meet the fuel economy standards already being deployed in large numbers around the world.
- Improvements in conventional powertrains and load reduction will be far greater than expected
  - Driven, in part, by increasing worldwide adoption of efficiency requirements
- Developing countries will be able to take advantage of learning and economies of scale along the way.
For more information…

- ICCT Passenger Vehicles website: http://www.theicct.org/passenger-vehicles
- EU LDV CO2 Regulation: http://www.theicct.org/policies/eu-light-duty-vehicle-co2-regulation
- Review and Comparative Analysis of Fiscal Policies to promote fuel economy: http://www.theicct.org/review-and-comparative-analysis-fiscal-policies
- CO₂ Standards: http://www.theicct.org/issues/co2-standards
Consumers are, in general, LOSS AVERSE

2002 Nobel Prize for Economics
(Tversky & Kahnemann, J. Risk & Uncertainty 1992)

- Technology cost is paid up front
- Savings accrue in the future over many years and are highly uncertain:
  - What MPG will I get (your mileage may vary)?
  - How long will my car last?
  - How much driving will I do?
  - What will gasoline cost?
  - What will I give up or pay to get better MPG?

“‘A bird in the hand is worth two in the bush.’”

Technology market is not economically efficient, as most customers severely discount future fuel savings.
Role of Fuel Economy Standards in Managing Performance – Fuel Consumption Tradeoff: US Example


Phase III (1987-2006): Performance gains take priority over fuel consumption reduction

Phase IV (2007-?): Fuel consumption reduction takes priority over performance again

Data from EPA 2013 Fuel Economy Trends Report