CAFE Beyond 2021

Key questions and challenges

Ryan Keefe
Volpe National Transportation Systems Center

July 23, 2014
Roadmap

- Impact of MY2017 – 2025 standards on society/consumers
- Background on CAFE program and current status
- Regulatory Analysis
  - Important elements
  - Sources of information
  - The CAFE Compliance and Effects Model (aka “The Volpe model”)
- Simulating manufacturers’ responses to CAFE standards
- Important considerations for next analysis
MY 2017 - 2025 rulemaking creates large benefits to society net of technology costs
Largest benefits are value of fuel savings: “Private perspective” is important

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Measure</th>
<th>Value at Alternative Discount Rates</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>New Car Loan Rate (5.16%)</td>
<td>Consumer Rate (7%)</td>
<td>Credit Card Rate (13.8%)</td>
<td></td>
</tr>
<tr>
<td>MY 2025 Passenger Car</td>
<td>Fuel Savings</td>
<td>$4,200</td>
<td>$3,800</td>
<td>$2,800</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Price Increase</td>
<td>$1,400</td>
<td>$1,400</td>
<td>$1,400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>$2,800</td>
<td>$2,400</td>
<td>$1,400</td>
<td></td>
</tr>
<tr>
<td>MY 2025 Light Truck</td>
<td>Fuel Savings</td>
<td>$4,900</td>
<td>$4,500</td>
<td>$3,300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Price Increase</td>
<td>$1,100</td>
<td>$1,100</td>
<td>$1,100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>$3,800</td>
<td>$3,400</td>
<td>$2,200</td>
<td></td>
</tr>
</tbody>
</table>
Standards Beyond 2021

- Process and requirements subject to statutory requirements
  - APA (notice and comment)
  - EPCA/EISA (structure and stringency of CAFE standards)
- CAFE standards are in place through 2021
- CAFE standards are not in place beyond 2021
- No later than April 2020, DOT/NHTSA must issue a de novo rule about stringency for MYs 2022 and beyond
  - Augural standards shown in 2012 notice can be among the range of considered alternatives, but can receive no special consideration
- Per EPCA/EISA, post-2021 standards must be set at the maximum feasible levels separately for each fleet (cars, light trucks) and each model year
- “Mid Term” for Related EPA GHG standards
  - Agencies continue to discuss scope and plan – nothing to announce today
  - Expect continued coordinated approach and harmonized (as practical) standards
What are the standards?

- Headline numbers are generally misleading
  - For example, “54.5” is not the standard in MY 2025 described in latest rule
Corporate Average Fuel Economy

- Specific vehicle models have a “target” not a “standard”
- Compliance is based on fleet-wide average, for each OEM
  - Attribute based standard, differs by class (passenger cars, light trucks)
  - Different fleet compositions change the average required level (LT share, distribution of sales by footprint)
- Standards provide flexibility, as specified in statute:
  - manufacturers can add technology to vehicles or shift product mix
  - bank and borrow credits
  - transfer credits between fleets
  - trade credits
- EPCA/EISA requires that OEMs pay fines for any failure to comply.
So how’s it going lately?

- CAFE standards have been steadily increasing since 2005 for LTs and 2011 for PCs
Regulatory action requires choosing among regulatory alternatives and their impacts

- Consider multiple specifications/stringencies
  - Different schedules based on footprint (shapes of curves)
  - Consider different levels of efficiency increase per model year (e.g. 2% per year vs. 6% per year)
  - Different class distinctions (e.g., definition of a “light truck”)

- Integrate relationships between standards, changes in technology adoption, exogenous factors, economic assumptions
  - Model manufacturers’ decision to address standards (add technology, pay fines, borrow/generate/use credits) over multiple years, simultaneously
  - That decision in context of assumed consumer willingness-to-pay for fuel economy increases and prevailing fuel prices

- Compare standards across variety of metrics
  - (Private) Change in average vehicle cost, benefits to consumers
  - (Social) Total net benefits (to society), total fuel/GHG savings, etc.
Supporting analysis requires information about...

<table>
<thead>
<tr>
<th>Industry status and outlook</th>
<th>Available technology</th>
<th>Exogenous factors</th>
<th>Economic valuations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Vehicles offered, baseline attributes, technology, and fuel economy; product development cadence</td>
<td>• Both now and over model years spanned by rule • Estimated fuel efficiency improvement, costs (both direct and indirect) • Decision trees, application logic and engineering constraints</td>
<td>• Forecasts of fuel prices, fuel properties, new vehicle sales, annual vehicle usage (miles) and survival throughout the vehicle’s useful life</td>
<td>• Social cost of carbon, relevant discount rates, time saved, additional travel, energy security, consumer valuation of fuel economy, pollutant damages</td>
</tr>
</tbody>
</table>
Multiple sources provide critical data

- Technology costs and effectiveness values
  - Agency-sponsored tear-down studies, full vehicle simulation studies, National Academy of Sciences reviews

- Baseline vehicle sales, characteristics, and fuel economy
  - CAFE certification data provided by manufacturers
  - Public sources of vehicle attributes (OEMs, Edmunds, Wards automotive)
  - Future sales from commercial forecasts/Annual Energy Outlook
  - Can also use manufacturer-provided forecasts, but must protect confidentiality of this information

- Vehicle usage data
  - National Household Travel Survey (NHTS)
  - Annual Energy Outlook
  - National vehicle registration data (state DMVs provide to R.L. Polk)
  - Crash data (mass-safety analysis)

- Academic literature informs determination of economic inputs
CAFE Compliance and Effects Modeling System (the “Volpe model”) was developed to support CAFE rulemaking activities

- Continuous development and refinement of model since 2002, informed by extensive and detailed external review
- Simulates manufacturers’ year-by-year and fleet-by-fleet responses to new standards
- Executable file, model documentation, source code, and input and output files from recent regulatory analysis available on NHTSA’s website

**Inputs**
- Market data
- Standards
- Technology
- Economic

**Model**
- Apply tech to comply with standards
- Minimize cost

**Outputs**
- Resulting fleet
- Compliance status
- National impacts
Simulating manufacturers’ decisions

- Compliance simulated at manufacturer level
- Some more constrained by standards than others
  - Differences in sales mix, existing fuel economy, credit position
  - Credit/fine payment strategy
- Add technology where possible (product cadence matters)
  - Increase fuel economy in a performance neutral manner
  - Planning for multiple years at each decision point
  - Limited number of engines across larger number of models
  - Engines redesigned less frequently than (most) models
  - Vehicle models inherit new engines at redesign (refresh?)
  - Other technologies platform-specific or model-specific
  - Technology carried between redesign/refresh model years
- Pay fines
- Generate/apply credits
**Toyota Tacoma example**

- **Powertrain:** SGDI, engine turbocharging/downsizing, dual cam phasing, continuous VVL, and engine friction reduction.
- **Other:** aerodynamic improvements and 1.5% mass reduction.

- **Powertrain:** upgraded transmissions.
- **Other:** EPS, improved accessories, lower-drag brakes, and further aerodynamic improvements.

### Technology Cost ($, vs. MY2010)

<table>
<thead>
<tr>
<th>Model Year</th>
<th>Redesign</th>
<th>Refresh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2023</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2024</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unintended impacts of standards could affect manufacturers’ ability to comply

- Will standards affect product cadence?
  - Big technology application is limited to redesigns
  - Currently frequent enough to meet pace of increasing CAFE standards?
  - How will those changes impact global platform development cycles, technology availability, allocation of engineering resources, stranded capital, etc?
  - Impact on suppliers?

- How will the new vehicle market respond to increases in prices?
  - Shifting distribution of fuel economy/costs among models and classes may change fleet mix (e.g., PC/LT ratio) for constrained OEMs
  - Price increase large enough to increase length of ownership, or impact used car market?
  - Alternative fuel technology adoption rates?
Key challenges for next phase analysis

- Estimate likely impact of future standards many years in advance
- Represent availability of technology with fidelity
- Incorporate accurate information about changing system
  - Per-capita VMT and demographic shifts
  - Evolution of preferences for vehicle attributes
  - Volatility in energy market
  - Timing of data source updates
- Combined impact of CAFE standards
  - PC, LT, MD regulations all in place for some years
  - Technology migration across fleets

Thanks