EPA UPDATE ON LIGHT-DUTY VEHICLE GHG EMISSIONS AND TECHNOLOGIES

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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

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

	2012 Projection	Summer 2016 Projection	Fall 2016 Projection
Fuel Price ($/gallon)	$3.87	$2.95	$2.97
Car/truck mix	67/33%	52/48%	53/47%
2025 Fleet CO_2 Compliance Level (g/mi, 2-cycle)	163	175	173
MPG-e (2-cycle)	54.5	50.8	51.4

2025 CO2 Standard is a Function of Car & Truck Production Volume and Vehicle Footprint

Passenger Car Target (g/mi) = (3.26 x **footprint**) – 3.2

- for vehicle footprints >41 and < 56 square feet

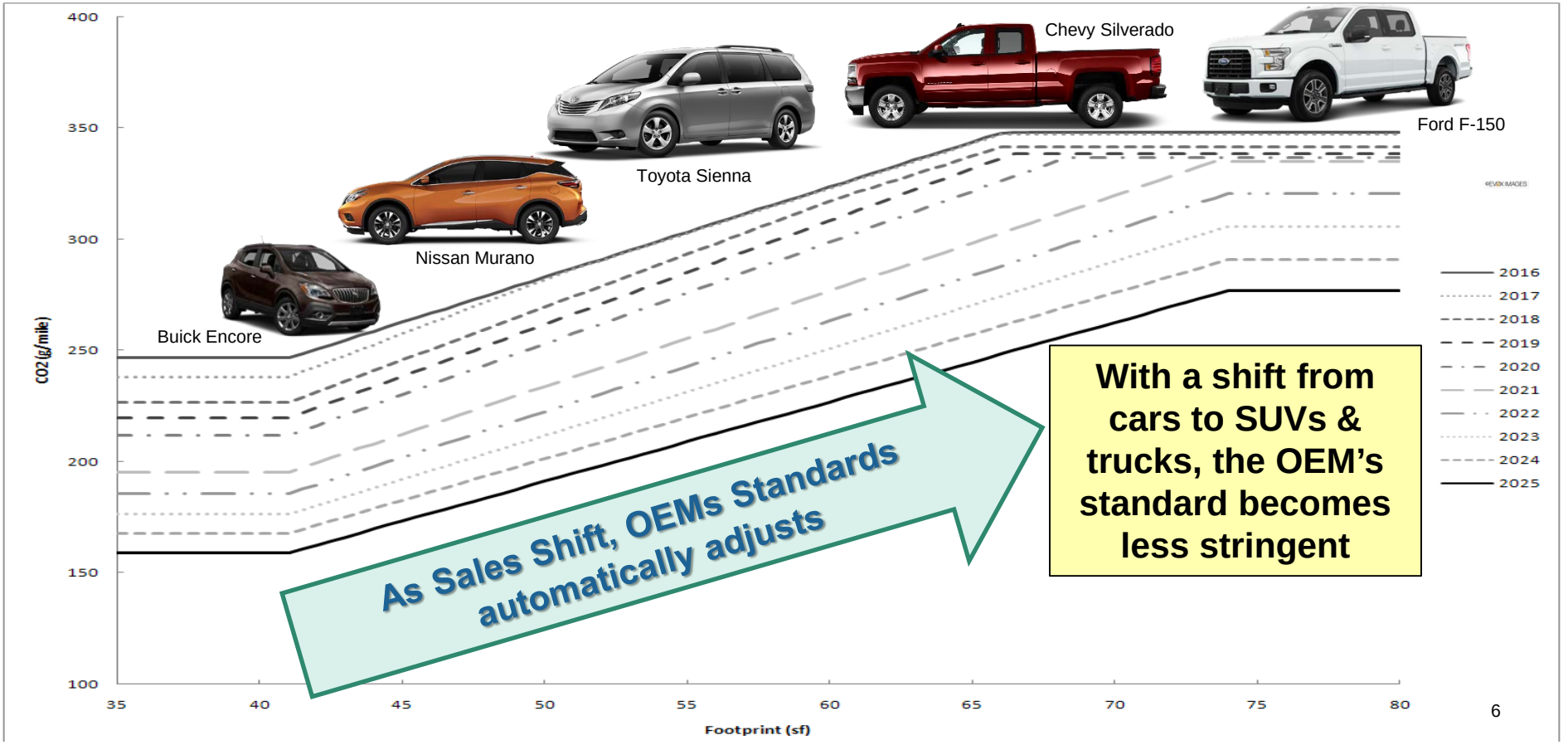
Light-Truck Target (g/mi) = (3.58 x **footprint**) +12.5

- 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**

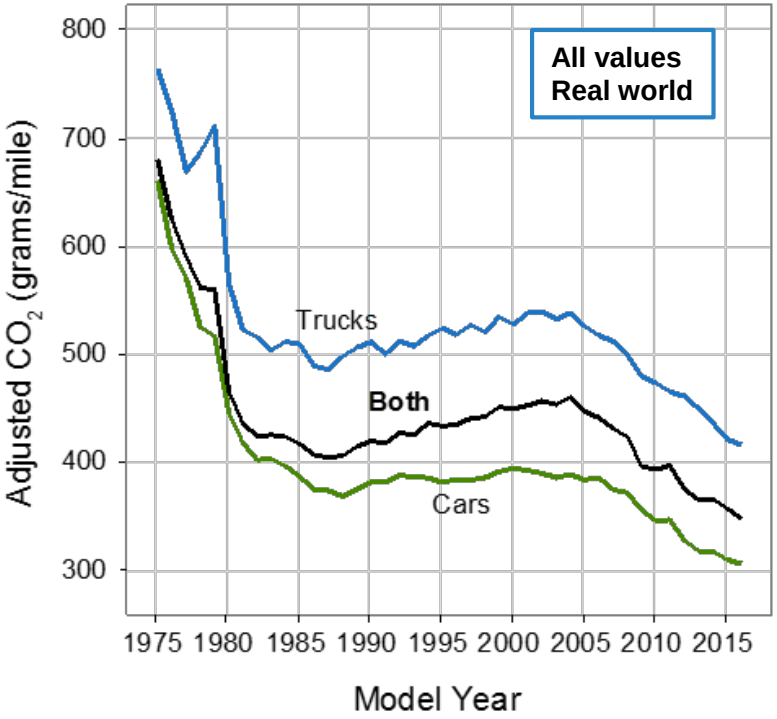
Footprint-based CO_2 Target Curves for Trucks – "The Standards"

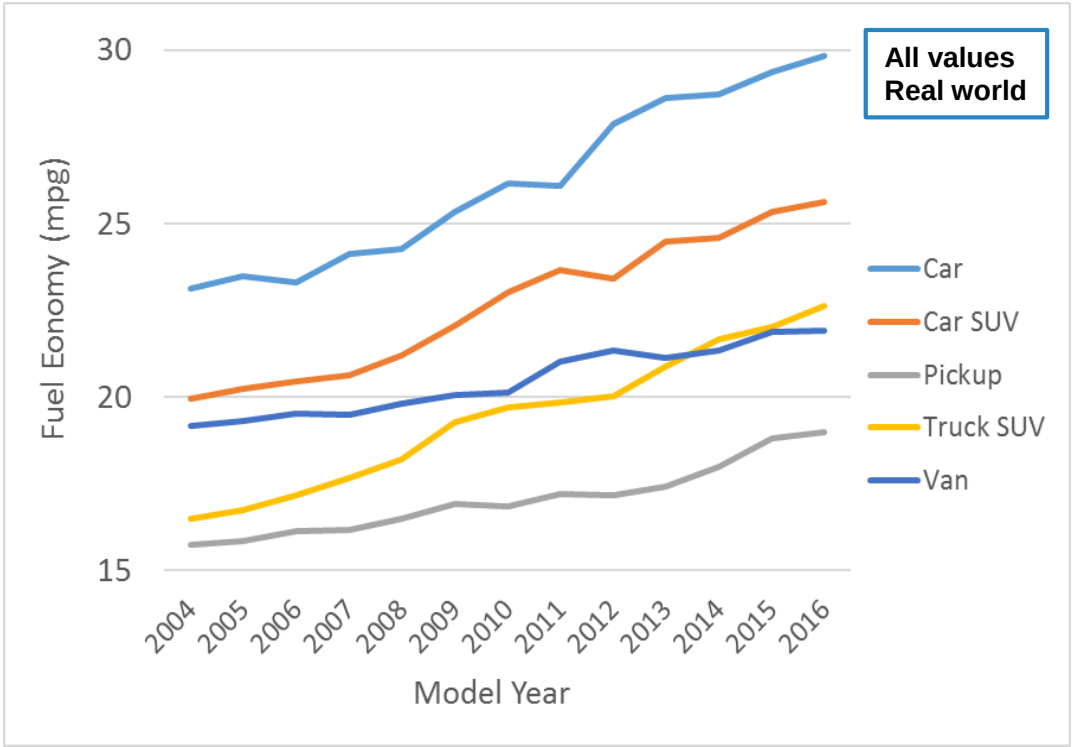
[separate footprint curve for Cars]



INDUSTRY PROGRESS TO DATE

Vehicle CO_2 Emissions at Record Low – every major vehicle category improving



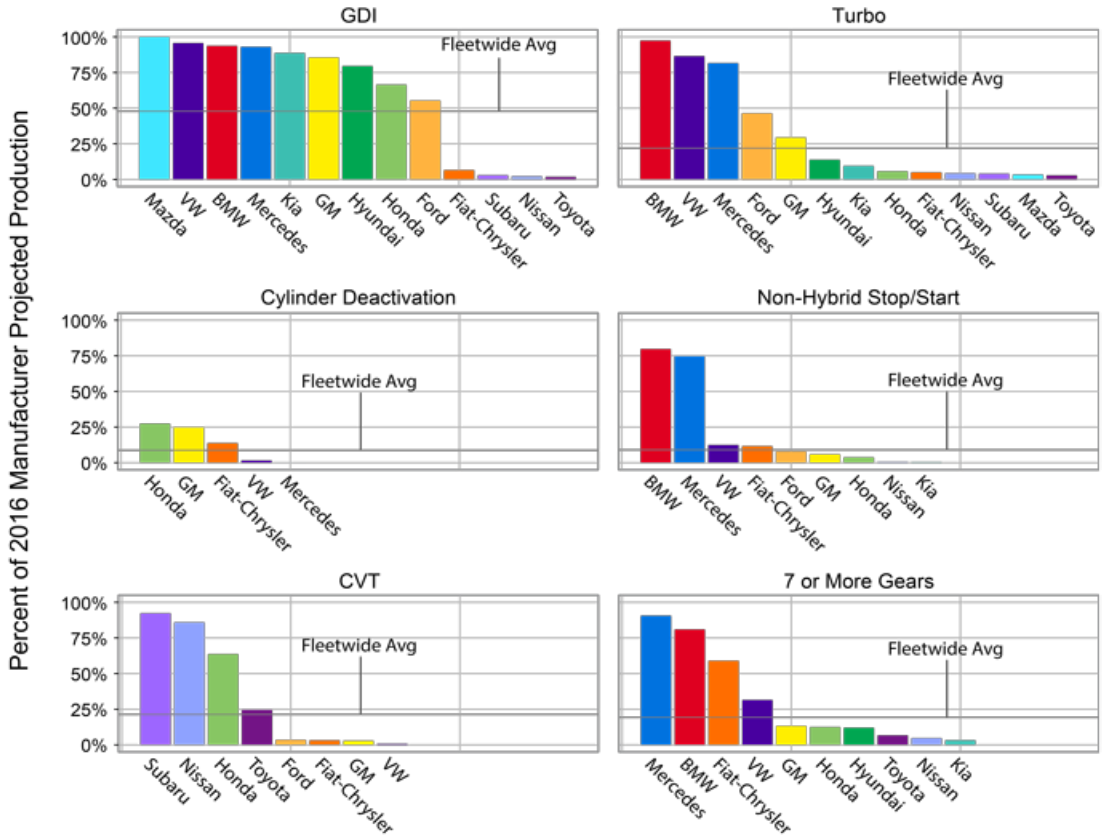


MY2015: 358 g/mi CO_2 (24.8 mpg)
MY 2016 Projected : 25.6 mpg

Truck SUVs highest % improvement since 2004, up 33%
Pickups improved most in past year, up 0.8 mpg to 18.8 mpg

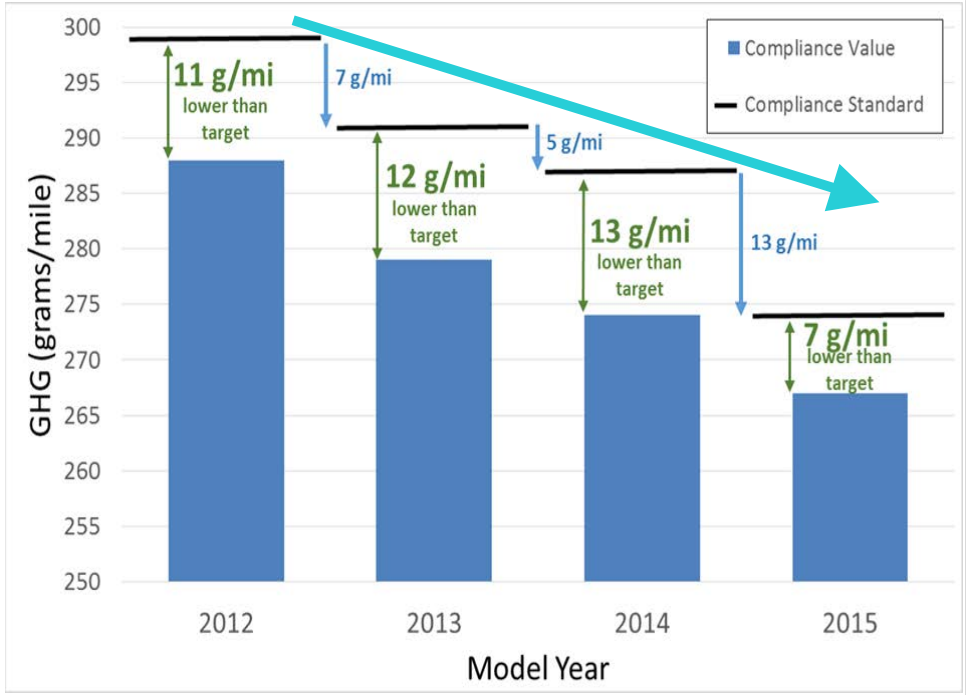
Automakers Adopting a Wide Array of Technologies at Rapid Rates

- **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

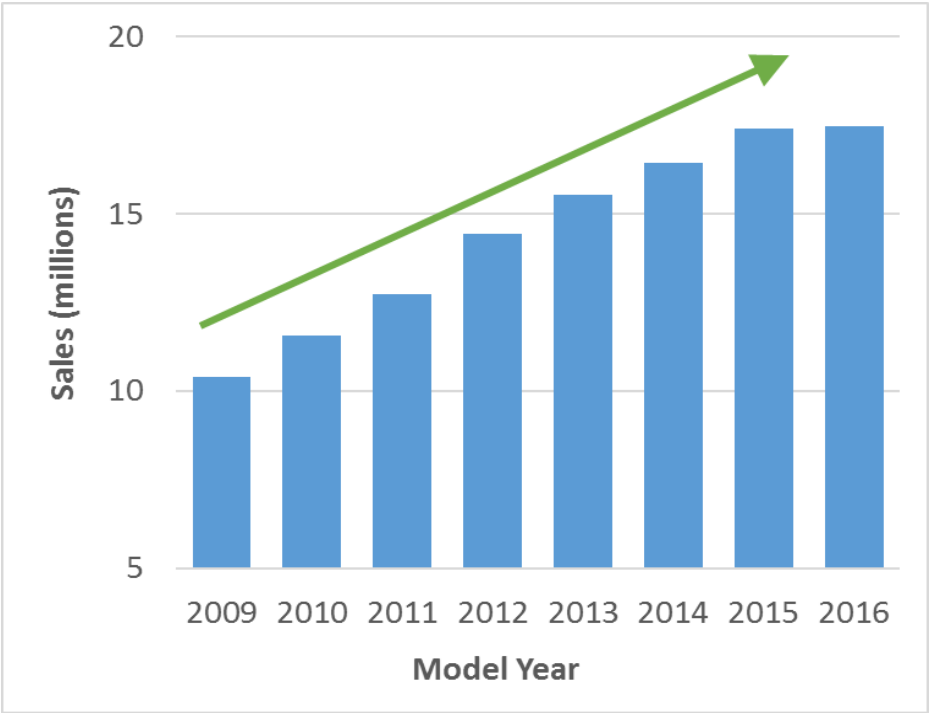


Early Years of Program Producing Positive Results

Industry Outperforming Standards



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



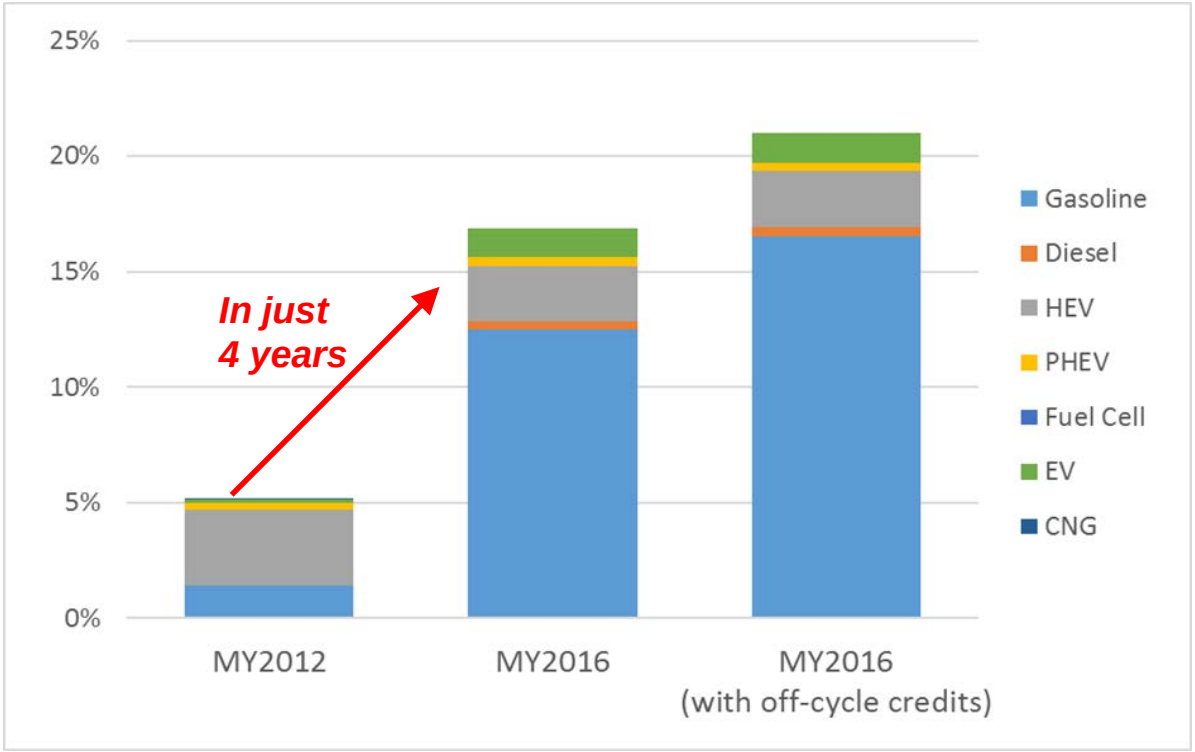
What Happens to the Over Compliance?

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

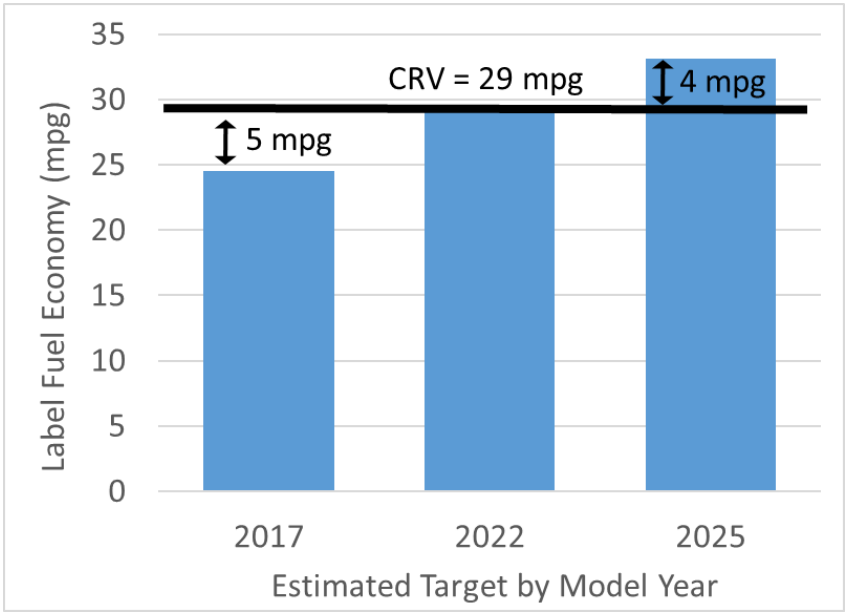
Advanced Gasoline Vehicles can Take the Industry Much Further …
many vehicles already meet future targets

Vehicle Production that Meets or Exceeds MY2020 CO_2 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.

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 CO_2 compliance targets, assuming A/C credits and 5 g/mi off-cycle credits*

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

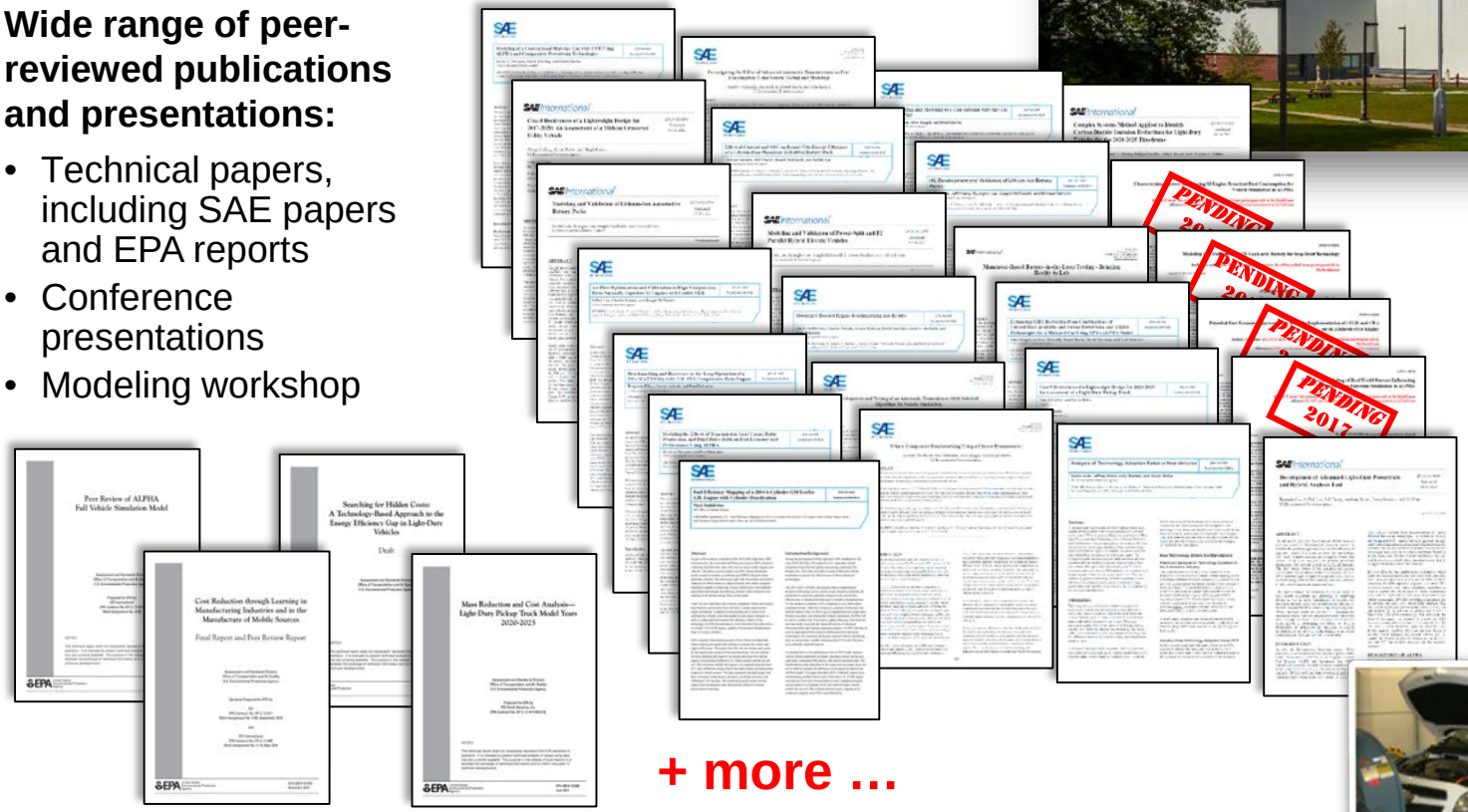
- Hundreds of meetings with automakers, suppliers, NGOs, consumer groups, labor, states/local governments, others
- Collaboration with NHTSA, CARB, DOE, Transport & Environment Canada

EPA technical information available to all stakeholders/public

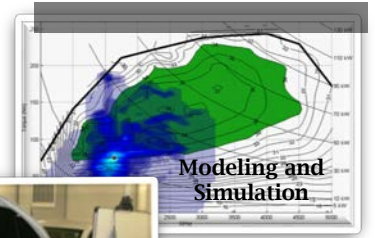
EPA's National Vehicle and Fuel Emissions Laboratory
Ann Arbor, MI

Wide range of peer-reviewed publications and presentations:

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



+ more …



EPA Most Recent Assessment –
Standards can be Met Mostly with Advanced Gasoline Technologies

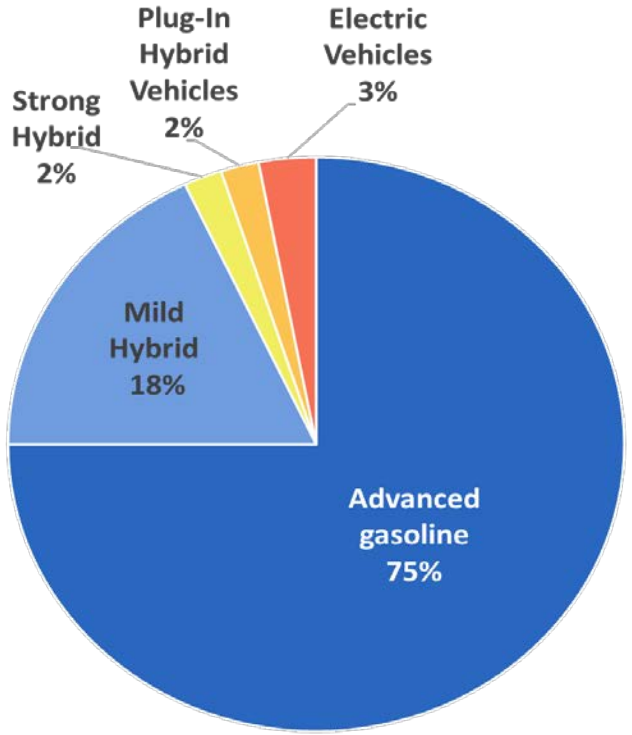
Cost estimate of $875/vehicle

- ✓ Advanced engines and transmissions
- ✓ Vehicle light-weighting
- ✓ 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

One possible pathway EPA modeled



MTE Results: MY 2025 Fleet Projections

Selected Technology Penetrations (Absolute) and Per-Vehicle Average Costs* to Meet MY2025 Standards

Technology	Draft TAR	Proposed Determination	
		Primary Analysis	Range of Sensitivities Analyzed
Turbocharged and downsized engines	33%	34%	31~41%
Higher compression ratio, naturally aspirated gasoline engines	44%	27%	5~41%
8-speed and other advanced transmissions	90%	93%	92~94%
Mass reduction	7%	9%	2~10%
Off-cycle technology	Not modeled	26%	13~52%
Stop-start	20%	15%	12~39%
Mild Hybrid	18%	18%	16~27%
Strong Hybrid	<3%	2%	2~3%
Plug-in Hybrid electric vehicle	<2%	2%	2%
Electric vehicle	<3%	3%	2~4%
Per vehicle cost (2015$)	$920	$875	$800~$1,115

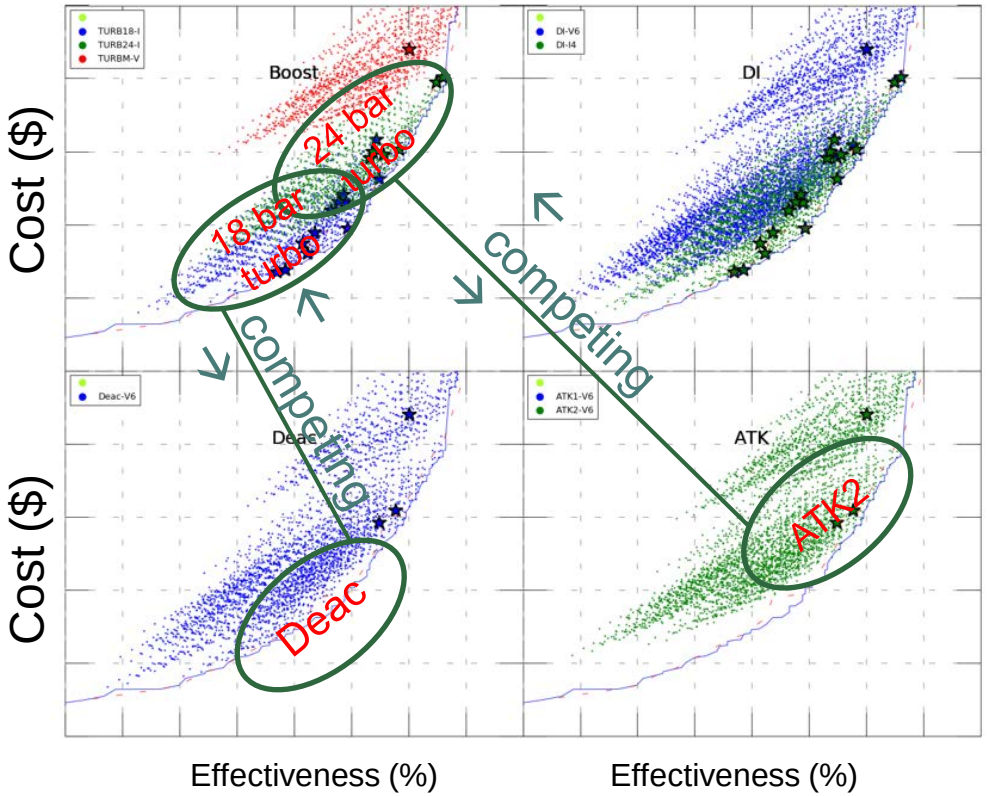
* Incremental to the Costs to Meet the MY2021 Standards

Example of Competing Technologies: Engines

Manufacturers have multiple cost-effective options for compliance

Engine Example:

- **Different engine technologies compete for the frontier of cost-effective options**
  - Turbocharging and downsizing
  - Atkinson Cycle/ Deac
- **Small changes in package cost and/or effectiveness can result in one or the other technology being applied**
  - However, overall costs remain very stable
- **Manufacturers will choose which technology best fits their product applications**



Example of Competing Technologies: Transmissions

Similar alternatives exist for vehicle manufacturers regarding the selection of transmission technologies

Manufacturers are predominantly applying three current primary transmission architectures:

- **Conventional automatic transmissions**
- **Continuously variable transmissions**
- **Dual clutch transmission**

All three transmission types are driving towards the same goal of providing maximum flexibility to operate the engine and maximum transmission efficiency.

Once again, vehicle manufacturers will select the transmission architecture that best fits its product portfolio.

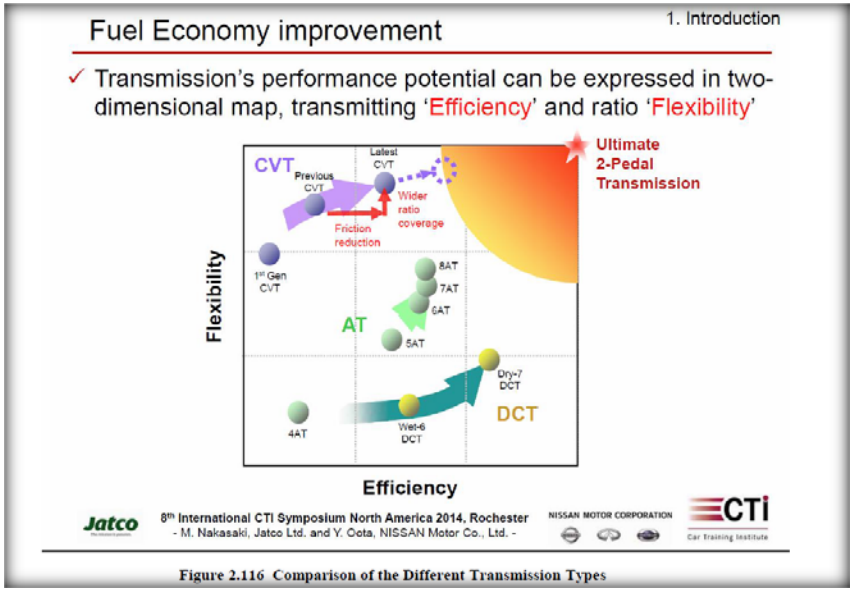


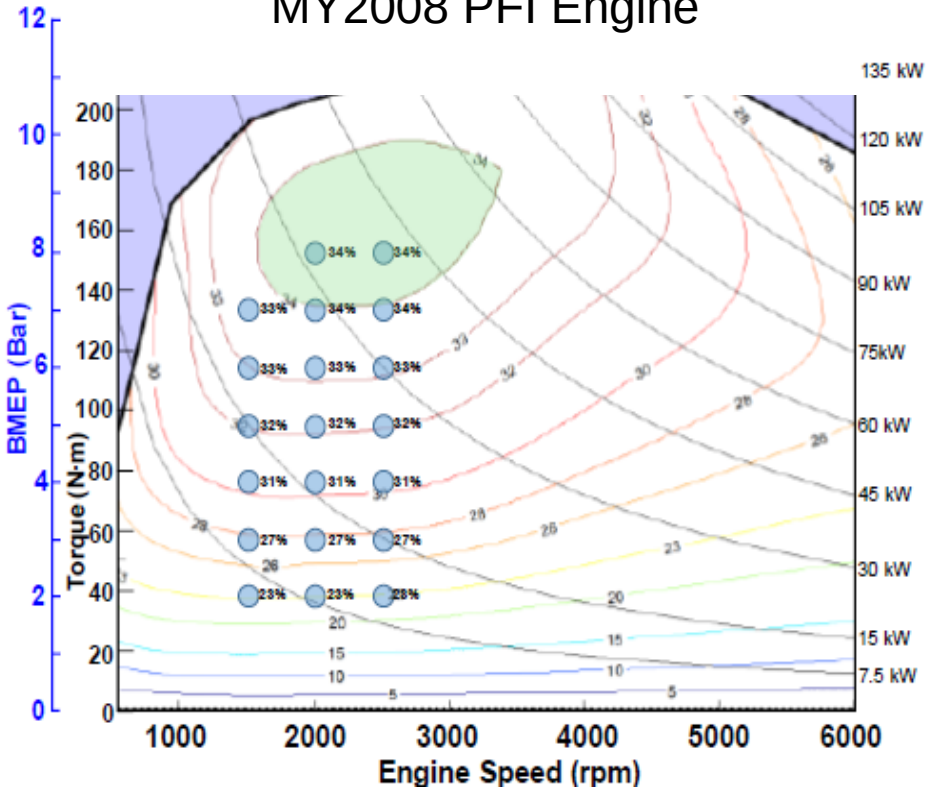
Figure 2.116 Comparison of the Different Transmission Types

Progress in Engine Efficiency

MY2008 Actual PFI Engine

- Peak thermal efficiency **34%**
- Narrow efficiency region

MY2008 PFI Engine



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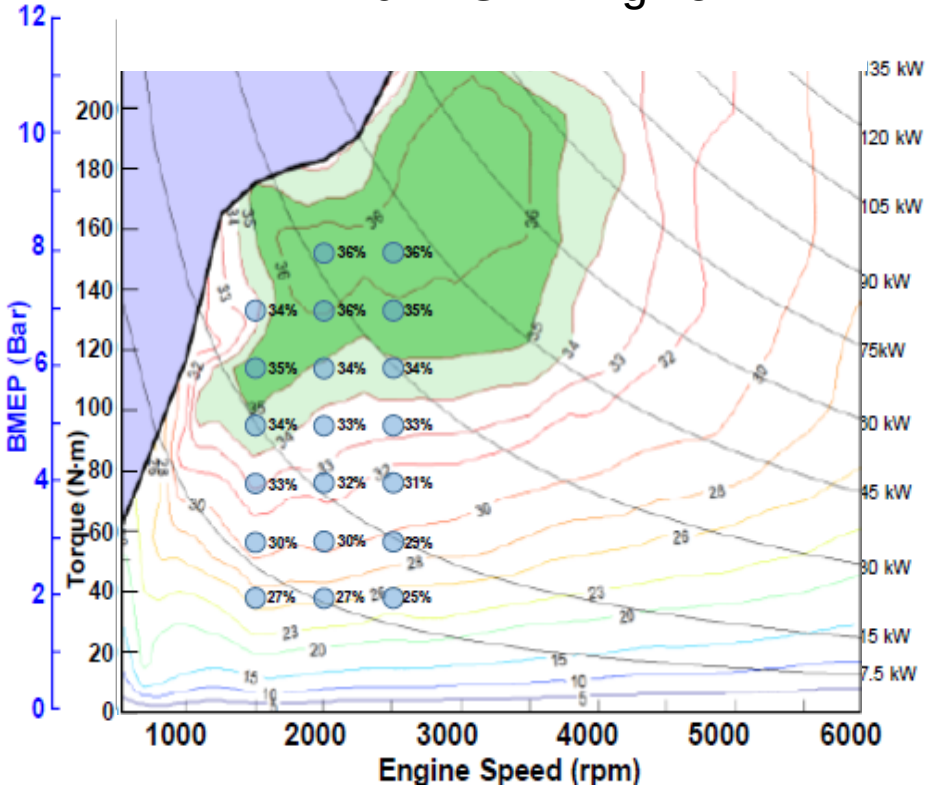
MY2014 Actual GDI Engine
- Peak thermal efficiency **36%**
- Broader efficiency region

MY2014 GDI Engine



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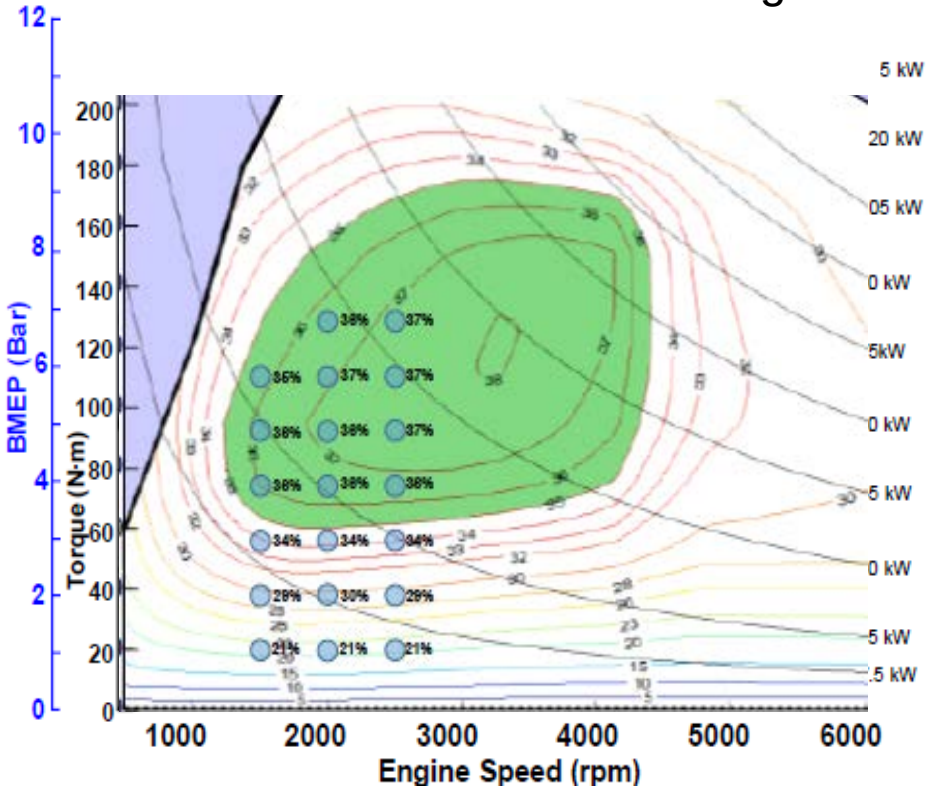
MY2016 Actual Turbo downsized Engine
- Peak thermal efficiency **38%**
- Very broad efficiency region
- Large overlap with 2-cycle test operation

MY2016 Turbo downsized Engine



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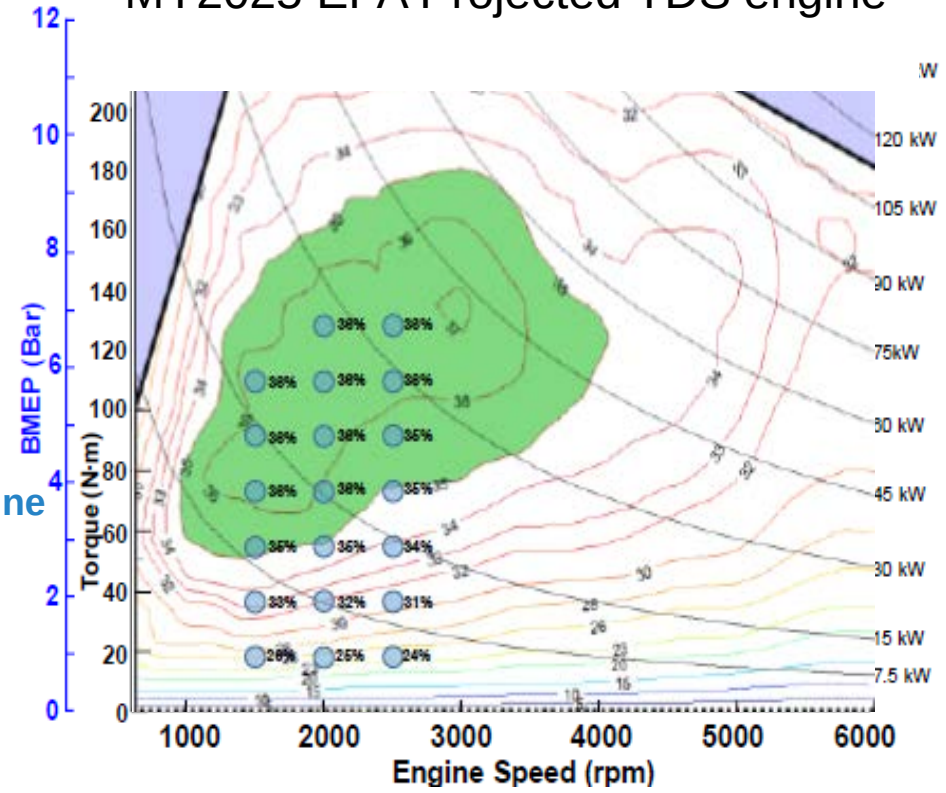
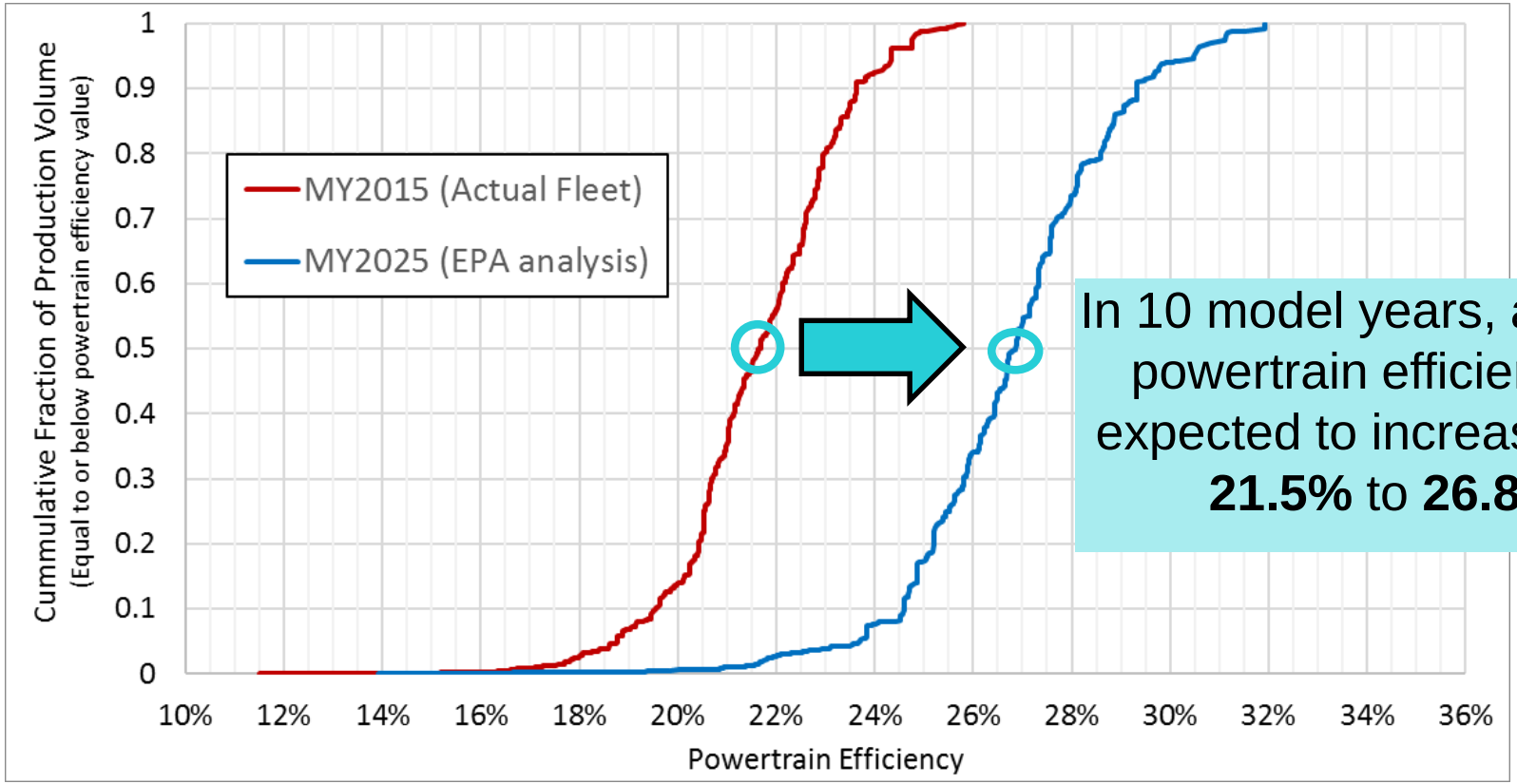
- Peak thermal efficiency 38%
- Very broad efficiency region
- Large overlap with 2-cycle test operation

MY2025 EPA projected turbo downsized engine
- Peak thermal efficiency **38%**
- Similar efficiency region as MY2016 actual engine
- Hardware improvements provide some improved low-load efficiency

MY2025 EPA Projected TDS engine

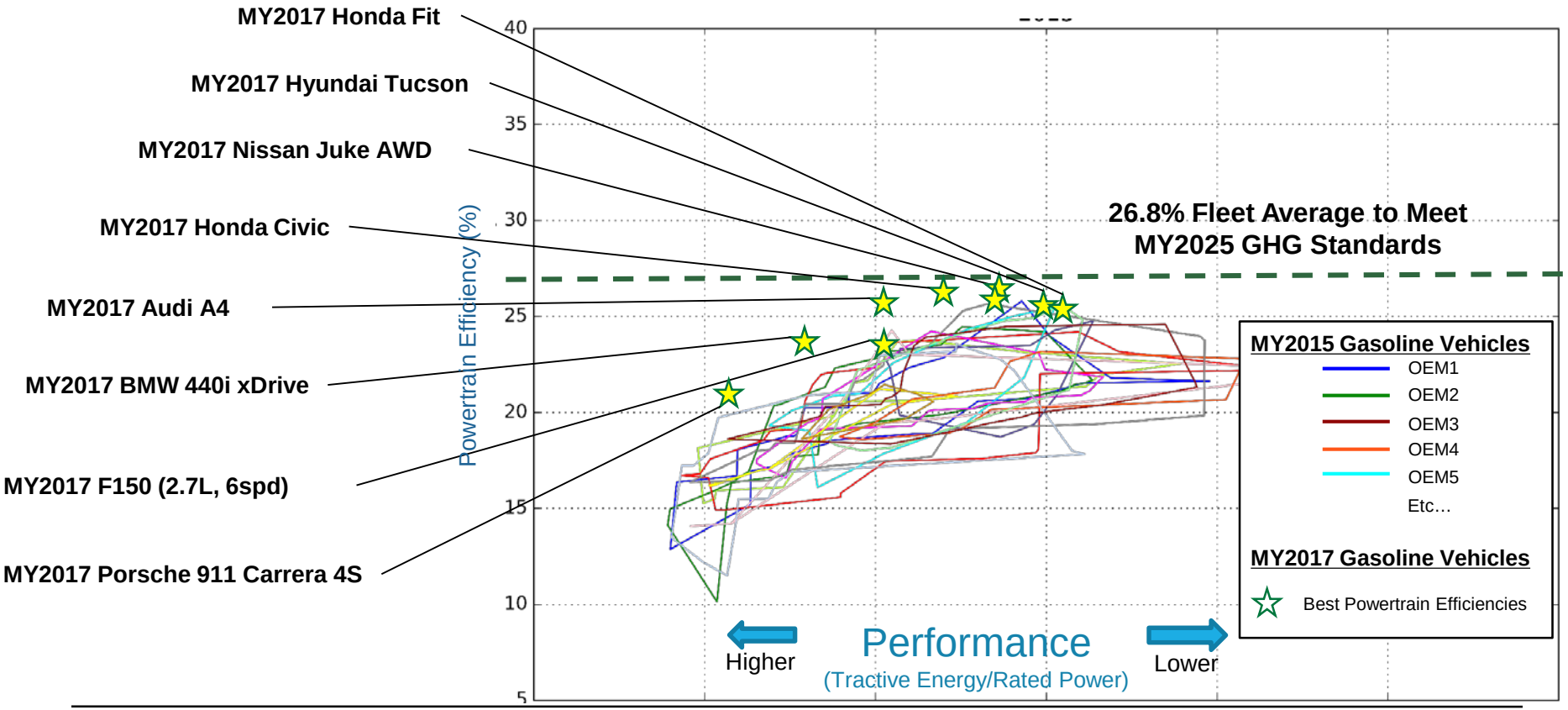


Current vs. Future Gasoline Powertrain Efficiencies



In 10 model years, average powertrain efficiency is expected to increase from **21.5%** to **26.8%**

Powertrain Efficiency: Current Levels and Projected Improvement Needed



WHAT COMES NEXT?

EPA's Reconsideration of the MTE Final Determination

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."

EPA Continues its In-depth Evaluation of Advanced Powertrains

Component benchmarking efficiency maps:

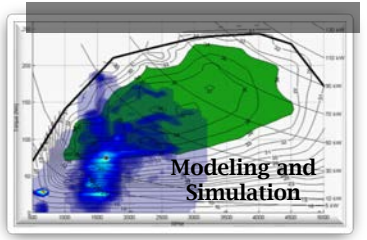
- MY2016 Mazda CX-9 2.5 liter GDI-turbo-charged w/ 6-speed AT
- MY2016 Honda Civic 1.5 liter GDI-turbo-charged 10.6:1 w/ CVT

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

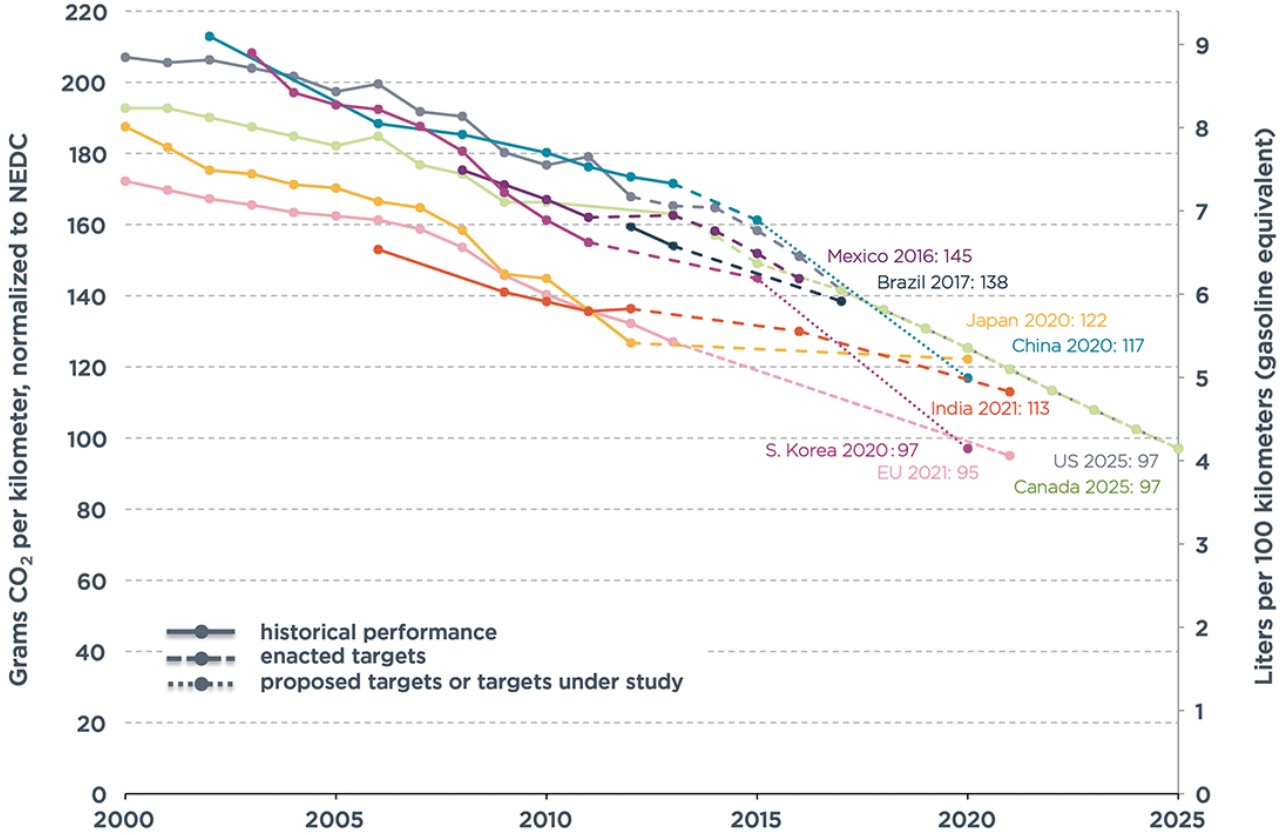
Demonstration and Modeling:

- 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



Modeling and Simulation

Global Passenger Car CO2 Standards



Source: International Council for Clean Transportation.

http://www.theicct.org/blogs/staff/improving-conversions-between-passenger-vehicle-efficiency-standards