

# Updates to Energy Rates and Sourcebin Distribution in MOVES 2010a

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The word "MOVES" is displayed in a stylized, metallic, three-dimensional font with a glowing effect, set against a dark, gradient background.

# Report Overview

- **Updates to 2008 and later light duty energy rates**
  - Emission rate table changes
    - Updated MOVES database (DB) with data on MY 2008-2010 vehicles
    - Updated MOVES DB with MY 2011 Fuel Economy (FE) final rule projections
    - Updated MOVES DB with MY 2012-2016 FE/GHG final rule projections
- **Modifications to the structure of energy rates in MOVES database (DB)**
  - Improved consistency between energy rates and remainder of MOVES
    - Resolution
    - Data availability
    - Aims
  - Changes to many “under-the-hood” tables
    - Redefined energy rate structure
    - Removed unused engine technologies from the MOVES DB
    - Removed unused emission rates from MOVES DB

# MOVES & Energy Consumption

- **MOVES can output energy consumption**
  - Energy rates first introduced in MOVES 2004
    - Energy rates are organized by Vehicle Specific Power (VSP) bin
    - Operating mode distribution and distance/time driven are major determinants of energy consumptions
  - Energy can be used to calculate fuel consumption
  - Energy is used to calculate other emission quantities
    - Carbon Dioxide (CO<sub>2</sub>)
    - Sulfur Dioxide (SO<sub>2</sub>)
    - Sulfate Particulate Matter (PM Sulfate)
    - Refueling

# Timeline of Energy Rates in MOVES

- **MOVES2004**
  - Released with full suite of energy rates to allow estimation of fuel consumption and GHG emissions
  - MOVES 2004 Energy and Emission Rate Inputs (Report: EPA420-P-05-003, February 2005)
  - Rates developed for fine detail of vehicle attribute and advanced technology, anticipating need for policy modeling (ex. *“How does reducing vehicle weight affect energy consumption?”*)
- **MOVES2010**
  - Relatively minor updates from MOVES2004
  - HD energy rates updated based on new VSP methodology
  - LD rates updated to include 2008-2011 MY 2011 Corporate Average Fuel Economy (CAFE) Standards for light trucks
- **MOVES2010a**
  - Rates updated substantively to account for CAFE MY 2011, LD GHG MY 2012-2016 standards
  - Rates updated structurally to greatly simplify MOVES' energy approach with focus on inventory development, rather than policy modeling

# How are Emission Rates Stored in the MOVES DB?

- Emission rates are defined by sourcebin discriminators
- **MOVES** allows different emission rates to be defined by different sourcebin discriminators
- A given pollutant/process combination can require information for any combination of these discriminators

Sourcebin Discriminators
Fuel type
Engine Technology
Regulatory Class
Model Year Group
Engine Size
Weight Class

## MOVES 2004 Sourcebin discriminators

**Table 4-1 – MOVES Source Bin Definitions for Total Energy**

Fuel Type	Engine Technology	Model Year Group	Loaded Weight	Engine Size
Gas	Conventional IC (CIC)	1980 and earlier	Null	Null
Diesel	Advanced IC (AIC)	1981-85	<= 2000 lbs	< 2.0 liters
CNG	Moderate Hybrid - CIC	1986-90	2001-2500	2.1-2.5 liters
LPG	Full Hybrid - CIC	1991-2000	2501-3000	2.6-3.0 liters
Ethanol (E85)	Moderate Hybrid - AIC	2001-2010	3001-3500	3.1-3.5 liters
Methanol (E85)	Full Hybrid - AIC	2011-2020	3501-4000	3.6-4.0 liters
Gas H <sub>2</sub>	Fuel Cell	2021 and later	4001-4500	4.1-5.0 liters
Liquid H <sub>2</sub>	Hybrid - Fuel Cell		4501-5000	> 5.0 liters
Electric	(See Table 4-14 for combinations of fuel type and engine technology used in MOVES2004)		5001-6000	
			6001-7000	
			7001-8000	
			8001-9000	
			9001-10,000	
			10,001-14,000	
			14,001-16,000	
			16,001-19,500	
			19,501-26,000	
			26,001-33,000	
			33,001-40,000	
			40,001-50,000	
			50,001-60,000	
			60,001-80,000	
			80,001-100,000	
			100,001-130,000	
			>=130,001	

# Data Sources underlying MOVES 2004 Energy Rates

- All data used for generating energy rates were second-by-second (1 Hz) resolution data.
- Data from:
  - 16 EPA test programs covering approximately 500 vehicles
  - 26 Non-EPA test programs covering approximately 10,760 vehicles
- “Holes” in the data were filled using one of two methods:
  - The Physical Emission Rate Estimator (PERE) (Report: Fuel Consumption Modeling of Conventional and Advanced Technology Vehicles in the Physical Emission Rate Estimator (PERE) EPA420-P-05-001, February 2005)
  - Interpolation

# Contrasting Criteria Pollutants and Energy in MOVES 2010

Criteria Pollutants	Energy
Fuel type	Fuel type
Engine Technology	Engine Technology
Regulatory Class	Regulatory Class
Model Year Group	Model Year Group
Engine Size	Engine Size
Weight Class	Weight Class
Age Group	Age Group



# Structural Changes

- Along with removing engine size and vehicle weight, MOVES 2010a removed most engine technologies from the model
  - Level of detail is not required in a fleet inventory model
  - Data availability issues (1 hz test data on all of these engines?)
  - Emergence of the OMEGA model lessened the need to model technologies in MOVES (<http://www.epa.gov/oms/climate/models.htm>)
  - Significantly reduced database size

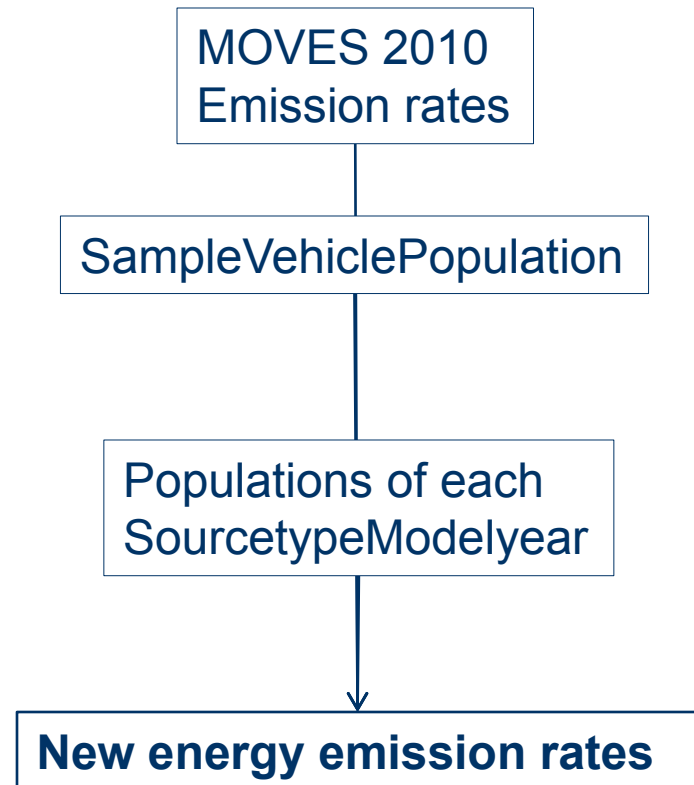
engTechID	Engine Technology Name	In MOVES2010a
1	Conventional Internal Combustion	YES
2	Advanced Internal Combustion	
11	Moderate Hybrid - Conventional Internal Combustion	
12	Full Hybrid - Conventional Internal Combustion	
20	Hybrid - Advanced Internal Combustion	
21	Moderate Hybrid - Advanced Internal Combustion	
22	Full Hybrid - Advanced Internal Combustion	
30	Electric	YES
40	Fuel Cell	
50	Hybrid - Fuel Cell	

## Changes to Energy Sourcebin Discriminators between MOVES 2010 and 2010a

Descriptors used in MOVES2010	Descriptors used in Moves2010a
Fuel type	Fuel type
Model year group (decadal)	Model year group (single year)
Engine size	Regulatory class
Vehicle Weight	
Size and weight distribution by sourcetype	
Engine Technology	

# Analysis

- **Change in Sourcebin discriminators was accomplished by analyzing MOVES 2010 database and “collapsing” the emission rate structure.**
- **Generated weighted average emission rates for each of the new 2010a sourcebinids based on the data in the MOVES 2010 database**
  - SampleVehiclePopulation table
    - Engine size distributions
    - Vehicle weight distributions
    - Engine technology distributions
  - Vehicle populations by regulatory class
- **Details found in report**



# New Data and Projections

- **Gasoline**

- MY 2008 and MY 2009 from Fuel Economy Trends report (<http://www.epa.gov/oms/fetrends.htm>)
- MY 2010 interpolated
- MY 2011-2012 from analysis published in MY 2012-2016 LD GHG final rulemaking (<http://www.epa.gov/oms/climate/regulations.htm>)

- **Diesel**

- Diesel vehicle sales are a small portion of the light duty market
- Diesel fuel has approximately 15% more energy and carbon per gallon than gasoline
- Assumed equivalent MPG under MY 2008-2011 CAFE rules
- Assumed equivalent CO<sub>2</sub> under MY 2012-2016 GHG rules

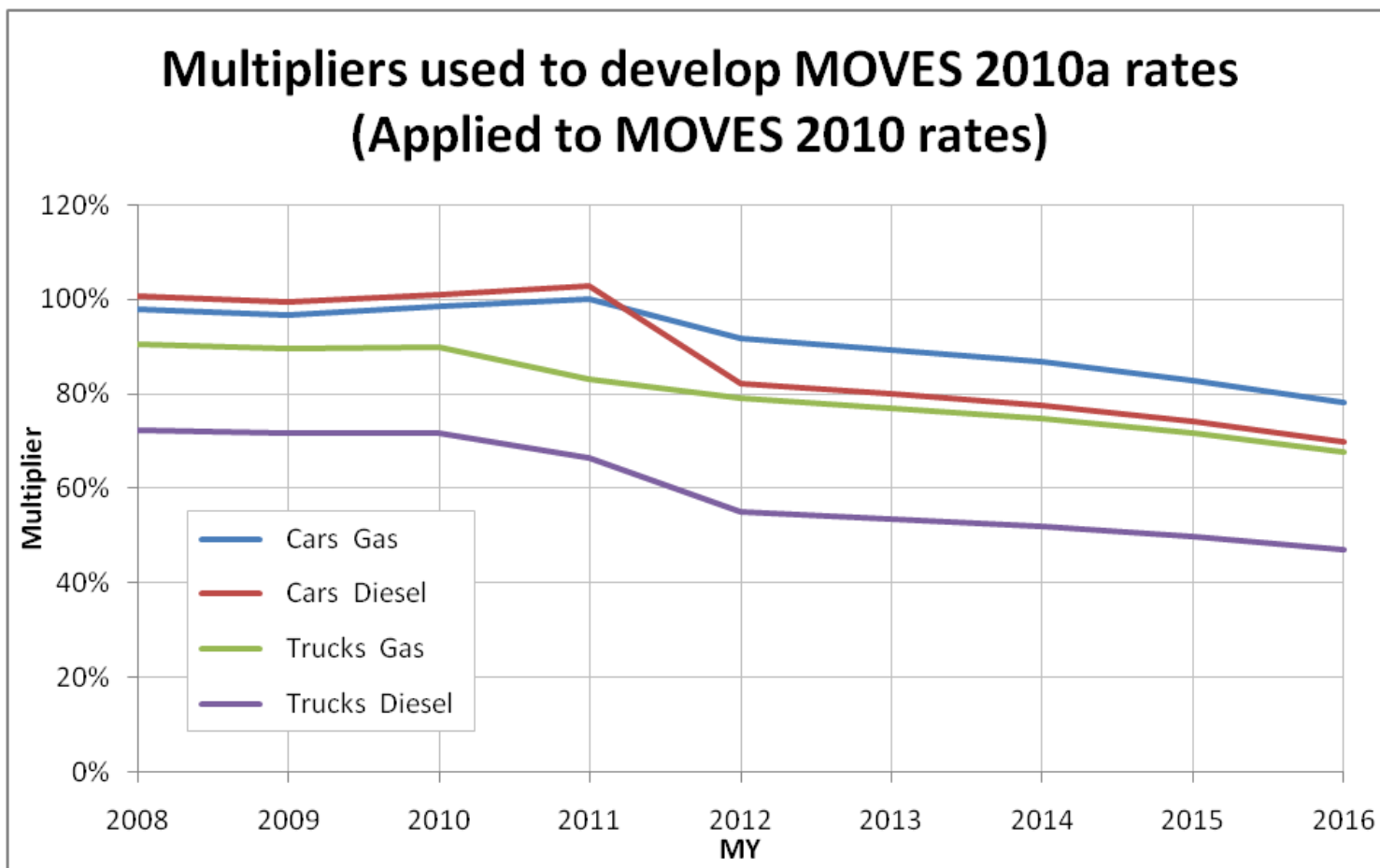
# Modeling New Rules in MOVES

- **2008 and later MY energy rates updated to account for rulemakings and new data**
- **New rates were generated top-down**
  - CO<sub>2</sub> emissions are directly proportional to energy consumption rates in MOVES, so CO<sub>2</sub> was used as a surrogate for energy consumption
  - Baseline CO<sub>2</sub> values were derived by running MOVES 2010 at the national/annual level for the desired regulatory classes
  - CO<sub>2</sub> output from MOVES was calibrated to a projected CO<sub>2</sub> emission rate from the rulemaking documents and reports
  - Adjustments were simple ratios between the old emission rates and the desired emission rates (kept same ratios between VSP bins)

# Update Notes

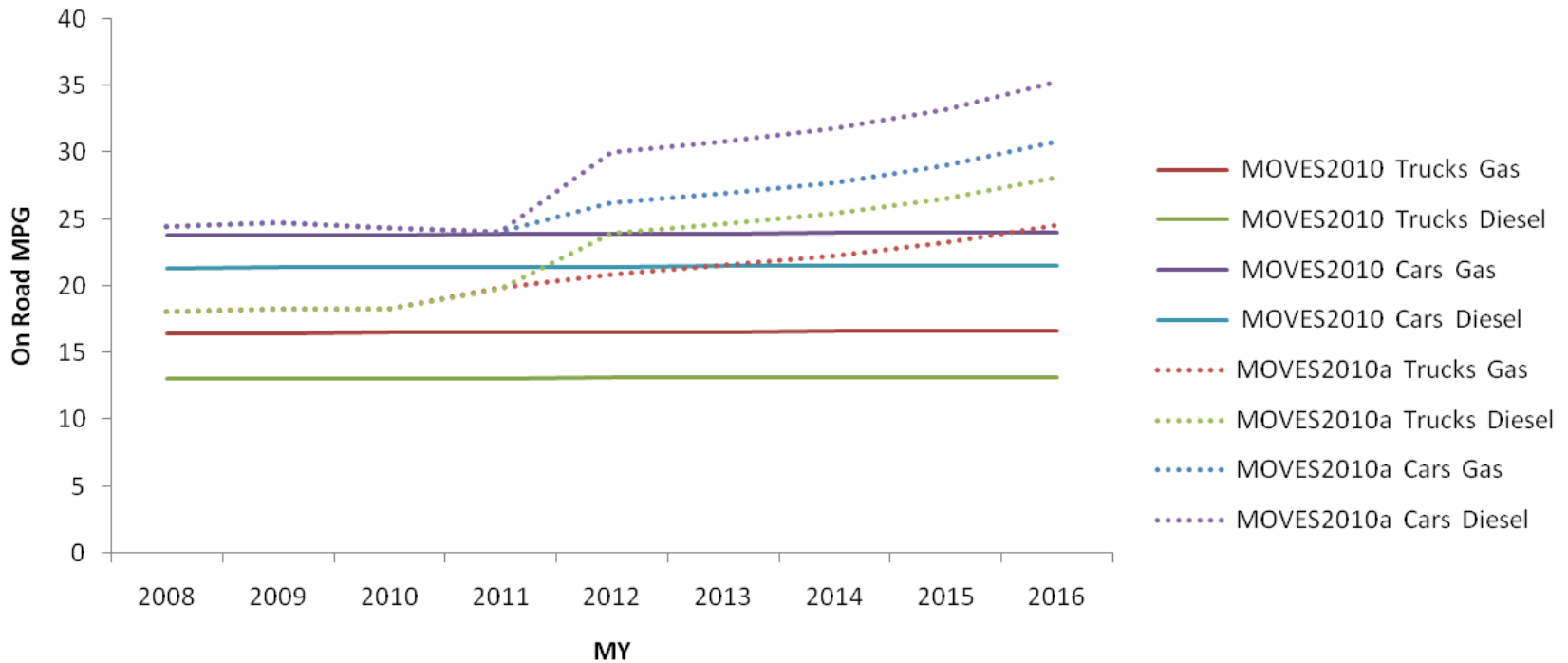
- **Changes to Car and Truck definitions**
  - MOVES “Car” and “Truck” regulatory classes are based on EPA criteria pollutant regulatory definitions.
  - The new car and truck rates from the CAFE/GHG rulemakings are based on significantly altered definitions
    - Rates were translated from CAFE/GHG rulemaking documents into MOVES Car and Truck definitions.
    - No changes to the MOVES regulatory definitions of “Cars” and “Trucks”
- **Appendix contains additional notes regarding MY 2008-2011**

## Ratios used



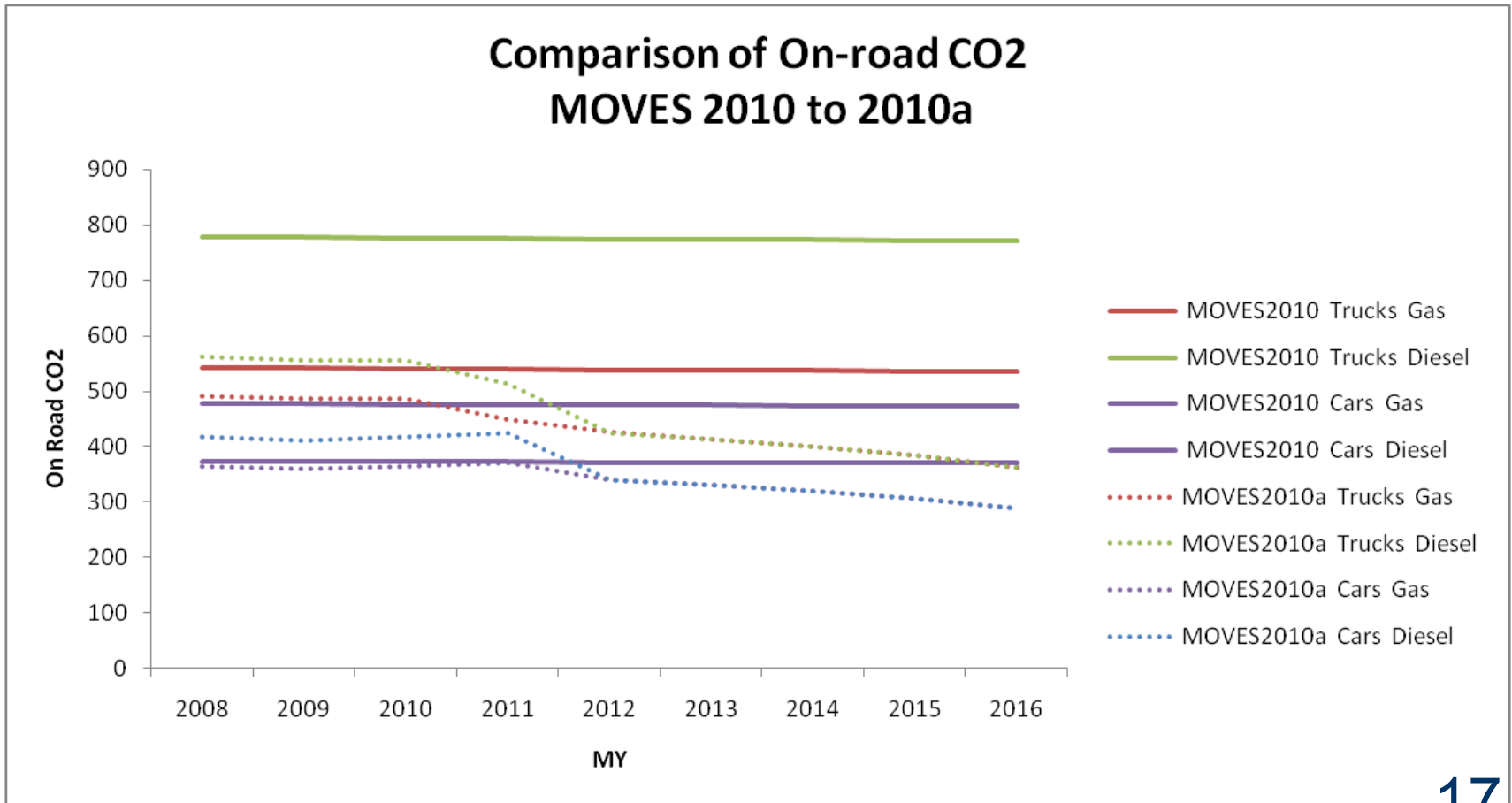
## MOVES Projected On-Road MPG

Comparison of On-road MPG  
MOVES 2010 to 2010a



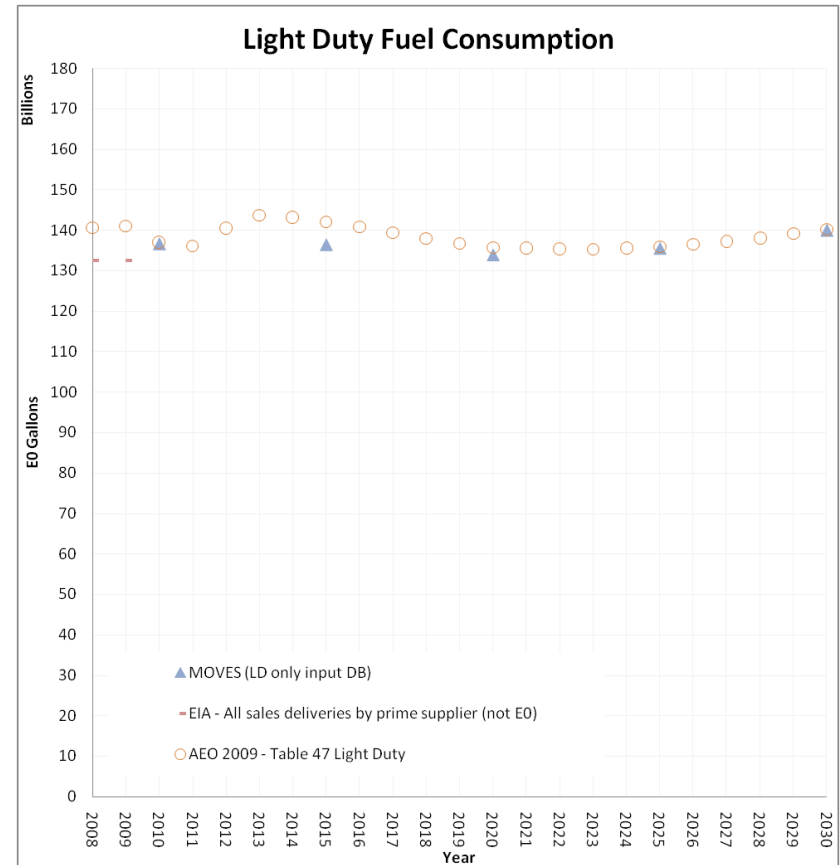


## MOVES Projected On-Road CO<sub>2</sub>



## Comparison to EIA projection of LD Gasoline Consumption

- **MOVES Runs conducted in 2010, 2015, 2020, 2025, 2030**
  - Input database used that produced emissions only from light duty regulatory classes.
  - Other inputs as defaults (AEO 2009 VMT for LD)
- **EIA data from**
  - Total Sales/Deliveries by Prime Supplier (Historic)
  - AEO 2009 Table 47 (Projections)
    - Adjusted for constant diesel fraction
- **Projections are largely similar for this time period**



# Inventory Impact of Changes relative to MOVES 2010

- **Structural changes**
  - Little impact on results
    - For any pollutant, runs conducted in calendar year 2001 with the new database differ by less than 0.1% as compared to MOVES 2010
    - A few specific processes related to energy differ by greater amounts (<10%), but have no meaningful impact on inventories
    - No changes in processes unrelated to energy
- **New Light Duty Energy Rates**
  - Decrease light duty energy consumption and related emissions
    - Starting in MY 2008, energy rates decrease relative to MOVES 2010
      - Model years after MY 2016 remain at MY 2016 levels
    - Inventory decreases related to energy rates
      - Energy
      - SO<sub>2</sub>
      - CO<sub>2</sub>
      - PM Sulfate
      - Refueling emissions (VOC)
  - No changes in processes unrelated to energy

## For More Details:

**EPA Report - “Updates to Energy Rates and Sourcebin Distribution in MOVES 2010a”**

**To be posted at:**

**[http://www.epa.gov/otaq/models/moves/movesback  
.htm](http://www.epa.gov/otaq/models/moves/movesback.htm)**

# Appendix – MY 2008 to 2011

- **Modeling MY 2008-2011 CAFE Light Truck Rule in MOVES2010**
  - In MOVES2010, we reflected the MY 2008-2011 light duty truck CAFE standards by increasing the proportion of “advanced gasoline” engine technology
    - No changes were made to the emissionrate table.
    - Energy consumption output was lower because advanced gasoline technology vehicles have lower energy consumption
- **Modeling MY 2008-2011 CAFE Light Truck Rule in MOVES2010a**
  - In MOVES2010a, we made all energy rate updates in the emissionrate table
    - Engine technologies were removed from MOVES
    - Redid analysis of the 2008-2011 MYs based on new data
    - Updated emissionrate table with new analysis
    - Comparisons on slides 15-17 do not reflect the updates to MY 2008-2011 in MOVES 2010.