



MOVES

Motor Vehicle Emission Simulator

Planned Updates to Default Fuel Supply for MOVES3

Presentation for MOVES Review Work Group

October 22, 2020

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Outline of Topics

- Diesel vs. gasoline fuel supplies
- Fuel regions overview & updates
- Updates to gasoline fuel supply
 - Fuel properties, volatility correlations, E0 and E15 blends
- Updates to diesel fuel supply
 - Sulfur & biodiesel
- Updates to Fuel Wizard
- Peer review



Diesel vs Gasoline Fuel Supplies

- Gasoline and diesel fuel supplies are developed differently
- For gasoline:
 - We have a large year-by-year dataset available for several fuel properties via refinery batch reports
 - Also have smaller amounts of retail survey data
 - Nonroad and onroad gasoline supplies are identical
 - MOVES fuel supply tracks 20+ representative formulations each calendar year to cover local and regional fuel properties



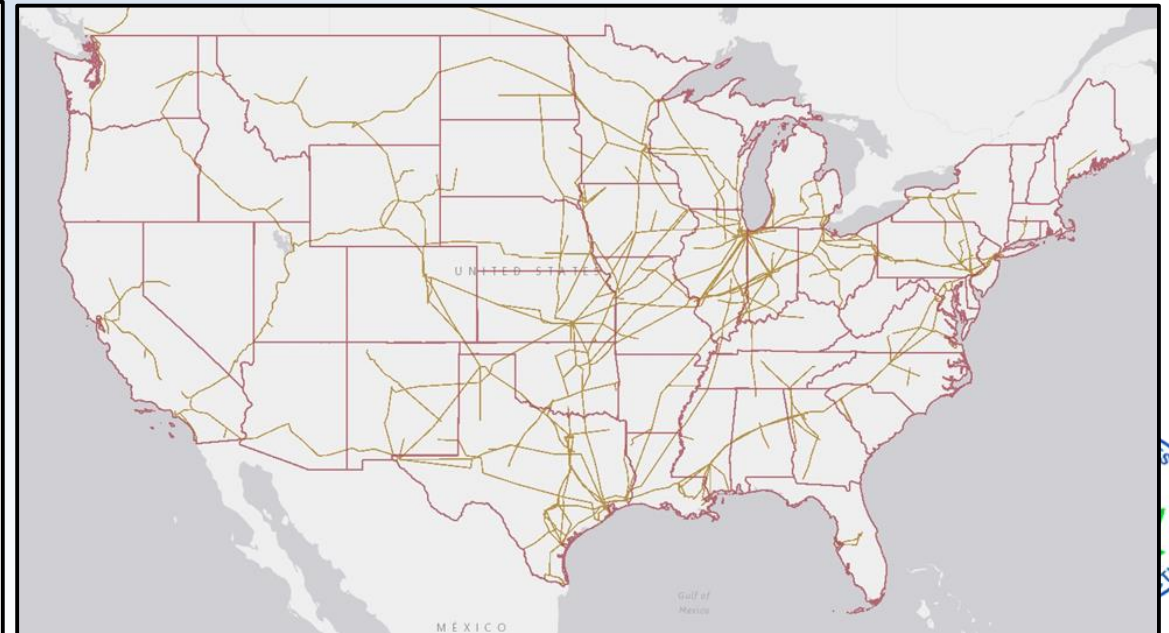
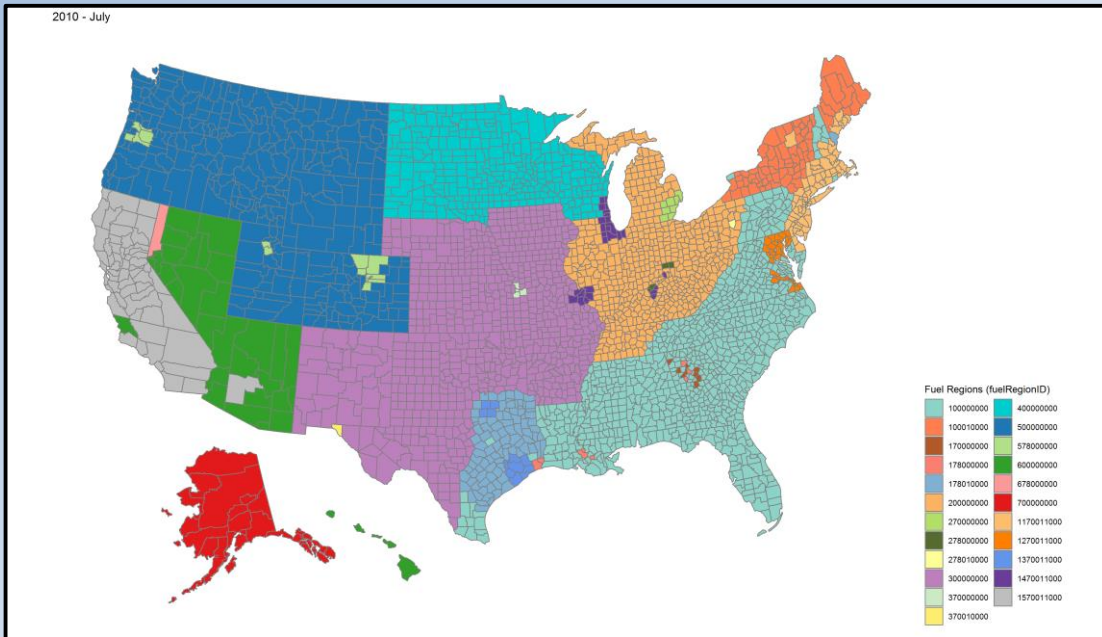
Diesel vs Gasoline Fuel Supplies

- Diesel has fewer fuel property reporting requirements
 - So we have less detailed data, mainly from surveys covering a small fraction of production volume
- Separate nonroad, onroad, and marine formulations
 - Differ in sulfur and biodiesel levels
- Single formulation nationwide for each calendar year (no regional or local fuel programs like gasoline)



Gasoline Fuel Regions Overview

- Seven base regions consider “Petroleum Area for Defense Districts” and fuel distribution networks (pipelines, terminals)
 - Local fuel control programs are overlaid on a county-level basis
 - Total of 23 unique regionID values used across all calendar years



Fuel Region Updates for MOVES3

- Revised Region 15 (California) fuel supply based on retail survey data¹
- New Base Region 7 (Alaska) fuel supply based on retail survey data¹
- Moved US Virgin Islands and Puerto Rico from Base Region 6 to Region 1
- Many other county-level changes to make the fuel supply more historically representative of RFG and volatility controls changing over time
 - These are described in detail in the technical documentation

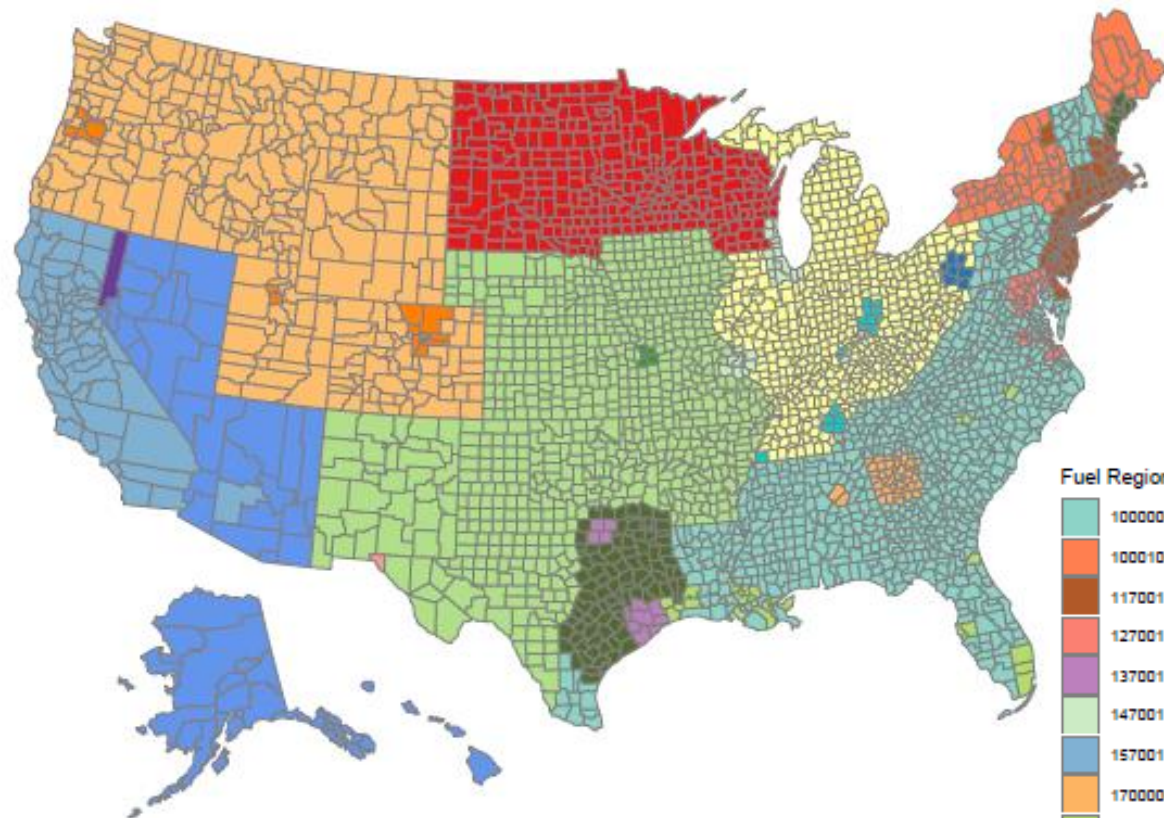


¹Alliance of Automotive Innovators North American Fuel Survey

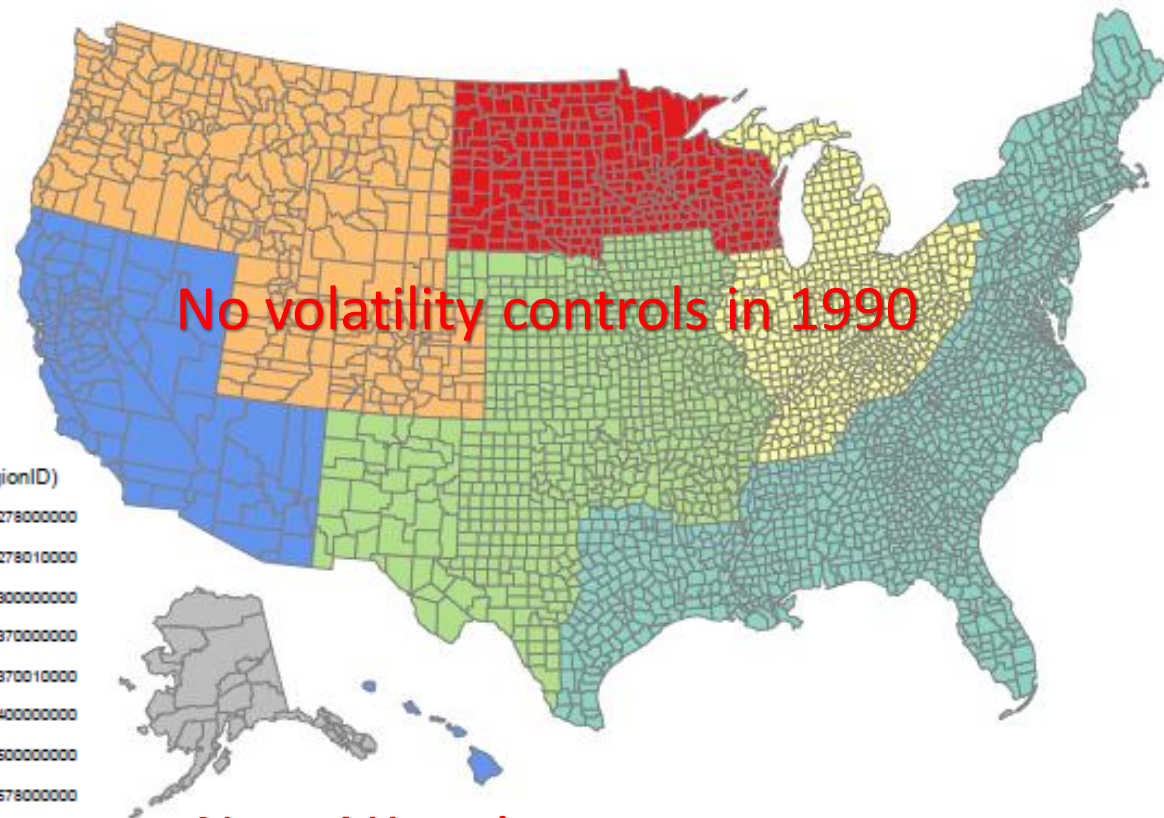
1990 Fuel Region Maps Comparison

1990 - July

MOVES2014



MOVES3



No volatility controls in 1990

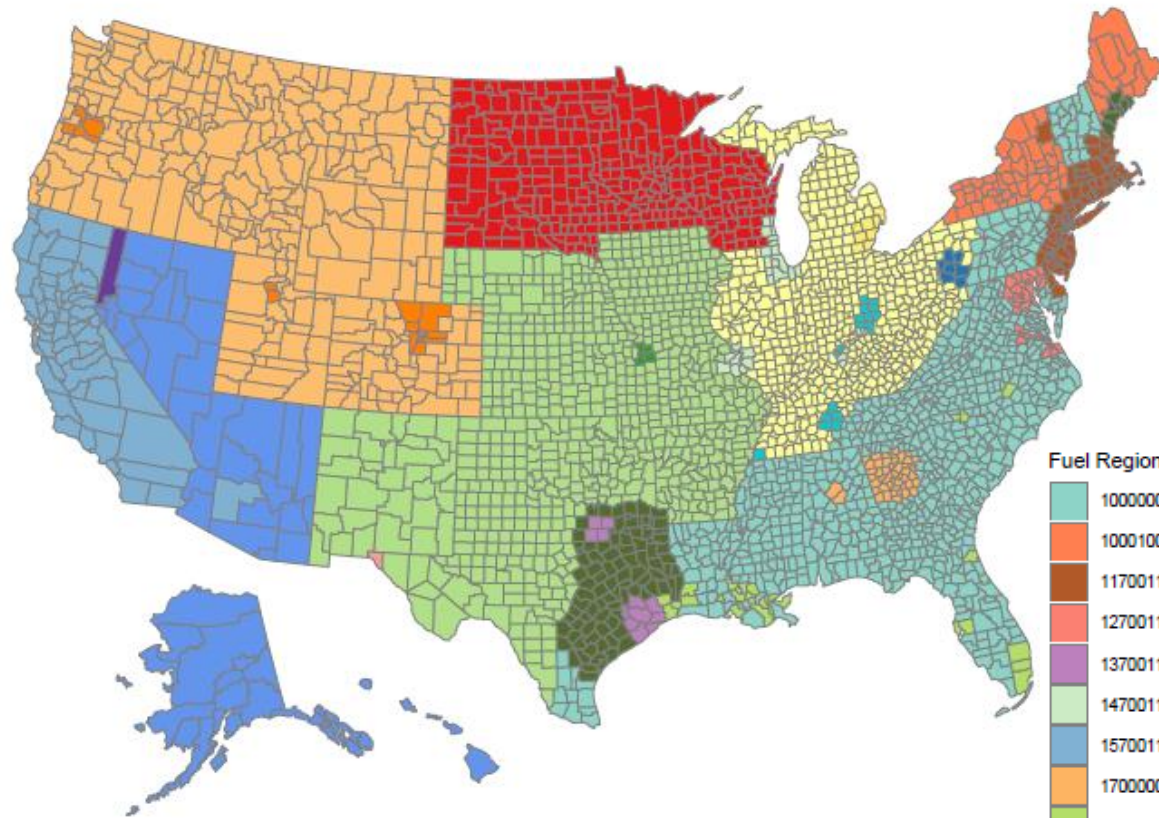
New AK region



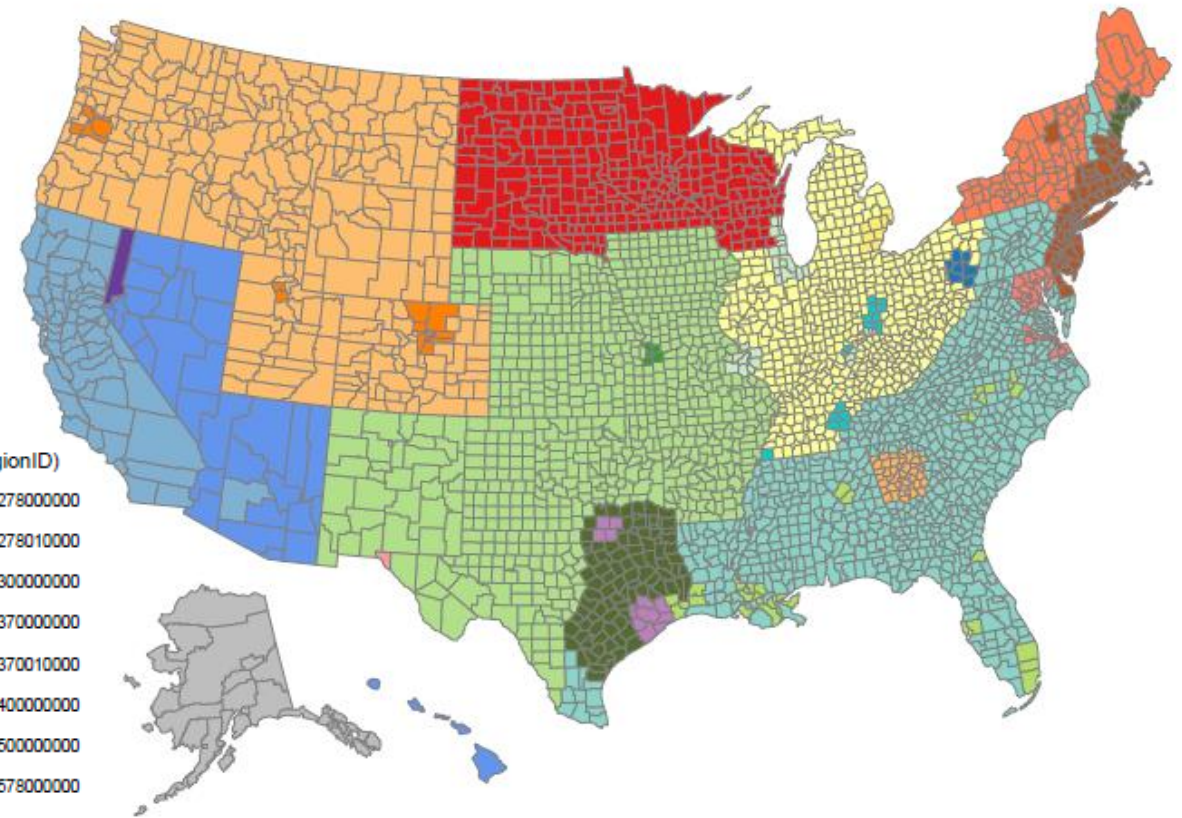
2010 Fuel Region Maps Comparison

2010 - July

MOVES2014



MOVES3



Fuel Regions (fuelRegionID)

100000000	278000000
100010000	278010000
1170011000	300000000
1270011000	370000000
1370011000	370010000
1470011000	400000000
1570011000	500000000
170000000	578000000
178000000	600000000
178010000	678000000
200000000	700000000
270000000	

Minimal difference in 2010

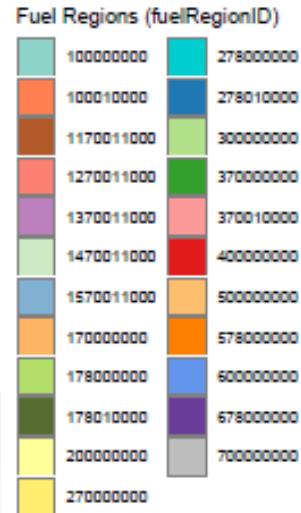
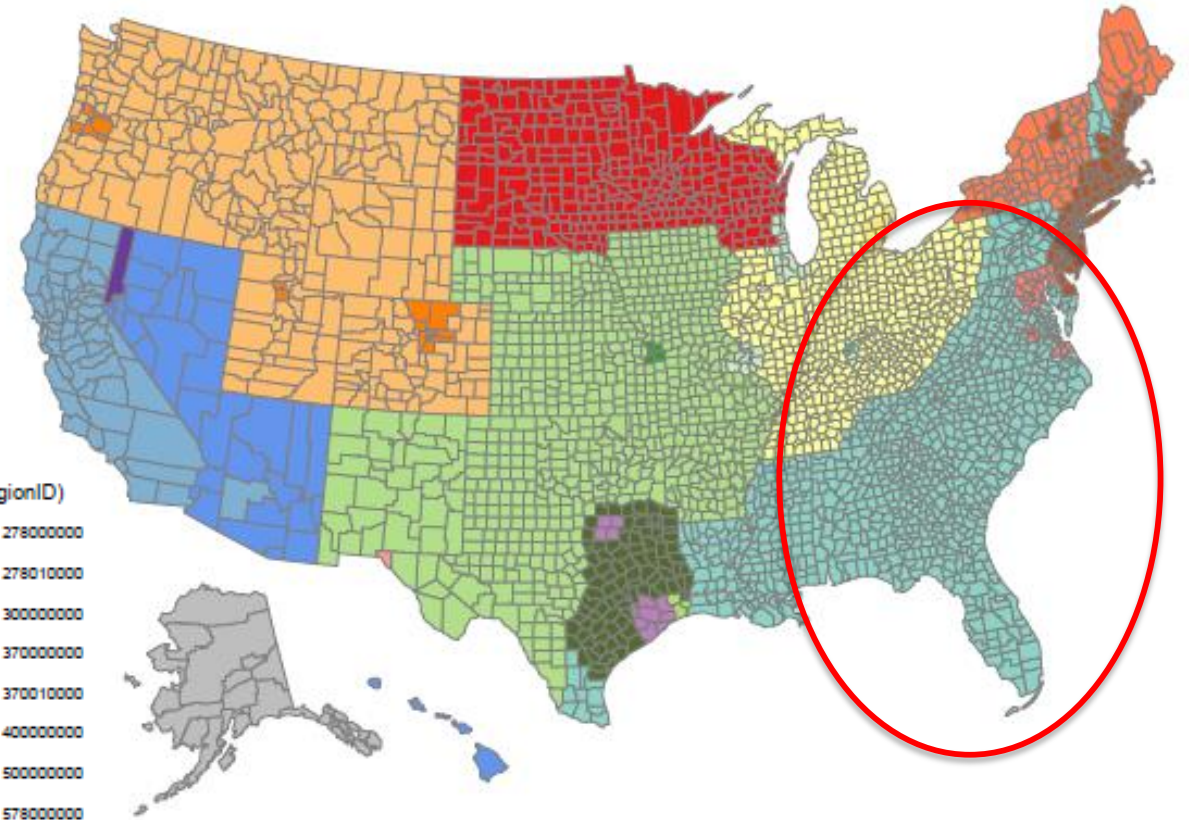
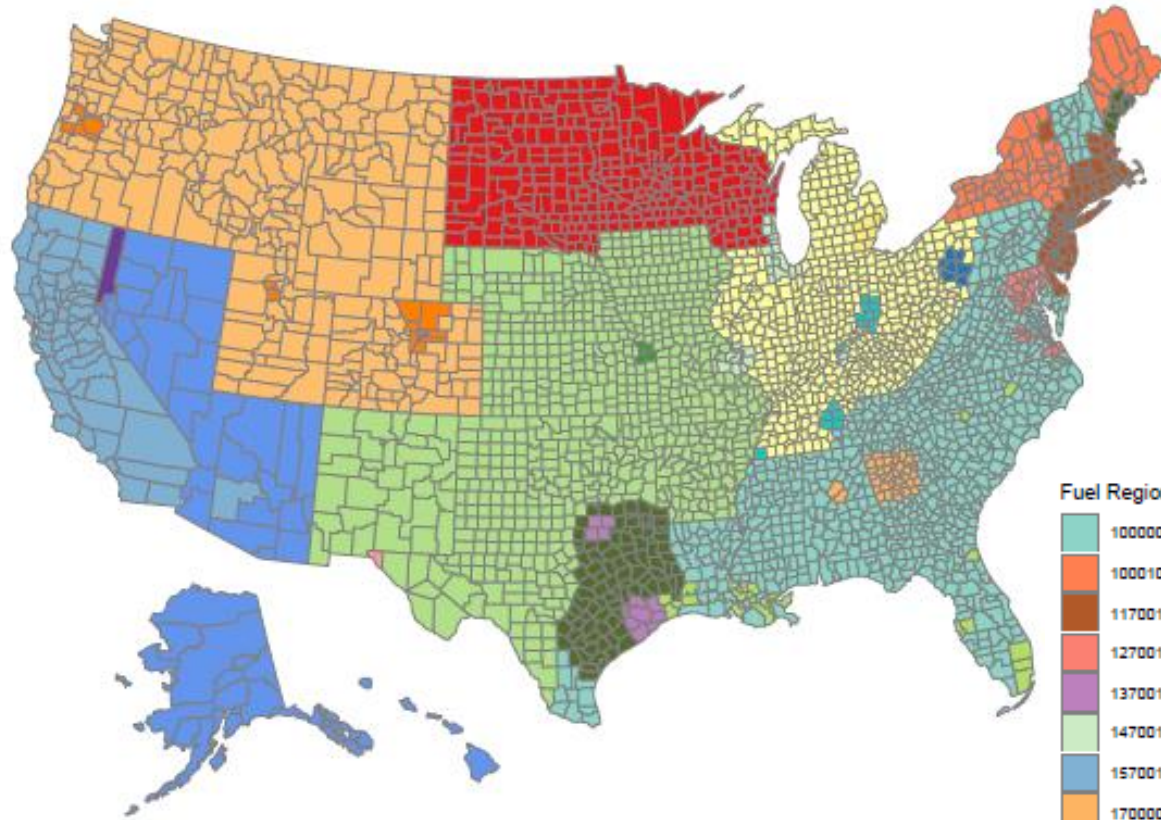


2020 Fuel Region Maps Comparison

2020 - July

MOVES2014

MOVES3

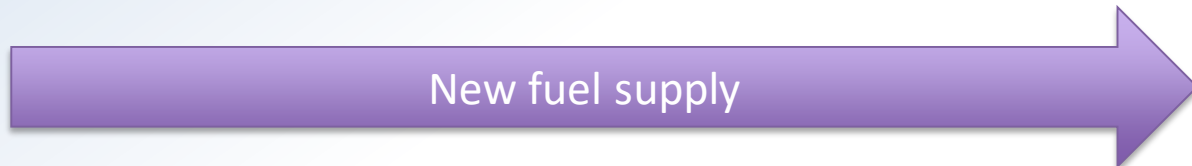
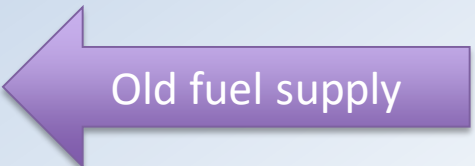


Many volatility control programs have ended by 2020



Overview of Gasoline Formulation Updates

Calendar year --->	1990-2011	2012	2013	2014	2015	2016	2017	2018	2019	2020+
E0 formulations	MOVES2014			Computed E0 properties from each year's E10 formulation using Fuel Wizard factors (i.e., reverse match blending)						
E10 formulations	MOVES2014 with updated distillation correlation			Adjusted 2016 values using batch data and any local RVP changes	Refinery batch data	Adjusted 2016 values using batch data and any local RVP changes	Derived from 2018 using Fuel Wizard sulfur effects assuming 10 ppm in all fuels by 2020, and any local RVP changes			
E15 formulations	None			Computed splash-blends from local E10 for winter season only (Summer RVP waiver was extended to E15 in 2019)				Computed splash-blends from local E10		
Market share	MOVES2014				100% E10					



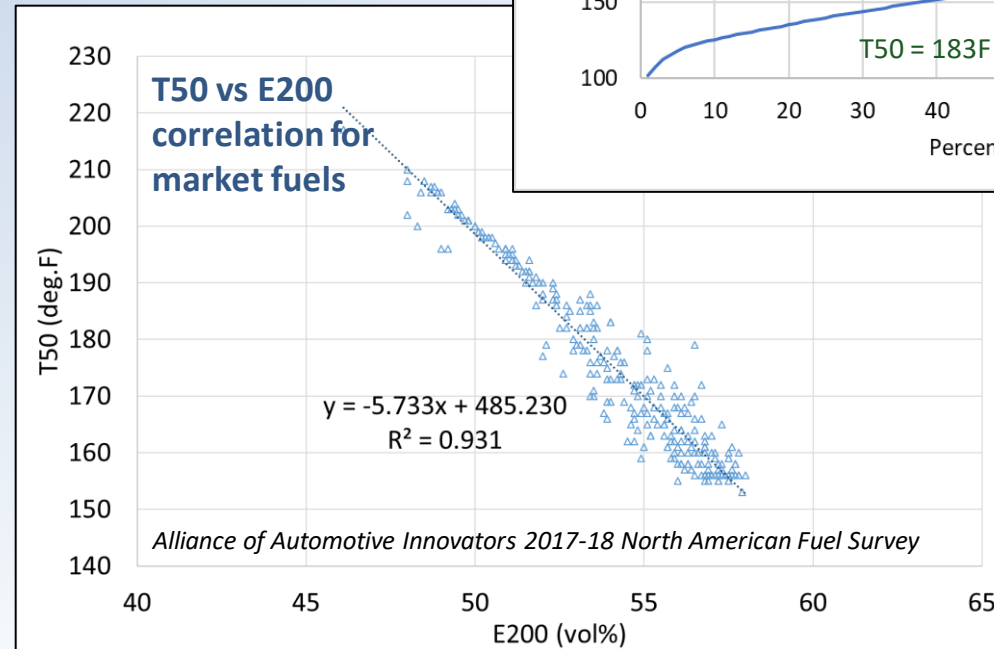
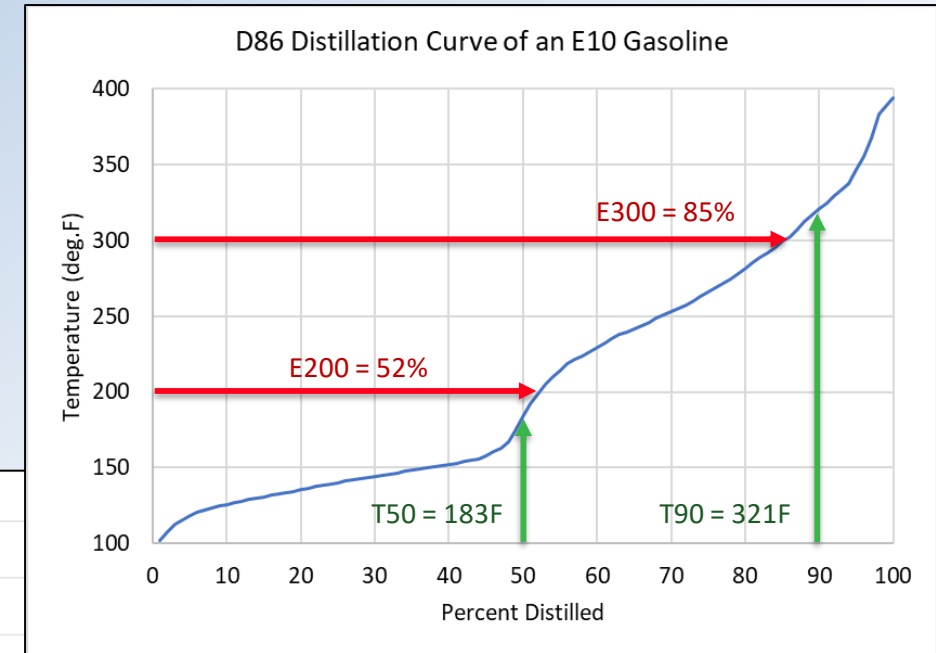
Gasoline for CY 2013 and Earlier

- For 2013 and earlier, MOVES3 uses the MOVES2014 fuel supply verbatim except for the following updates:
 - Removal of region designations not referenced by the RegionCounty table, and their associated formulations
 - Removal of “near duplicate” formulations with tiny differences in properties
 - Those within 0.5 ppm sulfur, 0.05 psi RVP, 0.05 vol% others
 - Replacement of small E15 market shares with E10 (~1% in some regions)
 - Revised T50 & T90 for E10 fuels (from updated review of ASTM D86 data)



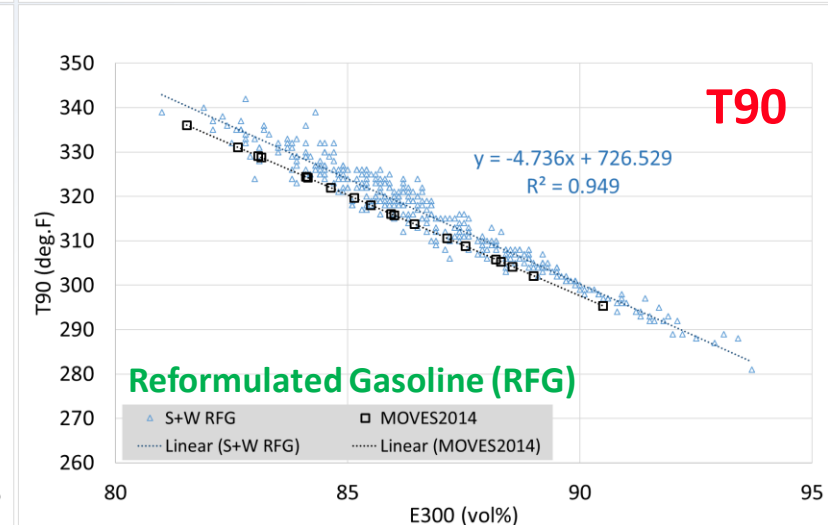
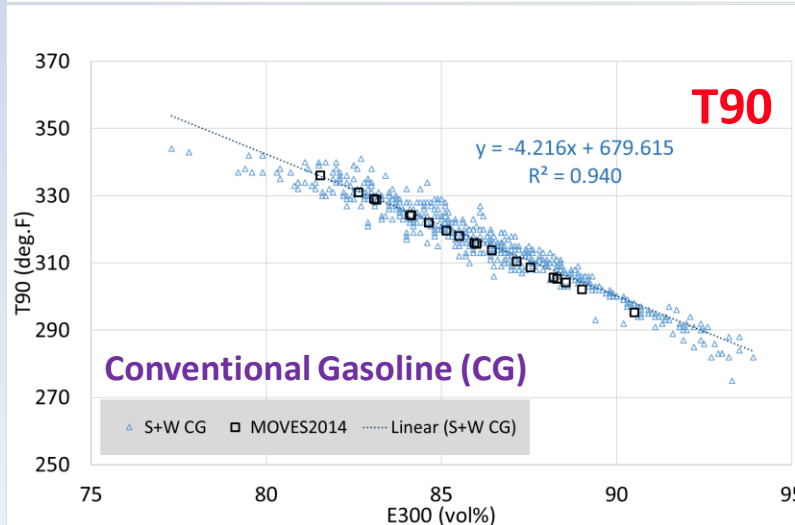
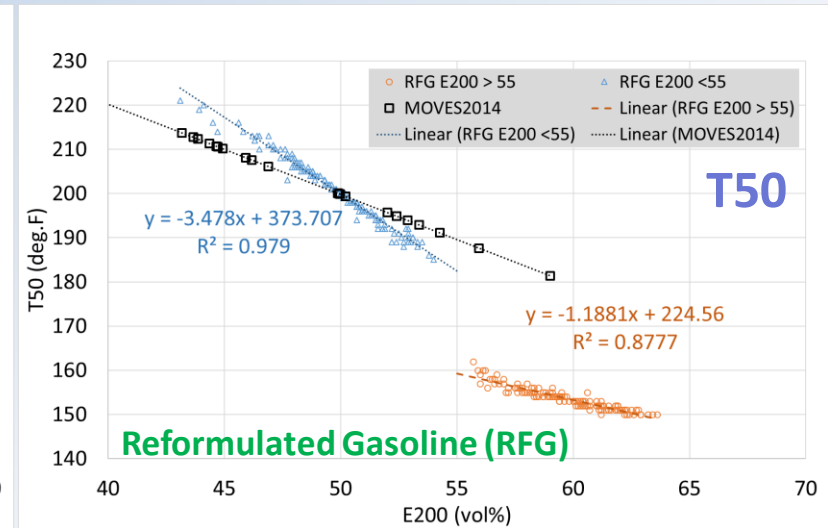
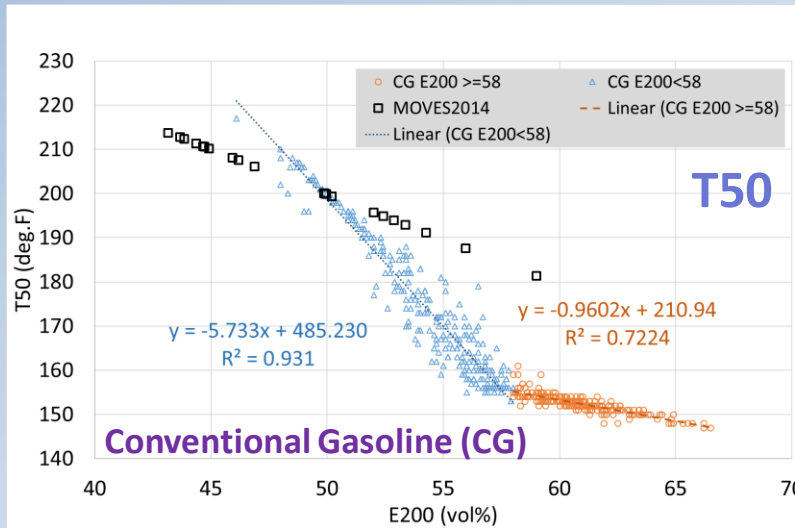
D86 Distillation Correlations

- Gasoline batch data used to develop the fuel supply primarily contains E-number volatility data, while emission models in MOVES rely on T-number inputs
 - Use market fuel correlations to translate E- to T-number
- E-numbers refer to volume percent evaporated at XX temperature
- T-numbers refer to the temperature at which XX percent has been distilled



Updated T50 & T90 Correlations

- 2017-18 retail survey data for regular grade E10 fuel was used to develop correlations between E200/T50 and E300/T90
 - Total of ~880 samples from 28 cities
- Observations supported fitting six relationships
 - For T50: RFG and CG, summer (blue points) and winter (orange points)
 - For T90: RFG and CG combined seasons



Gasoline 2014 and later

- 2016 gasoline fuel supply was the basis for these years
 - Produced from 2015-2016 refinery batch data²
 - Then calendar years 2014, 2015, 2017, and 2018 were produced using adjustment factors derived from batch data
 - Years 2019 and 2020 were produced from 2018 by reducing sulfur levels to the 10 ppm required by Tier 3, and adjusting other properties accordingly
- Year 2020 is duplicated forward to 2060

²US EPA. *Public Data on Gasoline Fuel Quality Properties*. 2020. <https://www.epa.gov/fuels-registration-reporting-and-compliance-help/public-data-gasoline-fuel-quality-properties>



Updated Fuel Wizard

- Tool that allows users to create custom fuel property inputs for “what if” analyses
 - Uses factors that estimate the collateral impact of a specified change on other properties
 - Fuel Wizard approximates match blending, not splash blending
- Allows input of three properties: ethanol, sulfur, RVP
- Ethanol blending factors were updated based on recent refinery modeling
 - Factors are additive, e.g., an E10 blend made to match octane of an E0 fuel in the same market is expected to have 2.2 vol% lower aromatics and 26 deg.F lower T50 in the summer season

MODELED CHANGE	RVP	SULF	AROM	OLEF	BENZ	E200	E300	T50	T90
Vol% to Vol%	psi	ppm	Vol%	Vol%	Vol%	Vol%	Vol%	Deg.F	Deg.F
E0 to E10 Winter	0.80		-1.7	1.7	-0.01	6.4	0.2	-23.8	-0.63
E0 to E10 Summer	0.90		-2.2	1.6		7.0	-0.2	-26.0	0.63
E10 to E15 Winter	-0.15		-0.85	0.85	-0.01	3.2	0.1	-11.9	-0.32
E10 to E15 Summer	-0.15		-1.1	0.80		3.5	-0.1	-13.0	0.32



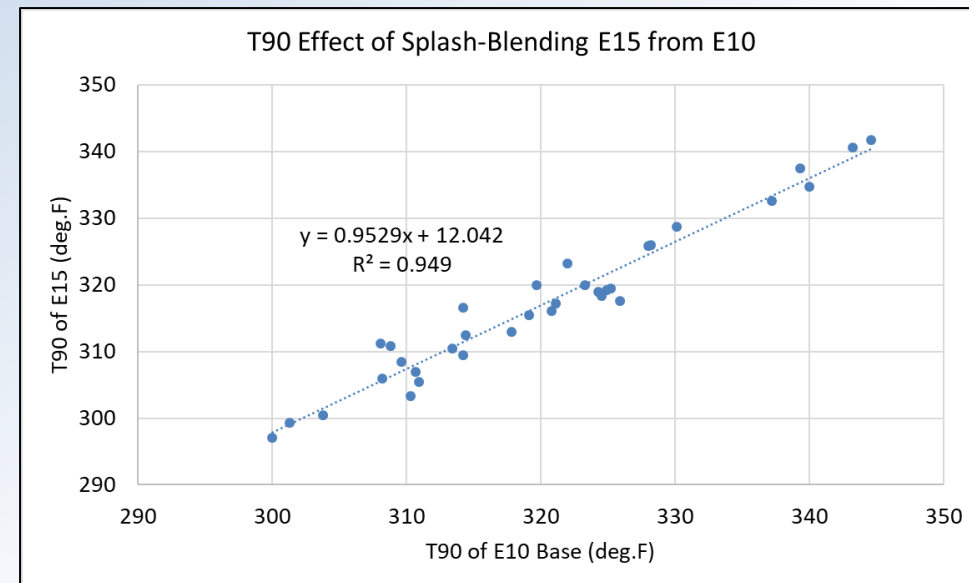
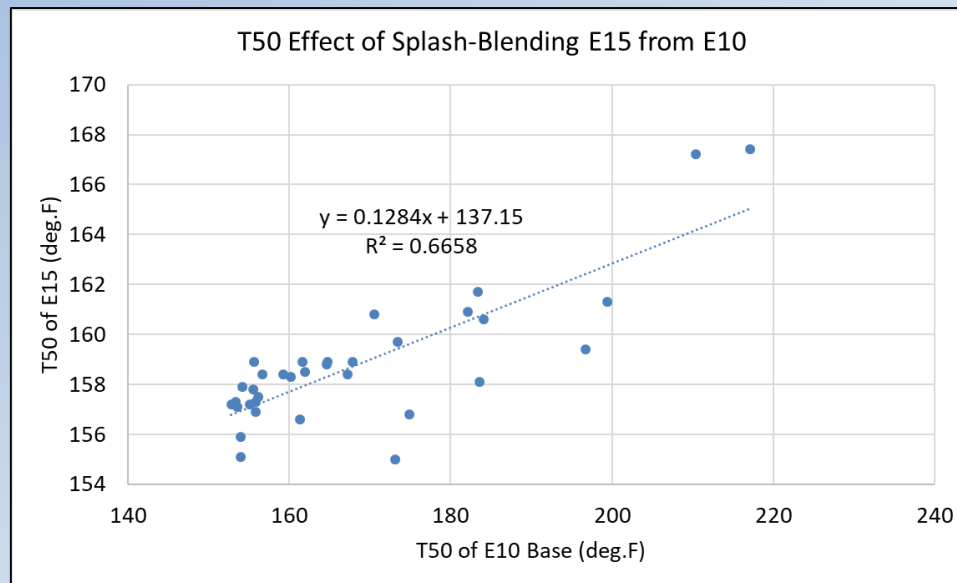
Default E0 and E15 Formulations

- Since E0 and E15 blends are of interest to model users, we created those formulations in each fuel region for 2014 and later years
 - Set their default market share to zero
- E0 blends were produced from the local E10 fuels using “reverse match blending” with updated Fuel Wizard factors shown previously



Default E15 Splash Blends

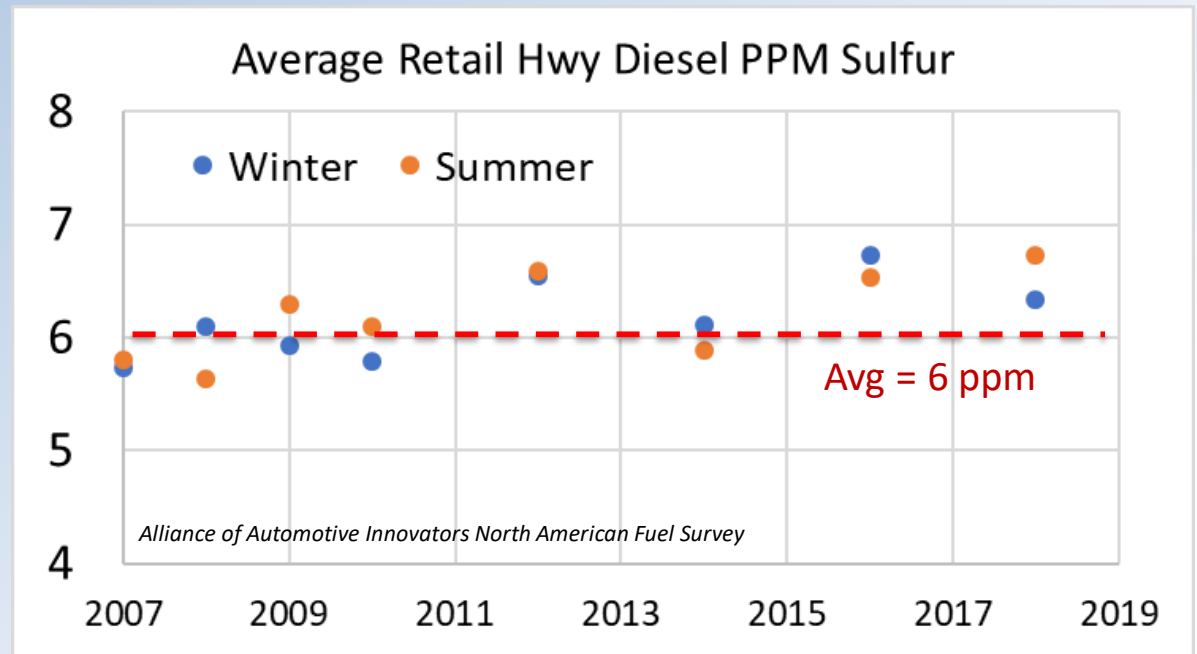
- E15 fuels were created for each region based on splash blending with the local E10 (not using the Fuel Wizard)
 - Distillation and RVP values do not blend according to dilution and were determined using data from the 2010 API blending study³



³American Petroleum Institute. Determination of the Potential Property Ranges of Mid-Level Ethanol Blends, Final Report. April 2010.

Onroad Diesel Sulfur

- Onroad diesel sulfur level was reduced to 6 ppm nationwide starting in 2007 based on review of retail survey data⁴
 - Showed consistent sulfur levels in the single digits for nearly all samples and locations in 2007 and later
 - Indicated 2006 was a transition year, so sulfur level was held at previous year value of 130 ppm versus 15 ppm in MOVES2014



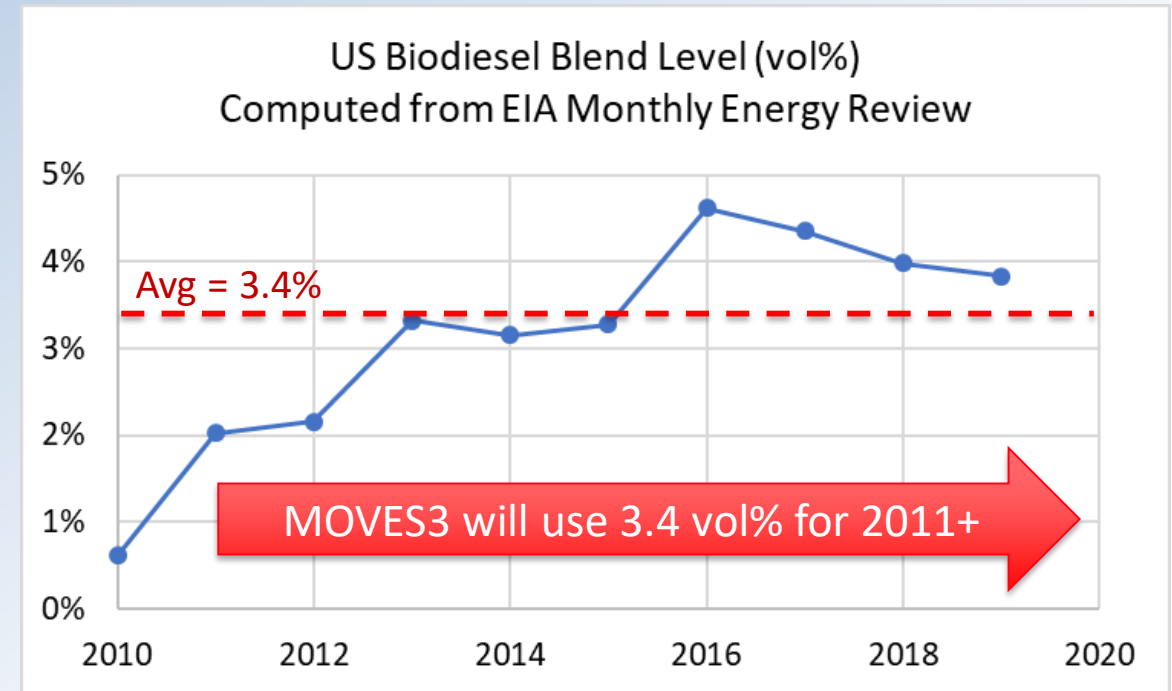
Year	Sulfur level, ppm	Biodiesel, vol%
1990	1000	0
1999-2006	130	0
2007-2010	6	0
2011+	6	3.4

⁴Alliance of Automotive Innovators North American Fuel Survey



Biodiesel Blend Level

- MOVES2014 had 5 vol% for 2014 and later
- Revised to 3.4 vol% for 2011 and later in all onroad diesel (zero before 2011)
 - 2011 is the first year the blend level exceeded 1 vol% nationally
 - 3.4% is the national average blend level over 2011-2019



Energy Information Administration, Monthly Energy Review, Tables 10.4 and 3.7c, August 2020 version.



Nonroad Diesel

- Nonroad diesel sulfur was set to 6 ppm for 2012 and later
 - Onroad and nonroad refinery products merge after end of phase-in period
- No changes were made to locomotive/marine diesel sulfur
- Nonroad is assumed to contain no biodiesel

Calendar Year	Nonroad	Marine
1999 and earlier	2284	2640
2000	2284	2640
2001	2284	2635
2002	2284	2637
2003	2284	2637
2004	2284	2637
2005	2284	2637
2006	2242	2588
2007	1139	1332
2008	351	435
2009	351	435
2010	165	319
2011	32	236
2012	6	124
2013	6	44
2014 and later	6	15



Peer Review

- Underlying data and analysis used to develop the draft MOVES3 fuel supply were peer-reviewed earlier this year
- Substantive comments on the database included:
 - Consider moving AK, PR, and USVI out of Base Region 6 (addressed)
 - RFG and other volatility programs shouldn't be included in 1990 fuel supply (addressed)
 - Single national biodiesel blend level stepping from zero to 5% in 2014 doesn't represent state/regional differences or changes over time
 - New national average blend level better reflects the most recent data, but we don't have sufficient data to develop state-specific biodiesel blends at this time



Summary

- MOVES3 generally uses the same regional fuels structure and fuel formulation data sources as MOVES2014
- Gasoline formulations 2014 and later reflect updated batch data with Tier 3 sulfur phase-down applied
- Ethanol blends have been simplified to reflect 100% E10 market share in all regions for 2012 and later
 - There are E0 (match blend) and E15 (splash blend) formulations available for all regions (default market shares set to zero)
- Revised T50 and T90 distillation values for ethanol blends
- Updated Fuel Wizard factors for ethanol blending
- Final diesel sulfur values reduced from 15ppm to 6ppm



Additional Information

- Lots more details are available in the technical report, to be released with the model
- Peer review comments and EPA responses will be posted on the EPA Science Inventory site
- Questions can be submitted to: mobile@epa.gov

