MOVES2014 update

Edward Nam and Darrell Sonntag

EPA STAR Transportation Emissions Research Forum - March 4-5, 2014

Agenda

▸ What is MOVES2014?

▸ What's our process of updating MOVES?

▸ What are the major data updates to MOVES2014?

▸ What's next after MOVES2014?

Updates to MOVES2014

Overview

What is MOVES?

- <u>Mo</u>tor <u>V</u>ehicle <u>E</u>mission <u>S</u>imulator
- Estimates emissions & energy use from highway mobile sources
  - Criteria pollutants
  - GHG pollutants
  - >180 air toxics
- Accounts for national emission standards, vehicle populations and activity, local rules, fuels and meteorology

MOVES is a Science-Based Policy Tool

▶ **MOVES serves two broad "required" user groups**

  ▶ Internal EPA for regulatory and analytic support

  ▶ State and local governments for SIP and Conformity analysis

    ▶ Used for state implementation plans, transportation conformity determinations, NEPA assessment, EPA regulations, research

▶ **Many researchers and consultants also use MOVES**

▶ **CAA requires EPA to review and (if necessary) revise emission factors at least every 3 years**

  ▶ Important to balance the needs for model stability for States/regions with incorporating the latest science and regulations

MOVES is a Bottom-Up Emission Model

▶ Emission rates are tied directly to the physical processes that create those emissions

  ▶ Linked to the activity and technology

    ▶ Running emissions: Based on operating modes through Vehicle Specific Power

    ▶ Start emissions: incorporates technology, soak time/ambient temperature dependence

    ▶ Crankcase emissions: models failures in crankcase ventilation systems, venting of diesel crankcase emissions

    ▶ Evaporative emissions: permeation/vapor venting/leak processes

    ▶ Brake & Tire Wear: physical driven model

    ▶ Auxiliary power unit emissions, extended idle emissions (hotelling), refueling emission processes

▶ Bottom-up approach enables MOVES to:

  ▶ Evaluate impact of vehicle technologies and fuel properties on emissions

  ▶ Use consistent approach in estimating project-level inventories as well as national-level inventories

Ongoing Process for Updating MOVES

▸ Collect
- ▸ MOVES is a data driven model
- ▸ Data from EPA test programs, relevant research programs, peer-reviewed literatures
- ▸ User concerns, recommendations, suggestions
- ▸ Problems, potential errors, inaccuracies

▸ Analyze
- ▸ New data, determine appropriateness of inclusion into MOVES
- ▸ Confirm issues and/or evaluate recommendations
- ▸ Projections of future incorporating the impacts of regulations

▸ Develop Code

▸ Prioritize
- ▸ Based upon impact to user, data accuracy, impact on results

▸ Test Code, Document and Peer Review

▸ Release

▸ Validate

▸ Collect Feedback

▸ Repeat!

Processes for Peer Review and Receiving Feedback

- **FACA workgroup**
  - EPA presented details of technical updates on six, ½ day meetings
  - Reviewers included: Industry Trade Groups, Environmental Groups, Federal/State/Local Government, Research Consortiums, Academia
- **Peer-reviewed 8 MOVES technical documents**
- **Training courses**
  - Over 50 trainings to date, with over 1300 attendees
  - Additional hands-on courses and webinars planned for 2014
  - MOVES workshop in 2011, attended by over 230 stakeholders
- **MOVES inbox, web pages and Frequently Asked Questions**
  - Provided over 2500 responses to user questions
- **Support to air quality and transportation agencies**

MOVES2010 Validation paved the path to data collection for MOVES2014

- **Validation of a model like MOVES is multi-faceted**
  - Studies must be scrutinized carefully
- **Validation work on MOVES 2010 provided direction for updates**
  - Dynamometer test programs (e.g. CRC E55/59)
  - Remote sensing (e.g. Houston Drayage Data)
  - Tunnel & road side studies
  - Air quality modeling and ambient air quality monitoring
  - Fuel consumption surveys
- **Showed energy rates, emission rates, fleet and activity generally favorable**
- **Along with feedback, validation guide and help us to prioritize analysis of new data, development of functional**
  - 9 **improvements**

New Test Programs & Data in MOVES2014

- Fuel Effects
  - EPAct study on Gasoline fuel effects
  - Effects of E85 on emissions
  - EPA In-Use Sulfur Test Program
- Evaporative Emissions
  - CRC E-77 – Ethanol, RVP, leak magnitude
  - High Evap Field Study – leak frequency
  - Running loss vapor leak study
  - Multiday Diurnal Testing
- PM Emissions
  - Kansas City light-duty gasoline study
- Temperature Effects
  - EPA Cold Temperature Study

- Heavy Duty
  - In-Use Compliance Program PEMS data
- Population and Activity
  - R.L. Polk 2011 Vehicle Population
  - 2011 FHWA VMT
  - 2014 AEO Vehicle Sales and VMT Projections
  - 2011 National average speed distribution using TomTom GPS data
- Fuel Supply
  - Refinery batch fuel certification
  - Updated AEO fuel distributions projections

MOVES Future Projections

- Retrospective modeling provides solid foundation on which to project future emissions
  - Regulatory Control programs (e.g. OTAQ regs and IM)
  - Deterioration rate (and high emitters/emissions) analysis
- EPA Regulations implemented in MOVES2014
  - Heavy-Duty Greenhouse Gas (HD GHG) MY 2014-2018
    - Decrease in heavy-duty energy consumption rates
    - Decrease in criteria pollutant emissions as a result of improved aerodynamics and rolling resistance.
    - Increase in criteria emissions from auxiliary power units
  - Light-Duty Greenhouse Gas (LD GHG) MY 2017-2025
    - Decrease in light duty energy consumption rates
  - Tier 3 Vehicle Emissions and Fuel Standards Program MY 2017-2025
    - Decrease in light-duty and medium-duty emission rates
    - Reduction in gasoline sulfur level
    - Significant reductions in vapor venting, permeation and evaporative leakage
  - Renewable Fuel Standard (RFS)
    - Updated mandated ethanol volumes
    - Updated flex-fuel vehicle (FFV) penetrations

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MOVES2014 "Functional" Improvements

- Improved integration of MOVES with air quality models
  - TOG and PM Speciation
  - Improved SMOKE-MOVES
- Fuel Wizard
  - Automatically adjust fuel property changes based on user-made fuel property changes (e.g. ethanol)
- Incorporate NONROAD model into MOVES
- Added Features for local inputs
  - MOVES HPMS vehicle categories aligned with new FHWA definitions
  - Hoteling importer for local users to use own hoteling activity
  - Start importer for local users to import own start activity data
  - Upgraded tool to estimate fleet-wide impacts of retrofit strategies
  - Additional road types to separately account for ramp activity
- GUI improvements
  - Better error checking, reg-class output option, ramp-only/highway-only road type option, removal of leap years

What's Next?

▶ MOVES2014 release expected in spring, 2014

▶ Validation of MOVES2014

▶ We will be initiating a large new data collection survey

  ▶ Nonroad

  ▶ On-road

  ▶ Fleet and activity

▶ Collect early feedback from users

▶ Continually improve model science, functionality, and performance

Technical updates to MOVES2014

Evaporative Emissions Modeling

▶ **Previous modeling tied to certification test procedures, based on data from 1990's:**

  ▶ **Running Loss** – vapor lost during vehicle operation

  ▶ **Hot Soak** – vapor lost while a vehicle cools after engine turn-off

  ▶ **Diurnal/Cold Soak** – vapor lost while parked at ambient temperature

  ▶ **Refueling Loss** – vapor lost and spillage occurring during refueling

▶ **MOVES revised approach based on *underlying physical processes,* has driven development of new test procedures**

  ▶ **Permeation** – migration of HC through materials in fuel system

  ▶ **Tank Vapor Venting** – vapor generated in fuel system lost to atmosphere when not contained by evap emission control system

  ▶ **Liquid Leaks** – Liquid fuel leaking from the fuel system, evaporating to atmosphere

  ▶ **Refueling Emissions** – spillage and vapor displacement as a result of refueling

MOVES Vehicle Evap Sources

Vapor Leaks - e.g., gas caps, compromised vent lines, connections, fittings

Vapor Venting includes: Running Loss, Hot Soak and Cold Soak (Diurnals)

Vapor is generated by fuel tank heating, due to increasing ambient temps and/or vehicle operation

Refueling –
Except for HDGVs,
ORVR canister controlled
ORVR drives canister size

Breakthrough - canister cannot contain all of the generated vapor; can result in large increase in HC emissions
Breakthrough happens with higher temperatures, higher RVP, less fuel in tank, and/or > 3 days
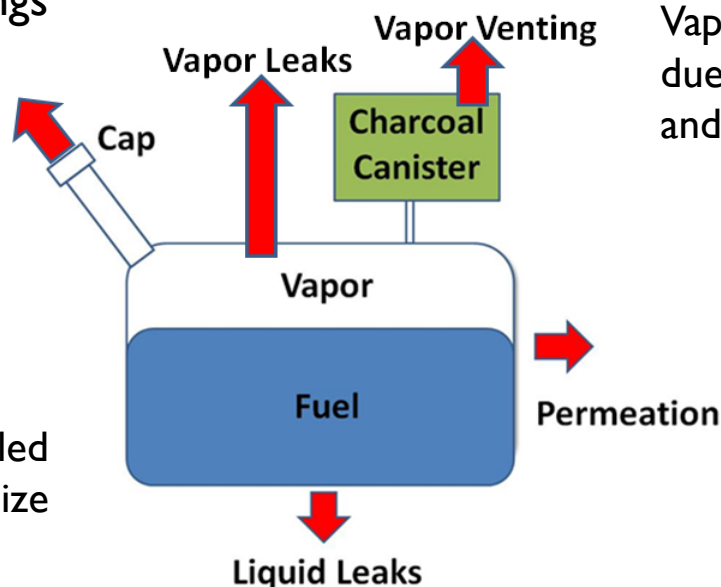
Liquid leaks - fuel tank/fuel line holes

Permeation - emissions through polymer walls, worsened by ethanol and controlled by changing fuel system materials

Offgassing from polymers

Diagram labels: Vapor Leaks, Vapor Venting, Cap, Charcoal Canister, Vapor, Fuel, Permeation, Liquid Leaks

Recent Testing Program Objectives

- Develop new test procedures to distinguish the evaporative mechanisms
- What are fuel ethanol and RVP effects?
- What are the effects of leaks in various locations of the vehicle?
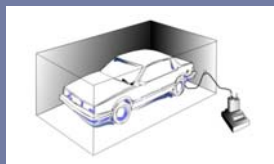
E-77 Test Programs

- How often do leaks occur in real world?
- What is the range of magnitude of these leaks?
- Where are they most likely to occur?

High Evap Field Studies

- When do newer technology vehicles experience canister breakthrough?
- What is the backpurge rate over extended parked period?
- How does fuel RVP affect multiday diurnals?
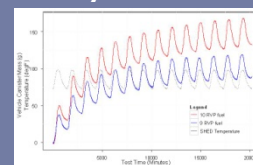
Multiday Diurnal Testing

- What are RL emissions for newer technology vehicles?
- What are RL emissions for leaking vehicles?
- What are purge rates for different types of driving and how do they affect leaking vehicles?

Running Loss (RL) Testing
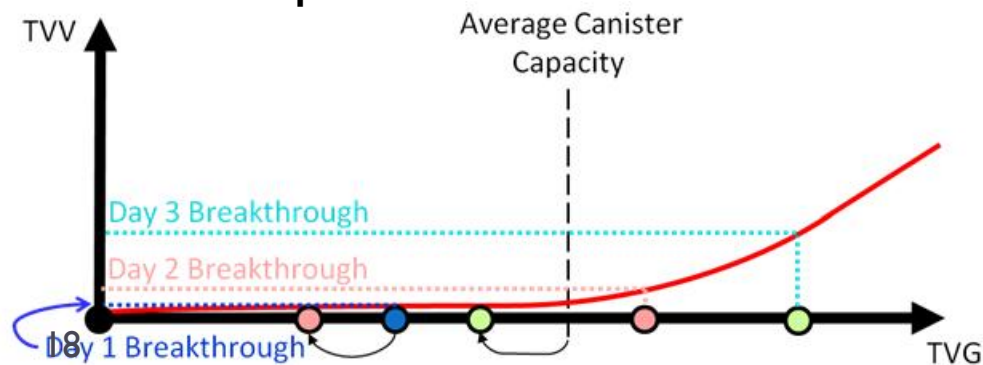
Multi-day Modeling with DELTA

Multiday Vapor Accumulation in Charcoal Canister
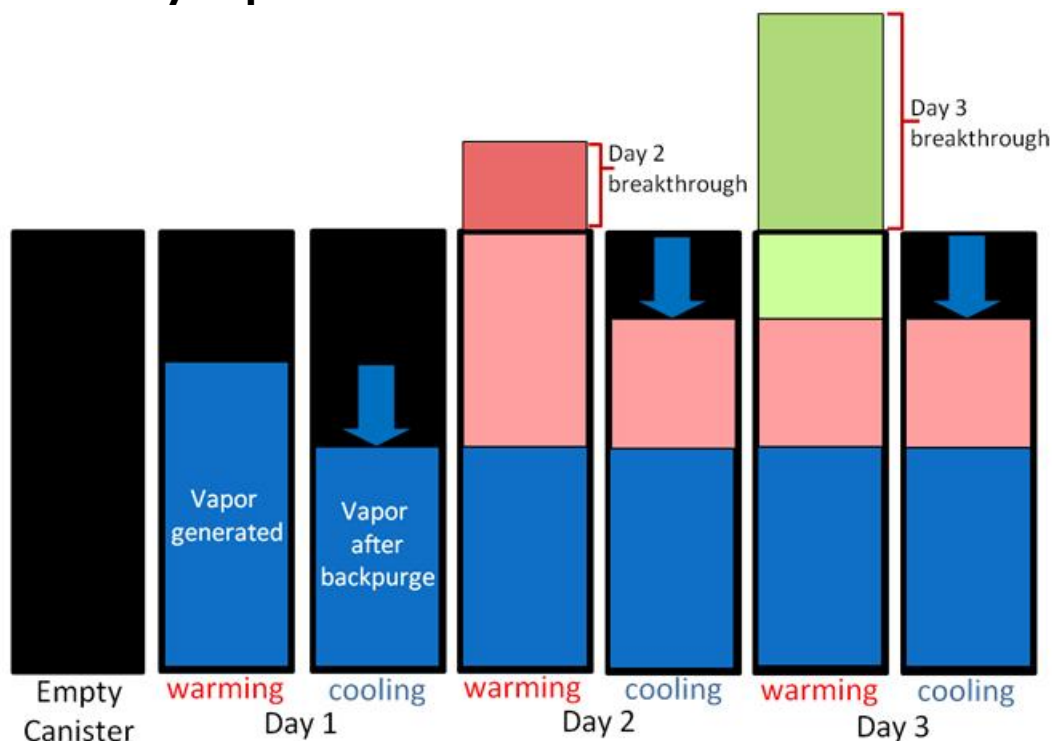
Dynamic behavior within a charcoal canister over three days of continuous cold soaking
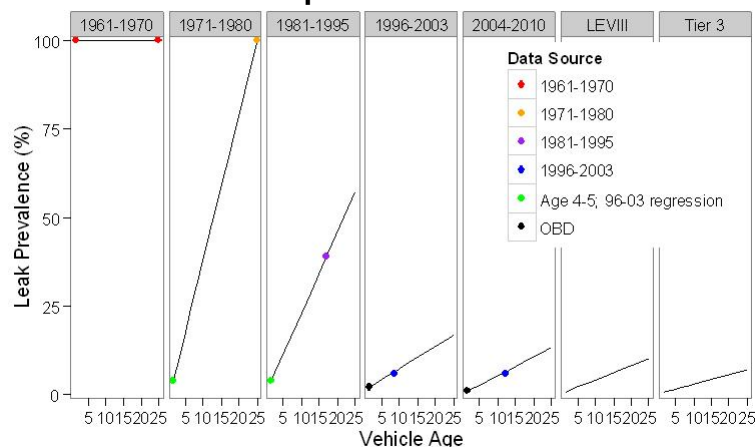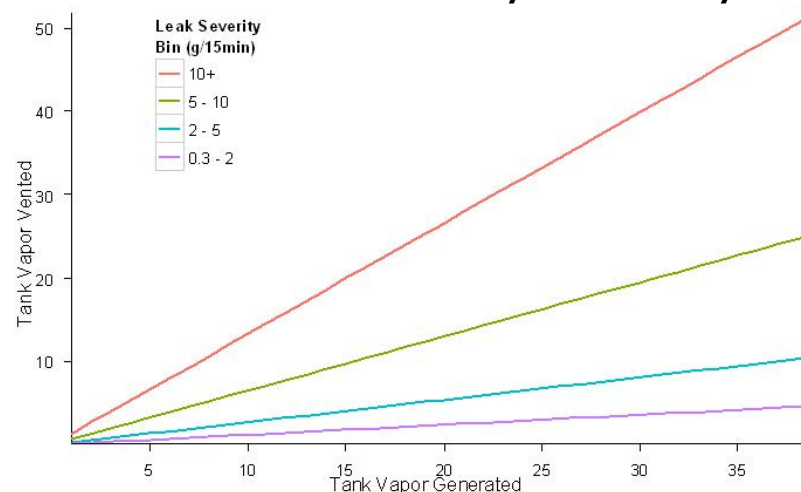
Blue down arrows indicate backpurge

Averaging for fleet of vehicles leads to Vapor Vented Curve in MOVES

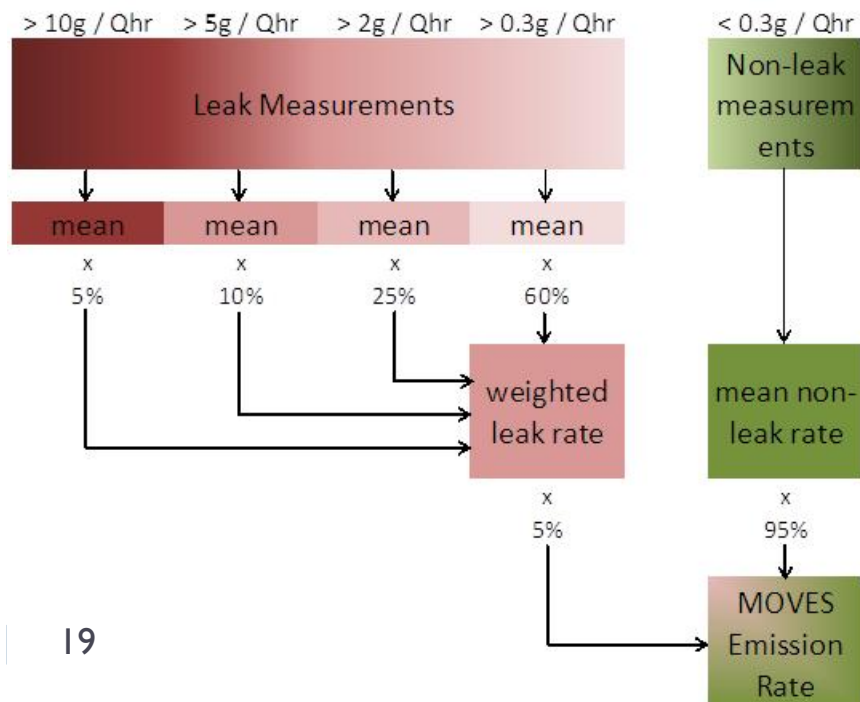# Modeling Leaking Vehicles

Non-IM Vapor Leak Prevalence for Leaks> 0.3 g/15 min Extrapolated from Data

Leak Emission Rates by Leak Severity Bin

**Calculate Weighted Evaporative Emissions**

Leak emission rates include: Hot Soak, Cold Soak (Diurnal), Running Loss for leaking vehicles

Non leak rates are weighted with the leaking emission rates for particular model year group and leak severity bin

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Heavy-duty Exhaust

▸ Two Real-world in-use data sets available for MOVES2014

▸ Heavy-Duty Diesel In-Use Testing (HDIU)

  ▸ Data collected by manufacturers during normal operation and use

  ▸ ~5 engines tested per family

  ▸ Within useful life (< 450,000 miles), well-maintained

  ▸ MY: 2005-2010

▸ Houston Drayage Data

  ▸ Collected emissions and activity data on HD drayage trucks using PEMS and PAMS in 2009-2010

  ▸ Trucks selected for PEMS testing based on remote sensing scores
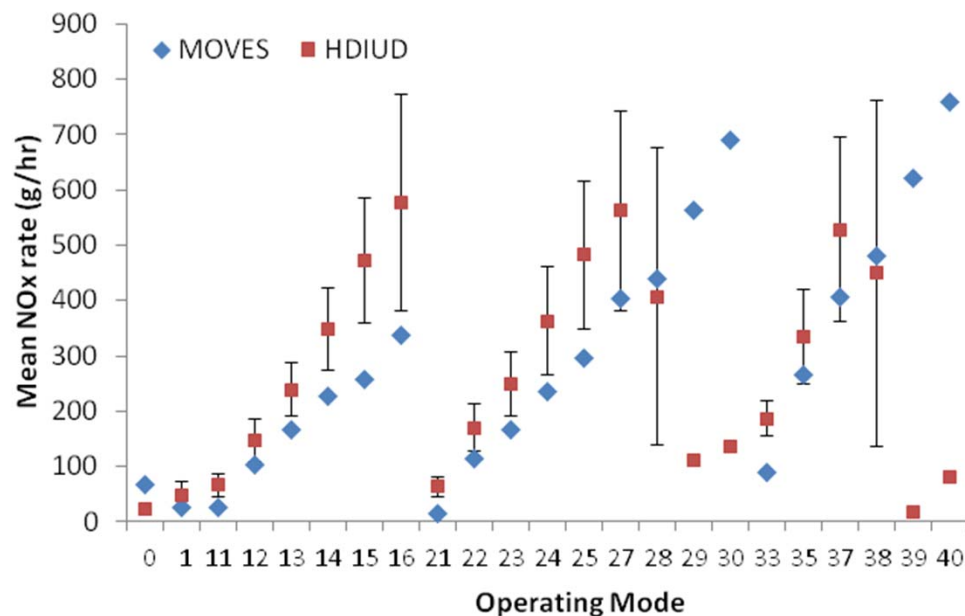
  ▸ Generally higher mileage (> useful life)
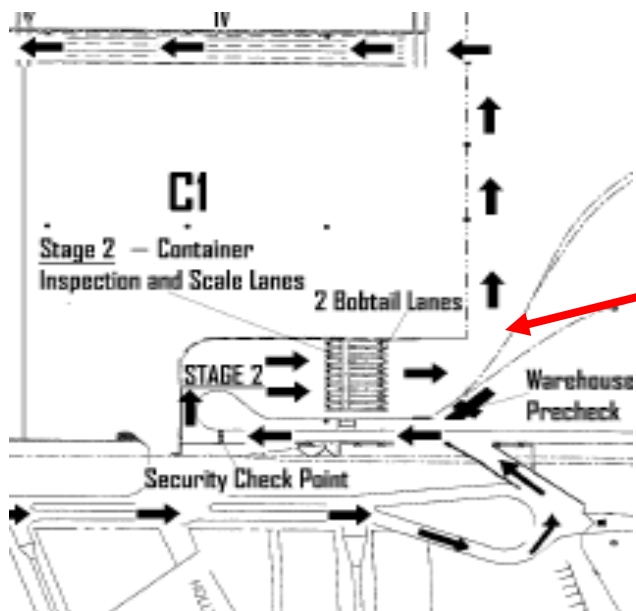
Location of RSD equipment

RSD equipment

Heavy-duty Exhaust

▸ **Studies validated current heavy-duty NOx MOVES rates for**

  ▸ Pre-2006 model years

▸ **NOx rates updated from HDIU program for**

  ▸ MY 2007-2009

  ▸ Indicate larger NOx emissions than MOVES2010

Fuel Effects/Fuel Supply Updates

▸ EPAct Tier 2 Gasoline Model

  ▸ 27 fuels tested in 15 Tier 2 vehicles, E85 tested in 4 FFVs

  ▸ Impacts of ethanol and other key fuel properties

▸ EPA Sulfur Effects Model

  ▸ Impact of ultra-low gasoline sulfur levels on emissions from in-use Tier 2 gasoline vehicles

▸ E85 Fuel effects

  ▸ Analyzed data from four E85 test programs

▸ Compressed Natural Gas

  ▸ Based on literature review of 9 studies

▸ New Fuel Supply

  ▸ Based on Regional Fuels

    ▸ Approx. 28,000 batches of CG reported in 2007

    ▸ Reduces Fuels in MOVES from ~300 to ~40

    ▸ More reliable data than fuel surveys at the gas pump

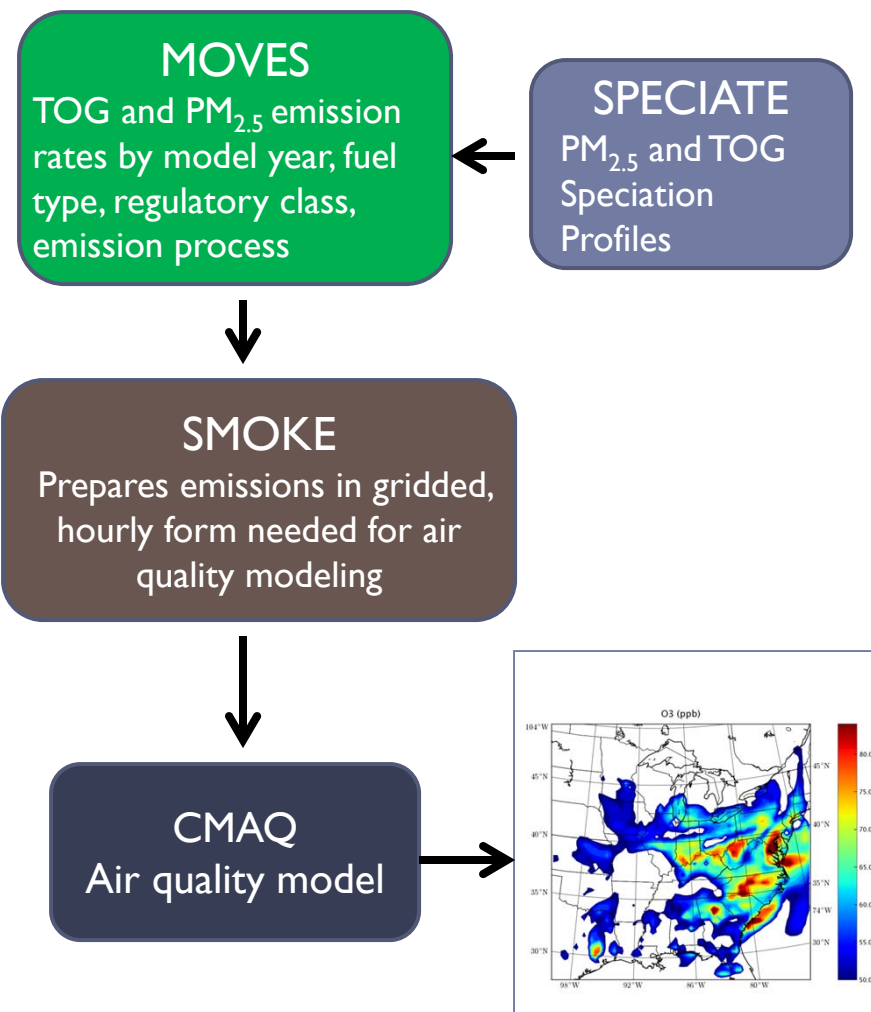 ▸ Contains most current ethanol (E10, E15, E85) and fuel formulation projections based on AEO2014

Fuel Supply Regions in MOVES2014

2007platform.fuelsupply
2007platform.fuelformulation
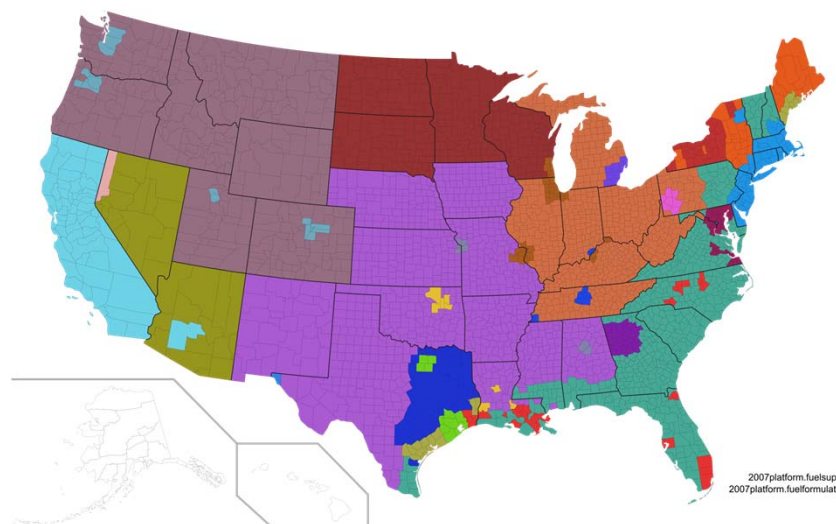
Air Quality Modeling in MOVES2014

- ## MOVES2014
  - Incorporates TOG and PM Speciation profiles from EPA SPECIATE database
  - Total Organic Gases (TOG)
    - Produces CB05 air quality model species (Carbon-bond chemical mechanism)
  - Particulate Matter
    - Produces 18 $PM_{2.5}$ species needed for CMAQv5 Aerosol Module Version 6 (AE6)
  - Allows differentiation in PM and TOG speciation profiles by:
    - Technology/Regulatory class
      - (e.g. pre-2007/2007+ diesel)
    - Model year
    - Fuel Type
    - Emission process (running, start, extended idle)
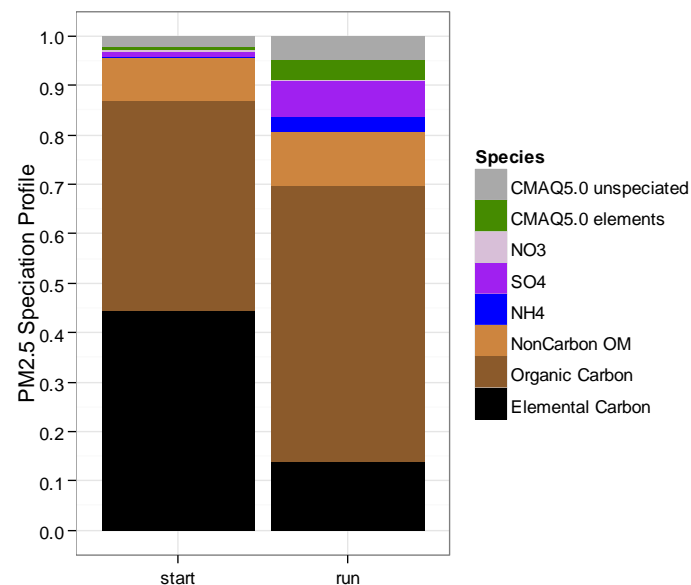
MOVES
TOG and $PM_{2.5}$ emission rates by model year, fuel type, regulatory class, emission process

SPECIATE
$PM_{2.5}$ and TOG Speciation Profiles

SMOKE
Prepares emissions in gridded, hourly form needed for air quality modeling

CMAQ
Air quality model

21 Total Organic Gases Profiles in MOVES2014

SPECIATE Profile ID	Description	Fuel	Affected Vehicles	MOVES ProcessID
8766	E0 evap permeation	E0	All	11
8769	E10 evap permeation	E10	All	11
8770	E15 evap permeation	E15	All	11
8753	E0 Evap	E0	All	12,13,19
8754	E10 Evap	E10	All	12,13,19
8872	E15 Evap	E15	All	12,13,19
4547	Diesel Headspace	Diesel	All	12,13,19,11,18,19
8934	E85 Evap	E85	All	12,13,19,11,18,19
8775	2007+ MY HDD exhaust	Diesel	2007+	1,2,15,16,17,90
8774	Pre-2007 MY HDD exhaust,	Diesel	Pre-2007 and all auxiliary power units	1,2,15,16,17,90,91
8750a	Pre-Tier 2 E0 exhaust	E0	Pre-Tier 2	1,2,15,16,17,90
8756	Tier 2 E0 Exhaust	E0	Tier 2	1,2,15,16,17,90
8757	Tier 2 E10 Exhaust	E10	Tier 2	1,2,15,16,17,90
8758	Tier 2 E15 Exhaust	E15	Tier 2	1,2,15,16,17,90
8752	Pre-Tier 2 E85 exhaust	E85	Pre-Tier 2	1,2,15,16,17,90
8855	Tier 2 E85 Exhaust	E85	Tier 2	1,2,15,16,17,90
8751a	Pre-Tier 2 E10 exhaust	RFG, E10, E15	Pre-Tier 2	1,2,15,16,17,90
8869	E0 Headspace	E0	All	18
8870	E10 Headspace	E10	All	18
8871	E15 Headspace	E15	All	18
1001	CNG Exhaust	CNG	All	1,2,15,16,17,90

7 PM$_{2.5}$ Profiles in MOVES 2014

- HD Vehicle Chassis Dyno Testing for Emissions Inventory (CRC E-55/E59)
  - Conducted 2001-2005
  - 9 trucks tested for speciation of 75 total vehicles
  - In-use vehicles ranging from 1985 to 2004 model year
  - Separate Profiles developed for idle and transient cycles
- Phase 1 of the HEI & CRC Advanced Collaborative Emissions Study
  - 2007+ Technology
    - Four 2007 heavy-duty diesel engines
  - Includes exhaust and crankcase speciation measurements
  - Source of updated 2007+ Diesel crankcase emission factors
- CNG Transit Bus Emissions measured at the California Air Resources Board
  - CNG New Flyer bus with 2000 MY Detroit Diesel Series 50g Engine w/ & w/o oxidation catalyst
  - Also source for TOG speciation and PAHs in MOVES for CNG

- Kansas City Light-duty Gasoline Vehicle Study (CRC E-69)
  - Conducted in Summer/Winter of 2004-2005
  - 99 vehicles tested for speciation of total 496 tested vehicles
  - In-use vehicles ranging from 1976 to 2004 model year
  - Separate profiles developed for start and running (see below)

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MOVES2014 Data & Analysis Summary

▸ **Emissions**

  ▸ Contains major emission updates regarding:

    ▸ Gasoline fuel effects

    ▸ Evaporative emissions

    ▸ PM and TOG Speciation

    ▸ Heavy-duty diesel emissions

    ▸ Alternative fuels (E85, CNG, light-duty diesel)

▸ **Population, Activity, and Fuels**

  ▸ Updates reflect current estimates and projections on:

    ▸ Vehicle sales

    ▸ Vehicle miles traveled (VMT)

    ▸ Operating characteristics (Average speed, and driving cycles)

    ▸ Fuel supply

Questions?

Extra Slides

MOVES Documentation

▶ **Technical Reports:**

   ▶ Evaporative Emissions

   ▶ Fuel Effects

   ▶ Toxic Emission Rates

   ▶ TOG and PM Speciation

   ▶ Heavy-duty Vehicle Emission Rates

   ▶ Light-duty Vehicle Emission Rates

   ▶ Temperature, Humidity, Air Conditioning and I/M Effects

   ▶ Brake and Tire Wear

   ▶ Vehicle Population and Activity

   ▶ Energy and Greenhouse Gas Emissions

   ▶ Fuel Supply

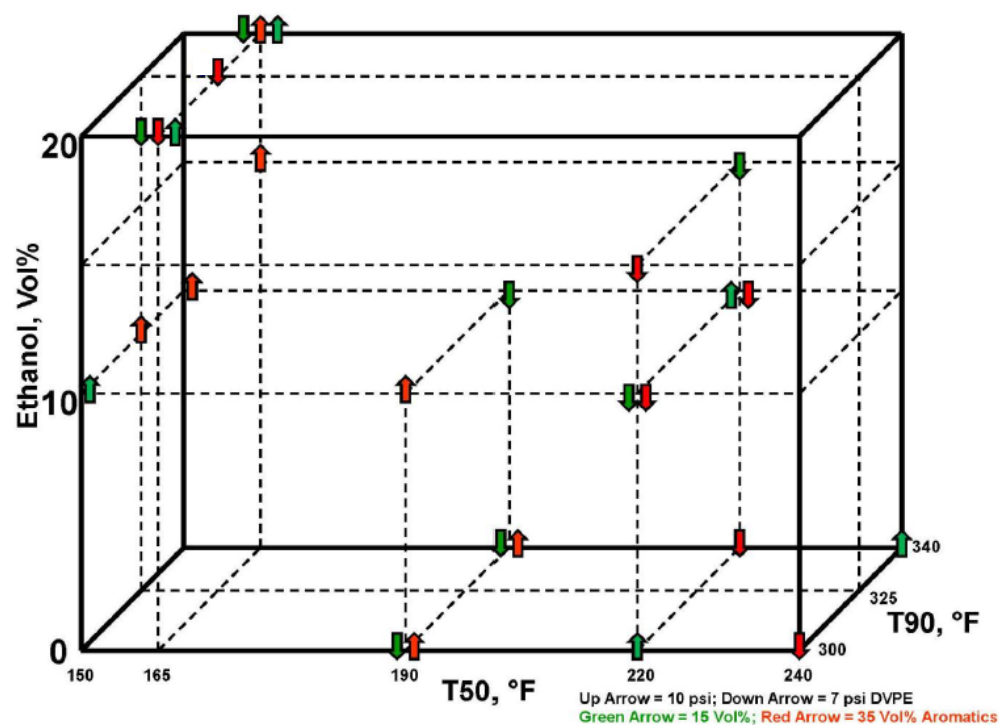   ▶ MOVES2014 Validation Report

Fuel Effects Effect Models– EPAct

▸ Energy Policy Act of 2005 ("EPAct") directed EPA to produce an updated emissions model reflecting fuel property effects

▸ Phase 3 Main fuel matrix (EPA/DOE/CRC)

  ▸ 27 fuels tested in 15 Tier 2 vehicles, E85 tested in 4 FFVs

  ▸ LA92 test cycle at 75F

  ▸ Two replicates of each fuel/vehicle combination = ~60 tests/veh

  ▸ Testing completed in mid-2010

▸ EPAct Models in MOVES

  ▸ Fuel 5 properties, including interactions

    ▸ Ethanol, Aromatics, RVP, T50, T90

  ▸ Impacts emissions of 10 pollutants

    ▸ 4 directly modeled:

      ☐ THC, CO, NOx, PM

    ▸ Toxic/THC ratios modeled:

      ☐ Benzene, Ethanol, 1,3-Butadiene, Formaldehyde, Acetaldehyde, Acrolein
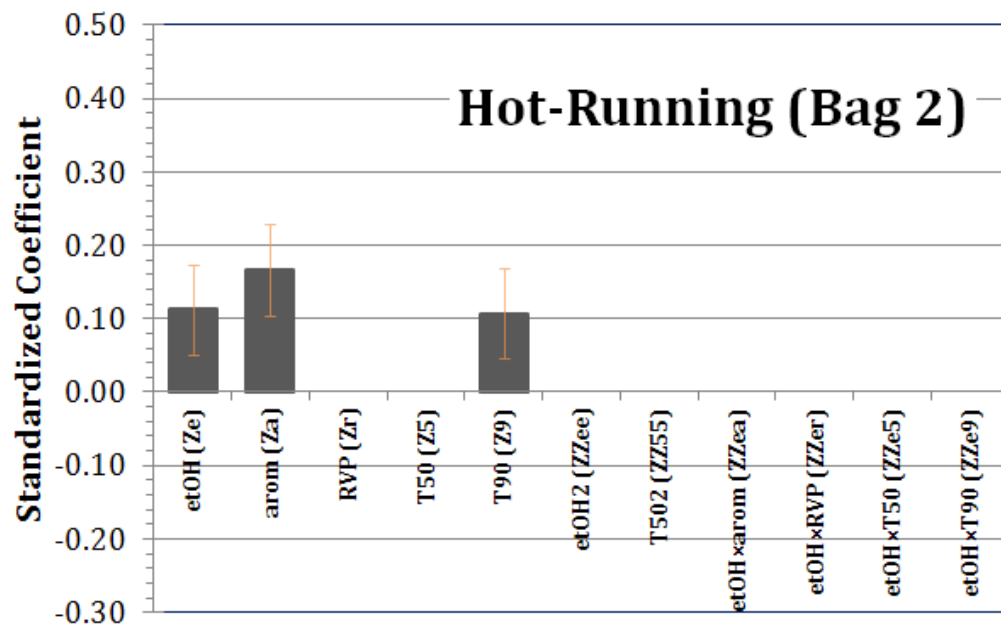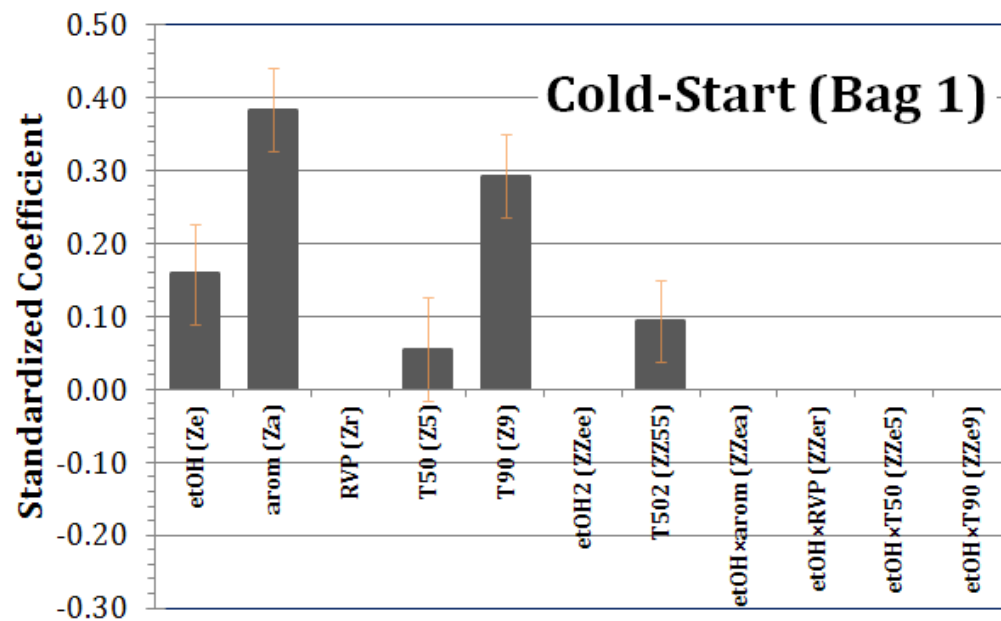
EPAct Fuel Matrix Summary

Fuel No.	T_{50}, °F	T_{90}, °F	EtOH, %	DVPE, psi	Aro, %
1	150	300	10	10	15
2	240	340	0	10	15
3	220	300	10	7	15
4	220	340	10	10	15
5	240	300	0	7	35
6	190	340	10	7	15
7	190	300	0	7	15
8	220	300	0	10	15
9	190	340	0	10	35
10	220	340	10	7	35
11	190	300	10	10	35
12	150	340	10	10	35
13	220	340	0	7	35
14	190	340	0	7	15
15	190	300	0	10	35
16	220	300	10	7	35
20	165	300	20	7	15
21	165	300	20	7	35
22	165	300	20	10	15
23	165	340	20	7	15
24	165	340	20	10	15
25	165	340	20	10	35
26	165	340	15	10	35
27	220	340	15	7	15
28	220	300	15	7	35
30	150	325	10	10	35
31	165	325	20	7	35

ETOH
ARO
T50
T90
RVP

$T50^2$
$ETOH^2$
ETOH*ARO
ETOH*T50
ETOH*T90
ETOH*RVP

Up Arrow = 10 psi; Down Arrow = 7 psi DVPE
Green Arrow = 15 Vol%; Red Arrow = 35 Vol% Aromatics

Courtesy of Douglas R. Lawson

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Cold-Start (Bag 1)

Hot-Running (Bag 2)

Example of EPAct model coefficients:

PM

Aromatics and T90 are the primary drivers,

For both starts and running

Heavy components in the fuel contribute to PM

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Fuel Effects Model –Sulfur Updates

- EPA Sulfur Effects Study
  - 93 vehicles recruited from owners in SE Michigan
  - MY 2007-2009 passenger cars and light trucks with 20,000 to 40,000 odometer miles
  - Measured effect of high sulfur fuel (28 ppm) and low sulfur fuel (5 ppm) on emissions
- Reversible sulfur effects
  - Sulfur poisoning is occurring in the in-use Tier 2 fleet and has a measurable effect on emissions
  - Effectiveness of clean-out procedure is limited when operating on higher sulfur fuel
- Overall sulfur benefits
  - Reducing the fuel sulfur levels from 28 to 5 ppm expected to achieve significant reductions in emissions from in-use Tier 2 vehicles
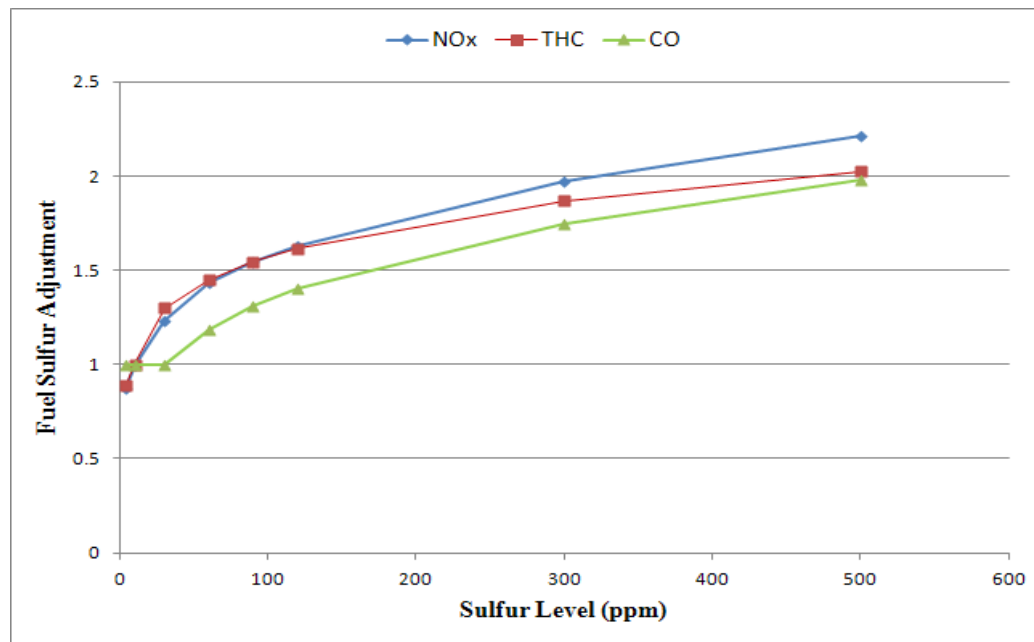
E85 Fuel Effects

▸ E85 fuel effects derived from paired analysis of E10 and E85
  ▸ THC, CH4, NMHC, VOC, CO, NOx, PM,
  ▸ HAPs (e.g. ethanol, benzene, acetaldehyde)
▸ Analyzed data from four test programs
  ▸ Energy Policy Act (EPAct) Test Program
    ▸ Conducted by EPA in partnership with DOE(NREL) and CRC
  ▸ NREL E40 Program
    ▸ Conducted by National Renewable Energy Laboratory (NREL)
  ▸ CRC E-80 Project
    ▸ Conducted by the Coordinating Research Council
  ▸ PM Speciation Program
    ▸ Coordinated test program between EPA/OAR/OTAQ (Ann Arbor) and EPA/ORD/NRMRL (Research Triangle Park)

|	EPAct	NREL E40	CRC E80	PM Speciation
Num. of vehicles	3	9	7	2
Replicates	2	2-3	1	2
Test Cycle	LA92	LA92	FTP, US06, LA92	LA92

CNG Emissions

- CNG Transit Bus Emission added to MOVES2014
- Based on literature review of 9 studies
- Includes all MOVES pollutants:
  - THC, VOC, Methane, Energy, CO, NOx, PM, air toxics (e.g. formaldehyde)

Paper/Article	Lead Research Unit	Driving Cycle(s)	Number of Unique Measurements
Melendez 2005	National Renewable Energy Laboratory (NREL)	WMATA	7
Clark 1999	West Virginia University (WVU)	CBD	7
Ayala 2002	California Air Resources Board (CARB)	CBD, NYB, S55, UDDS	8
Ayala 2003	CARB	CBD, SS55	12
Lanni 2003	New York Department of Environmental Conservation	CBD, NYB	6
McCormick 1999	Colorado School of Mines	CBD, UDDS	8
LaTavec 2002	ARCO (a BP Company)	CBD	2
McKain 2000	WVU	CBD, NYB	6
Clark 1997	WVU	CBD	10
TOTAL			**66**

Fuel Supply Updates

- Data sets:
    - Certification data: batch-by-batch refinery gate reports on fuel properties
        - Approx. 28,000 batches of CG reported in 2007
    - Reformulated gasoline fuel (RFG) certification database
    - Hart Study: Ethanol penetration by state 2006-2009
    - AEO Month-to-Month penetrations projected to 2020
- Regional Fuels MOVES
    - Reduces Fuels in MOVES from ~300 to ~40
    - More reliable data than fuel surveys at the gas pump
- Contains most current ethanol (E10, E15, E85) and fuel formulation projections based on AEO2014

Fuel Supply Regions in MOVES2014

2007platform.fuelsupply
2007platform.fuelformulation
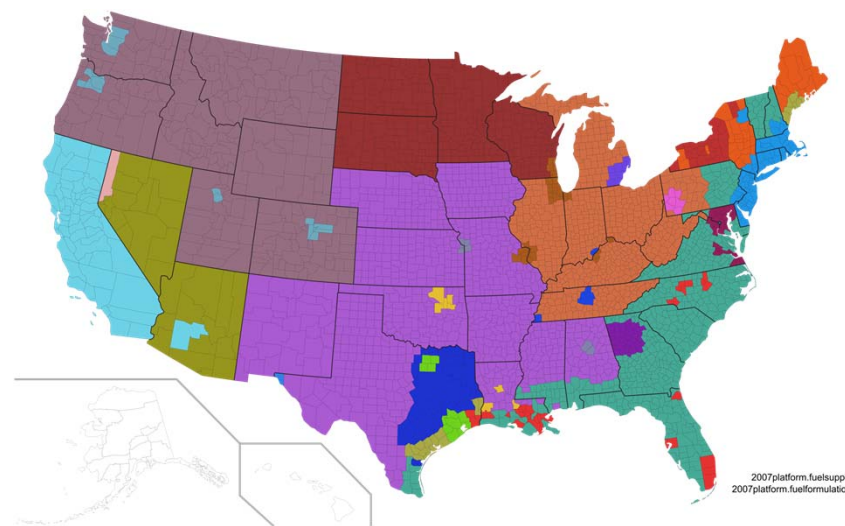
Temperature Effects

- ▶ Cold Temperature Test Program
  - ▶ 8 port-fuel injected (PFI) vehicles (MY 2010, Tier 2, and Cold Temperature MSAT-2 compliant)
  - ▶ 2 GDI vehicles (2006, and 2010) vehicles
  - ▶ Tested at 0, 20, and 75 FIncreased temperature effect for HC
- ▶ MOVE2014 Updates
 - ▶ Updated HC, CO, and PM temperature effects from test programs for modern vehicles
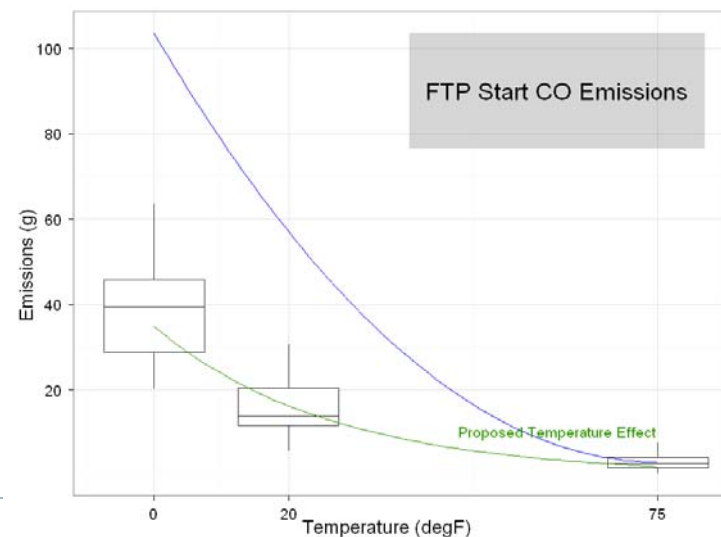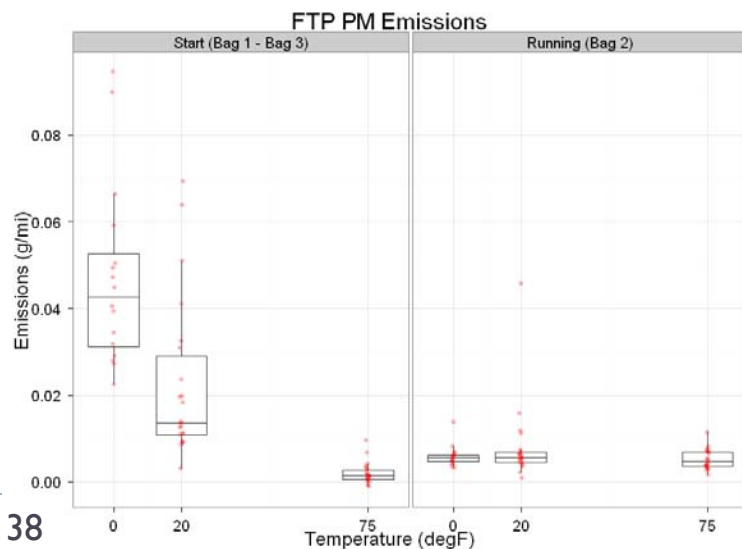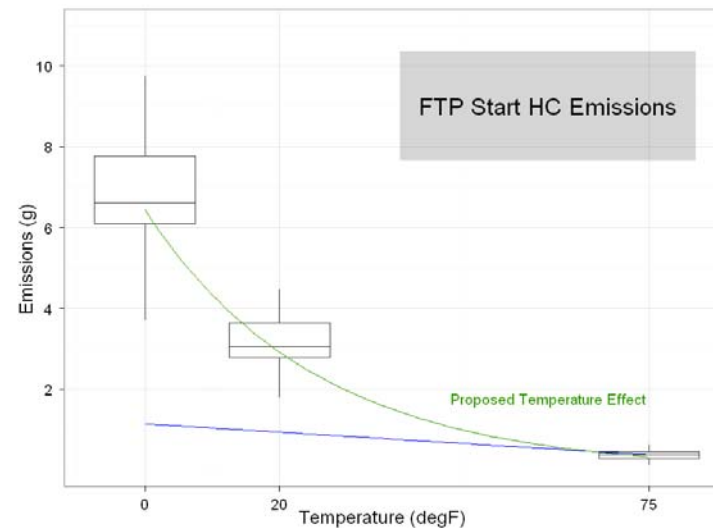
Population and Activity Updates

- **Average Speed Update**
- **EPA purchased summary information from TomTom GPS users within the US**
- **2011 National average speed distribution by:**
  - road type
  - hour of the day
  - day of the week
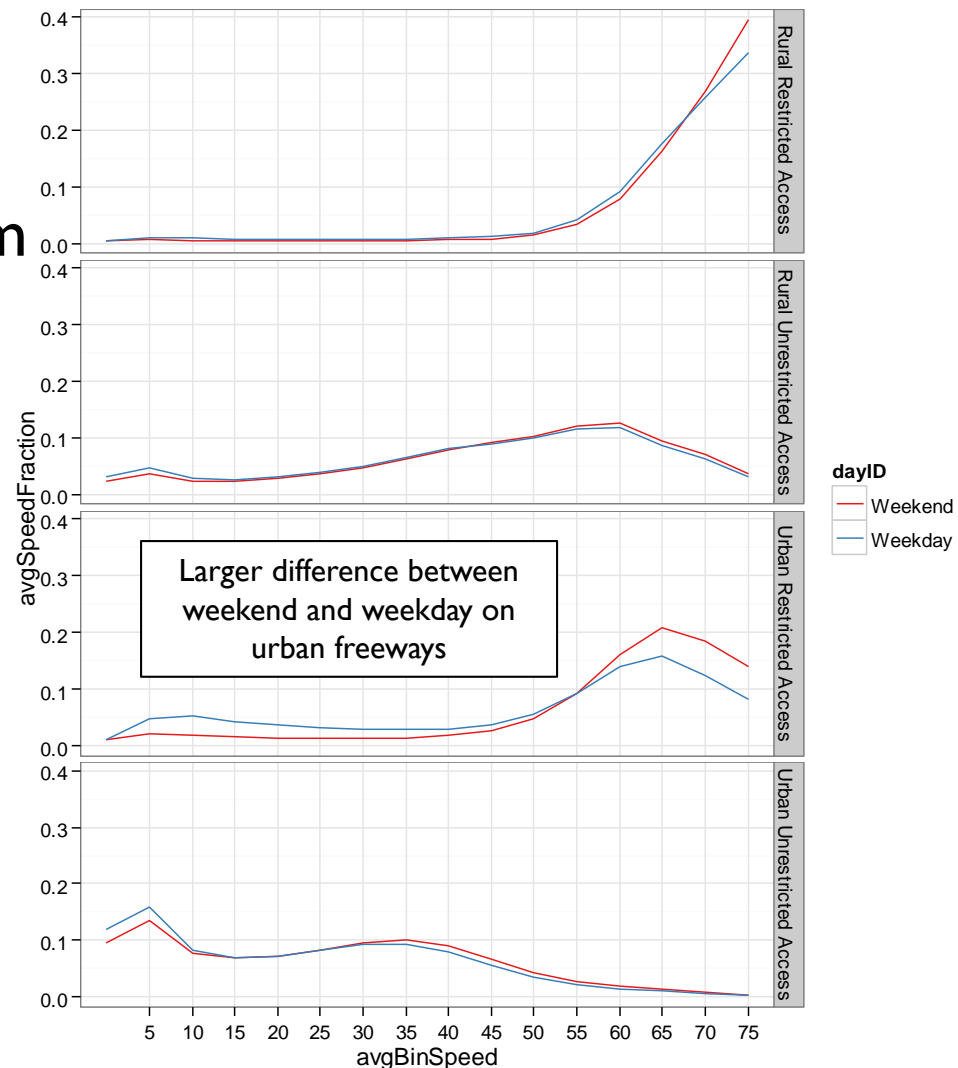
Population and Activity Updates

- New 2011 Base Year Vehicle Population
- Based on vehicle registration and usage survey data
  - R.L. Polk and Co.
  - VIUS (Vehicle Inventory and Use Survey)
- 2000-2011 Populations
  - Based on historic FHWA vehicle populations
- Future population and age distributions
  - Based on AEO 2014 sales projections, and historical scrappage estimates

National 2011 Population by Model Year
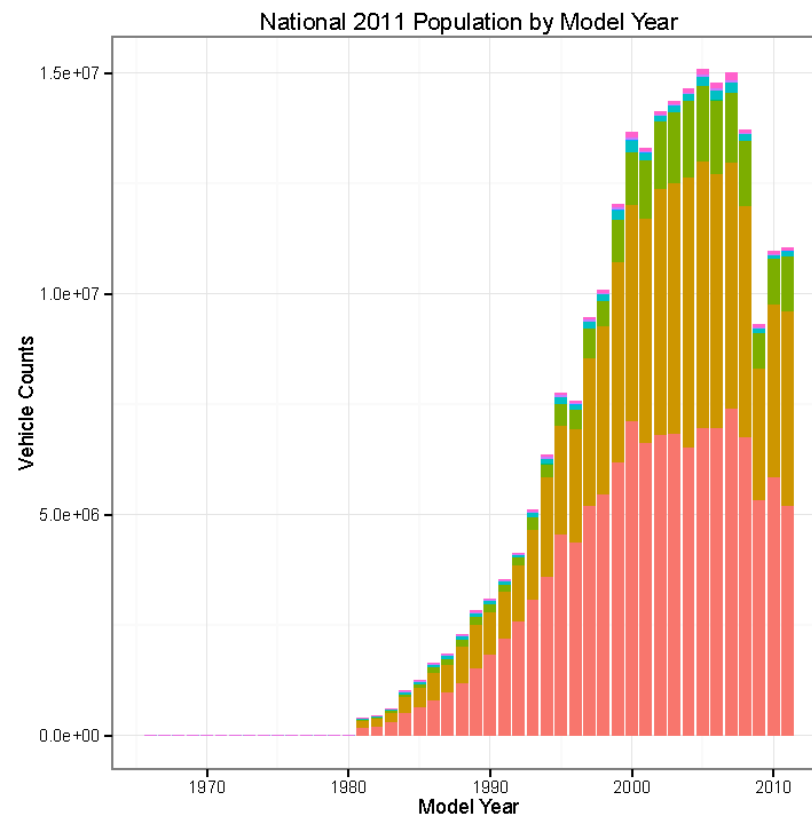
MOVES2014 – Other Data Updates

‣ **Emission Rates**

- ‣ Updated light-duty diesel emission rates
- ‣ Updated toxic emission rates (metals, PAHs, dioxins, brake and tire wear)
- ‣ Updated crankcase emission factors based on the ACES Heavy-duty engine test program
- ‣ Updated PM crankcase speciation
- ‣ Updated sulfate emission rates for diesel and gasoline
- ‣ Updated CO_2 equivalent factors

‣ **Population and Activity Data**

- ‣ State supplied data from the 2011 National Emission Inventory
- ‣ Updated VMT, vehicle sales for calendars years 2000 through 2011
- ‣ VMT growth rates updated for future years
- ‣ New heavy-duty drive cycles
- ‣ Seasonal VMT motorcycle usage
- ‣ New operating mode distribution for on/off freeway ramps
- ‣ New hourly temperature and RH data (2001-2011) by county