MOVES4:
Overview of Planned Updates

July 20, 2023
Public Webinar

What is MOVES?

- MOVES is EPA's MOtor Vehicle Emission Simulator

- Estimates emissions and energy use for onroad vehicles and many categories of nonroad equipment

- Estimates emissions of criteria pollutants, greenhouse gases (GHGs), and air toxics, as well as fuel consumption

- Accounts for national emission standards, vehicle populations and activity, state and local rules, fuels & temperatures

- Used by U.S. EPA and by U.S. state and local governments, as well as by others with an interest in mobile source emissions

- MOVES3 was released in November 2020.

  - We have since released minor updates and patches available on our website, https://www.epa.gov/moves

MOVES4

- Official release currently targeted for later this summer
- MOVES4 development processes
  - Peer review technical reports by independent experts
    - Search https://cfpub.epa.gov/si/ for Record ID: 356887 and 356914
  - Beta testing by experienced MOVES modelers
  - MOVES4 "release candidate" shared on GitHub 6/13/2023
    - https://github.com/USEPA/EPA_MOVES_Model/releases/tag/MOVES4-RC2
    - **Not** the official release version of MOVES4.0, thus results will differ
    - **Not** approved for regulatory use
    - May be useful for modelers who want to get an early start preparing for MOVES4.0.

MOVES4—Planned Changes

- Account for new and changed emission rules

- Update modeling of electric vehicles

- Update default data and projections for vehicle populations & activity

- Update default data and projections for fuel properties

- Improved emission rates and emission adjustments

Emission Standards

HD2027 rule
- Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards
- Published in January 2023
- This rule sets tighter emission standards for NO_x, PM, VOC and CO from heavy-duty onroad vehicles and engines starting in model year 2027

Heavy-duty diesel vehicles:
- Reduce NO_x emission rates for running, start, and extended idle processes for MY 2027+
- Adjustment for running and extended idle NO_x for ambient temperatures below 77°F
- Reduced change with age for running emission rates for NO_x, $PM_{2.5}$, HC and CO due to longer regulatory useful life and warranty requirements
- Revised crankcase emission rates to account for impacts of the closed crankcase design option available in the rule

Heavy-duty gasoline vehicles:
- Revised NO_x, $PM_{2.5}$, HC and CO emission rates for running processes only
- Revised refueling emissions to account for new HD ORVR requirements

Heavy-duty natural gas vehicles:
- No updates were made since the average NO_x emissions are already close to 0.1 g/hp-hr
  - Further reductions due to the rule are expected to be small

Emission Standards

- **LD GHG 2023-2026 rule**

  - Incorporated greenhouse gas standards for light-duty passenger cars and trucks (LDGHG 2023)

  - Rule was published in December 2021

  - These standards set tighter carbon dioxide (CO_2) limits for light duty (LD)

- **Removal of HDGHG2 trailer program**

  - A 2021 appeals court ruling vacated the portions of the 2016 HDGHG2 rule that apply to trailers

  - We revised MOVES inputs that describe weight, aerodynamics, rolling resistance and "other efficiency improvements" for combination trucks of MY2018 and later

  - This change slightly increases the modeled emissions of CO_2 and other pollutants from these trucks

Modeling of EVs

- Better estimates of energy use by electric vehicles (EVs)
- Forecasts default national EV fleet fractions and provides Alternate Vehicle and Fuel Technology (AVFT) Tool allowing users to enter local EV fractions
- Adjusts HC and NOx from internal combustion engine (ICE) vehicles to account for Tier 3 fleet averaging with EVs
  - Increases average ICE g/mile emission rates
- Adds
  - Heavy-duty battery EVs and fuel cell vehicles
  - EV and CNG long-haul combination trucks
    - Including ability to model hotelling from these vehicles

More info on EV modeling later in this webinar

Vehicle Populations and Activity
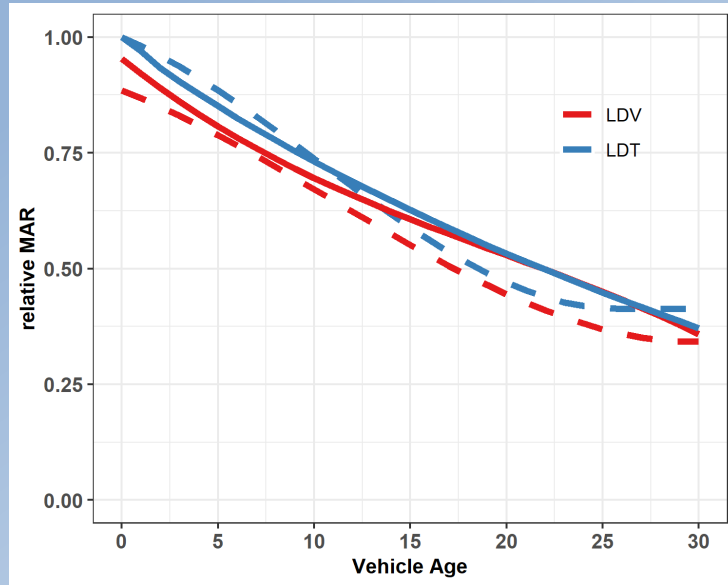
LDV and LDT relative mileage accumulation rates for MOVES4 (solid lines) and MOVES3 (dashed lines)

- Adds default EV fraction projections– *more info in EV presentation*
- Updated default VMT and vehicle populations from latest historical data and projections
  - Historical data from Highway Statistics (2021) and National Transit Database (2021)
  - Projections from DOE Annual Energy Outlook 2023
- Updated age distributions
  - MOVES default age distributions based on 2020 registration data
  - On average, cars are older than in MOVES3
- Updated LD mileage accumulation
  - Updates were based on DOT analysis of odometer data from a random national sample of one million light-duty vehicles
  - The new analysis shows that cars and light trucks/SUVs are driven more similarly
  - It also shifts distribution of VMT from newer to older vehicles

Vehicle Populations and Activity

- Lower glider fractions
  - A glider is a new chassis with an old engine that doesn't meet MY2007 emission standards
  - Emissions can be much higher than that of a similar new truck
  - Data from glider manufacturers and assemblers suggests future glider populations will be insignificant for MY 2021 and later, due to the HD GHG Phase 2 provision

- Change to Class 3 truck mappings
  - MY 2017+ diesel trucks that are > 10,000 GVWR and are "engine certified" meet the same emission standards as Class 4 and 5
  - In MOVES4, they are now grouped together in RegClass 42

https://en.wikipedia.org/wiki/Valdez%E2%80%93Cordova_Census_Area,_Alaska

- New Alaska counties
  - Valdez-Cordova Census Area replaced by the Chugach Census Area and the Copper River Census Area

- VMT allocation to counties was updated to use values from 2020 NEI
  - This allocation is used to generate sub-national emissions when running MOVES at default scale

Fuel Changes

- Updated fuel carbon and energy content for diesel and gasoline fuels (including biofuel blends)

- Revised 2018+ gasoline properties based on updated refinery batch data

    – Reductions in gasoline sulfur content produced reductions in nonroad emissions as well as onroad
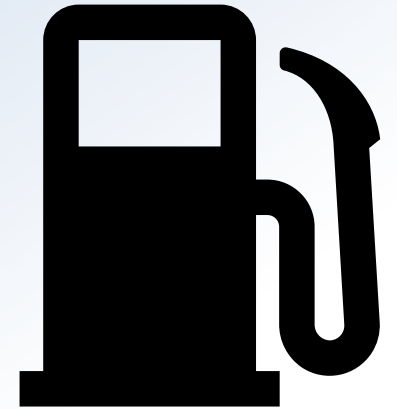
Updated Emission Rates and Adjustments

- We have updated specific vehicle emission rates and adjustment factors based on new data and improved analysis
- Including
  - Updated emission rates for NH_3, N_2O, NO & NO_2
    - *Details on NH_3 and N_2O in presentation later this webinar*
  - Streamlined emission speciation for air quality modeling
   - *Introduced in MOVES3.0.4*

Light Duty PM Emission Rates

- LD gasoline PM rates adjusted due to new data & projections of lower GDI prevalence

- Minor impact on net PM exhaust, but does shift the mix of start and running emissions, and the proportion of elemental carbon (EC) and non-EC PM

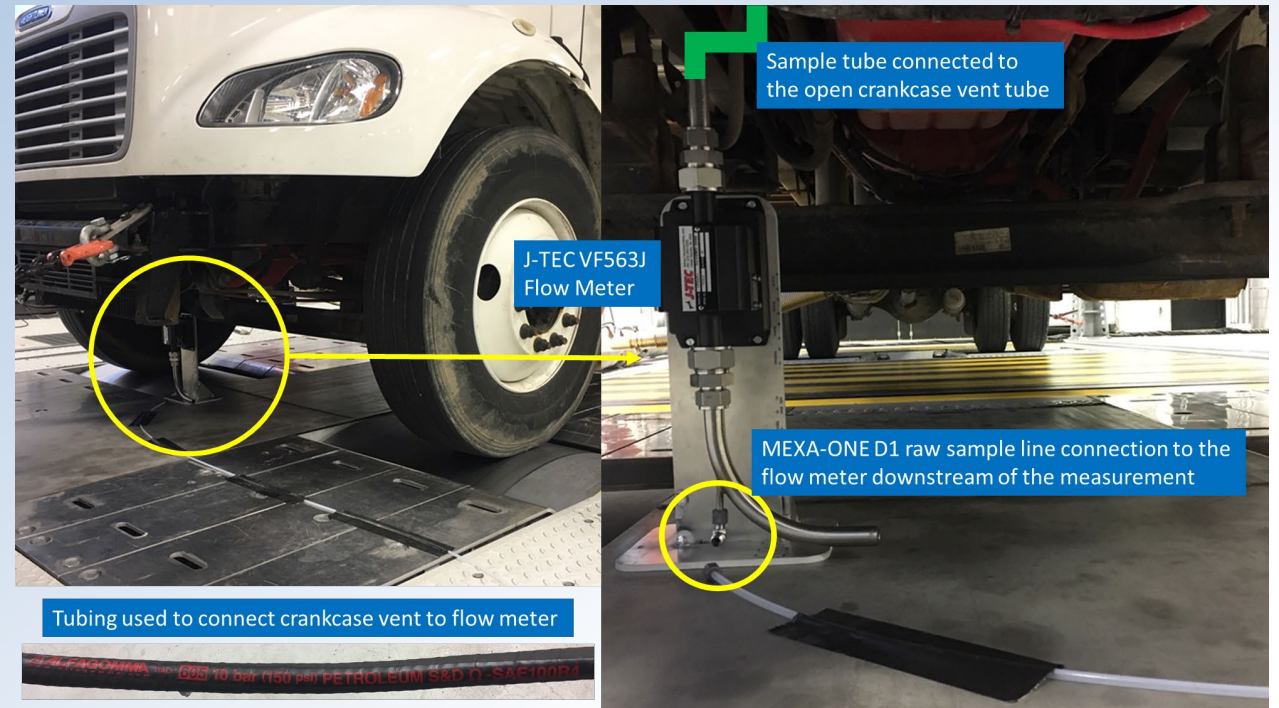 – GDI's have higher EC/PM$_{2.5}$ fraction
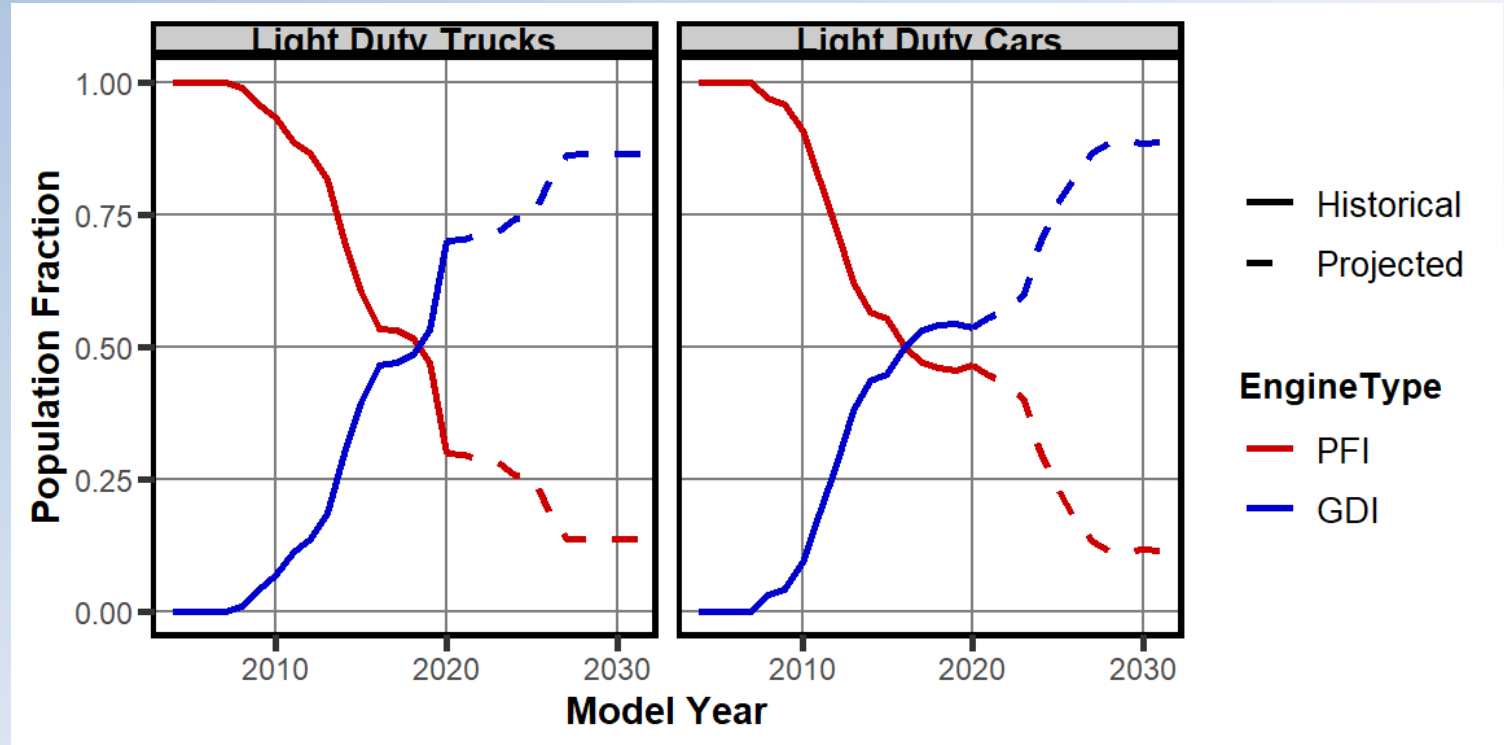
Refueling Emissions

- Updated based on data from EPA refueling study, July 2019

- Used infrared cameras at high-volume gas station to study more than 3,000 refueling events

  - Recorded visible plumes from vehicles where Onboard Refueling Vapor Recovery (ORVR) systems not capturing the displaced fuel vapors

- We updated the MOVES rates to account for ORVR failures over time

- We also improved the algorithm adjusting emissions for ambient temperature

- As noted above, we added HD coverage per the HD2027 rule

- We updated default information about which counties have Stage II refueling programs

/proj1/EPA_RefuelingEmissions_WA2-23/Summer2019/Analysis/find_plumes_ORVR.sas 27FEB20 17:22
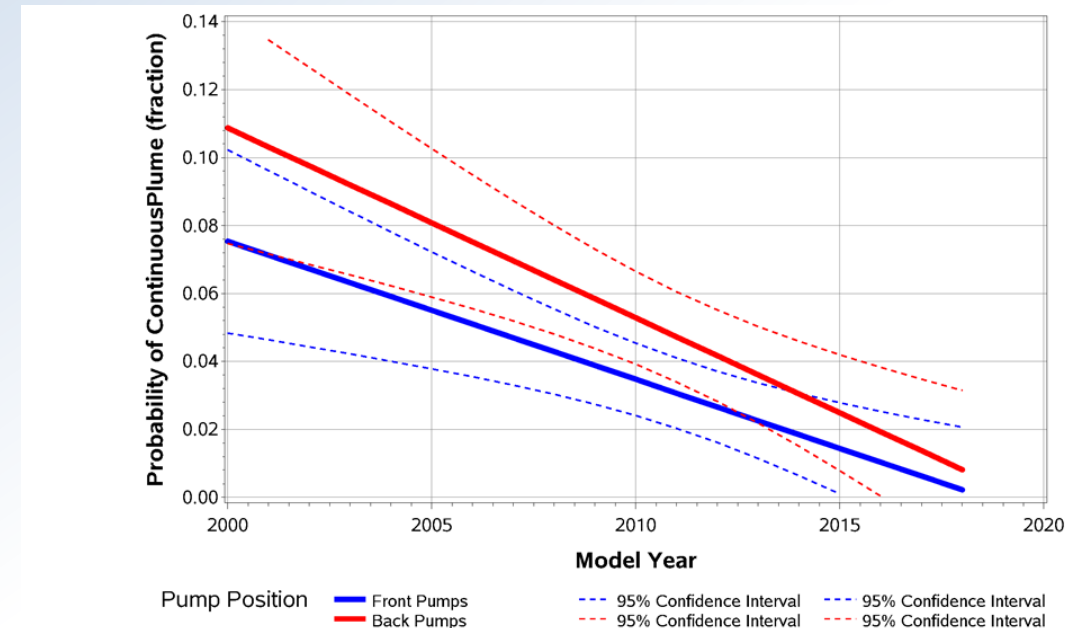
Crankcase Emissions

- Updated crankcase emission calculations so a function of regulatory class

  – Better corresponds to engine design differences

- Calculated as ratios to exhaust emissions

  – Same underlying data as used in MOVES3

- Assume manufacturers meet HD2027 standards with the closed crankcase option

  – That is, crankcase emissions equal zero for HD diesel MY2027+

  – Gasoline crankcase emission rates are unaffected by rule

Sample tube connected to the open crankcase vent tube

J-TEC VF563J Flow Meter

MEXA-ONE D1 raw sample line connection to the flow meter downstream of the measurement

Tubing used to connect crankcase vent to flow meter

Heavy-duty diesel crankcase emission testing at EPA

Additional Updates

- Corrected extended idle rates for elemental carbon (EC) and Non-EC PM
- Updated HD diesel deterioration
- Updated NO_x humidity adjustments

Stay Tuned…

- MOVES4 release planned for later this summer

- Followed by another webinar:

  – Overview of how MOVES4 emission results compare to MOVES3

  – Guidance on how and when to use MOVES4 for SIP development, transportation conformity, general conformity, and other purposes

  – Information on MOVES4 tools & inputs

    • Including how to update MOVES3 inputs to work with MOVES4

- Updated Technical Reports and Guidance Documents

QUESTIONS?

Acronyms

ACT	California Advanced Clean Trucks rule		ICE	Internal combustion engine
AVFT	Alternate Vehicle Fuel and Technologies		I/M	Inspection and Maintenance program
CNG	Compressed natural gas		LD	Light duty
DOE	Department of Energy		LDV	Light-duty vehicle (i.e. car)
DOT	Department of Transportation		LDT	Light-duty truck
EC	Elemental carbon		MOVES	Motor Vehicle Emission Simulator
EPA	Environmental Protection Agency		MY	Model year
EV	Electric vehicle		Non-EC	Particulate matter other than elemental carbon
FCEV	Fuel cell electric vehicle		ORVR	Onboard Refueling Vapor Recovery
GDI	Gasoline direct injection		PM	Particulate matter
GHG	Greenhouse gas		RFG	Reformulated gasoline
g/hp-hr	Grams per horsepower-hour		SIP	State implementation plan
g/mi	Grams per mile		SUVs	Sport utility vehicle
HD	Heavy duty		VMT	Vehicle miles travelled
HD2027	Heavy-Duty Engine and Vehicle Standards starting in 2027			
HDGHG2	2016 Heavy Duty GHG rule			