



## Planned Updates to EPA's MOVES Emission Model for Heavy-Duty Onroad Vehicles

Jaehoon Han\*, Gurdas Sandhu ^, Darrell Sonntag\*, Daniel Bizer-Cox\*

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\* Office of Transportation and Air Quality, US EPA

^ ORISE participant supported by an interagency agreement between EPA and DOE



# Outline

- Heavy-Duty Onroad Vehicle Emissions Inventory
- Scope of MOVES HD Updates
- Planned Update Topics
  - Emission Rates
  - Activity
  - New features...
- Summary
- Q&A

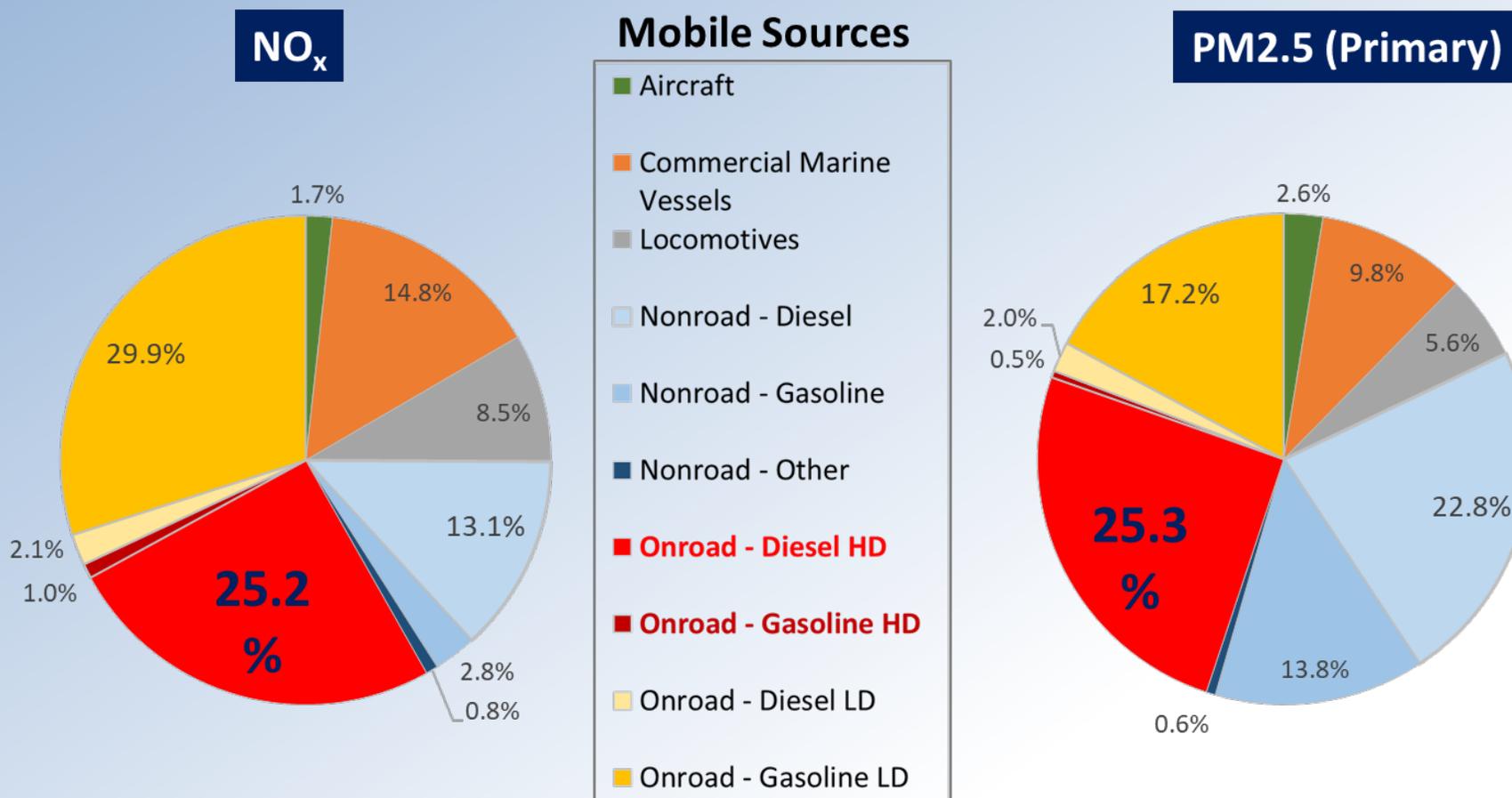


*This presentation includes preliminary results from analysis in progress.  
Implementation in future MOVES versions is subject to change.*



# Emission Contribution from Heavy-Duty Onroad Vehicles

- 2014 National Emissions Inventory (NEI) v2\* Data



\* <https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data>

# Scope of Planned MOVES HD Updates

- Emission rates
  - Running exhaust: Diesel, Gasoline, CNG
  - Start exhaust: Diesel, Gasoline
  - Extended idle exhaust/APU: Diesel
- Activity
  - Off-network idle
  - Hotelling
  - Starts, ...
- New features
  - Expanded fuel options
  - Gliders, ...



# Planned Running Emission Rates Updates

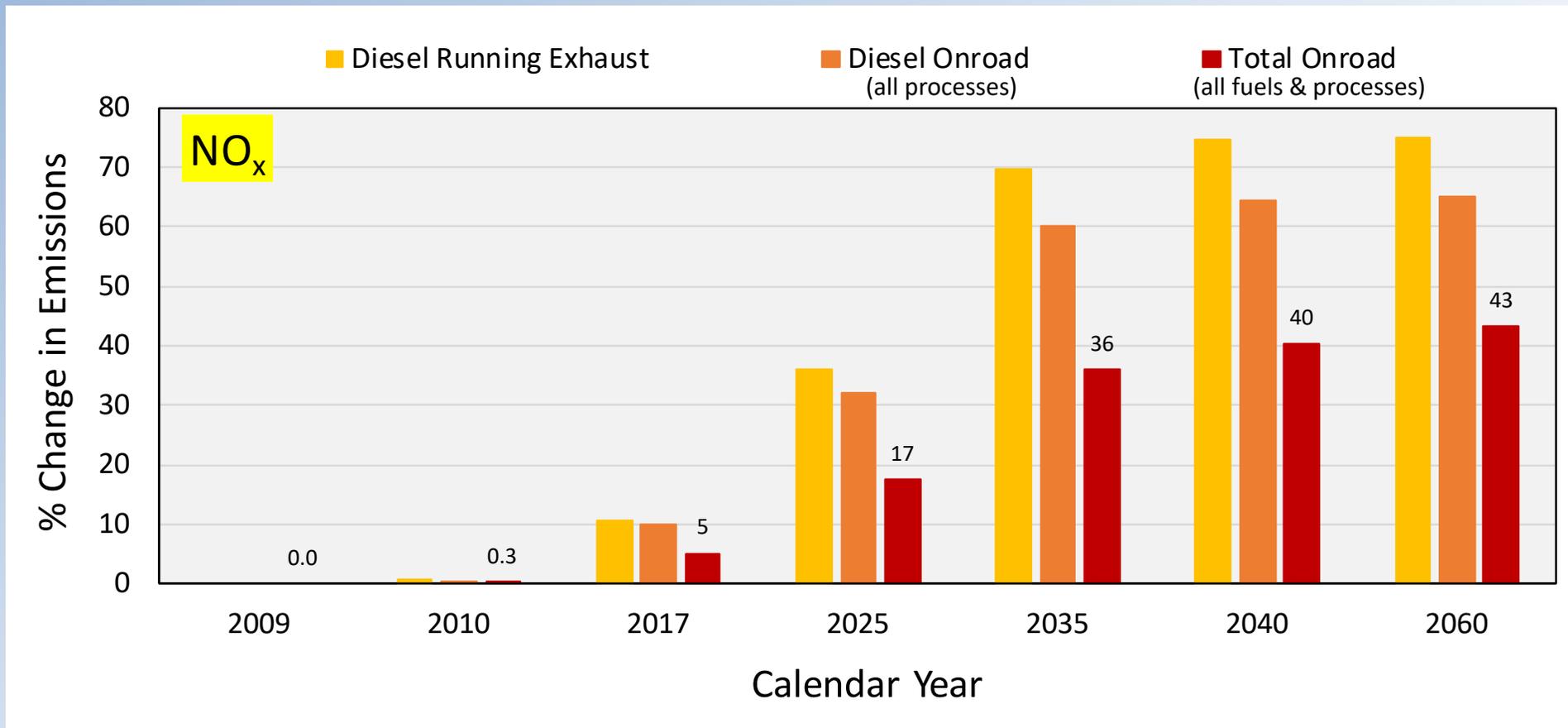
## Data Sources

	MOVES2014	MY2010+ updates
Diesel	NOx/PM rates based on MY 2003-2006 vehicles without SCR and DPF technology ratioed by difference in federal emissions standards.	<b>Heavy-duty in-use testing data for MY 2010-2015 vehicles with SCR and DPF</b> <ul style="list-style-type: none"> <li>• 291 vehicles and ~8 million seconds</li> <li>• All manufacturers</li> </ul>
Gasoline	Rates based on two MY 1998-2002 vehicles ratioed by difference in federal emissions standards.	<b>EPA lab data for MY 2015-2017 medium heavy-duty vehicle testing</b> <ul style="list-style-type: none"> <li>• 3 vehicles, ~400k seconds</li> <li>• Cover significant fraction of HD gasoline market</li> </ul>
CNG	Rates based on pre-MY2002 gasoline HD vehicles ratioed using same age CNG chassis data and recent MY CNG certification data.	<b>Heavy-duty in-use testing data for MY 2011 and 2014 CNG vehicles with three-way catalysts</b> <ul style="list-style-type: none"> <li>• 11 vehicles, ~300k seconds</li> </ul>



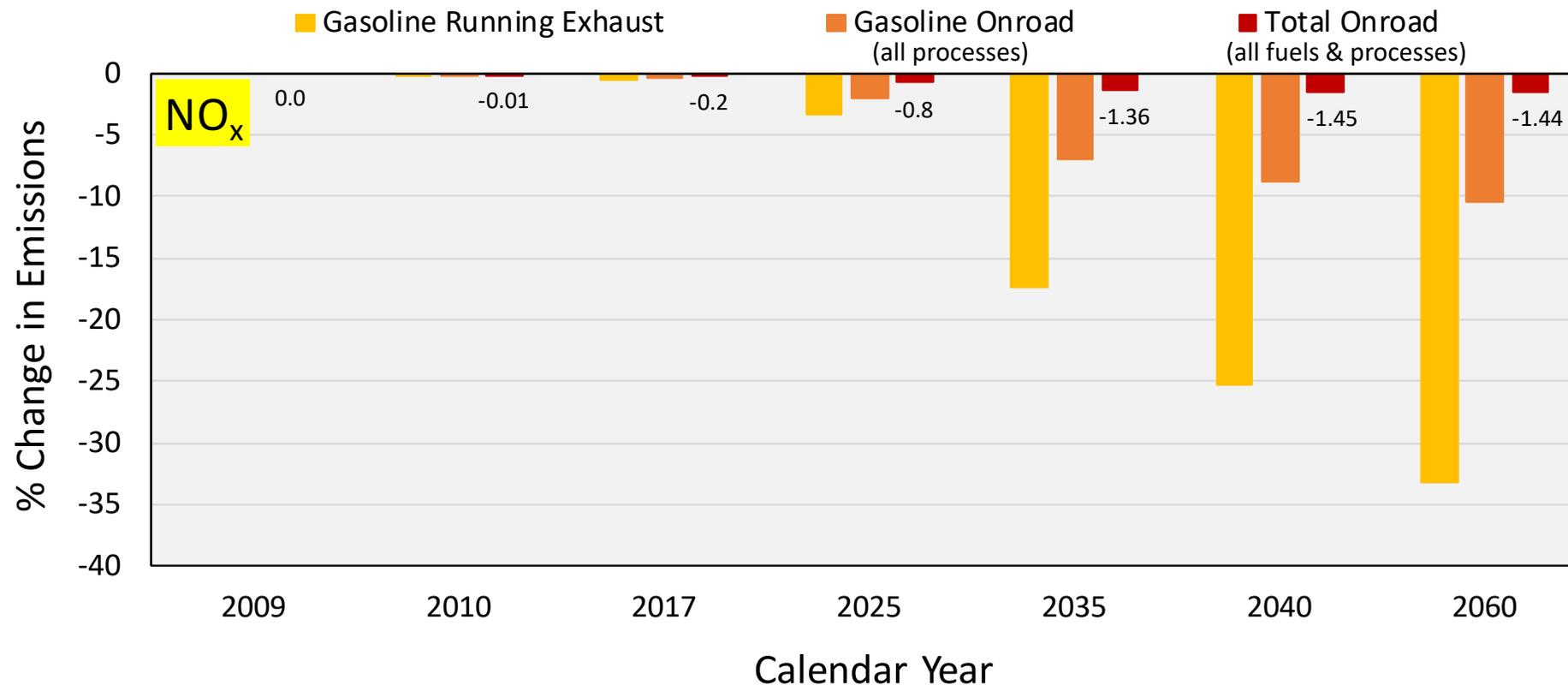
# Preliminary Emission Impacts - NO<sub>x</sub> MY 2010+ Diesel Running Emission Rates

- Changes in NO<sub>x</sub> emissions only due to this specific emission rate update
  - Based on a “typical” MOVES national scale run



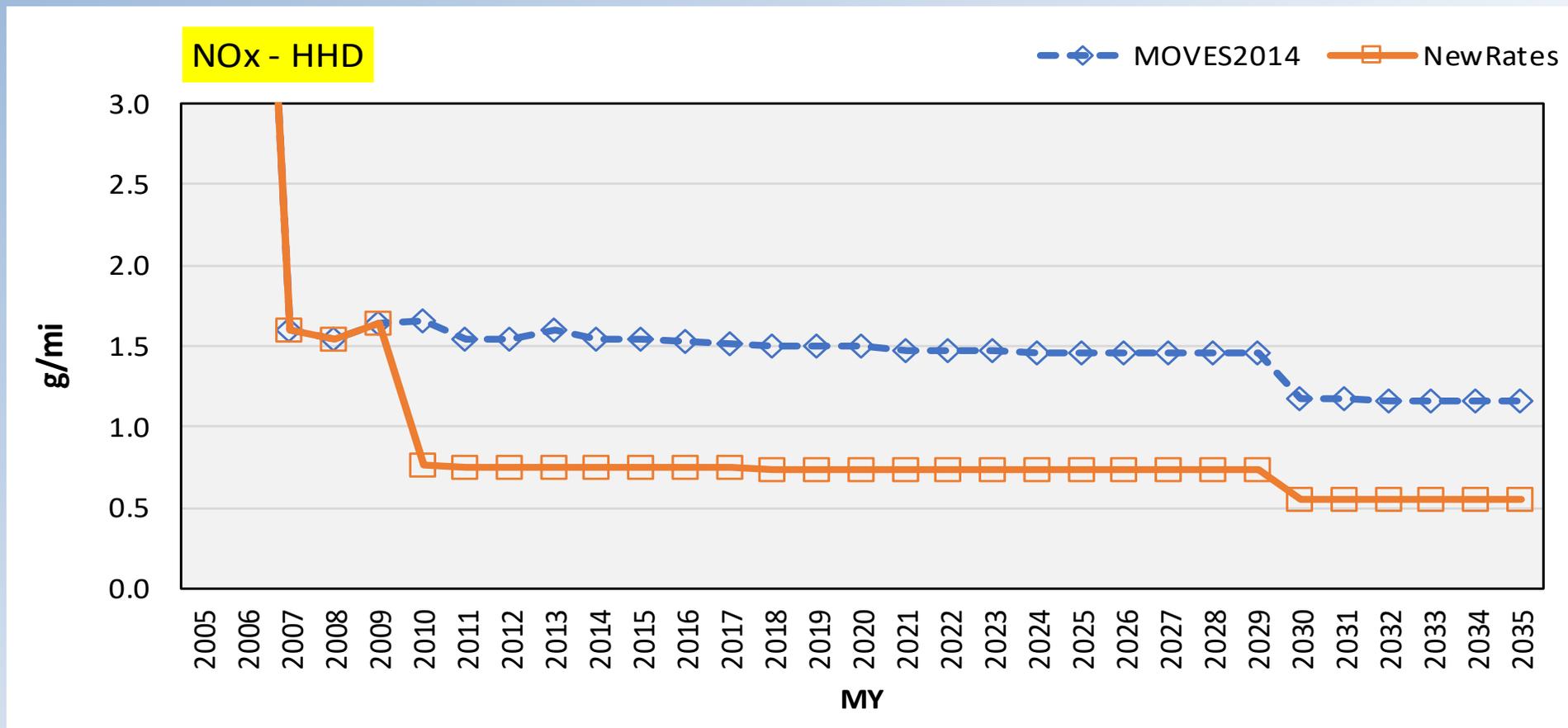
# Preliminary Emission Impacts - NO<sub>x</sub> MY 2010+ Gasoline Running Emission Rates

- Changes in NO<sub>x</sub> emissions only due to this specific emission rate update
  - Based on a “typical” MOVES national scale run

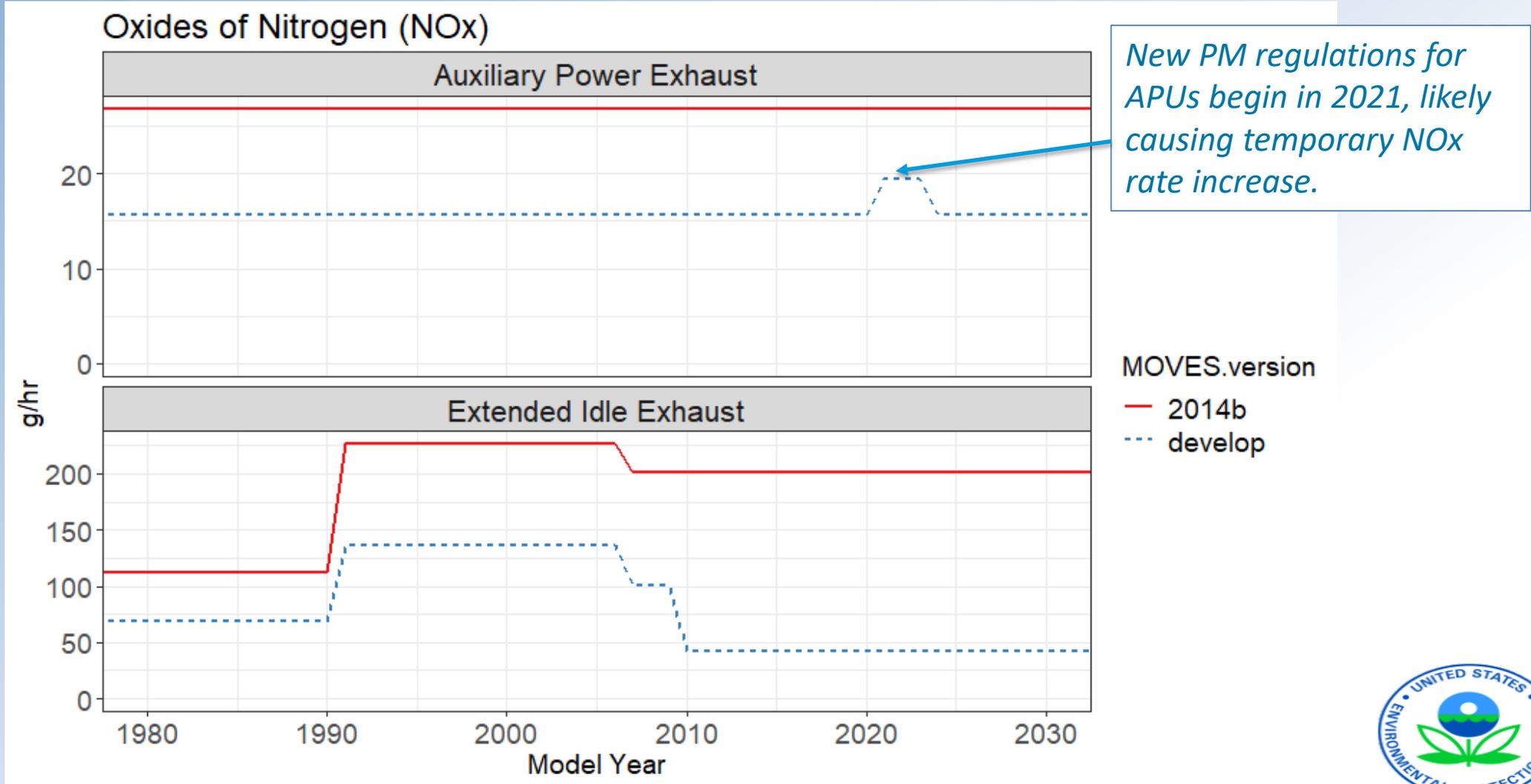


# Preliminary Emission Impacts - NO<sub>x</sub> MY 2010+ CNG Running Emission Rates

- Comparison of model output NO<sub>x</sub> “g/mile” rates for heavy-heavy-duty fleet
  - Based on a “typical” MOVES national scale run



# Planned Extended Idle and APU Emission Rate Updates



References: 1. December 2016 MOVES Workgroup Presentation: *Updated Emission Rates for Extended Idle and Auxiliary Power Units.*

2. Draft Report: *Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES201X*



# Planned HD Emission Rate Updates

## Other Updates

Topic	Description	Expected Impact On NOx	Expected Impact On PM
HD GHG Phase 2 standards	Incorporate Heavy-duty 2017-2025 GHG regulation into MOVES	↓	↓
Start emission rates	Update 2010+ Diesel and 2008+ Gasoline starts based on compliance data  Update relationship of starts vs. parking time	↑	≈



# Heavy-Duty Vehicle Activity

- Activity has a significant impact on the performance of after-treatment systems such as:
  - Selective Catalytic Reduction for NO<sub>x</sub>
  - Diesel Particular Filters for PM
- Duty cycles vary considerably by HD truck vocations and fleets
- Limited data compared to light-duty vehicles
  - But telematics is beginning to provide insights



## MOVES Activity Updates Using Fleet DNA Data: Interim Report

Andrew Kotz and Kenneth Kelly

National Renewable Energy Laboratory

Produced under direction of the U.S. Environmental Protection Agency by the National Renewable Energy Laboratory (NREL) under Interagency Agreement 92402501.



# Planned HD Activity Updates: Idle

## Driving Idle



- Already in MOVES
- Part of MOVES drive schedules (speed <1 mph) for running emission process

## Off-Network Idle



- **New! (not in MOVES2014)**
- Emissions from off-network operation (parking lots, driveways, warehouses, etc.)
- Emission rates set equal to driving idle rates
- HD idle activity based on instrumented truck studies

## Extended Idle



- Only for long-haul combination trucks (idling engine for more than 1 hour during hotelling)
- Already in MOVES, but updating activity

# Planned HD Activity Updates: Total Idle Fraction

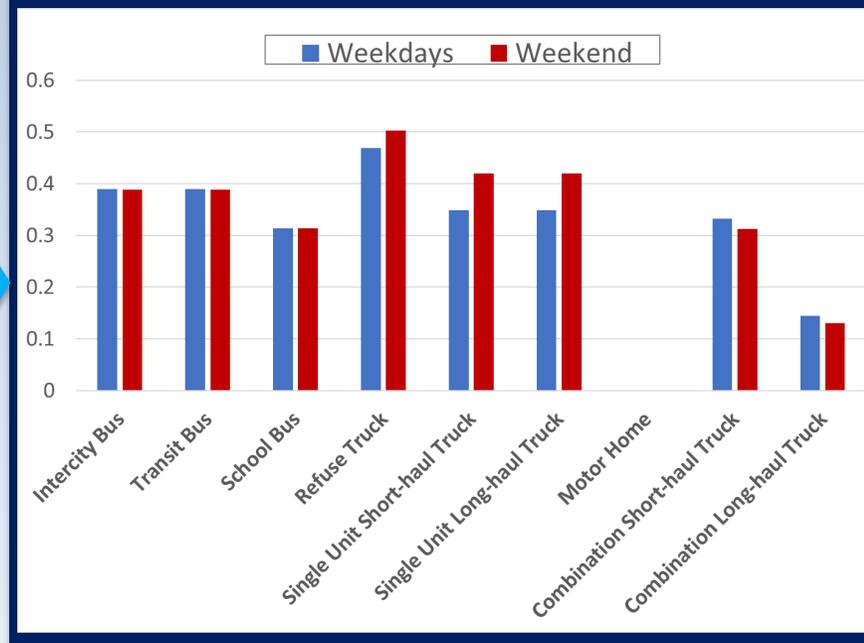
- New input table “*TotalIdleFraction*”

$$\equiv \frac{\text{Total idle hours}}{\text{Source operating hours}} = \frac{\text{Driving idle hours} + \text{Off-network idle hours}^*}{\text{Source operating hours}}$$

NREL data from instrumented vehicles



“TotalIdleFraction” values



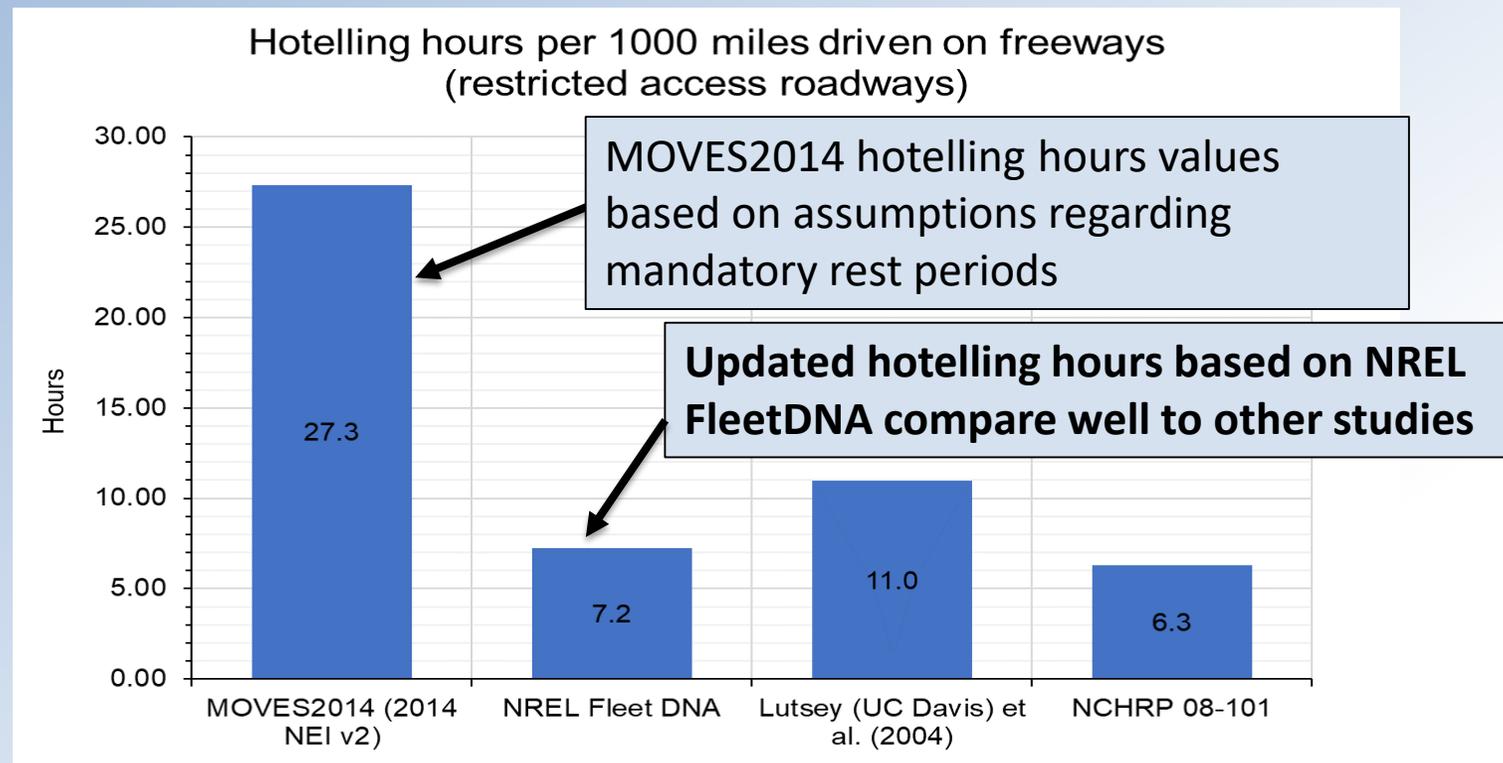
MOVES calculates “Off-network Idle” using the definition and other inputs (VMT, speed, drive cycles, ...)



\* For long-combination trucks, idle times over 1 hour duration are excluded and instead considered as “extended idle” as part of hoteling; Motor Homes are assumed to have zero off-network idle hours.

# Planned HD Activity Updates: Hotelling

- Hotelling: Using truck as a residence during long layovers between trips for long-haul truck drivers



Note: Hotelling hours estimated based on extended idling data recorded in the NREL, Lutsey, and NCHRP studies combined with MOVES VMT on restricted access roadways and % of hotelling time spent in extended idle.



# Planned HD Activity Updates: Starts

- New “starts” activity data from NREL’s FleetDNA telematics database
  - Provides more details to update MOVES national default
  - Also available to users as a baseline

<b>MOVES input table</b>	<b>Content</b>	<b>Data grouped by</b>
<i>StartsPerDayPerVehicle</i>	Average number of starts per day per vehicle	<ul style="list-style-type: none"><li>• source (vehicle) type</li><li>• day type (weekday/weekend)</li><li>• age</li></ul>
<i>StartsHourFraction</i>	Distribution of starts across hours of the day	<ul style="list-style-type: none"><li>• source (vehicle) type</li><li>• day type (weekday/weekend)</li><li>• hour</li></ul>
<i>StartsOpModeDistribution</i>	Distribution of the amount of parking time (soak time) preceding starts	<ul style="list-style-type: none"><li>• source (vehicle) type</li><li>• day type (weekday/weekend)</li><li>• hour</li></ul>



# Planned New Features: Expanded Fuel Options

- CNG option for other HD sourcetypes besides Transit Bus
- Gasoline option for Intercity Bus

The screenshot shows the MOVES software interface with the following sections:

- Fuels:** Compressed Natural Gas (CNG), Diesel Fuel, Electricity, Ethanol (E-85), Gasoline
- Source Use Types:** Combination Long-haul Truck, Combination Short-haul Truck, Intercity Bus, Light Commercial Truck, Motor Home, Motorcycle, Passenger Car, Passenger Truck, Refuse Truck, School Bus, Single Unit Long-haul Truck, Single Unit Short-haul Truck, Transit Bus
- Selections:** A list of fuel combinations for various source use types. Two items are highlighted with red boxes: "Compressed Natural Gas (CNG) - Single Unit Short-haul Truck" and "Gasoline - Intercity Bus".

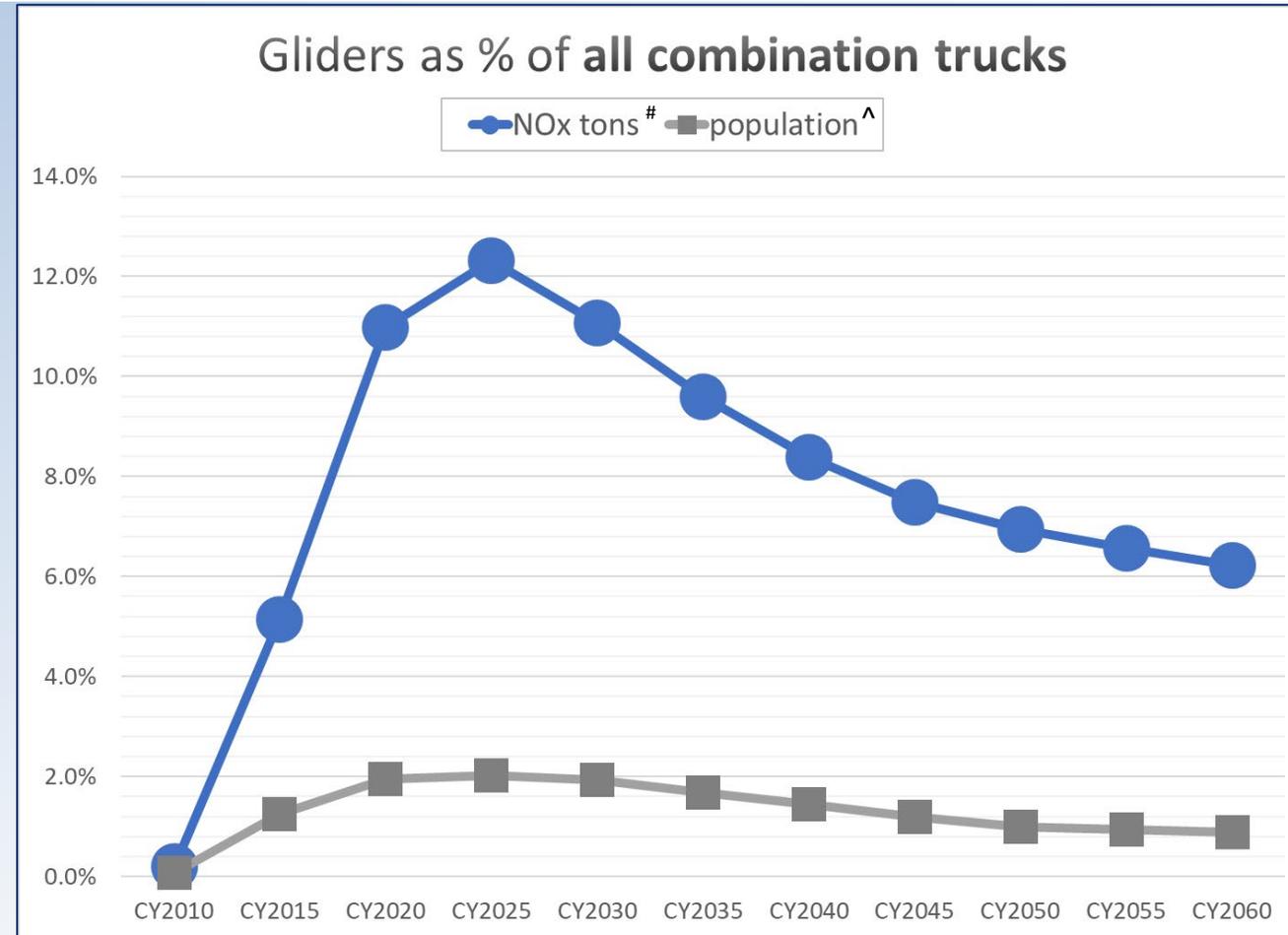


- As before, local fleet data can be entered thru AVFT table



# Planned New Features: Modeling Gliders in MOVES

- “Gliders”: vehicles with old powertrain combined with a new chassis and cab assembly
- For modeling, all gliders presumed to be tractor-trailers (combination trucks) running on diesel
  - Exhaust emission rates: equivalent to MY2000 HHD rates
  - Vehicle characteristics (aero/rolling resistance/APU/brake & tire PM rates): same as new (non-glider) HHD fleet
- Glider sales (population at age 0) estimated based on the production data provided by manufacturers\*



\* CBI. Redacted version at <https://www.regulations.gov/document?D=EPA-HQ-OAR-2014-0827-2379>

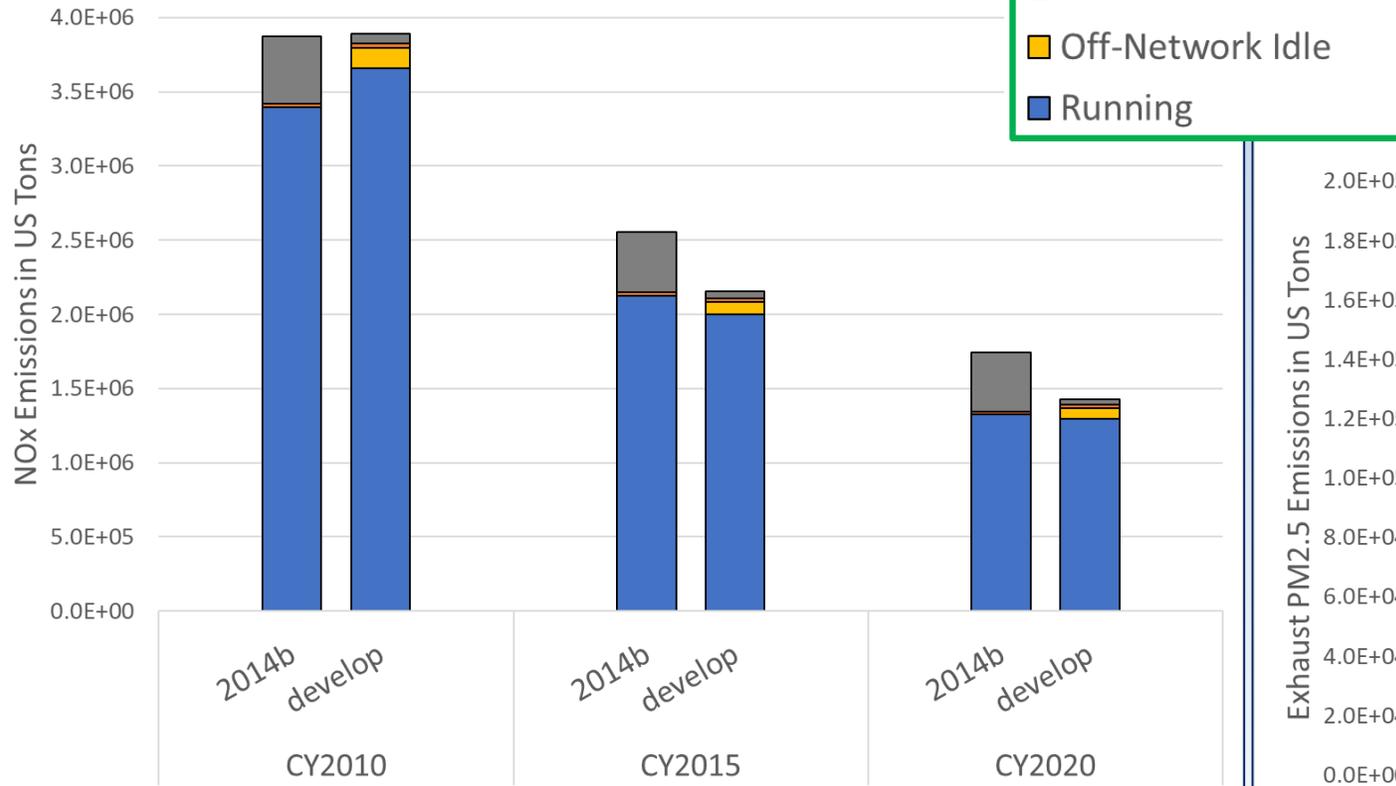
^ MY2018+ estimates assume that the glider provisions in HD GHG Phase 2 rule remain in place

# Preliminary estimates based on EPA's current development version of MOVES

# Preliminary Estimates: Combined Impact of Planned Updates on HD Emissions

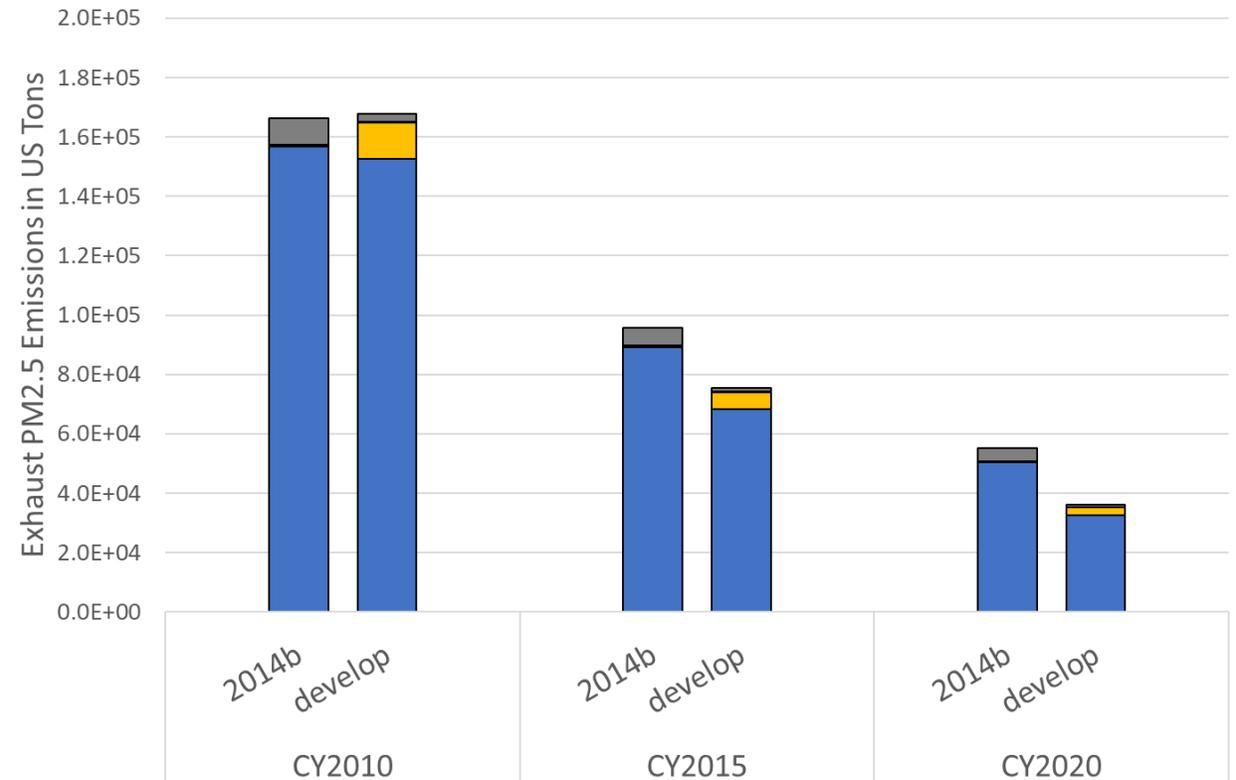
**NO<sub>x</sub> from HD Sourcetypes by Process**

MOVES2014b vs Internal Development Version\*



**Exhaust PM2.5 from HD Sourcetypes by Process**

MOVES2014b vs Internal Development Version\*



\* Preliminary estimates based on EPA's current development version of MOVES

# Summary

- The planned heavy-duty updates discussed here are based on latest data and science and will inform future public version of MOVES
- In comparison with MOVES2014b, these updates will likely lead to:
  - Significant NOx increase in HD running emissions from MY 2010+ vehicles
  - Significant NOx decrease in HD extended idle emissions
  - Increase in NOx running emissions due to gliders
  - Addition of new “off-network idle” emissions
  - Decrease in PM in HD running emissions from MY 2010+ vehicles, despite PM increase from gliders
- The results shown in this presentation are still **preliminary**
  - Emission impacts will vary by location and calendar year
  - There are other planned changes that could result in changes in emissions (e.g., updates to light-duty presented by Claudia Toro)



# References

## MOVES Review Workgroup Presentations

<https://www.epa.gov/moves/moves-model-review-work-group>

Category	Topic	Meeting Date
Emission Rates	<i>Updates to MOVES Heavy Duty Running Exhaust Rates: Diesel, Gasoline and CNG</i>	April 2019
	<i>Heavy Duty Start Emission Rates</i>	June 2017
	<i>Updated Emission Rates for Extended Idle and Auxiliary Power Units</i>	December 2016
Activity and Population	<i>Heavy-Duty Vehicle Activity in MOVES: Idle, Starts, Soaks, and Hotelling</i>	June 2018
	<i>Updates to MOVES HD Source Masses using VTRIS</i>	December 2017
	<i>Telematics and MOVES</i>	June 2017
	<i>Vehicle Idle Activity in MOVES</i>	March 2017
	<i>MOVES Onroad Population and Activity Update</i>	December 2016
	<i>Updating Hotelling Hours in MOVES</i>	December 2016
General	<i>Modeling of Gliders in MOVES</i>	April 2019
	<i>Updates to HDV Fixed Mass Factor and Diesel PM rates</i>	December 2017
	<i>Heavy Duty CNG Vehicles in MOVES</i>	June 2017
	<i>Heavy-Duty Greenhouse Gas Phase 2 in MOVES</i>	September 2016



# References: Draft Technical Reports

Report	Location
Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES201X	Available on EPA's science inventory webpage: <a href="https://cfpub.epa.gov/si/">https://cfpub.epa.gov/si/</a>
Population and Activity of On road Vehicles in MOVES201X	Search "MOVES201X"  Includes peer-review comments
MOVES Activity Updates Using Fleet DNA Data: Interim Report	<a href="https://www.nrel.gov/docs/fy19osti/70671.pdf">https://www.nrel.gov/docs/fy19osti/70671.pdf</a>



**QUESTIONS?**



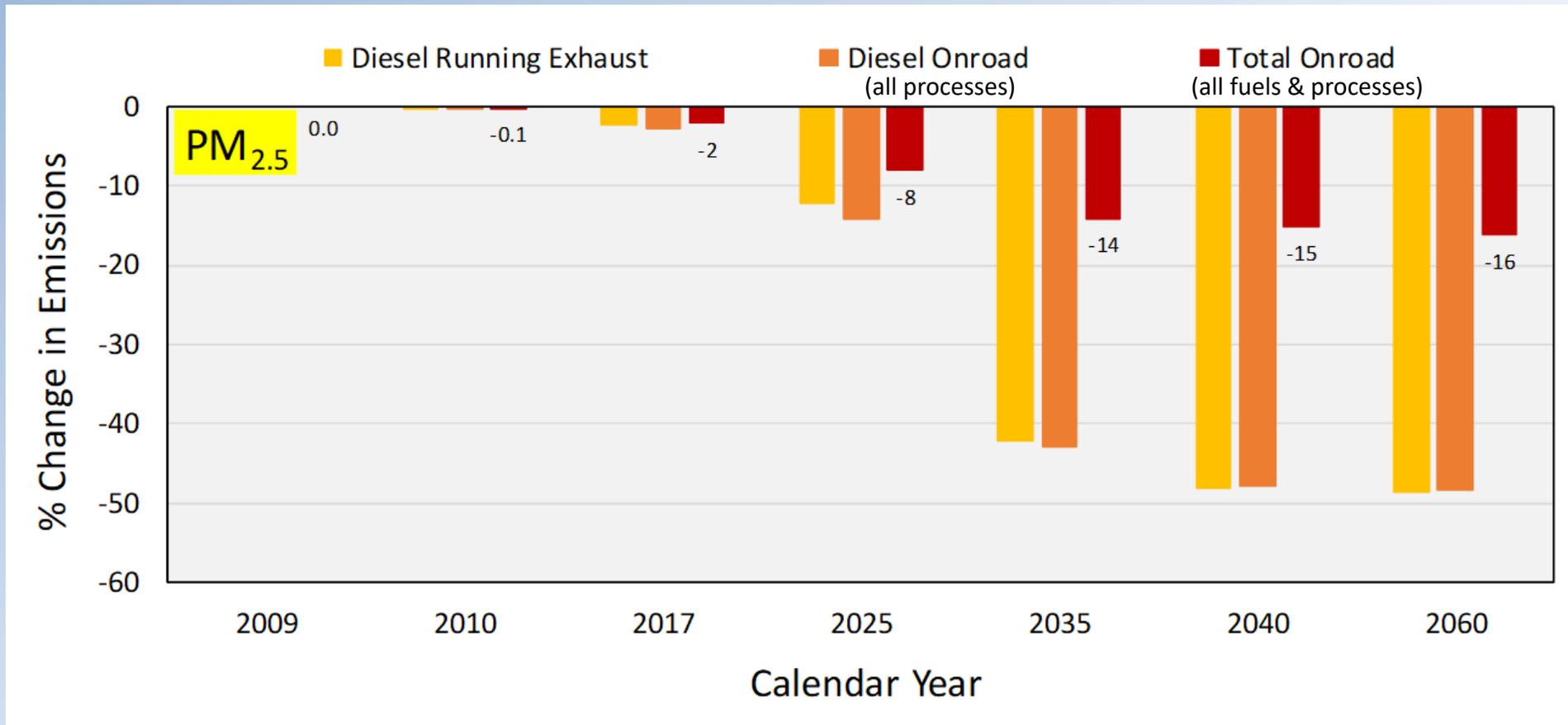
# APPENDIX



# Preliminary Emission Impacts – Exhaust PM<sub>2.5</sub>

## MY 2010+ Diesel Running Emission Rates

- Changes in PM<sub>2.5</sub> emissions only due to this specific emission rate update
  - Based on a “typical” MOVES national scale run



# Planned Extended Idle and APU Emission Rate Updates (PM)

