MOVES3
Introduction & Overview

MOVES Review Work Group
U.S. Environmental Protection Agency
Office of Transportation and Air Quality
12/10/2020

Overview

- Background on MOVES
- What's new in MOVES3?
- Comparison of MOVES3 and MOVES2014b Results
- MOVES3 Policy Guidance
- MOVES3 Technical Guidance
- Summary and Resources

Background on MOVES

- EPA's <u>MO</u>tor <u>V</u>ehicle <u>E</u>mission <u>S</u>imulator

- Estimates emissions and energy use for
  - Onroad vehicles
  - Nonroad equipment (except airplanes, locomotives, and commercial marine vessels)

- Estimates different types of emissions:
  - Engine running, engine starting, hotelling (extended idle), evaporative, brake and tire wear

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

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

- Used by EPA, states, tribes, local transportation and air agencies and others
  - However, California has its own emissions model, EMFAC

MOVES – Scales of Analysis

Default

Use:
- National estimates of program impacts
- High-level emission inventory projections

Input:
- MOVES default national averages (e.g., vehicle counts, VMT, temperature, fuel, etc.)

County

Use:
- SIPs and tribal AQ plans
- Inputs for air quality modeling
- Transportation conformity regional analyses

Input:
- County-specific inputs

Project

Use:
- Estimates for specific transportation projects
- Inputs for hot-spot analyses

Input:
- More detailed location-specific inputs

What's new in MOVES3?

New Naming Convention

- This is the 3rd major MOVES release
  - Follows MOVES2010 and MOVES2014

- Provides clarity on the various versions of the model
  - Future major revisions: MOVES4, MOVES5
  - Future minor revisions: designated by increments of the number after a decimal point (e.g., MOVES3.1)
  - EPA may also designate minor patches with an additional decimal and number (e.g., MOVES3.0.1).

MOVES3

- Based on analyses of millions of emission test results and considerable advances in EPA's understanding of vehicle emissions

- Incorporates rules not in prior MOVES version

- Includes new data on light-duty and heavy-duty emissions

- Improves user features

- New MOVES3 Policy Guidance and Technical Guidance will help state and local agencies use MOVES for regulatory analyses

Highlights: Light-duty and Fuel Updates

- Updated light-duty (LD) vehicle emission rates for hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x) based on in-use testing data

- Updated LD particulate matter (PM) rates, incorporating data on gasoline direct injection engines

- Added new fuel characteristic data from EPA fuel compliance submissions

- Updated fuel effect calculations to better characterize the base fuel used to develop LD base emission rates

- Incorporated the effects of the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule on light-duty fuel economy

Highlights: Heavy-duty Updates

- Improved heavy-duty (HD) diesel running emission rates based on manufacturer-run in-use testing program data from hundreds of HD trucks

- Updated HD diesel starts and extended idle emission rates

- Updated emission rates for HD gasoline and compressed natural gas (CNG) trucks

- Incorporated the effects of the HD GHG Phase 2 rule

Highlights: Activity Updates

- Includes vehicle start and idling activity patterns based on real-world instrumented vehicle data from Verizon for LD vehicles and the Department of Energy's (DOE) National Renewable Energy Lab (NREL) for HD vehicles:

  - "Off-network idle" accounts for emissions beyond the idling that is already considered in the MOVES drive cycles;

  - Default hotelling activity substantially reduced from MOVES2014, based on the NREL instrumented truck data;

- Updated national vehicle miles travelled (VMT) and vehicle population defaults with newer historical data from Federal Highway Administration (FHWA) and more recent forecasts from DOE; and

- Updated national onroad vehicle default fuel, regulatory class, and age distributions based on newer vehicle registration data.

Peer Review

Peer Review materials on EPA Science Inventory page: https://cfpub.epa.gov/si/

- 2017
  - Exhaust Emission Rates for Heavy-Duty On road Vehicles in MOVES201X
  - Fuel Supply Defaults for Regional Fuels and Fuel Wizard Tool in MOVES201X
  - Population and Activity of On road Vehicles in MOVES201X
  - Speciation and Toxic Emissions from On road Vehicles, and Particulate Matter Emissions from Light-Duty Gasoline Vehicles in MOVES201X

- 2019
  - Exhaust Emission Rates for Heavy-Duty Onroad Vehicles in MOVES CTI NPRM
  - Population and Activity of On-road Vehicles in MOVES CTI NPRM

- 2020
  - On road Emission Rate Updates to MOVES3
  - Fuel Supply Defaults: Regional Fuels and the Fuel Wizard in MOVES3.0

Comparison of MOVES3 and MOVES2014b

Changes in Emission Estimates

- In general, MOVES3 national emission estimates in MOVES3 are:
  - lower for most criteria pollutants in future years compared to MOVES2014b
  - higher for greenhouse gases in near future years compared to MOVES2014b
- Results will vary based on local inputs in a given area
  - Urban areas may see NOx increases

National Comparisons

- National annual results based on U.S. "average" activity, fuels, etc.
  - Results will vary based on local inputs in a given area
- Graphs compare MOVES2014b and MOVES3
- Nonroad changes (not shown) are limited to SO_2 and PM, which decrease with the decrease in diesel fuel sulfur levels.
  - Other nonroad results are virtually unchanged.

National: Onroad VMT

- Small changes due to new historical data & AEO forecast
- Predicted VMT continues to increase across onroad sectors

Legend: Gasoline | Diesel | CNG | Ethanol (E-85)

Charts for 2016, 2023, 2028, 2035, 2045 comparing MOVES2014 and MOVES3, with Total VMT (trillions of miles) on the y-axis.

Percentage labels: 2016 + 2%, 2023 + 3%, 2028 + 1%, 2035 − 3%, 2045 − 4%
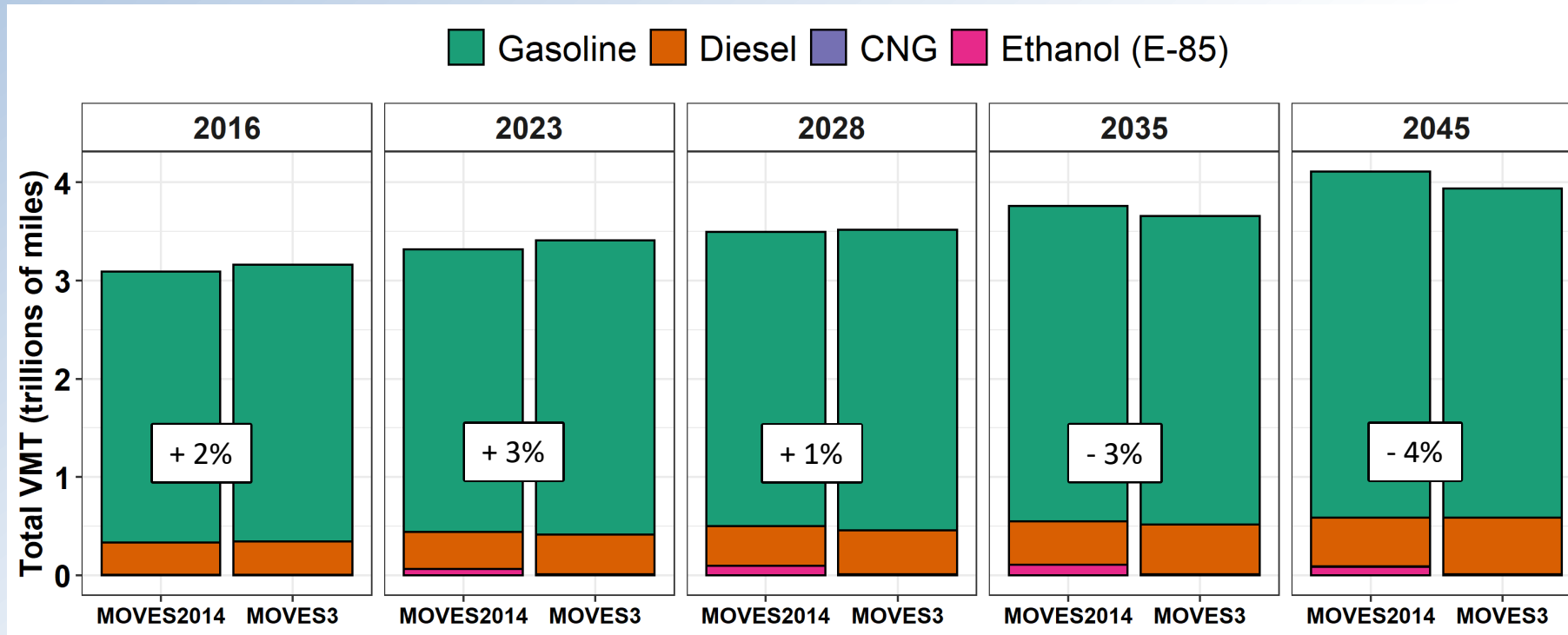
Percentage label indicates change from MOVES2014b to MOVES3.

National: Onroad GHGs

- LDGHG and HDGHG rules reduce future CO_2

- SAFE rule impacts seen in MOVES3 gasoline values

- Increase in CH_4
  - Updates to CNG population increase HD emissions
  - Updates to speciation (CH_4/THC ratios) change gasoline and diesel emissions
  - But still only a small fraction of a percent of GHG emissions.
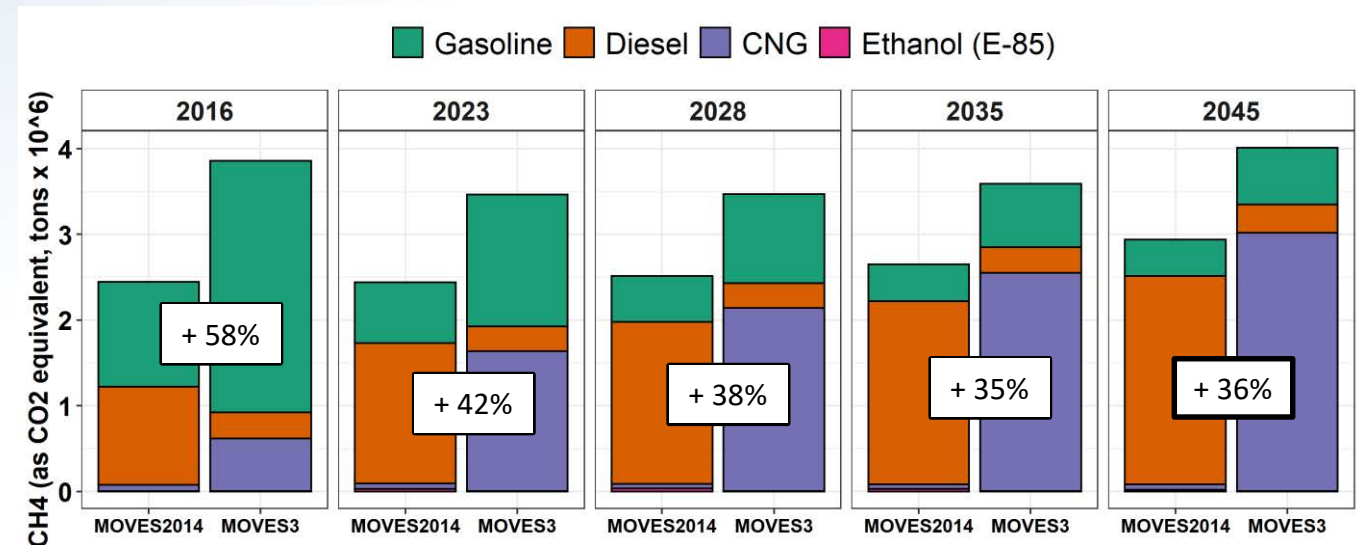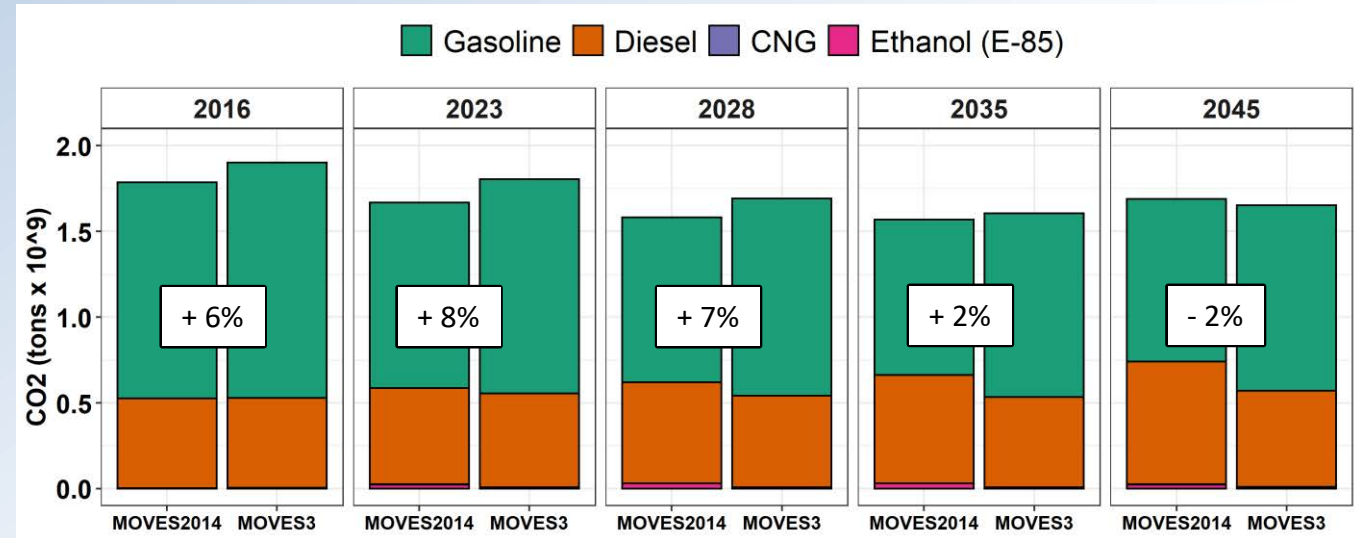
National: Onroad NOx

- Continue to see large drop in gasoline (LD) NOx with Tier 3
- At national scale, increase in diesel running NOx is outweighed by reduced extended idle from HD hotelling
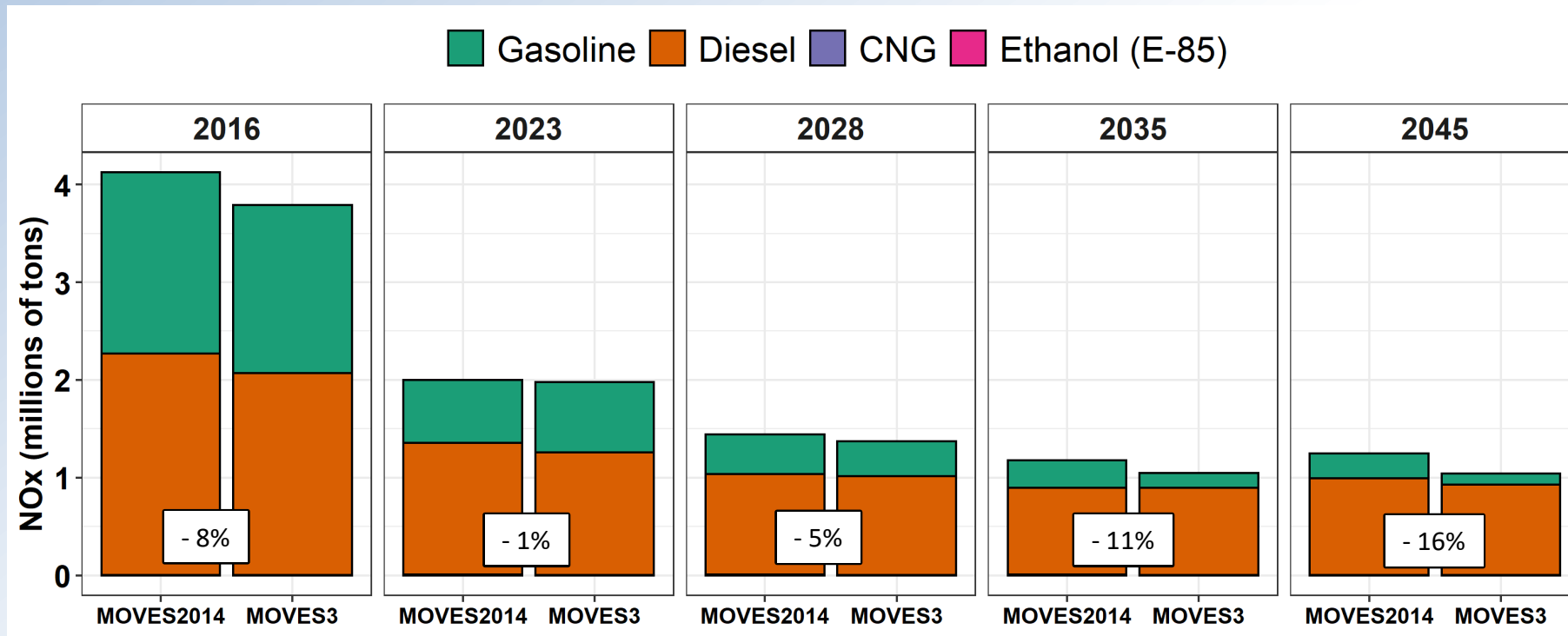
National: Onroad PM$_{2.5}$

- MOVES3 has less exhaust PM$_{2.5}$ due to decreased extended idle activity and lower HD emission rates

- Brake and tire wear constitute a growing fraction of PM emissions
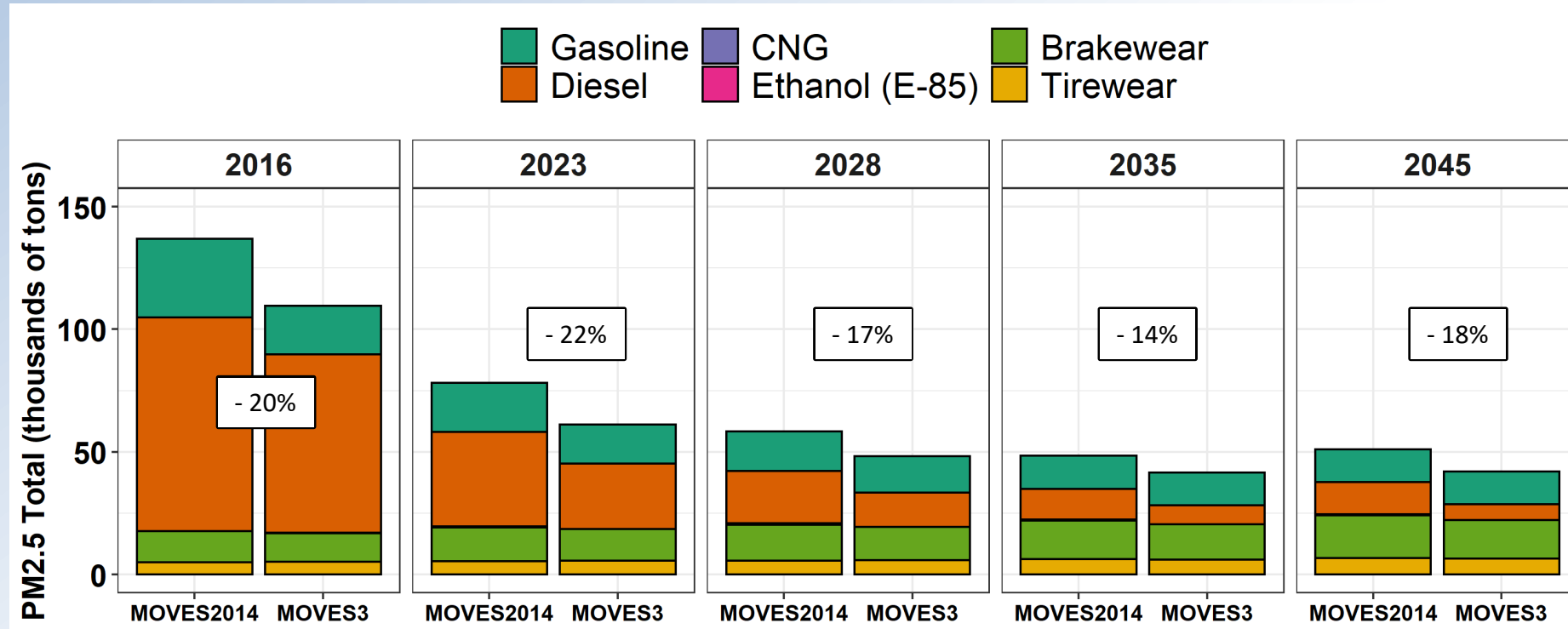
National: Onroad VOC

- Continue to see large drop in gasoline (LD) VOC with Tier 3

- Diesel declines in MOVES3 with extended idle

- Evaporative emissions are a growing fraction of future onroad VOC
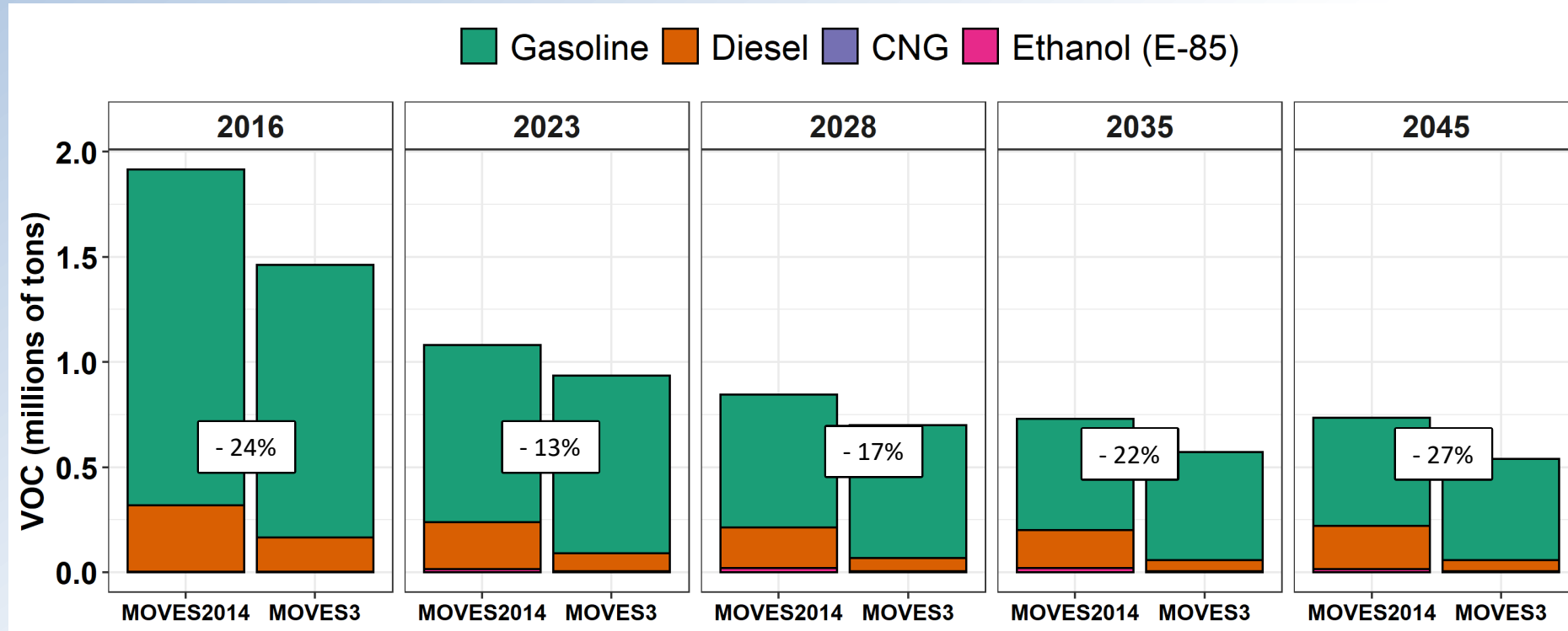
Comparisons for Sample Counties

- Next slides show results for two sample counties for selected years
  - Two core urban counties with different local travel patterns and ambient conditions

Sample Counties: Onroad NOx

In these counties, compared to MOVES2014b:

1. Lower gasoline NOx
2. Higher diesel NOx
   - Urban diesel is dominated by running NOx (which increased) rather than extended idle (which decreased)
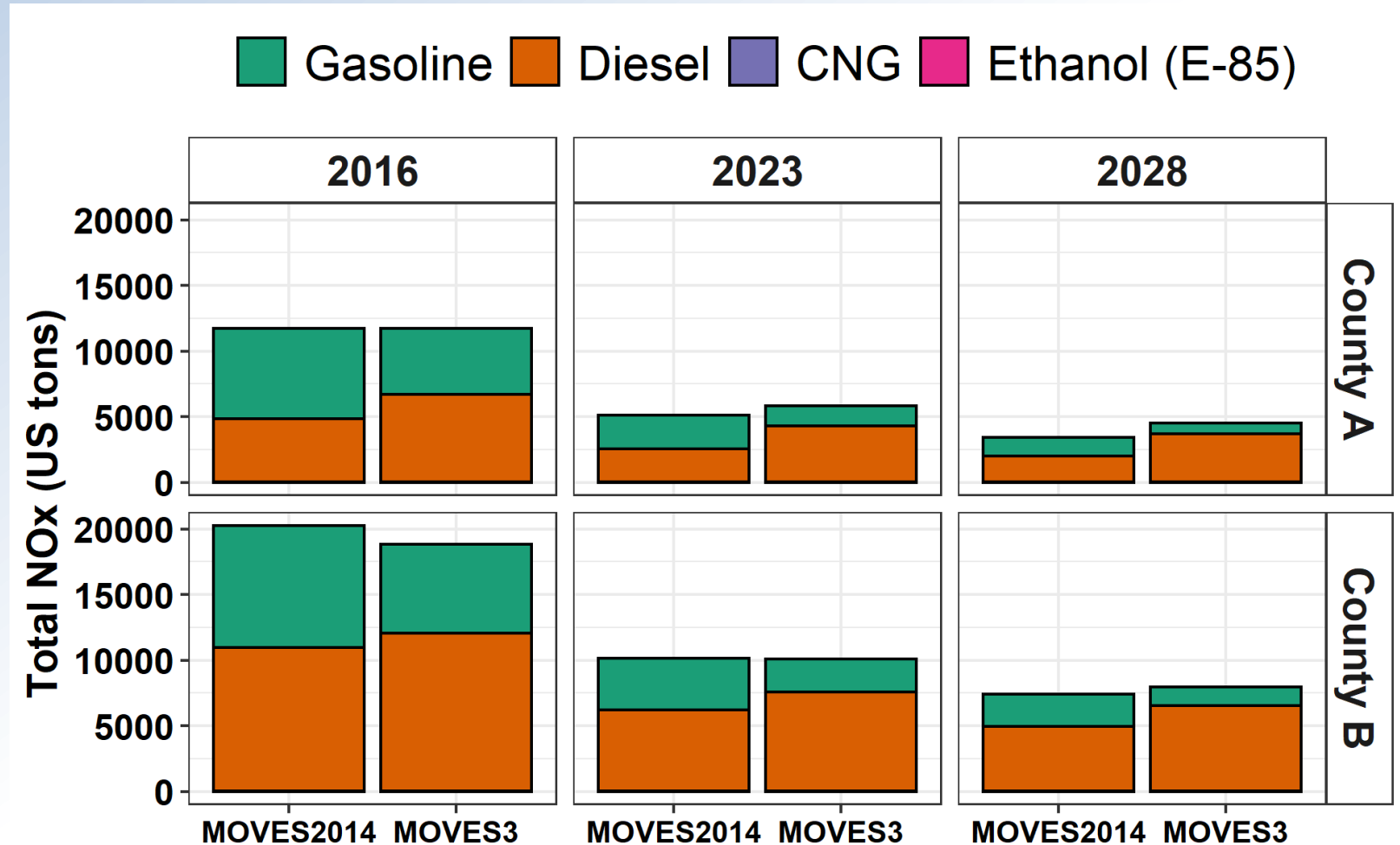
Sample Counties: Onroad PM$_{2.5}$

In these counties, compared to MOVES2014b:

1. Lower PM from gasoline
2. Lower PM from diesel
   • Dominated by running emissions & sensitive to local fleet mix
3. Brake and tire wear emissions are unchanged, but contribute a significant fraction of future year PM
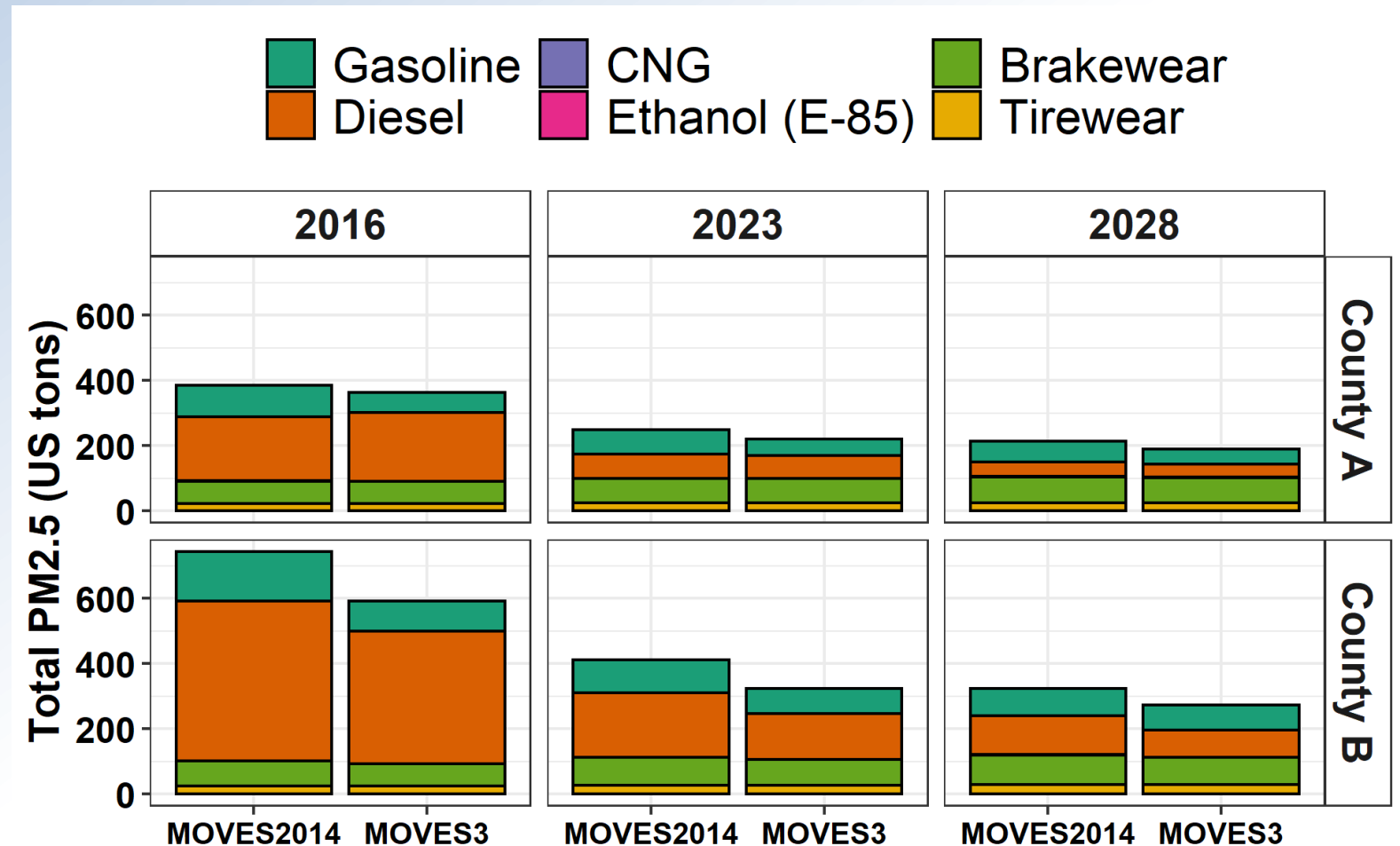
Sample Counties: Onroad VOC

In these counties, compared to MOVES2014b:

1. Less gasoline VOC; driven by reduced start emissions
2. Similar or less diesel VOC; dominated by running emissions
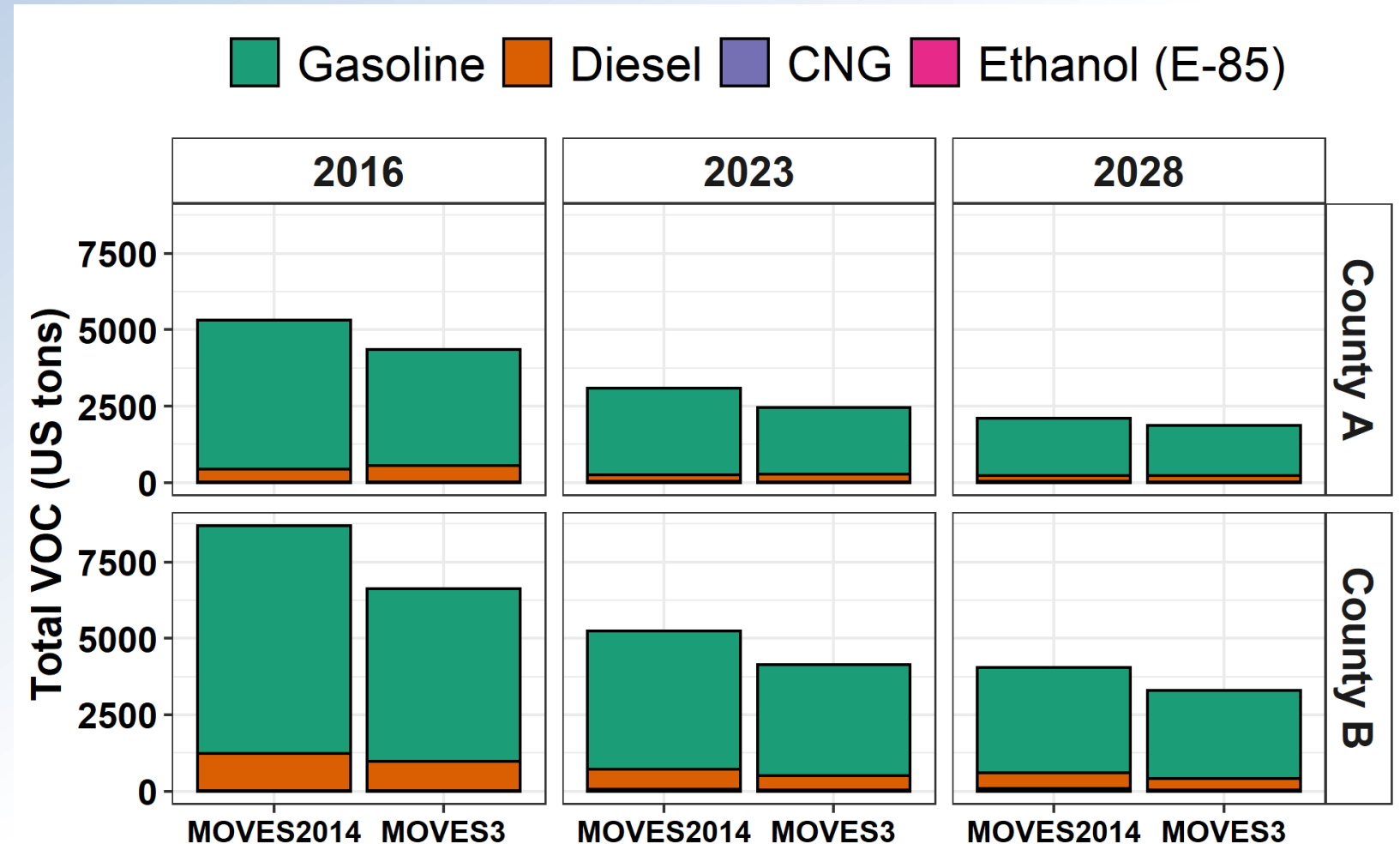
MOVES3 Policy Guidance

When to use MOVES3?

State Implementation Plans

- MOVES3 must be used in new SIPs after its release – there is no grace period

- However, if a state has done significant work on a SIP using MOVES2014b, it may continue with that model

- In general, incorporating MOVES3 into the SIP now could be useful in some areas; MOVES3 will have to be used for transportation conformity at the end of the grace period

Transportation Conformity

- EPA will be publishing a *Federal Register* notice to announce the availability of MOVES and establish:

  - A two-year grace period before MOVES needs to be used in regional emissions analyses

    - Unless MOVES3-based SIP budgets become applicable sooner

  - A two-year grace period before MOVES needs to be used in project-level conformity hot-spot analyses

- Analyses that are started during the grace period may use either MOVES3 or MOVES2014

- Analyses started after the grace period must use MOVES3

MOVES3 Technical Guidance

MOVES Technical Guidance

Provides guidance on

- Using MOVES at the County Scale for onroad emission inventory development in SIPs and conformity (in states other than California)
  - Section 2, planning an onroad emissions analysis with MOVES
  - Section 3, creating a MOVES Run Specification
  - Section 4, entering local data using the County Data Manager
- Developing nonroad inventories – Section 5
- Other guidance covers MOVES at the Project Scale (used for hot-spot analyses), using MOVES to model specific control programs (e.g., diesel retrofits/replacements), and using MOVES to estimate GHGs
  - Until updated, existing guidance generally applicable to MOVES3

MOVES Technical Guidance (cont'd)

- Covers main changes in MOVES3 from MOVES2014, e.g.,
  - New input options for start activity
  - New input options for entering local hotelling activity data, for long-haul combination trucks
  - New input option for off-network idling: vehicle engine is running, but not on the road (not hotelling), e.g.:
    - LD vehicles idling while waiting to pick up children at school or passengers at airport or train station,
    - Single unit and combination trucks idling while loading/unloading cargo or making deliveries
    - Vehicles idling at drive-through restaurants
  - Automatic selection of all fuel types in the Onroad Vehicles Panel, and other instances where model ensures consistency of user choices

MOVES Technical Guidance (cont'd)

- Discusses use of tools provided within MOVES, such as:
  - Input database converters: if a MOVES2014 input database has the latest information, it can be converted to work with MOVES3
  - Off-network idling tool: provides hours of off-network idling needed for Emission Rates runs
- Includes new appendix with a script to reduce the size of a nonroad output database
  - Will speed up other nonroad post-processing

Resources

MOVES Webpage

https://www.epa.gov/moves is the starting point for all MOVES information, with links to:

- Latest model (MOVES3)

- Limited use models (MOVES2014)

- Tools

- Training

- Background Information

  - Technical Reports

  - Software Information

MOVES3 Webpage

https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves has links and documents for MOVES3, including:

- EPA Releases MOVES3 Mobile Source Emissions Model: Questions and Answers

- Policy and Technical Guidance

- MOVES3 Installation File (Instructions and trouble shooting guide are included)

- Links to training materials and additional user materials

MOVES GitHub Site

- https://github.com/USEPA/EPA_MOVES_Model has links to the MOVES source code

- https://github.com/USEPA/EPA_MOVES_Model/tree/master/docs has links to additional user support documents, including:

- *Anatomy of a Runspec*

- *Command Line MOVES*

- *Input DB changes in MOVES3*

- *Tips for faster MOVES runs*

- *Onroad Cheat Sheet*

- *Nonroad Cheat Sheet*

Additional Resources

- MOVES3 Policy Guidance and Technical Guidance are also available at: www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission

- Coming soon: *Federal Register* notice, other guidance updates, webinar for experienced users, and information about training

- Join EPA's MOVES listserv to receive MOVES announcements, including training: www.epa.gov/moves/forms/epa-mobilenews-listserv

Questions?