MOVES
Motor Vehicle Emission Simulator

MOVES3
Introduction & Overview

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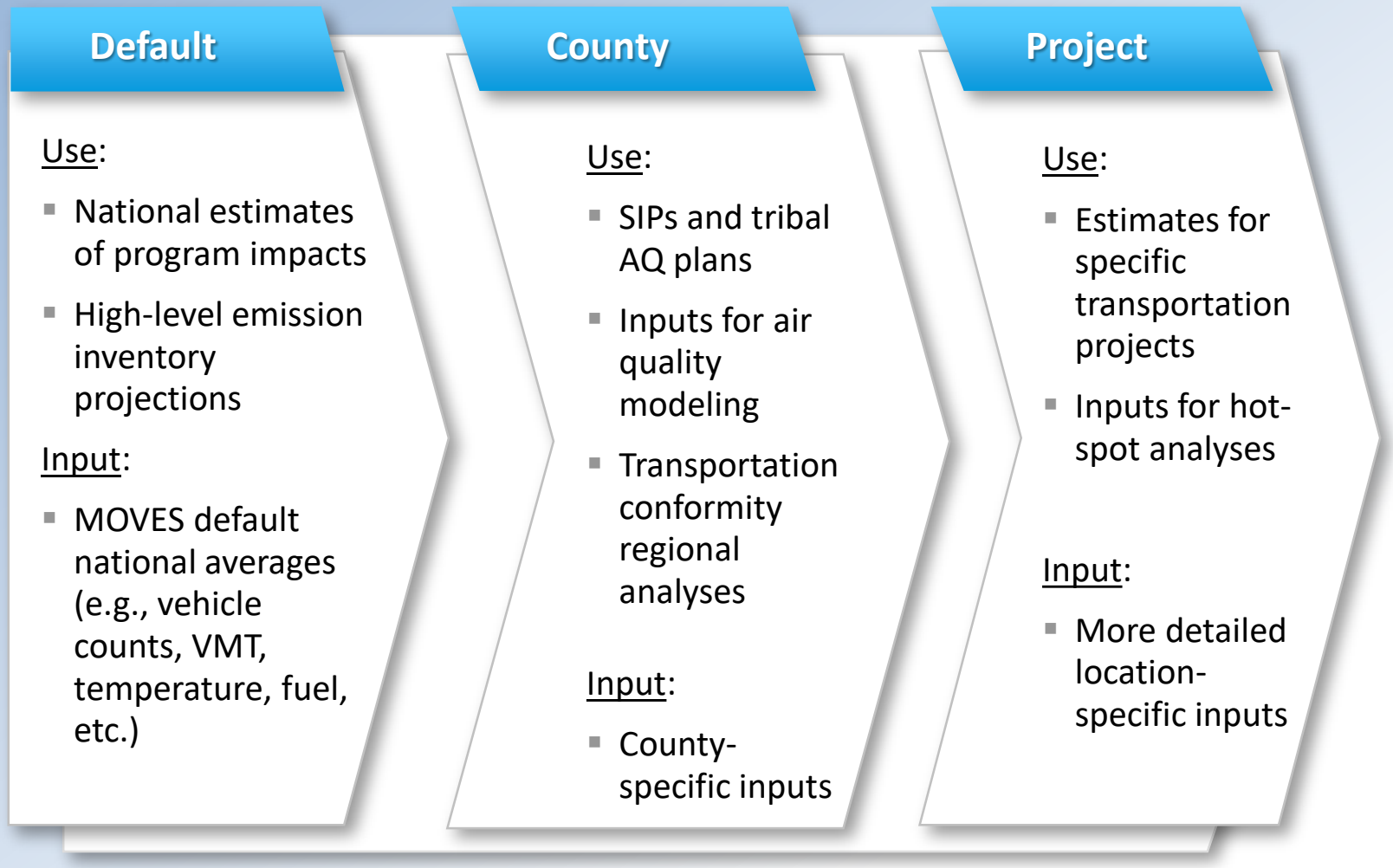
Overview

- 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 MOtor Vehicle Emission Simulator
- 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, as well as 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



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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 Overview

- Based on analyses of millions of emission test results and considerable advances in EPA's understanding of vehicle emissions
- Includes new data on light-duty and heavy-duty emissions
- Incorporates rules not in prior MOVES version
- 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 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 emission rates for HD diesel starts and extended idle
- 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's Annual Energy Outlook (AEO)
- Updated default fuel, regulatory class, and age distributions based on newer vehicle registration data

MOVES3 Review

Peer Review

- New MOVES3 inputs and algorithms have been reviewed by independent experts under EPA's peer review policies and procedures.
  - Peer review materials available on the Science Inventory page

Beta Testing

- A draft version of MOVES3 was tested by a small group of experienced MOVES users
  - Alerted EPA to potential errors and problems prior to release
  - Commented on user instructions, updated interface and the new installer

MOVES3 Review (cont'd)

MOVES Review Work Group

- Provides MOVES-related feedback to EPA via the Mobile Source Technical Review Subcommittee (MSTRS) of CAAAC
  - Members have expertise in modeling emissions from highway and nonroad vehicles and represent a spectrum of stakeholders
  - Work Group members coordinate within their organizations and with their constituents to solicit specific comments on EPA's work
- Since 2016, EPA has presented planned updates to MOVES3, including underlying data and analyses
  - Meeting notes and presentations available at https://www.epa.gov/moves/moves-model-review-work-group
- Early in 2021, Work Group will meet to discuss MOVES3 and suggestions for MOVES4 and future models

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Comparison of MOVES3 and MOVES2014b

Changes in Emission Estimates

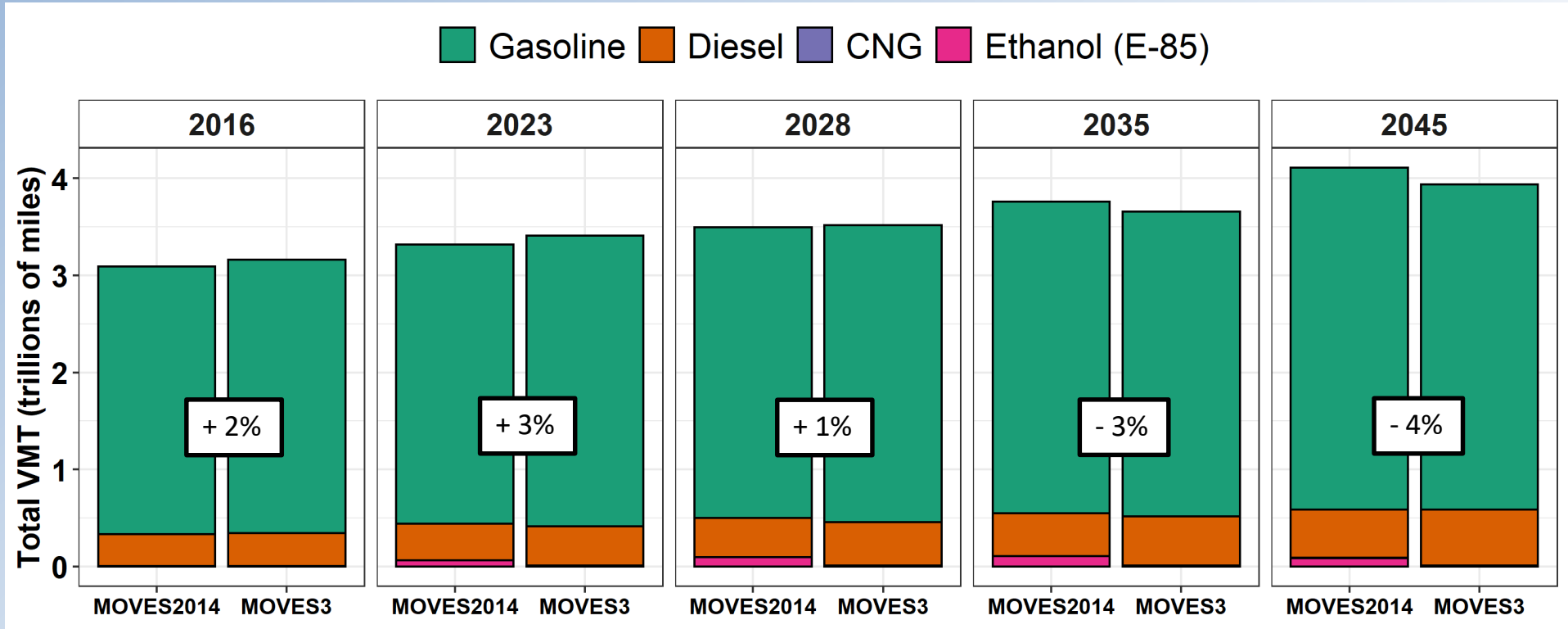
- In general, MOVES3 national emission estimates in MOVES3 are:
  - Lower for most criteria pollutants in future years compared to MOVES2014b
  - Higher for greenhouse gases in near future years compared to MOVES2014b
- Results will vary based on local inputs in a given area
  - Urban areas may see NOx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

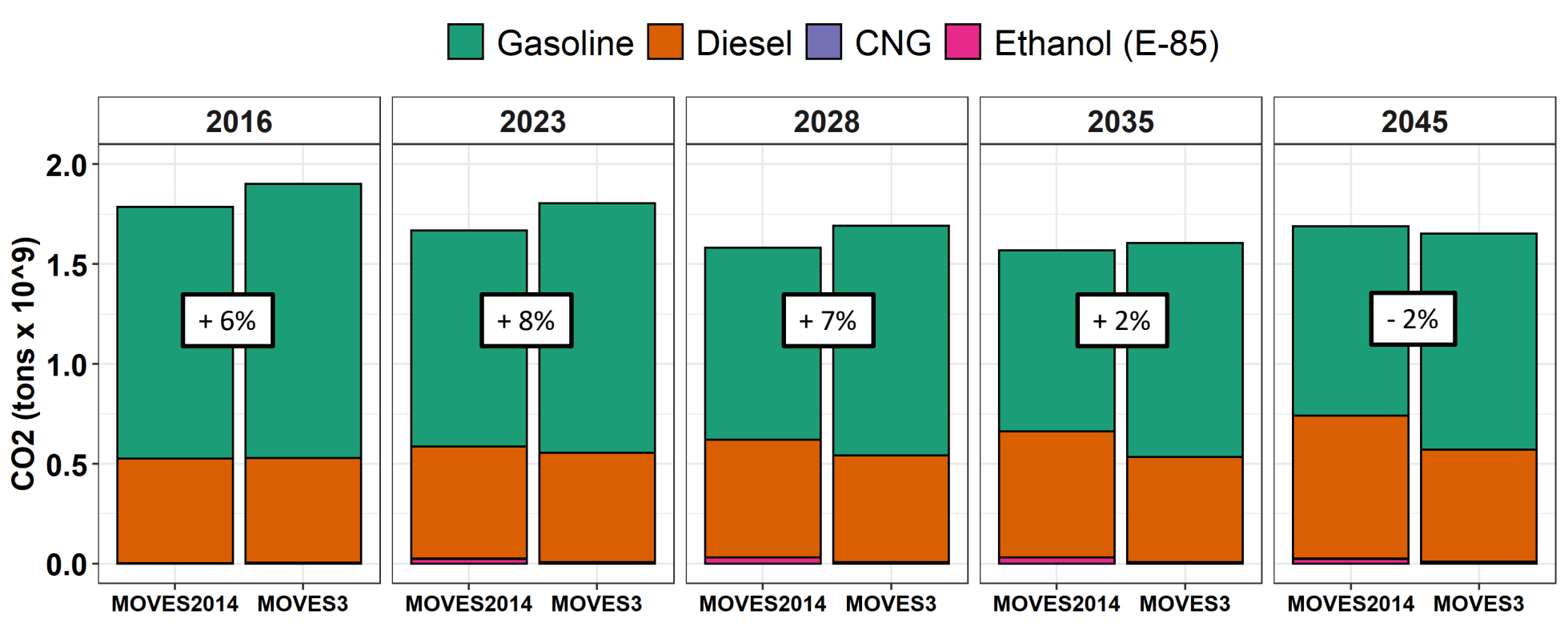
- Small changes due to new historical data & AEO forecast
- Predicted VMT continues to increase across onroad sectors



Percentage label indicates change from MOVES2014 to MOVES3.

National: Onroad GHGs

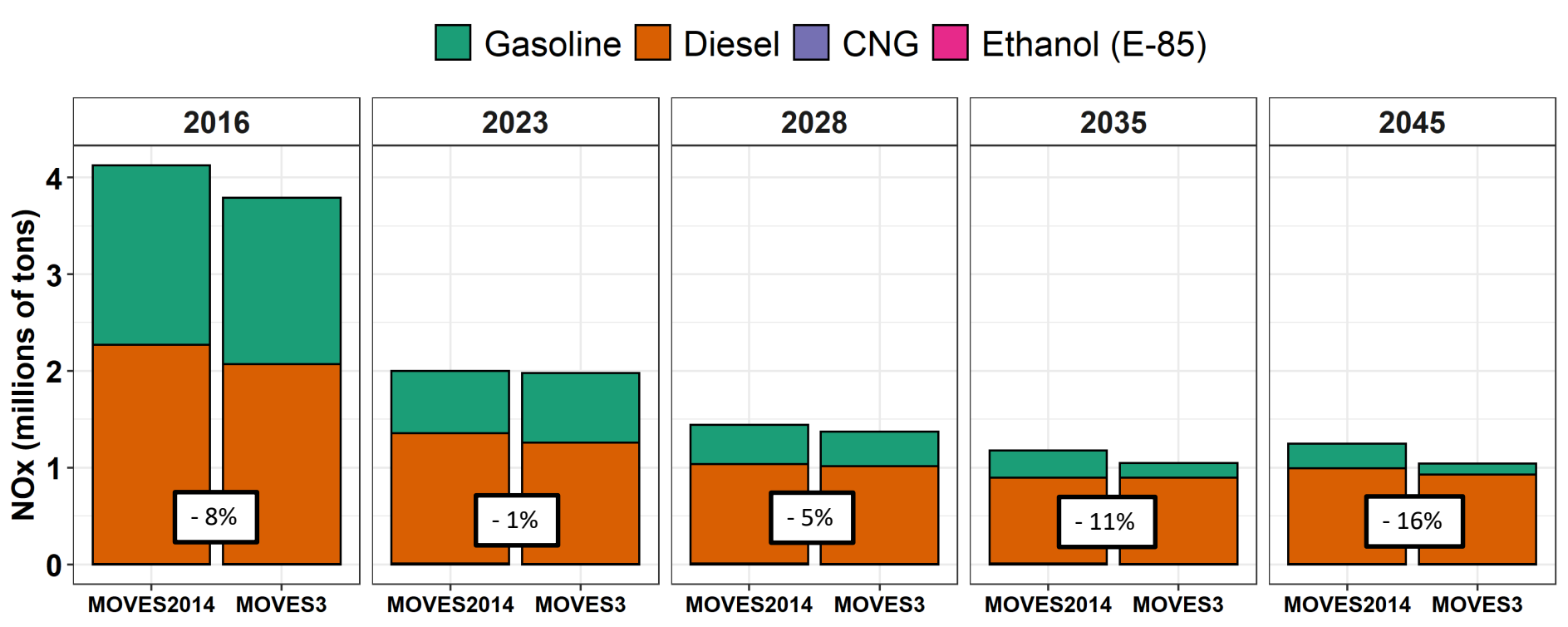
- LDGHG and HDGHG rules reduce future CO_2
- SAFE rule impacts seen in MOVES3 gasoline values



Percentage label indicates change from MOVES2014 to MOVES3.

National: Onroad NOx

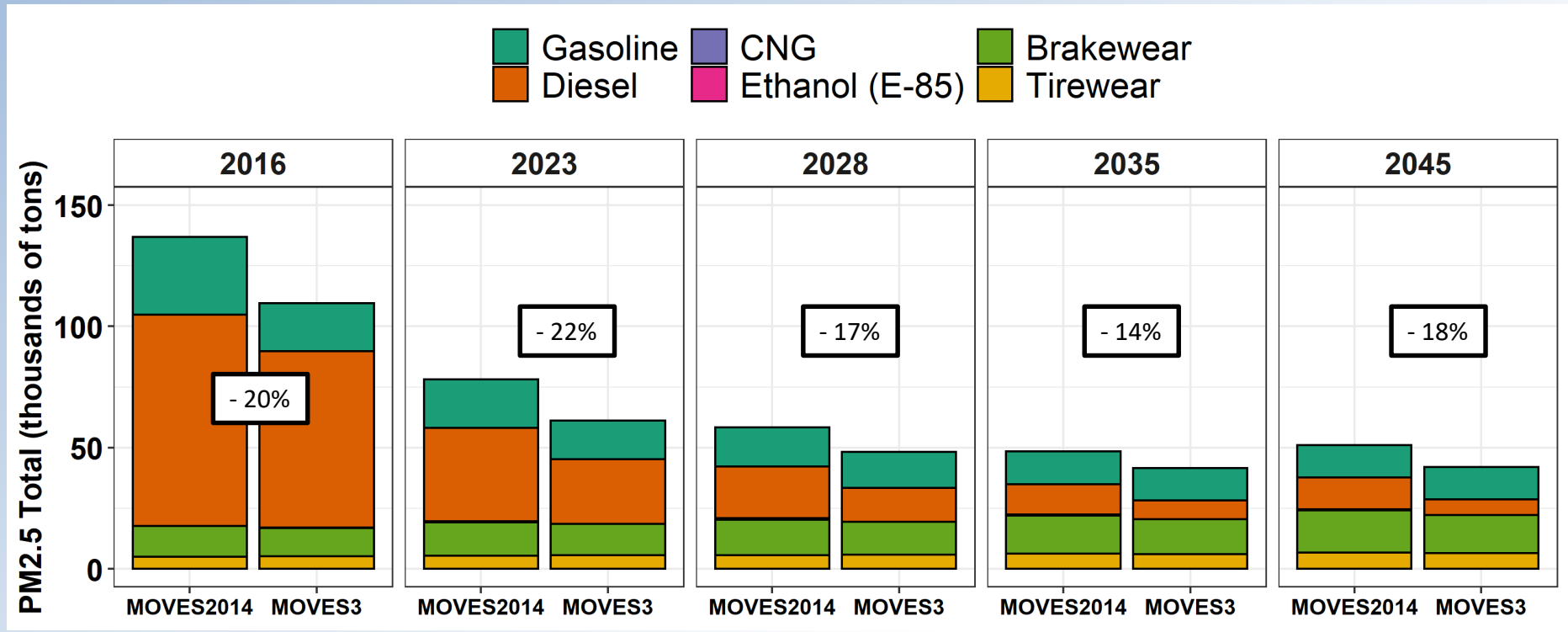
- Continue to see large drop in gasoline (LD) NOx with Tier 3
- At national scale, increase in diesel running NOx is outweighed by reduced extended idle from HD hotelling



Percentage label indicates change from MOVES2014 to MOVES3.

National: Onroad $PM_{2.5}$

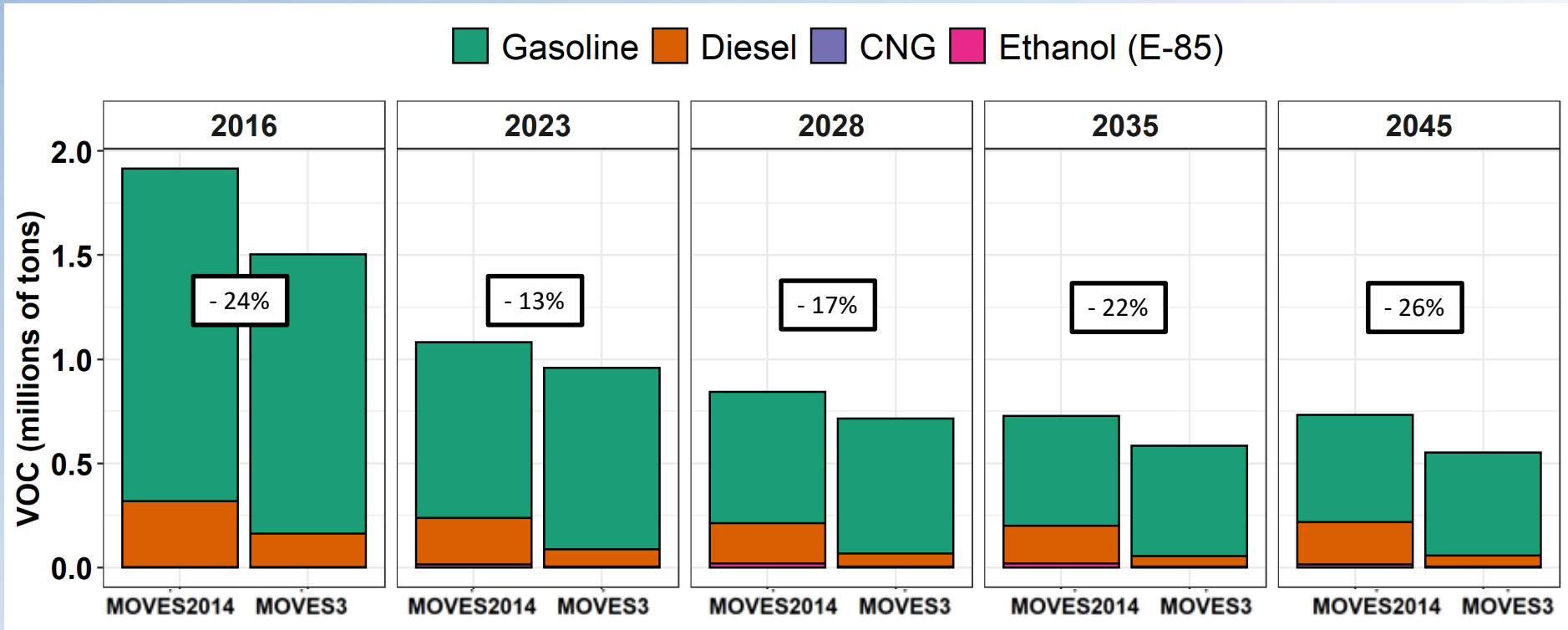
- MOVES3 has less exhaust $PM_{2.5}$ due to decreased extended idle activity and lower HD emission rates
- Brake and tire wear constitute a growing fraction of PM emissions



Percentage label indicates change from MOVES2014 to MOVES3.

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



Percentage label indicates change from MOVES2014 to MOVES3.

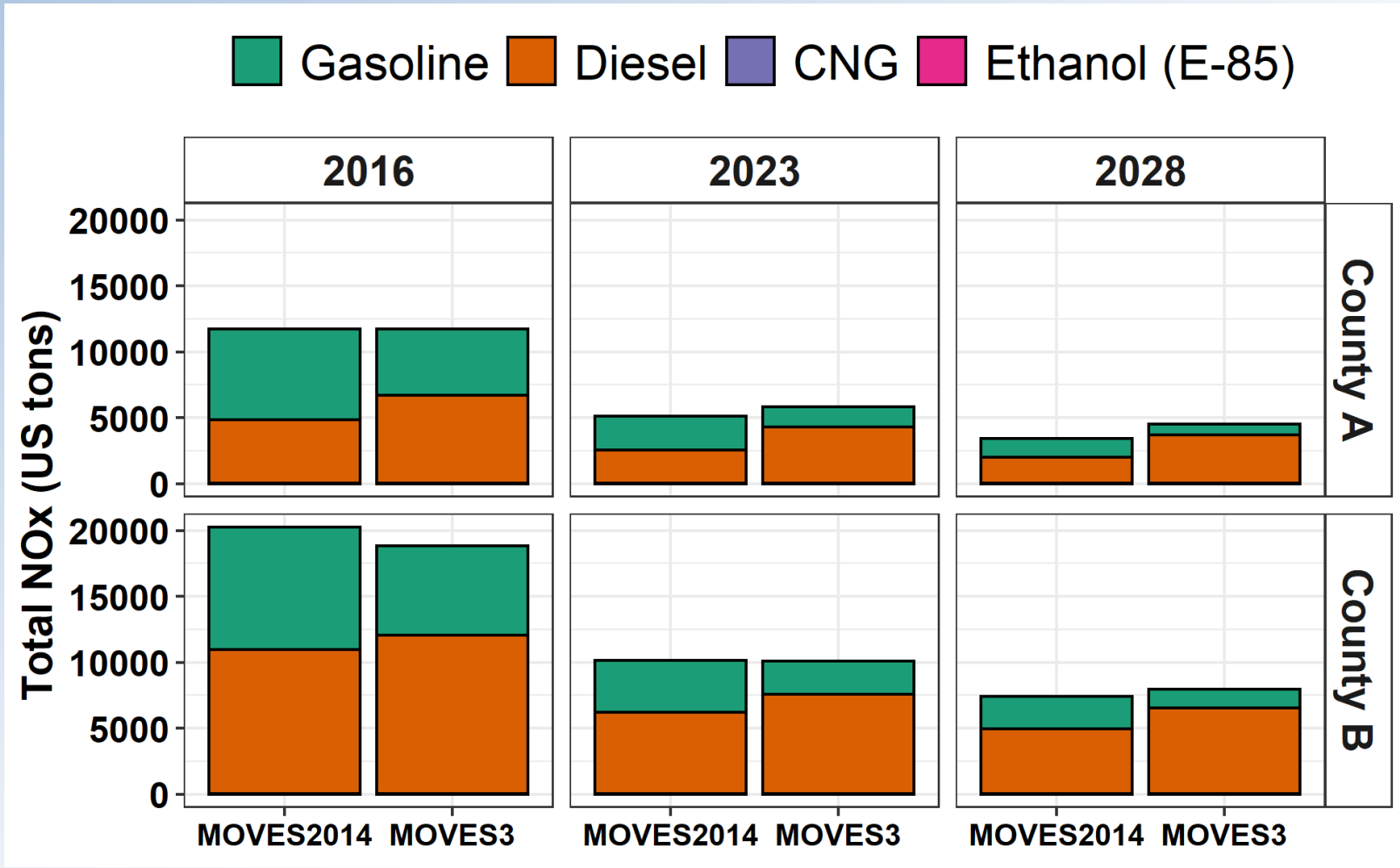
Comparisons for Sample Counties

- 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 MOVES2014:

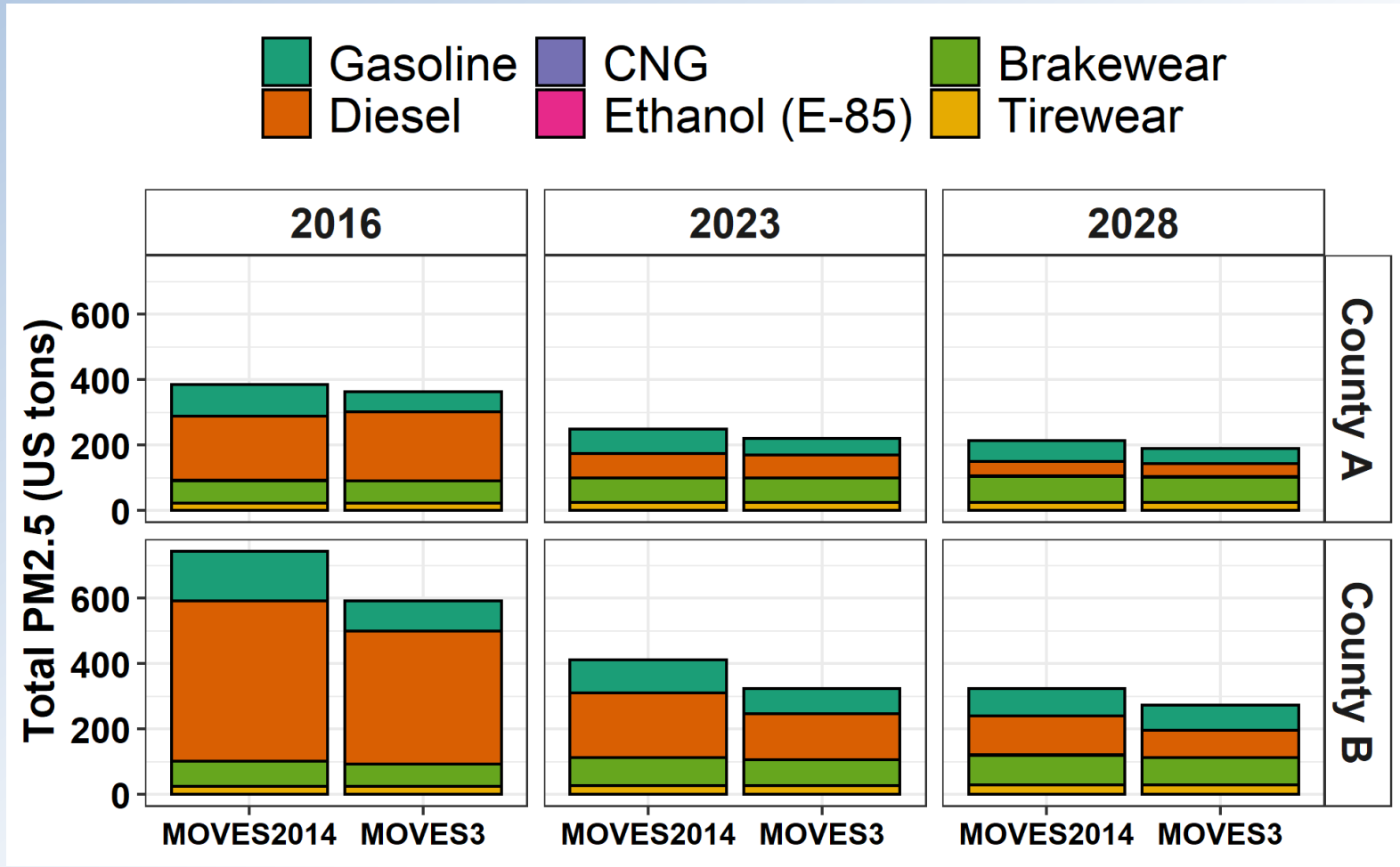
1. Lower gasoline NOx
2. Higher diesel NOx
   - Urban diesel is dominated by running NOx (which increased) rather than extended idle (which decreased)



Sample Counties: Onroad $PM_{2.5}$

In these counties, compared to MOVES2014:

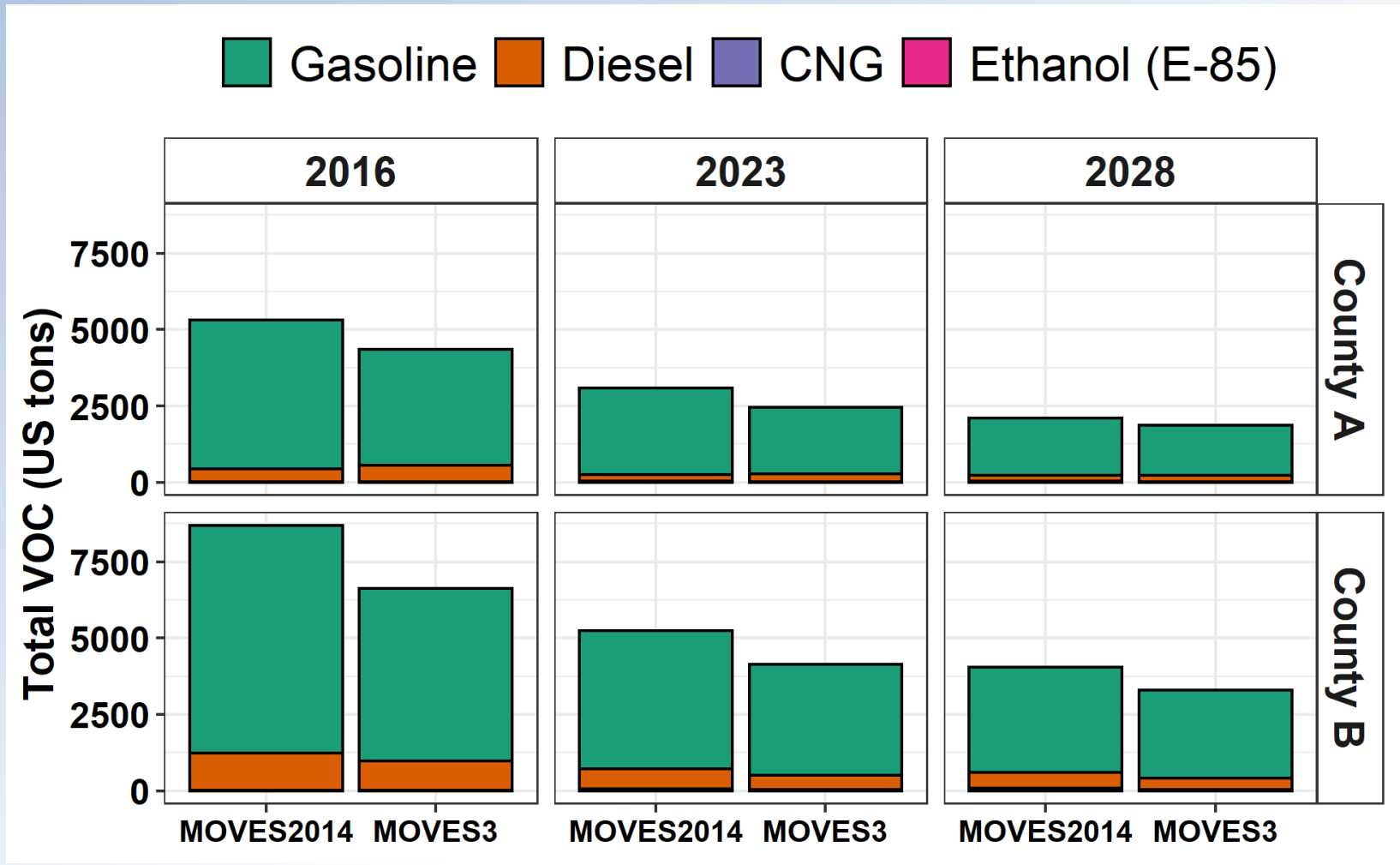
1. Lower PM from gasoline
2. Lower PM from diesel
   - Dominated by running emissions
   - Sensitive to local fleet mix
3. Brake and tire wear emissions are unchanged, but contribute a significant fraction of future year PM



Sample Counties: Onroad VOC

In these counties, compared to MOVES2014:

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



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MOVES3: Policy and Technical 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

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

Summary

- MOVES3 incorporates the latest data and new regulations as well as functional improvements
- In general, compared to MOVES2014, MOVES3 national emission estimates for criteria pollutants are slightly lower in future years
  - Actual results will vary based on local inputs in a given area
- In general, the transition from MOVES2014 to MOVES3 should be straightforward
  - The structure of the MOVES model is fundamentally the same
  - EPA will continue to provide guidance, technical support and training to users
- MOVES development work will continue for MOVES4+

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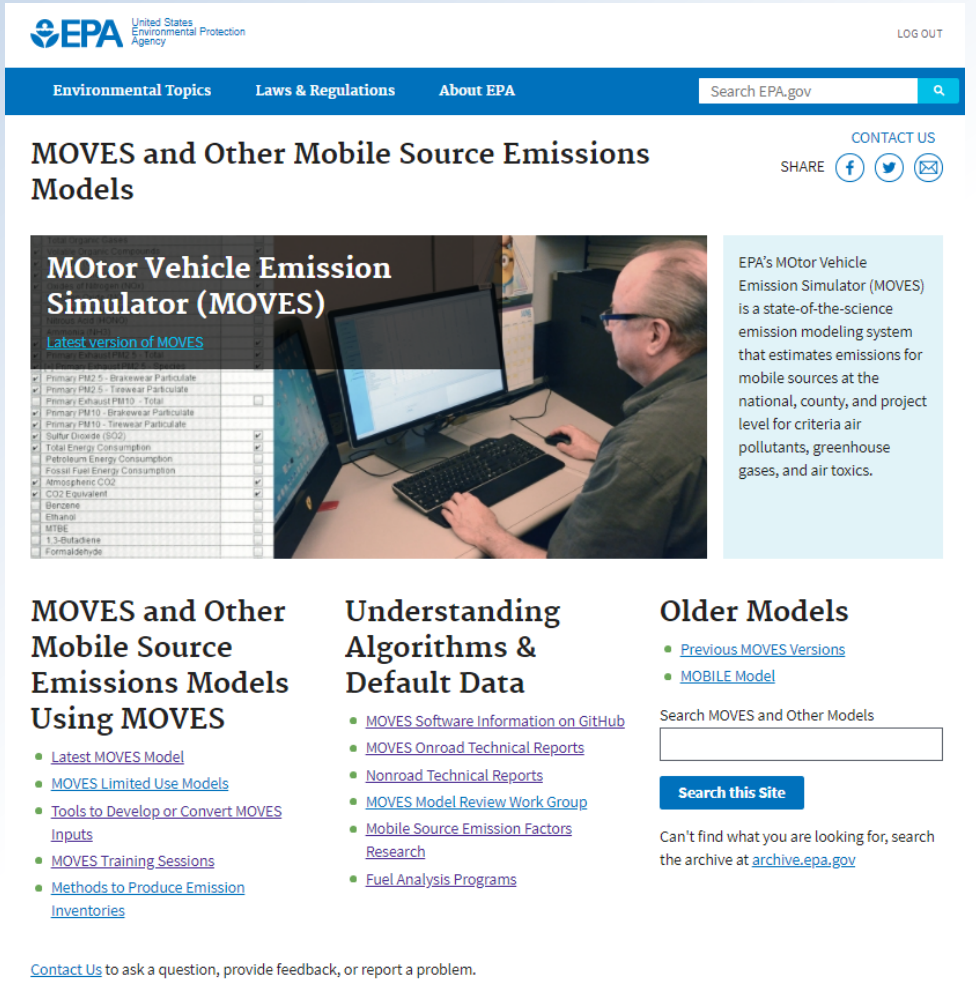
Resources

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
- Join EPA's MOVES listserv



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