

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

## What is MOVES, and why is the EPA releasing MOVES3?

EPA's MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics. Compared to the previous MOVES2014 modeling tool, MOVES3 allows users to model the benefits from new regulations promulgated since MOVES2014 was released, incorporates the latest emissions data, and has improved functionality.

## What has changed from MOVES2014b to MOVES3?

MOVES3 includes many updates to exhaust emission rates to better estimate the real-world emissions of new vehicle technologies. The model is based on analyses of millions of emission test results and considerable advances in EPA's understanding of vehicle emissions. We have updated heavy-duty (HD) diesel and compressed natural gas (CNG) emission running rates based on manufacturer in-use testing data from hundreds of HD trucks, and updated HD gasoline emission rates based on instrumented vehicles. We have updated light-duty (LD) emission rates for HC, CO & NO<sub>x</sub> based on over 100,000 emission measurements and we have updated LD particulate matter rates, incorporating new data on Gasoline Direct Injection (GDI) vehicles. We have also updated LD and HD start emission rates based on test data.

In addition, we have updated gasoline and diesel fuel parameters to incorporate data from EPA fuels compliance testing, including real-world data on gasoline and diesel sulfur content. We also have updated vehicle activity, such as vehicle start and idling activity patterns, based on real-world data, and we have updated vehicle miles travelled (VMT), and vehicle population inputs with newer historical data from FHWA and updated forecasts from DOE.

Other functional improvements based on user feedback have been added as well. MOVES3 better accounts for vehicle starts, long-haul truck hotelling, and off-network idling, and the interface has been improved to make the model easier to use. We have also updated MOVES for compatibility with newer software.

The structure of MOVES3 is fundamentally the same as MOVES2014, although there are new format options for some inputs, and the model run time may differ depending on the type of run and user inputs and computer configuration. Based on our testing, MOVES run time at the Default and County Scale should be about the same as runs with MOVES2014b. In addition, MOVES3 run time at the Project Scale may take notably longer compared to MOVES2014.

As for emissions, EPA performed a comparison of MOVES3 to MOVES2014b using default information in MOVES3 at the national level, and for two sample urban counties with different local travel patterns and ambient conditions. In general, compared to MOVES2014b, MOVES3 national emission estimates are slightly lower for most criteria pollutants in future years. However, in the two sample urban counties, NO<sub>x</sub> emissions estimates were higher in future years. This is due to higher running emissions from heavy-duty trucks outweighing declines from heavy-duty hotelling. Note that results for individual areas will vary based on the pollutant selected and that area's local inputs.

### **What needs to be done to switch to MOVES3?**

While earlier versions of MOVES required the user to manually install Java and MySQL before installing MOVES, MOVES3 improves this process by doing so automatically. MOVES3 relies on a newer version of Java and a different database server, MariaDB. The MOVES3 installer will automatically install all of the prerequisite software, including Java and MariaDB, along with the MOVES code and database. The installer includes a troubleshooting guide and quick start guide to using MariaDB.

Note that if MOVES3 is installed on a computer that also has MOVES2014, MOVES2014a, and/or MOVES2014b installed and configured to use MySQL, the setup wizard will offer to migrate all of the data in the old MySQL server to the new MariaDB server, as well as reconfiguring the older versions of MOVES to use MariaDB. Users are strongly encouraged to accept these default settings to avoid technical problems with installations. If MySQL is not used by other applications on the computer, it can be safely uninstalled after MOVES3 is installed.

When switching to MOVES3, new run specifications should be constructed using the improved MOVES3 Graphical User Interface. Additionally, EPA has updated the recommended tools for batch runs. For user input databases that still contain the latest data, MOVES3 contains a database conversion tool that may be used to help convert a MOVES2014 database to the MOVES3 format. The tool contains detailed instructions on performing this task.

### **How has EPA reviewed the new model?**

Technical reports that describe the new MOVES3 inputs and algorithms have been reviewed by independent experts under EPA's peer review policies and procedures. In addition, this work has been presented to the MOVES Review Work Group ([www.epa.gov/moves/moves-model-review-work-group](http://www.epa.gov/moves/moves-model-review-work-group)), which provides MOVES-related recommendations to EPA via the Mobile Source Technical Review Subcommittee (MSTRS) of the Clean Air Act Advisory Committee. Members of the work group represent a spectrum of stakeholders, including vehicle and engine manufacturers, fuel producers, state and local emission modelers, academic researchers, environmental advocates, and affected federal agencies. Finally, a draft version of MOVES3 was tested by a small group of

experienced MOVES users who alerted EPA to potential errors and provided comments on the new features including the updated interface and the new installer.

## **When should MOVES3 be used for state implementation plans (SIPs) and transportation conformity?**

EPA will be publishing a Federal Register notice to announce the availability of MOVES3 for official purposes. Details on when and how MOVES3 should be used for regulatory purposes are provided in EPA's *Policy Guidance on the Use of MOVES3 for State Implementation Plan Development, Transportation Conformity, General Conformity, and Other Purposes*, ([www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission](http://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission)) which EPA released with MOVES3. All states other than California should use MOVES3 for future SIPs to meet applicable requirements and to take full advantage of the improvements incorporated in this version.<sup>1</sup> However, state and local agencies that have already completed significant SIP work with MOVES2014, MOVES2014a or MOVES2014b may continue to rely on the earlier version of MOVES. In addition, EPA intends to include in the upcoming Federal Register notice a two-year grace period for using MOVES3 for regional transportation conformity purposes and a two-year grace period for project-level conformity purposes.

## **Is additional training required to use MOVES3?**

Users who are familiar with MOVES2014 will find MOVES3 easy to use, but we will offer a training webinar to demonstrate new features of the model and answer questions about changing from the old model to the new.

Modelers new to MOVES should review the MOVES2014 training materials available on the web since most of this information is still relevant. We will be updating this material soon.

When EPA schedules training, we update the MOVES training web site with the information about when and where and how to register and publicize this information via the MOVES listserv. Instructions on signing up for the listserv are available at [www.epa.gov/moves/forms/epa-mobile-news-listserv](http://www.epa.gov/moves/forms/epa-mobile-news-listserv).

## **What other resources are available for MOVES3?**

The MOVES web page ([www.epa.gov/moves](http://www.epa.gov/moves)) is the source for MOVES3 software as well as technical reports that document the data and algorithms used in MOVES, tools for use with MOVES, and information on MOVES training. In addition, EPA developed *MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity* to describe how to use MOVES for SIP development and regional transportation conformity analyses. This and other guidance documents can be found at: [www.epa.gov/state-and-local-transportation](http://www.epa.gov/state-and-local-transportation). Users can obtain technical support by emailing the EPA at [mobile@epa.gov](mailto:mobile@epa.gov); see MOVES3 guidance documents for additional EPA contact information.

Additionally, the EPA will offer a public webinar providing a general overview of MOVES3, and training materials as describe above.

---

<sup>1</sup> In California, a different onroad emissions model, EMFAC, is used for regulatory purposes instead of MOVES. MOVES can also model emissions in the District of Columbia, Puerto Rico, and the U.S. Virgin Islands.

## Appendix A: Major Updates in MOVES3

This table summarizes the major updates from MOVES2014b to MOVES3. Additional information is available in the MOVES3 Technical Reports.

Area	Description of Change
<b>Updates to Default Emission Rates, Fuels and Activity</b>	
LD PM rates	Included new data from GDI (Gasoline Direct Injection) vehicles, and updated PM temperature adjustments.
LD HC/CO/NOx rates	Updated LD running rates based on new Inspection and Maintenance (I/M) program, Portable Emission Measurement System (PEMS) and remote sensing data. Updated running and start rates. Reduced high-power emission rates.
LD Fuel consumptions and CO <sub>2</sub>	Increased fuel consumption and thus CO <sub>2</sub> to account for the Safer Affordable Fuel-Efficient (SAFE) rule.
LD start emission rates vs. parked time	Updated the relationship between starts and soak time based on data from EPA and the California Air Resources Board.
Fuel effects	Updated fuel effect calculations to better characterize the base fuel used to develop LD gasoline base emission rates
HD GHG Phase 2 standards	Incorporated the effects of the HD Phase 2 GHG rule.
HD diesel running rates	Updated with improvements to heavy-duty (HD) diesel running emission rates based on manufacturer in-use testing data from hundreds of HD trucks.
HD CNG and gasoline emission rates	Updated MY 2007+ CNG and 2008+ gasoline emission rates.
HD start emission rates	Updated MY 2010+ Diesel and MY2008+ gasoline starts based on compliance data. Updated relationship of starts vs. parking time.
HD extended idle rates	Updated HD diesel emission rates for extended idling and auxiliary power units.
Hotelling activity	Updated HD hotelling assumptions (extended idling for diesel long-haul combination trucks at truck stops) based on new information.
HD vehicle masses	Increased resolution in vehicle masses, using weigh-in-motion and other data.
Gliders	Accounted for gliders (new vehicles using older engines) in vehicle fleet.
HD Crankcase emissions	Updated rates for 2010+.
Improved speciation	Updated organic gas speciation profiles, including methane emissions.
LD and HD off-network idle time	Accounted for off-network and work-day idling (idling in parking lots, distribution centers, etc), based on detailed trip data for LD and HD vehicles.
LD and HD start activity	Updated start activity based on detailed trip data for LD and HD vehicles. Accounted for fewer starts by vehicle age.
Road type categories	Removed "ramps" as a separate road type. Ramp driving activity is now incorporated in rural and urban freeway driving.
LD and HD VMT and vehicle characteristics	Updated historic and projected VMT based on 2019 Highway Statistics and Annual Energy Outlook (AEO). Updated vehicle age distributions.
Fuel properties	Updated information on gasoline and diesel fuel properties based on fuel compliance data. These updates affect nonroad and onroad emissions.

## Appendix B: Changes to User Interface in MOVES3

The structure of MOVES3 is fundamentally the same as MOVES2014, although there are new format and other options. This table summarizes the changes in the MOVES graphical user interface (GUI), run specifications, input and output databases. For more information on how to use the new GUI changes for County Scale modeling, see EPA’s MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity, available at [www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission](http://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#emission). Additional information is also included in MOVES3 code documentation at [https://github.com/USEPA/EPA\\_MOVES\\_Model](https://github.com/USEPA/EPA_MOVES_Model).

	Description	Notes
<b>New Run Spec Requirements</b>		
	All roadtypes are required for onroad County Scale and Default Inputs (formerly “National Scale”) runs where the running process is selected	Needed to accurately estimate the emissions from off-network idle
<b>New Input Tables</b>		
	Start activity input tables have different names and structures	More details available in the County database (CDB) converter help file and the technical guidance
	Hotelling activity input tables have different names and structures	More details available in the CDB converter help file and the technical guidance
<b>Changed Definitions</b>		
	SourceTypeID 41, “Intercity Bus” is now called “Other Bus”	The previous definition only included diesel Class 8 buses on long distance routes. The new definition includes any kind of bus that is not owned or operated by a transit agency and is not a school bus.
	Changes to regulatory classes	RegClassID 40 & 41 were combined into RegClassID 41 that includes all ‘Class 2b and 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs)’; RegClassID 40 no longer exists; RegClassID 49 was added for “Glider Vehicles”
<b>New Capabilities and Output</b>		
	Off-network idle emissions	Running emissions on the “off-network” roadtype
	Ability to model calendar years up to 2060	MOVES2014 modelled only through 2050.
	Ability to model CNG vehicles for all heavy-duty source types.	MOVES2014 modelled only CNG transit buses. Users can now set CNG fractions for all HD source types using the Alternative Vehicle Fuels & Technologies (AVFT) importer.

<b>Changes in GUI</b>		
	Renamed "National Scale" as "Default Inputs"	Reflects that the distinction between Default and County Scales is based on the source of the inputs rather than the geographic area that can be modelled.
	Reorganized panels	To improve logical flow of activity and to better separate "typical" and "advanced" features
	Better keyboard-only navigation	To improve accessibility
<b>Software Changes</b>		
	MariaDB	MariaDB replaces MySQL as the database server for MOVES. MariaDB is a drop-in replacement for MySQL. The latest versions of MySQL have removed features that MOVES relies on, but MariaDB continues to support these features. It is also easier to install.
	JAVA	JAVA is embedded in MOVES3 so users will not need to install a separate version of JAVA on their computers.
<b>No Longer Available</b>		
	Custom Domain (an option within the County Scale) is no longer available	Users who have used custom domain to model partial counties or multiple counties will need to run at County Scale instead.
	Ramps are no longer a separate road type; their emissions are included in the restricted access road types	Ramps can still be modeled separately in the Project Scale.
	MOVES no longer accepts input of fuel with MTBE, TAME or ETBE content >0.	Use of these oxygenates in U.S. gasoline is now negligible.