

# Using MOVES for Estimating State and Local Inventories of Onroad Greenhouse Gas Emissions and Energy Consumption

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Transportation and Climate Division  
Office of Transportation and Air Quality  
U.S. Environmental Protection Agency

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## Section 1: Introduction

### 1.1 Purpose of this Guidance

Transportation sources emit greenhouse gases (GHGs) that contribute to climate change. The transportation sector is one of the largest sources of U.S. GHG emissions. In 2014, transportation represented approximately 26 percent of total U.S. GHG emissions. Between 1990 and 2014, GHG emissions in the transportation sector increased more in absolute terms than any other sector (i.e. electricity generation, industry, agriculture, residential, or commercial).<sup>1</sup> GHGs include carbon dioxide, methane, and nitrous oxide. In addition to GHGs, black carbon, a component of particulate matter and also emitted by transportation sources, has been linked to a range of climate impacts, including increased temperatures and accelerated snow melt.<sup>2</sup>

The onroad transportation sector's contribution to all of these pollutants can be modeled with the Environmental Protection Agency's (EPA) MOtor Vehicle Emissions Simulator (MOVES) model. This document provides guidance on how to use MOVES to estimate GHG emissions from onroad vehicles to create state or local inventories, or to estimate total energy consumption from onroad vehicles. EPA has updated the previous November 2012 guidance<sup>3</sup> to reflect the latest MOVES model, and today's guidance replaces and supersedes the previous guidance. Note, this guidance does not create a federal GHG analysis requirement but provides recommendations for using MOVES to conduct such an analysis, either voluntarily or as a result of a state or local requirement.

This guidance describes approaches for developing an onroad GHG inventory in different geographic areas and the implications of each of these approaches.<sup>4</sup> It discusses the data input options that are most important for estimating onroad GHG emissions and explores which inputs should be populated with locally-derived data, versus data from the MOVES default database, to improve the quality of the results. This guidance should help users develop an approach for using MOVES to estimate GHG emissions or energy consumption with the time and data resources available.

This guidance covers the use of MOVES for estimating onroad GHG emissions and energy consumption only; it should not be followed when using MOVES to develop criteria pollutant inventories for state implementation plan (SIP) or conformity purposes. EPA has guidance for using MOVES for SIP and conformity purposes; see Section 1.7 for information about other MOVES guidance and information.

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<sup>1</sup> EPA, "Fast Facts U.S. Transportation Sector Greenhouse Gas Emissions 1990-2014," EPA Office of Transportation and Air Quality, EPA-420-F-16-020, June 2016, available on the web at: [www.epa.gov/sites/production/files/2016-06/documents/420f16020.pdf](http://www.epa.gov/sites/production/files/2016-06/documents/420f16020.pdf)

<sup>2</sup> More information can be found in EPA's "Report to Congress on Black Carbon," March 2012, EPA-450/R-12-001, available on EPA's webpage at: [www.epa.gov/blackcarbon/](http://www.epa.gov/blackcarbon/).

<sup>3</sup> EPA, "Using MOVES for Estimating State and Local Inventories of On-Road Greenhouse Gas Emissions and Energy Consumption," EPA-420-B-12-068, November 2012.

<sup>4</sup>In GHG emissions literature, often a distinction is made between an "inventory," which is for a year in the past, and a "forecast," which is for a year in the future. The term "inventory" in this and other MOVES guidance refers to total emissions in a geographic area regardless of whether the year modeled is past or future.

While MOVES2014 incorporates EPA's nonroad emissions model, this guidance does not cover estimating nonroad GHG emissions or energy consumption. This guidance also does not include estimating onroad GHG at the Project Scale, which is used to model an individual transportation project such as a highway, intersection, or transit project. While not covered in this document, MOVES is EPA's best tool for project-level GHG analyses, and EPA may offer such guidance in the future, particularly if there is interest from the user community.<sup>5</sup>

EPA coordinated with the Department of Transportation during the development of this guidance.

## **1.2 Introduction to MOVES**

MOVES is a state-of-the-science model for estimating air pollution emissions from mobile sources under a wide range of user-defined conditions. MOVES incorporates analysis of millions of emission test results and considerable advances in the EPA's understanding of vehicle emissions. MOVES can estimate emissions from running and evaporative processes as well as brake and tire wear emissions for all types of onroad vehicles across multiple geographic scales for any part of the country, except California. MOVES is EPA's best tool for estimating GHG emissions from onroad mobile sources.

The latest version of MOVES that is available at the date of this guidance is MOVES2014a, available for download on the EPA's MOVES website.<sup>6</sup> MOVES2014 is a major revision to EPA's mobile source emission model and replaces MOVES2010 and its minor revisions (MOVES2010a and MOVES2010b). MOVES2014 (and its minor revisions such as MOVES2014a) allows users to benefit from new regulations promulgated since the release of MOVES2010b, incorporates new and up-to-date emissions data, and has improved functionality compared to MOVES2010b. MOVES2014 and MOVES2014a also have added the capability to model nonroad mobile sources by incorporating EPA's NONROAD2008 model. For an overview of the improvements in MOVES2014 and MOVES2014a, refer to EPA's factsheets, "MOVES2014 Questions and Answers," and "MOVES2014a Questions and Answers," found at EPA's MOVES website.

This guidance reflects MOVES2014 and MOVES2014a, and hereafter refers to "MOVES" to mean either of these two versions unless otherwise noted. EPA will be updating the MOVES model over time to account for revisions to GHG emissions and fuel economy standards as well as other new information. EPA will revise this guidance as needed to reflect future versions of MOVES.

Many state and local air quality agencies may already be familiar with MOVES, as it is currently used across the country, except in California, to develop onroad emission inventories of

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<sup>5</sup> MOVES users interested in estimating GHG emissions at the Project Scale could do so; this guidance and EPA's project-level MOVES CO guidance could be helpful (see Section 1.6).

<sup>6</sup> [www.epa.gov/otaq/models/moves/index.htm](http://www.epa.gov/otaq/models/moves/index.htm)

transportation-related criteria pollutants and their precursors.<sup>7</sup> These criteria pollutant inventories are needed either for state air quality plans (state implementation plans, or SIPs) or transportation conformity determinations, and existing EPA guidance describes how and when to use MOVES for these regulatory purposes.<sup>8</sup>

### **1.3 Latest Version of MOVES**

Users should use the latest version of MOVES for conducting a new GHG or energy analysis. Using MOVES2014a to estimate GHG emissions or energy consumption should allow users to take full advantage of recent improvements. MOVES2014a is the latest version of MOVES that has been released, and it accounts for all national fuel economy and GHG standards for cars and trucks as of October 2015, including heavy-duty vehicle GHG regulations that phase in during model years 2014-2018 and the second phase of light-duty vehicle GHG regulations that phase in for model years 2017-2025.

### **1.4 Types of GHG and Energy Analyses in MOVES**

MOVES can estimate GHG emissions and energy consumption at a variety of geographic scales – national, county, and project - for various time spans.<sup>9</sup> The national and county scales can be used to produce inventories for the nation as a whole, an individual county or state, and multi-state, multi-county, and metropolitan regions. MOVES can create an annual GHG emissions inventory for the year 1990 and any calendar year from 1999 through 2050. MOVES can also calculate daily inventories, but this guidance does not specifically address daily inventories. (The MOVES User Guide and Technical Guidance explain how to specify different time periods for analysis.)

MOVES can also be used for scenario planning and policy efficacy analysis in the area being modeled, be it a state, a region, or a county or a portion of a county. For example, with user-supplied information on travel activity, such as vehicle miles traveled (VMT) and speeds, MOVES can perform scenario analyses to assess the GHG and energy use impacts of various travel efficiency strategies, such as:

- Region-wide travel demand management e.g., rideshare programs, employer-based programs;

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<sup>7</sup> Onroad emissions include those emissions that result from the operation of on-highway vehicles such as passenger cars and trucks, commercial trucks, buses, motorcycles, and motorhomes. MOVES does not include “upstream” emissions, i.e., those emissions that come from the production and distribution of fuel, or nonroad vehicles such as construction equipment, agricultural equipment, or recreational off-road vehicles. For more information about the difference between onroad and nonroad sources, please refer to EPA’s website at:

[www.epa.gov/otaq/inventory/overview/examples.htm](http://www.epa.gov/otaq/inventory/overview/examples.htm). Transportation-related criteria pollutants are carbon monoxide (CO), ozone, nitrogen dioxide (NO<sub>2</sub>), and particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>).

<sup>8</sup> Refer to EPA’s website at [www.epa.gov/otaq/stateresources/transconf/policy.htm#models](http://www.epa.gov/otaq/stateresources/transconf/policy.htm#models) for the latest versions of EPA’s policy and technical guidance for using MOVES for SIP and conformity purposes.

<sup>9</sup> As noted earlier, this guidance does not cover using MOVES at the project scale to estimate GHG or energy consumption for an individual project, but it is possible for users to do so.

- Land use and smart growth strategies, e.g., transit-oriented development policies, policies to increase diversity and density of land uses;
- Transit-promoting programs, such as increased transit frequency or lower fares; and
- Pricing strategies, such as parking pricing or mileage fees.<sup>10</sup>

In addition, MOVES can be used to evaluate GHG or energy impacts of other types of strategies, such as those that affect vehicle and fuel technologies or that are designed to change the composition of the vehicle fleet. MOVES captures the effects of fleet turnover and the change in vehicle emissions and fuels over time. MOVES includes vehicle and fuel technologies that are currently in widespread use. Since MOVES emissions estimates depend on vehicle types, vehicle ages, vehicle activity (including speeds and operating modes), road types, and fuel types, MOVES can answer the question of how emissions would change in the future under various scenarios that affect any of these inputs. MOVES can estimate the effects of individual control measures and emission reduction strategies, or combinations of them, in any future year up to 2050.

In some cases MPOs and state DOTs are already using MOVES or will need to for analyzing criteria pollutants and precursors for SIP or conformity purposes. In these areas, it may be efficient for modelers to include GHG emissions and black carbon when running MOVES for these other purposes.

## **1.5 New MOVES Users**

EPA encourages using MOVES to estimate onroad GHG emissions or energy consumption regardless of the user's experience level. Though MOVES is a sophisticated model, EPA provides extensive documentation on how to use the model to help familiarize the user to the MOVES graphical user interface and MOVES data inputs. See the MOVES website for the MOVES User Guide and other relevant documents.

EPA also offers free classes on using MOVES; see the MOVES website for course material and details about course offerings. Between course offerings, users can download the course material and follow it on their own. The course material is also available from the MOVES website.

## **1.6 Other MOVES Resources**

EPA provides extensive resources and documentation for using the MOVES model to perform various types of analyses. The following EPA websites may be relevant to estimate onroad GHG emissions or energy consumption:

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<sup>10</sup> For more information about travel efficiency strategies and estimating emission reductions from them, please see the EPA's web page at [www.epa.gov/otaq/stateresources/ghgtravel.htm](http://www.epa.gov/otaq/stateresources/ghgtravel.htm), which includes links to the following documents: "Potential Changes in Emissions Due to Improvements in Travel Efficiency – Final Report," EPA-420-R-11-003, March 2011, available on the web at: [www.epa.gov/otaq/stateresources/policy/420r11003.pdf](http://www.epa.gov/otaq/stateresources/policy/420r11003.pdf), and "Transportation Control Measures: An Information Document for Developing and Implementing Emission Reduction Programs," EPA-430-R-09-040, March 2011, available on the web at: [www.epa.gov/otaq/stateresources/policy/430r09040.pdf](http://www.epa.gov/otaq/stateresources/policy/430r09040.pdf).



## MOVES (MOtor Vehicle Emission Simulator) website

Address: [www.epa.gov/otaq/models/moves/](http://www.epa.gov/otaq/models/moves/)

This website contains general information about the MOVES model including links to download the most recent version of the model. This site also hosts EPA guidance and documentation related to MOVES such as the MOVES User Guide and technical and policy guidance on using MOVES for SIPs and transportation conformity determinations.<sup>11</sup>

## Transportation Conformity Policy and Technical Guidance

Address: [www.epa.gov/otaq/stateresources/transconf/policy.htm](http://www.epa.gov/otaq/stateresources/transconf/policy.htm).

This website contains links to SIP and conformity guidance documents as well as transportation conformity guidance for using MOVES at the project level for PM hot-spot analyses and CO hot-spot analyses.<sup>12</sup> Users should review relevant links under the “Project-Level Conformity” and “Emission Models and Conformity” headings on this page.

## Estimating Onroad Greenhouse Gas Emissions

Address: [www.epa.gov/otaq/stateresources/ghgtravel.htm](http://www.epa.gov/otaq/stateresources/ghgtravel.htm).

This website contains additional resources for state and local planners interested in estimating GHG emissions from the onroad transportation sector and assessing the impact of specific travel efficiency strategies.

EPA will continue to update MOVES in the future, and will provide additional documentation and supplementary guidance as needed. EPA encourages MOVES users to check the MOVES website regularly and subscribe to EPA’s mobile source emissions model listserv (subscription information on the MOVES website) to find information about updates to MOVES and guidance for its use.

## **1.7 Contact Information**

General, technical, or policy questions related to this guidance or about using MOVES for estimating GHG emissions should be sent to [mobile@epa.gov](mailto:mobile@epa.gov). For questions regarding the application of this guidance to specific locations, please contact the mobile source expert at the

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<sup>11</sup>These documents include “MOVES2014 and 2014a Technical Guidance: Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity,” EPA-420-B-15-093, November 2015, and “Policy Guidance on the Use of MOVES2014 and Subsequent Minor Revisions for State Implementation Plan Development, Transportation Conformity, and Other Purposes,” EPA-420-B-14-008, July 2014.

<sup>12</sup> These documents include “Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas,” EPA420-B-15-084, November 2015, and “Using MOVES2014 in Project-Level Carbon Monoxide Analyses,” EPA420-B-15-028, March 2015.

appropriate EPA Regional Office. Contact information can be found at [www.epa.gov/otaq/stateresources/transconf/contacts.htm](http://www.epa.gov/otaq/stateresources/transconf/contacts.htm).<sup>13</sup>

### **1.8 Does this document create any new requirements?**

This document does not create any new requirements. There is no federal requirement to estimate onroad GHG emissions or energy consumption. This document does not impose legally binding requirements on EPA, DOT, states, or the regulated community, and may not apply to a particular situation based upon the circumstances. This document may be revised periodically without public notice.

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<sup>13</sup> This website provides a list of EPA Regional transportation conformity contacts who are familiar with MOVES. The use of MOVES for onroad GHG inventories is not subject to conformity, but since MOVES is used for both of these purposes, the EPA Regional transportation conformity contact is a good place to start if you have questions. Please be sure to indicate your question is related to GHG emissions rather than criteria pollutant emissions.

## Section 2: Modeling Approaches

### 2.1 Introduction

There are multiple ways to use MOVES to develop emissions and energy consumption estimates, however, different approaches affect the precision of the analysis. Section 2 explores the approaches a modeler could choose to develop an annual onroad GHG inventory or estimate of onroad energy consumption using MOVES, including selections for:

- Calculation type: using an emissions inventory or emission rates;
- Domain/Scale: Using County or National scale; each of which provides options for modeling the particular geographic area of interest; and
- Time Span: Options for level of time aggregation and modeling the particular time period of interest.

Note: When comparing GHG emissions between two cases, such as in two different years, or with and without a particular transportation strategy, EPA recommends using the same selections for calculation type, scale, geographic area, and time period between model runs.

### 2.2 Calculation Type Options

MOVES has two calculation types - Inventory or Emissions Rates. Either may be used to develop emissions estimates for GHGs or energy consumption.<sup>14</sup> However, each calculation type requires different inputs as noted in the descriptions below and later within the guidance text.

- Inventory: users input VMT and vehicle population data into MOVES and the model calculates an output inventory of total emissions in units of mass. Using the Inventory approach is the simpler method to generate a GHG emissions inventory and may be preferable when the user wants to minimize post-processing MOVES outputs thus avoiding inadvertent errors during post-processing.
- Emissions Rates: VMT and vehicle population must be manually applied to a MOVES generated emission rates output table to calculate an inventory (although VMT and vehicle population data are still needed as inputs for an Emission Rates MOVES run). Output data include emissions per unit of distance for running emissions, emissions per vehicle or per start for start emissions, and emissions per vehicle or per idle hour for hotelling emissions. (GHG emissions are not produced from evaporative processes, therefore for a GHG inventory users would not need to generate “emissions per profile” rates.) The Emission Rates method may be preferable when the user wants to apply emission rates to multiple geographic locations, or to use rates in conjunction with travel model post-processing software already developed to calculate total emissions of other pollutants.

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<sup>14</sup> Section 3.2.2 includes a discussion of the equivalency of the Inventory and Emission Rates options in calculating emissions.

## 2.3 Domain/Scale

MOVES allows users to analyze mobile emissions at various scales: National, County, and Project.

- The National scale can be used to model the entire nation, one or more states, or one or more counties. The National scale largely relies on MOVES default data to perform inventory calculations.
- The County scale can be used to model a single county or multi-county area. Calculations at the county scale rely heavily on user supplied data.
- The Project scale can be used to model an individual transportation project such as a highway, intersection, or transit project.

While the County scale is necessary to meet statutory and regulatory requirements for SIPs and transportation conformity, either the County or National scale can be used for GHG inventories. This guidance covers both of these scales with an emphasis on the County scale. This document does not contain guidance for use of the Project scale for estimating onroad GHG emissions or energy consumption.<sup>15</sup> However, MOVES is EPA's best tool for project-level GHG analyses, and EPA may offer such guidance in the future, particularly if there is interest from the user community.

### 2.3.1 County Scale

The County scale can be used to create onroad GHG inventories for an individual or multi-county area, a metropolitan area, a region of a state, an entire state, or a multi-state area or region. EPA recommends using the County scale for GHG or energy consumption analysis. The County scale allows the user to enter county-specific data through the County Data Manager (covered in Section 4). As indicated earlier, providing local data significantly improves the precision of the modeling results. In addition, the County scale is appropriate for creating an onroad GHG inventory that will be combined with or compared to GHG inventories for other sectors, such as industrial, commercial, and residential. The County scale is also appropriate when estimating differences that depend on detailed local data, such as comparing GHG emissions from various transportation planning alternatives in a metropolitan area. MOVES provides modelers with various options for analyzing emissions using the County scale, as described below. Some combinations may be more convenient than others depending on the number of counties to be modeled.

Users have two options for defining the Geographic Bounds when using the County scale: County or "Custom Domain" (described in Section 3.4 of this document). Selecting County allows the user to select a county from a pull-down list, however, this method is for modeling a single county. Users have two methods for modeling a multi-county area. One method is to select the County option and run MOVES multiple times, once for each county. This method allows users to easily access some of the MOVES default database inputs for individual counties, if appropriate, as described in Section 4 of this document. Each run where County is chosen will produce output for the county selected.

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<sup>15</sup> MOVES users interested in estimating GHG emissions at the Project Scale could do so; this guidance and EPA's project-level MOVES CO guidance could be helpful (see Section 1.6).

The second option for a multi-county area is to select Custom Domain as the region within the County Scale. This allows users to define a geographic area that may consist of multiple counties, parts of counties, or combinations of counties and partial counties described using a single set of inputs. MOVES2014 provides additional flexibility when using Custom Domain: users can vary vehicle activity and generate output by zone within a Custom Domain. Zones can be the individual counties within the Custom Domain. Vehicle age distribution, fuel inputs, and Inspection/Maintenance (I/M) program must be the same throughout the Custom Domain, but the user can vary meteorology inputs by zone and allocate vehicle activity among the zones. Total activity in terms of VMT and population is provided for the entire area, and MOVES allocates these data to the zones based on factors the user inputs. The advantage is that the user can model a multi-county area and generate output for each county (or zone) with a single run.

When Custom Domain is selected, users do not have direct access to county-specific information in the MOVES database, but modelers can obtain this information with some extra steps. Section 3.4 provides further information on County and Custom Domain, including how activity can be allocated by zone in MOVES2014a.

In summary, there are multiple approaches to create an onroad GHG inventory for an area made up of more than one county, such as a metropolitan area or an entire state. For example:

- Each county could be modeled individually, either with “Inventory” or with “Emission Rates,” depending on the user’s preference.
- The user could define the modeling area as one or more “Custom Domains.” One “Custom Domain” might be appropriate for a metropolitan area; more than one may be needed to represent an entire state. MOVES2014a allows the user to vary activity by county and generate output by county (or zone).
- Another option a modeler could use would be to model one county as a representative county with “Emission Rates” to generate emission rates at various temperatures. These emission rates could then be applied to a larger area, as long as fuel used in the larger area is the same as that modeled for the representative county. If methane emissions are modeled, the Inspection/Maintenance (I/M) program in the larger area also must be the same as that modeled for the representative county.

Table 2-1 summarizes the combinations of calculation type and geographic area definition that users can employ for creating GHG emissions inventories using the County scale. Any of the combinations will produce accurate results when executed correctly. The number of counties included in the area to be modeled and whether results for each individual county are needed are key considerations in choosing an approach.

**Table 2-1: Summary of Modeling Approaches Using the County Scale**

<b>Geographic Area to Be Modeled</b>	<b>Approach</b>	<b>Advantages</b>	<b>Considerations</b>
<b>One county, using County option</b>	Use Inventory	<ul style="list-style-type: none"> <li>• Shorter run time and smaller output files</li> </ul>	
	Use Emission Rates	<ul style="list-style-type: none"> <li>• Rates can be applied on a link basis if desired</li> </ul>	<ul style="list-style-type: none"> <li>• Longer run time, larger output files</li> <li>• Running, start, and hotelling rates must be post-processed to create GHG inventory</li> </ul>
<b>Multi-county area or an entire state using County option</b>	Use Inventory and County to model each county separately	<ul style="list-style-type: none"> <li>• Automatic access to MOVES default database</li> <li>• Produces results for each county</li> </ul>	<ul style="list-style-type: none"> <li>• An individual run is needed for each county, so this strategy is more feasible if the number of counties is small</li> </ul>
	Use Emission Rates and County to model a representative county (or counties), and create inventories from rates with activity data for each county	<ul style="list-style-type: none"> <li>• Only one run per representative county is necessary</li> <li>• Allows user to generate results for each county</li> <li>• Automatic access to MOVES default database</li> <li>• Rates can be applied on a link basis if desired</li> <li>• Better able to model an area when vehicle characterization (age distribution, fuel type, I/M) are uniform in the area, but temperatures vary widely</li> </ul>	<ul style="list-style-type: none"> <li>• Emission rates from the representative county can be used for other counties only if they have the same fuels, and if methane emissions are being modeled, the same I/M program as the representative county (i.e., a separate run is needed for each combination of fuel type and I/M program present in the area). See Sections 4.11 and 4.12 (Fuel and I/M Programs) for more information.</li> <li>• Running, start, and hotelling rates must be post-processed to create GHG inventory</li> </ul>
<b>Multi-county area or an entire state using Custom Domain</b>	Use Inventory and Custom Domain to model the entire area	<ul style="list-style-type: none"> <li>• Only one run per Custom Domain is necessary</li> <li>• Some vehicle activity can be varied by county within the Custom Domain and output can be generated by county</li> </ul>	<ul style="list-style-type: none"> <li>• No automatic access to MOVES default database</li> <li>• The same vehicle age distribution, fuels, I/M program, and temperature profile must apply throughout the area of the custom domain</li> </ul>
	Use Emission Rates and Custom Domain to model the entire area, and create inventories from rates with activity data for each county	<ul style="list-style-type: none"> <li>• Only one run per Custom Domain is necessary</li> <li>• Allows user to generate an inventory for each county, by taking the MOVES output of emission</li> </ul>	<ul style="list-style-type: none"> <li>• No automatic access to MOVES default database</li> <li>• The vehicle age distribution, same fuels and if methane emissions are modeled, same I/M program must apply throughout the area of the custom domain</li> </ul>

		<p>rates and multiplying them by activity data from each county</p> <ul style="list-style-type: none"> <li>• Rates can be applied on a link basis if desired</li> </ul>	<ul style="list-style-type: none"> <li>• Running, start, and hotelling rates must be post-processed to create GHG inventory</li> </ul>
<p><b>Multi-county area or an entire state, or a multi-state region with rates by temperature<sup>16</sup></b></p>	<p>Use Emission Rates and County to model a representative county; model each hour as a separate temperature to get emission rates for each temperature; then create inventories from rates at the appropriate temperature with activity data for each county</p>	<ul style="list-style-type: none"> <li>• Allows user to generate results for each county</li> <li>• Automatic access to MOVES default database</li> </ul>	<ul style="list-style-type: none"> <li>• For a multi-state area, several representative counties will need to be run to capture the combinations of fuels and I/M programs that exist</li> <li>• Running, start, and hotelling rates must be post-processed to create GHG inventory</li> <li>• Users will need to use care to ensure appropriate rates are used for each county</li> </ul>

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<sup>16</sup> See Section 4.2.1 of this guidance and the MOVES User Guide, Appendix A (Using MOVES to Generate Lookup Tables) for more information.

### 2.3.2 National Scale

MOVES may be used at the National scale for GHG analysis, however, users should understand the tradeoffs of estimates based on the National scale. The National scale is simple and convenient for GHG analyses. The National scale allows the user to model the entire nation or any smaller geographic region. Similarly, this scale allows the user to simultaneously model more than one geographic region (i.e. multiple counties or multiple states). The National scale also allows the user to model more than one year in one model run. However, this convenience comes at the cost of significantly reduced precision of local analysis. A National scale analysis relies entirely on MOVES default data for data inputs, (unless the user enters data via the Data Importer, which is similar in structure to the County Data Manager and serves a comparable function at the National scale). Default data are typically not the most current or best available information for any specific county. Users should use caution when considering the results from a MOVES run at the National scale for GHG analysis.

When the National scale is used to model counties or states, the default database information is applied to the area being modeled in different ways, which affects how well the information represents the geographic area chosen. For some data fields, the national average data, such as vehicle age distributions and speed distributions, are used for the area as-is, meaning that MOVES will use the national average for any county or state selected. However, in the real world, vehicle age distribution and speed distribution vary across the United States. For VMT and vehicle population (“source type population”), the national data are “scaled down” to the area using allocation factors within the model.<sup>17</sup> For fuel and I/M program inputs, the national default database includes survey data collected during model development that varies by county for fuel and I/M program type. The model will use the information it has for the specific county.

As stated, EPA encourages users to input local VMT and vehicle population data when using MOVES to develop more accurate onroad GHG inventories. EPA expects that users will always have more precise local VMT information than the National scale default VMT for the area. However, users cannot enter local data for either VMT or vehicle population via the Data Importer, because the model will treat this information as if it applies to the nation as a whole, producing erroneous results. EPA has developed a method to incorporate local VMT data when using the National scale, described in Appendix A. This method should improve the GHG estimates obtained compared to not including local VMT.

There is no analogous method for inputting vehicle population data when using the National scale. Users should expect their results to be less precise using the National scale, even when supplying local VMT data. If the user has local information for vehicle population, EPA recommends the use of the County scale instead of the National scale so that this important information can be included. Alternatively, users can perform an Emission Rates run MOVES at the National scale and apply local VMT and vehicle populations outside of the model using the approach described in Section 2.4 for the County scale.

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<sup>17</sup> The most recent national default VMT data included in MOVES2014a are for the year 2011. When a future year is modeled using the National scale, MOVES applies an annual growth rate to the 2011 national VMT for the appropriate number of years. A portion of this scaled-up VMT is then allocated to the geographic area of interest.



Although the National scale allows the user to model multiple years and multiple counties or states, the user can only enter more a single set of data through the Data Importer. If the analysis is for more than one year and local data are entered, it will apply to all analysis years. If users have information that varies by analysis years, again, EPA recommends using the County scale. For example, if the user is modeling two states and has information about each state's vehicle age distribution or speed distribution, both sets of information could not be entered for the run. In this case, the user should use the County scale, and include the information unique to each state via the County Data Manager (see Section 2.4 for various approaches).

There may be instances when GHG estimates using the National scale will be sufficient for a user's purpose. For example, because the user does not have to input local data, the National scale may help new users become familiar with the model. The National scale may be sufficient for users in areas that are not already using MOVES for other purposes. In addition, the National scale may be helpful for a screening analysis designed to inform more detailed subsequent analyses, or for some types of comparative GHG analyses, where the relative difference in emissions between different scenarios is more important than the precision of the absolute level of emissions. Examples of comparative analyses could include developing simple projections of GHG emissions trends over time or over different speeds, or comparing GHG emissions rates of different vehicle types (e.g., passenger cars versus passenger trucks) or different road types. If a statewide inventory is needed, the user may want to use the County scale for each county for which the user has local data, and the National scale for the rest of the counties in the state, with local VMT information applied for those counties as described in Appendix A.

In summary, the National scale with MOVES default database information produces a less precise estimate of onroad GHG emissions. Including local VMT information will improve the precision of this estimate. If in addition to VMT, the user has other local data, or the user has data that varies by analysis year, users are encouraged to run MOVES at the County scale instead of the National scale.

## **2.4 Time Spans**

MOVES can use a range of time periods to calculate an annual onroad GHG inventory. For example, MOVES can generate an annual GHG inventory by estimating hourly emissions individually and summing them to produce the year's emissions. In MOVES, this is referred to as "pre-aggregating" data over time to estimate emissions. The main reason for pre-aggregating hourly data over a longer time period such as "Year," "Month," or "Day," instead of "Hour" is to reduce model run time. Generally, pre-aggregation reduces model run time while also reducing precision. For more details, see the MOVES2014 User Guide.<sup>18</sup>

Pre-aggregation over a specified time period computes a weighted average of some data otherwise differentiated by a smaller unit of time, such as VMT distributions and temperature, prior to the execution of the run. For example, if the user chooses Month, the model will average

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<sup>18</sup> The latest version of the User Guide can be found at: [www.epa.gov/otaq/models/moves/documents/](http://www.epa.gov/otaq/models/moves/documents/)

the temperature of all selected days and hours into an average Month set, and perform the simulation with these average values for the selected month or months.

Pre-aggregation affects the various input data differently. Pre-aggregation accounts for hourly variations in travel activity data because the model weights each hour's activity when it averages over the time period. However, temperature effects are non-linear, therefore, pre-aggregation does not account as well for variations in temperatures, and some information about peak emissions at high and low temperatures will be lost. Runs using average temperatures typically produce lower emissions than runs that account for all the high and low temperatures.

EPA's general recommendation is for users to consider the purpose of the analysis and how the results will be used when deciding whether to pre-aggregate and over what time period. Users will want to consider how much variation exists in their input data, how sensitive MOVES is to those inputs, and whether any control strategies being considered will affect those inputs. For example, temperature and humidity vary over the course of a day and year, yet this variation may not be of concern for a particular run. At very low temperatures, elemental carbon emissions will be greater for light-duty gasoline vehicles, but this effect would be irrelevant if only CO<sub>2</sub> is being modeled. At high temperatures, air conditioner use, estimated by the model as a function of temperature and humidity, affects fuel economy and will increase CO<sub>2</sub> emissions, but this effect may be less of a concern in northern states.

Users should strongly consider how pre-aggregating their runs will produce output that meets their needs for precision. There may be applications where precision is not as important as the general trends over time or differences between scenarios where pre-aggregation may make sense. There may also be some analyses, such as comparing an onroad GHG inventory to a GHG inventory for other source sectors, where precision is more important. Users may want to do a simple sensitivity analysis to determine whether the range of temperatures that occur in the area being modeled has a significant impact on their GHG emissions inventory.

Specific recommendations:

- If temperatures matter for a GHG inventory, EPA recommends using the default selection of Hour for the time aggregation level on the Time Spans Panel instead of pre-aggregating over a day, month, or year. EPA recommends that users model all 24 hours in a single run to reduce the post-processing steps needed. (There is no substantial advantage to running only some and not all hours. If users do not have unique data inputs for all 24 hours of the day, users should apply the data for the hours they do have to the 24 hours of the day as appropriate. Sections 3 and 4 provide further information.) In addition to choosing all 24 hours, EPA recommends using a set of 12 average temperature and humidity profiles, each one representing a month of the year. Results will need to be aggregated appropriately (i.e., the 24-hour total emissions in each month need to be multiplied by the number of days in that month, and these 12 monthly totals summed together) to represent emissions over the entire year.
- Where temperature variations are less important in the GHG analysis, users could save time when using Inventory mode by pre-aggregating by day, month, or year, depending on the level of detail desired in the output. Pre-aggregated MOVES runs may also be

useful for purposes such as approximate comparisons of GHG emissions between two different years, even if they are not accurate enough for assessing the effects of various programs or control strategies. Before using pre-aggregated MOVES output for a GHG inventory, users may want to compare results with different levels of aggregation to determine how much these differences matter based on local inputs.

- When using Emission Rates instead of Inventory, the time aggregation level is automatically set to Hour and no other selections are available. Pre-aggregating time does not make sense when using Emission Rates and would produce emission rates that are not meaningful. All running and start emission rates vary with temperature, and start emission rates also vary by time of day because vehicle activity differs throughout the day. For example, the temperature may be the same at 8 am and 8 pm, but there are more starts at 8 am, and a higher fraction of those are cold starts. Thus start emission rates at 8 am will be considerably higher than at 8 pm. This variation in emission rates in different hours would be lost if the Time Aggregation Level was anything other than Hour.

## Section 3: Creating a Run Specification (RunSpec) File

### 3.1 Creating a Run Specification (RunSpec) File

The MOVES Run Specification (RunSpec) defines the geography and time period of the analysis as well as the vehicle types, road types, fuel types, and the emission-producing processes and pollutants that will be included in the analysis. The RunSpec is a computer file in XML format that can be edited and executed directly, or accessed, changed, and run through the MOVES graphical user interface (GUI).

Setting up a RunSpec involves accessing the Navigation Panel in the MOVES GUI. The Navigation Panel consists of a series of other panels and tabs that describe the input options to create the RunSpec. For a GHG inventory, the user would progress through the Navigation Panel and make the appropriate selections or enter the appropriate data in each one of the following panels:

- Description
- Scale and Calculation Type (Inventory or Emission Rates)
- Time Spans
- Geographic Bounds
- Vehicles/Equipment
- Road Type
- Pollutants and Processes
- Manage Input Data Sets
- Strategies
- Output
- Advanced Performance Features

Each panel is described below. Note that selections made in some panels affect available options in other panels. While MOVES allows the user to complete these panels in any order, we recommend completing them in the order they appear in the Navigation Panel.

The information below applies for all GHG and energy consumption analyses unless otherwise indicated (e.g., there are some differences between the County and National scales). Additional guidance for developing a National Scale RunSpec is found in Appendix A, which describes how to include local VMT information when using the National scale.

#### 3.1.1 Description

The Description Panel allows the user to enter a description of the RunSpec using up to 5,000 characters of text.<sup>19</sup> Entering a complete description of the RunSpec will help users keep track of their MOVES runs. Users may want to identify key aspects to help identify the run later, such as the GHG emissions, geographic area, and time period modeled.

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<sup>19</sup> Due to restrictions in MySQL software, no quotation marks, ampersands, or backslashes are allowed.

## **3.2 Selecting Scale and Calculation Type**

Selecting Scale on the Navigation Panel accesses the Model, Domain/Scale, and Calculation Type Panel. MOVES allows users to choose either onroad or nonroad emissions. Either the National or County scale can be used for estimating onroad GHG emissions for a county, a metropolitan area, a region of a state, or an entire state; Section 2 contains a discussion of the two scales. In addition, MOVES provides two options for calculation type: Inventory or Emission Rates. Either option can be used, depending on the user's preference and purpose, as described in Section 2.

This guidance provides additional detail where necessary to indicate the differences that result from selecting the Inventory versus the Emission Rates option.

### **3.2.1 Model**

Unlike previous versions of MOVES, MOVES2014 and MOVES2014a include the capability of estimating emissions of nonroad equipment and engines. Within MOVES2014 and MOVES2014a, the onroad and nonroad capabilities exist as separate modules, and users must select one or the other. For this first implementation of nonroad capabilities, MOVES2014 simply adds existing NONROAD2008 code into the MOVES GUI and database structure. MOVES2014a adds new VOC and air toxics options to MOVES and updates the default nonroad fuels database. Future versions of MOVES will update the underlying nonroad code and data and more fully integrate the onroad and nonroad capabilities of MOVES. Until then, this guidance only covers the onroad capabilities of MOVES.

### **3.2.2 Domain/Scale**

Each scale option in MOVES has an intended purpose and the amount of data that the user must supply varies depending on the selection:

- National scale can be used to estimate emissions for the entire country, for a state, for a group of counties, or for individual counties. At the National scale, MOVES uses information in its default database to calculate emissions for the geographic area chosen. The default data used for a county or state is based on a mix of national data, allocation factors, and pre-loaded local data. In general, EPA cannot certify that the default data in the national database is the most current or best available information for any specific county. Users can also input local data using the Data Importer, if desired; see Section 4.2 for more information about the Data Importer.
- County scale requires the user to enter data to characterize local meteorology, fleet, and activity information through the County Data Manager. The County Data Manager facilitates the input of local data and also allows the user to review county data included in the MOVES default database. The County scale will generally give more precise GHG estimates compared to the National scale. See Section 2 for more information about choosing between the National and County scale. Section 2.4 describes possible approaches for creating inventories for geographic areas comprised of multiple counties. Detailed guidance on specific inputs in the County Data Manager, including the use of default inputs, is given in Section 4 of this guidance.

- Project scale allows analysis of emissions on individual roadway links or locations where emissions from vehicles starts or hotelling activity occur. The Project scale could be used to examine GHG emissions from a specific travel facility, or to examine GHG impacts of changes that affect travel (number of trips or driving behavior) on a specific facility. This document does not cover the use of the Project scale for estimating onroad GHG emissions. EPA may offer such guidance in the future, particularly if there is interest from the user community. In the meantime, EPA has provided guidance on the use of the Project scale in MOVES for quantitative hot-spot analysis for transportation conformity.<sup>20</sup> Users can refer to that guidance for information about setting up run specifications and using the Project Data Manager for Project scale MOVES runs.

### 3.2.3 Calculation Type

Under the Scale Panel, MOVES gives users the option to calculate emissions either as:

- Inventory (total emissions in units of mass) or,
- Emission Rates (emissions per unit of distance for running emissions or per vehicle for starts and hotelling emissions) in a look-up table format.<sup>21</sup>

The selection of calculation type is required early in the RunSpec construction process because this choice affects the available options in later panels.

- If Inventory is selected, MOVES provides emissions estimates as mass, using VMT and vehicle population entered by the user. For additional guidance when using the National scale and Inventory, see Appendix A of this guidance.
- If Emission Rates is selected, MOVES provides emission rates as mass per unit of activity. The Emission Rates option produces a look-up table of emission rates that must be post-processed to produce an inventory. Even though vehicle activity would be applied outside of MOVES when developing an onroad GHG inventory using Emission Rates, when using the county scale vehicle activity inputs are still important because they are used by MOVES to calculate the relative amounts of running and non-running activity, which in turn affects the rates for these processes.

As discussed in Section 2 of this document, each calculation approach has advantages and considerations and users will need to decide which approach is more appropriate for their type of analysis. Both approaches use the same underlying emission data and will produce the essentially same results if the user calculates an inventory from rates in the same way that MOVES does this internally. Table 1 in Section 2 provides a summary of modeling approaches.

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<sup>20</sup> See Section 4 of “Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM<sub>2.5</sub> and PM<sub>10</sub> Nonattainment and Maintenance Areas,” EPA-420-B-10-040, December 2010; and “Using MOVES in Project-Level Carbon Monoxide Analyses, EPA-420-B-10-041, December 2010. Both documents are available at: [www.epa.gov/otaq/stateresources/transconf/policy.htm](http://www.epa.gov/otaq/stateresources/transconf/policy.htm).

<sup>21</sup> Evaporative emission rates would not need to be generated when using MOVES to estimate onroad GHG emissions.

As noted in Section 2, the Emission Rates approach is more complex than the Inventory approach. Successful application of this approach requires careful planning and a clear understanding of the rates calculations in MOVES. Large differences in results between the Inventory and Emission Rates approaches are usually an indication of a mistake in post-processing of the emission rates. The most common mistakes when using the Emission Rates approach are not including all pollutant processes or multiplying emission rates by the wrong activity. To correctly compile an emissions inventory using rates, running rates must be multiplied by VMT, while emission rates from processes that occur when the vehicle is parked, such as start and hotelling rates must be multiplied by the total population of vehicles in the area. Note that there are alternative rates for some of the processes that occur when the vehicle is parked:

- Start emission inventories can be calculated either by multiplying the rate per vehicle by the total population of vehicles in the area, or by multiplying the rate per start by the total number of starts;
- Hotelling emissions can be calculated by multiplying the rate per vehicle by the total population of long-haul combination trucks in the area or by multiplying the rate per hour by the hours of hotelling activity.<sup>22</sup>

There are no GHG emissions associated with refueling or evaporative processes.

Even when done correctly, minor differences in post-processing methods can create small differences in results. EPA recommends that the same approach be used in any analysis that compares two or more cases (e.g., a comparison of emissions with and without a control strategy).

If you select Emission Rates, you must assign a MOVESScenarioID which will be used in the rates tables. The MOVESScenarioID should be a unique identifier for the scenario for which the rates apply.

### **3.3 Time Spans**

The Time Spans Panel includes five sections – one to select the Time Aggregation Level, and four more to select specific years, months, days, and hours. This section provides guidance for each of these time span inputs. See Appendix A for additional guidance on time span selections when using the National scale.

#### **3.3.1 Time Aggregation Level**

Time aggregation level determines the amount of pre-aggregation of input data. A longer time span will aggregate (or average) input data to create a single value for the time aggregation level chosen. The Time Aggregation Level has four options: Year, Month, Day, and Hour. For example, if the user chooses Hour, MOVES will calculate emissions for each hour of a day based

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<sup>22</sup> More information about creating complete inventories using the Emission Rates calculation type can be found in the presentations used in EPA's 2-day training course, available for download on the web at: [www.epa.gov/otaq/models/moves/training.htm#2](http://www.epa.gov/otaq/models/moves/training.htm#2).

on the specific inputs for that hour (e.g., temperature, speed distribution, etc.). If the user chooses Day, MOVES calculates emissions for a day based on the average of the hourly inputs for the day, e.g., a single average temperature is applied to the whole day. Likewise, if the user chooses Month or Year, MOVES will calculate emissions based on single monthly or annual average inputs, e.g., a single average temperature will be applied to a full month or year. Refer to Section 2.5 for discussion regarding when the aggregation at a level above Hour could be used for a GHG inventory.

### **3.3.2 Calendar Year of Evaluation**

MOVES can model calendar years 1990 and the years 1999 through 2050. The County scale in MOVES allows only a single calendar year in a RunSpec. Users who want to model multiple calendar years using the County scale will need to create multiple RunSpecs, with local data specific to each calendar year, and run MOVES multiple times. MOVES can be run in batch mode operation to automate the process of doing multiple MOVES runs.<sup>23</sup>

Alternatively, MOVES can model multiple calendar years when operating at the National scale.

### **3.3.3 Month of Evaluation**

MOVES allows users to calculate emissions for any month of the year. Emissions for multiple months may be produced by a single RunSpec. The best choice for developing an annual inventory of onroad GHG emissions is to select all months. Since MOVES can model all 12 months in one run, there is no advantage to running only some months and not all of them.

When modeling multiple months (e.g., all 12), the user must be aware of how MOVES treats the input data. Fuel Supply and Meteorology can vary by month in a single RunSpec because the month is defined in the data tables used for these inputs. However, the other data fields in the County Data Manager (or CDM, described in Section 4 of this document) can be input only as a single set applied to all months selected. Therefore, if the user has, for example, Average Speed Distribution data that vary by month, the user would have to execute multiple RunSpecs to use each data set with the corresponding month.

If the user has selected the Emission Rates option, the Month can be used to input groups of temperatures as a shortcut for generating rate tables for use in creating inventories for large geographic areas. However, this is useful only for estimating running exhaust emissions, and not start or hotelling emissions. The MOVES training materials provide more details.<sup>24</sup>

### **3.3.4 Type of Day of Evaluation**

Weekdays and weekend days can be modeled separately in MOVES. MOVES provides the option of supplying different speed and VMT information for weekdays and weekend days to allow the calculation of separate emissions estimates by type of day. Average Speed

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<sup>23</sup> For information on batch runs, contact EPA's MOVES in-box at [mobile@epa.gov](mailto:mobile@epa.gov).

<sup>24</sup> The latest MOVES training materials can be downloaded from: [www.epa.gov/otaq/models/moves/training.htm](http://www.epa.gov/otaq/models/moves/training.htm).



Distribution, Day VMT Fraction, Hour VMT Fraction, and Starts are the only inputs in the CDM that differentiate between weekdays and weekend days.

If separate weekend day data is available for speed distributions, daily VMT fractions, and/or hourly VMT fractions, select both weekdays and weekend days and input the weekday and weekend day speed and VMT data accordingly.

However, if speed distribution data is available for only one type of day, use the same information for both types of days. This makes using built-in post aggregation tools easier. These tools are covered in Section 3.10.4 of this document, “Output Emission Detail.” (Note that if data are input for only one type of day, and Month or Year is selected in this panel, MOVES will provide an incorrect result. The Month or Year will be the total emissions from only one day type (e.g., weekdays) in that month or year and emissions from the other day type (e.g., weekend-days) will be missing.)

For the Day VMT Fraction, users can generate the appropriate mix of VMT on each type of day with the EPA-provided AADVMT Converter for MOVES2014 (described in Section 4.6 of this document). If only one type of day is selected, the calculator will appropriately adjust the day fraction to account for VMT for a single weekday or weekend day.

The Hour VMT Fraction can also differ by type of day and users can supply this information if available; however, if information is available only for a single type of day, either the default value or the user-supplied value for the single day can be used for the other type of day.

### **3.3.5 Hour of Evaluation**

This option allows users to select single or multiple hours. However, to properly estimate emissions for a day, month or year, EPA recommends that the user select all 24 hours to reduce the post-processing steps needed (see Sections 2.3 and 2.4 for additional explanation). Note, when the Time Aggregation Level is Day, then all 24 hours should be selected; with Month, then all 24 hours and both day types should be selected; with Year, then all 24 hours, both day types, and all 12 months should be selected. Refer to Section 2.6 for additional explanation of time aggregation level.

### **3.3.6 Time Span Panel Sections: Emission Rates Mode**

When Emission Rates is chosen, users may choose to approach the selection of options in the Time Spans Panel differently than when running MOVES in Inventory mode. For example, when modeling running emission rates, instead of entering a diurnal temperature profile for 24 hours, users can enter a range of 24 temperatures in increments that represent the temperatures over a period of time. By selecting more than one month and using a different set of incremental temperatures for each month, users could create a table of running emission rates by all the possible temperatures over an entire season or year.

For start emissions, users can create a start emissions table that could be used for an entire season or year by selecting more than one month and entering a different diurnal temperature range or profile for each month.

Users should consult Section 4.3.1 for additional guidance on developing rate lookup tables. It is important to note that the selected month will have no impact on the emissions results (assuming identical fuel and temperature inputs). For instance, a temperature of 40 degrees for a particular hour will result in the same emission rate regardless of what month is chosen.

## **3.4 Geographic Bounds**

### **3.4.1 National Scale**

When using the National scale, the Region section choices in the Geographic Bounds Panel are “Nation,” “State,” and “County.” As this guidance is focused on using MOVES to create state or local GHG and/or energy consumption estimates, users should choose either State or County rather than Nation. Choosing State will give the user an alphabetical list of states plus the District of Columbia, Puerto Rico, and the Virgin Islands to select. Users can select one or multiple states at the National scale. Choosing County will give the user the list of states, and once a state is selected, a list of counties will appear. Users can select one or multiple counties at the National scale. For additional guidance on selections to be made in this panel when using the National scale, see Appendix A of this guidance.

### **3.4.2 County Scale**

Once the County scale is selected, the Region section of the Geographic Bounds Panel gives the user the choice between County or Custom Domain. Either option can be used for estimating onroad GHG emissions. The user should choose the one that is best suited for the data they have. These options are discussed in Section 2.4 and each option is explained in greater detail below.

#### **3.4.2.1 County Option**

Within the County scale, the user would select the County option if:

- Only one county is being analyzed, or
- Unique data are available (e.g., different vehicle age distribution, fuels, or I/M program) for each county being modeled.

If users choose County, they also specify which county they are modeling in the Geographic Bounds Panel. The County scale allows only one county and one calendar year to be analyzed at a time. As a result, users will need to do multiple runs of MOVES, using multiple RunSpec files, to develop emission estimates for multiple counties.

Use of the County option has two advantages. The county option allows the user to more easily employ some of the MOVES database default inputs for that county if appropriate, as described in Section 4 of this document. The County option also provides individual output for each county.

### 3.4.2.2 Custom Domain Option

A custom domain is a geographic area that may consist of multiple counties, parts of counties, or combinations of counties and partial counties that can be described using a single set of inputs in the County Data Manager. The custom domain area is described by a single RunSpec file. Using the Custom Domain option can reduce the number of MOVES runs required, as long as inputs are appropriate to the entire domain or appropriately varied within the domain, as described in Section 4.13).

Unique fractions of running, start, and hotelling activity can be applied to each zone within the custom domain, and output will be disaggregated by zone. Users who choose to define each county in a custom domain as a separate zone can then get separate output for each county (zone).

As an alternative, when using the Emission Rates calculation option, MOVES produces a lookup table of emission rates. These emission rates can then be post-processed outside of MOVES to produce separate emissions estimates for each county by multiplying the emission rates by the appropriate source type population and VMT for each county. Using Custom Domain and Emission Rates is an option to develop emissions estimates for a large number of areas with similar characteristics, while preserving the ability to specify the emissions within each area. Users should consider whether this advantage outweighs the convenience of using a single representative county with Emissions Rates.

For a Custom Domain, users will create a generic “county” for which no data are available in the default database. Therefore, users must supply data for all the tabs in the County Data Manager (see Section 4 of this document) and essentially re-create entries in the County and CountyYear Tables of the default database by providing information about the area on the Geographic Bounds Panel. Users can refer to these tables to find data for the counties that comprise the custom domain being created. Users must provide the following information to create new entries for the County and CountyYear Tables for the custom domain:

- CountyID (e.g. a unique number to identify the domain),
- Description (e.g., the name of the custom domain),
- Geographic Phase-in Area (GPA) Fraction,
- Barometric Pressure (in inches of mercury), and
- Refueling Vapor and Spill Adjustment Factors.

The Geographic Phase-in Area (GPA) is an area around the Rocky Mountains where the Federal Tier 2 sulfur control program was implemented on a delayed schedule. Users should enter 1 if the custom domain falls within the GPA and 0 if it is outside the GPA; in the unlikely event the custom domain is split, users should enter the fraction of VMT that occurs inside the GPA. The refueling Vapor and Spill Adjustment Factor terms are factors that describe the extent and effectiveness of a Stage II refueling program in the area, but have no impact on GHG emissions. Users can refer to the CountyYear Table in the MOVES default database to see the default factors for the counties in the Custom Domain.

### 3.4.3 Domain Input Database

In this section of the Geographic Bounds Panel, the user can open the CDM by clicking on the “Enter/Edit Data” button (the CDM can also be accessed from the Pre-Processing Menu).

*Tip: The user should complete the rest of the RunSpec panels before importing data in the CDM.*

Once a database has been completely populated, users should select the database in the Database section of this panel. Users may have to hit the Refresh button to make sure the database they create appears on the drop down list.

When the National scale has been chosen, there is no Domain Input Database section in the Geographic Bounds Panel.

## 3.5 Vehicles/Equipment: Onroad Vehicle Equipment

MOVES describes vehicles by a combination of vehicle characteristics (e.g. passenger car, passenger truck, light commercial truck, etc.) and the fuel that the vehicle is capable of using (gasoline, diesel, etc.). The Vehicles/Equipment Panel is used to specify the vehicle types included in the MOVES run. MOVES allows the user to select from 13 “source use types” (the terminology that MOVES uses to describe vehicles), and six different fuel types (gasoline, diesel, ethanol E-85, compressed natural gas (CNG), electricity, and liquefied petroleum gas (LPG)<sup>25</sup>). Some source/fuel type combinations are not valid and therefore not included in the MOVES database (e.g., diesel motorcycles).

For estimating onroad GHG emissions, users should select the appropriate fuel and vehicle type combinations in the On Road Vehicle Equipment Panel to reflect the full range of vehicles that will operate in the county. In general, users should select all valid Compressed Natural Gas, Diesel Fuel, Ethanol (E-85), and Gasoline vehicle and fuel combinations. Ethanol should be selected even if there is no E-85 fuel sold in the area. Flex-fueled E-85 capable vehicles are a component of the vehicle fleet in every county in the U.S. and MOVES automatically assigns some VMT to these vehicles. For more information on the relationship between source types and HPMS vehicle types, see Section 4.5 of this document.

The vehicle and fuel combinations selected on this panel will be affected by the Fuel Tab (see Section 4.11 of this document) in the County Data Manager. If no changes are made on the Fuel Tab, national default fuel fractions will be used. If the user has data indicating that no E-85 fuel is available in the county, this would be specified in the Fuel Usage Fraction input of the Fuel Tab. If the user has other data detailing the fleet and activity of alternative fuel/vehicle combinations, then those combinations should be selected using the AVFT input in the Fuel Tab. For example, if you are restricting your analysis to only diesel fueled buses, the MOVES default will still allocate some of the VMT to gasoline and CNG buses and thus the results may underestimate emissions. The Fuel Tab AVFT Table is a way to correct the fraction of fleet by fuel type. See Section 4.10 for more information. Additionally, the user must supply valid fuel

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<sup>25</sup> The default MOVES database does not include any emission factors for onroad LPG vehicles.

formulations for all vehicle-fuel combinations selected in the Onroad Vehicle Equipment Panel in the Fuel Supply Table, accessed through the Fuel Tab of the CDM. See Section 4.11 of this document for more information about the requirements for this tab.

*Tip: Even if you do not have any E-85 sold in your area, be sure to include Ethanol (E-85) in your fuel/source type combinations. Otherwise, VMT and emissions from E-85 capable vehicles will not be included in your inventory. If there is no E-85 sold locally, use the Fuel Usage Fraction input in the Fuel Tab to indicate that. MOVES will then calculate emissions for E-85 vehicles using gasoline fuel.*

*Tip: If your local transit bus fleet uses only one type of fuel (CNG, diesel, or gasoline), use the AVFT input in the Fuel Tab to change the fractions of the bus fleet appropriately (e.g., with a fraction of 1.0 for that fuel and 0.0 for the others). Otherwise, MOVES will, by default, allocate some of the VMT to buses that use the other fuels and thus the results may underestimate emissions.*

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Detailed information describing the local vehicle fleet and its activity can be entered in the CDM using the Source Type Population, Age Distribution, Vehicle Type VMT, Average Speed Distribution, and Road Type Distribution Tabs. See Section 4 of this document for more information on these input options and the use of default vs. local information.

### 3.6 Road Type

The Road Type Panel is used to define the types of roads that are included in the run. MOVES defines five different road types as shown in Table 3-1.

**Table 3-1: MOVES Road Types**

Roadtypeid	Road type	Description
1	Off-Network	Locations where the predominant activity is vehicle starts, parking and idling (parking lots, truck stops, rest areas, freight or bus terminals)
2	Rural Restricted Access	Rural highways that can be accessed only by an on-ramp
3	Rural Unrestricted Access	All other rural roads (arterials, connectors, and local streets)
4	Urban Restricted Access	Urban highways that can be accessed only by an on-ramp
5	Urban Unrestricted Access	All other urban roads (arterials, connectors, and local streets)

Generally, all road types should be selected including Off-Network. The determination of rural or urban road types should be based on the Highway Performance Monitoring System (HPMS)

classification of the roads in the county being analyzed. Onroad GHG emissions estimates should include the Off-Network road type in order to account for GHG emissions from vehicle starts and hotelling activity. The Off-Network road type is automatically selected when start or hotelling pollutant processes are chosen. Off-Network activity in MOVES is primarily determined by the Source Type Population input, which is described in Section 4.4 of this document. Hotelling activity is determined in MOVES2014 and MOVES2014a by the user defined rural highway long-haul combination truck VMT.

MOVES uses Road Type to assign default drive cycles to activity on roadtypes 2, 3, 4, and 5. For example, for unrestricted access road types, MOVES uses drive cycles that assume stop and go driving, including multiple accelerations, decelerations, and short periods of idling. For restricted access road types, MOVES uses drive cycles that include a higher fraction of cruise activity with less time spent accelerating or idling, although some ramp activity is also included.

Selection of road types in the Road Type Panel also determines the road types that will be included in the MOVES run results. Additionally, MOVES can provide a separate output for ramps. This panel contains a button to toggle this option on or off. This option should only be selected if output is needed for ramps and highways separately. More information about how this option works is found in Section 3.6 of the MOVES Technical Guidance.<sup>26</sup> Different characteristics of local activity by road type are entered in the CDM using the Average Speed Distribution and Road Type Distribution importers as described in Sections 4.7 and 4.8 of this document.

### **3.7 Pollutants and Processes**

The Pollutants and Processes Panel allows users to select from various pollutants, types of energy consumption, and associated processes of interest. In MOVES, a pollutant refers to particular types of pollutants or precursors of a pollutant but also includes energy consumption choices. Processes refer to the mechanism by which emissions are created, such as running exhaust or start exhaust. Users should select all processes associated with a particular pollutant in order to account for all emissions of that pollutant. This can be done by checking the box to the left of the pollutant, which selects all of the relevant processes for that pollutant. Note that checking the box next to any of the GHG pollutants selects only running, start, and hotelling processes. Evaporative processes do not produce GHG emissions.

For many pollutants, the emissions calculation is based on calculations of another pollutant. In such cases, users must select all of the associated pollutants and processes. MOVES will display warning messages in the box on the Pollutants and Processes screen until all necessary base pollutants are selected. Clicking the button “Select Prerequisites” automatically selects all necessary pollutants and will clear the warning messages.

When using the Inventory calculation type, the total emissions for a particular pollutant are the sum of the emissions for all pollutant processes that apply to the pollutant. When using the

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<sup>26</sup> MOVES2014 and 2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, November 2015, EPA-420-B-15-093, on the web at [www.epa.gov/otaq/models/moves/documents/420b15093.pdf](http://www.epa.gov/otaq/models/moves/documents/420b15093.pdf)

Emission Rates calculation type, the total emissions for a particular pollutant are the sum of the product of emission rates and the appropriate activity measure (VMT or vehicle population) for each vehicle type for all pollutant processes that apply to that pollutant and vehicle type.

### 3.7.1 Pollutants

Users may want to select any of the following pollutants, depending on the purpose of their analysis:

- Atmospheric CO<sub>2</sub>;
- Methane (CH<sub>4</sub>);
- Nitrous Oxide (N<sub>2</sub>O); and
- Elemental Carbon (equivalent to black carbon).

If “Atmospheric CO<sub>2</sub>” is chosen, then “Total Energy Consumption” must also be chosen. The “Select Prerequisites” button can be used in this case.

If methane is chosen, the user will be prompted to select “Total Gaseous Hydrocarbons.” Using the “Select Prerequisites” button will select only the necessary processes, whereas checking the button to the left of Total Gaseous Hydrocarbons would select all processes for hydrocarbons, including evaporative processes. Evaporative processes for hydrocarbons should not be selected when modeling methane, because methane is a result of combustion.

“Elemental Carbon” can be found under “Primary Exhaust PM<sub>2.5</sub> – Species” on the Pollutants and Processes Panel. When the user clicks “[+],” Elemental Carbon is in the list of PM<sub>2.5</sub> species displayed.

Additionally, users may select “CO<sub>2</sub> Equivalent” or CO<sub>2</sub>e in the Pollutants and Processes Panel. The CO<sub>2</sub> Equivalent pollutant is the sum of the global warming potential of other greenhouse gases expressed as a unit of CO<sub>2</sub>. The CO<sub>2</sub> equivalents that MOVES uses are as shown in Table 3-2:

**Table 3-2: CO<sub>2</sub> Equivalence Factors in MOVES**

Pollutant	CO <sub>2</sub> Equivalent <sup>27</sup>
<b>CO<sub>2</sub></b>	1
<b>Methane (CH<sub>4</sub>)</b>	25
<b>Nitrous Oxide (N<sub>2</sub>O)</b>	298

If CO<sub>2</sub> equivalent is checked, MOVES will report the CO<sub>2</sub> equivalent of the pollutants that the user has selected. For example, if you want MOVES to calculate the CO<sub>2</sub> equivalent of methane only, select CO<sub>2</sub> equivalent from the list as well as methane. If you want the total CO<sub>2</sub> equivalent of all three GHGs, select CO<sub>2</sub> equivalent as well as CO<sub>2</sub>, methane, and nitrous oxide. (Note CO<sub>2</sub> equivalent will include CO<sub>2</sub> if CO<sub>2</sub> has been selected in this panel. MOVES provides reminders

<sup>27</sup> Greenhouse gas equivalencies are quantified as CO<sub>2</sub>-equivalent (CO<sub>2</sub>e) emissions using weightings based on the 100-year Global Warming Potentials, using IPCC Second Assessment Report values unless otherwise stated.

of which pollutants will not be included in the CO<sub>2</sub> equivalent calculation if all three have not been selected.) Elemental carbon is not included in the CO<sub>2</sub> equivalent calculation even if elemental carbon is selected on the panel.

### 3.7.2 Energy Consumption

This panel can also be used to select different types of energy consumption, which are listed with the pollutants. Choices are:

- Total energy consumption, which estimates the total energy consumed from all fuel types selected;
- Petroleum energy consumption, which does not include compressed natural gas or ethanol; and
- Fossil Fuel energy consumption, which does not include ethanol.

### 3.7.3 Pollutants and Processes in Emission Rates Mode

Users should be aware that MOVES produces separate output tables with different activity measures for different emission processes:

- Rate per Distance Table - emissions in mass per distance (e.g., grams/mile); user multiplies these rates by total VMT by vehicle type:
  - Running exhaust
  - Crankcase running exhaust
  - Brake wear (select this process only if Elemental Carbon is being analyzed)
  - Tire wear (select this process only if Elemental Carbon PM is being analyzed)

Note: The processes Evaporative permeation, Evaporative fuel vapor venting, Refueling displacement vapor loss, and Refueling spillage loss are not necessary to select as they produce no GHG emissions.

- Rate per Vehicle Table – emissions in mass per vehicle (e.g., grams/vehicle); user multiplies these rates by total vehicle population by vehicle type:
  - Start exhaust
  - Crankcase start exhaust
  - Exhaust hotelling emissions (long-haul combination trucks only)
  - Crankcase exhaust hotelling emissions (long-haul combination trucks only)

Note: Rates for evaporative and refueling processes are not necessary to use for a GHG inventory as they produce no GHG emissions.

MOVES includes alternative rates for some of the emissions reported in the Rate per Vehicle Table. These rates represent alternative forms (units) of some of the emissions reported in the Rate per Vehicle Table, not additional emissions. Users should not apply both sets of rates to the same emissions processes, in order to avoid double-counting.



- Rate per Start Table (alternative to using Rate per Vehicle Table for start emissions) – emissions in mass per start (e.g., grams/vehicle-start); user multiplies these rates by the number of individual vehicle starts:
  - Start exhaust
  - Crankcase start exhaust
  
- Rate per Hour (alternative to using Rate per Vehicle Table for extended idle and auxiliary power emissions) – emissions from hotelling activity in mass per hour (e.g., grams/hour); user multiplies these rates by the number of hours of hotelling activity:
  - Extended idle exhaust (long-haul combination trucks only)
  - Extended idle crankcase exhaust (long-haul combination trucks only)
  - Auxiliary Power Exhaust (long-haul combination trucks only)

In order to calculate a total emissions inventory using the emissions rate mode, users need to properly sum the products of emission rates and activity for each vehicle type, for each applicable pollutant process in each of the applicable tables.

### **3.8 Manage Input Data Sets**

Most analyses will not use the Manage Input Data Sets Panel.

This panel allows users to create alternate data tables that are used in place of data from the MOVES default database. For GHG analyses in MOVES, the County Data Manager at the County scale and the Data Importer at the National scale serve the same function. However, if the user wishes to enter additional data about the area being analyzed that is not one of the input requirements in the CDM or Data Importer, then the data could either be included in the generic importer or referenced in this panel. Users should consult with EPA before using the Manage Input Data Sets Panel to input other additional data.

### **3.9 Strategies**

The Strategies option in the Navigation Panel provides access to the Rate-of-Progress check box. The Rate of Progress Panel applies only to SIP analyses in certain ozone nonattainment areas. It is not applicable to GHG inventories, therefore is not covered in this guidance.

### **3.10 Output**

The Output option in the Navigation Panel provides access to two panels – General Output and Output Emissions Detail. In general, users can generate output in whatever form works best for their specific needs. The following subsections provide some considerations when specifying output details and format. For additional guidance on selections to be made in this panel when using the National scale, see Appendix A of this guidance.

The General Output Panel includes three sections: Output Database, Units, and Activity. The Output Emissions Detail Panel also includes several sections.

### **3.10.1 General Output Panel: Output Database**

EPA recommends that users indicate that a database is an output database (such as using “\_out” at the end of the output database name). Results from multiple RunSpecs can be stored in a single output database, but generally these RunSpecs should be similar in units and aggregation because, typically, the user wants to compare results (e.g., RunSpecs that are identical except that a different fuel formulation was used) or sum them (e.g., RunSpecs for multiple counties that are part of the same metropolitan area). EPA recommends that users create a new output database for RunSpecs that are considerably different from RunSpecs whose output is already stored in existing output databases. Users will also want to consider total database size when deciding which RunSpecs to store in the same output database.

### **3.10.2 General Output Panel: Units**

Users are free to choose any of the mass unit selection options, but should generally choose a unit whose magnitude is appropriate for the parameters of the RunSpec so that interpretation and processing of the output is easier. For example, selecting tons in the output for a run aggregated hourly may produce emissions of “0” if emissions are significantly less than one ton. For CO<sub>2</sub> emissions at the county level, selecting tons may be appropriate. If the National scale is used, and local VMT will be incorporated into the analysis according to Appendix B, grams may be a better choice (because MOVES will compute CO<sub>2</sub> per mile traveled). For other GHG emissions such as elemental carbon or methane, users may want to select grams.

### **3.10.3 General Output Panel: Activity**

MOVES allows the user to select multiple activity output options. These options are:

- Distance Traveled,
- Source Hours,
- Hotelling Hours,
- Source Hours Operating,
- Source Hours Parked,
- Population, and
- Starts.

For Inventory calculations, activity output is not required, but can be useful to verify whether activity was properly entered in MOVES and whether the monthly and daily VMT fractions are correctly allocating the annual VMT inputs. Therefore EPA recommends selecting “Distance Traveled,” and “Population” so that the user can compare these outputs with the VMT and population that the user included in the input database. Users providing vehicle start information through the Starts Importer of the CDM should always select “Starts” in the Activity portion of the General Output Panel. Similarly, users providing hotelling information using the Hotelling Importer of the CDM should always select “Hotelling Hours” here.

For Emission Rate calculations, distance and population are reported automatically, but the values in the output are intermediate steps in the rate calculation and do not represent the true activity. Also see Appendix A for applicable selections when running MOVES at the National scale and using the “EmissionRates” post-processing script.

### 3.10.4 Output Emission Detail Panel

This panel allows the user to select the amount of detail provided in the output. More detail may be aggregated later by the user for various types of analysis, however, too much detail can lead to longer run times, large output tables, longer query execution in MySQL, and adds to complication to post processing. Users should determine exactly what output detail is needed and care should be taken to determine where analysis will be focused in post-processing. Once the run is executed, detail that was not selected cannot be recovered without re-running MOVES. In the event that another run is needed for more output detail, MOVES run execution times for energy consumption and/or CO<sub>2</sub> are relatively short. For additional guidance on selections to be made in this panel when using the National scale, see Appendix B of this guidance.

**Time:** Output at the Hour level is recommended for Time unless the user is certain that emission results are not needed by time of day. As described in Section 3.3, if the user only selected a single type of day in the Time Spans Panel because the user had a single Average Speed Distribution, then selecting any time period longer than the Portion of the Week would not be appropriate.

**Location:** The County scale allows only one county or custom domain to be modeled at a time, so selection of “County” is automatic. For the National scale where more than one county is selected, the user can have the output reported by “Nation,” “State,” or “County.” If state is selected, MOVES will show the output by state but only for the counties selected. For example, if four counties in one state and five counties in another state were selected in the Geographic Bounds Panel and “State” is selected in the Output Emission Detail Panel, the output for these counties will be grouped by state. For the National scale, see Appendix A for recommendations in this panel.

**For the All/Vehicle Equipment Categories:** In most cases Model Year does not have to be selected; it would only be selected if the user has activity information by model years. Note that selecting Model Year will increase the rows of output 31 times. Detailing output by Fuel Type may be helpful if the AVFT was used to input activity by alternate fuel vehicles or if separate output for gasoline and diesel vehicles are needed. Users can select Emission Processes to obtain output for each emissions process; otherwise MOVES will aggregate the results.

**On Road:** Detail for Source Use Type and/or Road Type can provide useful information and users will generally want to select at least one of these to be able to differentiate light and heavy duty emissions or restricted and unrestricted roadway emissions. If you checked the “Provide separate ramp output” box in the Road Type Panel, then select Road Type here (otherwise, you will get output aggregated for all road types and not get separate ramp output).

Two additional output options are SCC (Source Classification Code) and Regulatory Class. EPA uses SCCs to classify different types of anthropogenic emission activities. The existing SCCs for onroad vehicles are combinations of vehicle type and road type based on the classifications used in MOVES source type and roadtype IDs. Regulatory Class is a system EPA uses to classify vehicles for emission standards purposes. EPA recommends using Source Use Type and Road Type instead of SCC or Regulatory Class.

#### **3.10.4.1 Output Emission Detail When Using Emission Rate Mode**

When the Emission Rates option is chosen in MOVES, Road Type is automatically selected in the Output Emissions Detail Panel. Users should also select Source Type when using the Emission Rates option. If Source Type is not selected, MOVES will calculate aggregate emission rates for all source types based on the VMT and population by source type used as an input in the RunSpec (i.e., values entered using the County Data Manager). Thus, the output emission rates would be valid only for the mix of VMT and population by source type used to aggregate them. When users select Source Type in Output Emissions Detail and produce a table of running emission rates by road type and source type, these emission rates can be correctly applied to VMT and population estimates that may have different amounts of VMT by individual source type.

Likewise, it is recommended to leave model year and fuel type unchecked, unless the user has VMT and population by model year or fuel type that could be applied to these more specific rates. Producing more detailed rate tables can provide flexibility, by allowing these rates to be applied across large geographic areas that have different age, fueltype or VMT distributions. However, smaller geographic areas may not have activity data in this level of detail, and they may find that more aggregated rates are easier to use in producing an inventory.

When Road Type and Source Type detail are selected, MOVES produces lookup tables of emission rates by source type and road type. For running emissions, users then post-process these lookup tables outside of MOVES to apply local VMT by source type, road type, and speed bin to the gram per mile emission rates for each speed bin (based on local distributions of average speed). For start and hotelling emissions, users would post-process the Rate per vehicle lookup tables outside of MOVES to apply local source type population information to the per vehicle emission rates (or alternatively, Rate per Start and/or Rate per Hour Table, see Section 3.7.3). Additional detail on the applicability of data entered in the CDM when using the Emission Rates approach is provided in the individual subsections of Section 4 of this document.

### **3.11 Advanced Performance Features**

The Advanced Performance Features Panel is used for EPA internal testing and is not necessary for creating estimates of onroad GHG emissions. Use of these features requires knowledge of the detailed software components of the MOVES program, the inputs they require, and the outputs they produce. Users interested in these features should review the appropriate sections in the MOVES User Guide and the MOVES Software Design and Reference Manual.<sup>28</sup>

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<sup>28</sup> These documents can be downloaded from [www.epa.gov/otaq/models/moves/#user-2014a](http://www.epa.gov/otaq/models/moves/#user-2014a).

## Section 4: Creating the Input Database

After completing the RunSpec, the next step is to supply MOVES with data to create an input database. If using the National scale, the Data Importer can be used to incorporate local data, but it is optional and a National scale run can operate with national default data instead. If using the County scale, the County Data Manager (CDM) is used to create an input database and populate it with local data. Users that have several local data inputs are encouraged to use the County scale instead of the National scale. Refer to Section 2 for more information about the difference between the scales and when each would be appropriate for a GHG analysis.

As with any model, the quality of the data inputs greatly affect the accuracy of the outputs. MOVES requires input data to describe the location, time, and characteristics of the vehicle fleet being modeled to calculate emissions. Modelers can either rely on MOVES default information or local data that the user inputs. The data contained in the MOVES default database are typically not the most current or best available for any specific county. Therefore, with the exception of fuels, EPA recommends using local data for MOVES for GHG analyses when available to improve the accuracy of GHG emissions estimates. At a minimum, EPA strongly encourages the use of local VMT and vehicle population data.<sup>29</sup> EPA believes these inputs have the greatest impact on the quality of results. However, if local data are not available, MOVES default data may be useful for some inputs without affecting the quality of the results. This section explores the process of entering data inputs and discusses the various data input tabs.

### 4.1 Data Importer and County Data Manager Tabs

The Data Importer, which is available when using the National scale, and the CDM available with the County scale, serve the same function: they simplify importing specific local data without requiring direct interaction with the underlying input database. The Data Importer and CDM include multiple tabs, each one of which opens importers that are used to enter specific local data. These tabs and importers include the following:

- Meteorology Data
- Source Type Population
- Age Distribution
- Vehicle Type VMT
- Average Speed Distribution
- Road Type Distribution
- Ramp Fraction
- Fuel
- I/M Programs
- Zone (used with Custom Domain only)

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<sup>29</sup> The national default VMT data included in MOVES2014a are for the year 2011. When a future year is modeled using the National scale (see Section 2.4), MOVES applies an annual growth rate to the 2011 national VMT for the appropriate number of years. A portion of this scaled-up VMT is then allocated to the geographic area of interest. Thus EPA expects that users will always be able to find more recent and accurate VMT information than what is available within the MOVES model.

- Starts
- Hotelling
- Retrofit Data
- Generic

Each of the importers allows the user to create an import template file with required data field names and some key fields populated. The user will then edit these templates to add specific local data with a spreadsheet application or other tool, and import each data file into an input database for the run. In some importers, there is the option to export default data from the MOVES default database to review it. Once the user determines that the default data are applicable to the particular analysis, or determines that the default data need to be changed and makes those changes, the user then imports that data into the input database. Details of the mechanics of using the data importers are provided in the MOVES User Guide. Guidance for the use of these importers for estimating onroad GHG emissions is given below.

## ***4.2 Importing Local Data When Using the County Scale***

Use of the CDM is necessary when the scale is set to County. In order to complete a RunSpec at the County scale, the user must either import local data, or review and import default data for each tab in the CDM except for Ramp Fraction.

The CDM can be accessed either from the “Pre-Processing” pull-down menu at the top of the MOVES User Interface, or by selecting “Enter/Edit Data” on the Geographic Bounds Panel. However, before a user can input any locality specific data, an input database must be created on the Database Tab on the Geographic Bounds Panel. EPA recommends that this database name end with “\_in” to indicate it is a user input database. When the database is created, MOVES keeps track of the selections made in the RunSpec at that moment. Users should be careful of making changes to the RunSpec after the Domain Input Database has been created, because this can create inconsistencies between the Domain Input Database and the rest of the RunSpec.

In Emissions Rates runs, entering reasonable activity inputs in the CDM is important even though activity data will be applied outside of MOVES to calculate an inventory. Vehicle activity inputs are important because MOVES uses them to calculate the relative amounts of running and resting activity, which in turn affects the rates for start and hotelling. As a general rule, users should input accurate activity for the scenario being modeled regardless of whether MOVES is being used in Inventory or Emissions Rates mode.

## ***4.3 Importing Local Data When Using the National Scale***

As described in Section 2, the National scale could be sufficient for some types of GHG analyses. At the National scale, local data other than VMT and vehicle population can be imported to an input database for a MOVES run using the Data Importer, which has the same set of importers as the County Data Manager, each on its own tab.

When using the National scale for a smaller geographic area than the entire nation, do not use the Data Importer to import local VMT or vehicle population (“source type population”) data.

MOVES will treat VMT and population data entered as applying to the nation as a whole and apportion only some fraction of what is entered to the chosen geographic area, thus producing erroneous results. When using the National scale, VMT information can be included using the process described in Appendix A. In this process, the user will run MOVES to calculate an inventory, have MOVES post-process the inventory to calculate emissions rates, and then multiply those rates by the VMT in the area. Emissions resulting from vehicle starts will be included in the estimated emissions rates rather than calculated based on vehicle population. Therefore with this method, the user cannot include local information about vehicle population. If the user has both VMT and vehicle population information, EPA encourages the use of the County scale rather than the National scale so this information can be utilized by the model for a more precise estimate of emissions.

The Data Importer can be accessed from the “Pre-Processing” pull-down menu at the top of the MOVES User Interface. Users will be prompted to create an input database name on the Database Tab. EPA recommends that this database name end with “\_in” to indicate it is a user input database.

*The remainder of Section 4 describes the panels to create an input database file in terms of the County Data Manager. Because of the similarities between the County Data Manager and the Data Importer, this information applies to the Data Importer except where otherwise noted.*

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#### **4.4 Meteorology Data**

Ambient temperature and relative humidity data are important inputs for estimating onroad GHG emissions with MOVES. Ambient temperature and relative humidity are important for estimating GHG emissions from motor vehicles as these affect air conditioner use. MOVES requires a temperature (in degrees Fahrenheit) and relative humidity (in terms of a percentage, on a scale from 0 to 100) for each hour selected in the RunSpec. For example, MOVES requires a 24-hour temperature and humidity profile to model a full day of emissions on an hourly basis. EPA has created a tool (available at [www.epa.gov/otaq/models/moves/tools.htm](http://www.epa.gov/otaq/models/moves/tools.htm)) that takes minimum and maximum daily temperatures and creates an hourly temperature profile that could be used as input to MOVES. EPA recommends that users input the average daily temperature profile for each month if they are modeling all 12 months.

Temperature assumptions used for estimating onroad GHG emissions should be based on the latest available information. The MOVES database includes default monthly temperature and humidity data for every county in the country. These default data are based on average monthly temperatures for each county from the National Climatic Data Center for the period from 2001 to 2011. These national defaults can be used for a GHG inventory, or more recent data can be used.<sup>30</sup> Detailed local meteorological data are available from the National Climatic Data Center at [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov). EPA recommends documenting the sources of temperature data and any

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<sup>30</sup> In general, more recent temperature data is likely to be warmer, which may increase emissions because MOVES estimates vehicle air conditioner use based on temperature.

methods used to adjust them to fit the requirements of MOVES, as a means of keeping track of the inputs to the analysis and to ensure that the same method can be replicated over time.

#### **4.4.1 Meteorology Data in Emission Rate Calculations**

Users can develop Emission Rates for either a single county or a Custom Domain. If the Emission Rate calculation type is chosen in the RunSpec, users can enter a different temperature and humidity for each hour of the day to create an emission rate table that varies by temperature for running emissions processes. Emission rates for all running processes that vary by temperature can be post-processed outside of MOVES to calculate emissions for any mix of temperatures that can occur during a day. This creates the potential to create a lookup table of emission rates by temperature for the range of temperatures that can occur over a longer period of time such as a month or year from a single MOVES run.

However, for emissions from any non-running processes that occur on the “off-network” road type, i.e., start and hotelling emissions, it is still necessary to define a temperature profile for each hour of the day. Unlike running emissions that depend entirely on temperature, off-network emissions depend on both temperature and hour of day. It is possible to model both running and off-network emission rates in one run to create a lookup table that can be post-processed into an inventory. See the MOVES User Guide and the MOVES Technical Guidance for further information.<sup>31</sup>

#### **4.5 Source Type Population**

*Use this importer with the CDM (County scale) only. Do not use this importer with the Data Importer (National scale). MOVES will treat source type population data entered in the Data Importer as applying to the nation as a whole and apportion only some fraction of what is entered to the chosen geographic area, thus producing erroneous results. If users have information about source type population, the County scale should be used.*

Source type (vehicle type) population is used by MOVES to calculate start and hotelling emissions. It is also used to calculate evaporative emissions, but as stated earlier, evaporative emissions are not necessary when estimating GHG emissions. Start and hotelling emissions depend more on how many vehicles are parked and started, rather than how many miles they are driven. Therefore, in MOVES, start emissions are a function of the population of vehicles in an area and therefore users need to develop local data for vehicle population.

MOVES categorizes vehicles into 13 source types, which are subsets of five HPMS vehicle types in MOVES, as shown in Table 4-1.<sup>32</sup> EPA believes that states should be able to develop population data for many of these source type categories from state motor vehicle registration data (e.g., passenger cars, passenger trucks, light commercial trucks, motorcycles). States may

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<sup>31</sup> MOVES2014 and 2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, November 2015, EPA-420-B-15-093, on the web at [www.epa.gov/otaq/models/moves/documents/420b15093.pdf](http://www.epa.gov/otaq/models/moves/documents/420b15093.pdf).

<sup>32</sup> There are actually 6 HPMS vehicle Type IDs, but MOVES uses Vehicle Type ID 25 to substitute for HPMS Type IDs 20 (short wheelbase light-duty) and 30 (long wheelbase light-duty) for VMT input only.



be able to obtain population data for other types of vehicles from their owners or operators: population data for intercity buses may be available from bus companies, data for transit buses may be available from local transit agencies, data for school buses may be available from school districts, and data for refuse trucks may be available from refuse haulers or local governments.

Estimating population for other source types may be more difficult. If population is not available for a particular source type, users could estimate population for that source type based on the MOVES default split of that source type within the HPMS vehicle class. In the absence of any other source of population data, users could base population estimates on the VMT estimates for a particular source type and the ratio of MOVES default population to VMT by source type. That ratio can be calculated by doing a very simple MOVES run at the national scale for the county in question, and including VMT and population in the output (a running emissions process must be selected to generate VMT).<sup>33</sup> Local VMT multiplied by the ratio of default population to default VMT will give an estimate of local population based on local VMT.

**Table 4-1: MOVES Source Types and HPMS Vehicle Types**

MOVES		HPMS	
Source Type ID	Source Types	Vehicle Type ID	Vehicle Type
11	Motorcycle	10	Motorcycles
21	Passenger Car	25	Light Duty Vehicles
31	Passenger Truck		
32	Light Commercial Truck		
41	Intercity Bus	40	Buses
42	Transit Bus		
43	School Bus		
51	Refuse Truck	50	Single Unit Trucks
52	Single Unit Short-haul Truck		
53	Single Unit Long-haul Truck		
54	Motor Home		
61	Combination Short-haul Truck	60	Combination Trucks
62	Combination Long-haul Truck		

<sup>33</sup> Population isn't available in the Summary Reporter, so users will have to access the output database through MySQL.

*Tip: A useful quality check on population and VMT inputs is to divide VMT by source type by source type population to estimate VMT per vehicle, and then determine whether these estimates are reasonable.*

## **4.6 Source Type Population in Emission Rate Calculations**

Users can develop Emission Rates for either a single county or a custom domain. If the Emission Rates option is used at the County scale and Source Type is selected in the Output Emission Detail Panel, MOVES will produce emission rates for start emissions and hotelling emissions by source type in terms of unit of mass (e.g., grams) per vehicle. Total start and/or hotelling emissions would then be calculated outside of MOVES by multiplying the emission rates by the vehicle populations for each source type. However, users will still need to enter data using the Source Type Population Importer that represents the population of vehicles in the total area where the lookup table results will be applied. This is necessary because MOVES uses the relationship between source type population and VMT to determine the relative amount of time vehicles spend parking vs. running. If the lookup table results will be applied to a large number of counties, use the total source type population for all the counties covered. The guidance in this section concerning the use of local vehicle population data applies both for generating the total population as an input to the model and for generating more geographically detailed population values to use in applying the emission rate results.

To generate the non-running portion of the inventory from rates, multiply the rates from the Ratepervehicle Table by vehicle population. Alternatively, for start emission processes, use the Rateperstart Table, which requires multiplying by the number of vehicle starts and/or for hotelling processes, use the Rateperhour Table, which requires multiplying by the number of hotelling hours. All of these rate tables are found in the output database.

## **4.7 Age Distribution**

A typical vehicle fleet includes a mix of vehicles of different ages, referred to as Age Distribution in MOVES. MOVES covers a 31 year range of vehicle ages, with vehicles 30 years and older grouped together. MOVES allows the user to specify the fraction of vehicles in each of 30 vehicle ages for each of the 13 source types in the model.

The age distribution of vehicle fleets can vary significantly from area to area and affects emissions. Generally, fleets with a higher percentage of older vehicles have higher emissions. Older vehicles have typically been driven more miles and experience more deterioration in emission control systems. Likewise, a higher percentage of older vehicles means that there are more vehicles in the fleet that do not meet newer, more stringent emission standards or CAFE standards. Surveys of registration data indicate considerable local variability in vehicle age distributions, which is not reflected in the default age distributions in MOVES. MOVES uses a single national default age distribution for each vehicle type in each year for every county.

For estimating onroad GHG emissions, EPA recommends and encourages states to develop age distributions that are applicable to the area being analyzed (e.g., for one or more individual counties, a state as a whole, etc.). Only one age distribution can be entered for the area being

modeled, so if you have age distribution information that varies by county, you would have to do a run for each county to utilize it. An age distribution may have already been developed for SIP and conformity purposes and if so, could also be used for estimating onroad GHG emissions. Tools for creating and converting age distributions are available at [www.epa.gov/otaq/models/moves/tools.htm](http://www.epa.gov/otaq/models/moves/tools.htm). As users develop new data in the future, EPA recommends recording those data according to MOVES vehicle classifications and model year breakdown.

While the MOVES Age Distribution input asks for an age distribution by source type, EPA does not expect that detailed local age distribution data will be readily available for all 13 of these source types. If local age distribution information is not available for some source types, states can use the same age distribution for all source types within an HPMS vehicle class (see Table 4-1 for a comparison of MOVES source types to HPMS vehicle classes). For example, states could use the same age distribution for Source Types 31 and 32 if separate age distributions for passenger trucks and light commercial trucks are not available.

Local age distributions can be estimated from local vehicle registration data. If users are unable to acquire data to develop a local age distribution or have reason to believe that data about locally registered vehicles is not necessarily representative of that entire portion of the fleet (as may be the case with long-haul trucks), then MOVES national default age distributions can be used.<sup>34</sup> A set of these national default age distributions for all source types and all calendar years is available on EPA's website at [www.epa.gov/otaq/models/moves/tools.htm](http://www.epa.gov/otaq/models/moves/tools.htm). (Age distributions cannot be exported directly from the default database within MOVES.)

The default age distributions in MOVES are specific to each calendar year and include assumptions about changes in age distributions over time. If local registration age distributions are used, they normally should not change across calendar years. That is, regardless of analysis year, the same percentage of the fleet can be assumed to be 0-1 year old, 1-2 years old, 2-3 years old, etc. The vehicle fleet turns over as people replace aging vehicles, but the age distribution generally remains the same.

However, very large temporary changes in vehicle sales and scrappage rates occurred as a result of the recession that began in 2008. Therefore, EPA has created the "Age Distribution Projection Tool for MOVES2014," found at [www.epa.gov/otaq/models/moves/tools.htm](http://www.epa.gov/otaq/models/moves/tools.htm). This tool will take a user supplied age distribution from 2011 or later and apply the same methods that EPA uses for projecting default national age distributions in MOVES to change the local age distribution in future years. This tool reduces the impact of the recession, which caused a temporarily older age distribution, on the vehicle fleet with time.<sup>35</sup>

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<sup>34</sup> For example, if an entire fleet of trucks belonging to a national freight company are registered in the county being modeled and these trucks operate across a larger region of the U.S., it may be more accurate to use the MOVES national default age distributions for long-haul trucks rather than the county's long-haul truck registration data. The county's data may be unduly influenced by the freight distributor's particular fleet.

<sup>35</sup> Details of the projection algorithm in the Age Distribution Projection Tool may be found in "Population and Activity of Onroad Vehicles in MOVES2014," Section 7.1.2.2 (pp. 56-58), available at: [www.epa.gov/otaq/models/moves/documents/420r16003a.pdf](http://www.epa.gov/otaq/models/moves/documents/420r16003a.pdf).

It is recommended that users fully document the sources of data and methods used to develop local age distributions as a means of keeping track of the inputs to the analysis and to ensure that the same method can be replicated over time.

It is possible to model the effects of an accelerated vehicle retirement program on GHG emissions or energy consumption, when such programs exist in a given area. One way is to modify the age distribution by increasing the fraction of new vehicles and decreasing the relative fractions of the model years targeted for retirement reflecting the effect of the program on the vehicle fleet. The effect of an accelerated vehicle retirement program can also be modeled by obtaining emissions rates output by model year, and calculating the effects of the program outside of the MOVES model using information on how vehicle activity would change by model year. Note that an accelerated vehicle retirement program would have to be quite large to have a discernable effect on fleetwide GHG emissions in MOVES. Note that while either of these approaches could be used for a GHG analysis, it is not acceptable to assume that a future fleet will be younger than the existing age distribution when modeling emissions for SIP and conformity analyses, unless there is some enforceable mechanism to bring about this change.

#### **4.8 Vehicle Type VMT**

*Use this importer with the CDM (County scale) only. Do not use this importer with the Data Importer (National scale). MOVES will treat vehicle type VMT data entered in the Data Importer as applying to the nation as a whole and apportion only some fraction of what is entered to the chosen geographic area, thus producing erroneous results. To include local VMT information when using the National scale, see Appendix A.*

As stated in Section 2.2, EPA believes VMT inputs have the greatest impact on the results of a state or local GHG or energy consumption analysis. Regardless of calculation type, MOVES requires VMT as an input. MOVES estimates emissions based on travel activity multiplied by emission factors. MOVES will multiply the VMT from each vehicle source type, on each road type, by the corresponding emission factors to generate an emissions inventory.<sup>36</sup> MPOs or state DOTs may have VMT estimates that can be used in MOVES. If VMT data are not available locally, other sources of VMT and vehicle population data are available. For a historical year, one source of VMT data is the Federal Highway Administration's Highway Performance Monitoring System (HPMS).<sup>37</sup> For a future year, travel activity information for a GHG analysis can be estimated using a variety of methods. Future VMT can be estimated by applying a growth rate to historical VMT, or with a commercially available sketch planning tool, or a traditional four-step travel demand model. For example, in EPA's Travel Efficiency Assessment Method, a sketch planning tool was used to estimate changes in travel activity resulting from various transportation control strategies. Then MOVES was used to estimate the changes in criteria pollutant and GHG emissions.<sup>38</sup>

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<sup>36</sup> This is true even when the calculation type is Emission Rates.

<sup>37</sup> For more information, see the Federal Highway Administration's website at: [www.fhwa.dot.gov/policyinformation/hpms.cfm](http://www.fhwa.dot.gov/policyinformation/hpms.cfm).

<sup>38</sup> For more information, see "Potential Changes in Emissions Due to Improvements in Travel Efficiency," EPA-420-R-11-003, March 2011, on the web at [www.epa.gov/otaq/stateresources/policy/420r11003.pdf](http://www.epa.gov/otaq/stateresources/policy/420r11003.pdf) and EPA's

MOVES can accommodate whatever VMT data is available: annual or average daily VMT, by HPMS class or MOVES sourcetype. Therefore, there are four possible ways to enter VMT, allowing users the flexibility to enter VMT data in whatever form they have. EPA recommends that the same approach be used in any analysis that compares two or more cases (e.g., the base year and a future year) in a GHG analysis. If users have annual VMT, it may be a better for annual GHG inventories.

Annual or Daily VMT: EPA recommends that users with average annual daily VMT use MOVES2014a (rather than MOVES2014) to take advantage of the daily VMT input option. For users who want to use MOVES2014 or annual VMT in MOVES2014a to take advantage of capabilities in MOVES to allocate VMT across different time periods, EPA has created a spreadsheet-based tool, the “ADVMT Converter for MOVES2014.” This converter allows users to input average annual daily VMT as well as monthly and weekend day adjustment factors to create the annual VMT by HPMS class and appropriate monthly and daily adjustments needed by MOVES2014.

VMT by HPMS Vehicle Classes: The Federal Highway Administration recently modified the methodology used to generate VMT estimates in HPMS. As a result of that change, the old categories 20 and 30, which previously represented passenger cars and 2-axle, 4-tire trucks respectively, now represent short wheelbase and long wheelbase light-duty vehicles. Because the short wheelbase/long wheelbase distinction does not map well to MOVES source types, MOVES now uses a single category 25 to include all light-duty cars and trucks for VMT only. All VMT for HPMS categories 20 and 30 should be summed, and entered as category 25. Note that although HPMS categories 20 and 30 are combined for VMT entry purposes in MOVES, all other fleet and activity inputs (vehicle population, age distribution, average speed distribution, etc.) for Source Types 21, 31, and 32 are still handled separately in MOVES and all emission calculations and results are based on the emission and activity characteristics of each of these source types.

VMT by MOVES Source Type: MOVES2014a also includes the option to enter VMT by MOVES Source Types shown in Table 4-1 in Section 4.5 above. For users who are able to develop VMT data by the MOVES Source Types, entering VMT by Source Type will bypass the default allocation of VMT from HPMS class to Source Type that MOVES does internally.

#### **4.8.1 Vehicle Type VMT in Emission Rate Calculations**

If the Emission Rates option is used, and Source Type is selected in the Output Emission Detail Panel, MOVES will produce emission rates for running emissions by source type and road type in terms of grams per mile. Total running emissions would then be calculated outside of MOVES by multiplying the emission rates by the VMT for each source type and road type. However, users will still need to enter data using the Vehicle Type VMT Importer that reflects the VMT in the total area where the lookup table results will be applied. This is necessary because MOVES uses the relationship between source type population and VMT to determine

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related documents to EPA’s Travel Efficient Assessment Method found at:  
[www.epa.gov/otaq/stateresources/ghgtravel.htm#assess](http://www.epa.gov/otaq/stateresources/ghgtravel.htm#assess).

the relative amount of time vehicles spend parked vs. running. If the lookup table results will be applied to a large number of counties, use the total VMT for all the counties covered. The guidance in this section concerning the use of local VMT data applies both for developing the total VMT to input and for developing the geographically detailed VMT to use when applying the emission rates.

#### **4.9 Average Speed Distribution**

Vehicle power, speed, and acceleration have a significant effect on vehicle emissions, including GHG emissions. MOVES models those emission effects by assigning activity to specific drive cycles. While direct input of operating modes and drive schedules is possible using Project scale inputs, the model also can use the distribution of vehicle hours traveled (VHT) by average speed to determine an appropriate operating mode distribution. Thus, for estimating onroad GHG emissions where activity is averaged over a wide variety of driving patterns, a local speed distribution by road type and source type is a reasonable surrogate for more detailed local drive cycles or operating mode distributions. In these cases, states could develop and use local estimates of average speed. The Average Speed Distribution Importer in MOVES calls for a speed distribution in VHT in 16 speed bins, by each road type, source type, and hour of the day included in the analysis. EPA urges users to develop the most detailed local speed information that is reasonable to obtain. However, EPA acknowledges that average speed distribution information may not be available at the level of detail that MOVES allows. The following paragraphs provide additional guidance regarding the development of average speed distribution inputs.

Average speed, as defined for use in MOVES, is the distance traveled (in miles) divided by the time (in hours). This is not the same as the instantaneous velocity of vehicles or the nominal speed limit on the roadway link. The MOVES definition of speed includes all operation of vehicles including intersections and other obstacles to travel which may result in stopping and idling. As a result, average speeds, as used in MOVES, will tend to be less than nominal speed limits for individual roadway links.

Selection of vehicle speeds is a complex process. One recommended approach for estimating average speeds is to post-process the output from a travel demand model. In most transportation models, speed is estimated primarily to allocate travel across the roadway network. Speed is used as a measure of impedance to travel rather than as a prediction of accurate travel times. For this reason, speed results from most travel demand models must be adjusted to properly estimate actual average speeds.

An alternative approach to develop a local average speed distribution is to process on-vehicle GPS data. There are a number of commercial vendors that can provide raw, or processed vehicle speed data from cell phone and other on-vehicle GPS collection devices. This information can be used to calculate a MOVES average speed distribution. As part of the MOVES2014 model, EPA used GPS data to calculate a national default average speed distribution. Users wishing to process their own GPS data into an average speed distribution should ensure that the data are representative of the modeling domain, and accurately capture variation in vehicle average speeds across the day, and year.

In cases where onroad emissions modeling has been done to meet SIP and conformity requirements for criteria pollutants, areas may already have developed this information. Users may want to find the latest average speed distribution used in onroad emissions modeling for a SIP or conformity determination in the area.

Speed is entered in MOVES as a distribution rather than a single value. Table 4-2 shows the speed bin structure that MOVES uses for speed distribution input. Section 4.7.3 of this document explains how to create a speed distribution from a single average speed. However, EPA encourages users to use underlying speed distribution data to represent vehicle speed as an input to MOVES, rather than one average value. Use of a distribution will give a more accurate estimate of emissions than use of a single average speed. This is particularly important for GHG analysis, since GHG emission rates are highest at low speeds and very high speeds. A single average speed will tend to be in the middle of the speed range where emission rates are lower, leading the analysis to underestimate GHG emissions.

**Table 4-2: MOVES Speed Bins**

Speed Bin ID	Average Bin Speed	Speed Bin Range
1	2.5	speed < 2.5mph
2	5	2.5mph <= speed < 7.5mph
3	10	7.5mph <= speed < 12.5mph
4	15	12.5mph <= speed < 17.5mph
5	20	17.5mph <= speed < 22.5mph
6	25	22.5mph <= speed < 27.5mph
7	30	27.5mph <= speed < 32.5mph
8	35	32.5mph <= speed < 37.5mph
9	40	37.5mph <= speed < 42.5mph
10	45	42.5mph <= speed < 47.5mph
11	50	47.5mph <= speed < 52.5mph
12	55	52.5mph <= speed < 57.5mph
13	60	57.5mph <= speed < 62.5mph
14	65	62.5mph <= speed < 67.5mph
15	70	67.5mph <= speed < 72.5mph
16	75	72.5mph <= speed

As is the case for other MOVES inputs, EPA does not expect that users will be able to develop distinct local speed distributions for all 13 vehicle source types. If a local average speed distribution is not available for some source types, states can use the same average speed distribution for all source types within an HPMS vehicle class. For example, users could apply the same average speed distribution for source types 31 and 32 if separate average speed distributions for passenger trucks and light commercial trucks are not available. Users could also apply the same speed distributions across multiple HPMS vehicle classes if more detailed information is not available.

Average speed estimates for calendar years other than the calendar year on which the average speed estimates are based should be logically related to the current year methodology and estimates, with no arbitrary or unsupported assumptions of changes in average speeds. Future average speed estimates should account for the effect of growth in overall fleet VMT on roadway congestion and average speeds.

#### **4.9.1 Additional Guidance for Speeds on Local Roadways**

MOVES uses four different roadway types that are affected by the average speed distribution input: rural restricted access, rural unrestricted access, urban restricted access, and urban unrestricted access. In MOVES, local roadways are included with arterials and collectors in the urban and rural unrestricted access roads category. Therefore, EPA recommends that the average speed distribution for local roadway activity be included as part of a weighted distribution of average speed across all unrestricted roads: local roadways, arterials, and connectors. Users who want to treat local roadways and arterials separately can develop separate average speed distributions and estimate results using two separate MOVES runs, each with appropriate VMT, one using the local roadway average speed distribution for unrestricted access roads and one using the arterial average speed distribution for unrestricted access roads. However, using properly weighted average speed distributions for the combination of all unrestricted access roads should give the same result as using separate average speed distributions for arterials and local roadways.

#### **4.9.2 Average Speed Distributions in Emission Rates Calculations**

The guidance in this section concerning the use of local speed distribution data still applies whether local average speed distributions are applied within MOVES using the Inventory option or outside of MOVES using the Emission Rate option.

If the Emission Rates option is used, and Source Type is selected in the Output Emission Detail Panel, MOVES will produce a table of emission rates by source type and road type for each speed bin. Total running emissions would then be calculated outside of MOVES by multiplying the emission rates by the VMT for each source type in each speed bin. However, the CDM still requires a complete speed distribution to work, and the information provided in this input is used by MOVES to calculate the relative amounts of running and non-running activity, which in turn affects the rates for these processes. Users should supply an accurate speed distribution to produce the necessary emission rates (and at the National scale, the user could rely on the default speed distribution).

Users can develop Emission Rates for either a single county or a custom domain. With a Custom Domain, users would define one average speed distribution for the entire domain; it cannot vary by zone.

#### **4.9.3 Average Speed Distributions for Highways and Ramps**

For rural and urban restricted access highways, users should enter the speed distribution of vehicles traveling on the highway only, not including any activity that occurs on entrance and



exit ramps. The current version of MOVES automatically calculates a speed distribution for ramp activity based on the speed distribution of vehicles traveling on the highway.<sup>39</sup> Faster or slower highway speeds result in faster or slower ramp speeds (and higher or lower acceleration rates) calculated by MOVES. MOVES then calculates emissions for ramp activity based on this internally-calculated speed distribution for the ramps, using the appropriate distribution of operating modes related to that speed distribution, and the fraction of VHT that occurs on ramps. At this point, MOVES adds emissions for ramp activity to emissions calculated for vehicles traveling on the highway itself to get the total emissions for restricted access roads. MOVES2014/2014a also allows users to separate emissions between ramps and highways.

Section 4.9 describes the Ramp Fraction input and how it might be used to model ramps separately from highways. As noted in that section, even when ramps are handled separately from highways, the speed distribution entered in MOVES should be the speed distribution for the associated highways, not a ramp-specific speed distribution.

#### **4.10 Road Type Distribution**

The fraction of VMT by road type varies from area to area and can have a significant effect on GHG emissions from onroad mobile sources. EPA expects states to develop and use their own specific estimates of VMT by road type. The VMT fractions by road type used in inventory modeling for estimating onroad GHG emissions should be consistent with the most recent information used for transportation planning. For each source type, the Road Type Distribution Table of the input database stores the distribution of VMT by road type (e.g., the fraction of passenger car VMT on each of the road types).

As in the case for other MOVES inputs, EPA does not expect that users will be able to develop local distributions of VMT by road type for all 13 vehicle source types. If local road type distributions are available for some, but not all source types, the same road type distribution can be used for all source types within an HPMS vehicle class. For example, users could apply the same road type distribution for source types 31 and 32 if separate average speed distributions for passenger trucks and light commercial trucks are not available. Users could also apply the same road type distribution across multiple HPMS vehicle classes if more detailed information is not available.

EPA recommends using the same approach for custom domain zones. Users will define one road type distribution and allocate it via the Custom Zone Tab using reasonable local data.

##### **4.10.1 Road Type Distributions in Emission Rate Calculations**

If the Emission Rates option is used, MOVES will automatically produce a table of running emission rates by road type. Running emissions would then be calculated outside of MOVES by multiplying the emission rates by the VMT on each road type for each source type in each speed bin. In that case, data entered using the Road Type Distribution Importer is still required, but is not used by MOVES to calculate the rate. However, road type distribution inputs are important

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<sup>39</sup> The algorithm that calculates the ramp speed distribution was incorporated in MOVES2010a.

for Emission Rates runs involving non-running processes, because they are used by MOVES to calculate the relative amounts of running and non-running activity, which in turn affects the rates for the non-running processes. Road type distribution inputs for Rates runs that include any non-running processes should reflect realistic activity for the area. The guidance in this section concerning the use of local road type data still applies whether local road type distributions are applied within MOVES using the Inventory option or outside of MOVES using the Emission Rates option.

#### **4.11 Ramp Fraction**

Use of the Ramp Fraction Tab is optional. The default ramp fraction on both rural restricted roads (Road Type 2) and urban restricted roads (road type 4) is 8% of VHT and this default value of 8% will be automatically applied if the user does not import local data. Users who have good local data indicating a different fraction for ramp activity should use it to modify the default value.

The Ramp Fraction Tab imports a table that duplicates the Roadtype Table in the MOVES default database. The user enters the fraction of VHT on ramps for either rural restricted (Road Type 2) or urban restricted (Road Type 4) roads in the rampFraction field of this table.

For both Inventory and Emission Rates modes, the default output from MOVES combines highway and ramp activity. However in Inventory mode, users can have MOVES report results for ramps separately from highways. To obtain results for ramps and highways separately, users would check the “Provide separate ramp output” box in the Road Type Panel of the RunSpec, and select “Road Type” on the Output Emissions Detail Panel. This option should only be selected if there is a need to separate ramp emissions from highway emissions. Typically, when developing an emissions inventory, this level of detail is not necessary.

Separate ramp output is not available in Emission Rates mode in MOVES2014 or MOVES2014a. In Emission Rates mode, aggregate ramp/highway emission rates will be produced that should be combined with aggregate ramp/highway VMT.

For those defining a custom domain, users will define one ramp fraction for each restricted road type for the entire domain. This cannot vary by zone.

#### **4.12 Fuel (Supply, Formulation, Usage Fraction, and AVFT)**

MOVES has four tables – called FuelFormulation, FuelSupply, FuelUsageFraction, and AVFT (alternative vehicle fuels and technology) – that interact to define the fuels used in the area being modeled. In MOVES2014, these tables are accessed through a single tab in the CDM called Fuel. The MOVES defaults for all four tables are accessible using the Export Default Data button in the Fuel Tab of the CDM.

- The FuelSupply Table identifies the fuel formulations used in a region (the regionCounty Ttable defines which specific counties are included in these regions) and each formulation’s respective market share;

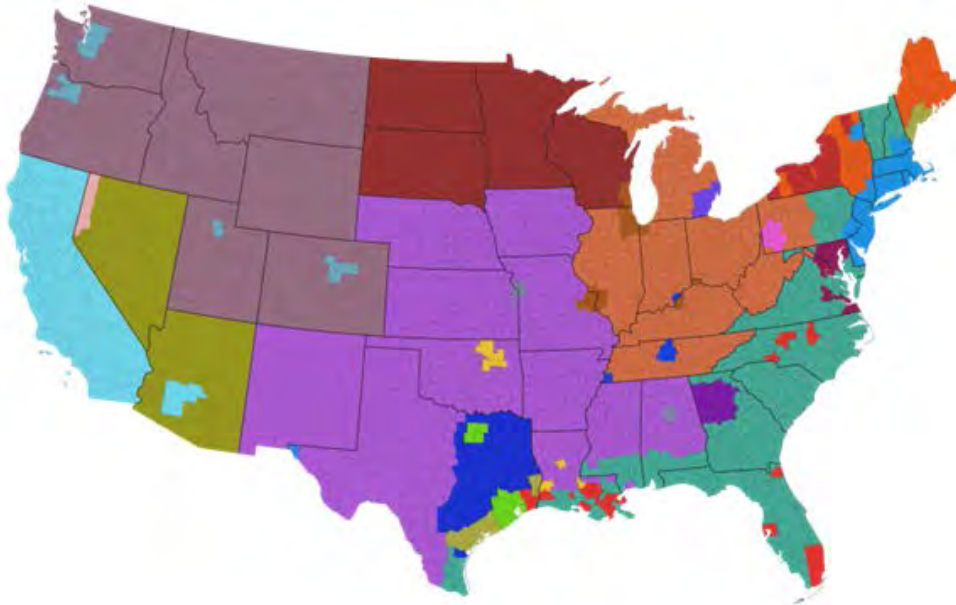
- The FuelFormulation Table defines the properties (such as RVP, sulfur level, ethanol volume, etc.) of each fuel;
- The FuelUsageFraction Table defines the frequency at which E-85 capable (flex fuel) vehicles use E-85 vs. conventional gasoline; and
- The AVFT Table is used to specify the fraction (other than the default included in the sampleVehiclePopulation Table) of fuel types capable of being used (such as flex fuel vehicles) by model year and source type.

In general, users should rely on the default county-level fuel information in MOVES in a GHG analysis. The default fuel tables in MOVES2014a have been revised and reflect EPA's latest information about fuel use in the U.S.

The following subsections of this document specify situations where changes to the MOVES default fuel data are appropriate. This guidance will apply for county or custom domain zones, and for Emission Rates and Inventory runs. When running MOVES for a custom domain, the same fuel formulation, fuel supply, fuel usage, and AVFT information must apply across the entire custom domain. If different counties in the domain have different fuel characteristics, the counties must be analyzed using separate runs.

MOVES has default gasoline, E-85, and diesel fuel formulation and supply information for every county-year-month combination that can be selected. These default tables are based on volumetric fuel data for thousands of batches of fuel in each of the fuel regions. In MOVES2014, we have simplified the county-level fuel properties within the MOVES fuel supply, based on averages of survey data as well as data provided to EPA at the refinery gates as part of our fuel compliance programs. EPA believes this average data by region provides a more consistent and maintainable basis for the model and, by aggregating fuel survey data as well as incorporating refinery batch-by-batch fuel compliance data, a more representative fuel supply was created for the final default. These new fuel supply and fuel formulation tables better account for fuel production and distribution networks, natural borders, and regional/state/local variations in fuel policy and increase confidence that the default fuels in a particular region represent the actual fuels used in that region. The new fuel regions in MOVES2014 and MOVES2014a are shown and described in Figure 4-1 and Table 4-3 below.

**Figure 4-1: Fuel Regions in MOVES2014 and MOVES2014a**



**Table 4-3: Description of Fuel Regions in MOVES2014 and MOVES2014a**

Region ID#	Region Name	Description
1	East Coast	East coast states up to Appalachians, Florida, and gulf coast region
2	Midwest	Midwest states up to Appalachians (not including Wisconsin), Tennessee, Kentucky
3	South	Southern states not including gulf coast, and Nebraska, Iowa
4	North	North and South Dakota, Minnesota, Wisconsin
5	Rocky Mts	Pacific northwest, Rocky mountain states, Utah
6	CA/NV/AR	California, Nevada, Arizona, AK, and HI NOT using Reformulated Gasoline (RFG)
11	East Coast RFG	East coast states and regions using RFG fuel or under a controlled fuel program
12	MD/VA	Maryland and Virginia regions using RFG fuel or under a controlled fuel program
13	Texas RFG	Texas regions using RFG fuel or under a controlled fuel program
14	Midwest RFG	Midwest regions using RFG fuel or under a controlled fuel program
15	California	California using California fuel, Nevada and Arizona regions using California Fuel

### 4.12.1 Fuel Formulation and Fuel Supply Guidance

In general, users should review the default fuel formulation and fuel supply data and make changes only where precise local volumetric fuel property information is available. EPA strongly recommends using the default fuel properties for a region unless a full local fuel property study exists.

The lone exception to this guidance is in the case of Reid Vapor Pressure (RVP) where a user should change the value to reflect any specific local regulatory requirements and differences between ethanol- and non-ethanol blended gasoline not reflected in the default database. Any changes to RVP (or to any other fuel formulation parameters) should be done using the “Fuels Wizard” tool in the Fuel Tab of the CDM. This tool can be used to adjust unknown fuel formulation properties based on known fuel properties. For instance, changing a fuel’s RVP will affect other fuel properties due to changes in refinery configuration in order to create that new fuel. The Fuels Wizard calculates the appropriate values consistent with EPA’s refinery modeling. The Fuel Wizard should be used whenever changing any default fuel property for gasoline and gasoline-ethanol blends in the FuelFormulation Table.<sup>40</sup>

Fuel properties are not likely to have a significant impact on GHG emissions. Ethanol does not have an impact on estimates of CO<sub>2</sub> emissions in MOVES, but users may want to quantify ethanol used when preparing a GHG inventory because ethanol is a renewable fuel. Users that want information about the biofuels included in MOVES should consult the most recent version of the MOVES User Guide on the web (see Section 1.7 of this document).

When running MOVES for a custom domain, the same fuels information must apply across the entire custom domain.

#### ***Fuel Formulation***

The FuelFormulation Table defines the attributes (such as RVP, sulfur level, ethanol volume, etc.) of each fuel. Users who would like more information about fuel formulation portion of the Fuel Tab in MOVES can refer to the MOVES Technical Guidance.<sup>41</sup> The SIP and conformity guidance provides detail about each field in the FuelFormulation Table and highlights the characteristics users should be able to provide and where default data can be used.

#### ***Fuel Supply***

The FuelSupply Table identifies the fuel formulations used in an area and each formulation’s respective market share. After the fuel formulations for the area being modeled have been reviewed and/or modified, the FuelSupply Table can be populated. There are six fields in this table. The fuelregionID field identifies the area being modeled (see Figure 4-1, describing fuel regions, above). The monthgroupID is the same as the monthID; monthgroupID was built in to allow for the possibility of seasonal fuels, but that option is not currently functional. The fuelformulationID is explained above. The marketshare is described in detail below.

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<sup>40</sup> The Fuel Wizard is not used for E-85, Diesel, or CNG fuels.

<sup>41</sup> MOVES2014 and 2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, November 2015, EPA-420-B-15-093, on the web at [www.epa.gov/otaq/models/moves/documents/420b15093.pdf](http://www.epa.gov/otaq/models/moves/documents/420b15093.pdf).

The marketshare is each fuel formulation’s fraction of the volume consumed in the area. The marketshare should sum to one within each fuel type, listed below in Table 4-4:

**Table 4-4: MOVES Fuel Types**

fuelTypeID	Description
1	Gasoline
2	Diesel Fuel
3	Compressed Natural Gas (CNG) <i>*Note: CNG fuel is not in defaults; must be manually added to the FuelSupply Table</i>
5	Ethanol (E-85)
9	Electricity

In many cases, only gasoline and diesel fuel vehicles will be selected and therefore only these two fuel types have to be imported. Within each fuel type, multiple fuel formulations can be listed as long as the market share sums to one (e.g., three gasoline fuel formulations with market shares of 0.5, 0.4, and 0.1, and two diesel fuel formulations with market shares of 0.6 and 0.4).

If more vehicle-fuel combinations are selected on the On Road Vehicle Equipment Panel (and some fraction of VMT assigned to them on the AVFT portion of the Fuel Tab), then each additional fuel type must also be entered. However, it should be noted that only gasoline and diesel fuels exist in the default FuelSupply Table; so if other fuel types are selected and the defaults are exported from the CDM, no default alternative fuel formulations will be exported. Therefore, it is the user’s responsibility to enter the FuelFormulationID for the alternative fuel type in the FuelSupply Table before importing.

The GHG effects of changes in the fuel mix used by vehicles can also be modeled in MOVES. AVFT can be used to change the fraction of future vehicles using gasoline, diesel, CNG and electricity.<sup>42</sup> These changes will be reflected in MOVES GHG results. Note that while this type of “what-if” analysis is reasonable for GHG emissions analysis, it would not be acceptable for SIP or transportation conformity analyses without an enforceable mechanism to ensure that the anticipated change in fuel use actually occurred; please consult the relevant guidance documents.

#### 4.12.2 Fuel Usage Fraction

E-85 capable vehicles, also known as flex-fuel vehicles (FFVs) exist throughout the country and are capable of using either conventional gasoline or E-85 fuel (a blend of 85% ethanol and 15%

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<sup>42</sup> In MOVES, the only vehicles that can be fueled by CNG are transit buses; however, future versions may include other fuels and vehicle technologies for other source types. For electric vehicles, MOVES assumes no emissions directly from the vehicle and does not estimate emissions from electricity generation. Please check the user guide and other appropriate documentation for the version of the model you are using to understand any changes from previous versions.

gasoline). The FuelUsageFraction Table allows the user to change the frequency at which E-85 capable vehicles use E-85 fuel vs. conventional fuel, when appropriate. MOVES2014 contains default estimates of E-85 fuel usage for each county in the U.S. In most cases, users should rely on the default information. If local data are available that indicate different E-85 usage, the fraction of gasoline (fuelsupplyfuelID = 1) and E-85 (fuelsupplyfuelID = 5) can be specified for sourceBinFuelTypeID = 5.

Note that this table defines the fraction of E-85 use among E-85 capable vehicles, not the fraction of use among all vehicle or the fraction of E-85 capable vehicles in the fleet. A fuel usage fraction table entry of 1.0 for fuel supply fuel type ID = 5 would mean that E-85 capable vehicles (FFVs) are using E-85 100% of the time. A fraction of 0.0 for fuel supply fuel type ID = 5 and a fraction of 1 for fuel type ID = 1 would mean that FFVs are using conventional gasoline 100% of the time, e.g., if there is no E-85 available in the local fuel supply. For example, if you know that no E-85 is used in the county you are modeling, for sourceBinFuelTypeID 5, for fuelsupply 1 (gasoline), you would change the usagefraction to 1, and for fuelsupply 5 (E-85), you would change the usagefraction to zero.

As noted in Section 3.5 of this document, Ethanol (E-85) should always be selected in the Onroad Vehicle Equipment Panel because FFVs are present throughout the national fleet; the Fuel Usage Fraction inputs are the appropriate place to account for the amount of actual E-85 usage by these vehicles.

#### **4.12.3 AVFT**

The AVFT Table allows users to modify the fraction of vehicles using different fuels and technologies in each model year. In other words, the Fuel Tab allows users to define the split between diesel, gasoline, ethanol, CNG, and electricity, for each vehicle type and model year.<sup>43</sup> For example, if in a certain county, sales data show that more diesel vehicles are sold than gasoline vehicles, this tab could be used to make the adjustment. In most cases, the default VMT split between diesel, gasoline, CNG, and E-85 can be used. If local data is used for present years, that information will be assumed for future years.

For transit buses, the default table assumes that gasoline, diesel, and CNG buses are present in the fleet for most model years. Note that if the user relies on the model's default allocation of vehicle activity, portions of the transit bus activity are always assumed to be diesel, gasoline, and CNG. This is true even if one or more of these combinations is not selected in the On Road Vehicle Equipment Panel. That is, if the user selects only gasoline and diesel vehicles in the On Road Vehicle Equipment Panel, MOVES still assumes some CNG transit bus VMT.

If the user has information about the fuel used by the transit bus fleet in the county modeled, the user should be sure it is reflected in the AVFT Table. For example, if there are no transit buses fueled by CNG in the modeling area, the user needs to allocate zero activity to CNG transit buses in the AVFT Table to calculate the correct emission results for transit buses. Otherwise, some VMT will be allocated to CNG transit buses and the emissions associated with this VMT will not

be included in the output, as only gasoline and diesel vehicles were selected in the On Road Vehicle Equipment Panel. Or if the transit bus fleet in a county is entirely diesel, then the user should assign 100 percent of the transit bus activity to diesel (i.e., a “1”), and assign a zero for gasoline and CNG transit bus activity. The same general principle applies to school buses, which are a mix of gasoline and diesel in the default distribution. After making appropriate adjustments to reflect fuel usage by the transit bus fleet, ensure that the AVFT fractions sum to 1.0 for each model year.

Similar concerns apply to E-85 capable flex-fueled vehicles (FFVs). As noted in Section 3.5 of this document, Ethanol (E-85) should always be selected in the Onroad Vehicle Equipment Panel because FFVs are present throughout the national fleet. However, in contrast to transit buses, in general, users should rely on default AVFT assumptions of the fractions of local FFVs, and use the Fuel Usage Fraction Table to adjust for any differences in the local availability of E-85 fuel.

EPA recommends the same approach for county or custom domain zones. For custom domains, users will define one Fuel Type and Technology for the entire domain. This factor cannot vary by zone.

### **4.13 Inspection and Maintenance Programs**

If a user is modeling methane emissions, and is modeling an area where an inspection and maintenance (I/M) program applies, the user should include the same I/M program inputs used for SIP and conformity analyses and should refer to Section 4.10 of the MOVES Technical Guidance for more information.<sup>44</sup> However, if a user is modeling CO<sub>2</sub>, N<sub>2</sub>O, and/or elemental carbon emissions only, or modeling an area where no I/M program applies, the user can skip this tab altogether.

### **4.14 Zone (Custom Domain Only)**

The Zone Importer can be used to define multiple zones within a larger custom domain region. The Zone Tab will appear only when a custom domain is selected in the Geographic Bounds Panel. Table 4-5 lists which inputs can vary by zone. The zone option may be advantageous when modeling a region of multiple counties that share the same fuels, vehicle age distribution, and I/M program. Rather than modeling each individual county in separate runs, users can divide activity (e.g., VMT) between multiple zones and run MOVES only once. Emission results will be produced for each defined zone. Although fuels, age distribution, and I/M programs cannot vary between zones, users can define specific temperature and humidity values for each zone within the custom domain. This information should be imported through the Meteorology Importer – discussed in Section 4.3.

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<sup>44</sup> MOVES2014 and 2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, November 2015, EPA-420-B-15-093, on the web at [www.epa.gov/otaq/models/moves/documents/420b15093.pdf](http://www.epa.gov/otaq/models/moves/documents/420b15093.pdf).



**Table 4-5 MOVES Custom Domain Inputs by Zone**

<b>MOVES input</b>	<b>Can be varied by zone?</b>	<b>How is the input changed?</b>
Meteorology	Yes	Temperatures and Humidity are defined for each zone using the "Meteorology" input
Source Type Population	Yes	Population (starts, evaporative, and hotelling emissions) are allocated to each zone using the "Zone" input
Vehicle Type VMT	Yes	VMT (running emissions) are allocated to each zone and road type using the "ZoneRoadType" input
Starts	Yes	Starts can be varied using the starts fraction of the "Zone" input
Hotelling	Yes	Hotelling can be varied using the extended idle fraction of the "Zone" input
Age Distribution	No	Not applicable
Average Speed Distribution	No	
Road Type Distribution	No	
Ramp Fraction	No	
Fuels	No	
I/M programs	No	
Fuel Type and Technology	No	

The Zone Importer includes three input tables: Zone, ZoneRoadType, and SCCRoadTypeDistribution.

The Zone Table is used to allocate off-network activity between each zone. Users should specify the distribution of starts (startAllocFactor), hotelling (idleAllocFactor), and parking (SHPAllocFactor) for each defined zone. Since most off-network emissions are proportional to vehicle population in MOVES, the Zone Table is useful when modeling regions where starts

may not be directly tied to population. For example, some urban centers may have a relatively low vehicle population as determined by vehicle registration data, but commuters may contribute to high start and evaporative (parked) emissions during the day. (As noted earlier, no GHG emissions result from evaporation.) Using this input table can address such situations. If specific start, hotelling, and parked fractions are not available, users can rely on the distribution of vehicle population among each zone to determine the allocation factors.

The ZoneRoadType Table is used to vary onroad activity (VMT) by road type and zone. The source hours operating (SHOAllocFactor) must sum to one for each road type. The allocation factors should be based on the distribution of VMT for each road type and zone. Users can use the ZoneRoadType Table to model situations where one zone may have much more highway VMT but lower arterial/local VMT than other zones by changing the SHO allocation factors. If data are not available, these factors may be identical for each road type within each zone.

The SCCRoadTypeDistribution Table describes the mapping of MOVES road type to SCC road types. This table is used only when modeling a custom domain and selecting output by SCC and would only be imported in this case. It does not impact the emissions calculations within MOVES.

#### **4.15 Starts**

The Starts Tab is used to import local information on vehicle start activity. This input is optional and should only be used if local data are available. There are several sources for vehicle start information, but typically this is derived from origin/destination surveys used for travel demand modeling. If no starts information is available, this importer should not be used and MOVES will calculate start activity based on user-supplied vehicle populations (sourcetypeyear input) and default assumptions of vehicle activity.

The Starts Tab contains multiple importers. Depending on the information available, one or more of these importers can be used to supply local start information. These importers include:

- Starts,
- StartsPerDay,
- StartsPerHourFraction,
- StartsSourceTypeFraction,
- StartsMonthAdjust, and
- StartsOpModeDistribution

The importers are used to create the Starts Table in MOVES. This is a very detailed table containing start information by source type, hour, day, and month. Typically, local data will not be available to populate the entire starts table. In a case where a user supplied only one table, MOVES will use that information to create the Starts Table, and will rely on default information for the inputs not provided. For instance, if total starts per day are provided through the Startsperday Table, those values will be used, and will be distributed to source types, months, and hours based on MOVES default allocations.

Users should confirm in the output that MOVES used the correct number of starts. By selecting “Starts” Activity in the Output Emissions Detail Panel of the RunSpec, the number of starts used in the MOVES run will be reported in the MOVESactivityoutput Table of the output database.

This table can be used to confirm the correct number of starts and/or correct allocations were used in MOVES.

### **Starts**

The Starts Table can be used to completely replace the MOVES generated Starts Table. Information on starts must be provided by month, hourdayID, sourcetypeid, and vehicle ageID. To use this input, vehicle starts information must be available for all fields. This input should only be used independently, and should not be used in combination with other starts inputs. Note that a complete table must be provided that includes all combinations of month, hourdayID, sourcetypeid selected in the RunSpec. If you have some but not all of the information required for this table, use one or more of the tables described below, as appropriate.

### **StartsPerDay**

The Startspersperday Table can be used when vehicle start information is available for total starts for weekend and/or weekdays. Total starts should be provided for a typical weekday and weekend day (dayID 5 and 2 respectively.) This input can be used independently, or in combination with other start input tables.

### **StartsPerHourFraction**

The Startspershourfraction Table can be used when local start information is available by hour of day. Fractions can be provided to correctly allocate starts to the appropriate hour. Fractions should be provided for both weekday and weekend day. The fractions should sum to one for each day type. This input can be used independently, or in combination with other start input options.

### **StartsSourceTypeFraction**

The Startssourcetypefraction Table can be used when local start information is available by source type. Fractions can be entered in the table to allocate total starts to each of the 13 MOVES source types. Fractions should sum to one. This input can be used independently, or in combination with other start input options.

### **StartsMonthAdjust**

The Startsmoonthadjust Table can be used to vary the vehicle starts between different months. An adjustment factor of 1.0 for each month will model a situation where annual starts are evenly divided between months. This is likely an unrealistic scenario. Usually, start activity increases in the summer and decreases in the winter. Local starts information can be used to adjust starts up or down depending on the month (or season) by changing the adjustment factors for each month. Users should make sure total starts are conserved by checking the MOVESactivityoutput Table in the output database.

### **StartsOpModeDistribution**

The Startstopmodedistribution Table can be used to provide local soak-time distributions. A soak-time is the period between “key-off” and “key-on.” Longer periods of soak typically result in higher start emission rates. If local data are available, the MOVES default soak-time assumptions can be overwritten by changing the opmodedistribution fractions in this table. This

input can be used independently, or in combination with other start input options. Note that evaporative emissions will not be affected by changing this table.

## **4.16 Hotelling**

The Hotelling Tab is used to import information on combination truck hotelling activity. In MOVES2014 and MOVES2014a, hotelling can be divided into four operating modes: Extended Idle, Diesel Auxiliary Power (APU), Battery Power, and Engine-Off.<sup>45</sup> Extended Idle is defined as long-duration idling with more load than standard idle and a different idle speed. It is used to account for emissions during hotelling operation when a truck's engine is used to support loads such as heaters, air conditioners, microwave ovens, etc. Diesel Auxiliary Power refers to use of auxiliary power units that allow for heating/cooling/power for the cab without running the truck's engine. Engine-Off refers to hotelling when the truck's engine is off and an APU is not being used. This could include hotelling resulting from truck-stop electrification.

All hotelling processes only apply to long-haul combination trucks (sourcetype = 62).

The Hotelling Tab contains two importers: HotellingActivityDistribution and HotellingHours.

### **HotellingActivityDistribution**

In most cases, users should rely on the national default hotelling operating mode fractions. In this case, no action is necessary for the Hotelling Tab. However, if users have detailed local hotelling data, it can be used to define the fraction of hotelling hours that are in each of the hotelling modes by model year.

### **HotellingHours**

In most cases, users should rely on the MOVES generated hotelling hours, which are determined based on the amount of rural restricted access VMT imported. However, the Hotelling Tab also includes an optional input for Hotelling Hours. This input can be used if users have detailed local information on total hotelling hours by hour of day, day type, month, and vehicle model year. Note that a complete table must be provided that includes all combinations of Month, HourDayID, and Hour selected in the RunSpec.

## **4.17 Retrofit Data**

The Retrofit Data Tab in MOVES allows users to enter retrofit program data that apply adjustments to vehicle emission rates. There are no default retrofit data in MOVES. However, users are not required to input retrofit data into MOVES unless they have a retrofit program that they wish to model. Users should consult EPA's SIP and Conformity Retrofit Guidance ([www.epa.gov/otaq/stateresources/transconf/policy.htm#quantify](http://www.epa.gov/otaq/stateresources/transconf/policy.htm#quantify)) for additional information.

## **4.18 Generic**

The Generic Tab can be used to export, modify, and re-import any of the default MOVES tables not covered by the County Data Manager. Users should note that there are complex interactions

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<sup>45</sup> Note that the Battery Power operating mode produces the same emissions as the Engine Off mode.

between tables in MOVES, and there may be unintended consequences from changing any table. Generally, other than the Stage II vehicle refueling controls – which are not needed in a GHG or energy consumption analysis – most tables should never be changed; results would be compromised if such tables are modified.<sup>46</sup> EPA recommends that users consult with their EPA regional office before modifying any of the default MOVES tables accessible through the Generic Tab.

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<sup>46</sup> See the MOVES Technical Guidance and the MOVES User Guide (Section 1.6 indicates web locations for these documents) for further information about Stage II vehicle refueling in MOVES.

## **Appendix A: Including Local VMT Information Using the National Scale**

### ***A.1 Introduction***

EPA strongly encourages users to use local VMT information in MOVES, even when using the National scale. As explained in Section 4, at the National scale VMT information for one or more counties or states cannot be included via the Data Importer. This is because MOVES will treat VMT entered via the Data Importer as applying to the nation as a whole rather than the geographic area chosen, and will apportion only some fraction of this VMT to the geographic area chosen, producing erroneous results.

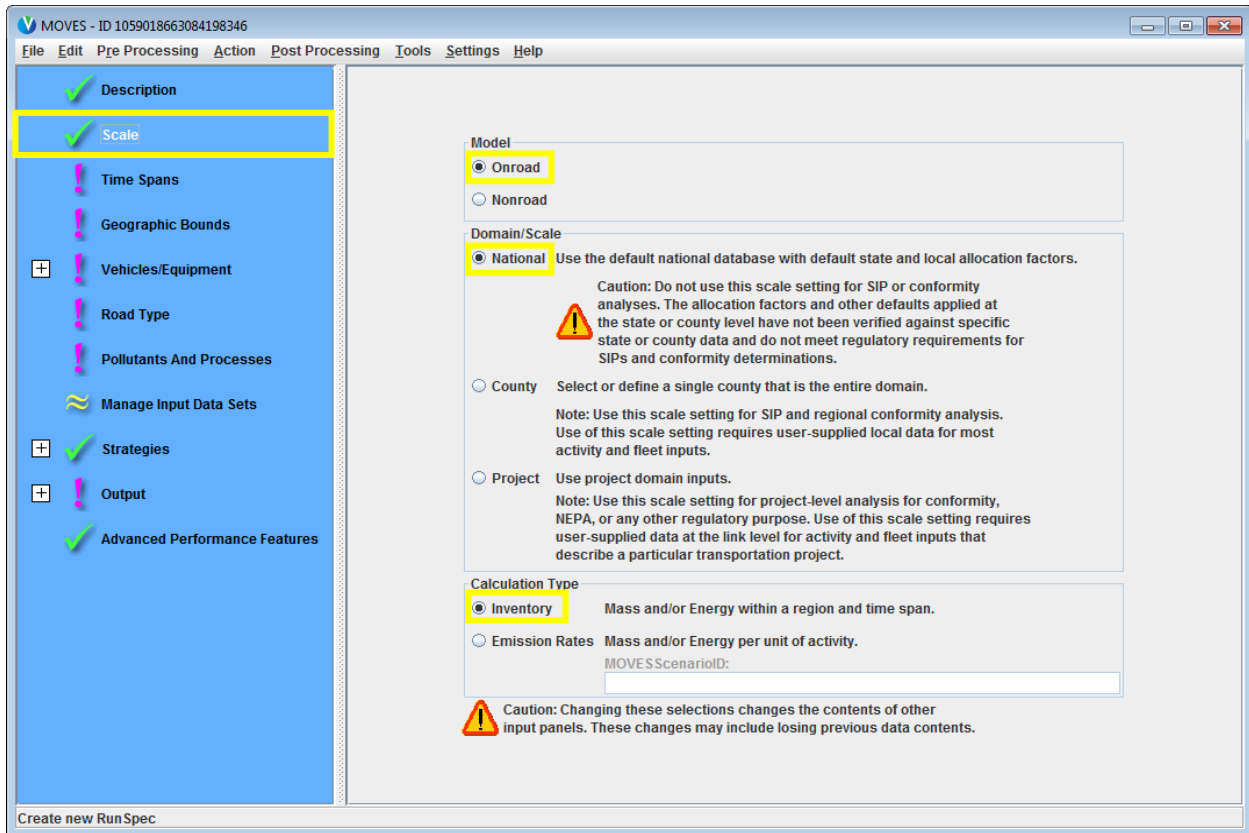
Instead, the directions given below can be used to include local VMT information when MOVES is run using the National scale. In this process, the user has MOVES calculate an inventory for the geographic area chosen. Once MOVES is executed, the user runs a “post-processing” script to have MOVES calculate one or more emissions rates from this inventory. The user then applies these emission rates to their local VMT information. EPA believes these additional steps to include local VMT information will produce a more precise estimate of GHG emissions or energy consumption than the National scale results that MOVES produces. See Section 2 for additional discussion.

### ***A.2 RunSpec Settings***

Assuming the user has chosen the National scale, the user should make certain selections in the Scale, Time Spans, Geographic Bounds, and Output Panels depending on the local VMT information that the user has, as described below. These directions are not a comprehensive guide to creating a RunSpec, which is covered in Section 3 of this document.

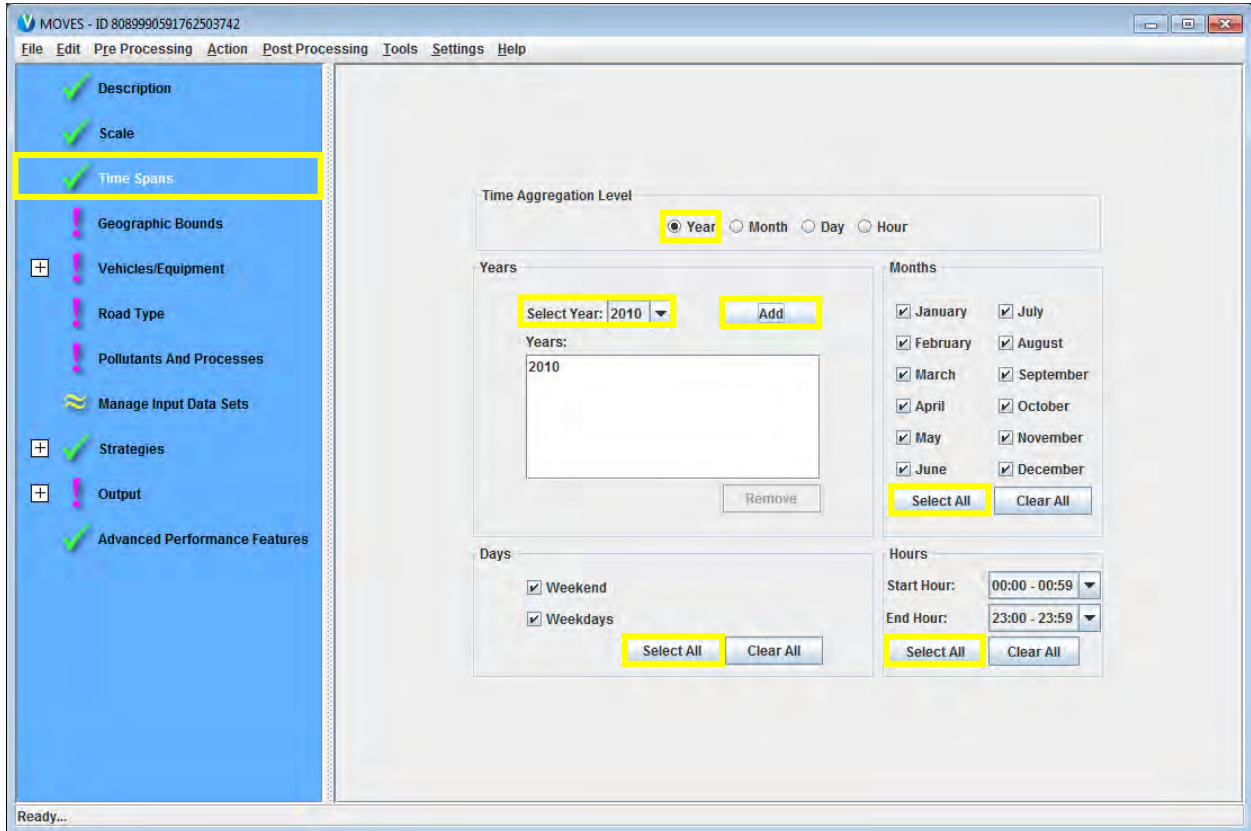
## A.2.1. Scale Panel

Select “Inventory” for calculation type, as shown below.



## A.2.2. Time Spans Panel

After selecting the appropriate year, and choosing a time aggregation level (see Section 2.6 for a discussion of time aggregation level), select “Months, Days, and Hours” according to the local VMT information you have. For example, if you have annual VMT for the geographic area being modeled, then select all months, all days, and all hours. These selections are shown below.

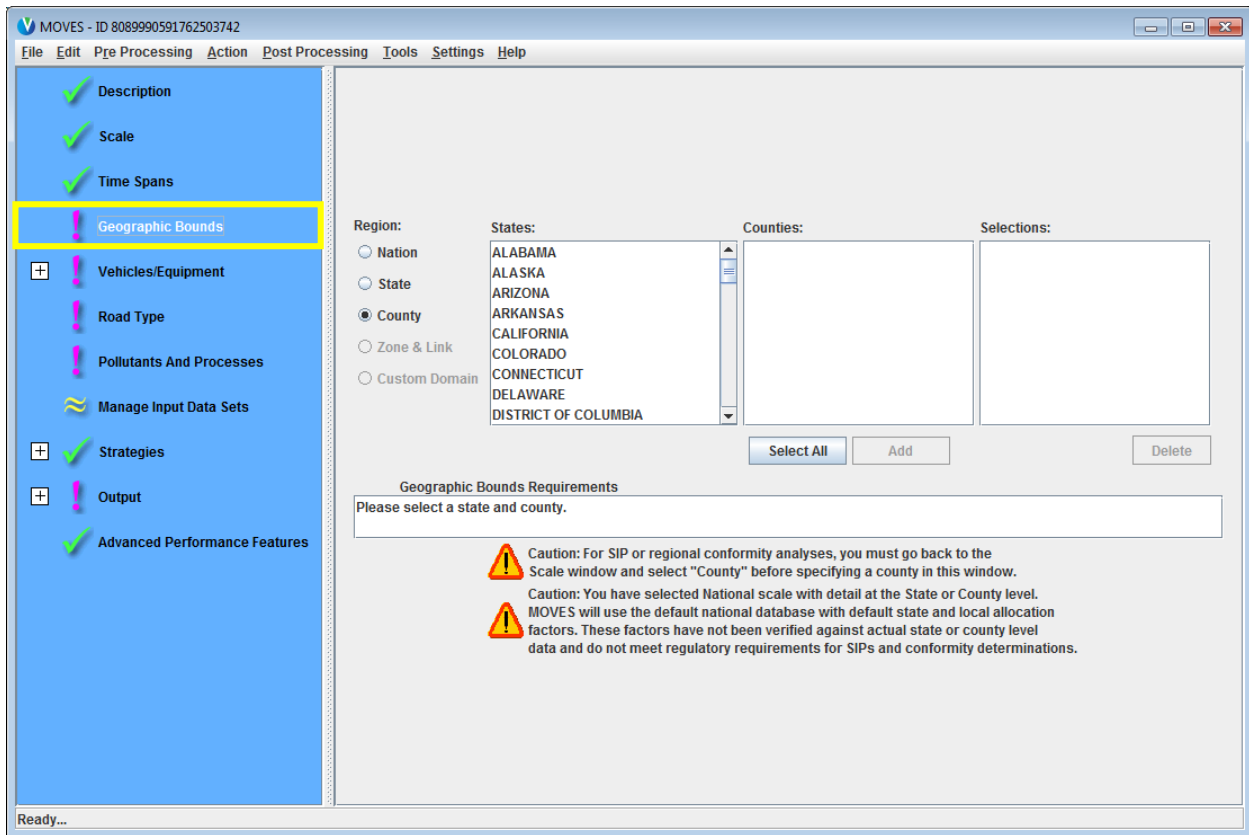




### A.2.3. Geographic Bounds Panel

If your local VMT data differs by county, then select County in this panel. Selecting County in this panel will mean that the script will calculate an emissions rate for each county selected in the run. If your VMT data differs by state, or applies to the entire state, select State in this panel. If State is selected in this panel, the script will calculate an emissions rate for each state selected in the run. Note that the input VMT data will need to be labeled with the appropriate state and county codes, or error messages will be produced.

You will also need to select the counties or states to be modeled in this panel.

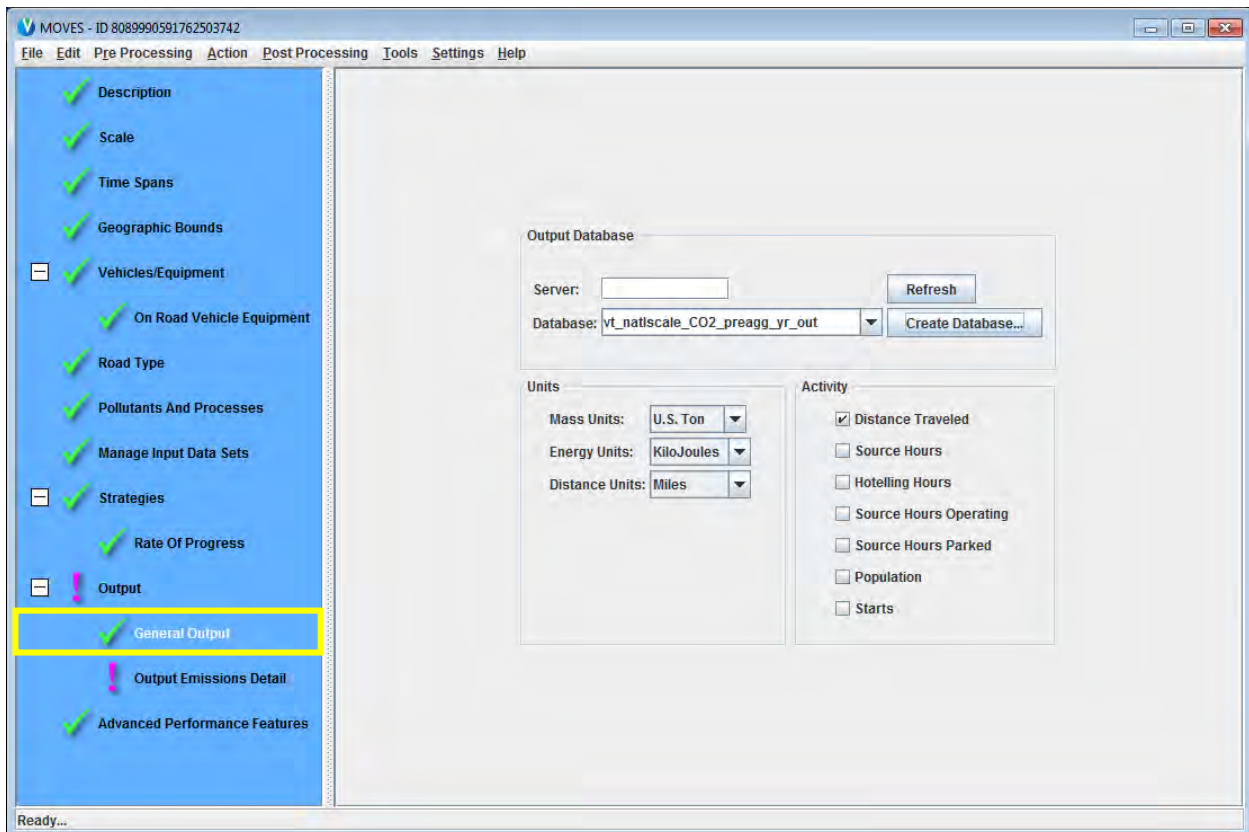


## A.2.4 Output Panel

This panel includes two other panels, the General Output Panel and the Output Emissions Detail Panel.

**General Output Panel:** Under “Activity,” “Distance Traveled” must be selected for the post-processing script to run. You will also need to select the appropriate units and create an output database in this panel. Mass units of grams may be a good choice because with the post-processing script, mass units will be divided by VMT to produce an emissions rate.

The screen below shows these selections, with an output database called “vt\_natlscale\_CO2\_preagg\_out.” (You may want to include the name of the state or county in the output database name. EPA recommends naming output databases with “\_out” at the end to identify it as an output database, as noted in Section 3.10.1).

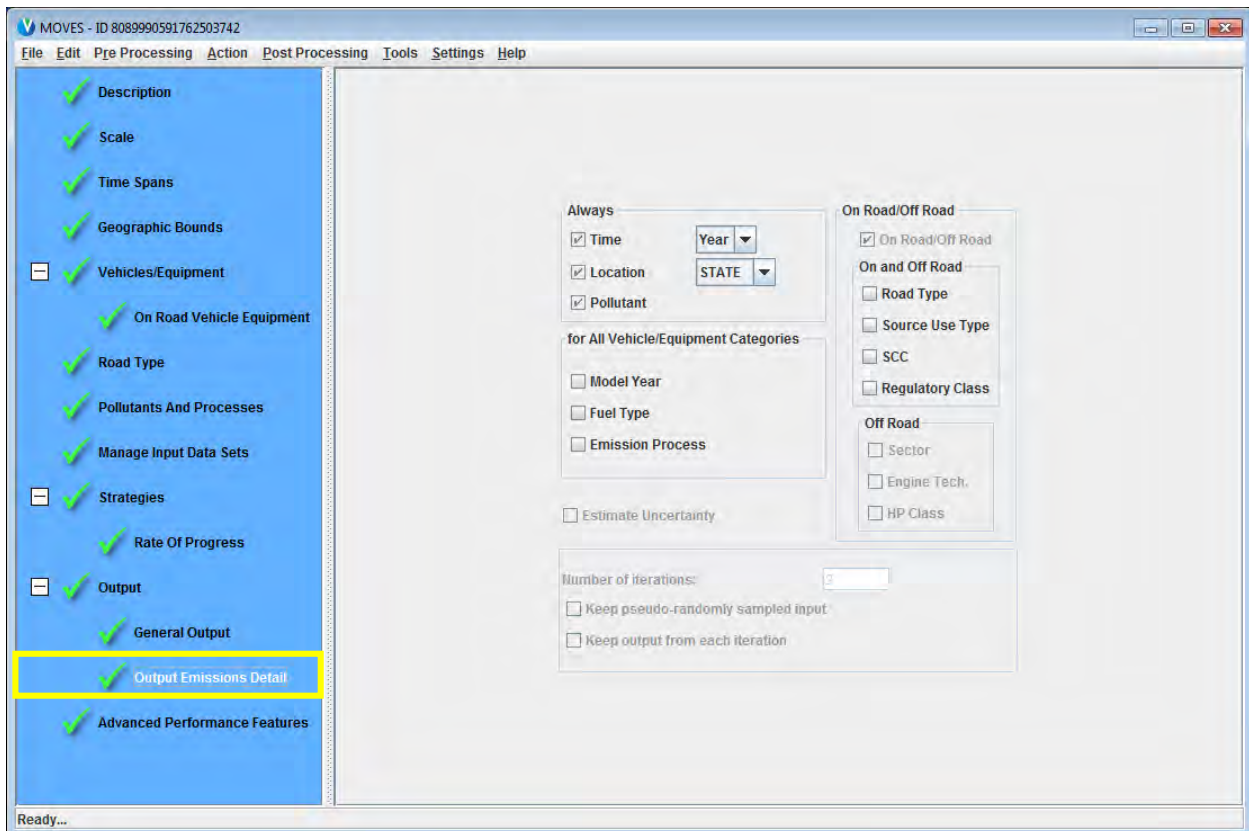


**Output Emissions Detail Panel:** Depending on what type of detail is present in your local VMT data, you will need to make selections in the in the Output Emissions Detail Panel as follows.

If local VMT data is for the entire year, then under the “Time” pull-down menu, select “Year.” If your VMT data varies by day or by hour, as noted above, EPA recommends running MOVES at the County scale to take advantage of the detail in the local data instead of the National scale approach.

If local VMT data varies by state, then under the “Location” pull-down menu, select “STATE.” If local VMT data varies by county, then under the “Location” pull-down menu, select “COUNTY.”

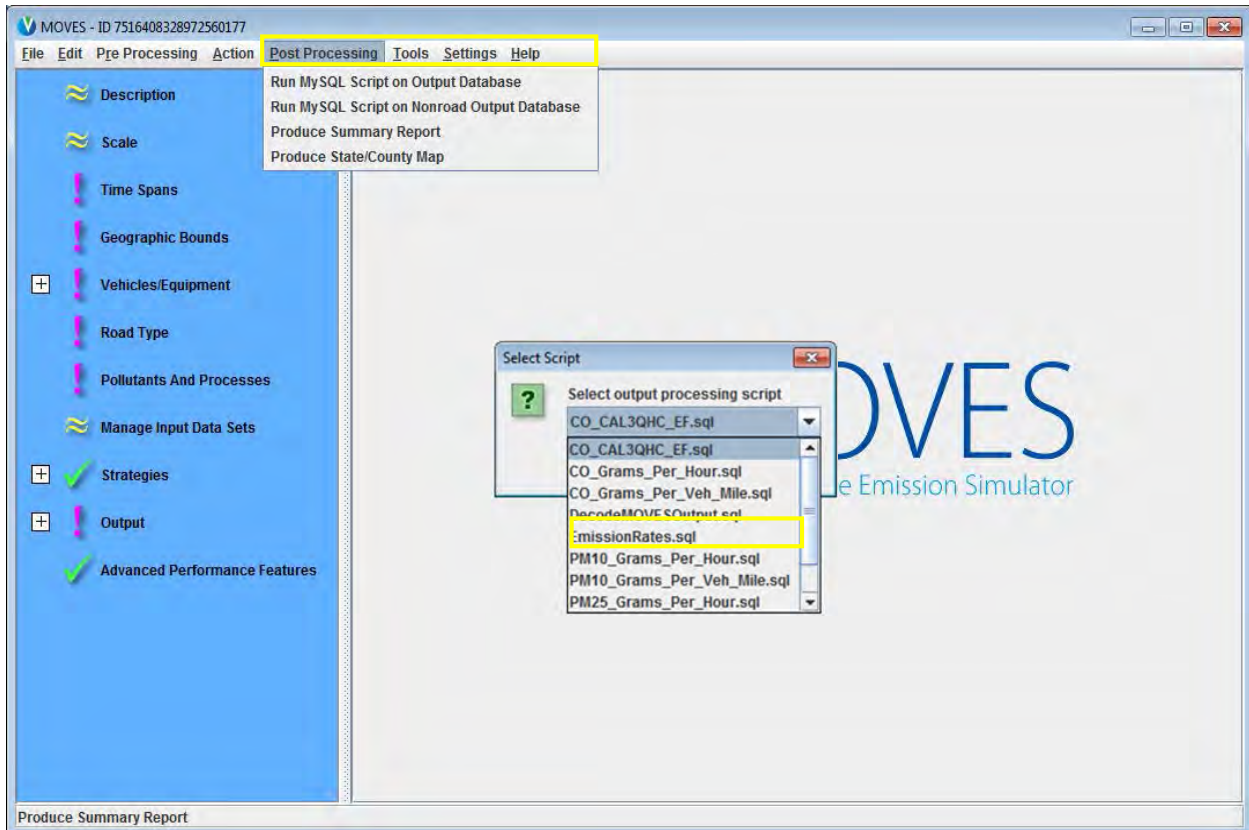
Furthermore, if local VMT data varies by road type, then select “Road Type,” if it varies by vehicle type, then select “Source Use Type.” Your local VMT data may not contain this level of detail, in which case you should leave them blank. The screen below highlights the fields that would vary depending on the local VMT information you have, and in this case, the local VMT data to be applied is for the entire year, for the entire state.



### A.3 Execute the Run and Post-Process Results

When the RunSpec has been completed, go to the “Action” pull-down menu at the top of the screen and select “Execute.” This will run MOVES and results will be included in the output database you specified.

Once the MOVES run has been successfully executed, go to the “Post Processing” pull-down menu at the top of the screen, and select “Run MySQL Script on MOVES Output Database.”



From the list of scripts available in the pull-down menu, select the script called, “EmissionRates.sql.”

After getting a message that the script has been successfully executed, open MySQL Workbench. In the output database created for the MOVES run, there will be a new data table produced by the script called “movesrates.” This table provides emission rates per unit of distance for the GHG emissions selected in the Pollutants and Processes Panel of the RunSpec. The user can find emission rates in this data table according to what was selected in the RunSpec, and multiply these rates by the appropriate VMT. These rates will include emissions for all processes selected in the Pollutants and Processes Panel in the RunSpec, expressed in units of mass per distance, regardless of whether some of these processes (e.g., starts and hotelling) are a function of distance.