MOVES-Mexico User Guide

MEXICO LOW EMISSIONS DEVELOPMENT PROGRAM (MLED).

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El presente estudio fue elaborado por Eastern Research Group, Inc. Los autores principales son Allison DenBleyker y John Koupal bajo la supervisión de Cynthia Menéndez y Ricardo Troncoso de WWF, con la colaboración técnica y de aporte de información del Instituto Nacional de Ecología y Cambio Climático (INECC) de México, en el marco del Programa para el Desarrollo Bajo en Emisiones de México (MLED), patrocinado por la Agencia de los Estados Unidos para el Desarrollo Internacional (USAID), bajo el contrato "AID-523-C-11-00001" implementado por Tetra Tech ES Inc.

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MOVES-Mexico User Guide

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1.0 Introduction

This document provides an introduction to how to use MOVES-Mexico, a version of U.S. EPA's MOVES2014a vehicle emissions estimation model adapted to Mexico. The technical approach to adapt MOVES2014a to Mexico is discussed in a separate report. This guide is designed as a companion to the U.S MOVES user documents for MOVES2014a, which MOVES-Mexico users will also need to consult. These documents are as follows:

1. **MOVES2014a User Guide** (EPA-420-B-15-095, November 2015), also referred to as the U.S. MOVES Users Guide, provides an overview of MOVES2014a and basic step by step instructions to navigate through the graphical user interface (GUI), execute runs, and process outputs. The document is posted on U.S. EPA's MOVES website, and can be downloaded directly from this link: http://www3.epa.gov/otaq/models/moves/documents/420b15095.pdf

2. **MOVES2014a User Interface Reference Manual** (EPA-420-B-15-094, November 2015) goes into more detail than the User Guide, providing information for advanced users. The document is posted on U.S. EPA's MOVES website, and can be downloaded directly from this link: http://www3.epa.gov/otaq/models/moves/documents/420b15094.pdf

This document's focus is to provide basic instruction for installing and using MOVES2014a and highlighting areas that are unique to the Mexico implementation of MOVES. Throughout this user guide we directly reference chapters of the U.S. MOVES User Guide and User Interface Reference Manual to indicate where additional information about MOVES is available. Section 2 discusses the scope of MOVES-Mexico, Section 3 explains how to install the model, Section 4 provides an introduction to the MOVES graphical user interface (GUI) highlighting what is unique for Mexico, and Section 5 addresses how to run MOVES, including the various run options and working with the outputs.

2.0 Scope of MOVES-Mexico

MOVES was developed in the U.S. as a replacement to the MOBILE vehicle emissions model, with the first official release of the model occurring in 2010. MOVES produces emission estimates for all on-road vehicle sources, including total emissions inventories, for a wide range of criteria, greenhouse gas and toxic pollutants. MOVES has since been updated to the current version, MOVES2014a, and also includes off-road emissions sources such as construction and agricultural equipment. MOVES is used in the U.S. primarily for development of the U.S. National Emissions Inventory and modeling uses required in the U.S. Clean Air Act, such as State Implementation Plan (SIP) inventories and transportation conformity analyses. Key features of MOVES are the following:

- MOVES has two output modes: **Inventory**, which produces either total emission inventories for specified geographic areas, or **Rates**, which produces emissions/distance emission rates; MOBILE produced only emission rates.

- MOVES can operate at three geographic scales: **National**, which estimates emissions at the nation, state or county level based on data already populated in the default database; **County**, meant for regional analysis and requiring input of basic vehicle fleet and activity data by the user; or **Project**, which estimates emissions at finite "hot spot" locations such as intersections, roadways or bus terminals.

- MOVES incorporates state-of-the-science data on car and truck emissions measured over the past decade. Sources of data include inspection programs for cars and light trucks, and portable emission measurement systems (PEMS) for heavy trucks. Research programs focused on understanding the impact of fuel properties on emissions, gasoline particular matter (PM) emissions and evaporative hydrocarbon (HC) emissions have been used to populate MOVES as well.

- Emission rates in MOVES are characterized with power-based operating mode, enabling flexibility to estimate emissions over different driving patterns such as congested vs. uncongested.

The goals in developing MOVES-Mexico were to enable the same model structure and functionality as the U.S. version of MOVES, for onroad emissions. To accomplish this, MOVES-Mexico was developed as a national default database for Mexico that can work directly the existing U.S. MOVES2014a software, replacing the U.S. national default database that is provided when the model is downloaded from the U.S. EPA website. No modification was made to the MOVES2014a software, so that software and technical tools provided by U.S. EPA can be relied on for MOVES-Mexico users as well. Using a Mexico national default database provides MOVES-Mexico users with the ability to estimate emissions at the national, state or *municipio* level, for multiple years, without needing to provide data. The default model can also serve as a foundation for users who want to use MOVES County Scale to improve local inventories with specific data, or even for "hot spot" modeling using MOVES Project Scale feature. **The offroad component of MOVES has not yet been updated to Mexico, and will not produce valid estimates for Mexico; users in Mexico should ignore this element of MOVES for now.**

Compiling a national default database for Mexico required a) nation-wide totals of vehicle fleet and activity inputs such as populations, kilometers travelled, age distribution and speeds; b) factors to allocate vehicle population and activity to the Mexican *municipios*; c) localized data on meteorology, fuels and vehicle inspection/maintenance and d) updated emission rates to reflect significant differences between U.S. and Mexican vehicle standards. The data and methods used to populate the MOVES-Mexico database are described in the technical report. This document covers model installation in Section 3; an overview of MOVES-Mexico in Section 4; and details on setting up and executing MOVES in Section 5.

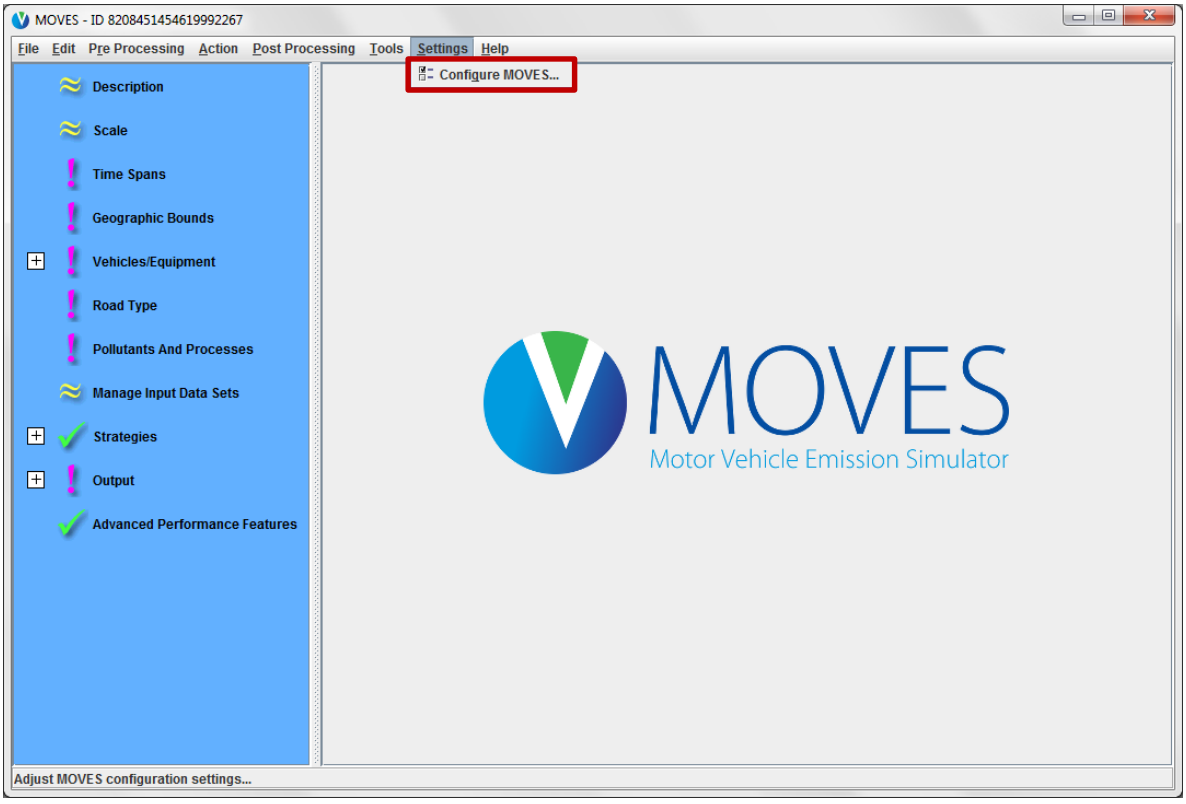
3.0 Installing MOVES-Mexico

MOVES-Mexico consists of a Mexico database that works directly with MOVES2014a. Therefore, the first step is to download MOVES2014a from EPA's website: http://www3.epa.gov/otaq/models/moves/#downloading-2014a. After downloading the installer, run the file **MOVES2014a-Setup-20151201.exe** and follow the on-screen instructions to complete the installation. During the installation process, MOVES will prompt you to choose a MySQL data directory. It is important to save or remember the location of this directory because it is where the Mexico database will need to be stored, described in the next step. A common MySQL data directory location is C:\MySQL\data, although the installer may suggest a longer path which you may accept or reject and set your own file path. Many MOVES users find it helpful to save a desktop shortcut to their MySQL data directory.

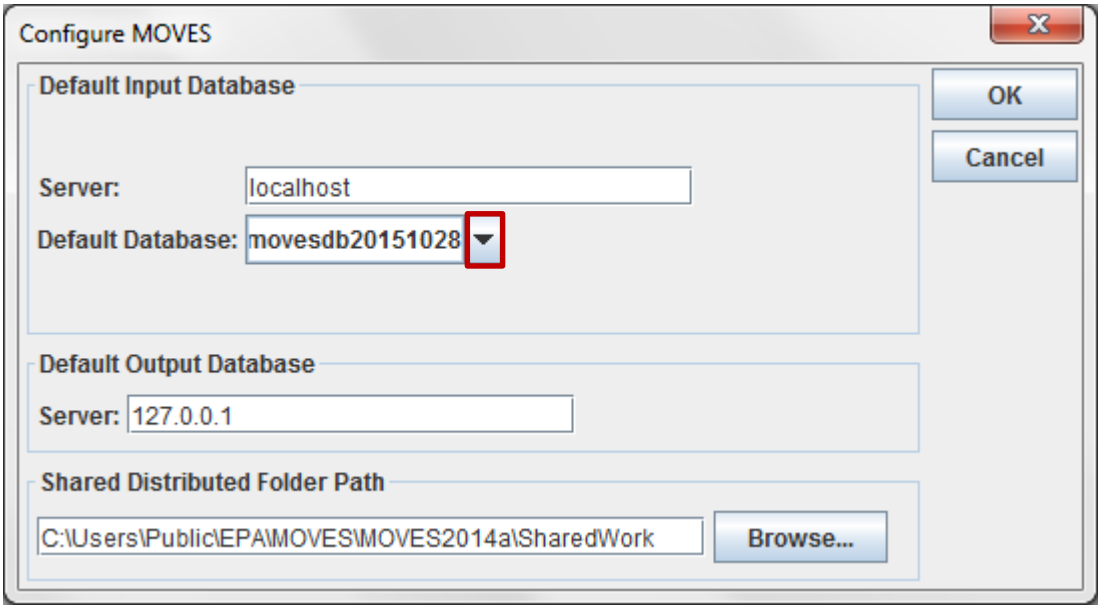
The second step is to download the Mexico-specific MOVES database. ERG provided the compressed file **movesmexdb20151028.zip** on the website ftp://ftp.erg.com/ (user name *movesmexico* and password *Move44Mexico*). The date imbedded in this filename – October 28 2015 - is set to match the date of the latest U.S. database, which is the basis of the MOVES-Mexico database. Download the file, unzip it, and move it to your MySQL data directory. Be careful that your archiving software does not introduce a duplicate directory layer of "movesmexdb20151028" when you unzip this database – for example:

Correct: C:\MySQL\data\movesmexdb20151028\agecategory.frm
Incorrect: C:\MySQL\data\movesmexdb20151028\movesmexdb20151028\agecategory.frm

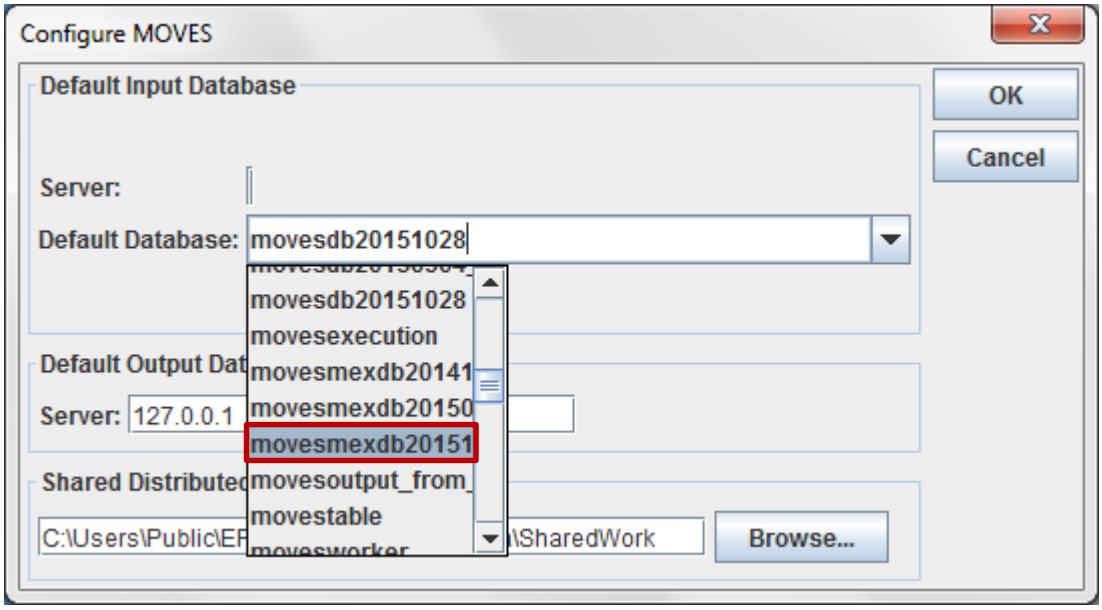
The final step is to configure MOVES2014a to read the Mexico database instead of the U.S. database. First, launch the MOVES2014a GUI from the start menu, desktop icon, or command line. On the top menu bar, click **Settings**, then click **Configure MOVES**.

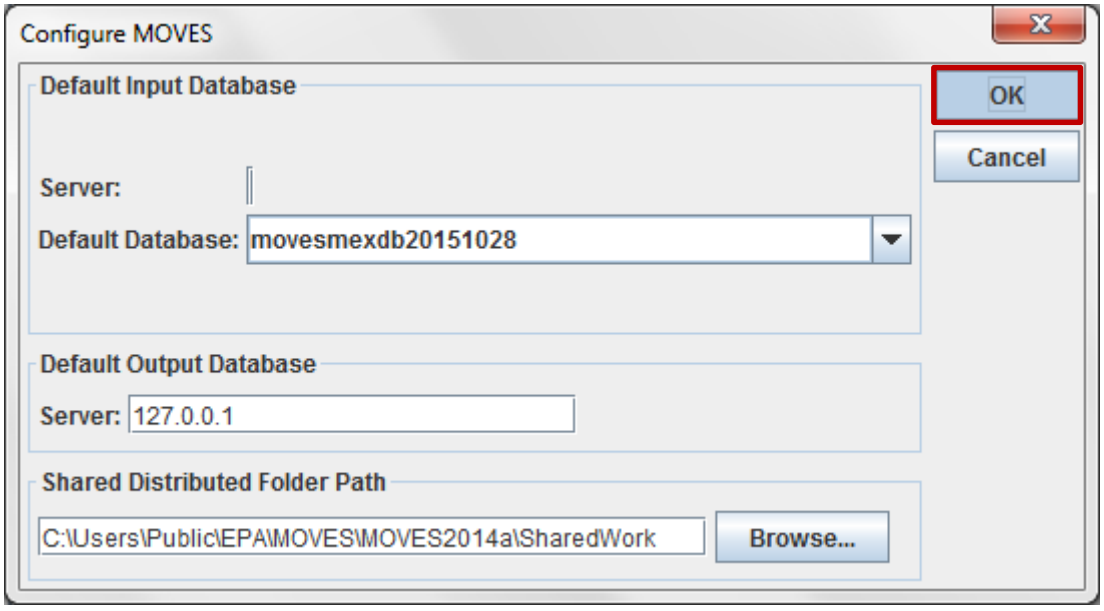


This action will launch a Configure MOVES pop-up window, shown below. Click the drop down menu adjacent to Default Database to reveal the list of all MySQL databases located in the MySQL data directory. By default, MOVES2014a reads the U.S. database **movesdb20151028.**

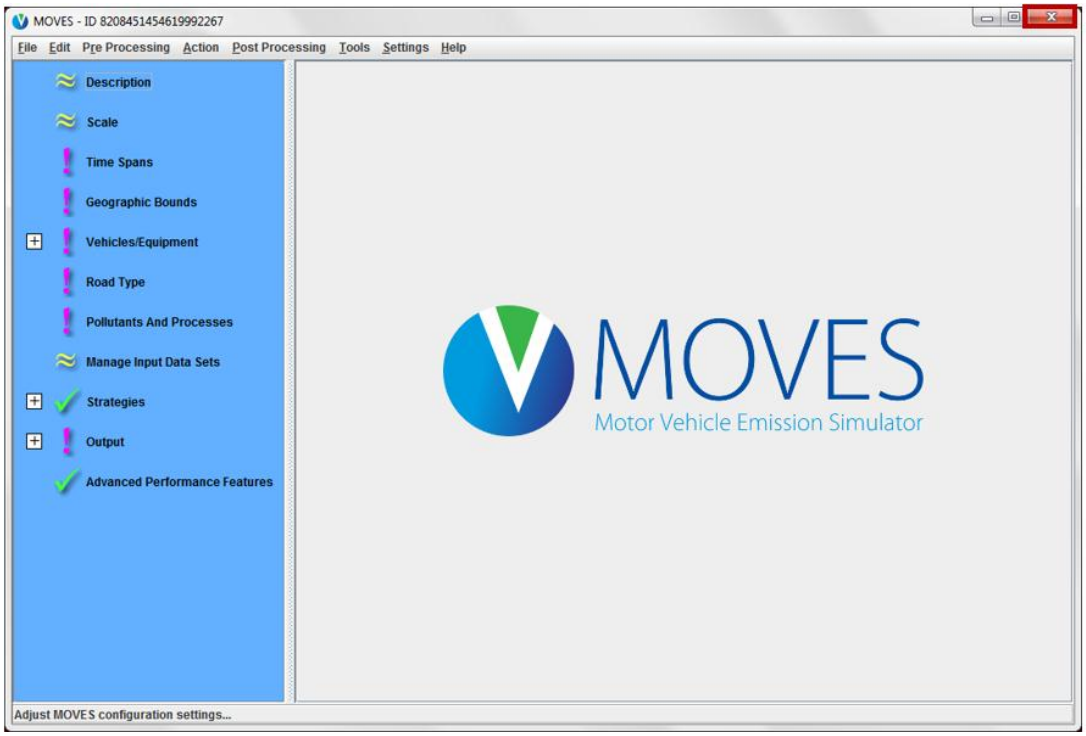


Use the scroll bar if necessary to find the Mexico database named **movesmexdb20151028**, click it to select, and then click **OK**.





At this point, the GUI will appear to freeze for a few moments; this is expected because MOVES is performing checks on the new database. When the configuration is complete, the Configure MOVES window will close. Finally, it is important to close and re-open the MOVES GUI. To close the GUI, click on the red X at the upper right corner of the screen. This step will refresh the lists of fuels and vehicles, etc., so that options in the GUI panel are specific to Mexico.



Each time MOVES is launched from now on, it will point to the Mexico database.

4.0 Unique Elements of MOVES-Mexico

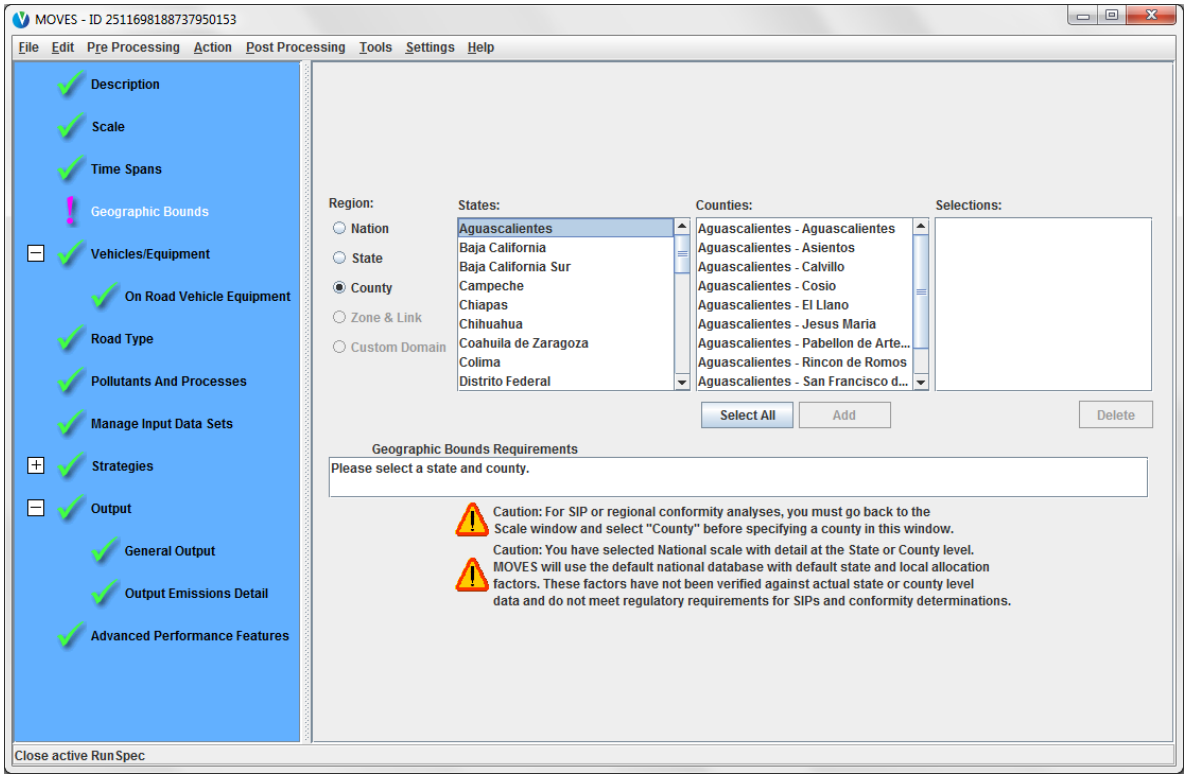
Chapter 1 of the U.S. MOVES User Guide and the User Interface Reference provide an overview of each option in the GUI. This section highlights only what is unique about MOVES-Mexico. The specific parts of the MOVES interface that differ for Mexico are the following sections of the Navigation Panel: (1) Geographic Bounds, (2) Vehicles/Equipment, (3) Road Type, and (4) Pollutants and Processes.

As discussed in Section 2, MOVES has three scales – National, County, and Project. Table 1 shows the geographic options for each of these. For a National Scale run, you may run all of Mexico as a single area, or alternatively one or more states or *municipios* within a single run. In contrast to the National Scale, the County and Project scales may run only one *municipio* or custom domain per run. The custom domain option in MOVES is not used often, and we do not expect most users of MOVES-Mexico will use it. For more information on this, see Chapter 4 of the U.S. MOVES User Guide.

Table 1: Geographic Bounds Panel's Region Choices

Scale Panel Selection	Options for Geographic Bounds Panel Regions
National	Nation – all of Mexico
	State – select one or more states
	County – select one or more *municipios*
County	County – select one *municipio*
	Custom Domain
Project	County – select one *municipio*
	Custom Domain

The only difference between U.S. and Mexico MOVES regarding geographic bounds is that that County corresponds to *municipios* instead of U.S. counties. The screenshot below shows the Geographic Bounds panel of a National Scale run with the County option populated with the Mexico states and *municipios*. Note that accent marks and symbols are not included in the names because the GUI is unable to open a saved input file (or "RunSpec" for run specification) with these characters.



The next portion of the MOVES-Mexico GUI that differs from the U.S. version is the Vehicles/Equipment panel. Table 2 lists MOVES vehicle classes, known as "source use types" (or alternatively, "source types"), and how they relate to the native Mexico vehicle classes that INECC provided data for. The simplest mapping is motorcycles, a one-to-one relationship. Mexico vehicles classified as Passenger Car or Taxi are combined and represented by one MOVES source type, Passenger Car. Similarly, the Mexico categories Buses and Microbus/Midibus are combined and represented by the Transit Bus source type. The remaining Mexico vehicle categories map to multiple MOVES source types, as shown below in Table 2. Where Mexico vehicle classes map to multiple source types, the percentage split between source types is shown (refer to the MOVES-Mexico technical report for explanation of how these percentages were determined). Four additional U.S. source types are not used in Mexico, because they were not included in the Mexico vehicle data: intercity bus, school bus, refuse trucks and motorhomes. These are not visible in the Vehicle/Equipment panel for MOVES-Mexico.

Table 2 also shows the numerical identification (Source Type ID) associated with each source type. As discussed in Section 6, MOVES uses such numerical codes in the input and output databases for model parameters (including states, municipios, pollutants, and emission processes) for more efficient model processing. A key for understanding the numerical codes is contained in Appendix A of the MOVES2014a User's Guide ("MOVES Onroad Decoder").

Table 2: Mexico Vehicle Classes Mapped to MOVES Source Types

Source Type ID	MOVES Source Use Type	Mexico Vehicle Classes mapped to MOVES Source Use Type
11	Motorcycle	Motorcycles
21	Passenger car	Passenger cars
		Taxi
31	Passenger Truck (97%)	Public transport light truck Pickup trucks Trucks with GVW < 3 ton
32	Light Commercial Truck (3%)	
42	Transit Bus	Buses
		Microbus/Midibus
52	Single Unit Short-haul Truck (96%)	Trucks with GVW > 3 ton
53	Single Unit Long-haul Truck (4%)	
61	Combination Short-haul Truck (49%)	Trailer trucks
62	Combination Long-haul Truck (51%)	

Another element of MOVES-Mexico that differs from the U.S. MOVES User Guide is the definition of road types. While MOVES-Mexico uses the same road types as U.S. MOVES, the mapping of Mexico roadway designations to these road types is unique to Mexico. Table 3 shows the five road types listed in the Road Type panel of the GUI (along with the numerical code used in the input and output databases, RoadTypeID), and the description.. The Off-Network road type only includes start exhaust and resting evaporative emissions; it excludes extended idle emissions because extended idle activity is unique to the U.S.

Table 3: Available Road Types in the Road Type Panel

RoadTypeID	Road Type	Definition for MOVES-Mexico
1	Off-Network	Captures emissions that occur while the vehicles are not moving: start exhaust and resting evaporative emissions.
2	Rural Restricted Access	Captures running emissions, including running evaporative emissions. Restricted indicates limited vehicle access via ramps. Examples include *boulevard, circuito, periferico, viaducto,* and *carretera.*
3	Rural Unrestricted Access	Captures running emissions, including running evaporative emissions. Unrestricted indicates all other roads not included in Restricted. Examples include *avenida, calzada, calle, ampliacion, callejon, cerrada, circunvalacion, continuacion, corredor, diagonal, eje vial, privada, prolongacion,* and *retorno.*
4	Urban Restricted Access	Captures running emissions, including running evaporative emissions. Restricted indicates limited vehicle access via ramps. Examples include *boulevard, circuito, periferico, viaducto,* and *carretera.*
5	Urban Unrestricted Access	Captures running emissions, including running evaporative emissions. Unrestricted indicates all other roads not included in Restricted. Examples include *avenida, calzada, calle, ampliacion, callejon, cerrada, circunvalacion, continuacion, corredor, diagonal, eje vial, privada, prolongacion,* and *retorno.*

The final GUI navigation panel that differs for Mexico is the Pollutants and Processes panel. MOVES-Mexico includes all the emission processes of the U.S. except for Extended Idle Exhaust, Crankcase Extended Idle Exhaust, and Auxiliary Power Exhaust, because these emissions are all associated with hotelling, an activity unique to the U.S. These three emission processes do not appear in the MOVES-Mexico GUI.

5.0 Running MOVES-Mexico

5.1 Overview

All MOVES runs require a choice of (1) scale and (2) calculation mode in the Scale panel of the GUI. The calculation mode Inventory generates mass emissions in a specific geographic area over specific time period (e.g., kilograms of NO_X per day in Aguascalientes), while Rate mode generates lookup tables of emission factors (e.g., grams/mile NO_X) over a wide range of conditions of temperature, vehicle speed bins, hour of the day, etc. An Inventory mode run is the more common approach and simpler than a Rate mode MOVES run, where emission factor lookup tables are used to develop detailed emission inventories outside of MOVES. An example application of a Rate mode MOVES run would be to use the lookup tables with data from a travel demand model to calculate emission inventories by "link" or roadway segment.

As previously mentioned in Sections 2 and 3, one of the first choices a user must make running MOVES is the scale of the model run – National, County, or Project. The next three subsections are devoted to each of these scales. The National Scale subsection goes in to the most detail because it is not as thoroughly addressed in the U.S. MOVES User Guide as the County or Project scales. We provide a detailed example of how to set up a National Scale RunSpec file with step-by-step instructions, including how to replace any type of data in the default database using the model's data importers. The County Scale and Project Scale user instructions are described in great detail the U.S. MOVES documentation, and their functionality does not change for MOVES-Mexico.

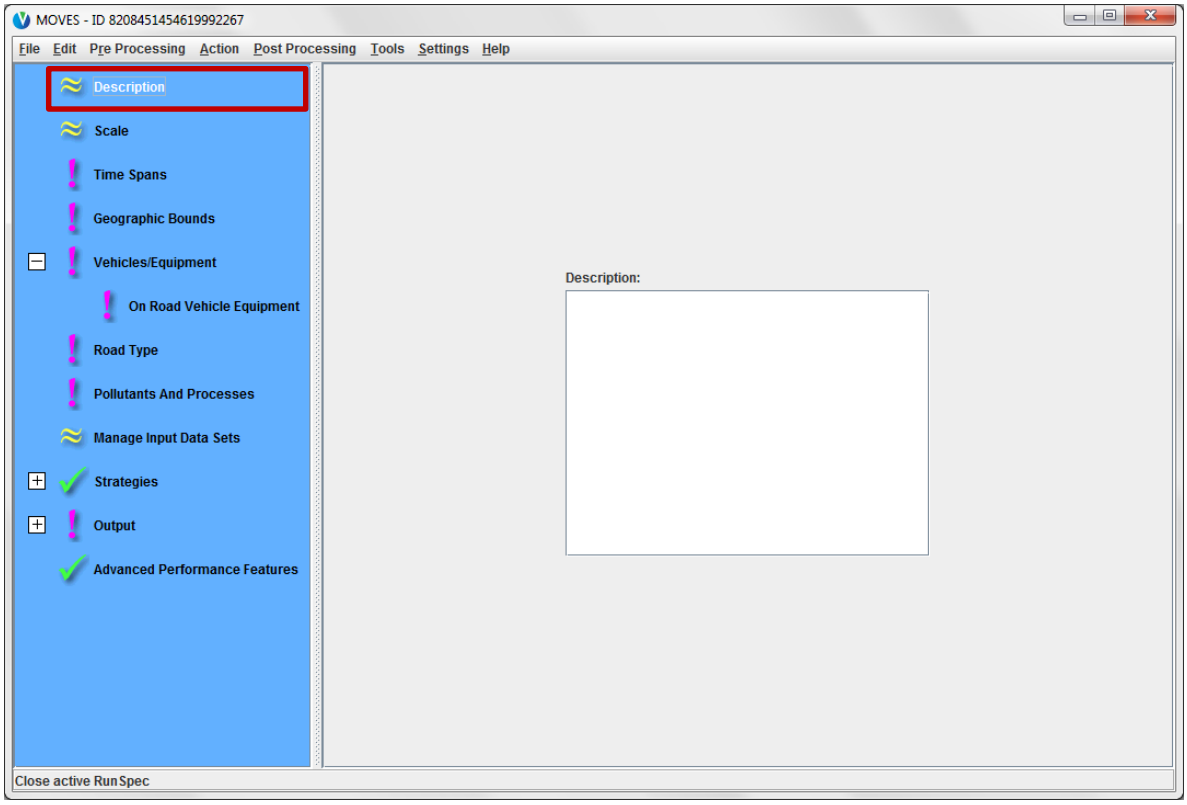
5.2 National Scale

There are no required data inputs for a National Scale run, but any number of data tables may be updated optionally. This section provides quick instructions on how to set up a new MOVES run and how to optionally update the fuel supply table for a National Scale run. The same procedure for replacing the default fuel supply may be applied for other data tables.

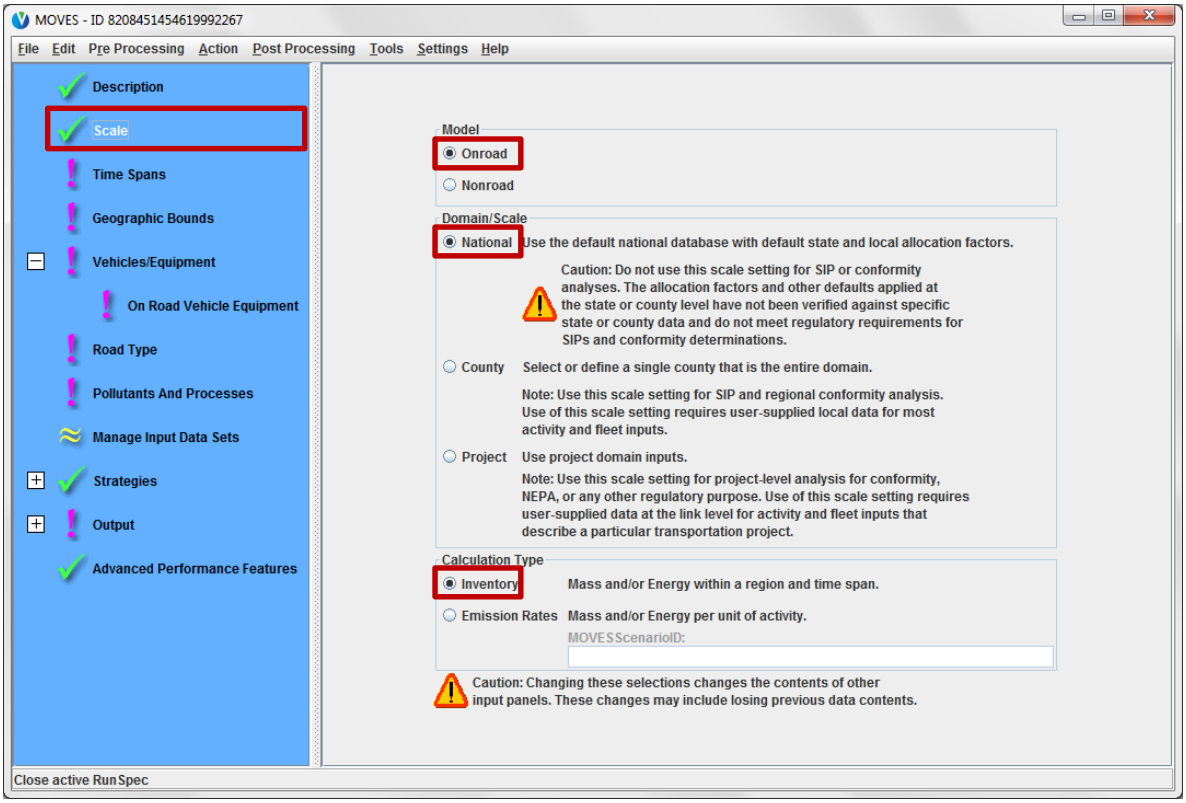
5.2.1 Setting up a RunSpec - Example

Prior to introducing any local data to MOVES, it is best practice to completely fill out a RunSpec file. By completing a RunSpec prior to importing data, the GUI's filters can assist you in providing the correct level of detail in your data for the particular run. Here we provide an example that will estimate NOx emissions for gasoline passenger cars in Canales municipio, Durango, from 8-9am for a typical weekday in July 2013.

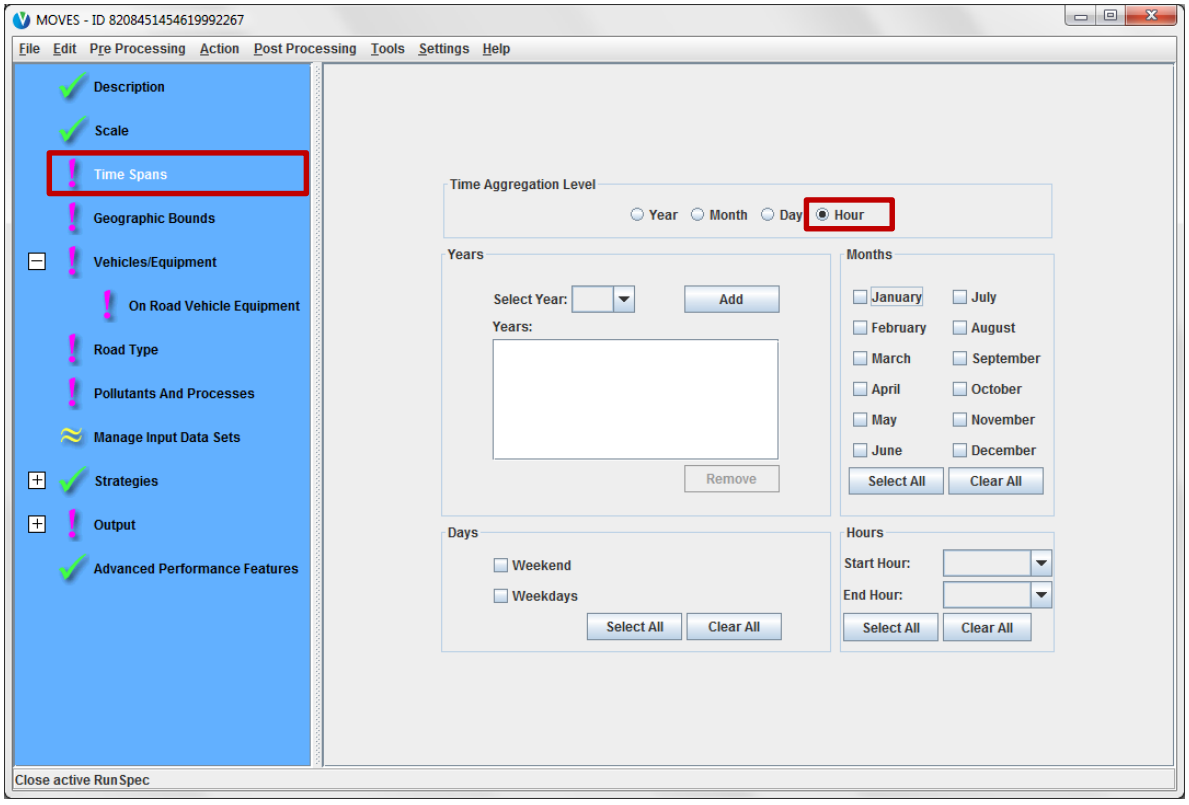
First, launch the GUI and click on Description in the navigation panel. In the white text box, you may optionally enter a description of your run that will be carried to the MOVES output database and is useful for keeping track of the purpose or scope of a given run.



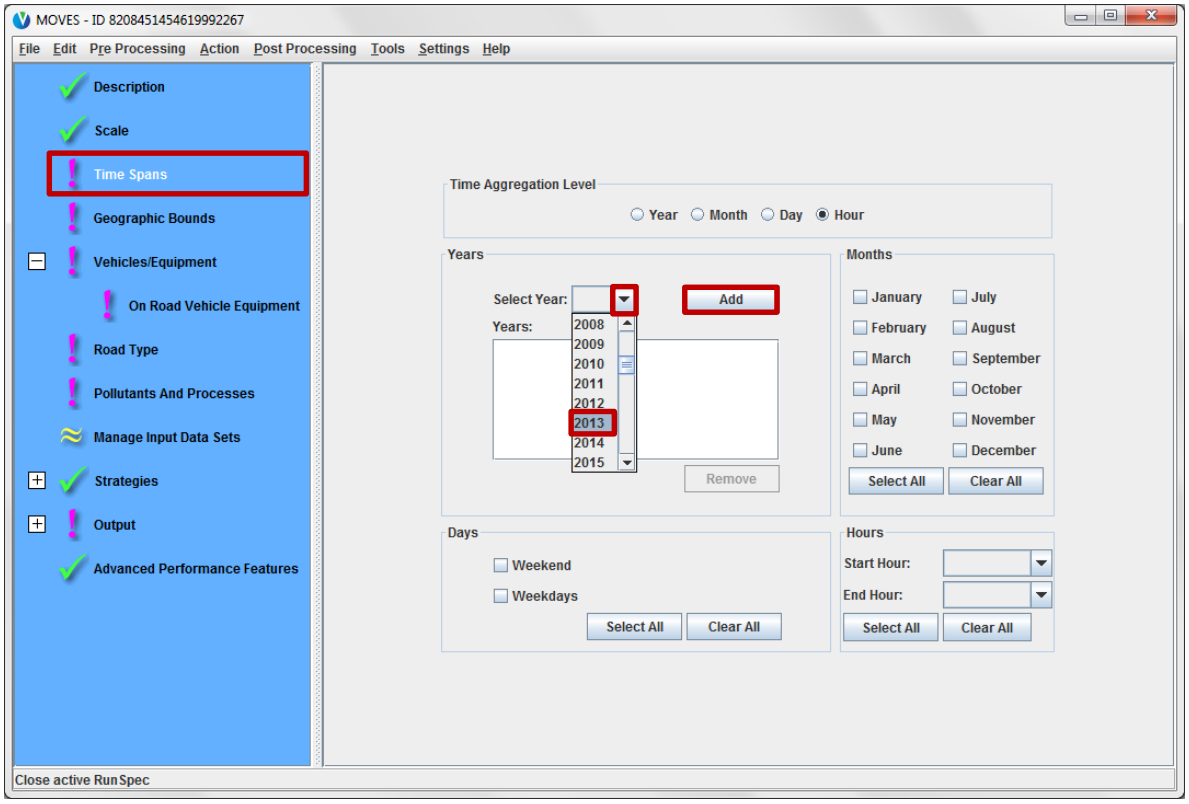
Next, click the **Scale** panel. Choose Onroad (Nonroad doesn't work in MOVES-Mexico), National, and Inventory.



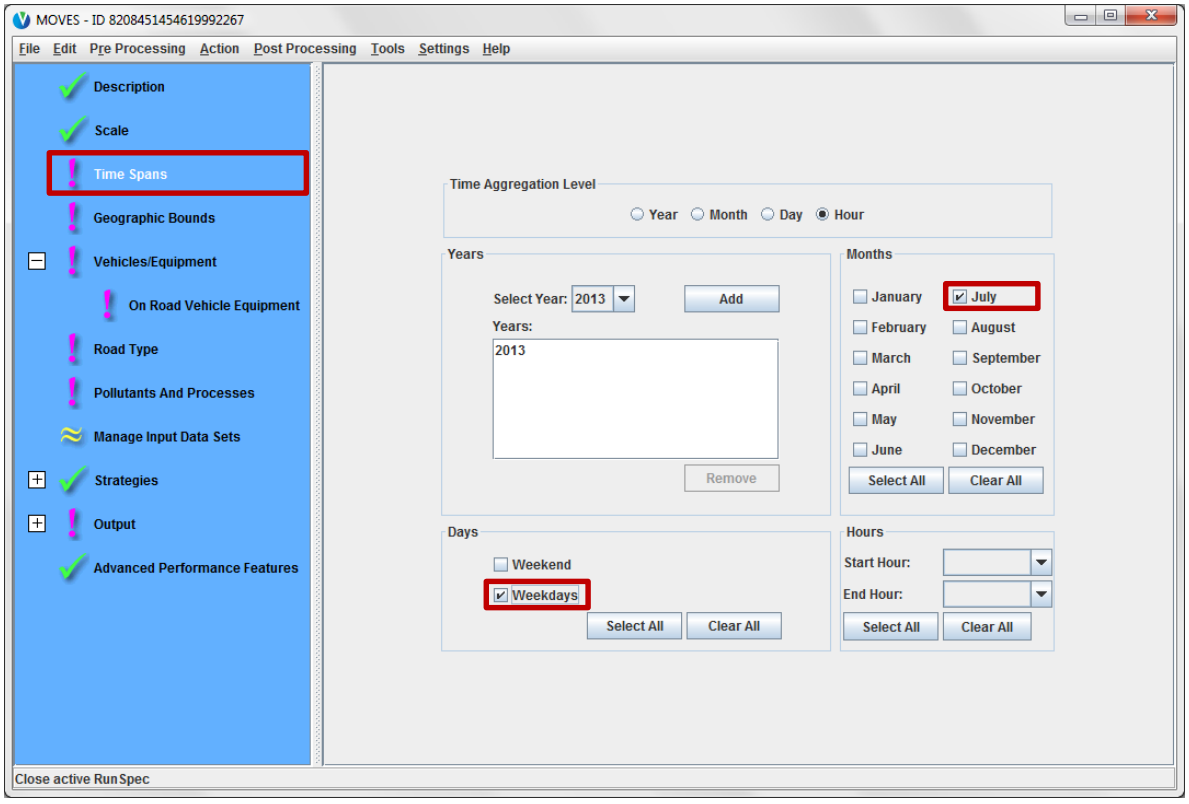
Next click on the Time Spans panel. There are four subpanels with options– Time Aggregation Level, Years, Months, Days, and Hours. Under Time Aggregation Level, choose Hour.



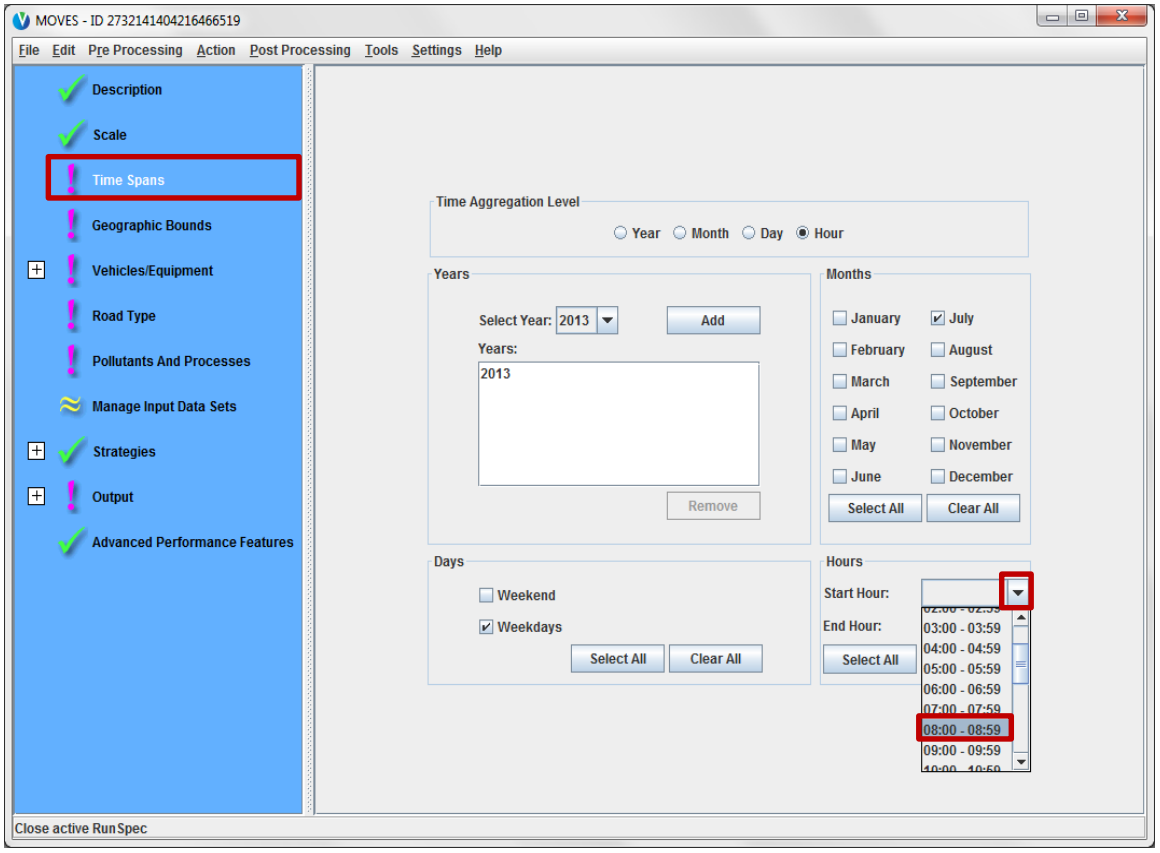
Under Year, you may select one or more years to include in the run. Use the drop down menu to select 2013 from the list and click **Add**.



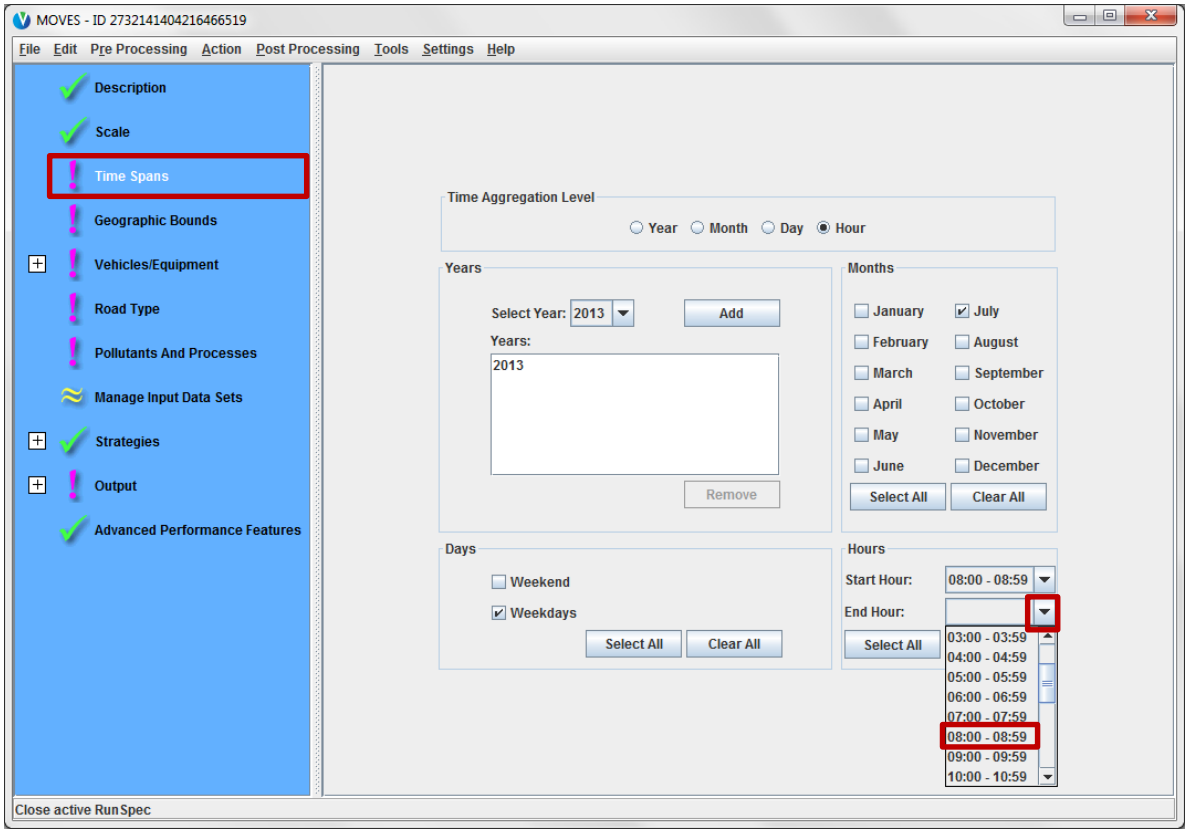
Under Months, you may click one or more months. You may also select Weekdays, Weekend or both day types under the Days subpanel. Click the boxes next to July and Weekdays.



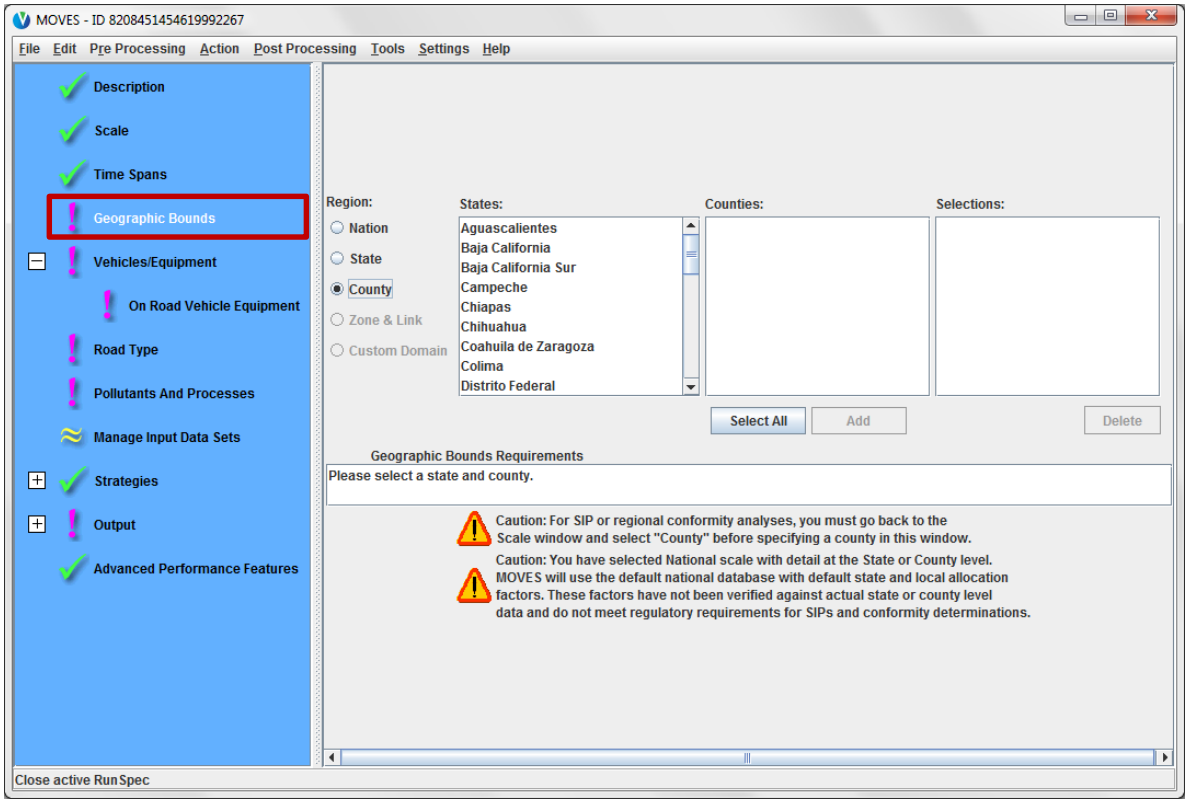
Under Hours, you may run one or more hours. For this example, use the drop down menu to select the hour 08:00-08:59 adjacent to the Start Hour.



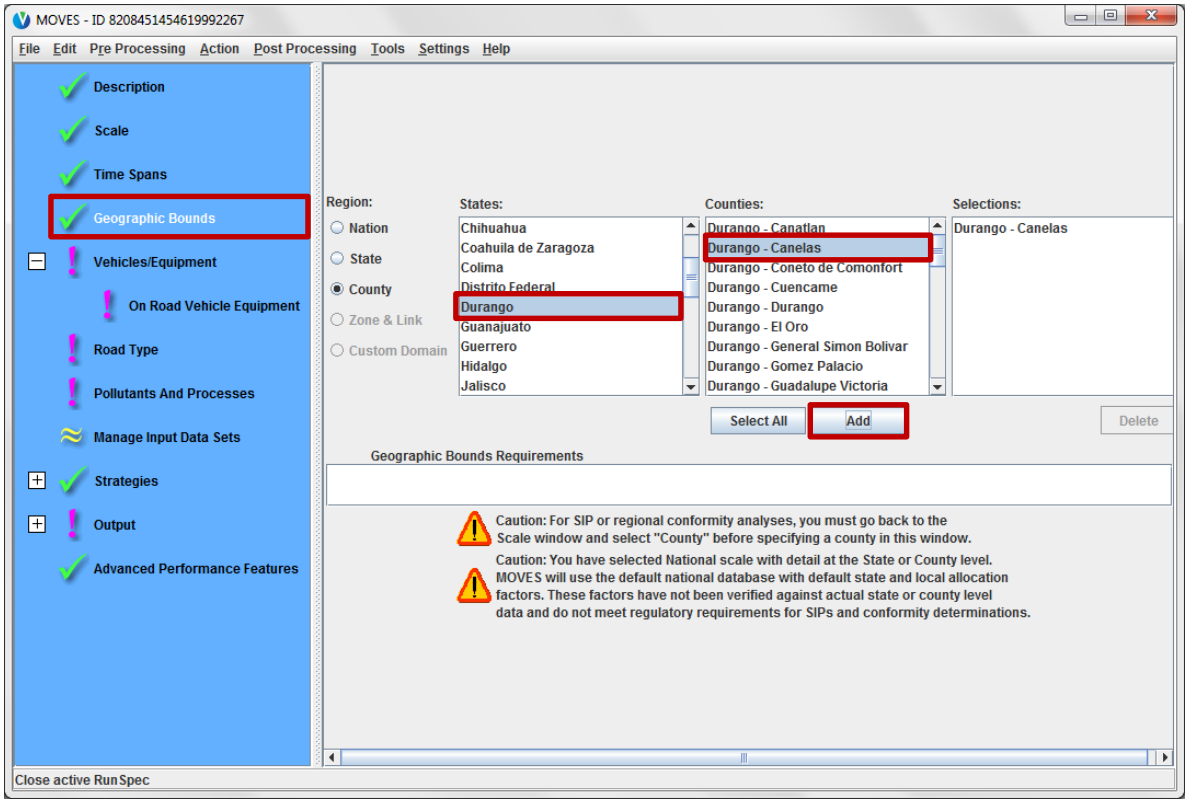
Repeat this step for the End Hour. Using the same start and end hour will result in emissions being estimated for just that hour.



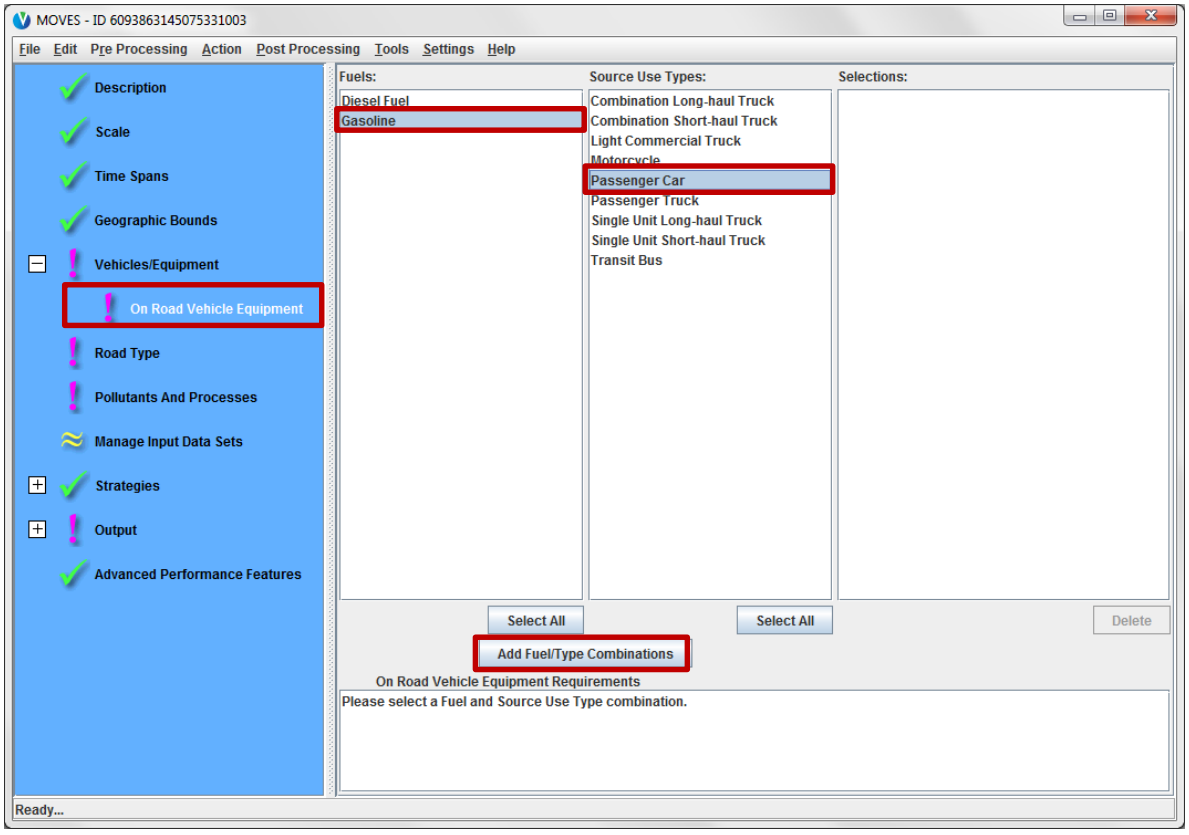
Select the Geographic Bounds panel next. By default, the County option should be checked and a list of Mexico states should appear.

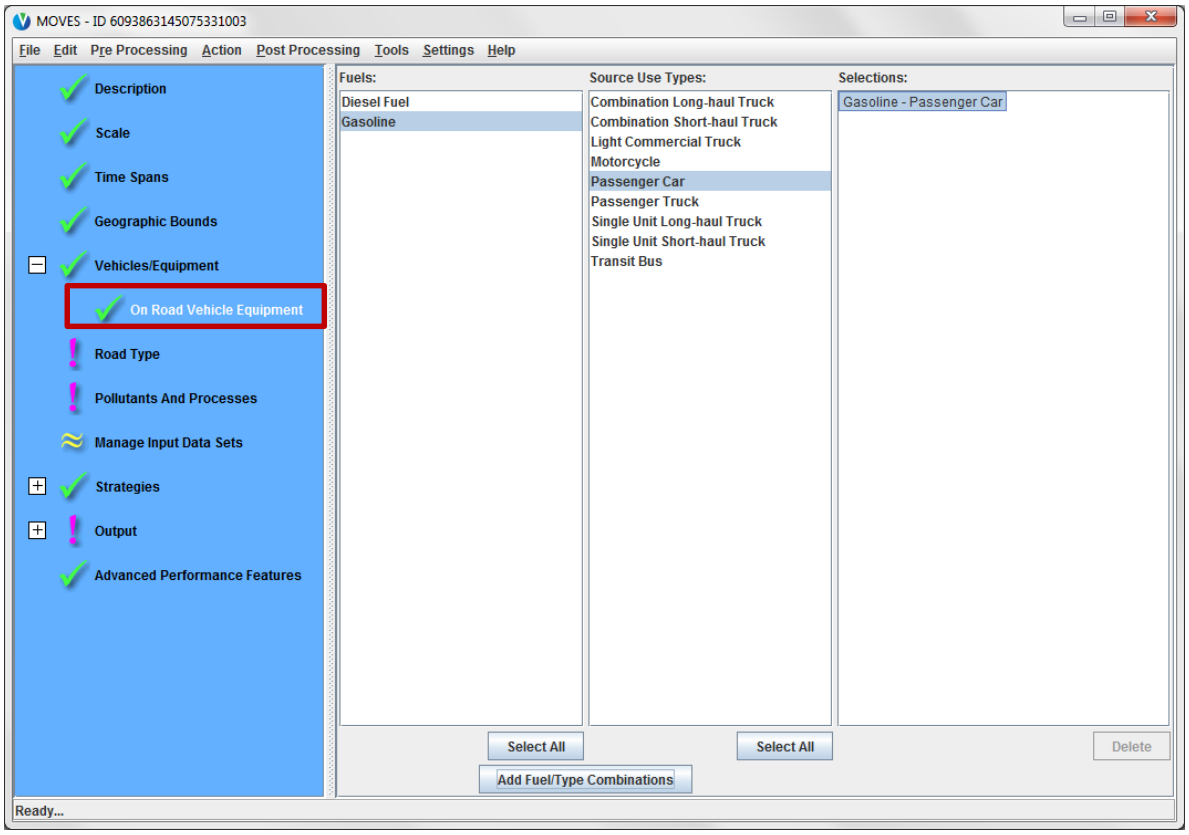


Scroll through the list of states and click on Durango, which will populate the list of *municipios* in the state. Click the *municipio* Canelas, then click **Add** to include the *municipio* in the Selections box.

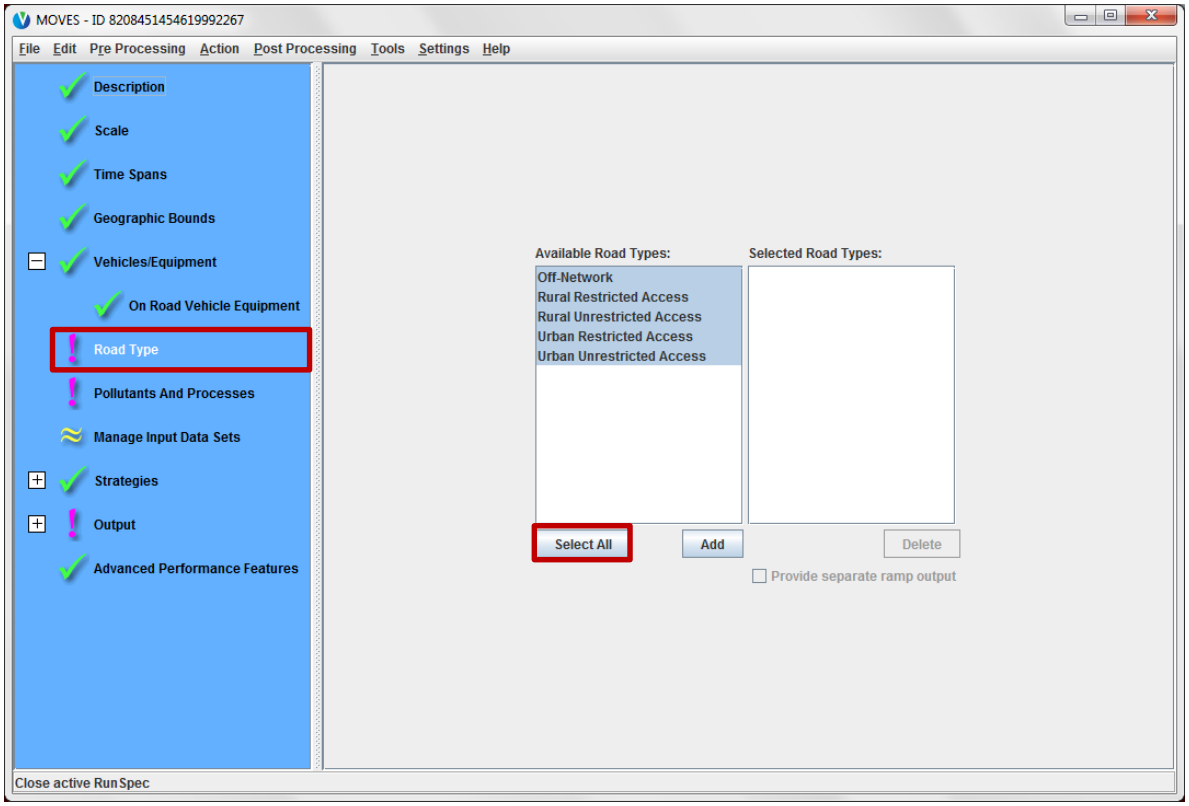


Now move on to the Vehicles/Equipment panel. Under Fuels, click Gasoline and under Source Use Types, click Passenger Car. Then click the **Add Fuel/Type Combinations** button to add this to the Selections box.

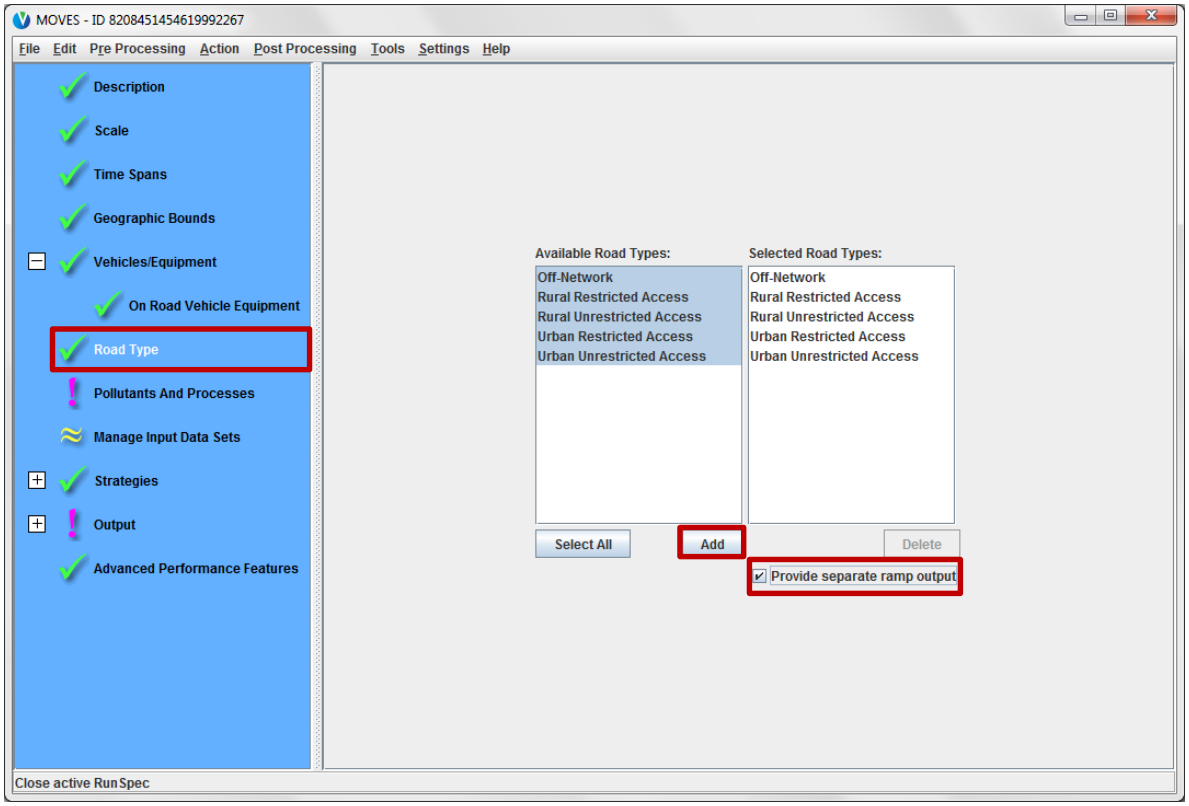



MOVES - ID 6093863145075331003
File Edit Pre Processing Action Post Processing Tools Settings Help
Description
Scale
Time Spans
Geographic Bounds
Vehicles/Equipment
On Road Vehicle Equipment
Road Type
Pollutants And Processes
Manage Input Data Sets
Strategies
Output
Advanced Performance Features
Fuels:
Diesel Fuel
Gasoline
Source Use Types:
Combination Long-haul Truck
Combination Short-haul Truck
Light Commercial Truck
Motorcycle
Passenger Car
Passenger Truck
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus
Selections:
Gasoline - Passenger Car
Select All
Select All
Delete
Add Fuel/Type Combinations
Ready...

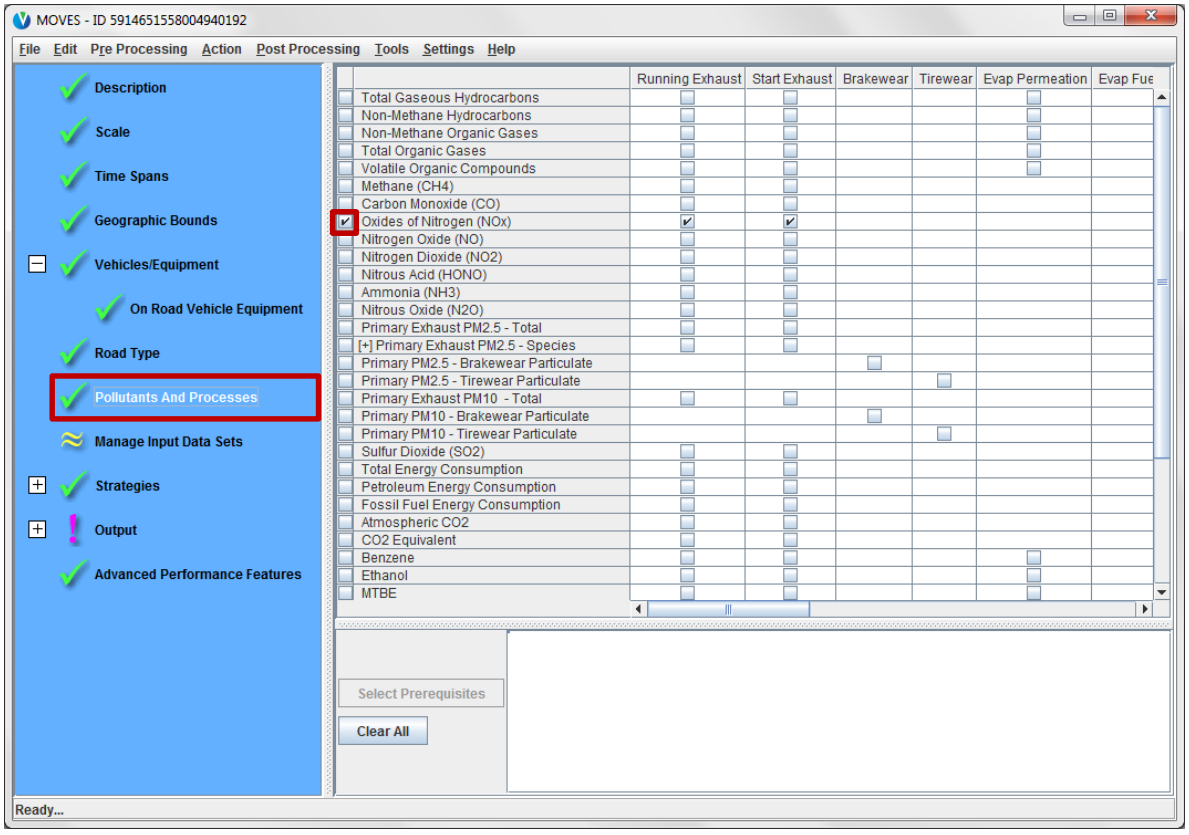
In the Road Type panel, click the **Select All** button to include all road types for the Selected Road Types box.



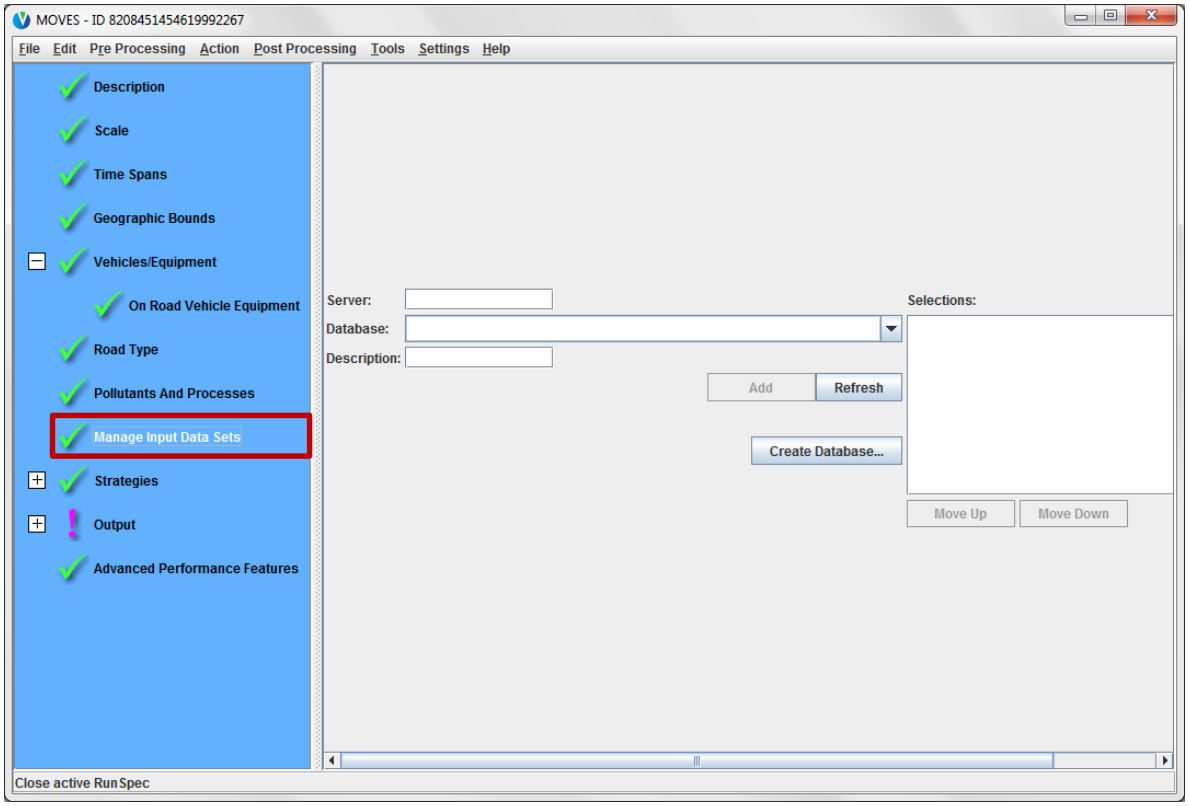
Next click **Add** and check the box for **Provide separate ramp output.** The last check box is optional. If you do not check the box, MOVES will include activity and emissions for freeway on and off ramps as part of the inventory listed for Rural Restricted Access and Urban Restricted Access roads.



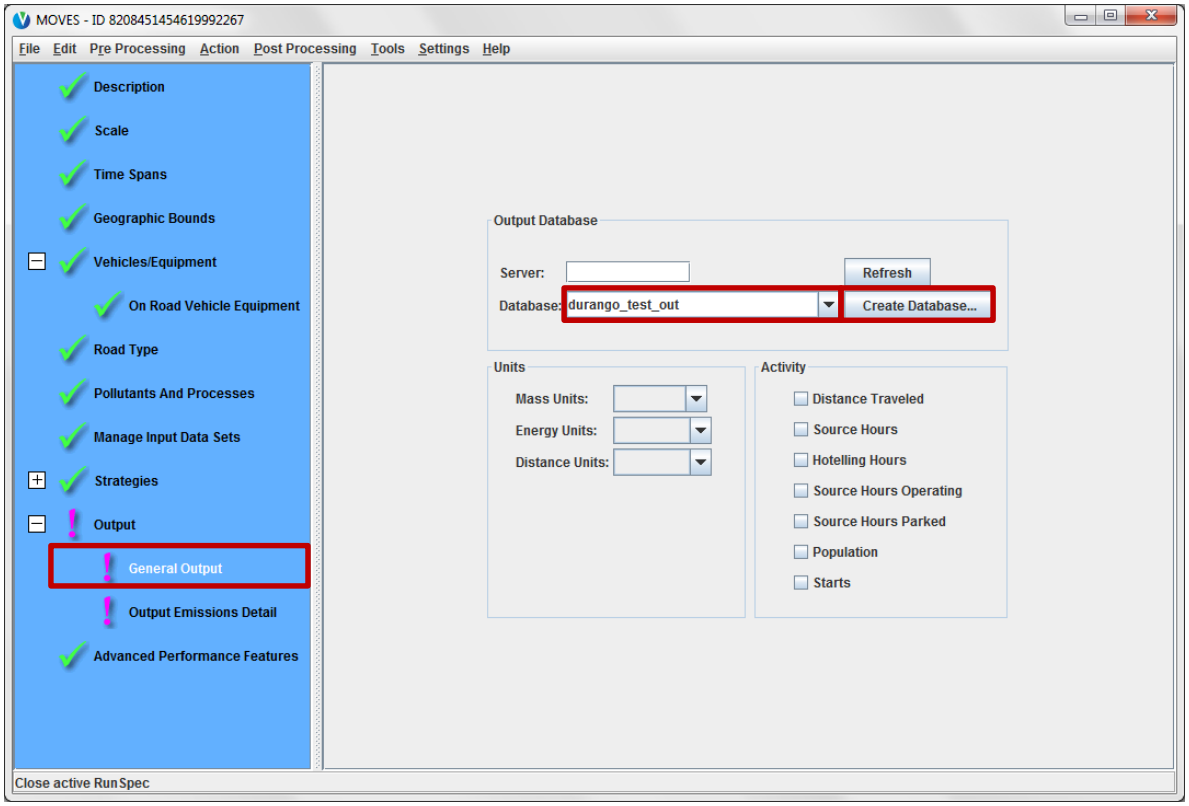
In the Pollutants and Processes panel, click the box to the left of Oxides of Nitrogen (NOx). This leftmost column of boxes automatically checks all emission processes for the pollutant, located to the right of each pollutant name.



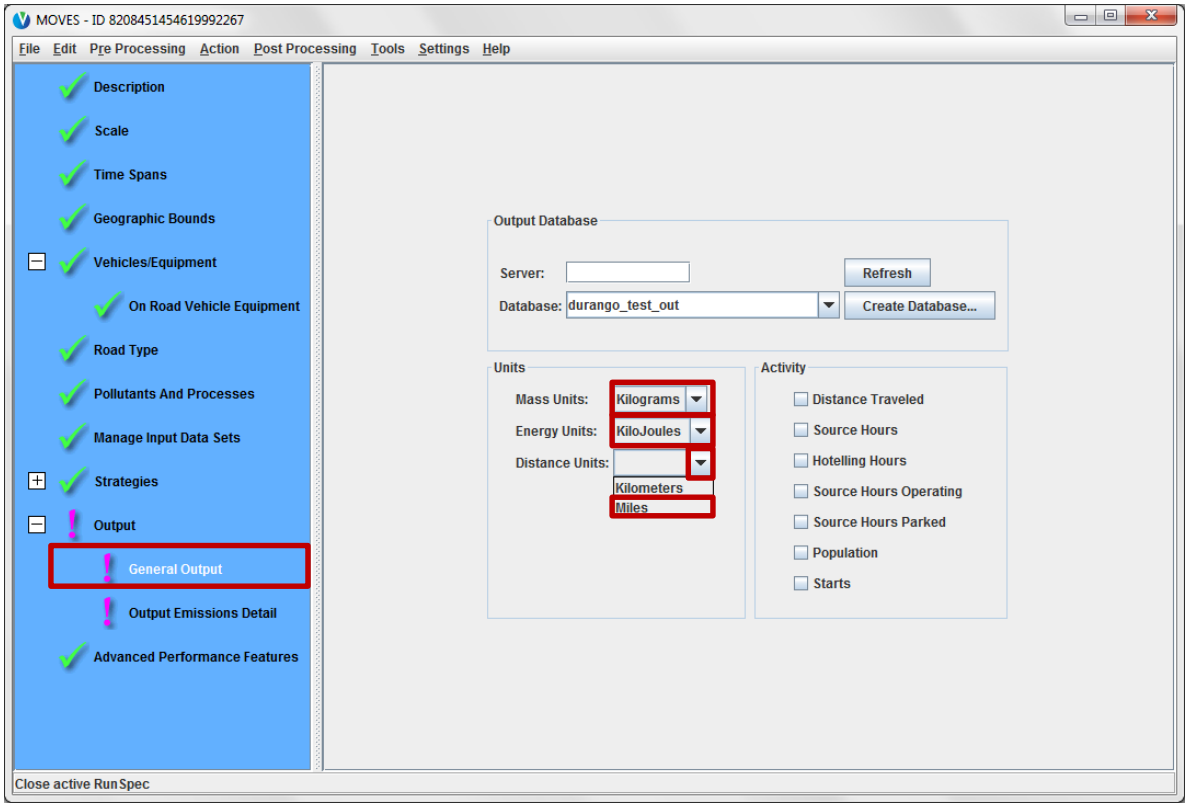
Click on the Manage Input Data Sets panel. This panel is used to read in alternate database inputs, but is not required, and we won't use it for this example. To read more about Manage Input Data Sets, refer to page 17-18 of the U.S. User Interface Reference. Skip the Strategies panel; it relates to U.S. emissions scenarios that remove the effects of the U.S. Clean Air Act.



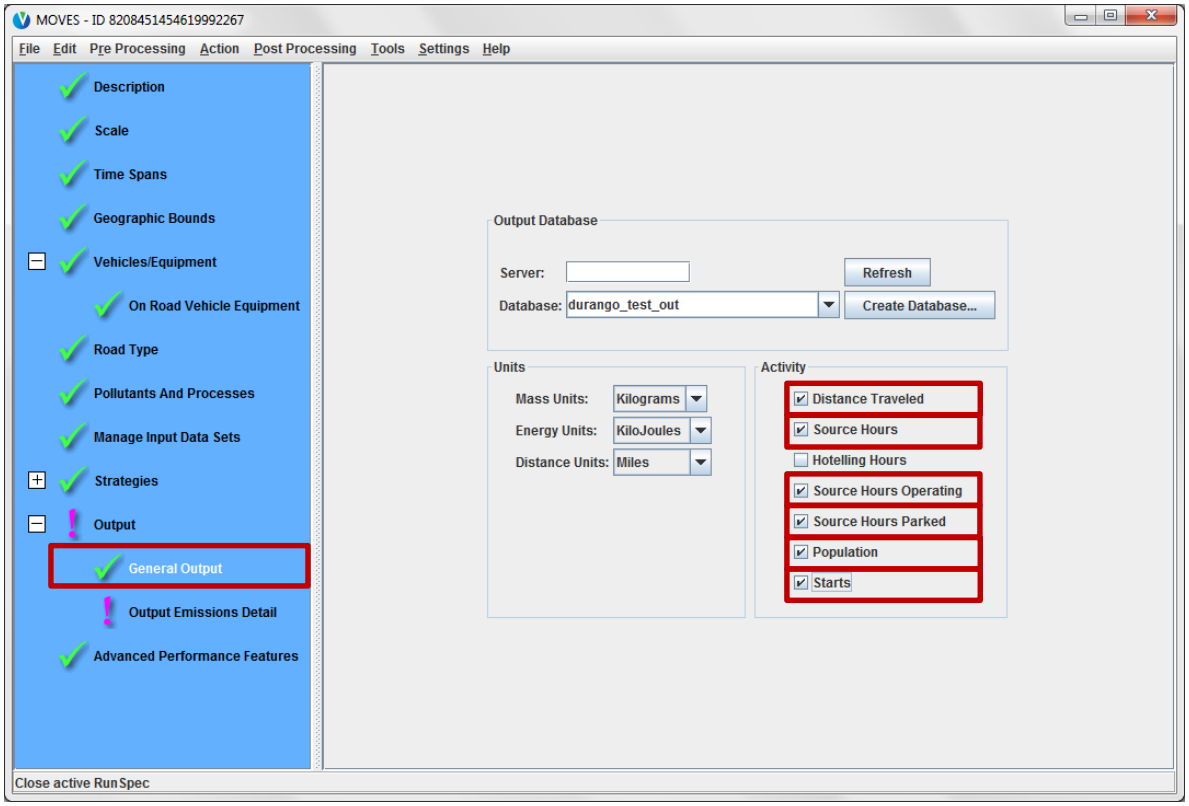
Expand the Output panel and click on the General Output panel. In the text box adjacent to Database, enter your desired database name then click the **Create Database** button.



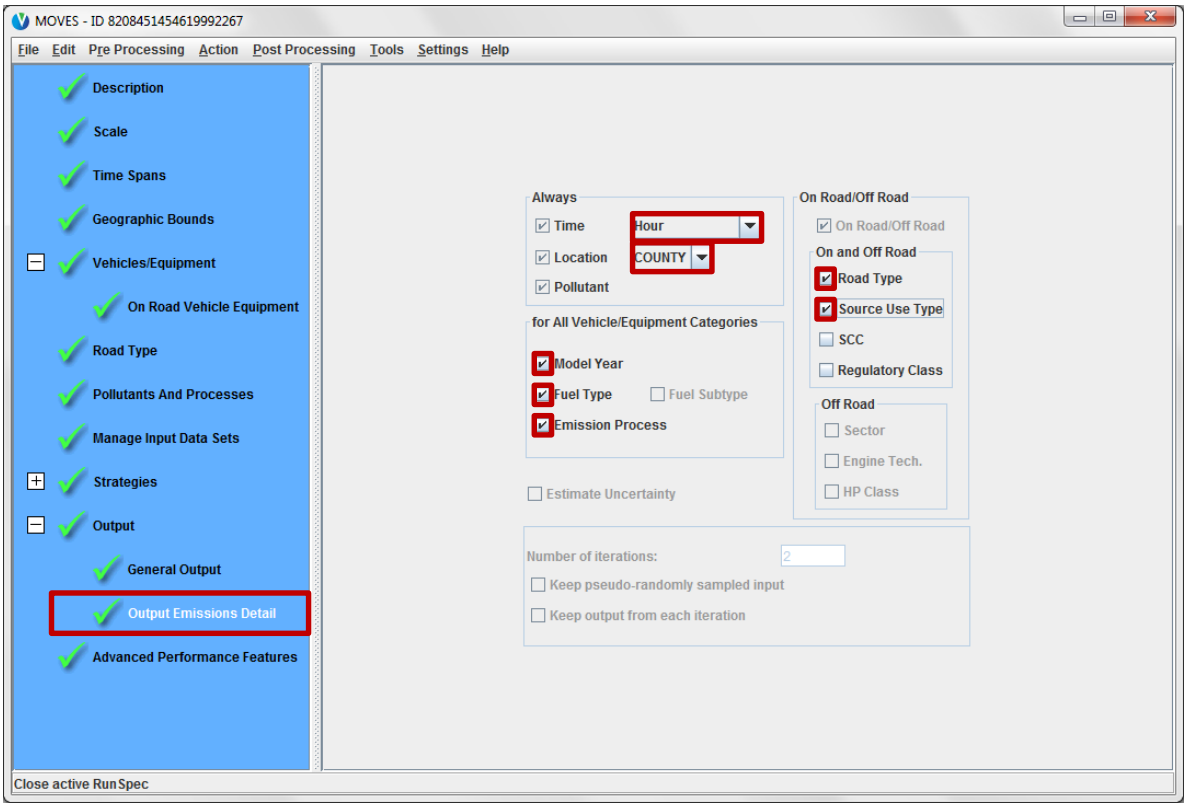
Chose units for mass, energy, and distance using the drop down menus.



Click on each activity type available in MOVES-Mexico to include in the output database. Note that Hotelling Hours is not enabled for Mexico.



Next click on the Output Emissions Detail panel. Under the Always subpanel, choose Hour and COUNTY from the drop down menus so that the results will be listed by hour and *municipio*. Under the All Vehicle/Equipment Categories subpanel click the boxes next to Model Year, Fuel Type, and Emission Process. These selections will include the level of detail in the outputs. If you do not select them, MOVES will aggregate emissions and activity results over these categories. Under the On and Off Road subpanel, click Road Type and Source Use Type to include this level of detail.

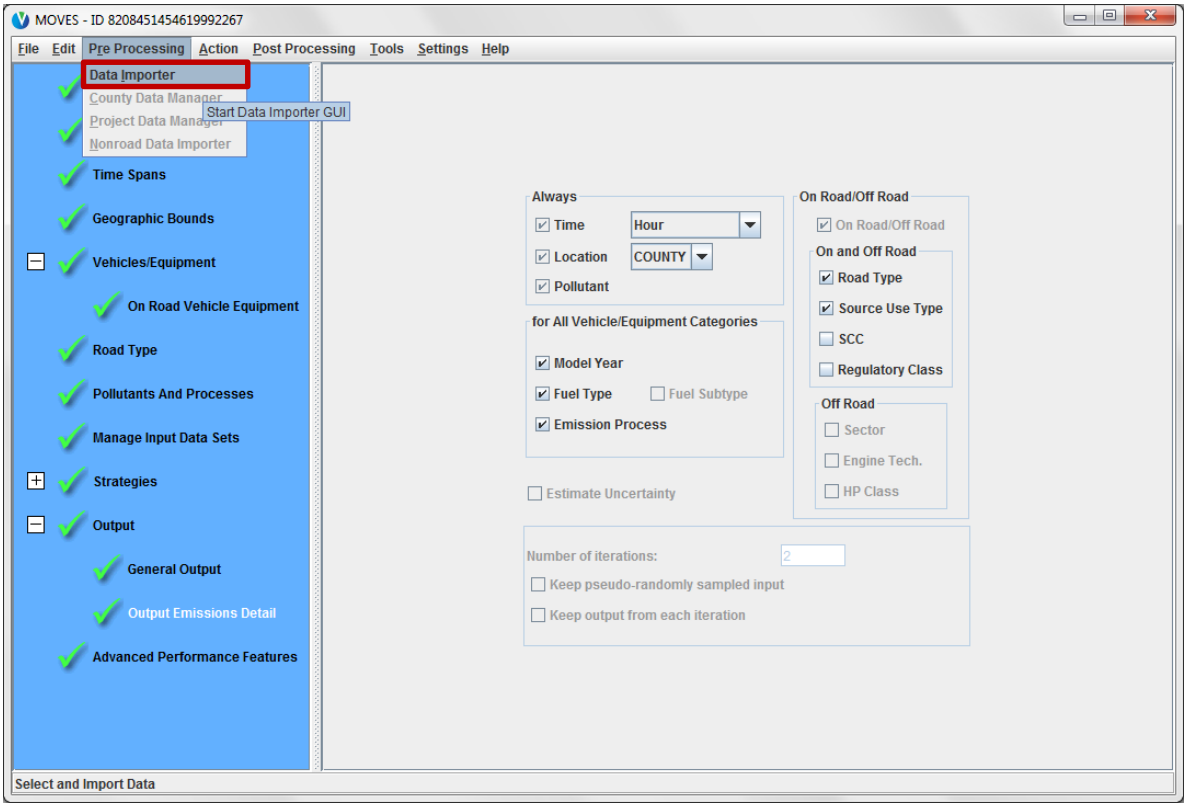


Skip the Advanced Performance Features panel. Most users do not need this feature of MOVES, but more information can be found on page 26 of the U.S. User Interface Reference.

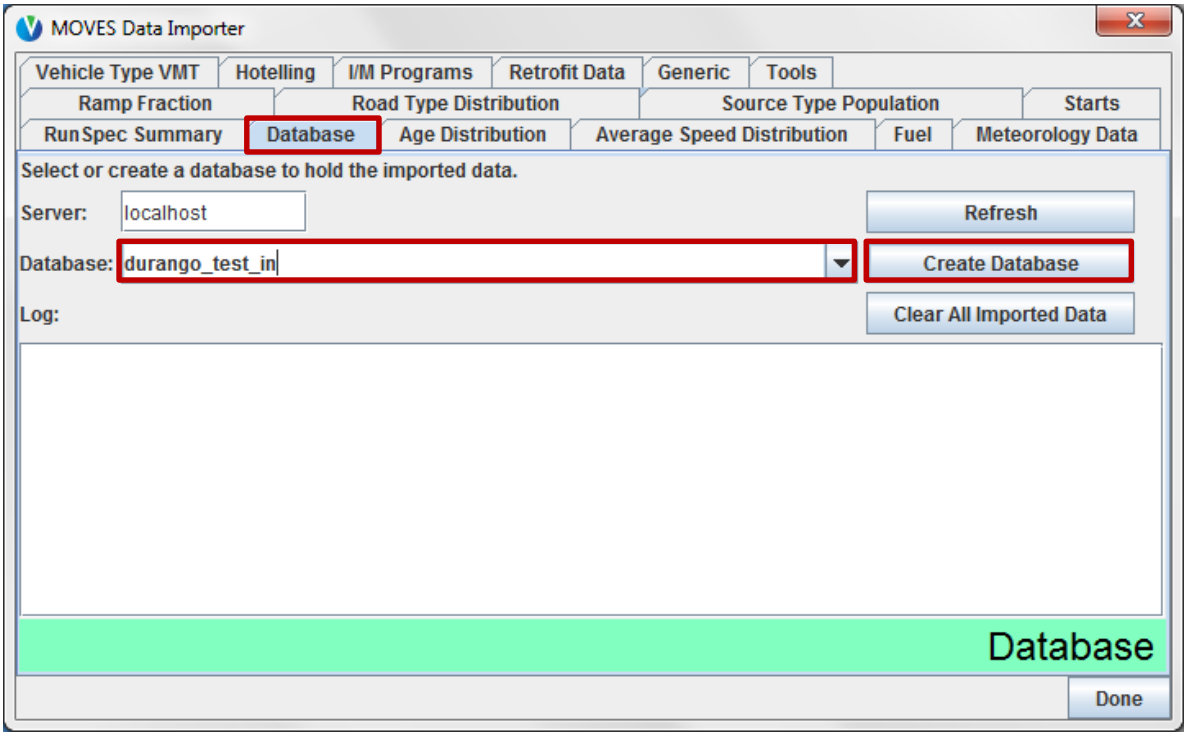
5.2.2 Optional Data Customization – Example

At this stage, the RunSpec file is complete, and the model could be executed by choosing Execute from the Action menu, as shown in Section 5.2.3. Such a run would use only the default information already populated in the MOVES-Mexico database, as detailed in the MOVES-Mexico technical report. Optionally, the user could also put in custom data for any of the MOVES input database tables to replace default data for that input. MOVES is structured so that as little as a single variable can be provided to replace the default (e.g., sulfur level for one municipio), and MOVES will fill in the rest of the database with default data. While possible to update many tables at the National Scale, larger scale data replacements are more common at the County or Project Scales, as detailed in the Sections 5.3 and 5.4.

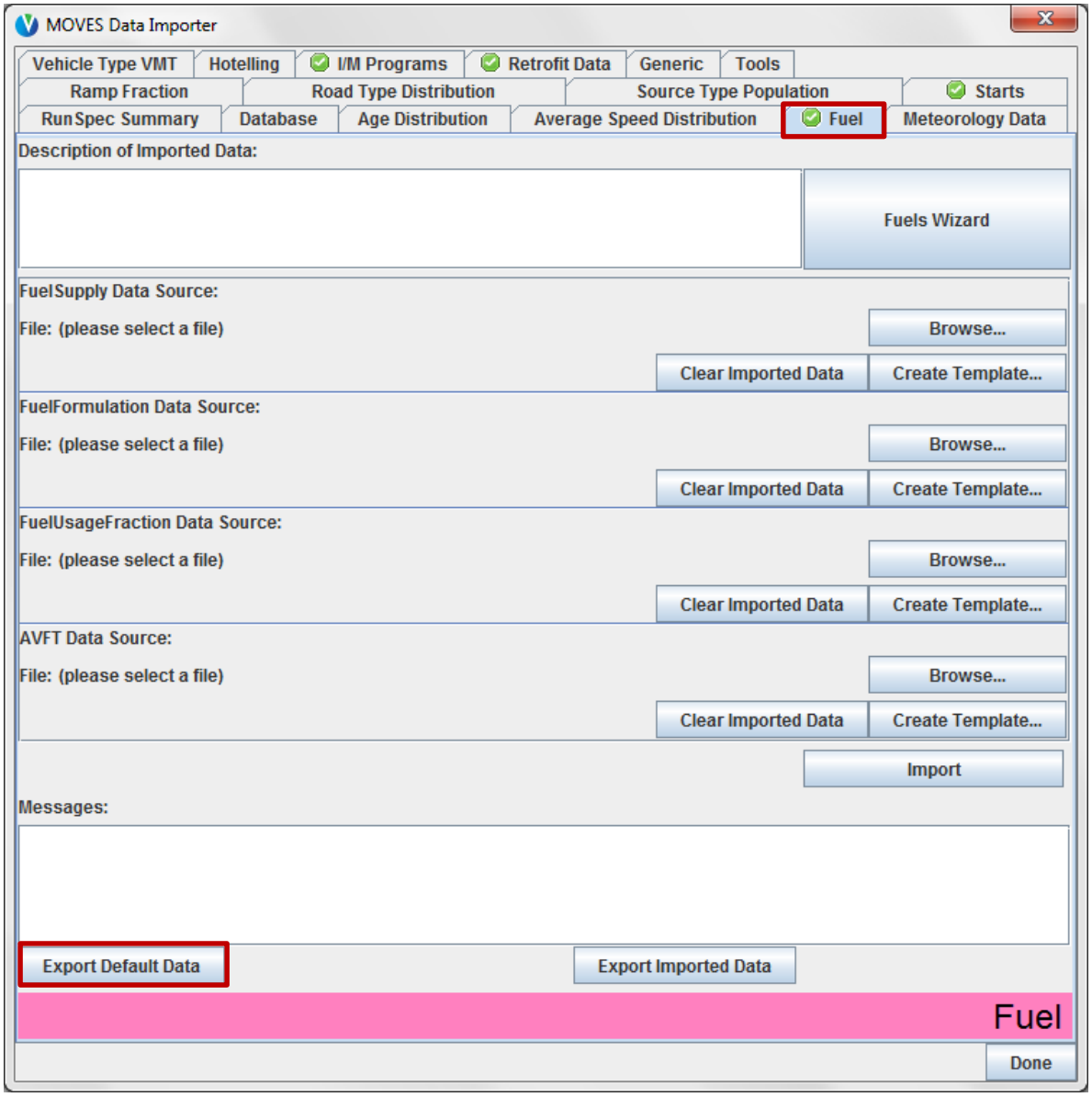
In this example for optional data customization at the National Scale, we will replace fuel supply data for the Durango example. Specifically, this example looks at how to review the fuels data for Durango, and how to change and import new data for the Fuel Supply table. On the top menu bar, click Pre Processing, then click Data Importer.



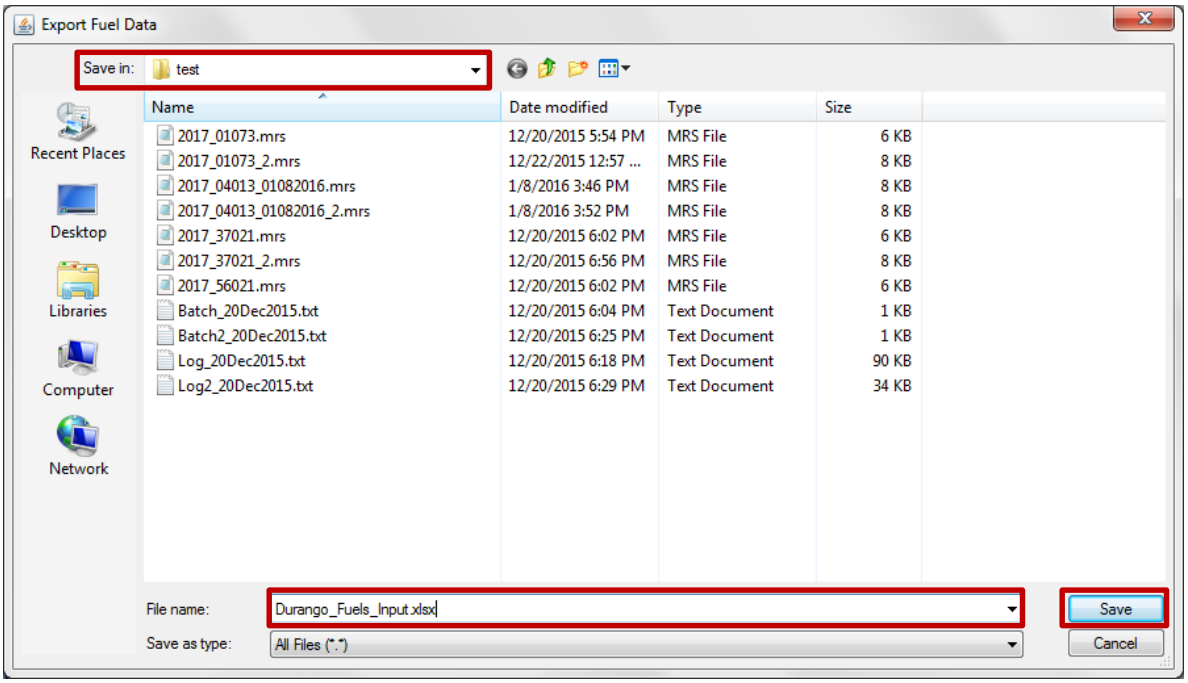
This action launches the MOVES Data Importer window shown below. The importer contains several tabs corresponding to groups of MOVES tables. By default the importer opens to the Database tab. The first step is to enter a name for your new data in the text box adjacent to Database and click the **Create Database** button.



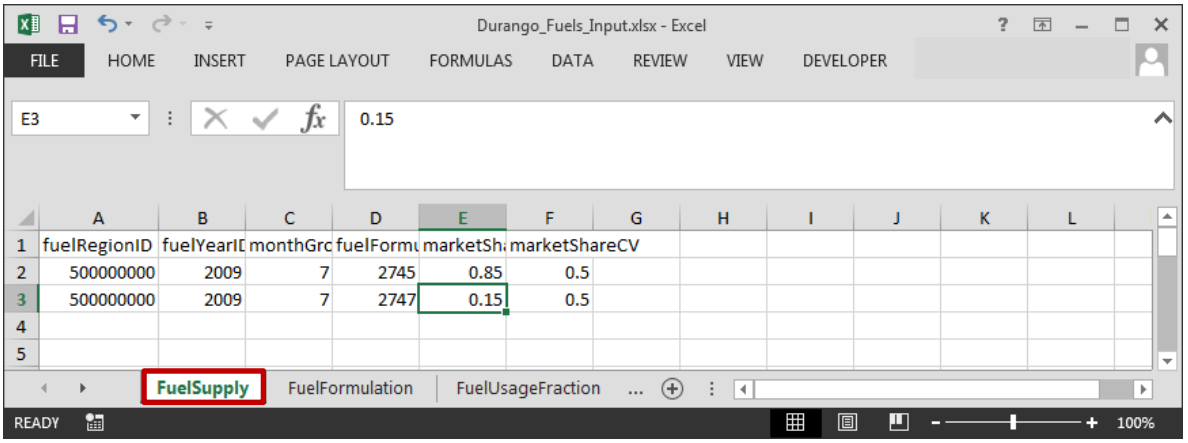
Because we are updating fuel supply data for this run, click on the Fuel tab next. You will see a Fuel Wizard button (refer to the page 39-40 U.S. User Interface Reference for more information), followed by a series of buttons for four tables – FuelSupply, FuelFormulation, FuelUsageFraction, and AVFT. At the lower left corner of the screen, click the **Export Default Data** button. Exporting default fuel information associated with your RunSpec (i.e., 2013, Durango, July, etc.) will filter the default database.



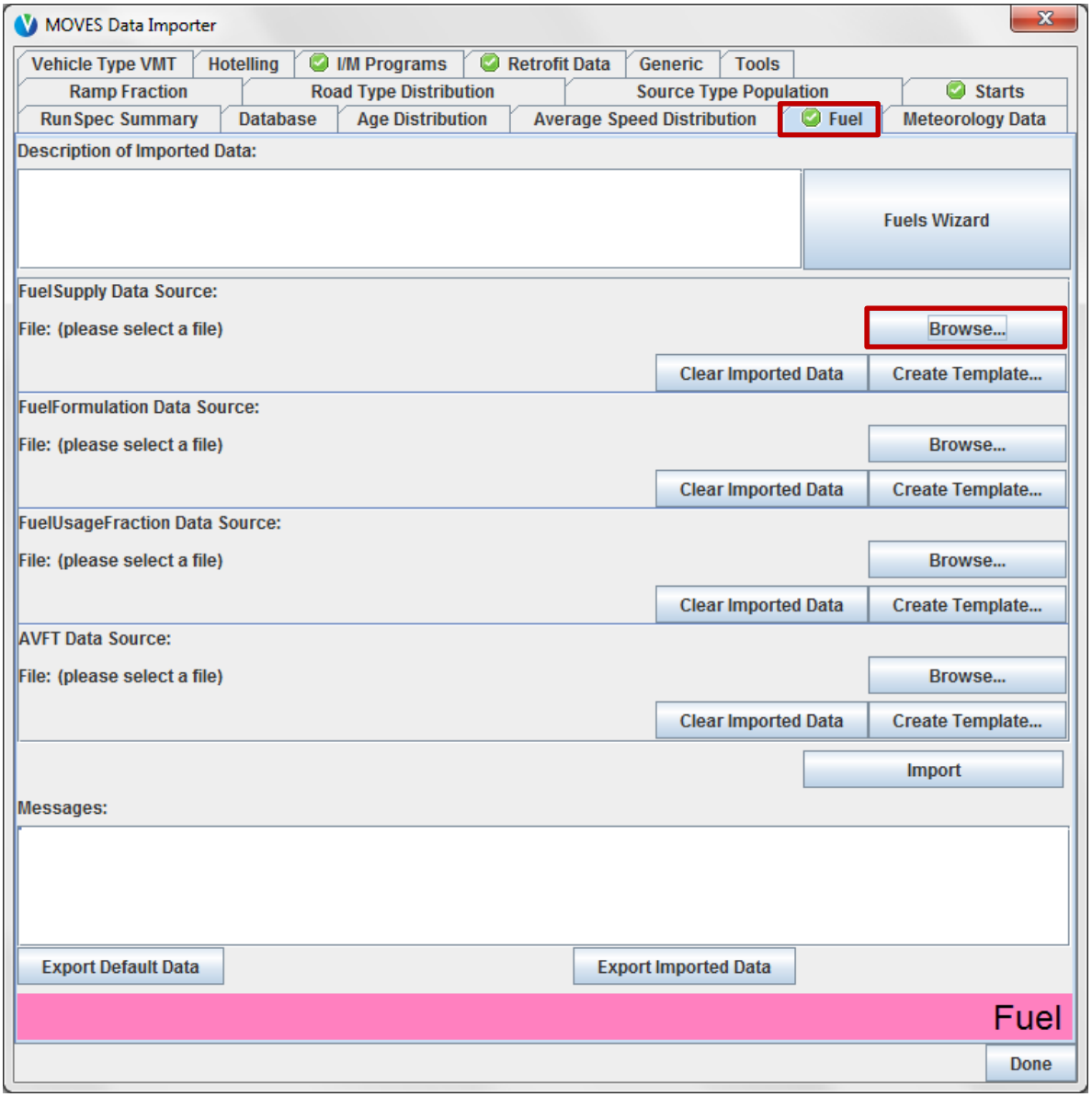
After clicking the **Export Default Data** button, MOVES will prompt you to save the file. Choose a Microsoft Excel file type extension (.xls or .xlsx) so that all four fuel tables defaults will write to a single file. Navigate to a desired location, give the data a filename, and click **Save**.



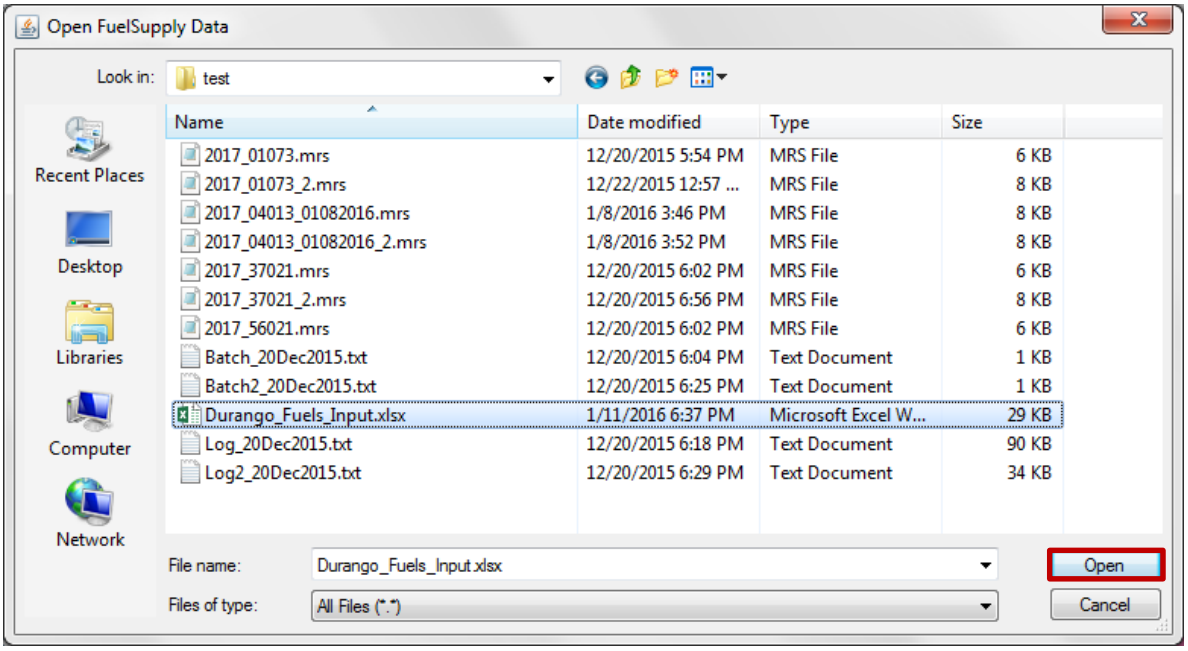
To modify the fuel data, open your Excel spreadsheet you just saved. The FuelSupply tab shows the fuel region of Durango, the fuel year (2009), month (7), and two gasoline formulations with their market share fraction ("fuel year" defines a set of fuel properties which may apply to a range of calendar years in MOVES, and in this case the fuel year for 2013 is 2009). Diesel does not show up here because during the RunSpec creation we only selected gasoline. The file shows two gasoline fuels being used, with FuelFormulationIDs of 2745 (85 percent market share) and 2747 (15 percent market share). Though not shown below, the properties for these fuels (sulfur, RVP, etc.) can be found in the FuelFormulation tab; fuel 2745 has 300 ppm sulfur, and fuel 2747 has 30 ppm sulfur. By changing the market shares of these fuels, we can change the fuel parameters applied to emission estimates for Durango. For example, we can model the effect of shifting to 100 percent 30ppm sulfur fuel by changing the market share of fuel 2747 to 1, and the market share of fuel 2745 to zero. Then save and close the Excel file.



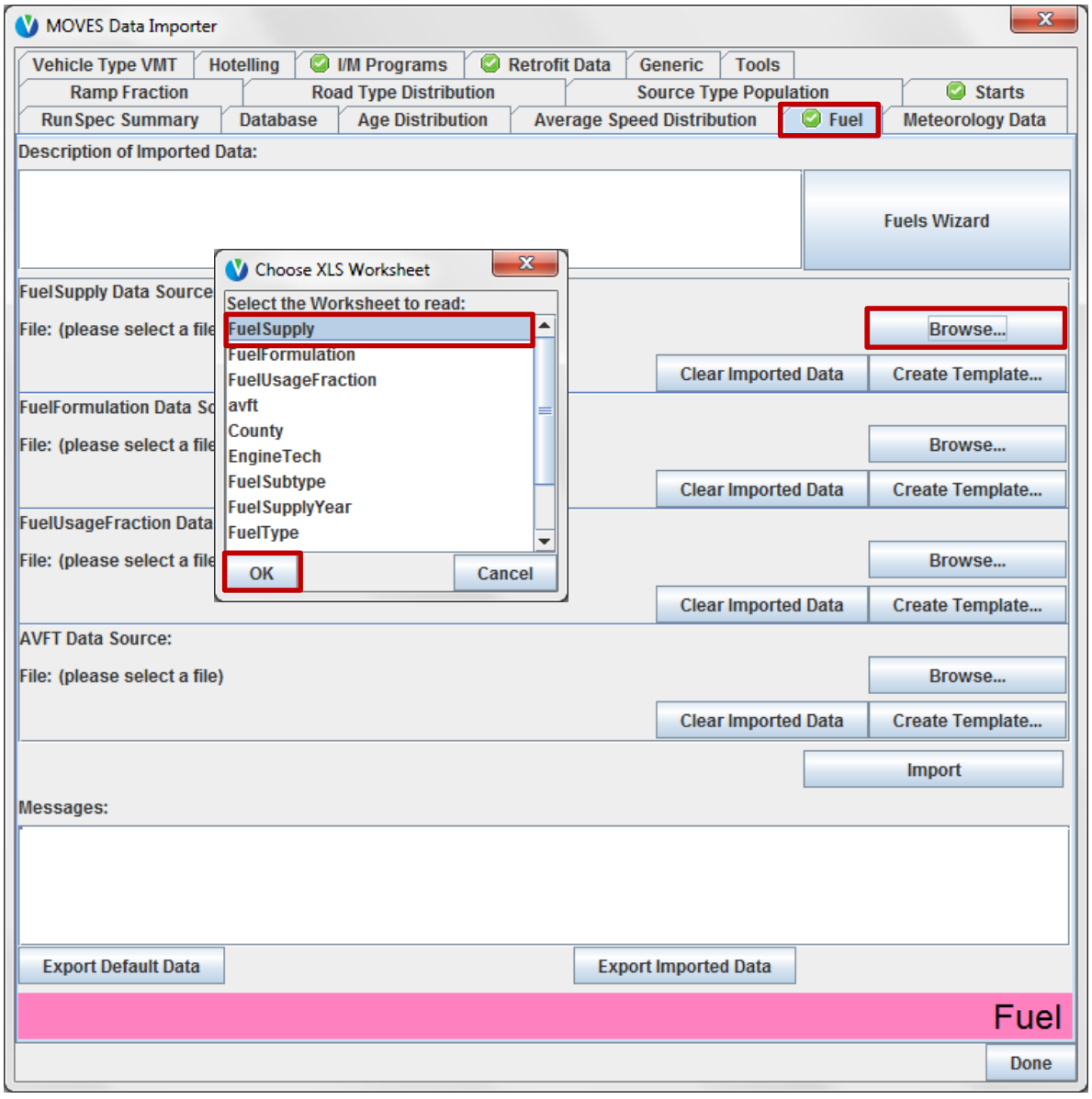
Next, re-import your new, modified fuels data by clicking on the **Browse** button under FuelSupply Data Source.



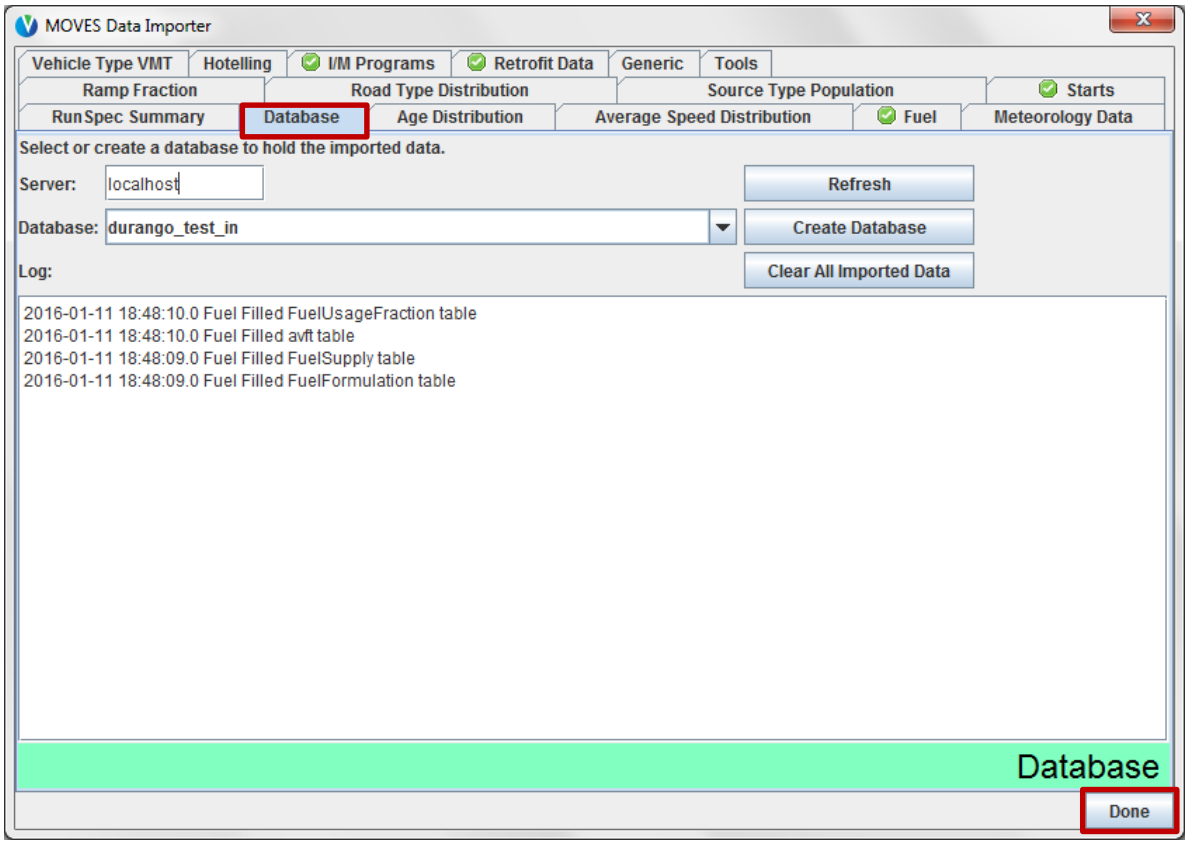
Navigate to your Microsoft Excel data file for MOVES, select it, and click **Open**.



Next MOVES will open a pop-up window called Choose XLS Worksheet; it will automatically list each tab in your Excel file. Select FuelSupply and click OK.

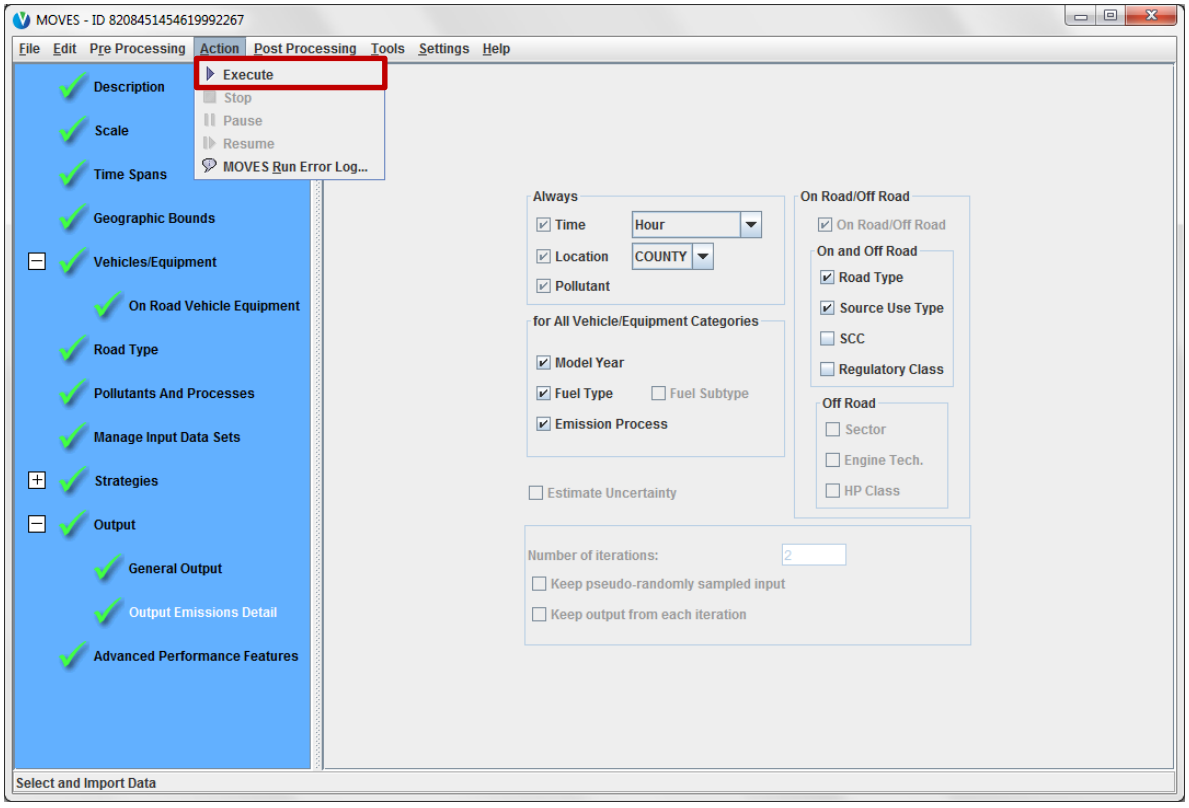


Proceed for the other three tables if desired, FuelFormulation, FuelUsageFraction, and AVFT. When done, click the **Import** button. You may now move on to other tabs, if desired, to change other data in a similar manner. Not all tabs have a **Export Default Data** button, however. For example, the Age Distribution tab export options are limited to the **Create Template** button. This button works similarly to **Export Default Data**, except there will be no data populated in the Excel file. When finished importing your data, go back to the Database tab to review a record of which tables you updated under the Log box. After confirming you have updated all of the intended tables, click **Done** to close the importer. You are now ready to run the model with the new input(s).

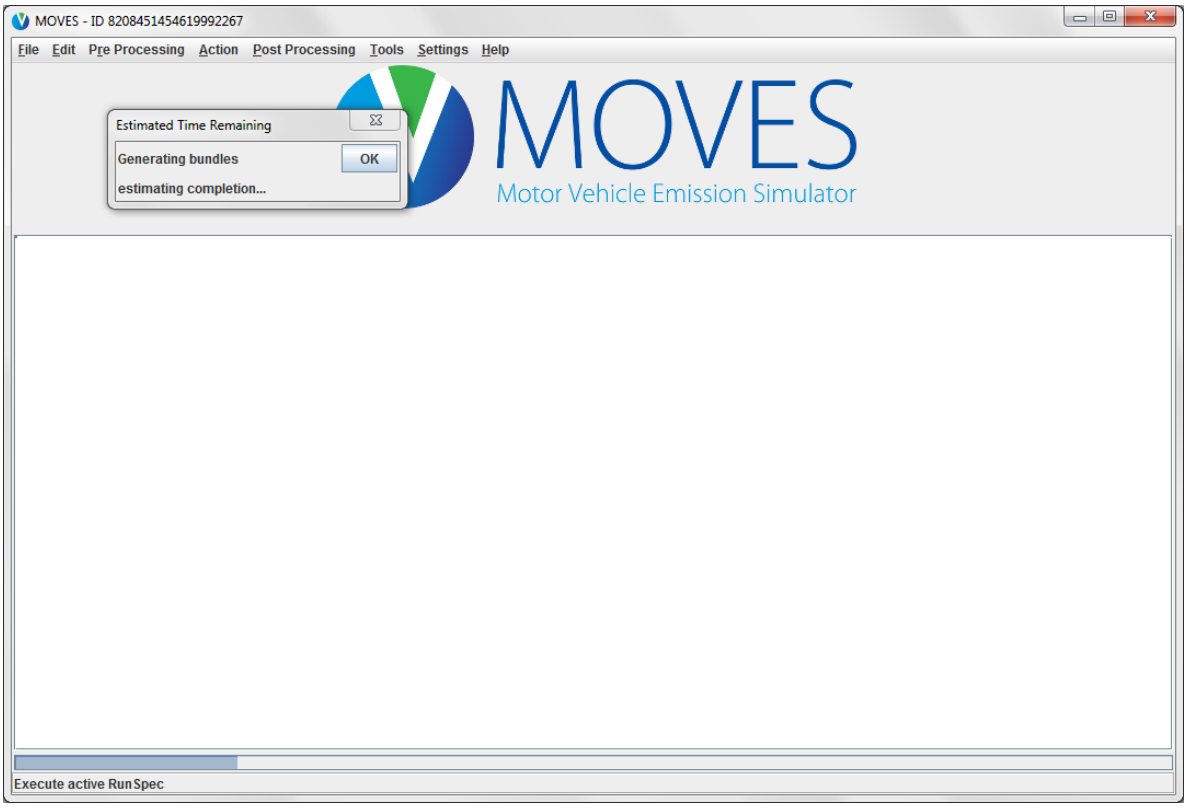

MOVES Data Importer
Vehicle Type VMT
Hotelling
I/M Programs
Retrofit Data
Generic
Tools
Ramp Fraction
Road Type Distribution
Source Type Population
Starts
RunSpec Summary
Database
Age Distribution
Average Speed Distribution
Fuel
Meteorology Data
Select or create a database to hold the imported data.
Server:
localhost
Refresh
Database:
durango_test_in
Create Database
Log:
Clear All Imported Data
2016-01-11 18:48:10.0 Fuel Filled FuelUsageFraction table
2016-01-11 18:48:10.0 Fuel Filled avft table
2016-01-11 18:48:09.0 Fuel Filled FuelSupply table
2016-01-11 18:48:09.0 Fuel Filled FuelFormulation table
Database
Done

5.2.3 Executing the Model

With the RunSpec complete and (optional) data imported, you are ready to launch the MOVES run. Click the **Action** menu item, then click **Execute**.



Wait. This MOVES run should complete in three to five minutes. Runs with a broader scope will take longer, and depending on computer configuration, the duration of a run can be quite long. Strategies for reducing MOVES runtime is discussed in more detail in Section 8.



MOVES provides notification when the run is complete.

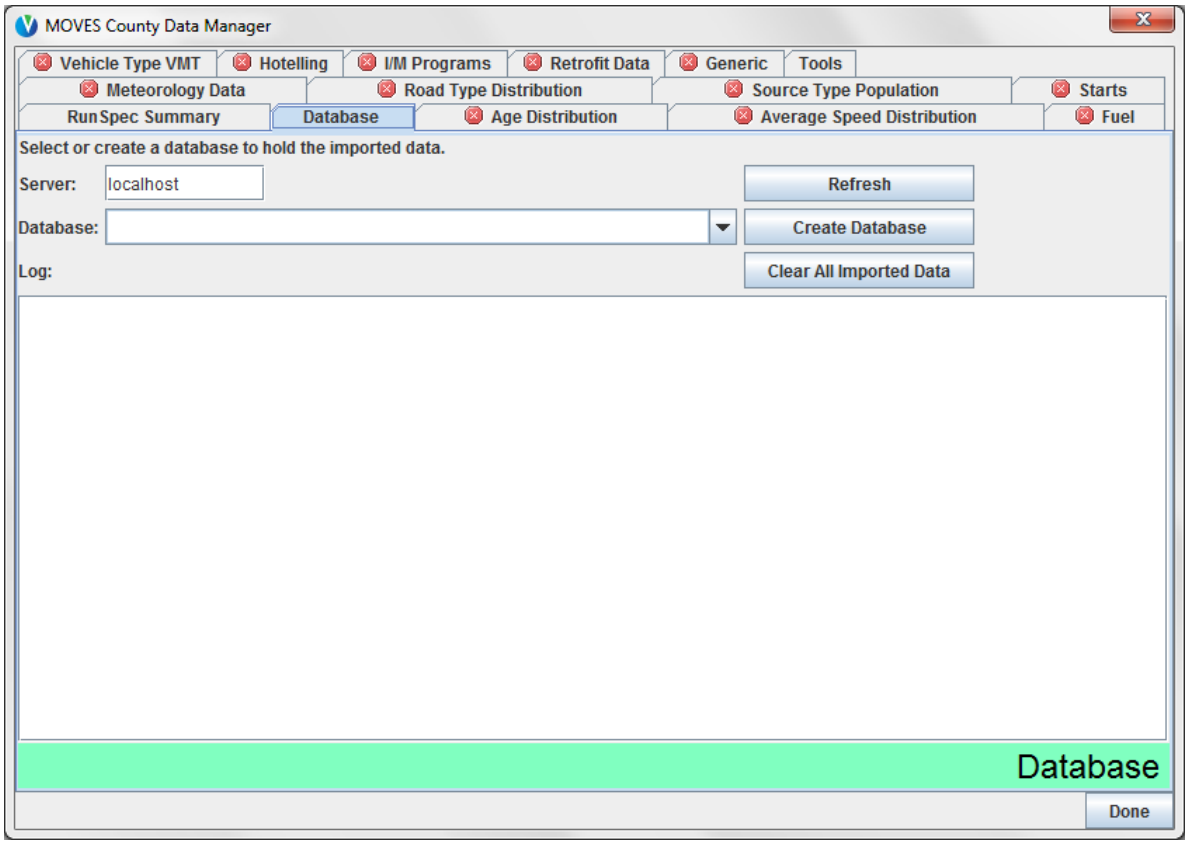
Section 6 of this document addresses how to work with the model output.

5.3 County Scale

The County Scale of MOVES allows significant customization of data for a specific *municipio.* In contrast to the National Scale where data input was optional, many data tables are required inputs to MOVES and the model will not run unless all data requirements are fulfilled.

You may want to use the County Scale to better represent conditions and vehicle activity in a local area, such as a *municipio* or custom domain. For example, to estimate emissions for a *munipio* using the National Scale, MOVES allocates nationwide VMT to the *muncipio* using allocation factors in a database table (the ZoneRoadType table). If better VMT data (or population, fuels, age distribution, etc.) exist for your *municipio*, it is better to use the County Scale implementation of MOVES to directly model these local data instead of relying on the national default methods.

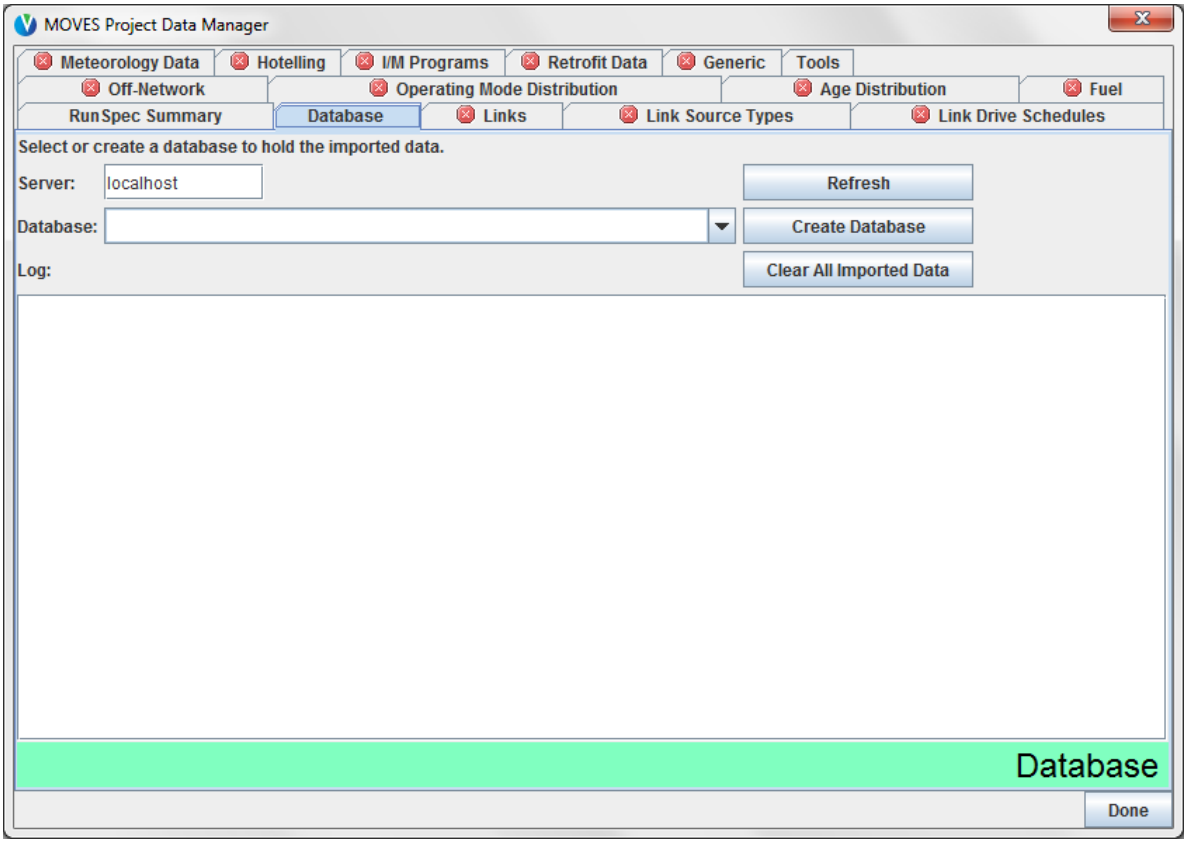
Similar to the National Scale, best practice is to completely fill out the MOVES RunSpec file prior to entering data through a data input interface known as the County Data Manager. In the Scale panel of the GUI, choose County, and then proceed using similar steps as previously described for the National Scale. After completing the RunSpec file, launch the County Data Manger using either method (1) click the Pre Processing menu item and click County Data Manager, or (2) in the Geographic Bounds panel, click the **Enter/Edit Data** button under the Domain Input Database subpanel. Either way, the following screen will appear.



Chapter 2 of the U.S. MOVES User Guide contains step-by-step instructions for entering data into the County Data Manager starting on page 2-35, which will be the same for MOVES-Mexico. Ignore the Hotelling tab of the importer because this activity is specific to the U.S., and in the U.S. version of MOVES it is optional.

5.4 Project Scale

The Project Scale is the finest level of modeling in MOVES Onroad. You may choose this option to model a specific transportation project such as an intersection, or an off-network location such as a parking lot which may produce start emissions. Chapter 6 of the U.S. MOVES User Guide provides instructions for entering data into the Project Data Manager. The importer screen is shown below; similar to the County Data Manager, ignore the Hotelling tab.



6.0 Working with Model Output

The results of a MOVES run is stored in a MySQL database consistent of several tables that contain quantitative emissions and activity results for the run, and meta information about the run itself. For an Inventory mode run, emissions are stored in a database table called movesoutput and the activity (VMT, population, starts, etc.) is stored in the table movesactivityoutput. For a Rates mode run (discussed in Section 7), emission factors are stored in five different stables (RatePerDistance, RatePerVehicle, RatePerProfile, RatePerHour, and RatePerStart).

With output in the MySQL database, there are several options to view and further process that data. To work with the outputs, you may run a post-processing script from the MOVES GUI on your output database, or directly summarize results yourself using MySQL queries. The Post Processing menu provides options to run an existing MySQL script to perform functions such as computing gram/mile emission rates from inventory mode output, or add text labels to output databases that decode the numerical codes in the database. There is also an option to Produce Summary Report, which provides a quick summary of model results without having to work in MySQL. Chapter 3 of the U.S. MOVES User Guide describes how to launch a post-processing script, but does not contain instructions on how to use MySQL directly to work with output. EPA provided training materials on how to use MySQL in the context of working with MOVES outputs, located on the web at http://www.epa.gov/otaq/models/moves/documents/moves2014-2day-trainingmaterials.zip.

7.0 Using Emission Rate Mode

The purpose of a Rate mode MOVES run is to produce detailed emission factors of onroad emissions that can be multiplied by activity estimates outside the MOVES framework to develop an inventory. The emission factor outputs are often referred to as "lookup tables" because the emission factors are listed for a range of speed bins from 1 to 16, corresponding to speeds of 2.5 to 75 miles per hour (mph). Combining the correct VMT with the correct emission factor requires a lookup of the speed bin corresponding to the speed of the VMT activity. Listing emission factors by speed bin is a major difference with Inventory mode, where output emissions reflect an average speed based on a distribution of speeds in each hour of day. The lookup tables also list results by all of the usual level of detail available from an Inventory mode run, including year, month, day type, hour, source type, fuel type, model year, etc.

The speed based emission factors are located in the MOVES output table RatePerDistance with units of grams per mile. The other four lookup tables are associated with off-network emissions: (1) RatePerStart has start emission factors in units of grams per vehicle start, (2) RatePerHour has hotelling related emission factors in units of grams per hour (not relevant to the Mexico implementation of MOVES), (3) RatePerVehicle contains evaporative emissions from resting vehicles in grams per hour parked, and (4) RatePerProfile contains one particular evaporative emission process called Evaporative Fuel Vapor Venting (grams per hour parked).

Chapter 5 of the U.S. MOVES User Guide discusses the topic of Emission Rate mode in greater detail.

8.0 Reducing MOVES Runtime

MOVES is a computationally intensive model, and as a result the duration of individual MOVES runs can become quite long. While long runtimes with larger MOVES runs cannot be avoided completely, there are some tools and strategies that can reduce MOVES runtime, in some cases dramatically. These are summarized as follows, with more information available on EPA's MOVES website. The effectiveness of these will depend on the scope of a user's run, and the level of output detail needed.

Strategies for reducing MOVES runtime:

- **Use pre-aggregation functions by geography and time period whenever possible.** Although MOVES can produce very detailed emissions (e.g. by *municipio* and hour of the day), it only needs to be run at this level when this detail is required. MOVES can be run with geographic pre-aggregation (selected in the "Region" menu in the Geographic Bounds panel) to produce emissions more efficiency by nation or state. Similar, MOVES can be run with time period pre-aggregation (selected in the "Time Aggregation Level" menu in the Time Span panel). Pre-aggregation is a simplification, because it aggregates location-specific inputs such as meteorology, fuels and I/M program, or time-specific inputs such as trip activity, into a single area and time span. But the tradeoff is a much faster run if more aggregate output is needed. For example, annual emissions for all of Mexico can be produced either by running each municipio for each hour, day and month in the year; or they can be produced by choosing "nation" and "annual" pre-aggregation. The runtime of the latter approach will be significantly less, and depending on computer configuration may be the only viable option.

- **Do not ask for more detail than is needed in the MOVES RunSpec.** Similar to pre-aggregation, a general rule is that MOVES runs should be set up to provide only the output and level of detail needed by the user. Choosing geographic areas, time periods, vehicle classes, fuels etc. that are not needed will increase runtime unnecessarily. MOVES also provides output aggregation options in the Output Emissions Detail pane, which can reduce the size of model output and thereby ease the manageability of MOVES results.

- **Run exhaust and evaporative emissions in separate runs.** Evaporative emission processes (primarily permeation and tank vapor venting) require intensive processing, and also require runs to be performed at an hourly level (i.e. time period aggregation can't be used for evaporative emissions). These factors combined make evaporative emission runs much longer. If both evaporative and exhaust emissions are desired, a typical approach is to run exhaust processes separately,

choosing the level of detail needed (e.g. day, month or year), and isolate the hourly runs to only the evaporative processes needed. Batch processing discussed in the next section makes multiple runs more streamlined.

- **Break up runs by vehicle class, geography, or year.** The processing time of runs with many selections across many dimensions (geography, vehicle classes, years etc.) will increase exponentially. Sometimes, running several runs with fewer selections will be faster, especially if they can be run in parallel on multiple computers. Large scale, detailed runs (e.g. every municipio in Mexico, as needed for air quality modeling) can be broken up and run in parallel on a network or cloud computer environment as discussed in the next section, with the clock time of only a single run.

Tools to aid efficient processing:

- **Faster computers.** MOVES runtimes have benefitted significantly with improvements in computer processing speed, memory and multiple processor configurations.

- **Multiple processer / computer configurations.** MOVES was designed with a "master/worker" architecture that facilitates runs across multiple computers connected to the same network, or even multiple processors on the same computer. This is a powerful option to reduce runtime, particularly runs with several combinations of geography, vehicles, years etc. A typical configuration is one master with multiple workers that process independent elements of a run in parallel, which can reduce runtime severalfold. More information on this can be found in the MOVES Software Design Reference Manual, available at http://www3.epa.gov/otaq/models/moves/documents/420b15096.pdf

- **Command line memory allocation.** MOVES can be run directly from a command line interface, rather than the GUI. This provides the ability to increase memory settings in Java, and flexibility to set up multiple runs using **Batch processing.** MOVES provides tools to support this approach, which is useful for executing many repetitive runs automatically. More information on this can be found in the MOVES Software Design Reference Manual.

- **Cloud computing.** Cloud computing environments provide users with access to large banks of virtual computers that can run several parallel MOVES runs at once. The runtime benefits of this can be substantial; ror example, U.S. EPA has used cloud computing with MOVES to produce emissions for several hundred U.S. counties in parallel, with the clock time of a single county. This option is becoming more viable for runs that require a large scale that can be broken up into several parallel components (e.g., the same run for many *municipios*). More information on this approach can be found on EPA's MOVES website.

www.mledprogram.org