APPENDIX 8

Spatial Emission Estimator

(SEE)

Documentation for the Spatial Emissions Estimator (SEE) Model

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SEE Documentation

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1.0 Background

In 2014, Eastern Research Group, Inc. (ERG) and Cambridge Systematics, Inc. developed a modeling framework called the Spatial Emissions Estimator (SEE) for estimating regional on-road emission inventories of criteria, toxic and greenhouse gas (GHG) emissions for each hour of a day with highly detailed spatial resolution, including emission "hot-spots" not on the traditional travel network, such as truck stops and port terminals. In the past, this framework employed MOVES2010b at both the project and county scales to cover all needed emission processes in accordance with EPA modeling guidance. Among the novel features of SEE at that time were a) the application of MOVES project scale to develop a regional emissions inventory, which introduced the possibility of including road grade impacts at an area-wide level; and b) allocation of off-network emissions to Transportation Analysis Zones (TAZs) based on travel demand model origin/destination matrices and spatial analysis of truck extended idle locations. For future implementation, this framework could also be extended to include heavy-duty emission "hot spots" not already accounted for in the travel model network, such as port terminals and distribution centers. SEE also incorporated an updated version of a link processing script (TRANSVMT) developed by the Texas Transportation Institute (TTI). The updated TRANSVMT includes the option of a new speed post-processing model which provides a broader range of average network speeds, to allow a more accurate assessment of speed distribution and related emissions across the Houston-Galveston-Brazoria area. Under follow-on contract with the Houston-Galveston Area Council (H-GAC), ERG upgraded SEE to include a new graphical user interface (GUI) and fully integrate with MOVES2014a.

In 2017, SEE was substantially restructured in an effort to decrease runtime and disk space requirements, as well as to make SEE's results consistent with an established emissions inventory for the Houston-Galveston-Brazoria (HGB) area. Major changes implemented in this updated version of SEE include:

- on-network emissions calculated using a County Scale Rate Mode MOVES run instead of a Project Scale Inventory Mode run
- off-network emissions calculated using the same County Scale Rate Mode MOVES run as used for on-net emissions instead of a separate County Scale Inventory Mode run
- use activity data – vehicle miles traveled (VMT) and source hours parked (SHP) – from a County Scale Inventory Mode MOVES run to convert off-network evaporative emission rate per vehicle outputs from MOVES into rate per activity, i.e., rate per SHP
- direct calculation of emissions for all links instead of using representative (distinct) links
- use of link average speeds with a precision of three decimal places instead of rounding to the nearest 1 or 5 mph
- use of an hourly fleet mix instead of a daily fleet mix

In the November 2021 project, SEE underwent minor modifications to simplify the input file requirements and output three new condensed emission factor reports. As of 2021, trip matrices are no longer a required input for SEE, and only one set of AVFT files (fuel type fractions) are needed.

In 2022 to 2023, ERG again updated SEE and primarily for compatibility with MOVES3. The latest version of SEE at the time of writing is "6jan2023." The version can be checked clicking About > Version in the upper right corner of the GUI. To prepare the 6jan23 version, ERG

migrated SEE from MOVES2014b to the latest MOVES3.1 emissions modeling system from U.S. EPA. This MOVES change retired the use of MySQL in favor of MariaDB; SEE also now uses MariaDB. SEE was updated to handle MOVES3 run specification and input data changes and pollutant options. In addition, ERG changed the GUI to accommodate streamlined inputs, fewer scripts, and ability to specify the database port in case the user would like to keep MySQL in addition to MariaDB. Previously confusing error messages were prevented from being written to SEE's run log, additional QA was added, and a button to launch MOVES workers was introduced to the GUI, allowing SEE to run more efficiently. In another efficiency improvement, SEE no longer performs MOVES inventory mode runs for each county, MOVES runs whose sole purpose was to produce population and SHP for an intermediate SEE calculation to convert the off-network evaporative emission rate per vehicle outputs. Instead, SEE now calculates the population and SHP directly. ERG performed extensive QA to ensure that the source code changes caused no unexpected changes to the modeling results and that SEE's methodology and results remained consistent with those of the TTI Utilities and MOVES3. Lastly, at the request of the H-GAC Project Manager, ERG moved a VMT summary of the TRANSVMT network much earlier in the SEE processing so that users can quickly summarize new TRANSVMT networks without running a full emissions analysis.

This report serves as the detailed technical documentation of the updated SEE's scripts and GUI. Section 2.0 provides an overview of the installation process. Section 3.0 discusses the execution time and hard drive space requirements for a typical scenario. Section 4.0 is a tour of the GUI's inputs and capabilities. Following the GUI discussion, Section 5.0 contains detailed documentation of the data flow in SEE, including each SEE script's calculations and outputs.

After the calculation and outputs discussion, Section 6.0 documents the naming convention and format of each input file. Section 7.0 briefly describes SEE's summary output files. Section 8.0 describes the emission inventory that was used to validate the outputs of SEE.

The authors would like to acknowledge the assistance of several individuals in developing SEE and preparing this documentation:

- The Houston-Galveston Area Council project team: Graciela Lubertino, Pramod Sambidi, Chi-Ping Lam, Michael Onuogu, and former H-GAC employee Chris Van Slyke
- Cambridge Systematics, Inc.: David Kall and Tara Rima
- The Texas Transportation Institute: Madhu Venugopal, Chaoyi Gu, and former TTI employees L.D. White and Dennis Perkinson
- ERG Mobile Sources Modeling Team: John Koupal, Sandeep Kishan, and former ERG employees Scott Fincher and Doug Jackson.

2.0 Installation

In the current version of SEE, all the Perl scripts and configuration files are bundled with the GUI installer. When SEE is launched, it automatically copies all of the scripts and other files it needs into the user's local AppData folder, which is a folder used by applications to store temporary data on Windows machines. Specifically, SEE uses a folder located at C:\Users*username*\AppData\Local\ERG, where *username* is the name of the current user. This folder and the files contained within it do not need to be accessed by users during normal use of SEE – in fact, accessing files in this directory is discouraged, as it could interfere with the proper functioning of the tool.

Before installing SEE, it is essential to uninstall any previous versions. This is done using the *unins000.exe* executable that resides within the SEE installation folder, typically at C:\Program Files\SEE\unins000.exe. After the uninstallation is complete, install the new version of SEE using the installer executable. Next, copy the folder containing your input files to the C: drive, typically to C:\SEE.

2.1 Prerequisites

A Perl installation with all the required modules, MOVES3, and MariaDB are all required to run the tool.

Perl: Installation of Perl will be detailed below.

MariaDB: It is assumed that a functioning version of the MariaDB server has been installed as part of a MOVES3 installation, so installation of MariaDB is not covered in this document. However, you will need to know the MariaDB port number (most likely 3306 or 3307) and there may be some steps necessary to configure the server properly to run SEE; these are described below.

64-bit PC: No additional software needs to be installed to run the GUI itself, as the installer for the GUI contains all the software it requires in a self-contained package. However, the GUI does require a 64-bit computer to run (most newer machines should fulfill this requirement).

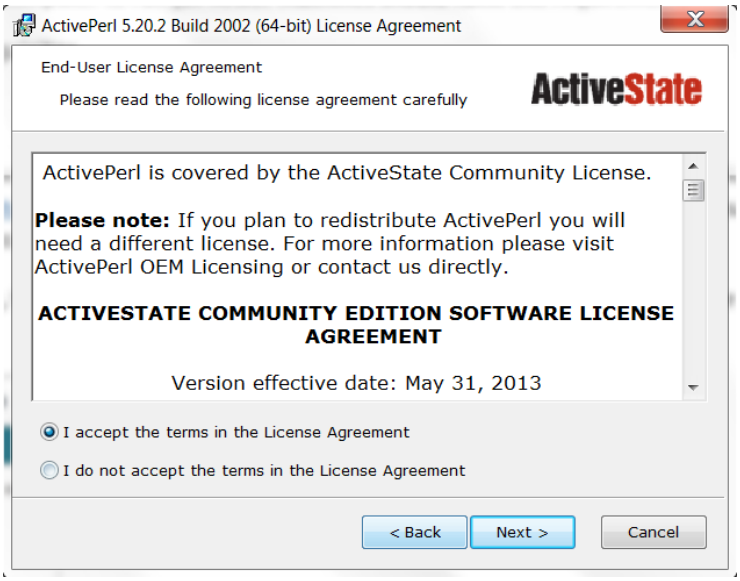
2.2 Installing and configuring the prerequisites

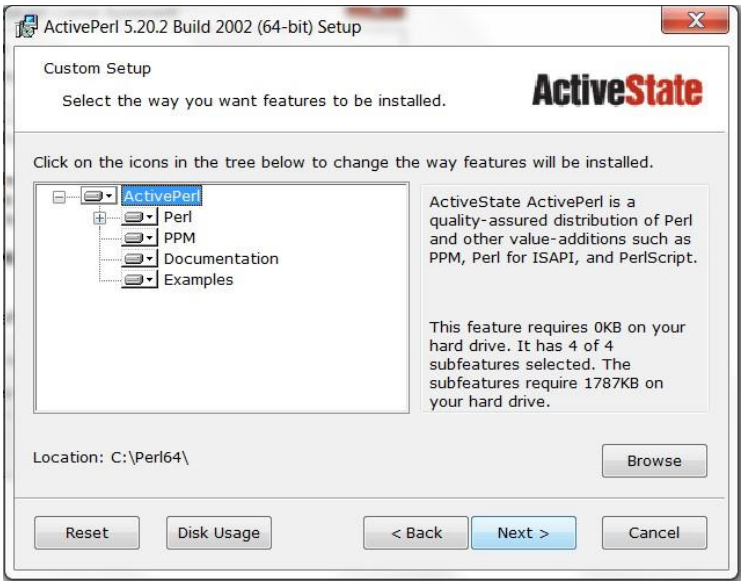
2.2.1 Perl

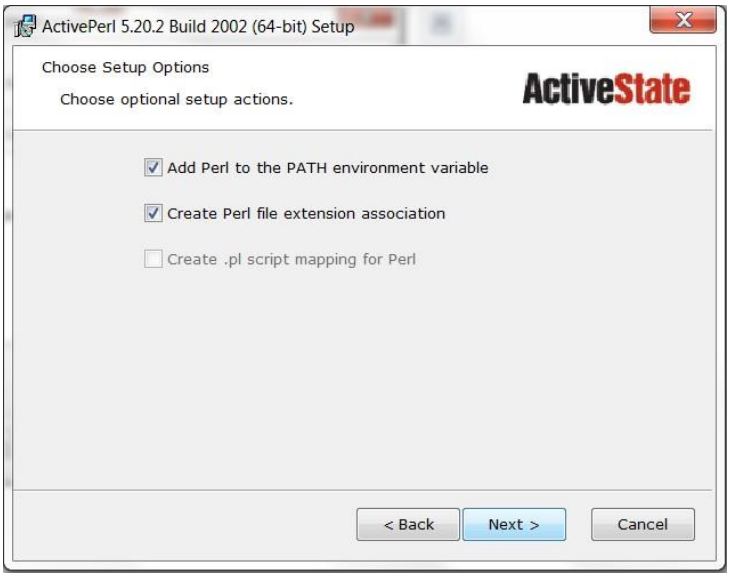
SEE has been tested using the freely-available Community Edition of ActivePerl, available here: http://www.activestate.com/activeperl. This version of Perl contains all of the modules necessary to run the tool and is the recommended version.

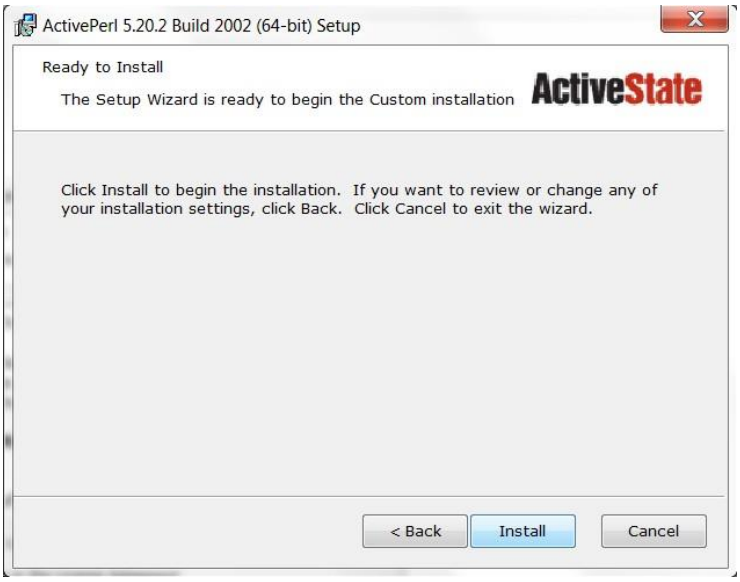
At the time of writing, the download link was near the bottom of the page, and appeared as follows:

The Download link will take you to another page, where you can choose between version for x86 (32-bit) or 64-bit (x64): choose the 64-bit version. After you download the installer (a *.msi file), double click to launch it. Accept the license agreement and choose the default installation options, as shown below.




ActivePerl 5.20.2 Build 2002 (64-bit) Setup
Custom Setup
Select the way you want features to be installed.
ActiveState
Click on the icons in the tree below to change the way features will be installed.
ActivePerl
Perl
PPM
Documentation
Examples
ActiveState ActivePerl is a quality-assured distribution of Perl and other value-additions such as PPM, Perl for ISAPI, and PerlScript.
This feature requires 0KB on your hard drive. It has 4 of 4 subfeatures selected. The subfeatures require 1787KB on your hard drive.
Location: C:\Perl64\
Browse
Reset
Disk Usage
< Back
Next >
Cancel


ActivePerl 5.20.2 Build 2002 (64-bit) Setup
Choose Setup Options
Choose optional setup actions.
ActiveState
Add Perl to the PATH environment variable
Create Perl file extension association
Create .pl script mapping for Perl
< Back
Next >
Cancel


ActivePerl 5.20.2 Build 2002 (64-bit) Setup
Ready to Install
The Setup Wizard is ready to begin the Custom installation
ActiveState
Click Install to begin the installation. If you want to review or change any of your installation settings, click Back. Click Cancel to exit the wizard.
< Back
Install
Cancel

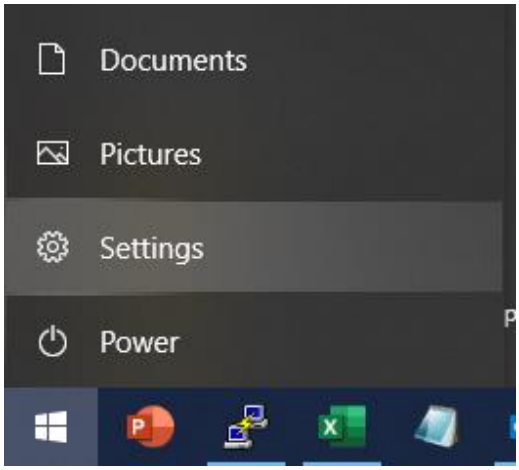
2.2.2 MariaDB

SEE connects to MariaDB from the Windows command line, which requires that the Path environment variable be set properly to point to the MariaDB server executable (the file that actually launches MariaDB). The Path variable is a basic feature of Windows that many programs require to run correctly, so care must be taken to only add to the existing Path variable, i.e., to not delete anything from it.

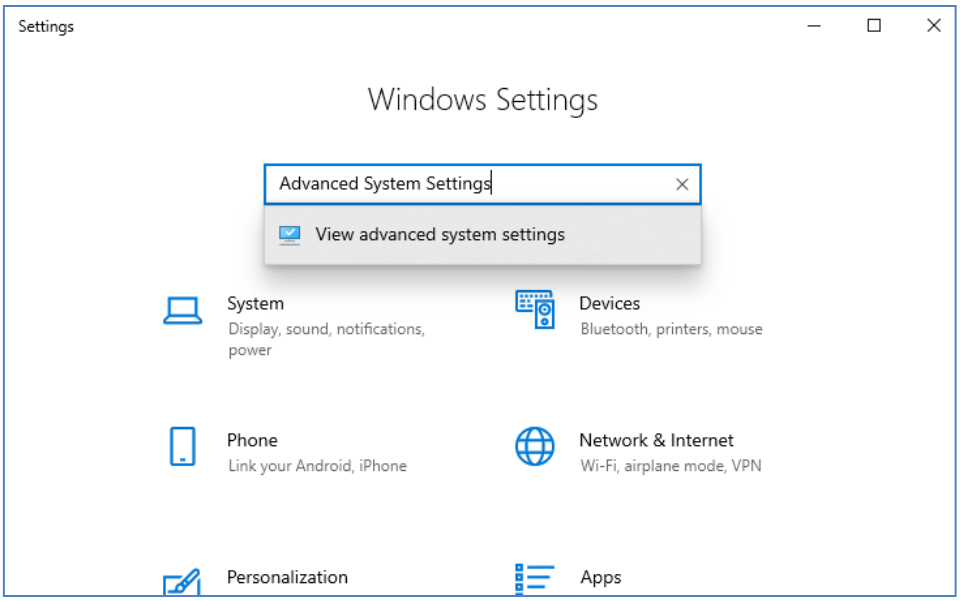
When running SEE on a computer for the first time, it is important to know the port number that MariaDB uses. Most likely it will be 3306 or 3307, and it is necessary to know which one, and to enter the port number into the GUI. Subsequent SEE runs will "remember" the port number setting, so this only needs to be done once. To find your MariaDB port number, the simplest way is to check the MOVES3 installation directory. By default, the location of the MOVES3 installation directory is C:\Users\Public\EPA\MOVES\MOVES3.0. In this directory, open the file "MySQL.txt" if it exists, and the number inside that file is your MariaDB port number. If MySQL.txt does not exist in your MOVES installation directory, then your MariaDB port number is the default 3306.

MOVES3 installs MariaDB 10.4 Server and is probably the version your Path variable should point to. The executable will likely be located in C:\Program Files\MariaDB\MariaDB 10.4\bin, but it should be verified that this path exists on your machine, i.e., that your MariaDB Server is this version and is saved in this location.

Setting the Path variable is accomplished via the Control Panel in Windows 10, as illustrated below. First, choose Settings next to the gear icon from the Start Menu:

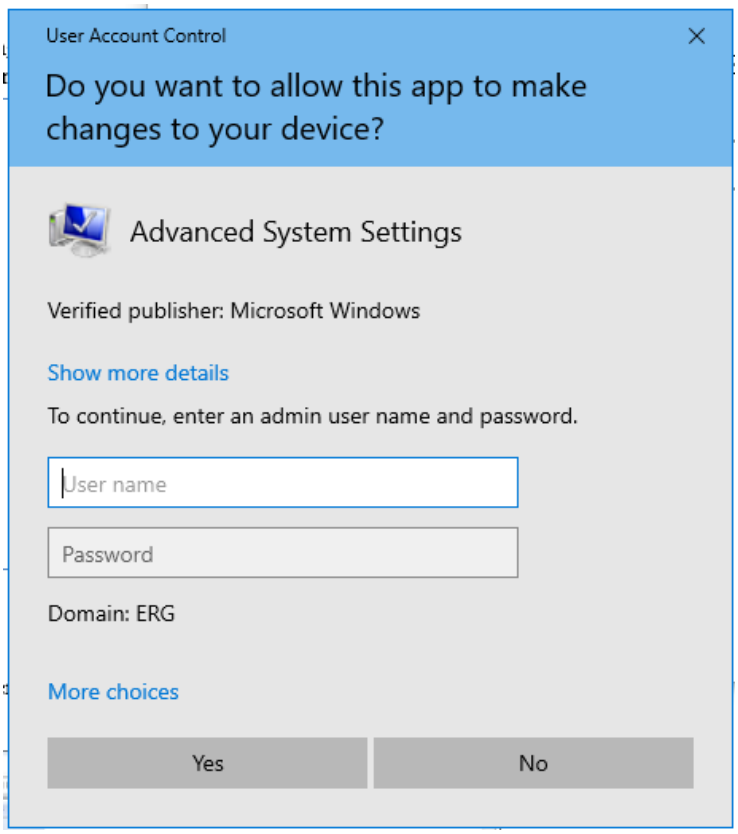


In the Settings window search bar, type “Advanced System Settings” and click View advanced

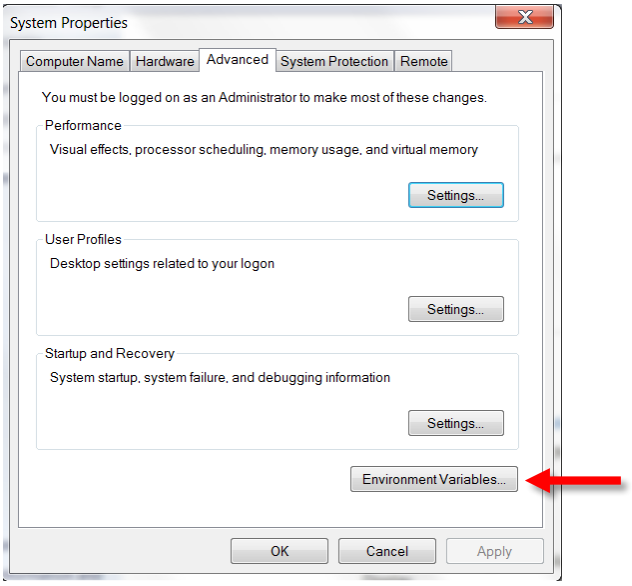


system settings.

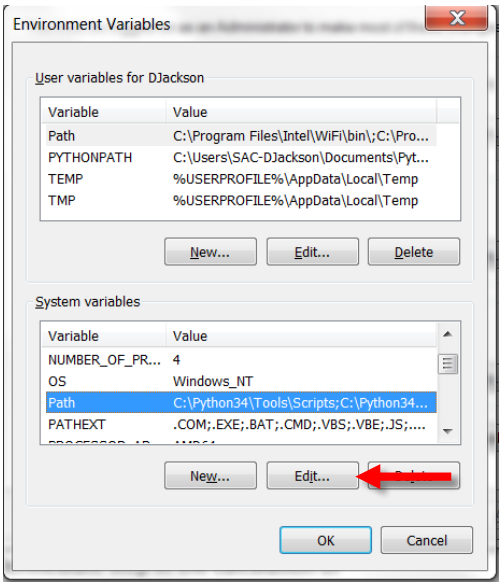
Next, a User Account Control window should pop up. Enter your administrative username and password and click the “Yes” button to proceed to the System Properties window.



Select Environment Variables from within Advanced System Settings:

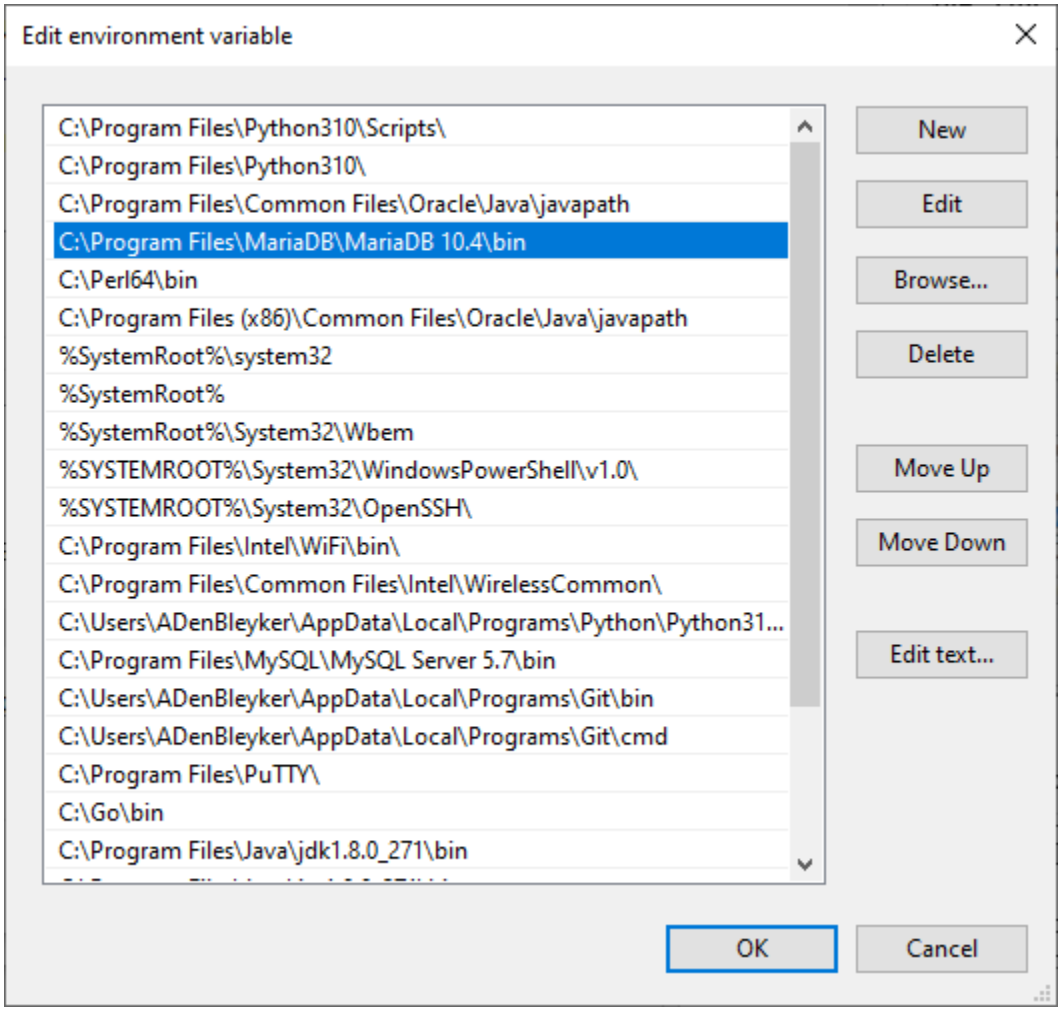


Under System Variables (the bottom of the two sections), scroll down until you see the Path variable. This variable should already exist. In the rare event that it doesn't, you can create it by selecting New. Otherwise, click on the Path variable to highlight it, and then select Edit:



At the very end of the existing path (it is very important that you go to the very end and that you NOT delete any part of the existing path), type a semicolon (if necessary) and then enter the path to your MySQL installation directory, e.g., C:\Program Files\MariaDB\MariaDB 10.4\bin.

For example (but only as an example!), your complete Path variable might look like the following after you add the MariaDB Server path:



Once you have entered the path, click OK in the Edit System Variable window, then click OK in the Environment Variables, and then click OK in the System Properties window.

3.0 Execution Time and Hard Drive Space Requirements

The total execution time and hard drive space required to run SEE are dependent on the number of counties being modeled. Furthermore, some counties take longer than others to run. For example, Harris County has more links than Chambers, and as a result SEE takes much longer to compute the emission inventory. Also, enabling the compilation of link-level emissions totals (Section 4.1.12), which is required for exporting link-level emissions (see Section 5.9), will increase both runtime and hard drive space requirements. Execution time is also a function of the number MySQL threads (see Table 1) and the number of MOVES workers used.

As an example of the total execution time and hard drive space required for a typical scenario, a complete run of SEE (all scripts) for the 8 counties in the Houston-Galveston-Brazoria area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller counties) for VOC, CO, and NO_x, required approximately 20 hours to run on a computer with a 4.3 GHz AMD Ryzen 7 2700x (8 cores, up to 16 threads) with 16 GB RAM, using 8 MOVES workers and 8 MySQL threads. The total hard drive space requirement was approximately 110 GB. The majority of this space was for the working databases (ranging from 2 GB for Chambers County to 75 GB for Harris County).

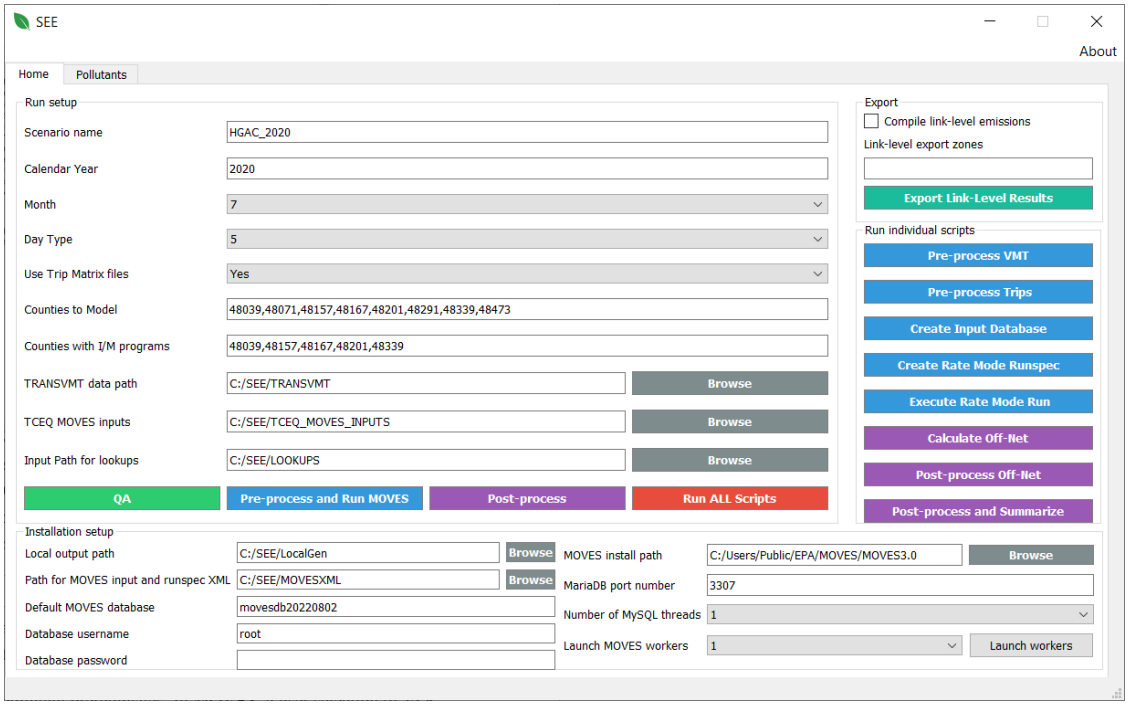
4.0 Graphical User Interface

This section describes the full capabilities of SEE's GUI. A home tab provides areas for user input and buttons that instruct SEE to perform various functions, and a pollutant screen allows the user to select which pollutants to include.

4.1 Home Tab

Figure 1 shows the Home tab, which has many editable text boxes and drop-down menus. Some of these input elements have brief reminders that will appear after a short delay when the cursor is hovered over them. For example, hovering your mouse over the text box adjacent to Calendar Year will produce the reminder, "Four-digit year. Only one year permitted at a time."

Figure 1. GUI Home Tab



The Home tab of the GUI contains four panes: the *Run setup* (top left and center), *Installation setup* (bottom), *Export* (top right), and *Run individual scripts* (center right). The *Run setup* pane has 10 required input fields and will need to be edited the most frequently. Each input field is discussed next, one at a time.

4.1.1 Scenario Name

In this text box, you should provide SEE with a meaningful scenario name that will help distinguish your modeling scenarios from one another. We recommend including the calendar year as part of the scenario name. SEE uses this input to name the working databases as well as the emission factor reports and Excel summary result. For example, a scenario name of "hgb_2020" would result in the following ten MySQL databases (assuming all eight HGB counties were also included under **Counties to Model**). The first eight databases numbered below are SEE's working databases, followed by the SEE off-network database, and number 10 is the SEE summary database.

1. hgb_2020_48039
2. hgb_2020_48071
3. hgb_2020_48157
4. hgb_2020_48167
5. hgb_2020_48201
6. hgb_2020_48291

7. hgb_2020_48339
8. hgb_2020_48473
9. hgb_2020_offnet
10. hgb_2020_summary

In addition, SEE would name the summary results spreadsheet ***hgb_2020**_results.xlsx* and the summary emission factor files ***hgb_2020**_ratePer*.txt*, located in the local output path, after the **Post-process and Summarize** script completes.

4.1.2 Calendar Year

This input is an editable text box, where you should enter one four-digit year corresponding to your modeling scenario year. Only one year may be entered here, and the acceptable values are those allowed by MOVES (i.e., 1990, 1999-2060). SEE uses this input to set the year for MOVES runs, and it also sets the year that later determines the pass/fail status for some of the quality assurance (QA) checks. QA checks are discussed in detail in Section 4.3.1.

4.1.3 Month

This input is a drop-down menu where you may select a single month, 1 through 12. This choice determines the month of the MOVES run, and the default setting (provided with the installation) is 7, for July.

4.1.4 Day Type

Another drop-down menu, you may select "5" for weekday or "2" for weekend. This selection determines the day type of the MOVES runs, which influences the magnitude of the off-network emission rates. The default setting is 5.

4.1.5 Use Trip Matrix Files

Select "Yes" to process trip files, or "No" to bypass the trip files. Choosing "No" will save runtime and produce the same answers as when "Yes" is selected; however, emissions will not be allocated to TAZs.

4.1.6 Counties to Model

Enter at least one county code in this text box as a 4- or 5-digit integer county FIPS code. If you enter multiple counties, they should be separated by commas (e.g., *48039,48071,48157*).

4.1.7 Counties with I/M Programs

This text box has identical format requirements to the **Counties to Model** input. The box may be left blank if the counties in your modeling scenario do not have any I/M programs. If you do

enter one or more counties, SEE's QA checks require valid records within the *I/M Coverage* files for the county(ies).

4.1.8 TRANSVMT Data Path

This text box shows the path to the location of the 24 hourly VMT files processed through TRANSVMT and the trip origin destination matrices by period. To simplify correct specification of an existing path name, the path is chosen using the "Browse" button to the right of the text box; this field is not directly editable. The default setting for this path is C:/SEE/TRANSVMT.

Note: A suggested naming convention of including a year in the pathname would allow multiple conformity datasets to reside on the same computer (e.g., **C:/SEE/TRANSVMT_2020** and **C:/SEE/TRANSVMT_2040**).

4.1.9 Path for TCEQ MOVES Inputs

This text box shows the path to the location of your MOVES inputs such as age distribution, I/M programs, and fuels. To simplify correct specification of an existing path name, the path is chosen using the "Browse" button to the right of the text box; this field is not directly editable. The default location is C:/SEE/TCEQ_MOVES_INPUTS.

4.1.10 Input Path for Lookups

This text box shows the path to the location of other SEE lookups such as the files *CountyLookup.tab*, *RoadtypeLookup.tab*, *TimePeriodLookup.tab*, and others. To simplify correct specification of an existing path name, the path is chosen using the "Browse" button to the right of the text box; this field is not directly editable. The default setting is C:/SEE/LOOKUPS.

The next section discusses the installation setup pane, located at the bottom of the GUI **Home Screen**.

4.1.11 Installation Setup

In this pane is a group of inputs that are mostly SEE intermediate file paths and system parameters that will not change with scenario. These will likely only have to be set once (if ever) because each time you launch SEE, the GUI will load the previously-saved settings from the configurations previously stored the last time the tool was run. Table 1 shows the installation setup pane's input fields, their default settings, and additional details about their purpose and how/where SEE uses them.

Table 1. Installation Setup Paths and Settings

Input Field	Default Setting	Details
Local output path	C:/SEE/LocalGen/	This is a SEE intermediate file repository that houses the SEE and MOVES log files and user's pollutant selections. The Post-process and Summarize script also writes output that end up in the Excel results file.
Default MOVES database	movesdb20221007	SEE uses some tables from the default MOVES3 database, so the name of this database must be specified here.
Database username	root	Your MySQL username
Database password	moves	Your MySQL password (if any)
Path for MOVES input and runspec XML	C:/SEE/MOVESXML	SEE writes all of the MOVES Runspec files, Data Importer XML files, and Batch executables to this location.
MOVES install path	C:/Users/Public/EPA/MOVES/MOVES3.1	SEE needs to know where MOVES is installed because it launches MOVES from the command line.
Number of MySQL threads	1	Determines how many simultaneous MySQL queries to run using multithreading. This number should be less than the total number of threads available on your machine. If you do not know how many threads your computer is capable of handling, look up the technical specifications of your machine's processor (CPU).

4.1.12 Export Link Level Emissions

The top, right portion of the GUI **Home Tab** provides an extra (and optional) export of link-level emissions for a subset of links that reside in a set of one or more TAZs.

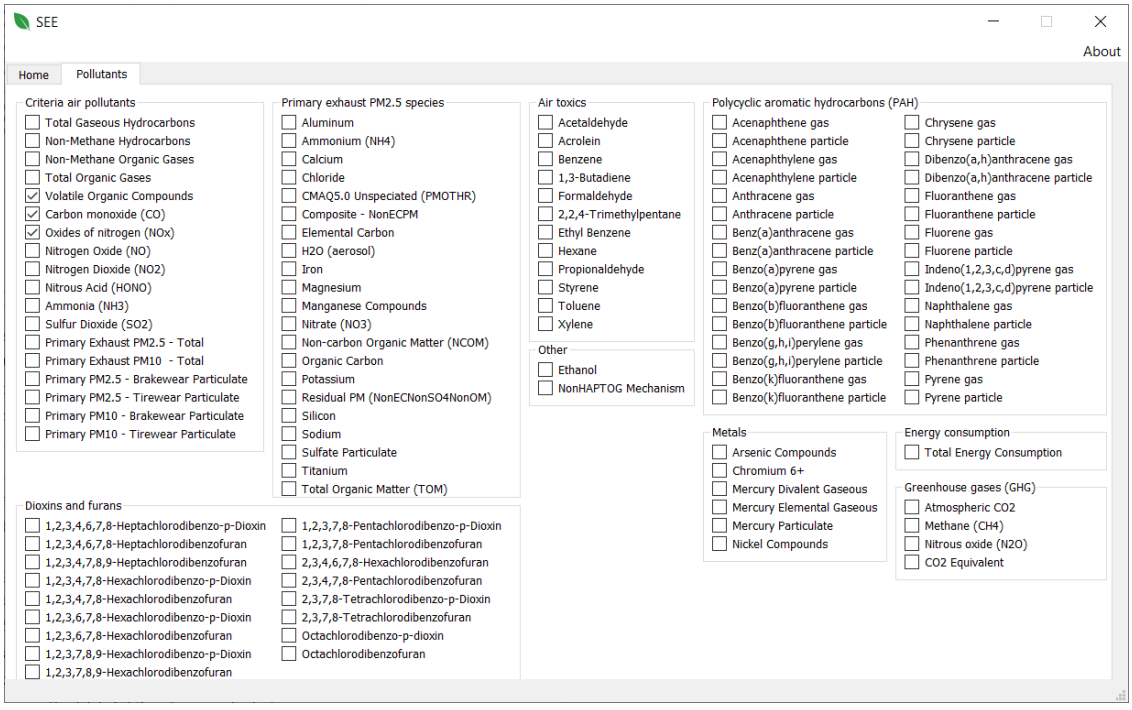
As a reminder, several output summaries are automatically generated in the **Post-process and Summarize** script, which will appear in the file named *GUI-Scenario-Name*_results.xlsx in your local output path. If you wish to export link-level results, you must select the "Compile link-level emissions" prior to running SEE. Then, enter the list of zones, separated by commas if there are more than one. After SEE is done executing, click the **Export link-level results** button, and the Excel results file from the **Post-process and Summarize** script will be replaced with a new one that has an additional worksheet containing the link-level emissions.

Note: This optional button launches the **Export Link-Level Results** script (fully described in Section 5.9), and the results are not instant, though the wait is typically only a few minutes after the main run has completed. The precise wait time will depend on the number of zones you request, but likely the additional results will take less than five minutes. SEE will notify you with a pop-up window when the new Excel results file is available.

4.2 Pollutants Tab

To access the pollutant choices, click **Pollutants** (adjacent to the **Home** tab) at the top of the GUI. Figure 2 shows the available list of pollutants for MOVES3. Located to the left of each pollutant name is a clickable checkbox.

Figure 2. GUI Pollutants Tab



When you select pollutant, a check mark should appear in the checkbox. SEE automatically saves your pollutant selections plus any MOVES prerequisite pollutants (the user does not need to select any prerequisites), to be included downstream in the run instructions for MOVES. The next page shows representative examples of the XML sections of pollutants that SEE saves for later MOVES runs, using an example user selection of the pollutants VOC and NO_X. These XML text sections are updated whenever the user switches between the **Pollutants** and **Home** tabs. SEE automatically includes all emission processes for the pollutants selected, except for refueling.

VOC XML section for MOVES rate mode runs (ratesPollutants.xml):

```
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="1" processname="Running Exhaust"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="2" processname="Start Exhaust"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="11" processname="Evap Permeation"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="12" processname="Evap Fuel Vapor Venting"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="13" processname="Evap Fuel Leaks"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="15" processname="Crankcase Running Exhaust"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="16" processname="Crankcase Start Exhaust"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="17" processname="Crankcase Extended Idle Exhaust"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="90" processname="Extended Idle Exhaust"/>
<pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds" processkey="91" processname="Auxiliary Power Exhaust"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="1" processname="Running Exhaust"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="2" processname="Start Exhaust"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="11" processname="Evap Permeation"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="12" processname="Evap Fuel Vapor Venting"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="13" processname="Evap Fuel Leaks"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="15" processname="Crankcase Running Exhaust"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="16" processname="Crankcase Start Exhaust"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="17" processname="Crankcase Extended Idle Exhaust"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="90" processname="Extended Idle Exhaust"/>
<pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="91" processname="Auxiliary Power Exhaust"/>
<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="1" processname="Running Exhaust"/>
<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="2" processname="Start Exhaust"/>
<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="11" processname="Evap Permeation"/>
<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="12" processname="Evap Fuel Vapor Venting"/>
<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="13" processname="Evap Fuel Leaks"/>
<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="90" processname="Extended Idle Exhaust"/>
```

```
<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="91" processname="Auxiliary Power Exhaust"/>
```

NOx XML section for MOVES rate mode runs (ratesPollutants.xml):

```
<pollutantprocessassociation pollutantkey="3" pollutantname="Oxides of Nitrogen (NOx)" processkey="1" processname="Running Exhaust"/>

<pollutantprocessassociation pollutantkey="3" pollutantname="Oxides of Nitrogen (NOx)" processkey="2" processname="Start Exhaust"/>

<pollutantprocessassociation pollutantkey="3" pollutantname="Oxides of Nitrogen (NOx)" processkey="15" processname="Crankcase Running Exhaust"/>

<pollutantprocessassociation pollutantkey="3" pollutantname="Oxides of Nitrogen (NOx)" processkey="16" processname="Crankcase Start Exhaust"/>

<pollutantprocessassociation pollutantkey="3" pollutantname="Oxides of Nitrogen (NOx)" processkey="17" processname="Crankcase Extended Idle Exhaust"/>

<pollutantprocessassociation pollutantkey="3" pollutantname="Oxides of Nitrogen (NOx)" processkey="90" processname="Extended Idle Exhaust"/>

<pollutantprocessassociation pollutantkey="3" pollutantname="Oxides of Nitrogen (NOx)" processkey="91" processname="Auxiliary Power Exhaust"/>
```

4.3 Home Tab – Launch Buttons

The **Home Tab** inputs were described in Section 4.1. This section explains each launch button that initiates a script.

4.3.1 QA Inputs

The QA button checks a variety of user-supplied MOVES input files and SEE inputs. These QA checks will not prevent all errors but were designed to prevent typos made in the naming of a directory or the most common types of omissions that might occur if using the TTI Utilities to prepare MOVES inputs. The **QA** button GUI feature checks for the presence of files, and, in some cases, their data contents.

Upon clicking the **QA** button, SEE will:

- Create a "renamed" subfolder in the MOVES input data folder (e.g., TCEQ_MOVES_INPUTS_*) and in the lookups folder (e.g., LOOKUPS_*).

- Look for files inside of TCEQ_MOVES_INPUTS matching the following naming conventions, and move them to the "renamed" subfolder, where "*YR*," "*CTY*," etc. are placeholders for the scenario year, county, etc., and * is a wildcard. When the files are moved, the file names are simplified by removing any characters matched by the wildcard. The QA fails if there is more than one match for any file.

    - *YR*_*CTY*_sutage*.csv
    - *YR*_imcoverage*.csv
    - *YR*_fuelsupply*.csv
    - fuelFormulation_*YR**.csv
    - AVFT_*YR**.csv
    - FuelUsageFraction*.csv
    - HotellingActivityDistribution*.csv
    - ZoneMonthHour*.csv
    - county_*CTY**.csv

- Look for files in the LOOKUPS data folder matching the following naming conventions and move them to the "renamed" subfolder.

    - ExtendedIdle_Capacity*.txt
    - RoadTypeLookup*.txt
    - TimePeriodLookup*.txt
    - TxLEDadjustments*.txt
    - CountyLookup*.txt
    - *YR*_VMX*.txt
    - *YR*_SHP*.txt
    - *YR*_hotelling*.txt
    - *YR*_ONI*.txt
    - *YR*_starts*.txt

- Check that the years in the *YR*_*CTY*_sutage*.csv file match the year of the scenario being modeled.

- Check that there are TRANSVMT files in the TRANSVMT data path (e.g., TRANSVMT_*) that match the *T*HR* naming convention (e.g., HGAC_2020_transvmt.T01, …, HGAC_2020_transvmt.T24) and report the number of files found.

- If the Home Screen has "Use Trip Matrix Files" set to "Yes," then check that there are trip matrix files in the TRANSVMT data path that match the *.asc naming convention and report the number of files found. If "Use Trip Matrix Files" is set to "No," then this QA check is skipped.

- Verify that the trip matrix file names contain a valid time period (e.g., AM) in the correct position. This check relies on the TimePeriodLookup*.tab file listed above to identify valid time periods.

- Verify the MOVES installation path by checking for the setenv.bat file in the specified path.

- Verify that the default MOVES database specified in the GUI exists.

Any failure of a check listed above (e.g., *YR*_*CTY*_sutage*.csv contains the wrong year) will result in a descriptive message of the error in a pop-up window. Otherwise, the pop-up message will read "Passed QA."

4.4 Running SEE

The simplest way to execute a SEE run is to click the red button, **Run ALL Scripts,** to run everything with a single click. However, if desired, it is also possible to run only the pre-processing and MOVES runs portion of SEE by clicking the blue **Pre-process and Run MOVES** button. If the pre-processing scripts and MOVES runs have already completed, you may then optionally run the post-processing portion of SEE by clicking the purple **Post-process** button. Alternatively, SEE may be run one script at a time using the buttons in the *Run individual scripts* pane. For example, to run all scripts sequentially, click the **Pre-process VMT** button, followed by the **Pre-process Trips** button, and so on, through **Post-process and Summarize**. If run in this manner, the scripts must be run in order from top to bottom. The inputs and outputs from each script, as well as calculations, are described next in Section 5.1 through Section 5.8. Section 5.9 describes a final script which generates the optional output of detailed link-level results for a group of links.

5.0 SEE Data Flow: Inputs, Calculations, and Outputs

In this version of SEE, calculations proceed linearly through 10 major steps, with each step performed by a particular Perl script. These steps and their associated scripts, in order of execution, are:

- pre-process link characteristics, such as VMT and average speed (**Pre-process VMT**

  script)

- pre-process trip data to determine how off-network emissions should be allocated (**Pre-process Trips** script)

- create an input database for the MOVES runs (**Create Input Database** script)

- create a MOVES runspec for a County Scale Rate Mode run to generate off-network and on-network emission rates (**Create Rate Mode Runspec** script)

- execute the County Scale Rate Mode run (**Execute Rate Mode Run** script)

- combine the activity outputs (VMT and SHP) with the rate outputs to calculate off-network rates per SHP; combine rate per activity with activity inputs to calculate total off-network emissions (**Calculate Off-net** script)

- allocate off-network emissions using the factors calculated by the **Pre-process Trips** script (**Post-process Off-net** script)

- calculate on-network emissions by combining emission rates with links using link average speeds and interpolated emission rates; perform various post-processing and summarization steps (**Post-process and Summarize** script)

5.1 Pre-process VMT Script

The primary task performed by the **Pre-process VMT** script is aggregating link characteristics, such as average speed and VMT.

Table 2 lists the final tables prepared by the **Pre-process VMT** script, which are later used by the **Post-process and Summarize** script.

Table 2. Pre-process VMT Script's Final MySQL Tables and their Purpose

Database Table Name, **where *ONDB_CTY* = the SEE on-network database for a specific county and *HR* = hour from 01 to 24**	**Next Used By**	**How Table is Used**
ONDB_CTY.link_definitions	**Post-process and Summarize** script	**Post-process and Summarize**: join linkIDs to linkTotals table; **Export Link-Level Results:** extract linkIDs for specific TAZs for link-level emissions export
*ONDB_CTY.HR*_Links_All	**Post-process and Summarize** script	**Post-process and Summarize**: join emissions rates with links to calculate link-specific emissions

5.2 Pre-process Trips Script (Optional)

Processing trips data from the travel model is optional. To enable pre-processing of trips, ensure that the Home tab of the SEE GUI shows a "Yes" setting adjacent to "Use Trip Matrix Files." Choosing Yes instructs SEE to import trip data and allocate starts, parking, and extended idling to TAZs. The calculations involved in this script are simple sums and fractions of totals.

The first step in the **Pre-process Trips** script is the allocation of extended idling to TAZ as a fraction of the total extended idling that occurs in a given county. The fraction of extended idling in a TAZ is inferred based on the number of truck stops. The number of truck stops per TAZ is loaded from the *ExtendedIdle_Capacity.tab* input file. The fraction of extended idling occurring in a particular TAZ is simply the number of truck stops in the TAZ divided by the total number of truck stops in the county. This fraction is the allocation factor used to allocate County Scale extended idling emissions back to the TAZ level.

The second operation in the **Pre-process Trips** script is the calculation of the number of trips originating in a TAZ and the number of trips ending in a TAZ. These are calculated from the trip files (the *Matrix.asc input files), which provide the number of trips that begin in a specific TAZ and end in another TAZ in a specific time period. From these data, the total number of trips originating in a TAZ can be calculated as a simple sum, as can the number of trips that end in a specific TAZ. To allocate County Scale emissions from starts and parking (trip ends), the fractions of these activities that occur in a given TAZ are then calculated to derive allocation factors. The start allocation factors are simply the fractions of starts that occur in a given TAZ at a time period divided by the total number of starts in the county during that time period. The trip end allocation factors are calculated in a similar manner. Table 3 lists the final database tables

prepared by the **Pre-process Trips** script which are all later used by the **Post-process Off-Net** script to post-process the MOVES run results.

Table 3. Pre-process Trips Script's Final MySQL Tables and their Purpose

Database Table Name, **where *OFFDB* = SEE off-network database**	**Next Used By**	**How Table is Used**
OFFDB.timePeriodLookup	**Post-process Off-Net** script	Allocate emissions to TAZ based on time period
OFFDB.alloc_tripstarts	**Post-process Off-Net** script	Allocate trip starts to TAZ
OFFDB.alloc_tripends	**Post-process Off-Net** script	Allocate trip ends to TAZ
OFFDB.alloc_idlespots	**Post-process Off-Net** script	Allocate idling to TAZ

5.3 Create Input Database Script

The **Create Input Database** script generates two types of files: an XML file that provides instructions to the MOVES importer, and a single Windows batch script that launches the MOVES importer using the XML import specification file. The primary purpose of the XML import specification file is to instruct MOVES to load the input files, described in more detail in Section 6.0, into the input database. All of the files generated by the **Create Input Database** script – the CountyScale_County_*CTY*_Year_*YR*_Month_*MNTH*_Input.xml files and *CountyScale_XMLImporter.bat* file – are saved to the C:\SEE\MOVESXML directory.

5.4 Create Rate Mode Runspec Script

The **Create Rate Mode Runspec** script creates a County Scale Rate Mode MOVES runspec XML for each county, and an associated batch script to launch all of the Rate Mode MOVES runs. This batch script is also called by the **Execute Rate Mode Run** script. All of the files created by the **Create Rate Mode Runspec** script – the rates_*CTY*_Year_*YR*_Month_*MNTH*.mrs files and the *rates_ExecuteMOVES.bat* file – are saved in the C:\SEE\MOVESXML directory.

The runspec XML files specify the run options, such as the geographic bounds, the time span, etc. They also specify the pollutants, which are defined in the GUI by the SEE user. The

pollutants selected by the user, and any prerequisites, are saved in the file ratesPollutants.xml, which the **Create Rate Mode Runspec** script incorporates into the MOVES runspec XML files.

5.5 Execute Rate Mode Run Script

The **Execute Rate Mode Run** script serves primarily to launch the MOVES runs using the batch file generated in the preceding script. The **Execute Rate Mode Run** script also clears any existing Rate Mode output databases, which are named using the following convention: rates_county_*CTY*_year_*YR*_month_*MNTH* _output.

5.6 Calculate Off-Net Script

Off-network emissions are calculated by multiplying rate per activity emission factors by the scenario-specific activity. For example, the rate per start outputs in the MOVES *ratePerStart* table are multiplied by the number of starts per hour, source type, and fuel type to estimate total emissions by hour, source type, fuel type, process, and pollutant. Similarly, rates per hour can be combined with outputs in the *ratePerHour* table to estimate extended idling emissions.

Calculation of off-network evaporative emissions is complicated slightly by the fact that MOVES does not generate rate per activity outputs for evaporative emissions: Instead, it reports rates per vehicle in the *ratePerVehicle* (fuel leaks and permeation) and *ratePerProfile* (fuel vapor venting) tables. Therefore, an intermediate step is required to convert these rate per vehicle data into rate per activity. For evaporative emissions, activity is in terms of source hours parked (SHP).

Rate per SHP can be derived from rate per vehicle as follows:

$$ratePerSHP = ratePerVehicle \times \frac{vehicles}{SHP}$$

where *vehicles* is the vehicle population for a given hour, source type, and fuel type, and *SHP* is the corresponding hours parked for these vehicles. SEE calculates the number of vehicles and SHP for this calculation by source type, fuel type, and hour of the day, mirroring the approach of MOVES3 and using the information in the input databases discussed above in Section 5.3. These activity data come from the County Scale Inventory Mode MOVES runs, and the emission rates come from the County Scale Rate Mode runs.

Prior to aggregating the emissions, NOx, NO, NO2, and HONO, i.e., *pollutantIDs* 3, 32, 33, and 34, in counties with Texas Low Emission Diesel (TxLED) diesel fuel formulations are adjusted downwards by multiplying by a TxLED NOx adjustment factor.

5.7 Post-process Off-Net Script

In the **Post-process Off-Net** script, the emissions calculated by the **Calculate Off-Net** script run are allocated to individual links and to TAZs using the allocation factors calculated in the **Pre-process VMT** and **Pre-process Trips** scripts. If the SEE GUI "Use Trip Matrix Files" was set to "No" (see Section 5.2), then SEE assigns all the off-network emissions to a single "TAZ"

representing the county total. If the "Use Trip Matrix Files" was set to "Yes" however, SEE allocates the off-network emissions to the sub-county level as described below.

Allocation to TAZ is performed separately for start emissions, off-network evaporative emissions (trip end emissions), extended idling emissions, and short-duration idle ONI emissions. In the future, a spatial allocation file for ONI locations could be developed that include locations where vehicles idle for short periods during pick-ups and drop-offs. For now, the ONI emissions are assigned to the trip end emissions when "Use Trip Matrix Files" is set to "Yes." The off-network emissions by TAZ are then combined into a single table, *movesoutput_zone*, for later inclusion in the emissions summaries generated in the **Post-process and Summarize** script.

Start emissions by TAZ are obtained by multiplying the emissions for *processIDs* 2 and 16 by the trip start allocation factors from the **Pre- process Trips** script. Likewise, the off-network evaporative emissions are obtained by multiplying the emissions for *processIDs* 11, 12, and 13 by the trip end allocation factors. ONI emissions are generated by multiplying the emissions for *processIDs* 1 and 15 on *roadTypeID* 1 by trip ends allocation, which is the same as evaporative emissions. Extended idle emissions by TAZ are the emissions for *processIDs* 17, 90, and 91 multiplied by the extended idle allocation factors from the **Pre-process Trips** script. The **Post-process Off-Net** script does not produce any intermediate text files, but it does prepare a MySQL table, *movesoutput_zone*, in the off-network database that is used later by the **Post- process and Summarize** script.

5.8 Post-process and Summarize script

The **Post-process and Summarize** script is the most time-intensive part of SEE because it performs queries on large tables that are responsible for joining the on-network emission rates to the individual links to calculate emissions by link. Rates for all hours, road types, source types, fuel types, processes, and pollutants are joined to links using link average speeds. The **Post-process and Summarize** script also summarizes SEE results from on-network and off-network components and reports them together in the Excel file located at C:\SEE*GUI-Scenario-Name*_results.xlsx. At the conclusion of the SEE run, all of the messages that were reported to the command window console are copied into a text file located at C:\SEE\LocalGen\SEE_Perl.log. Each run of SEE overwrites this log file, so it should be renamed between runs if you want to keep a record of a previous run.

Like in the **Calculate Off-Net** script, the first step in processing the on-network emissions data is to multiply the diesel-fueled NOx emissions (*pollutantIDs* 3, 32, 33, and 34) in the TxLED counties by the NOx adjustment factor.

The next step performed by the **Post-process and Summarize** script is interpolation of the emission rates. MOVES Rate Mode generates emission rates by average speed bin, which are generally 5 mph bins. To estimate emissions at the same level of precision as TCEQ's inventories, these rates are interpolated to three decimal places to generate rates for intermediate speeds, as follows:

$$rate_{interp} = rate_{low} + interpFac \times \left(rate_{high} - rate_{low}\right)$$

where $rate_{interp}$ is the interpolated emission rate; $rate_{low}$ is the emission rate for the average speed bin below the link speed; and $rate_{high}$ is the emission rate for the average speed bin above the link speed. Interpolation of rates requires the use of harmonic averaging, as follows:

$$interpFac = \left(\frac{1}{speed_{link}} - \frac{1}{speed_{low}}\right) \Big/ \left(\frac{1}{speed_{high}} - \frac{1}{speed_{low}}\right)$$

where $speed_{link}$ is the link average speed; $speed_{low}$ is the speed corresponding to the average speed bin below the link speed; and $speed_{high}$ is the speed corresponding to the average speed bin above the link speed. On-network emission rates are in terms of rate per mile, so to calculate total emissions requires VMT by hour, road type, source type, and fuel type. This is calculated using a combination of the per-link VMT and hourly fleet mix from the TRANSVMT input files. The **Post-process and Summarize** script also uses these VMT allocations for the final SEE summary tables.

The **Post-process and Summarize** script also exports emission rate tables so they are available for future use and/or analysis external to SEE. These exports include the on-network emission rates in the *ratePerDistance* table and the off-network rates in the *ratePerStart, ratePerHour, ratePerVehicle*, *ratePerProfile*, and *ratePerSHP* tables. Note that *ratePerStart*, *ratePerHour*, and *ratePerSHP* emission factors are duplicates of emission processes already covered in the ratePerVehicle report. As of November 2021, there are three new reports *ratePerDistance_aggregated, ratePerVehicle_aggregated, and ratePerProfile_aggregated.* The aggregated reports contain the emission factors summed over emission process ID and summed over hour ID into travel model time periods (e.g., AM, MD, PM, ON). All the exported rates are final rates that reflect the TxLED adjustments.

Table 4 lists the final output text files created by the **Post-process and Summarize** script, and

Table 5 shows the one final table used in a later script (**Export Link-Level Results**) for optional link output reporting.

Table 4. Post-process and Summarize Script's Output Files and their Purpose

Final Output File from the Post-process and Summarize script Location: C:\SEE\LocalGen\	**Purpose**
CTEmissHourlySummary.txt	The HourlyEmiss tab of the Excel export file
CTEmissDailySummary.txt	The DailyEmiss tab of the Excel export file

Final Output File from the Post-process and Summarize script Location: C:\SEE\LocalGen\	**Purpose**
CTVMTHourlySummary.txt	The HourlyVMT tab of the Excel export file
CTVMTDailySummary.txt	The DailyVMT tab of the exported Excel file
SummaryTotals.txt	The Summary tab of the exported Excel file
offnetEmissions.txt	Generated for external QA of SEE output
linkEmissions.txt	Generated for external QA of SEE output
ratePerDistance.txt	On-network emission rates
ratePerDistance_aggregated.txt	On-network emission rates aggregated over emission processes and hours
ratePerStart.txt	Off-network start emission rates
ratePerHour.txt	Off-network extended idling emission rates
ratePerVehicle.txt	Off-network evaporative permeation and fuel leaks emission rates
ratePerVehicle_aggregated.txt	Off-network evaporative permeation and fuel leaks emission rates aggregated over emission process and hours
ratePerProfile.txt	Off-network evaporative fuel vapor venting emission rates
ratePerProfile_aggregated.txt	Off-network evaporative fuel vapor venting emission rates aggregated over emission process and hours
ratePerSHP.txt	Off-network evaporative emission rates per source hour parked

Table 5. Post-process and Summarize Script's Final MySQL Additional Table

SEE Table Name where *SUMDB* = the summary database	**Next Used By**	**How Table is Used**
SUMDB.linkSummaryTotals	**Export Link-Level Results** script	**Export Link-Level Results:** export link-level emissions

5.9 Export Link-Level Results Script

The **Export Link-Level Results** script is an optional summarization script that is launched by the **Export Link-Level Results** button in the SEE GUI. The summary reports detailed emissions (by link, pollutant, process, source type, fuel type, and hour of the day) for a subset of links within a zone or group of zones. If you wish to export link-level results, you must select the "Compile link-level emissions" prior to running SEE. Then, enter one or more zones into the field under **Link-level export zones** within the **Output options** panel of the GUI **Home Screen**, then click the **Export link-level results** button. After up to approximately five minutes, the Excel file originally created in the **Post-process and Summarize** script will have a new worksheet tab called `linkSummaryTotals` containing the additional detailed results.

The **Export Link-Level Results** script does not perform any new calculations; it simply queries a large SEE summary database table named *linkSummaryTotals* to extract results for a subset of link IDs. The **Export Link-Level Results** script does this in two steps, and the GUI then imports the output into the Excel results file. First, the **Export Link-Level Results** script determines which link IDs are requested by the user by using the input field from the GUI and cross referencing the user input zones with SEE's on-network database table *link_definitions*; the links that exist in the user's zones are stored in a new SEE summary database table named *linkIDsOfInterest*. Next, the **Export Link-Level Results** script exports results from *linkSummaryTotals* where the link ID matches the link ID contained in *linkIDsOfInterest*. The **Export Link-Level Results** script writes these results to the following file: C:\SEE\LocalGen\linkSummaryTotals.txt. Finally, the GUI imports this file as new spreadsheet tab in the file C:\SEE\LocalGen*GUI-Scenario-Name*_results.xlsx.

Table 6. Export Link-Level Results Script's Output Files and their Purpose

Final Output File from the Export Link-Level Results Script Location: C:\LocalGen\	**Purpose**
linkSummaryTotals.txt	The link level output for the Excel results file

6.0 Input Files

This section presents details on the input files that the user must provide, both for MOVES and SEE. The two tables below show which input files for MOVES the user must provide. Table 7 lists inputs for the MOVES runs and whether they must be provided by the user. The user does not need to supply any inputs marked as 'MOVES default.' For database table names that must be provided by the user, the input files should be placed under the directory C:\SEE\TCEQ_MOVES_INPUTS.

Table 7. User Responsibilities for County Scale MOVES Inputs

Database table name	Provided by User	MOVES default
AVFT	X	
avgSpeedDistribution		X
county	X	
dayVMTfraction		X
fuelUsageFraction	X	
fuelFormulation	X	
fuelSupply	X	
hotellingActivityDistribution	X	
hourVMTfraction		X
HPMSVtypeYear		X
*IMcoverage**	X	
monthVMTfraction		X
roadTypeDistribution		X
sourceTypeAgeDistribution	X	
sourceTypeYear		X
zoneMonthHour	X	

*IMcoverage should only contain the inspection and maintenance information for a single county.

Note that the IMCoverage input must only contain one countyID entry describing the I/M program. In the example working directory that accompanies SEE version 6jan23, the I/M coverage table provides

the program for just Brazoria County (48039) instead of all five affected counties in the Houston-Galveston-Brazoria area. SEE now requires this data to be provided only for a single county and will apply it over the entire IM area specified in the GUI.

The VMT mix and all of the off-network activity data files come from the TTI Utilities, including source hours parked (SHP), off-network idle (ONI), starts, hoteling hours, also comes from the TTI Utilities. These data should be stored in C:\SEE\LOOKUPS as the default location.

6.1 Input (Flexible) File Name Conventions

Most of SEE and MOVES's input files have new filenames which replace the longer, cumbersome names originally used during previous work on SEE during 2014. The goal of the new naming convention is to shorten file names while still including key identifiers such as the county code and year, where appropriate. In addition, the files may end with a wildcard, or any combination of letters, numbers, or symbols; SEE will still recognize them. Table 8 shows the filename conventions for MOVES input files and Table 9 show the names for SEE inputs. The asterisk symbol (*) indicates a wildcard.

Table 8. Flexible Filenames for MOVES

MOVES Table Name	Filename, where YR = 4-digit year, *CTY* = County FIPS Code, and * = wildcard
AVFT	AVFT_*YR**.csv
fuelUsageFraction	FuelUsageFraction*.csv
fuelFormulation	FuelFormulation_*YR**.csv
fuelSupply	*YR*_fuelsupply*.csv
IMcoverage	*YR*_imcoverage*.csv
sourceTypeAgeDistribution	*YR_CTY*_sutage*.csv
zoneMonthHour	ZoneMonthHour*.csv
county	county_*CTY**.csv
hotellingActivityDistribution	HotellingActivityDistribution*.csv

Table 9. Flexible Filenames for SEE

SEE Table Name, where *ONDB* = the on-network database and *OFFDB* = the off-network database	**Filename, where *YR* = 4-digit year, *CTY* = County FIPS Code, and * = wildcard**
OFFDB.ExtIdle_Raw	ExtendedIdle_Capacity*.txt
OFFDB.TimePeriodLookup	TimePeriodLookup*.txt
ONDB_CTY.RoadTypeLookup	RoadTypeLookup*.txt
ONDB_CTY.CountyLookup	CountyLookup*.txt
OFFDB.TxLEDLookup	TxLEDadjustments*.txt
ONDB_CTY.SUTmix_*CTY*_Lookup	*YR*_VMX*.txt
ONDB_CTY.SHP	*YR*_SHP*.txt
OFFDB.imported_hotellinghours	*YR*_hotelling*.txt
OFFDB.imported_oni	*YR*_ONI*.txt
OFFDB.imported_starts	*YR*_starts*.txt

6.2 Input File Formats for MOVES

This section describes the format requirements of each input file the user needs to provide for MOVES runs inside of SEE. The formats may not match those in the MOVES database, but they are the formats expected by MOVES data importers so that the model can read them correctly.

The user also needs to provide input files for SEE (rather than MOVES) and these formats are discussed separately in Section 6.3.

Table 10. Format of AVFT Input

Columns of the AVFT table For more information, see Section 4.8 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
sourceTypeID	smallint(6)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
modelYearID	smallint(6)	Numeric value identifying a model year.
fuelTypeID	smallint(6)	Identifies a basic kind of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Ethanol (E85) 9 = Electricity
engTechID	smallint(6)	Identifies an engine technology.
fuelEngFraction	double(22)	Fraction that must sum to 1 for each combination of sourceTypeID and modelYearID

Table 11. Format of Fuel Formulation Input

Columns of the Fuel Formulation Table For more information, see Section 4.8 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
fuelFormulationID	smallint(6)	Numeric value to uniquely identify a fuel type.
fuelSubtypeID	smallint(6)	Identifies a particular kind of fuel within a FuelType. e.g. Gasoline may be conventional, or RFG, diesel may be conventional, biodiesel, Fischer-Troppes, etc.
RVP	float(12)	Vapor pressure, expressed in psi.
sulfurLevel	float(12)	sulfur content, expressed in ppm
ETOHVolume	float(12)	Ethanol content, expressed in volume percentage
MTBEVolume	float(12)	MTBE content, expressed in volume percentage
ETBEVolume	float(12)	ETBE content, expressed in volume percentage
TAMEVolume	float(12)	TAME content, expressed in volume percentage
aromaticContent	float(12)	aromatic content, expressed as a volume percentage
olefinContent	float(12)	olefin content, expressed as a volume percentage
benzeneContent	float(12)	benzene content, expressed as a volume percentage
e200	float(12)	percentage vapor at 200 degrees F
e300	float(12)	percentage vapor at 300 degrees F
BioDieselEsterVolume	float(12)	percent volume of biodiesel in diesel fuel
CetaneIndex	float(12)	Not Used in MOVES
PAHContent	float(12)	Not used in MOVES
T50	float(12)	temperature in degrees F at which 50% of a sample of gasoline evaporates
T90	float(12)	temperature in degrees F at which 90% of a sample of gasoline evaporates

Table 12. Format of Fuel Supply Input

Columns of the Fuel Supply Table For more information, see Section 4.8 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
fuelRegionID	int(11)	Identifies the fuel region code of the county being modeled.
fuelYearID	smallint(6)	Identifies a year for which fuel supply data has been entered in the FuelSupply table. (May be used by multiple calendar years.)
monthGroupID	smallint(6)	Numeric value of 1-12 and the value ***must match the SEE GUI Month ID***
fuelFormulationID	smallint(6)	Numeric value to identify a fuel type and it must have a corresponding entry for the fuelFormulationID in the Fuel Formulation table.
marketShare	float(12)	Decimal Fraction of the supply of this fuel type which this fuel formulation constitutes. Market shares must sum to 1 over fuel subtype.
marketShareCV	float(12)	Not used in MOVES

Table 13. Format of Fuel Usage Fraction Input

Columns of the Fuel Usage Fraction Table For more information, see Section 4.8 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
countyID	int(11)	1000* FIPS state code + FIPS county identification code.
fuelYearID	int(11)	Identifies a year for which fuel supply data has been entered in the FuelSupply table. (May be used by multiple calendar years.)
modelYearGroupID	int(11)	Identifies a model year group. Use zero for a placeholder to indicate all model years.
sourceBinFuelTypeID	smallint(6)	Identifies the type of fuel the engine is capable of using: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Ethanol (E85) 9 = Electricity
fuelSupplyFuelTypeID	smallint(6)	Identifies the type of fuel: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Ethanol (E85) 9 = Electricity
usageFraction	double(22)	A fraction with value between 0 and 1. The usage fractions must sum to 1 over each combination of countyID, fuelYearID, modelYearGroupID, and sourceBinFuelTypeID.

Table 14. Format of I/M Coverage Input

Columns of the I/M Coverage Table For more information, see Section 4.9 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
polProcessID	int(11)	100*pollutantID + processID Set of valid combinations is determined by rows in this table.
stateID	smallint(6)	FIPS state identification code.
countyID	int(11)	1000* FIPS state code + FIPS county identification code. ***Only enter I/M program data for a single county.***
yearID	smallint(6)	An actual calendar year. ***This must match the SEE GUI calendar year***
sourceTypeID	smallint(6)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
fuelTypeID	smallint(6)	Identifies the type of fuel: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Ethanol (E85) 9 = Electricity
IMProgramID	smallint(6)	Numeric value to uniquely identify the application of an IM program to a set of model years.
inspectFreq	smallint(6)	"1" means annual "2" means biennial "3" means continuous
testStandardsID	smallint(6)	Numeric value corresponding to one of 13 exhaust emissions tests or 7 evaporative tests available in MOVES2014.
begModelYearID	smallint(6)	Numeric value identifying a model year.
endModelYearID	smallint(6)	Numeric value identifying a model year.
useIMyn	char(1)	"Y" means I/M program is in effect "N" means I/M program is turned off
complianceFactor	float(12)	Decimal fraction to indicate the I/M compliance rates, waiver rates and the regulatory class adjustment.

Table 15. Format of Age Distribution Input

Columns of the Source Type Age Distribution Table For more information, see Section 4.4 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
sourceTypeID	smallint(6)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
yearID	smallint(6)	An actual calendar year. ***This must match the SEE GUI calendar year***
ageID	smallint(6)	Identifies a SourceUseType age category. Values from 0 to 30. 0 = new 1 = one year old 2 = two years old ... 30 = thirty or more years old
ageFraction	double(22)	Fraction of total domain SourceUseType population which, in a given calendar year, are a given age. (A set of these elements is sometimes often referred to informally as a "registration distribution".)

Table 16. Format of Meteorology Input

Columns of the Meteorology (Zone Month Hour) Table For more information, see Section 4.2 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
monthID	smallint(6)	Numeric value of 1-12 and ***the value must match the SEE GUI Month ID***
zoneID	int(11)	Identifies a zone. Use the county ID * 10.
hourID	smallint(6)	Numeric value of 1-24.
temperature	float(12)	Units of degrees Fahrenheit.
temperatureCV	float(12)	Not used by MOVES
relHumidity	float(12)	The ratio of the amount of water vapor in the air at a specific temperature to the maximum amount that the air could hold at that temperature, expressed as a percentage.

Table 17. Format of County Input

Columns of the County Table This is not a typically required input for a MOVES Run.		
Field Name	**Data Type**	**Comment**
countyID	int(11)	1000* FIPS state code + FIPS county identification code.
stateID	smallint(6)	Two digit FIPS state code.
countyName	char(50)	Text string up to 50 characters long.
altitude	char(1)	Valid entries are “H” for high altitude or “L” for low altitude.
GPAFract	float(12)	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. Enter a value of 0 for Texas counties.
barometricPressure	float(12)	Barometric pressure in units of inches mercury
barometricPressureCV	float(12)	Not used in MOVES
countyTypeID	int(11)	Value of 0 or 1.
msa	char(255)	Name of the Metropolitan Statistical Area, if the county is in an MSA.

Table 18. Format of Hotelling Activity Distribution Input

Columns of the Hotelling Activity Distribution Table For more information, see Section 4.11 of the MOVES3 Technical Guidance https://www.epa.gov/sites/default/files/2020-11/documents/420b20052.pdf		
Field Name	**Data Type**	**Comment**
zoneID	int(11)	Identifies a zone. Use the county ID * 10.
beginModelYearID	smallint(6)	Numeric value identifying a model year.
endModelYearID	smallint(6)	Numeric value identifying a model year.
opModeID	smallint(6)	Code that identifies the operating mode. The relevant ones for this input are: 200=Extended Idling (i.e., using the Main Engine) 201=Hotelling Diesel Aux 203=Hotelling Battery AC 204=Hotelling APU Off
opModeFraction	float(12)	Fraction between 0 and 1 that should sum to 1 over operating mode IDs for a given set of beginModelYearID and endModelYearID.

6.3 Input File Formats for SEE

This section describes the format requirements of each input file the user needs to provide to SEE, excluding direct MOVES model inputs which were described above (Section 6.2).

Table 19. Format of SEE's Input County Lookup

Columns of the CountyLookup*.txt file where * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
County Code	int(11)	County code in the TRANSVMT files; values currently used are 1- 8.
DistrictCode	int(11)	TxDOT District Code system used by the TTI. As of 2023, TTI uses a district code of 5 for Liberty and Chambers, and a code of 13 for the other six counties in the HGB area.
countyID	int(11)	County FIPS code (e.g., 48201)
County Name	varchar(15)	County name (e.g., Harris). This field is not used by SEE.

Table 20. Format of SEE's Extended Idle Allocation

Columns of the ExtendedIdle _Capacity*.txt file where * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
countyID	int(11)	5-digit code (e.g., 48201)
TAZID	int(11)	Transportation Analysis Zone
TruckParkingSpots	int(11)	Number of Overnight Truck Parking Spaces in the TAZ

Table 21. Format of SEE's Input Road Type Lookup

Columns of the RoadtypeLookup*.txt file where * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
Road Type Code	int(11)	Road type code of each link from the TRANSVMT files. Past values have included: 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 40
Area Type Code	int(11)	Area type code of each link from the TRANSVMT files. Past values have included: 1, 2, 3, 4, 5, 40
MOVES roadTypeID	int(11)	Corresponding MOVES road type ID. Values can only be 2, 3, 4, or 5.

Table 22. Format of SEE's Input Time Period Lookup

Columns of the TimePeriodLookup*.txt file where * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
Hour ID	int(11)	Hour of Day, 1-24.
Description of Time Period	varchar(50)	Text description up to 20 characters. This field is not used by SEE.
Time Period ID	varchar(2)	Must be a two-character description of the time period (e.g., AM, MD, PM, ON)

Table 23. Format of the VMT Mix Input

Columns of the YR_VMX*.txt file where YR = 4-digit year and * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
DistrictCode	int(11)	TxDOT District Code system used by the TTI. These are assigned to counties in the CountyLookup*.txt file (Table 19)
dayPeriod	varchar(2)	ON for overnight; AM for morning; MD for mid-day; or PM for evening
roadTypeID	int(11)	Numeric value defining a MOVES road type. Values can be 2, 3, 4, or 5.
sourceTypeID	int(11)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
fuelTypeID	int(11)	Numeric value identifying a type of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Gasoline with 85% ethanol by volume (E85) 9 = Electricity
VMTmix	double	Decimal fraction for each combination of source and fuel type, must sum to 1 over each road type.
roadDesc	varchar(20)	MOVES description of the road type ID.
sourceTypeDesc	varchar(20)	MOVES description of the source type ID.
fuelTypeDesc	varchar(20)	MOVES description of the fuel type ID.

Table 24. Format of SEE's Input TxLED Adjustments

Columns of the TxLEDadjustments*.txt file where * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
yearID	int(11)	An actual calendar year. ***This must include the SEE GUI calendar year***
sourceTypeID	int(11)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
Adjustment Factor	double	Numeric value between 0 and 1. SEE multiplies this factor with diesel-fueled NOx emissions. A value of "0" will result in a 100% NOx reduction; a value of "1" will result in 0% NOx reduction (no change).

Table 25. Format of the SHP Input

Columns of the YR_SHP*.txt file **where YR = 4-digit year and * = wildcard** (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
countyID	int(11)	5-digit code (e.g., 48201)
hourID	int(11)	Hour of Day, 1-24.
sourceTypeID	int(11)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
fuelTypeID	int(11)	Numeric value identifying a type of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Gasoline with 85% ethanol by volume (E85) 9 = Electricity
SHP	double(22)	Total source hours parked by source type, fuel type, and hour

Table 26. Format of the Hotelling Input

Columns of the YR_hotelling*.txt file **where * = wildcard** (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
countyID	int(11)	5-digit code (e.g., 48201)
hourID	int(11)	Hour of Day, 1-24.
totalHotelling	int(11)	Sum all hoteling modes (SHEI, APU, electric battery, and engine-off)
SHEI	double	Source Hours of Extended Idle, hoteling using the main engine.
APU	double	Auxiliary Power Unit (APU) as the power source during hoteling.

Table 27. Format of the ONI Input

Columns of the YR_ONI*.txt file where * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
countyID	int(11)	5-digit code (e.g., 48201)
hourID	int(11)	Hour of Day, 1-24.
sourceTypeID	int(11)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
fuelTypeID	int(11)	Numeric value identifying a type of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Gasoline with 85% ethanol by volume (E85) 9 = Electricity
ONI	double	Hours of off-network idle.

Table 28. Format of the Starts Input

Columns of the YR_starts*.txt file where * = wildcard (in C:\SEE\LOOKUPS)		
Field Name	**Data Type**	**Comment**
countyID	int(11)	5-digit code (e.g., 48201)
hourID	int(11)	Hour of Day, 1-24.
sourceTypeID	int(11)	Numeric value defining a MOVES source type (e.g., 11 for motorcycle)
fuelTypeID	int(11)	Numeric value identifying a type of fuel used by SourceTypes: 1 = Gasoline 2 = Diesel Fuel 3 = Compressed Natural Gas (CNG) 5 = Gasoline with 85% ethanol by volume (E85) 9 = Electricity
starts	double(22)	Number of starts, defined as a key-on event.

7.0 Output Files

This section briefly describes the output files from the model.

7.1 Excel output file

SEE automatically produces an Excel spreadsheet at the end of each run, with the naming convention C:\SEE\LocalGen*GUI-Scenario-Name*_results.xlsx. The scenario name embedded in the results spreadsheet is the same that the user provides in the GUI. The spreadsheet has five tabs by default, or six if you select the optional link-level results after the run completes. The five core summaries in the results spreadsheet are the following:

1. HourlyEmiss
2. DailyEmiss
3. HourlyVMT
4. DailyVMT
5. Summary

If you decide to extract link-level results from the SEE simulation, a sixth tab will become available in the results spreadsheet. For instructions on how to use the link-level outputs feature, refer to Section 4.1.12. After SEE completes the link output extraction, it adds the following new tab to the results file:

6. linkSummaryTotals

The 'HourlyEmiss' and 'DailyEmiss' emissions summaries contain fields of: year ID, month ID, day ID (5 = Weekday), hour ID (for 'HourlyEmiss' tab only), county ID, fuel type ID, pollutant ID, road Type ID, and 13 columns corresponding to the 13 MOVES source types. The emissions in the source type columns are in units of kilograms.

The VMT summary table fields are: county ID, fuel type ID, road type ID, hour ID (for 'HourlyVMT' only), and 13 source type columns where the VMT is in units of miles.

The 'Summary' sheet contains total on-road emissions by county in units of kilograms.

The 'linkSummaryTotals' sheet has the fields county ID, SEE link ID, Anode, Bnode, hour ID, source type ID, fuel type ID, road type ID, pollutant ID, process ID, and emissionsKG. The emissions units are kilograms.

7.2 Emission factors

SEE exports the emission rates tables from MOVES to text files so they can be used for additional off-model analysis or future reference. These rates are after the TxLED adjustments are applied. The tables are exported to C:\SEE\LocalGen\ *GUI-Scenario-Name_tableName*.txt.

The tables exported are:

1. ratePerDistance
2. ratePerDistance_aggregated
3. ratePerStart
4. ratePerHour (hoteling)
5. ratePerProfile (fuel vapor venting, per vehicle)

6. ratePerProfile_aggregated
7. ratePerVehicle (fuel leaks and permeation, per vehicle)
8. ratePerVehicle_aggregated
9. ratePerSHP (fuel vapor venting, leaks, and permeation, per source hour parked)

As discussed in Section 5.8, the MOVES output tables *ratePerDistance, ratePerStart,* and *ratePerHour* are already in terms of rate per activity, which is the form that SEE requires for emissions calculations. The *ratePerSHP* table is a table derived by SEE from the *ratePerProfile* and *ratePerVehicle* tables, which are not in terms of rate per activity.

8.0 Quality Assurance

H-GAC and ERG continuously ensure with each SEE update that the SEE model (i.e., the method for the Conformity EI) remains consistent with the TTI Utilities (the method for the SIP).

To validate SEE in the past (2021 and earlier), ERG ran SEE with the same inputs used by the TTI Utilities with MOVES2014b for the HGB area's motor vehicle emissions budget (MVEB) prepared for the *Houston-Galveston Brazoria Attainment Demonstration State Implementation Plan Revision for the 2008 Eight-Hour Ozone Standard Nonattainment Area* (https://www.tceq.texas.gov/airquality/sip/hgb/hgb-latest-ozone). The emissions totals generated by SEE converted to tons per day (TPD) matched the MVEB out to two decimal places, as documented in Table 29.

Table 29. Prior Validation of SEE for the 2017 HGB Inventory

County	CO (tpd)	NOx (tpd)	VOC (tpd)
Brazoria	37.61	4.99	3.27
Chambers	12.35	4.51	0.76
Fort Bend	58.05	7.62	5.32
Galveston	28.95	3.31	2.40
Harris	487.25	61.50	35.93
Liberty	13.02	2.62	1.11
Montgomery	62.37	9.11	4.96
Waller	8.92	1.88	0.65
Total	708.52	95.56	54.40

Validation of the new SEE (6jan2023 version) required a comparison to EI that TTI recently developed using a not-yet-released version of the TTI Utilities with MOVES3. At the time of writing, there was no MVEB established with MOVES3, so the best or most rigorous comparison ERG could make to the expected SIP methodology was to compare a SEE run with a recent calendar year 2019 nonattainment demonstration run performed by TTI with the TTI

utilities, using all of the same input files. Table 30 shows exact agreement in CO and NOx emissions, but small differences in VOC that totals 0.2 TPD over the eight-county area.

Table 30. Current Validation of SEE for a 2019 EI

County	CO (tpd)			NOx (tpd)			VOC (tpd)		
	TTI	SEE	Difference	TTI	SEE	Difference	TTI	SEE	Difference
Brazoria	40.09	40.09	0.00	4.24	4.24	0.00	2.18	2.17	0.01
Chambers	14.18	14.18	0.00	3.05	3.05	0.00	0.50	0.50	0.00
Fort Bend	61.10	61.10	0.00	6.01	6.01	0.00	3.70	3.69	0.01
Galveston	33.72	33.72	0.00	2.99	2.99	0.00	1.89	1.88	0.01
Harris	560.53	560.53	0.00	54.20	54.20	0.00	27.22	27.08	0.15
Liberty	13.55	13.55	0.00	1.84	1.84	0.00	0.75	0.75	0.00
Montgomery	64.57	64.57	0.00	7.14	7.14	0.00	3.56	3.54	0.02
Waller	14.13	14.13	0.00	1.88	1.88	0.00	0.58	0.58	0.00
Total	**801.88**	**801.88**	**0.00**	**81.36**	**81.36**	**0.00**	**40.39**	**40.19**	**0.20**

The source of the small discrepancy is in the evaporative VOC emissions that occur off-network from permeation, fuel leaks, and vapor venting from gasoline-fueled vehicles that are parked. In SEE and the TTI Utilities, these emissions are calculated from an intermediate emission rate table called ratePerSHP. ERG worked closely with TTI to understand the methodology differences behind this table and TTI found they inadvertently were excluding a small fraction of the gasoline vehicles in a conversion step between ratePerVehicle and ratePerProfile converting into ratePerSHP. TTI stated in writing that they intend to update their tool and once finished, the results should match SEE. ERG will update this document when we receive updated 2019 results from TTI.