CMAQ EMISSIONS CALCULATOR TOOLKIT

The purpose of the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit) is to help a user with limited modeling experience estimate emission reductions associated with implementation of a CMAQ-funded project. The CMAQ Toolkit uses emission rates and activity data based on national-scale runs of the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES). This document explains the use and methodology of the Bicycle and Pedestrian Improvements Tool.

Emission estimates from the CMAQ Toolkit are not intended to meet specific requirements for State Implementation Plans (SIPs) or transportation conformity analyses. For further information regarding the specific setup of MOVES used to generate the emission rates provided in this tool, please refer to the Emissions Data Documentation associated with this emissions calculator.

On-Road Activity Calculator

The on-road activity calculator is a tool that was designed to help calculate specific activity values for the diesel retrofit and repower/replacement tools based on aggregate activity data. Please use this tool if the following circumstance applies:

- You have more than one piece of activity data, none of which are specific to the desired vehicle type and model year applicable to the project (e.g., VMT and vehicle population for all heavy duty vehicles in the county is known, but not VMT for the retrofit model years)

This document is organized into three sections – User Guide, Tool Methodology, and Examples – to aid the user in understanding and using this calculator in conjunction with the emission reductions calculators. The User Guide gives direction for the user to properly input values into the tool and provides definitions of both user inputs and tool outputs. The Tool Methodology outlines the equations and assumptions used to calculate activity values. The Examples included herein are also included in the documentation for the retrofit or repower/replacement tool, to aid in use with the project tools in calculating emission reductions.

The most current version is dated December 2021. To verify the version, check the date on the Introduction page of the tool. Release notes are included in the Change Log tab, which can be viewed by right-clicking on any tab in the tool, selecting "Unhide", and revealing the tab.

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USER GUIDE

This section lists the units and description for each user input and tool output. A description of emission reductions reporting and error messages, as well as other assumptions inherent in the tool, are provided.

User Inputs

The tool's input section functions like a wizarding tool, with questions intending to help the user input proper information for activity data calculation in a step-by-step process. The user-defined inputs for this type of project are described below:

Table 1. User Inputs

User Input	Units	Description
Evaluation year	-----	Use the drop-down menu to choose a year between 2019 and 2030.
Activity data Aggregation	-----	Use the drop-down menu to select the appropriate level of aggregation for the activity data that is not specific to the desired vehicle type and model year for the project. Aggregation levels are: light duty and heavy-duty vehicles, all heavy-duty vehicles, and one vehicle type.
Activity data Aggregation Fuel Type	-----	Use the drop-down menu to select the appropriate fuel type included in the level of aggregation for the activity data that is not specific to the desired vehicle type and model year for the project. Fuel types are: all fuels or diesel only.
Total vehicle miles traveled (check box)	-----	Click on the box if your aggregated activity data includes total vehicle miles traveled. This option may be checked concurrently with the vehicle population and/or hotelling hours option.
Total vehicles miles traveled	miles	Input the total value of annual vehicle miles traveled for all the vehicles in the aggregation level specified above.
Total vehicle population (check box)	-----	Click on the box if your aggregated activity data includes vehicle population. This option may be checked concurrently with the vehicle miles traveled and/or hotelling hours option.
Total vehicle population	vehicles	Input the number of vehicles or all the vehicles in the aggregation level specified above.
Total vehicle hotelling hours (check box)	-----	Click on the box if your aggregated activity data includes hotelling hours. This option may be checked concurrently with the vehicle miles traveled and/or vehicle population.
Total vehicle hotelling hours	hours	Input the total value of hotelling hours for the vehicles in the aggregation level specified above. This option is only available when the desired vehicle type for the project is combination long-haul trucks.

User Input	Units	Description
Daily/annual data	-----	Select either 'Annual' or 'Daily' to indicate the time aggregation of the input vehicle miles traveled or hotelling hours data. If only vehicle population data is input, this option will not affect calculations.
Project vehicle type	-----	Use the drop-down menu to choose the appropriate vehicle type among heavy-duty diesel (non-transit) vehicles. Vehicle types include: school bus, refuse truck, single unit short-haul truck, single unit long-haul truck, combination short-haul truck, and combination long-haul truck.
Specific model year of vehicle type for the project	-----	Input the model year for the vehicles that the project will affect. If you have a range of years, you may either input the individual years and vehicles separately or input a representative year. The model year cannot be later than the project year. Please refer to CMAQ policy for guidance regarding appropriate model years eligible for funding.

Once the parameters are input, click on the 'Calculate Per Vehicle Activity' button to calculate single vehicle outputs. Results will not automatically update, so any time changes are made to the input parameters, this button must be pushed to calculate the updated outputs. If you would like to return to default settings, please click on the 'Reset to Default Values' button.

Tool Outputs

Single Vehicle Output

The tool-produced single vehicle outputs for this type of project are detailed below:

Table 2. Single Vehicle Outputs

Output	Units	Description
Vehicle miles traveled per vehicle, annual activity for specified vehicle type and model year	miles/ vehicle	The calculated total vehicle miles traveled annually per vehicle for the specified vehicle type and model year for the project.
Hotelling hours per vehicle, annual activity for specified vehicle type and model year	hours/ vehicle	The calculated number of hotelling hours annually per vehicle for the specified vehicle type and model year for the project. This is only applicable for combination long-haul trucks.

Optional User Input

Table 3. Optional User Input

User Input	Units	Description
Project-specific vehicle populations	vehicles	If you know this number, please input the number of vehicles of the specified vehicle type and model year that will be retrofit or repowered/replaced. If you do not know this number, leave the entry blank. The default value is 0.

Total Output

Click on the "Calculate Total Activity" button to calculate total VMT, vehicle population, and for combination long-haul trucks hoteling hours.

Table 4. Total Output

Output	Units	Description
Total vehicle miles traveled, annual activity for specified vehicle type and model year	miles	The calculated total vehicle miles traveled annually by the vehicles to be retrofit or repowered/replaced.
Total vehicle population, annual activity for specified vehicle type and model year	vehicles	The number of vehicles to be retrofit or repowered/replaced, either input by the user or calculated using national activity rates.
Total hotelling hours, annual activity for specified vehicle type and model year	hours	The calculated total annual hotelling hours by the vehicles to be retrofit or repowered/replaced.

The total output values can be input into the retrofit or repower/replacement tool. For ease of use, please choose either 'Send Activity Data to Diesel Retrofit Tool' or 'Send Activity Data to Repower/Replacement Tool' to input the data into the appropriate tool to calculate emission reductions.

Error Messages

The error messages that the user may encounter in this tool, the reason for these error messages and their remedy is listed in the table below: (Note: Once you correct the error, please press 'Calculate Per Vehicle Activity' or 'Calculate Total Activity' to clear errors).

Table 5. Error Messages

Error Message	**Reason for Error**	**Solution**
Error! Choose at least one activity type	No activity type was chosen	Please choose an activity type to use the tool
Error! Model years cannot be later than project year. Year Input Error: This tool includes model years between 1989 and 2030. Please choose appropriate years within this range.	Invalid input for model year	Input a model year that is no earlier than 1989 and no later than the project evaluation year.
Warning: less than one vehicle is represented by the input activity values	The result is representative of a partial vehicle, based on national ratios of VMT to vehicle population	Just a warning, this is acceptable to get results. However, if you want at least one vehicle represented, please put '1' in the project-specific vehicle population box.

TOOL METHODOLOGY

Activity rates are calculated using national activity data from MOVES. To calculate activity rates from an aggregation to project-specific information required for the retrofit or repower/replacement tools, the equations are outlined below.

To solve for vehicle miles traveled, one of the following equations is used (depending on user input):

$$VMT = VMT_{agg.user} \cdot \left(\frac{VMT_{spec.national}}{VMT_{agg.national}}\right) \cdot X \quad (1)$$

$$VMT = POP_{agg.user} \cdot \left(\frac{VMT_{spec.national}}{POP_{agg.national}}\right) \quad (2)$$

$$VMT = HH_{agg.user} \cdot \left(\frac{VMT_{spec.national}}{HH_{agg.national}}\right) \cdot X \quad (3)$$

In which:
spec refers to specified vehicle type and model year to be used in the project,
agg refers to aggregation specified by the user,
user refers to data provided by the user,
national refers to data given by MOVES national activity rates,
VMT = vehicle miles traveled,
POP = vehicle population,
HH = hotelling hours, and
X = 1 for annual values, 365 for daily values of VMT or HH given by the user.

To solve for vehicle population, one of the following equations is used (depending on user input):

$$POP = POP_{agg.user} \cdot \left(\frac{POP_{spec.national}}{POP_{agg.national}}\right) \quad (4)$$

$$POP = VMT_{agg.user} \cdot \left(\frac{POP_{spec.national}}{VMT_{agg.national}}\right) \cdot X \quad (5)$$

$$POP = HH_{agg.user} \cdot \left(\frac{POP_{spec.national}}{HH_{agg.national}}\right) \cdot X \quad (6)$$

In which:
spec refers to specified vehicle type and model year to be used in the project,
agg refers to aggregation specified by the user,
user refers to data provided by the user,
national refers to data given by MOVES national activity rates,
VMT = vehicle miles traveled,
POP = vehicle population,
HH = hotelling hours, and
X = 1 for annual values, 365 for daily values of VMT or HH given by the user.

To solve for hotelling hours, one of the following equations is used (depending on user input):

$$HH = HH_{agg.user} \cdot \left(\frac{HH_{spec.national}}{HH_{agg.national}}\right) \cdot X \quad (7)$$

$$HH = POP_{agg.user} \cdot \left(\frac{HH_{spec.national}}{POP_{agg.national}}\right) \quad (8)$$

$$HH = VMT_{agg.user} \cdot \left(\frac{HH_{spec.national}}{VMT_{agg.national}}\right) \cdot X \quad (9)$$

In which:
spec refers to specified vehicle type and model year to be used in the project,
agg refers to aggregation specified by the user,
user refers to data provided by the user,
national refers to data given by MOVES national activity rates,
VMT = vehicle miles traveled,
POP = vehicle population,
HH = hotelling hours, and
X = 1 for annual values, 365 for daily values of VMT or HH given by the user.

Single vehicle output to the tool include vehicle miles traveled and hotelling hours, which are calculated as follows:

$$\frac{VMT}{VEH} = \frac{VMT}{POP} \quad (10)$$

$$\frac{HH}{VEH} = \frac{HH}{POP} \quad (11)$$

In which:
VMT/VEH = vehicle miles traveled per vehicle,
HH/VEH = hotelling hours per vehicle, and
VMT, POP, and HH were defined previously.

If the user provides the number of vehicles that will be retrofit or repowered/replaced, then the total activity is calculated as follows:

$$VMT = \left(\frac{VMT}{VEH}\right) \cdot POP_{user} \quad (12)$$

$$POP = POP_{user} \quad (13)$$

$$HH = \left(\frac{HH}{VEH}\right) \cdot POP_{user} \quad (14)$$

If the number of vehicles that will be retrofit or repowered/replaced is not provided, then the population will be calculated based on national ratios.

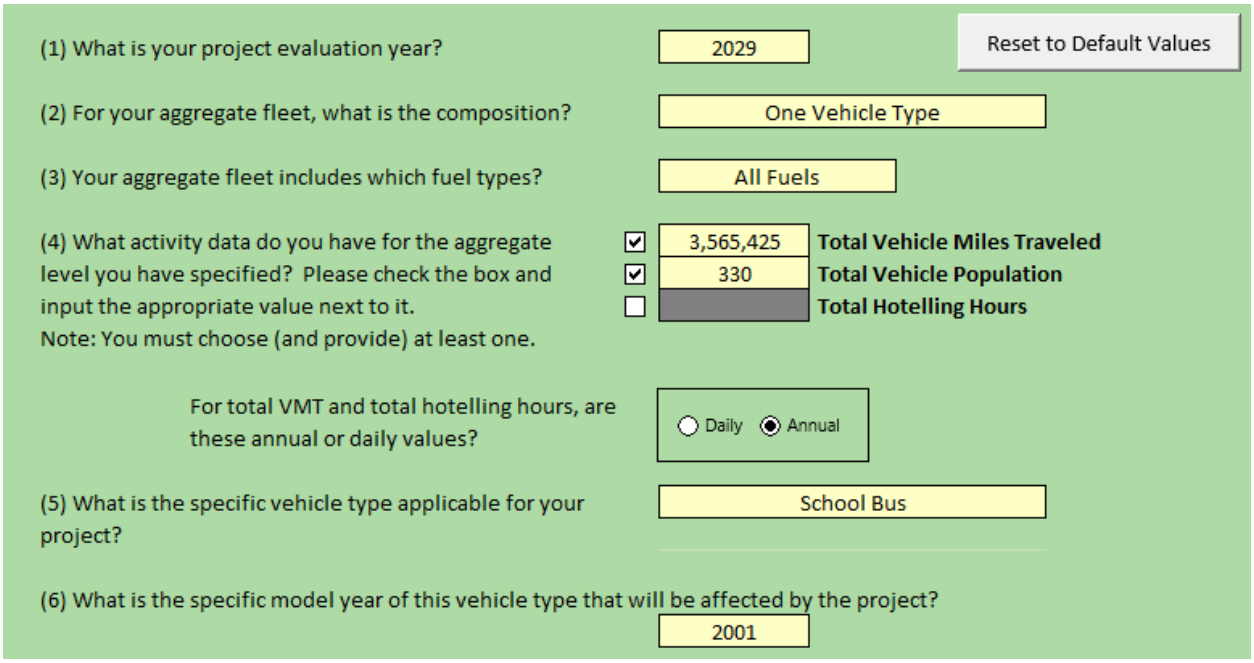
EXAMPLES

Example 1: Replacement of School Buses

Let's suppose that County X knows that their school bus fleet travels less than the national averages but they do not have specific information for the model year 2001 vehicles they are replacing. However, County X does know the total vehicle miles traveled for the 330 vehicles in their county's fleet is 3,565,425 miles. In this case, the activity calculator can be used to leverage the data inherent in MOVES to get a better estimate for vehicle miles traveled activity.

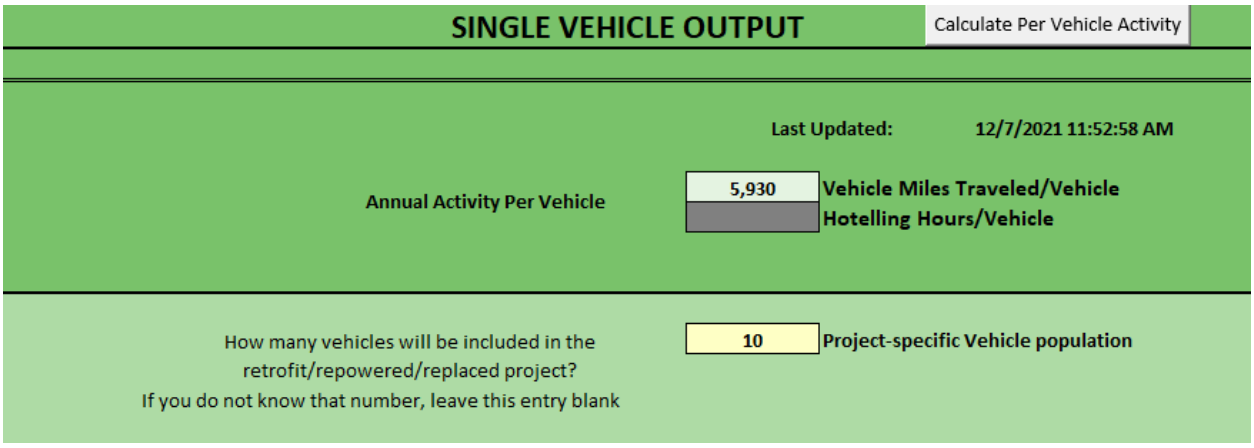
In this case, the activity calculator can first be used to determine the information that is specific for the model year 2001 vehicles that are being replaced.

Going to the activity calculator tab, input the following as shown in the image below:



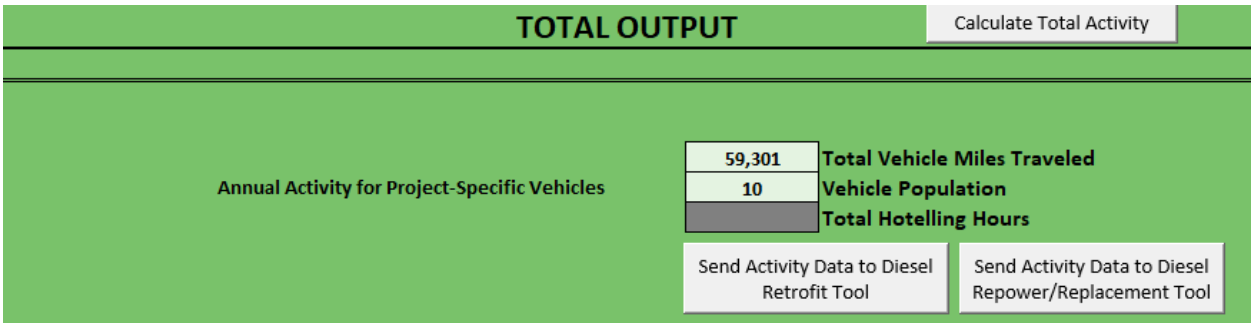
Project Evaluation Year: 2029
Fleet composition: One Vehicle Type
Aggregate Fleet: All Fuels
Total Vehicle Miles Traveled [check box]: selected
Total Vehicle Miles Traveled: 3,565,425
Total Vehicle Population [check box]: selected
Total Vehicle Population: 330
Annual/daily values: Annual
Specific vehicle type: School Bus
Model year of affected vehicles: 2001

Pressing Calculate gives an intermediate step of the calculated annual activity for the 2001 vehicles that will be replaced, as in the image below:

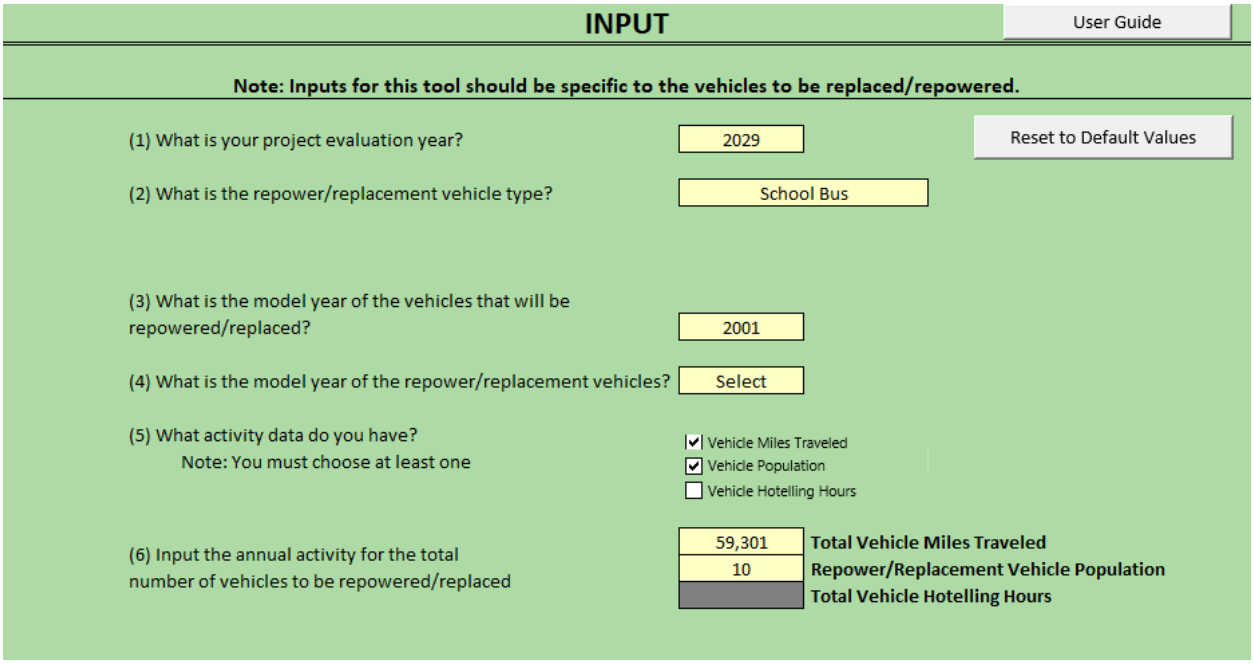


The annual activity for this fleet is 5,930 miles per vehicle, which is less than the national average. Next, the project-specific vehicle population can be input. By leaving this blank, the tool uses the distribution for vehicles by model year that occurs at the national level.

A second calculate button is then pushed to give specific activity values for the 2001 school buses to be replaced, as shown below. These values are sent to the repower/replacement tool by pressing the button labeled, “Send Activity Data to Diesel Repower/Replacement Tool”.

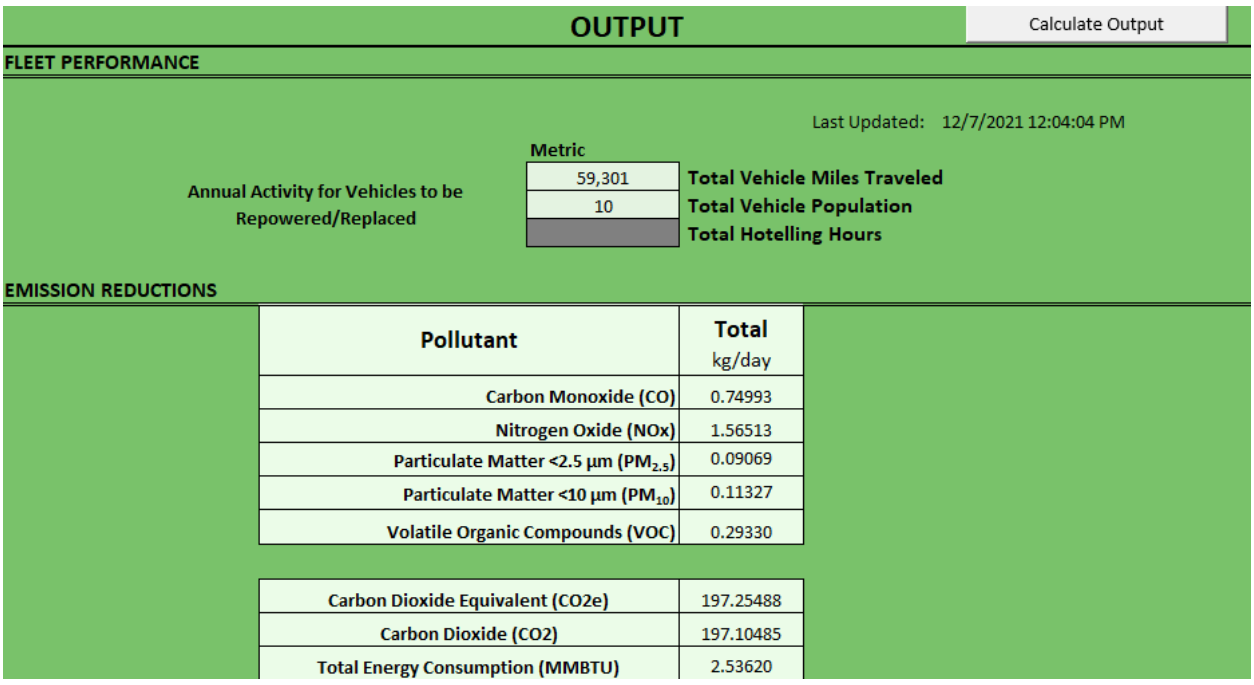


In the repower/replacement tool, the inputs should now look like this:



The only additional input that needs to be provided for proper calculation of the emissions is the model year of the vehicles that will replace the model year 2001 school buses (2029).

Emission benefits then are calculated and reported as follows:



The emission reductions in kg/day and TEC reductions in millions of British Thermal Units (MMBTU) are:

Carbon Monoxide (CO): 0.74993
Nitrogen Oxide (NOx): 1.56513
Particulate Matter (PM2.5): 0.09069
Particulate Matter (PM10): 0.11327
Volatile Organic Compounds (VOC): 0.29330

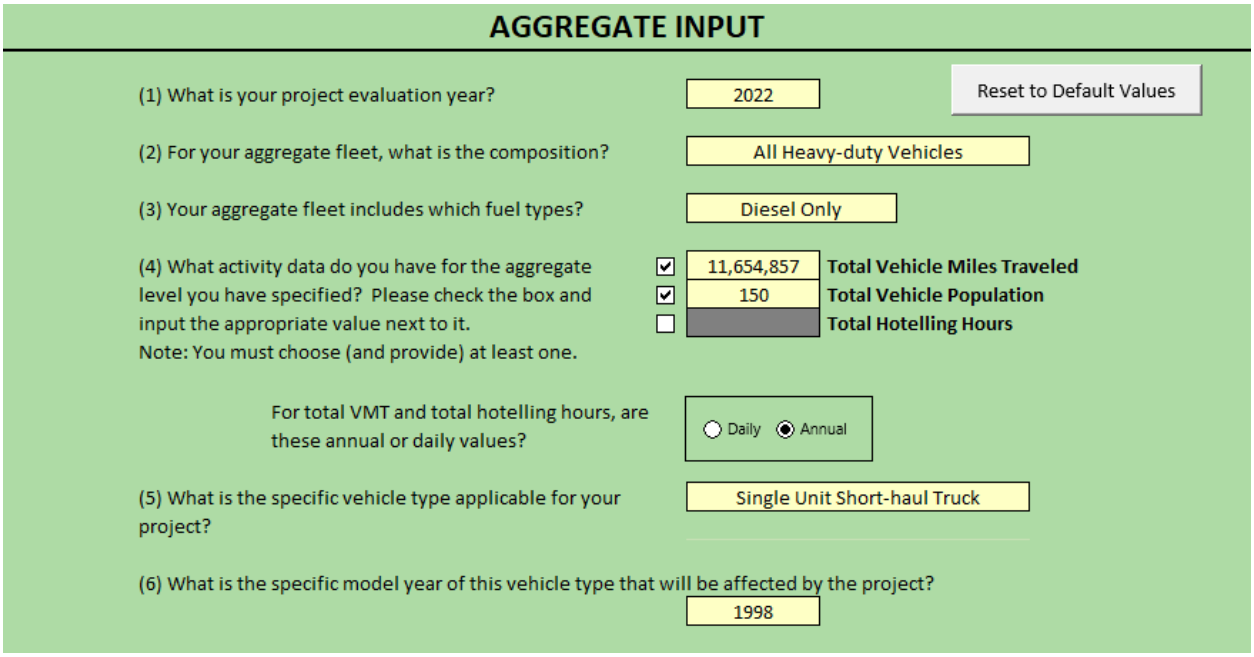
Carbon Dioxide Equivalent (CO_2e): 197.25488
Carbon Dioxide (CO_2): 197.10485
Total Energy Consumption (TEC): 2.53620

Example 2: Retrofitting Single Unit Short-Haul Trucks

County Z in State AA would like to retrofit 10 single unit short-haul trucks from 1998 with a diesel particulate filter. Let's suppose that County Z knows that their fleet of short-haul trucks drive more than the average short-haul truck, but they do not have specific information for the vehicles that are being retrofit. However, County Z does have total annual activity for all of the heavy-duty diesel vehicles in their county. For the 150 vehicles in the county's heavy-duty fleet, the total annual vehicle miles traveled are 11,654,857 miles.

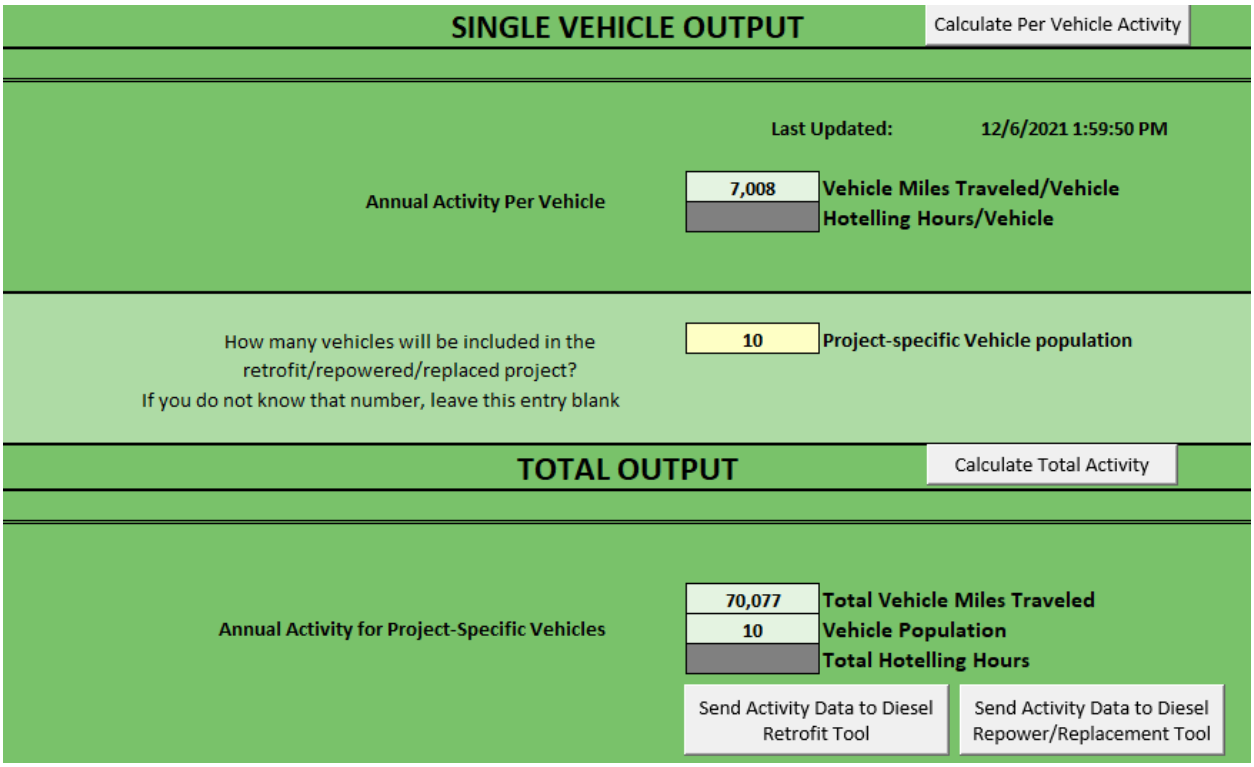
In this case, the activity calculator can first be used to determine the information that is specific for the vehicles to be retrofit.

Going to the activity calculator tab, the following information be input as shown in the image below:



Project Evaluation Year: 2022
Fleet Composition: All Heavy-duty Vehicles
Fuel Type: Diesel Only
Total Vehicle Miles Traveled [check box]: Selected
Total Vehicle Miles Traveled: 11,654,857
Total Vehicle Population [check box]: Selected
Total Vehicle Population: 150
Daily/Annual: Annual
Vehicle Type: Single Unit Short-haul Truck
Model Year of affected Vehicles: 1998

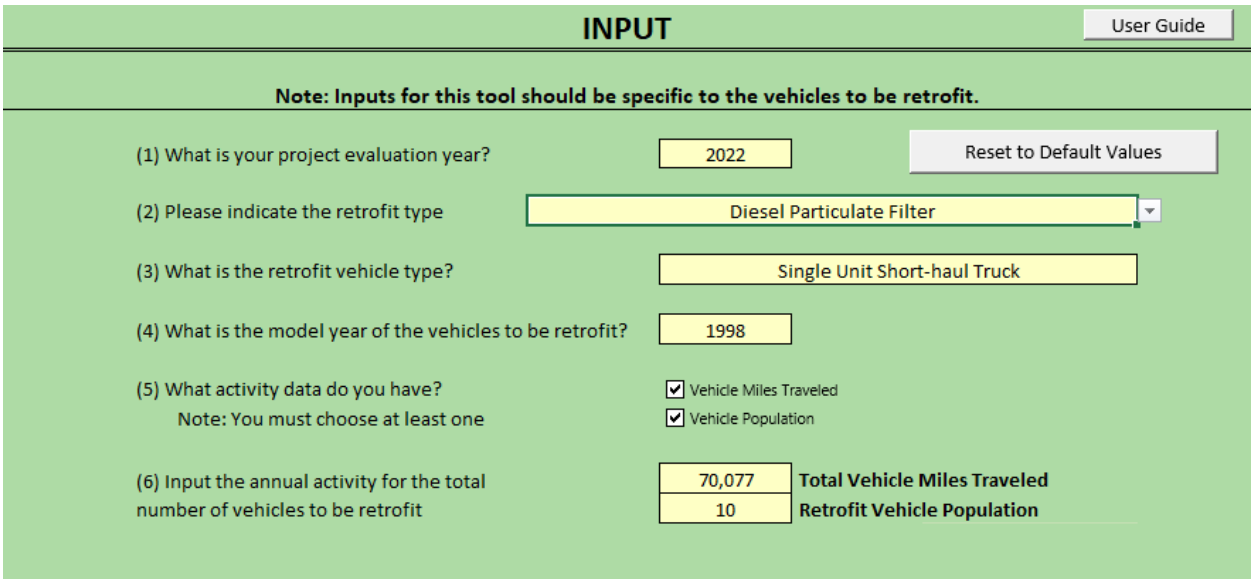
Pressing the Calculate button gives an intermediate step of calculating annual activity for the vehicles that will be retrofit, as in the image below:



The annual activity for the single unit short-haul trucks is 7,008 miles per vehicle, which is greater than the national average. Next, the retrofit-specific vehicle population can be input. Here, the number of vehicles that will be retrofit – ten – is input.

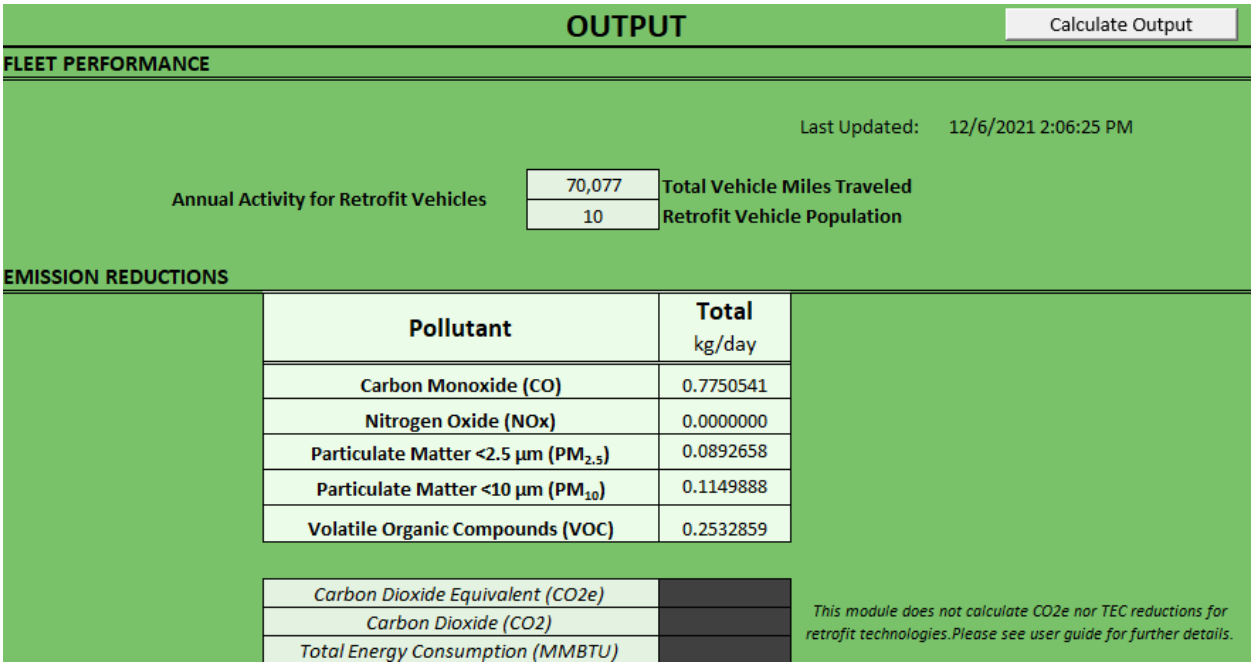
A second calculate button is then pushed to give specific activity values for the single unit short-haul trucks to be retrofit, as shown above. This gives 70,077 for total VMT and 10 for the vehicle population. These values can be sent to the retrofit tool by pressing the button labeled, “Send Activity to Diesel Retrofit Tool”.

Once the activity data have been sent to the retrofit tool, the retrofit tool will look as shown in the image below:



The only additional input that needs to be provided for proper calculation of the emission benefits is the retrofit type. In this example, the retrofit selected is the diesel particulate filter.

Emission benefits are then calculated and reported, as follows:



Annual activity for retrofit vehicles is:

Total VMT: 70,077

Retrofit vehicle population: 10

The emission reductions in kg/day and TEC reductions in millions of British Thermal Units (MMBTU) are:

Carbon Monoxide (CO): 0.77505
Nitrogen Oxide (NOx): 0.00000
Particulate Matter (PM2.5): 0.08927
Particulate Matter (PM10): 0.11499
Volatile Organic Compounds (VOC): 0.25329

Carbon Dioxide Equivalent (CO_2e): [blank]
Carbon Dioxide (CO_2): [blank]
Total Energy Consumption (TEC): [blank]

Note that CO_2e, CO_2, and TEC are not calculated by this module.