Emission Facts

Sample Calculation of Emission Reductions and Fuel Savings from a Carpool Program

The amount of pollution that a vehicle emits and the rate at which it consumes fuel are dependent on many factors. The U.S. Environmental Protection Agency (EPA) has developed a series of computer models that estimate the average emissions for different types of highway vehicles. This fact sheet is one of a series on highway vehicle emission factors. It illustrates the use of national average annual emissions and fuel consumption for gasoline-fueled light-duty vehicles (passenger cars) and light-duty trucks (pickup trucks, sport-utility vehicles, and the like) in estimating the benefits of carpool and ride-sharing programs.

Introduction

This fact sheet presents an example calculation illustrating how the emissions reductions and fuel savings resulting from implementation (or expansion) of a carpool or ride-share program can be estimated. The basic concept is to estimate the reduction in vehicle miles traveled (VMT) that will occur as a result of the program, and to combine that with estimates of average emissions and fuel consumption per vehicle per mile traveled, in order to obtain an estimate of the total fuel savings and emissions reductions.

The most current version of the computer model that EPA uses to estimate average in-use emissions from highway vehicles is MOBILE6.2. EPA, the States, and others use this model to estimate total emissions of pollutants generated by highway vehicles in various geographic areas and over specific time periods. The emission rates (or "emission factors") presented in this fact sheet are based on national average data representing the in-use fleet as of July 2008.

EPA United States Environmental Protection Agency

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The emission rates for hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOx), and particulate matter (PM_{10} and $PM_{2.5}$) are presented in the following tables. The HC numbers include both tailpipe and evaporative emissions, whereas the rates for the other pollutants are for tailpipe emissions only. They assume an average, properly maintained vehicle operating on typical gasoline on a warm summer day. Emission rates can be higher in very hot weather (especially HC) or very cold weather (especially CO).

The carbon dioxide (CO_2) emission factor used in the following tables is based on the average fuel economy of the in-use fleet of gasoline-fueled light-duty vehicles, 24.1 miles per gallon (mpg) for passenger cars, and 17.3 mpg for light trucks (e.g., pickup trucks and SUVs). This corresponds to a fuel consumption rate of (1/24.1 =) 0.042 gallons per mile driven (gal/mi) for cars and 0.058 gallons per mile for light-duty trucks. An average of 19.4 lb (8.81 kg) of CO_2 is produced per gallon of gasoline consumed.

More refined estimates of these benefits can be developed through use of the MOBILE6.2 highway vehicle emission factor model to estimate emission factors that are specific to the geographic area and time period of interest. However, for a first-order approximation of the benefits of such programs, use of the national average values as provided in this sample calculation should be sufficient.

Abbreviations and Acronyms Used

CO: Carbon monoxide; a regulated pollutant

CO_2: Carbon dioxide; the primary byproduct of all fossil fuel combustion

HC: Hydrocarbons; molecules formed of hydrogen and carbon that constitute gasoline, diesel, and other petroleum-based fuels; a precursor emission for ground-level ozone (“smog”) formation, which is a regulated pollutant

NOx: Nitrogen oxides; a regulated criteria pollutant

PM_{10}: Particulate matter under 10 microns diameter; a regulated pollutant

$PM_{2.5}$: Particulate matter under 2.5 microns diameter, sometimes referred to as “fine particulate”

SUV: Sport-utility vehicle

VMT: Vehicle miles traveled

VOC: Volatile organic compounds; equivalent to THC plus aldehydes minus both methane and ethane

Sample Calculation

The first step in calculating the benefits of a new or expanded carpool or ride-share program is to estimate the reduction in total vehicle miles traveled (VMT) that will result from such a program. This value is the product of the number of people (vehicles) no longer commuting alone in their own vehicles and the average distance in miles that those people normally commute. In this sample calculation, the following assumptions are made:

- The average commute is a 30 mile round trip
- There are a total of 1000 employees that will participate in the program
- Each of those employees currently commutes alone in their own vehicle
- After implementation of the program, each vehicle will carry two occupants

Thus, without a carpool program, the total number of miles this group of employees travels each business day is 30,000:

(1) 1000 employees x 1 vehicle/employee = 1000 vehicles
(2) 1000 vehicles x 30 miles/vehicle = 30,000 miles

With a carpool program that has two employees in each vehicle, the total number of miles is reduced to 15,000 each business day:

(3) 1000 employees x (1 vehicle / 2 employees) = 500 vehicles
(4) 500 vehicles x 30 miles/vehicle = 15,000 miles

Note that if the average vehicle occupancy under the carpool or ride-share program is greater than two, that average occupancy can be substituted for (persons/vehicle) in equation (3). For example, if it is estimated that the average occupancy of each vehicle under the program will increase to 2.5 persons (equivalent to two vehicles in use per five employees), then equations (3) and (4) become:

(3a) 1000 employees x (1 vehicle / 2.5 employees) = 400 vehicles
(4a) 400 vehicles x 30 miles/vehicle = 12,000 miles

To calculate the reduction in VMT resulting from the carpool program, subtract the new VMT (in equation 4) from the original VMT (in equation 2):

(5) 30,000 miles (daily VMT before program) - 15,000 miles (daily VMT after program) = 15,000 miles (daily VMT reduction)
(5a) 30,000 miles (daily VMT before program) - 12,000 miles (daily VMT after program) = 18,000 miles (daily VMT reduction)

The second step in calculating the benefits of a carpool program is to combine the estimated reduction in VMT with the emission factors (in grams per mile [g/mi]) and fuel consumption (in gallons per mile [gal/mi]) rates for the average vehicle.

Emission Facts

Average Emission Reductions and Fuel Savings
Per Day Per Vehicle for Gasoline Passenger Cars

Pollutant/ Fuel	**Emission Factor**	**Reduction in VMT**	**Calculations**	**Bene.t (Emission Reduction & Fuel Savings)**
VOC	1.034 g/mi	15,000 miles	1.034 g/mi x 15,000 mi x 1 lb/454 g	34.2 lb VOC
CO	9.400 g/mi	15,000 miles	9.400 g/mi x 15,000 mi x 1 lb/454 g	311 lb CO
NOx	0.693 g/mi	15,000 miles	0.693 g/mi x 15,000 mi x 1 lb/454 g	22.9 lb NOx
PM_{10}	0.0044 g/mi	15,000 miles	0.0044 g/mi x 15,000 mi x 1 lb/454 g	0.14 lb PM_{10}
$PM_{2.5}$	0.0041 g/mi	15,000 miles	0.0041 g/mi x 15,000 mi x 1 lb/454 g	0.14 lb $PM_{2.5}$
CO_2	368.4 g/mi	15,000 miles	368.4 g/mi x 15,000 mi x 1 lb/454 g	12,172 lb CO_2
Gasoline Consumption	0.042 gal/mi	15,000 miles	0.042 g/mi x 15,000 mi x 1 lb/454 g	630 gallons gasoline

Emission Facts

Average Emission Reductions and Fuel Savings Per Day Per Vehicle for Gasoline Light Trucks

Pollutant/ Fuel	**Emission Factor**	**Reduction in VMT**	**Calculations**	**Benefit (Emission Reduction & Fuel Savings)**
VOC	1.224 grams (g)	15,000 miles	1.224 g/mi x 15,000 mi x 1 lb/454 g	40.4 lb VOC
CO	11.84 g	15,000 miles	11.84 g/mi x 15,000 mi x 1 lb/454 g	391 lb CO
NOx	0.95 g	15,000 miles	0.95 g/mi x 15,000 mi x 1 lb/454 g	31.4 lb NOx
PM_{10}	0.0049 g	15,000 miles	0.0049 g/mi x 15,000 mi x 1 lb/454 g	0.16 lb PM_{10}
$PM_{2.5}$	0.0045 g	15,000 miles	0.0045 g/mi x 15,000 mi x 1 lb/454 g	0.15 lb $PM_{2.5}$
CO_2	513.5 g	15,000 miles	513.5 g/mi x 15,000 mi x 1 lb/454 g	16,966 lb CO_2
Gasoline Consumption	0.058 gallons (gal)	15,000 miles	0.058 g/mi x 15,000 mi	870 gallons gasoline

For More Information

The other fact sheets in this series and additional information are available on the Office of Transportation and Air Quality's Web site at:

Emission factor fact sheets:	www.epa.gov/otaq/consumer.htm
Modeling and estimating vehicle emissions:	www.epa.gov/otaq/models.htm
Fuel economy:	www.epa.gov/fueleconomy www.fueleconomy.gov
Improving fuel economy and reducing emissions:	www.epa.gov/epahome/trans.htm www.fueleconomy.gov/feg/drive.shtml
Finding the "greenest" vehicle:	www.epa.gov/greenvehicles
Voluntary emission reduction programs:	www.bestworkplacesforcommuters.org www.italladdsup.gov