Categorizing Mobile Emissions Factors for Vehicle Fleets

As Scope 5 works to bring continued innovation to sustainability data management, we often evaluate standard emissions factor libraries that are used in the industry. Many of these quantify mobile emissions from vehicle fleets, which can be a significant source of emissions for many organizations. A common reporting protocol used by many of Scope 5's clients, comes from the Greenhouse Gas Protocol (GHG Protocol) standards developed by World Resources Institute (WRI).

While the GHG Protocol is widely reputed, we find that the emissions factors offered for Mobile Combustion (Transport by Distance) can be improved upon. In this whitepaper, we look at several methods for applying these emissions factors.

The WRI's emissions factors for transport by distance are based on a single fuel-efficiency figure of 22.5 miles per gallon (MPG) across the range of model years for passenger vehicles. This efficiency equates to the EPA minimum CAFE standard for 2008. However, the fuel efficiency of vehicles has increased by 35-40% since 1980 for all light-duty vehicles (passenger cars and light trucks). WRI does vary the emissions of nitrogen dioxide (N_2O) and methane (CH_4), but these gases only account for less than 1% of total greenhouse gas emissions impact in modern vehicles.

The figure below displays fuel efficiency by year for four different categories by model year:

• Passenger Car Fleet Average

• Light Truck Fleet Average

• Model Year Average
(average of passenger cars and light trucks)

• WRI's standard rate of 22.5 MPG

In Figure 1, the average fuel efficiency of new vehicles is shown for the years 1980-2013, derived from U.S. Department of Transportation (U.S. DOT) data. During this time, MPG has increased steadily over time for passenger vehicles (green), light trucks (red), and the fleet average for all light-duty vehicles (blue). The gray line represents WRI's single rate of 22.5 MPG.

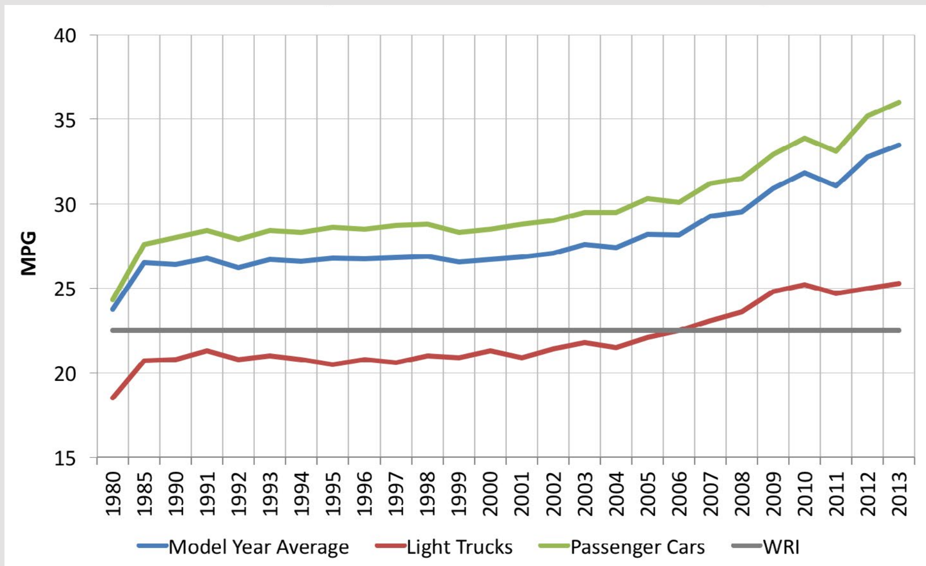


Figure 1: Comparison of Fuel Efficiency Using U.S. DOT and WRI Data

Using a single fuel efficiency figure to calculate emissions presents two significant issues:

1. It will overestimate emissions by nearly 30% over the range

2. It will not capture the emissions benefits of switching to a newer, more efficient fleet

The ideal way to calculate mobile fleet emissions is to break up the data by model year and vehicle type. But this could mean creating up to 80 different categories, each with their own fuel efficiency rating. If we could group some of the model years into bands of model years and retain data accuracy, it would greatly reduce the number of categories needed.

Testing the Theory

To test whether a simplified set of categories can be used, we can create a set of sample data to compare these methods. The data set uses WRI's 13 model year categories, starting with 10,000 miles for the first category and increases the miles by 5,000 for each model year, ending with 70,000 miles for the last category. This format was chosen to reflect that most vehicle fleets will be composed of recent model years, while retaining some data for earlier vehicles. Another data set with 10,000 miles per category was also analyzed and revealed similar results to those below.

From here, it's possible to compare disaggregated emission totals to aggregated totals, measured in kg CO_2-equivalent (CO_2e). Data can be aggregated by creating model year bands for passenger cars, light trucks and the model year average.

Using 4-6 aggregated bands and the same data set, we can see in Figure 2 and Table 1 below that the difference in emissions between these two methods is minimal, between 0-1.8%, for each vehicle category. Meanwhile, the passenger vehicle calculation using WRI standards is 202,000 kg CO_2e, about 30% higher than the aggregated or disaggregated totals for the model year method.

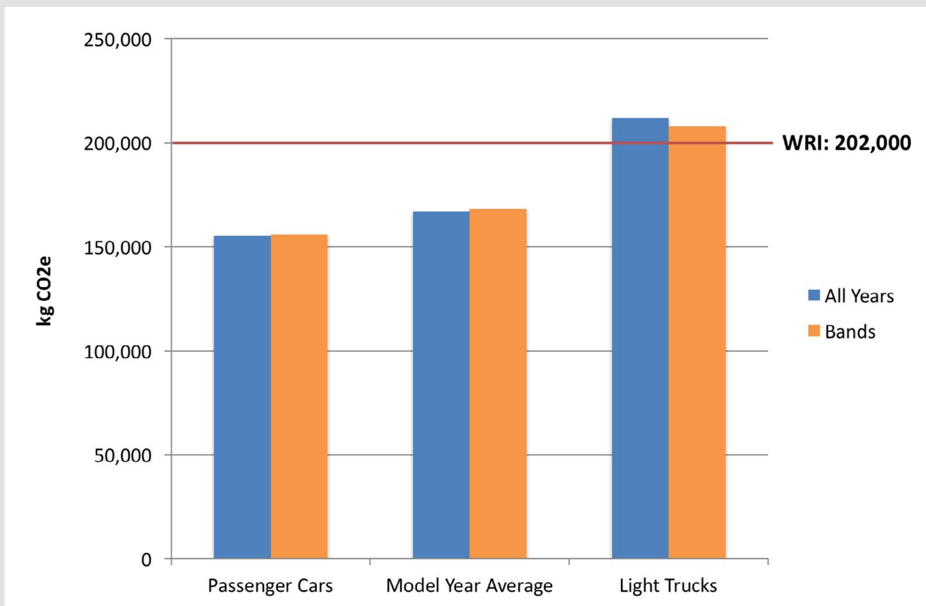


Figure 2: Emissions Calculations Using Disaggregated vs. Aggregated Data

Table 1: Emissions Comparison of Disaggregated vs. Aggregated Data

Vehicle Type	All Yrs (kg CO_2e)	Bands (kgCO_2)	Difference
Passenger Types	155,487	155,822	.21%
Model Year Average	166,740	168,218	.89%
Light Trucks	211,944	208,060	-1.83%

Building the Model

For simplicity in data management, our goal should be to use the fewest number of bands possible, while maintaining data integrity and accuracy. To create these bands, we chose ranges of model years using 4-6 different aggregated categories (classes) and averaging the actual MPG by all of the relevant years. In Figure 3, the percent error for each model year is calculated for a model that uses different numbers of classes when estimating emissions for passenger cars.

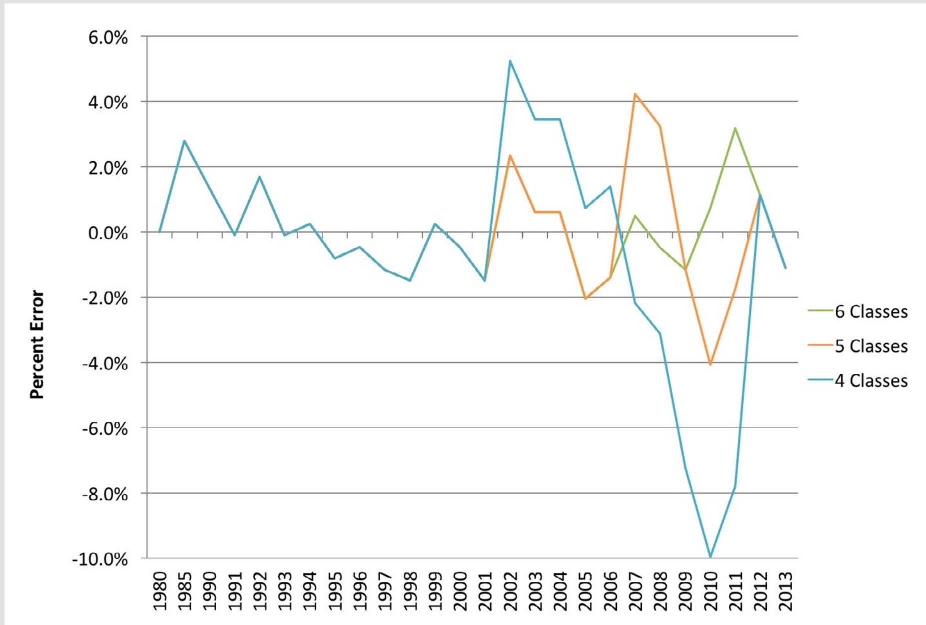


Figure 3: Percent Error by Model Year and Number of Classes for Passenger Vehicles

As we increase the number of classes per band, we decrease error, but as mentioned, increase data complexity. Four classes gives us error up to 10%, whereas five classes keeps error to 4% and under 2% over most of the range. Using six classes reduces error a bit more, to about 1-2%.

Although using six classes would increase accuracy somewhat, the issues are limited to the years 2007 and 2010. Most companies will have a range of model years in their fleets and the error will be a very minor contributor to overall emissions. Moreover, most organizations will only need to use 2-3 classes, since they will be mostly made up of recent model year vehicles. Therefore, a five-class categorization is recommended, which will balance the data maintenance workload and the need for accuracy as well as allow for easy calculation of light-duty mobile combustion emissions.

In Figure 4, actual efficiency for each model year (gray) is compared with a five-class categorization for fleets of passenger cars (green), the model year average (blue), and light trucks (red). The methods of greenhouse gas emissions calculation and tables of emissions factors in grams per mile are presented in Appendix A.

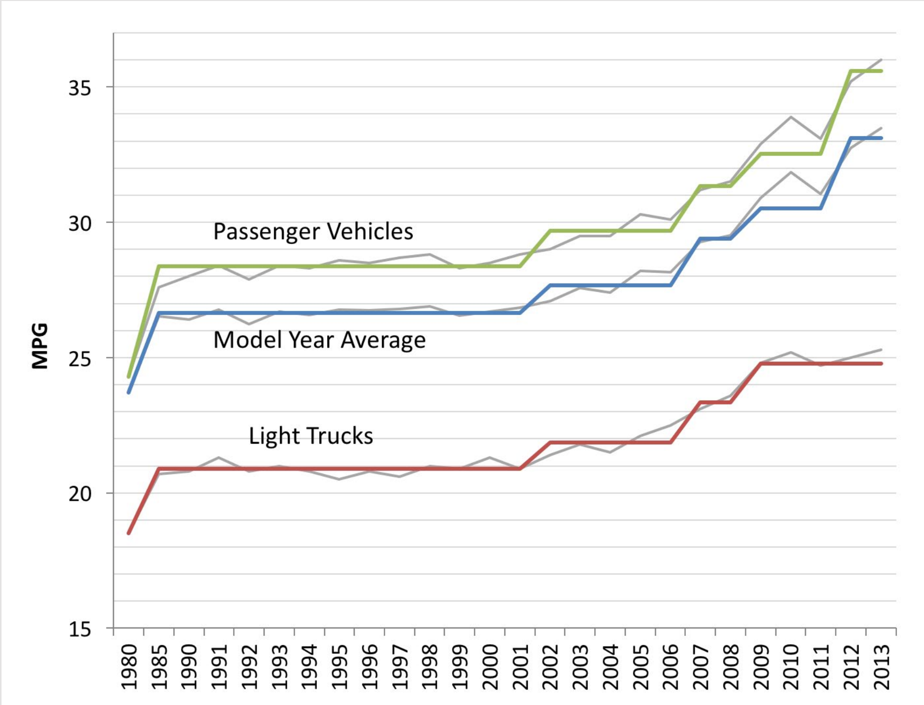


Figure 4: Actual vs. Modeled Fuel Efficiency

Discussion

Using this 5-class categorization simplifies data maintenance while maintaining (or even improving) accuracy. Moreover, it provides three emissions factor sets to choose from depending on the mix of vehicles in a fleet. Finally, this categorization enables organizations to capture the benefits of switching to newer, more fuel efficient fleets.

In selecting an emissions factor set, there are several things to consider. A fleet with a range of vehicle types and sizes will find the Model Year Average a convenient and efficient route. On the other hand, a fleet with a large proportion of trucks and SUVs may want to split their data between the Passenger Vehicle and Light Truck sets. The Model Year Average emissions set also allows an organization to create a rough estimate of their mobile emissions using limited information.

Appendix A: Mobile Emissions Library Emissions Factors

To get CO_2 in grams per mile, the carbon content of fuel (8598.734991 grams/gal) is divided by miles per gallon, which was averaged across the model years included in each band. Emissions for CH_4 and N_2O were derived from World Resources Institute (WRI) mobile combustion data based on 22.5 miles per gallon, which was multiplied by 22.5 to find grams per gallon. Because CH_4 and N_2O make up such a small proportion of emissions, only three classes were used: pre-1985, 1990s, and 2000s. The grams per gallon number was then divided by average miles per gallon for each class to convert back to grams per mile[1].

Passenger Vehicles

Vehicle Year & Type	Avg MPG	CO_2/mi (g)	CH_4/mi (g)	N_2O/mi (g)
Passenger: Gasoline Pre-1985	24.30	353.86	0.065	0.060
Passenger: Gasoline 1985-2001	28.37	303.10	0.025	0.035
Passenger: Gasoline 2002-2006	29.68	289.71	0.010	0.011
Passenger: Gasoline 2007-2011	32.52	264.41	0.009	0.010
Passenger: Gasoline 2012-Present	35.60	241.54	0.008	0.009

Light Trucks

Vehicle Year & Type	Avg MPG	CO_2/mi (g)	CH_4/mi (g)	N_2O/mi (g)
Light Truck: Gasoline Pre-1985	18.50	464.80	0.086	0.079
Light Truck: Gasoline 1985-2001	20.88	411.88	0.034	0.047
Light Truck: Gasoline 2002-2006	21.86	393.35	0.014	0.015
Light Truck: Gasoline 2007-2008	23.35	368.25	0.013	0.014
Light Truck: Gasoline 2009-Present	24.77	347.19	0.012	0.013

[1] We recognize that CH_4 and N_2O emissions are largely a function of distance driven and engine type. As such, this methodology introduces some error, the extent of which will be negligible for most vehicle fleets. For those fleets including a large proportion of older vehicles or heavy duty (agricultural and construction vehicles) this source of potential error should be considered.

Model Year Average

Vehicle Year & Type	Avg MPG	CO_2/mi (g)	CH_4/mi (g)	N_2O/mi (g)
Light Duty Fleet: Gasoline Pre-1984	23.75	362.05	0.067	0.055
Light Duty Fleet: Gasoline 1985-2001	26.66	322.58	0.027	0.037
Light Duty Fleet: Gasoline 2002-2006	27.86	310.65	0.011	0.011
Light Duty Fleet: Gasoline 2007-2011	30.52	281.77	0.010	0.011
Light Duty Fleet: Gasoline 2012-Present	33.11	259.68	0.009	0.009

DATA SOURCES

Light-duty Fleet fuel efficiency: U.S. Department of Transportation
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

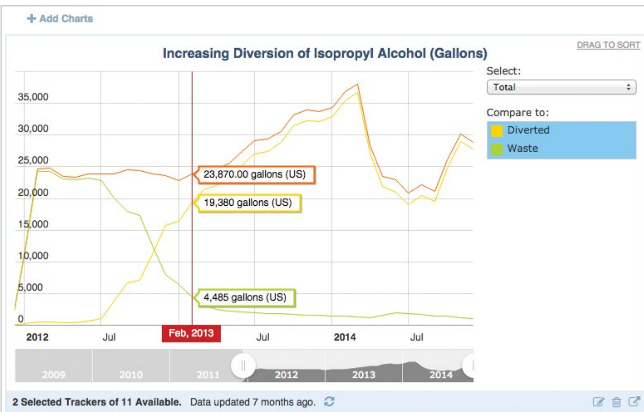
Emissions per mile (CO_2, CH_4, N_2O): WRI Emission Factors from Cross-Sector Tools
http://www.ghgprotocol.org/calculation-tools/all-tools

SCOPE 5

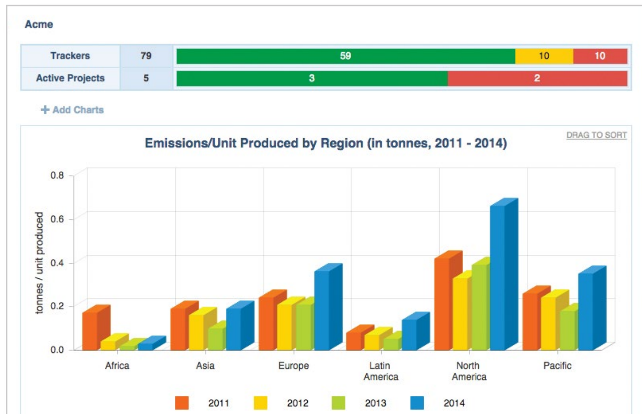
Scope 5 is a cloud-based software service that helps organizations of all types collect, structure, track, analyze and communicate their sustainability data, benefiting their top and bottom lines. In addition to using the service to produce GHG reports, many of our customers use ***Scope 5*** to go beyond reporting to identify opportunities and to communicate their progress to a variety of stakeholders.

Scope 5 includes resource libraries that put up-to-date emission factors from recognized authorities at your fingertips to make it easier for you to calculate your GHG emissions and to assure that your results are reliable and meaningful. ***Scope 5*** is intuitively and flexibly designed to be managed independently by your workforce talent or in conjunction with ours. We'd love the chacge to help make your data easy-to-use, convenient and work for you!

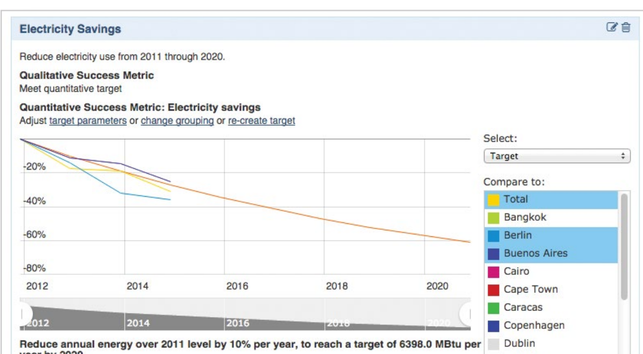
1 Capture and manage any activity data, whether environmental, social or governance.



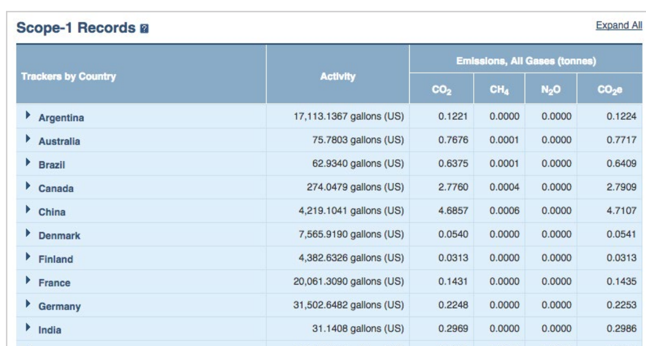
2 Calculate impacts of your activities such as greenhouse gas emissions, cost and other custom impacts.



3 Analyze your data to gain transparency and to identify opportunities to improve performance and save costs—demonstrate success!



4 Make reporting to the Carbon Disclosure Project, Global Reporting Initiative, B Corporation, and other reporting platforms easier.



Scope-1 Records

Expand All

Trackers by Country	Activity	Emissions, All Gases (tonnes)			
		CO_2	CH_4	N_2O	CO_2e
Argentina	17,113.1367 gallons (US)	0.1221	0.0000	0.0000	0.1224
Australia	75.7803 gallons (US)	0.7676	0.0001	0.0000	0.7717
Brazil	62.9340 gallons (US)	0.6375	0.0001	0.0000	0.6409
Canada	274.0479 gallons (US)	2.7760	0.0004	0.0000	2.7909
China	4,219.1041 gallons (US)	4.6857	0.0006	0.0000	4.7107
Denmark	7,565.9190 gallons (US)	0.0540	0.0000	0.0000	0.0541
Finland	4,382.6326 gallons (US)	0.0313	0.0000	0.0000	0.0313
France	20,061.3090 gallons (US)	0.1431	0.0000	0.0000	0.1435
Germany	31,502.6482 gallons (US)	0.2248	0.0000	0.0000	0.2253
India	31.1408 gallons (US)	0.2969	0.0000	0.0000	0.2986
Ireland	30,350.8532 gallons (US)	0.2166	0.0000	0.0000	0.2171