

The Make an Impact Calculator Methodology

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1. Introduction

The Make an Impact Calculator is a web-based calculator that allows individuals to calculate their carbon dioxide (CO₂) emissions footprint. The calculator is structured to allow users to input a minimal amount of data to receive the most accurate emissions profile based on location, a personal home energy profile and personal transportation choices.

This paper describes the methodologies employed in the calculator to calculate emissions. With the large number of carbon calculators available online, it is important that users understand what emission sources are included and how the magnitude of the emissions is determined. The purpose of this paper is to provide information on the data sources, methods, and assumptions used in the Make an Impact Calculator.

This paper discusses three topics:

1. Scope of the Calculator
2. Overview of the Emission Factors in the Calculator
3. Emission Estimation Methodologies

The descriptions of the methods used for calculating emissions follow the order of topics as seen by the user when completing the calculator. Literature references for the data and assumptions used in the calculations are provided in the footnotes.

2. Scope of the Calculator

2.1 Activities

The goal of the Make an Impact Calculator is to provide users with a picture of their CO₂ emissions footprint. The footprint is designed to include significant emissions resulting from the personal activities of household members, rather than emissions that occur in the workplace. Emissions are divided into two main categories with three sub-categories for transportation:

- Home
- Transportation
 - Personal Vehicles
 - Public Transportation
 - Air Travel

CO₂ emissions from the home include direct emissions from fossil fuel-burning equipment, as well as indirect emissions from electricity consumption. Transportation emissions include those from personal vehicles—cars, trucks, motorcycles—as well as public transportation and personal travel on commercial aircraft. A more detailed

description of these sources and the methods of calculating CO₂ emissions is provided in Section 4 of this paper.

Unlike some calculators that attribute all of the CO₂ emissions that occur in the U.S.—including those from businesses and governments—to households or individuals, The Make an Impact Calculator includes the direct emissions from sources owned or controlled by users. Thus for a personal automobile, for example, CO₂ emissions that occur as the result of burning gasoline are included in the footprint calculation, but not the emissions associated with producing and refining the gasoline or manufacturing the automobile, which would be accounted for by the companies producing the gasoline and automobile¹.

Several sources of indirect emissions are also included in the Make an Impact Calculator. Indirect emissions are those that occur as the result of the user's activities but occur at a source not owned or operated by the household. The indirect emissions included in the calculator are emissions associated with electricity consumption and shared transportation. The latter include public transportation, rail transportation, and commercial airliners. As with the direct emissions, the indirect emissions are those associated with fuel or electricity consumption by these sources and do not include full life-cycle emissions.

2.2 Greenhouse Gases

The Make an Impact Calculator includes emissions of the principal greenhouse gas: carbon dioxide (CO₂). Methane (CH₄) and nitrous oxide (N₂O) are also greenhouse gases that result from the same kinds of activities included in the calculator. The magnitude of these emissions are much smaller than those of CO₂, however, and therefore they are not considered to be significant and are not included in the calculations.

3. Overview of the Emission Factors in the Calculator

Combustion emissions of carbon dioxide depend on the type and quantity of fossil fuel being burned. The most common means of estimating carbon dioxide emissions is to multiply the quantity of fuel combusted by an emissions factor. The emission factors in the Make an Impact Calculator for direct emissions from stationary combustion sources (e.g., heating equipment) are those published by the U.S. Environmental Protection Agency for the mandatory reporting of GHG emissions². These factors are based on the assumption that all of the carbon in the fuel is converted to carbon dioxide during combustion. Direct emissions from personal motor vehicles are also based on EPA emissions data (described below) as are indirect emissions from electricity production.

¹ For motor vehicles that are fueled in whole or part by electricity, the emissions associated with the production and transmission of the electricity they use are included.

² Source: 40 CFR Part 98, Subpart C, Table C-1 (heating oil is assumed equal to distillate fuel No. 2)

4. Emission Estimation Methodologies

The goal of the Make an Impact Calculator is to provide users with the most accurate emissions results possible while maintaining a highly efficient question design.

Emissions from homes are based on the most recent survey data on energy consumption collected by the U.S. Department of Energy for various types of homes and household characteristics. Emissions from personal motor vehicles are based on measurement data collected by the U.S. Environmental Protection Agency for a wide range of vehicle types.

Gross averages are used to calculate indirect emissions associated with a household's electricity consumption and use of public transportation and commercial airlines. These emissions vary with the sources of electricity and the specific operating characteristics of the shared transportation trips that the users take. Therefore, a necessary limitation of using these averages to calculate emissions is that while they may accurately represent average conditions, they are unlikely to exactly represent the actual emissions of any specific individual.

4.1 Emissions at Home

The Make an Impact Calculator is designed for users who have limited information about their household energy consumption, such as annual fossil fuel and electricity consumption. Emissions are calculated using energy consumption data from the U.S. Department of Energy (DOE) Residential Energy Consumption Survey (RECS)³. Home energy consumption by end use is estimated based on four parameters:

- Location of the Home
- Type of Home
- Number of People Living in the Home
- Whether or Not the Home has Air Conditioning

The sources of the energy (specific fossil fuels or electricity) for the home end uses are then used to calculate emissions.

Within the Make an Impact Calculator, the zip code specified by the user is mapped to the state in which it is located and then to one of four regions for which RECS energy consumption data is summarized. The calculator asks user to enter the type of home they live in (e.g., mobile home, single family home, apartment building) and the number of people living in the home, as well as whether or not the home has air conditioning.

³ Residential Energy Consumption Survey (RECS) for 2009. U.S Department of Energy Washington, DC, <http://www.eia.gov/consumption/residential/data/2009>

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For each of four regions of the country, the DOE RECS household energy consumption data are provided for five categories of consumption:

- Space heating
- Water heating
- Air conditioning
- Refrigerators
- Other

Average energy consumption data are provided for each of these categories as a function of the type of home. Average household energy consumption data are also provided for each of these categories for specific states (or groups of states) within the region as well as for households of various sizes ranging from one to six or more household members.

Once the user enters the required information, the calculator obtains the average energy consumption for each of the five use categories of the RECS data for the selected home type and scales those figures to adjust for the user's state within the region and for the number of household members. The ratio of the state-specific energy consumption to the regional average is used in the calculator to scale the energy consumption in each of the five categories listed to adjust for the user's state, and the ratio of the energy consumption for the user's household size to the regional average is used to further adjust the calculated energy consumption for the number of members in the household.

The RECS data describe the quantity of energy consumed by end use but do not indicate what the source of this energy is. The user specifies what fuel is used for heating (natural gas, heating oil, propane, or electricity) and it is assumed that this fuel is used for both space heating and water heating. All other energy consumption (air conditioning, refrigerators, and other) is assumed to represent electricity consumption.

For those households that specify natural gas, heating oil, or propane as their heating fuel, household emissions from consumption of these fossil fuels are calculated using emission factors expressed in terms of the heating value of the fuel. These emission factors are listed in Table 1.

Table 1. Fossil Fuel CO₂ Emission Factors used in the Make an Impact Calculator

Natural Gas	Heating Oil	Propane
pounds/million Btu		
116.9	163.1	135.5

Source: 40 CFR Part 98, Subpart C, Table C-1 (heating oil is assumed equal to distillate fuel No. 2)

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Total electricity consumption is calculated as the sum of energy consumption from refrigerators and “other” plus air conditioning if the user specifies that the house has air conditioning. Energy consumption from space and water heating is added to this total if the user specifies electricity as the heating fuel.

Emissions from electricity consumption depend on the types of generating sources used to produce the electricity. The mix of generation sources varies from place to place and with time as generation capacity is increased and decreased to meet demand. For this reason, the estimation of indirect CO₂ emissions from electricity consumption is sometimes based on the national average emissions of the U.S. power grid. The Make an Impact Calculator uses a more refined approach to estimate electricity emissions.

The most recent CO₂ emission factors from the U.S. Environmental Protection Agency’s eGRID model⁴ are used to calculate household CO₂ emissions associated with electricity production. These factors are based on emissions for the year 2009. The eGRID subregion output emission rates are used to calculate the CO₂ emissions based on the zip code where the user resides. The mapping of zip codes to eGRID subregions is done using data provided by the U.S. EPA⁵.

The eGRID summary for 2009 provides information on subregion-level emission factors for CO₂ from electricity generation. These factors do not include emissions from electricity transmission and distribution losses. Consistent with other emissions inventory guidance, emissions associated with transmission and distribution losses are not included as part of the indirect emissions associated with home energy in the Make an Impact Calculator users as they would normally be accounted for by others.

4.2 Personal Transportation

The Make an Impact Calculator includes three types of personal transportation in its calculation of the user’s CO₂ emissions footprint:

- Personal motor vehicles (cars, trucks, motorcycles)
- Public transportation
- Commercial air travel

The calculator allows users who do not have detailed information on the annual consumption of motor fuels to estimate emissions based on the type of vehicles they drive and the estimated number of miles they drive the vehicles each year. Users may

⁴eGRID2012 Version 1.0 (April 2012) Year 2009 Summary Tables. U.S. Environmental Protection Agency, Washington, DC.

⁵ Power Profiler ZIP Code Tool with eGRID2012 Year 2009 Data, 3/1/2013, Version 4.1, U.S. Environmental Protection Agency Washington, DC.

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select their vehicles from any of the types listed in Table 2, and the corresponding average fuel economy shown for that type of vehicle is used to calculate emissions. (Since the fuel economy figures for passenger vans and pick-up trucks are so similar, they are combined into one category based the average of their fuel economies shown in the table.) Emissions for gasoline-fueled vehicles are based on 8887 grams CO₂/gallon and emissions from diesel vehicles they are based on 10,210 grams CO₂/gallon⁶.

Table 2. Average Fuel Economy of Gasoline Motor Vehicles in the Make an Impact Calculator

Vehicle Type	Fuel Economy, mpg	CO ₂ Emissions, pounds/mile
<i>Gasoline Vehicles</i>		
Hybrid	35.5	0.552
Plug-in Hybrid	NA	0.435
Electric	NA	0.415
Small Car	30	0.653
Family Sedan	26	0.754
Large Sedan	23	0.852
SUV	20.5	0.956
Minivan	21.5	0.911
Pickup Truck/Passenger Van	17.75	1.120
Motorcycle	48	0.408
<i>Diesel Vehicles</i>		
Small Car	32.5	0.693
Family Sedan	34.5	0.652
SUV	22	1.023
<i>Electric Vehicles</i>		
All Vehicles	NA	0.415

Notes:

1. Average mpg is the average of the range of mpg figures for the 2013 model year for conventional, regular gasoline fueled vehicles and diesel vehicles in each category. Fuel economy is not given for plug-in hybrid and electric vehicles because emissions depend on electricity consumption.
2. MPG data for gasoline and diesel vehicles (except motorcycles) are from the fueleconomy.gov website database: <http://www.fueleconomy.gov/feg/powerSearch.jsp>
3. Fuel economy for motorcycles from: *Total Motorcycle's Fuel Economy and Efficiency Guide for 2012* (average of all listed motorcycles)
4. Gasoline and electricity consumption for plug-in hybrids and electric vehicles from: <http://www.fueleconomy.gov/feg/label/calculations-information.shtml>

For plug-in hybrids and electric vehicles, emission associated with the electricity production needed to power the vehicles are included in the calculations. Electricity

⁶ Both values are from the U.S. EPA, for gasoline: <http://www.fueleconomy.gov/feg/label/calculations-information.shtml> and for diesel fuel: 40 CFR Parts 98, Subpart C, Table C-1 (calculated from emissions per million Btu and Btu/gallon for distillate fuel No. 2)

consumption in kilowatt-hours per mile comes from the U.S. EPA. Emissions are based on the national average electricity emission factor for CO₂: 551.65 grams/kWh⁷ with an average line loss of 6.5 percent, the figure used by EPA in its calculation of electric vehicle emissions.

The fuel economy figures listed in Table 2 must be combined with the total annual miles driven for each vehicle to calculate the fuel consumption and emissions. The user specifies the annual number of miles he or she drives each vehicle. Emissions are simply the product of the number of miles for the particular vehicle category and the corresponding CO₂ emission factor for that category.

4.3 Public Transportation

Emissions from the use of public transportation are typically given in terms of mass of emissions per passenger-mile traveled. The Make an Impact Calculator uses the emission factors provided by The Greenhouse Gas Protocol and listed in Table 3.

Table 3. CO₂ Emission Factors for Public Transportation

Transportation Mode	Total CO ₂ Emissions, kg CO ₂ /passenger-mile
City Bus	0.2997
Intercity Bus	0.0781
Subway / Local commuter train	0.16265
Intercity Rail (Amtrak)	0.1909
Shuttle / Vanpool	0.0684

Source: CO₂ Protocol Initiative⁸ except for Vanpool⁹

Users of the Make an Impact Calculator specify the number of miles they travel each week by the transportation modes listed in Table 3. These figures are extrapolated to an entire year by multiplying them by 52. The annual emissions for each mode of transportation are then calculated by multiplying the annual miles travelled for each mode by the corresponding emission factor listed in Table 3. Because the emission factors for a subway or tram and commuter rail are so similar, these three transport modes are considered to be one in the calculator and the average of the two corresponding emission factors listed in Table 3 is used to calculate their emissions.

⁷eGRID2012 Version 1.0 (April 2012) Year 2009 Summary Tables. U.S. Environmental Protection Agency, Washington, DC.

⁸World Business Council for Sustainable Development/World Resources Institute Greenhouse Gas Protocol Initiative: Mobile Combustion CO₂ Emissions Calculation Tool. January 2005. Version 1.3, Part 2. Emissions Calculated from Distance Traveled, All Modes of Transport.

⁹ Vanpool emissions based on 2010 gasoline passenger van achieving 13 miles per gallon and carrying 10 passengers

4.4 Air Travel

Emissions from commercial air travel in the Make an Impact Calculator are calculated based on the distance flown for personal travel by household members. Because aircraft use more fuel during take-off and landing than they do while cruising, shorter flights have greater average emissions per mile than longer flights. For this reason, the calculator asks the user for the distances flown for three different categories of flights based on the length of the flights. The emission factors used in the calculator are listed in Table 4.

Table 4. Average CO₂ Emission Factors for Air Travel

Length of Flight	Average Emissions, lbs/passenger-mile
Short, <1 hour (350 miles)	0.562
Medium, 1-6 hours (1000 miles)	0.331
Long, >6 hours (3000 miles)	0.390

Source: Defra, 2013¹⁰

Emissions from commercial air travel are calculated based on the distance travelled. Since users may not know the distance they have flown, but do know the number of flights taken, the calculator estimates emissions based on the number of flights specified. The user is asked the number of short, medium, and long flights taken, rather than the number of miles travelled on each of these types of flights. The definition of short, medium, and long are as listed in Table 4. Estimated emissions are based on the assumption that each short, medium, and long flight is 350, 1000, and 3000 miles, respectively. These figures are multiplied by the number of flights taken in each distance range to arrive at the total distance flown in each category. Once the total flight mileage is determined for each category, the calculation of emissions is simply the product of the total and the corresponding emission factor for the flight category.

Unlike some other footprint calculators, the Make an Impact Calculator does not adjust emissions from air travel to account for the greater warming impact of aircraft emissions than of ground-level emissions. The calculator takes this approach for several reasons. The magnitude of the enhanced warming is not clearly understood or accepted. In addition, the gases that lead to the greater warming, water vapor and ozone, are not within the scope of the calculator. For carbon dioxide, emissions from aircraft are no different from emissions that occur anywhere else on earth¹¹.

¹⁰ 2013 Government GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors, July 2013. Table 26: Average CO₂ emission factors for passenger flights for 2013 GHG Conversion Factors. UK Department for Environment, Food and Rural Affairs.

¹¹ Intergovernmental Panel on Climate Change, 1999. *Aviation and the Global Atmosphere. Summary for Policymakers.*

5. Comparison of Emissions Footprint with State Averages

The Make an Impact Calculator allows users to see how their calculated emissions footprint compares to average values for individuals living in the same state. Emissions from energy consumption at home are based on survey data from the U.S. Department of Energy and emissions from personal motor vehicle use are based on Federal Highway Administration survey data. Emissions from the use of public transportation and air travel are based on national averages. The ways in which each of these averages contributes to the total average individual emissions used for comparison are described below.

Total household energy consumption by fuel type and the total number of households are published for each state (or groups of states) by the U.S. Department of Energy using data collected through its Residential Energy Consumption Survey (RECS)¹². Using these data, the average energy consumption by fuel type is calculated for an average household in the same state as the user. Average household energy consumption is then converted to average CO₂ emissions. This is done in the same manner as listed in Section 4.1 for calculating individual emissions. The emission factors shown in Table 1 are multiplied by the consumption of natural gas, fuel oil, and propane. For electricity consumption, the emission factor for the same eGRID region as the user (based on the user's zip code) is applied so that the average home emissions is calculated on a basis that is consistent with the individual calculation. The average household CO₂ emission for each of the energy types is then summed to give the total. The final step is the division of this average household figure by the average household size used in the RECS system for the corresponding state to arrive at the average individual CO₂ emission from home energy consumption.

Average emissions from personal motor vehicle use are based on the annual vehicle miles traveled (VMT) by households in each state. The National Highway Administration periodically conducts the National Travel Household Survey¹³, and the most recent data from this survey (2009) is used to calculate average emissions for personal motor vehicle travel. Total VMT for each state is divided by the total number of households in each state and the average number of people for each household in that state using the state by state data for number of households and average household size in the RECS database. The result is the average annual VMT per household member for each state. The average VMT figure was then divided by an average fuel economy value of 23.5 miles/gallon¹⁴ to arrive at the average number of gallons of gasoline consumed per

¹² eGRID2012 Version 1.0 (April 2012) Year 2009 Summary Tables. U.S. Environmental Protection Agency, Washington, DC.

¹³ Federal Highway Administration, 2009 National Household Travel Survey (NHTS) Tabulation created on the NHTS website at <http://nhts.ornl.gov>

¹⁴ U.S. Department of Transportation, Bureau of Transportation Statistics. Average fuel efficiency of light duty vehicles (short wheelbase) in 2009 (and 2010):

household member. Gasoline consumption is converted to CO₂ emissions as described above in Section 4.2, using the same emission factor to arrive at average annual emissions per person in the user's state.

In the case of emissions from public transport and air transport, average emissions come from the U.S. national inventory of GHG emissions. Total U.S. emissions for these two categories as published by the U.S. EPA¹⁵ were divided by the total number of households in the U.S. and the average U.S. household size (both from the RECS data) to calculate individual average emissions in the corresponding categories. Since these figures represent averages across the U.S., individual results from the Make an Impact Calculator for individual household members will vary widely around them.

Table 5. Average Household Member CO₂ Emissions by Category

Emissions Category	Pounds CO ₂ /year
Public Transport	183
Air Transport	895

To compare the user's individual CO₂ footprint with the average individual emissions for the user's state, the average emissions for home energy consumption, personal motor vehicle transport, public transport, and air transport are summed, and the result used as the basis of comparison with the user's footprint.

http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

¹⁵Table A-115 of Draft Inventory of GHG Emissions and Sinks:1990-2012. U.S. EPA, February 21, 2014.