

Step by Step Instructions for the Using Sustainable Jersey Spreadsheet Tool to Calculate a Municipal Carbon Footprint

Inventory methods that municipalities can use to calculate their municipal carbon footprint can vary significantly. This inconsistency makes comparisons between municipalities difficult, raises questions around data quality, and limits the ability to aggregate local, subnational, and national government GHG emissions data. To allow for more credible and meaningful reporting, greater consistency in GHG accounting is required.

The Compact of Mayors is the world's largest cooperative effort among mayors and city officials to reduce greenhouse gas emissions, track progress and prepare for the impacts of climate change. Launched in September 2014, the Compact aims to undertake a transparent and supportive approach to reduce greenhouse gas emissions and address climate risk, in a manner consistent with – and complementary to – the international climate negotiation process under the United Nations Framework Convention on Climate Change. The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) responds to this challenge and offers a robust and clear framework that builds on existing methodologies for calculating and reporting city-wide GHG emissions.

The GPC has identified the following as required elements for a local government carbon footprint:

- Stationary Energy
- Transportation
- Waste Management
- Purchased Services of “significant value” and that are typically services provided by a municipality

Overview of Steps to Create a Footprint

STEP 1: Establish a Baseline Year

STEP 2: Calculate emissions from Scope 1 direct emissions from stationary combustion of fuels like natural gas, heating oil, coal, and diesel.

STEP 3: Calculate emissions from Scope 2 indirect emissions from consumption of purchased or acquired electricity.

STEP 4: Calculate emissions from Scope 1 direct emissions from mobile combustion of fuels in vehicle fleet (e.g., cars, trucks, off-road equipment).

STEP 5: Calculate emissions from waste related activities using the EPA WARM model

A spreadsheet is provided to assist with calculations and is available to download at: <http://www.sustainablejersey.com/editor/doc/p4!151.xls>

It includes the following three worksheets:

- **Worksheet 1, “Municipal Carbon Footprint,”** is used to enter your data on usage totals and then calculate emissions. It will produce the total carbon footprint from local government activities and will be used in all 5 steps.
- **Worksheet 2, “Electric, Gas & Heating Oil,”** should be reproduced for each municipal facility to determine usage of electricity, natural gas, and heating oil during the selected baseline year. It will be used in Steps 2 and 3.
- **Worksheet 3, “Vehicle CH₄ & N₂O,”** should be used to calculate the emissions of methane and nitrous oxide from all vehicles in the municipal fleet. It will be used in Step 4.

Below, we have provided extensive guidance and recommendations for implementing the action. You do not need to follow this guidance exactly as long as your finished product meets the requirements

STEP 1: Establish a Baseline Year

A baseline is the reference point against which you will measure greenhouse gas emissions increases and decreases over time. To select a baseline year, determine the earliest year for which ALL the required data (see list of data needs below) can be assembled to complete an emissions report. If the municipality is planning to conduct a Community Carbon Footprint in addition to the Municipal Carbon Footprint, consider community data collection requirements and data availability when selecting a baseline year.

Required data for Municipal Carbon Footprint

The following information must be gathered in order to complete Worksheet 1: Municipal Carbon Footprint:

- **Fuel used in combustion for stationary sources** (buildings, not vehicles) (therms of natural gas, gallons of heating oil, etc) during the baseline year for each municipal facility.
- **For each stationary combustion fuel type, annual usage in baseline year divided into four categories of municipal operations:**
 - Building & Facilities
 - Street Lights & Traffic Signals
 - Water & Wastewater Treatment Facilities
 - Other
- **Monthly kilowatt-hours of electricity consumption for each municipal facility.**

- **Annual kilowatt-hours of electricity consumption divided into four categories of municipal operations:**
 - Building & Facilities
 - Street Lights & Traffic Signals
 - Water & Wastewater Treatment Facilities
 - Other.
- **Annual fuel consumption of vehicle fleet during baseline year in gallons of each fuel type** including diesel, motor gasoline, compressed natural gas (CNG), etc (*If this information is not available, estimates must be made using mileage data*).
- **Annual mileage of each vehicle type during baseline year** (*There are 30 possible vehicle types determined by model year and vehicle characteristics*).
- **Tons of waste generated in each of 34 categories.**
 - For each waste category, tons recycled, tons landfilled, and tons combusted.
- **For significant purchased services, the line item budget amount spent for baseline year.** (e.g. \$350,000 in Contracted Waste Hauling)

STEP 2: Calculate emissions from Scope 1: direct emissions from stationary combustion of fuels like natural gas, heating oil, coal, and diesel.

Follow steps A. through C. below and enter the data into the worksheet to calculate the emissions:

A. Determine the annual consumption of each fuel combusted at your facilities.

- **Identify all fuels combusted at your facilities.** Determine annual consumption for each fuel by reading individual meters or from utility bills, fuel receipts or purchase records.
 - $Total\ Annual\ Fuel\ Consumption = Annual\ Fuel\ Purchases - Annual\ Fuel\ Sales + Fuel\ Stock\ at\ Beginning\ of\ Year - Fuel\ Stock\ at\ End\ of\ Year$
- **Reproduce a copy of Worksheet 2, “Electric, Gas & Heating Oil,” for each municipal facility/category. Complete relevant sections to calculate total fuel consumption for the selected baseline year.**
- Compile the annual usage of each facility into four municipal operations categories:
 - Building & Facilities
 - Street Lights & Traffic Signals
 - Water and Wastewater Treatment Facilities
 - Other
- **Enter the annual usage of each fuel type in each of these operations categories under Step 2 in Worksheet 1, “Municipal Carbon Footprint.”**

B. Calculate the total CO₂, CH₄, and N₂O emissions for each fuel.

- **For natural gas and heating oil, emissions of CO₂, CH₄, and N₂O will automatically be calculated by Worksheet 1, “Municipal Carbon Footprint.”**

For more information about how these emissions are calculated, see below.

- **For other fuel types in use, emissions data must be gathered from the Energy Information Administration website:**
https://www.eia.gov/environment/emissions/co2_vol_mass.cfm
- The formulas are set up to use the following emissions factors as defined by the U.S. Energy Information Administration:

Emissions from Natural Gas

116.9771 pounds of CO₂ per Million BTU
0.000005 metric tons CH₄ per Million BTU
0.0000001 metric tons N₂O per Million BTU

Emissions from Heating Oil

161.2680 pounds of CO₂ per Million BTU
0.00001 metric tons CH₄ per Million BTU
0.0000006 metric tons N₂O emissions per Million BTU

- Note that the Energy Information Administration provides carbon dioxide emissions in pounds. Therefore, CO₂ emissions must be converted to metric tons (1 pound (lb) = 0.0004535927 metric tons) to be added to the total CO₂ equivalent emissions.

Similarly, emissions factors for methane and nitrous oxide are provided in grams (g) per Million BTU. Therefore, the calculation of these emissions should include conversion from grams to tons (1 gram = 1.0 × 10⁻⁶ metric tons).

C. Convert CH₄ and N₂O emissions to CO₂ equivalent (CO₂e) and determine total CO₂e emission.

- **Worksheet 1, “Municipal Carbon Footprint,” will automatically convert methane (CH₄) and nitrous oxide (N₂O) emissions to metric tons of CO₂ equivalents.**
- The method of calculation is also outlined below.

Global Warming Potential (GWP) factors represent the ratio of the heat-trapping ability of each greenhouse gas relative to that of carbon dioxide. For example, the GWP of methane is 28 because one metric ton of methane has 28 times more ability to trap heat in the atmosphere than one metric ton of carbon dioxide.

To convert emissions of non-CO₂ gases to units of CO₂ equivalent, multiply the emissions of each gas in units of mass (e.g., metric tons) by the appropriate GWP factors in the following table.

Common Name	Formula	GWP
Carbon Dioxide	CO ₂	1
Methane	CH ₄	28
Nitrous Oxide	N ₂ O	265

Source: Global Warming Potentials (GWP) from the IPCC's Fifth Assessment Report

<http://www.ipcc.ch/report/ar5/wg1/>

CO₂ Emissions (metric tons CO₂e) = CO₂ Emissions (metric tons) X 1 (GWP)
CH₄ Emissions (metric tons CO₂e) = CH₄ Emissions (metric tons) x 28 (GWP)
N₂O Emissions (metric tons CO₂e) = CH₄ Emissions (metric tons) x 265 (GWP)
Total Emissions (metric tons CO₂e) = CO₂ + CH₄ + N₂O (metric tons CO₂e)

STEP 3: Calculate emissions from Scope 2 indirect emissions from consumption of purchased or acquired electricity.

Follow steps A. and B. below:

A. Determine the annual electricity use for each local government owned and operated facility and operation.

- **Collect monthly utility bills and record the monthly kilowatt-hours (electricity) consumed for each municipal facility during the baseline year. Record this data in the appropriate section of Worksheet 2, "Electric, Gas and Heating Oil," reproduced for each municipal facility.**
- **Compile the annual electricity consumption of each facility into four municipal operations categories:**
 - Building & Facilities
 - Street Lights & Traffic Signals
 - Water and Wastewater Treatment Facilities
 - Other
- **Enter the annual electricity consumption in each of these categories under Step 3 in Worksheet 1, "Municipal Carbon Footprint."**

B. Calculate the Carbon dioxide equivalent (CO₂e) emissions for electricity use.

- **Worksheet 1, “Municipal Carbon Footprint,” will automatically calculate the emissions of CO₂e once the annual kilowatt-hours of electricity consumption are entered for each operations category.**
- The following factor has been used in the calculations:
1312 lbs of CO₂e per MWh

This factor was provided by the NJ Department of Environmental Protection and is based on the 2015 average mix figure of 1219.54 lbs of CO₂ (source: PJM Environmental Information Services, Inc. Generation Attribute Tracking System <https://gats.pjm-eis.com/>), augmented to account for line losses and to include N₂O and CH₄ emissions from power plants.

STEP 4: Calculate emissions from Scope 1 direct emissions from mobile combustion of fuels in vehicle fleet (e.g., cars, trucks, off-road equipment).

Emissions from mobile combustion can be estimated based on vehicle fuel use and miles traveled data. CO₂ emissions, which account for the majority of emissions from mobile sources, are directly related to the quantity of fuel combusted and thus can be calculated using fuel consumption data. CH₄ and N₂O emissions depend more on the emission control technologies employed in the vehicle and distance traveled.

Calculating emissions of CH₄ and N₂O requires data on vehicle characteristics (which takes into account emission control technologies) and vehicle miles traveled. Because of this distinction, guidance on calculating CO₂ is provided separately from guidance on calculating CH₄ and N₂O.

Follow steps A. through D. below and enter the data into the worksheet to calculate the emissions:

*If you do not have fuel use data, but have detailed information about your fleet and annual mileage by vehicle, you may estimate your fuel consumption using the following steps:

- Identify the vehicle make, model, fuel type, and model years for all the vehicles you operate
- Identify the annual distance traveled by vehicle type
- Determine the fuel economy of each vehicle and
- Convert annual mileage to fuel consumption

A. Identify total annual fuel consumption by fuel type;

- **Find the annual fuel consumption for every type of fuel used** (gasoline, diesel, biodiesel, etc). This number includes bulk purchases and stored fuel, as well as any other fuel purchased throughout the year. Use the following equation to determine annual fuel usage for a given fuel type:

Total annual fuel consumption (gallons) = Total annual fuel purchases + Amount stored at beginning of the year - Amount stored at end of the year

Or, fuel consumption can be determined with annual mileage data. Identify the vehicle make, model, model year, and fuel type for all local government owned and operated vehicles. Then add up annual mileage for each vehicle type. Convert the annual mileage into fuel consumption by determining vehicle fuel economies and using the following formula developed by the Environmental Protection Agency (EPA): <http://www.fueleconomy.gov/feg/findacar.htm>.

Total annual fuel consumption (gallons) = Total miles ÷ [(Fuel Economy City mpg * .55) + (Fuel Economy Highway mpg * .45)]

The EPA estimates that 45% of mileage is from time spent on a highway, and 55% of accrued mileage is from time spent driving in a town or city. You may choose to make a different estimate of your fleet's behavior.

- **Sum the total annual fuel consumption for each vehicle type to calculate the total usage for each fuel type. Enter these data into Worksheet 1.**

B. Calculate the total CO2 emissions for each fuel and convert to metric tons.

- **Worksheet 1 will automatically calculate CO2 emissions for gasoline, diesel and CNG vehicle fuels.**
- **For other types of vehicle fuels, specify the fuel in Worksheet 1 under Step 4, and enter the total usage in gallons.**
 - See the Fuel Emission Factors spreadsheet provided by the Energy Information Administration at <http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls>.
 - **The emissions factors in Kilograms CO2 Per Million Btu should be selected from the right hand column of "Table 2. Carbon Dioxide Emission Factors for Transportation Fuels." The emissions will be calculated automatically in the Worksheet once the emission factor and gallons of usage are entered.**
- For more information about how these emissions are calculated, see below.

The general formula is:

Fuel A CO2 Emissions (metric tons) = Fuel Consumed (gallons) × Emission Factor (kg CO2/gallon) ÷ 1,000 (kg/metric ton)

- **The following emissions factors are already incorporated into Worksheet 1:**

CO2 emissions from motor gasoline = 19.54 lbs CO2 per gallon
CO2 emissions diesel fuel = 22.37 lbs CO2 per gallon
CO2 emissions natural gas = 120.36 lbs CO2 per 1000 cubic feet

Source: Fuel Emission Factors provided by the Energy Information Administration
<http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls>.

C. Calculate the total CH4 and N2O emission for each vehicle type.

- **Methane and nitrous oxide emissions must be calculated based on mileage, not on gallons of fuel consumption.** Emissions vary based on type of vehicle and model year.
- **Use Worksheet 3, “Vehicle CH4 & N2O,” to enter the annual mileage during the baseline year for each vehicle type.** Note that there are 30 vehicle types so completion of this section requires detailed information on the model years and baseline year mileage of all vehicles in the municipal fleet. (The information is collected as part of the “Green Fleets” action). Estimates are permitted where exact figures can not be obtained.
- **Worksheet 3 will automatically calculate CH4 and N2O emissions based on the following formulas:**

Vehicle Type A CH4 Emissions (metric tons) = Annual Distance (miles) X
Emission Factor (g CH4/mile) / 1,000,000 g/metric ton.

Vehicle Type A N2O Emissions (metric tons) = Annual Distance (miles) X
Emission Factor (g N2O/mile) / 1,000,000 g/metric ton.

D. Convert CH4 and N2O emissions to CO2 equivalent (CO2e) and determine total CO2e emission.

- **Enter the Metric Tons of CH4 and N2O calculated on Worksheet 3 into Step 4 of Worksheet 1, “Municipal Carbon Footprint.”** Worksheet 1 will automatically convert these emissions to metric tons of CO2 equivalents. See section C of Step 2 for method of calculation.

STEP 5: Calculate emissions from waste-related activities.

- Local governments are often responsible for providing solid waste services to their communities. This may include activities like collecting and transporting waste, sorting waste, managing recycling and composting programs and facilities, and managing landfills. However, experience indicates that it is often

very challenging for local governments to find reliable data on the amount of waste generated from local government operations.

- Local governments who wish to calculate emissions from waste related activities are encouraged to use the EPA's Waste Reduction model (WARM) for calculating the lifecycle emissions from waste generation. This tool is available as an excel spreadsheet or a web-based calculator:

US Environmental Protection Agency: Waste Reduction Model:
<https://www.epa.gov/warm>

- The web-based calculator will require input of an alternative management scenario as well as existing waste management figures. However, the numbers entered in the alternative management scenario will not affect the output needed for the Municipal Carbon Footprint. Identical figures may be entered in this section so that the calculator will move to the next step.

The calculator will ask for tons of waste generated in each of 34 categories. For each waste category, it will be necessary to indicate tons recycled, tons landfilled, and tons combusted.

- **For output, select “Metric Tons of Carbon Dioxide Equivalent (MtCO₂e)”**
 - **Choose “Create summary”**
 - **Note the figure of “GHG Emissions from Baseline Waste Management (MtCO₂e)”**
- **Add this figure to Step 5 of Worksheet 1, “Municipal Carbon Footprint.”**

STEP 6: Calculate emissions from Significant Purchased Services.

Determining whether to include emissions from purchased services in a municipality's carbon footprint should be based on three considerations according the GPC protocol:

- 1.) Is the service provided by the contractor a service that is normally provided by local government? If so, the local government must include these emissions to allow accurate comparison with other local governments.
- 2.) In any previous emissions inventory, was the contracted service provided by the local government and, therefore, included in the earlier inventory? If so, these emissions must be included to allow an accurate comparison to the historical base year inventory.

- 3.) Are the emissions resulting from a source over which the local government exerts significant influence? If so, these emissions must be included in order to provide the most policy relevant emissions information.

If it is determined that a purchased service meets these criteria, then the municipality will need to estimate the carbon emissions associated with the purchased service. This can be done using Carnegie Mellon's EIO/LCA model (see here: <http://www.eiolca.net/cgi-bin/dft/use.pl?searchTerms=&newmatrix=US428PURCH2002>)

There are four inputs required to get an estimate using this model:

1. **On Item #1** where it says "Choose a Model," select "US 2002 (428 sectors) Purchaser" from the drop down menu.
2. **On Item #2 - For the "select industry and sector" input, choose "Government and Special Services"** for the Broad group menu and "General state and local government services" for the Detailed sector menu.
3. **For Item #3, you will input the total dollar amount of the purchased services.** Since the model is calibrated in 2002 dollars, you will first need to convert whatever baseline year data you are using into 2002 dollars using the Consumer Price Index (found here: <https://data.bls.gov/pdq/SurveyOutputServlet>). Note that the input is entered in millions of dollars, so that \$250,000 would be entered as .25 in the model.
4. **For Item #4, choose "Greenhouse Gases"** from the dropdown menu.
5. Finally, **for Item #5 simply click the "Run Model" button to get the result.**
6. **Use the result from the first column under "S00700 – General State and local government services" as the input for Purchased Services in the carbon footprint spreadsheet.**

If your green team members need assistance or explanation on any of the steps described in this guidance document, please reach out to Sustainable Jersey staff at 609-771-2938 or by emailing info@sustainablejersey.com.