Municipal Carbon Footprint

For more information, see www.sustainablejersey.com

A Municipal Carbon Footprint measures the amount of greenhouse gas (GHG) emissions produced by local government operations in a given year. Creating a footprint is the first step to reducing municipal GHG emissions. The footprint will detail the sources of emissions so that actions can be focused on the largest emitters. The footprint will also enable a municipality to track its progress and determine if new policies are having an impact. Reporting your footprint can be a powerful tool for galvanizing public interest and support for new actions.

Completing a Municipal Carbon Footprint requires an accounting-like inventory of all the sources of GHG in your buildings, fleet, and operations.

**Recommended prerequisite: Energy Audit for Municipal Facilities**
Completion of the Sustainable Jersey toolkit “Energy Audit for Municipal Facilities” is recommended prior to undertaking this action. The Municipal Energy Audit requires collection of some of the same utility usage data that will be used to calculate the Municipal Carbon Footprint.

**Recommended follow-up action: Community Carbon Footprint**
A Sustainable Jersey action and tool is also available for a “Community Carbon Footprint” which combines the data from this “Municipal Carbon Footprint” tool with community-wide data that include emissions from homes and businesses.

**Who should lead and be involved with this tool?**

You will need staff to gather data from bills and other records, and a staff member or volunteer to do some basic calculations that we provide. Reporting and acting on the data will require more policy minded participation from officials, staff, and volunteers. Depending on a local government’s
organizational structure and accounting practices, this tool may require participation and data collection from one or more of the following:

- Accounts payable
- Departmental records
- Public Works
- Engineering department
- Facility engineer
- Fuel vendors/suppliers
- Real estate department
- Utility provider

**Timeframe**

Data collection and analysis may take a month to a year depending on the availability of data and staff resources.

**Project Costs and Resource Needs**

The cost of developing a Carbon Footprint varies significantly. The footprint can be accomplished with elbow grease by municipal staff and/or volunteers at minimal cost, however hiring a consultant to perform the task, or purchasing software to assess the results, could range between $5,000 and $20,000. Larger municipalities and cities with complex organizational structures may require more work.

**Why is it important**

The greenhouse effect is a natural process that results from naturally occurring heat-trapping gases in the atmosphere, such as carbon dioxide, water vapor, and methane. Because human activities have now sharply increased the presence of greenhouse gases in the atmosphere the earth trapping more heat and is warming rapidly.

The Intergovernmental Panel on Climate Change (IPCC) is the major international scientific effort to understand climate change and what can be done. According to a 2007 report issued by the IPPC, "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."\(^1\)

Global warming poses serious threats such as rising sea levels, changes in rainfall patterns, severe droughts and floods, more intense and frequent hurricanes and other windstorms, and new pathways for disease. With vast assets in facilities, parks, roads, bridges, waterfronts, and water and sewage networks, climate change creates significant risks for local governments in New Jersey.

The Stern Review, *The Economics of Climate Change*, concluded that the risks of climate change could be substantially reduced if greenhouse gas levels in the atmosphere can be stabilized between 450 and 550 ppm carbon dioxide equivalent (CO2e).\(^2\) The Stern Review’s conclusion is that “stabilization…requires that annual emissions be brought down to more than 80% below current levels.”

This is the same target established by New Jersey’s Global Warming Response Act, which calls for a reduction in greenhouse gas emissions to 1990 levels by 2020, approximately a 20 percent reduction, followed by a further reduction of emissions to 80 percent below 2006 levels by 2050.

Meeting greenhouse gas emission goals set by the state requires commitments at the local level. Conducting a Municipal Carbon Footprint establishes a baseline upon which progress towards greenhouse gas reduction targets can be evaluated. It helps develop an understanding of GHG emissions appropriate for making well-informed decisions regarding local policies and actions to reduce such emissions.

**What to do, and how to do it (“How to”)**

To establish a Municipal Carbon Footprint, also known as a Greenhouse Gas Inventory, data are collected in three areas (known as “scopes”), one of which is optional to receive Sustainable Jersey points. The required data reporting scopes are:

- **Scope 1**: direct emissions from stationary combustion of fuels like natural gas, heating oil, coal, and diesel and mobile combustion of fuels in fleet transportation sources (e.g., cars, trucks, off-road equipment), and
- **Scope 2** or indirect emissions from consumption of purchased or acquired electricity.

The optional reporting category (Scope 3) deals with emissions related to solid waste disposal and recycling. It is optional because reliable data is not always available at the local level, and because this scope has the smallest impact on your total footprint. However, if data is available we recommend that you attempt it.

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Overview of Steps to Create a Footprint

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 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.3

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 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).

Optional data: the following information must be gathered in order to complete optional Step 5, emissions from waste related activities:

- Tons of waste generated in each of 34 categories.
- For each waste category, tons recycled, tons landfilled, and tons combusted.

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

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3Note: For municipalities serviced by PSEG the baseline year should be 2008 – the earliest year for which PSEG can provide complete municipal-wide energy use data. In general, check with your local utility provider for the earliest year for which energy data is kept at the municipal level.
Follow these three steps and enter the data into the worksheet to calculate the emissions:4

A. Determine the annual consumption of each fuel combusted at your facilities;
B. Calculate the total carbon dioxide (CO2), methane (CH4), and nitrous oxide (N20) emissions for each fuel;
C. Convert CH4 and N20 emissions to CO2 equivalent (CO2e) and determine total CO2e 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 N20 emissions for each fuel.

For natural gas and heating oil, emissions of CO2, CH4, and N20 will automatically be calculated by Worksheet 1, “Municipal Carbon Footprint.”

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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:

CO2 emissions coefficients:
http://www.eia.doe.gov/oiaf/1605(coefficients.html)

Methane and nitrous oxide emission factors:
http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls

The formulas are set up to use the following emissions factors as defined by the U.S. Energy Information Administration:

**Emissions from Natural Gas**
117.080 pounds of CO2 per Million BTU
0.000005 metric tons CH4 per Million BTU
0.0000001 metric tons N20 per Million BTU

**Emissions from Heating Oil**
161.386 pounds of CO2 per Million BTU
0.000001 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 N20 emissions to CO2 equivalent (CO2e) and determine total CO2e emission.**

Worksheet 1, “Municipal Carbon Footprint,” will automatically convert methane (CH4) and nitrous oxide (N20) emissions to metric tons of C02 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 21 because one metric ton of methane has 21 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.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Formula</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>CO2</td>
<td>1</td>
</tr>
<tr>
<td>Methane</td>
<td>CH4</td>
<td>21</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>N20</td>
<td>310</td>
</tr>
</tbody>
</table>

Source: Global Warming Potentials (GWP) from the IPCC’s Second Assessment Report

\[
\text{C02 Emissions (metric tons CO2e) = C02 Emissions (metric tons \times 1 \text{ (GWP)}}
\]

\[
\text{CH4 Emissions (metric tons CO2e) = CH4 Emissions (metric tons \times 21 \text{ (GWP)}}
\]

\[
\text{N20 Emissions (metric tons CO2e) = CH4 Emissions (metric tons \times 310 \text{ (GWP)}}
\]

\[
\text{Total Emissions (metric tons CO2e) = CO2 + CH4 + N20 (metric tons CO2e)}
\]

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

Follow these three steps:\(^5\)

A. Determine the annual electricity use for each local government owned and operated facility and operation.
B. Calculate the total CO2, CH4, and N20 emissions for electricity use.
C. Convert CH4 and N20 emissions to CO2 equivalent (CO2e) and determine total CO2e emissions.

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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 CO2, CH4, and N20 emissions for electricity use.**

Worksheet 1, “Municipal Carbon Footprint,” will automatically calculate the emissions of CO2, CH4, and N20 once the annual kilowatt-hours of electricity consumption are entered for each operations category.

To learn more about how these emissions are calculated, see below.

The following factors have been used in the calculations:

**Electricity Emission Factors for eGrid 2006 sub-region RFC East:**

Total CO2 Emissions (metric tons) = Electricity Use (MWh) x Electricity Emission Factor (1,095.53 lbs CO2/MWh) ÷ 2,204.62 lbs/metric ton

Total CH4 Emissions (metric tons) = Electricity Use (MWh) x Electricity Emission Factor (.028 lbs CH4/MWh) ÷ 2,204.62 lbs/metric ton

Total N20 Emissions (metric tons) = Electricity Use (MWh) x Electricity Emission Factor (.017 lbs N20/MWh) ÷ 2,204.62 lbs/metric ton

Source: Appendix G, Table G.7 eGRID Electricity Emission Factors by eGRID Subregion (2004 data)

**C. Convert CH4 and N20 emissions to CO2 equivalent and determine total emissions.**

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6This tool was adapted from the Climate Registry’s *Electricity Calculation Tool*, 2008, available at [http://www.theclimateregistry.org/downloads/Electricity_Calculation_Tool.xls](http://www.theclimateregistry.org/downloads/Electricity_Calculation_Tool.xls).

Worksheet 1, “Municipal Carbon Footprint,” will automatically convert methane (CH4) and nitrous oxide (N2O) emissions to metric tons of CO2 equivalents. See section C of Step 2 for method of calculation.

**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 these four steps and enter the data into the worksheet to calculate the emissions:

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A. Identify total annual fuel consumption by fuel type*;
B. Calculate the total CO2 emissions for each fuel;
C. Calculate the total CH4 and N2O emission for each fuel;
D. Convert CH4 and N2O emissions to CO2 equivalent (CO2e) and determine total CO2e emission.

*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:
  o Identify the vehicle make, model, fuel type, and model years for all the vehicles you operate;
  o Identify the annual distance traveled by vehicle type;
  o Determine the fuel economy of each vehicle; and
  o 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

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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 years, 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\(^9\) and using the following formula developed by the Environmental Protection Agency (EPA):

\[
\text{Total annual fuel consumption (gallons)} = \frac{\text{Total Miles}}{(\text{Fuel Economy City mpg} \times 0.55) + (\text{Fuel Economy Highway mpg} \times 0.45)}
\]

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. The emissions factors should be selected from the right hand column of the table below. The emissions will be calculated automatically in the Worksheet.

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Table: Carbon Dioxide Emission Factors for Transport Fuels\(^{10}\)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Carbon Content kg C/MMBtu</th>
<th>Heat Content MMBtu/barrel</th>
<th>Fraction Oxidized</th>
<th>CO(_2) Emission Factor kg CO2/gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aviation Gasoline</td>
<td>18.87</td>
<td>5.048</td>
<td>1.00</td>
<td>8.32</td>
</tr>
<tr>
<td>Biodiesel (B100)*</td>
<td>NA</td>
<td>NA</td>
<td>1.00</td>
<td>9.46</td>
</tr>
<tr>
<td>Crude Oil Diesel</td>
<td>20.33</td>
<td>5.80</td>
<td>1.00</td>
<td>10.29</td>
</tr>
<tr>
<td>Ethanol (E100)*</td>
<td>17.99</td>
<td>3.539</td>
<td>1.00</td>
<td>5.56</td>
</tr>
<tr>
<td>Jet Fuel (Jet A or A-1) Kerosene</td>
<td>19.33</td>
<td>5.670</td>
<td>1.00</td>
<td>9.57</td>
</tr>
<tr>
<td>Liquefied Natural Gas (LNG)+</td>
<td>NA</td>
<td>NA</td>
<td>1.00</td>
<td>4.46</td>
</tr>
<tr>
<td>Liquefied Petroleum Gas (LPG)+</td>
<td>17.23</td>
<td>3.849</td>
<td>1.00</td>
<td>5.79</td>
</tr>
<tr>
<td>Ethane</td>
<td>16.25</td>
<td>2.916</td>
<td>1.00</td>
<td>4.14</td>
</tr>
<tr>
<td>Isobutane</td>
<td>17.75</td>
<td>4.162</td>
<td>1.00</td>
<td>6.45</td>
</tr>
<tr>
<td>n-Butane</td>
<td>17.72</td>
<td>4.328</td>
<td>1.00</td>
<td>6.70</td>
</tr>
<tr>
<td>Propane</td>
<td>17.20</td>
<td>3.824</td>
<td>1.00</td>
<td>5.74</td>
</tr>
<tr>
<td>Methanol</td>
<td>NA</td>
<td>NA</td>
<td>1.00</td>
<td>4.10</td>
</tr>
<tr>
<td>Motor Gasoline</td>
<td>19.33</td>
<td>5.218</td>
<td>1.00</td>
<td>8.81</td>
</tr>
<tr>
<td>Residual Fuel Oil (#5, 6)</td>
<td>21.49</td>
<td>6.287</td>
<td>1.00</td>
<td>11.80</td>
</tr>
<tr>
<td>Compressed Natural Gas (CNG)+</td>
<td>14.47</td>
<td>1027</td>
<td>1.00</td>
<td>5.31</td>
</tr>
</tbody>
</table>

\(^{*}\)CO\(_2\) emissions from biodiesel and ethanol combustion are considered biogenic and should not be reported as a direct mobile combustion emission. These biogenic CO\(_2\) emissions may be reported optionally.

Climate Leaders Mobile Combustion Guidance). Methanol emission factor is calculated from the properties of the pure compounds.

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

The general formula is:

\[
\text{Fuel A CO2 Emissions (metric tons) = Fuel Consumed (gallons) \times Emission Factor (kg CO2/gallon) ÷ 1,000 (kg/metric ton)}
\]

The following emissions factors are already incorporated into Worksheet 1:\(^{11}\)

CO2 emissions from a gallon of gasoline = 2,421 grams x 0.99 x (44/12) = 8,788 grams = 8.81 kg/gallon

CO2 emissions from a gallon of diesel = 2,778 grams x 0.99 x (44/12) = 10,084 grams = 10.15 kg/gallon

CO2 emissions from a gallon of compressed natural gas = 5.31 kg/gallon

C. Calculate the total CH4 and N20 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 & N20,” to enter annual mileage during 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” toolkit). Estimates are permitted where exact figures cannot be obtained.

Worksheet 3 will automatically calculate CH4 and N20 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 N20 Emissions (metric tons) = Annual Distance (miles) X Emission Factor (g N20/mile) / 1,000,000 g/metric ton.

\(^{11}\)Environmental Protection Agency and Intergovernmental Panel on Climate Change: http://www.epa.gov/otaq/climate/420f05001.htm.
D. Convert CH4 and N20 emissions to CO2 equivalent (CO2e) and determine total CO2e emission.

Enter the Metric Tons of CH4 and N20 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: (Optional) 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. As a result, Step 5 is optional.

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
http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

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 (MtC02e)”

Add this figure to Step 5 of Worksheet 1, “Municipal Carbon Footprint.”
What to submit to get credit/points

Satisfy the action for establishing a Municipal Carbon Footprint through the reporting and verification requirements specified in this tool. Data must be collected for the Scope 1 and Scope 2 emissions of three greenhouse gases from local government operations. A spreadsheet file is provided with worksheets that will assist in calculating the Municipal Carbon Footprint. Submit the completed spreadsheet to Sustainable Jersey.

Resources

Intergovernmental Panel on Climate Change  
http://www.ipcc.ch/index.htm

State of New Jersey – Global Warming  
http://www.state.nj.us/globalwarming/index.shtml

National Conversation on Climate Action  
http://www.climateconversation.org/

Mayors Climate Protection Center  
http://www.usmayors.org/climateprotection/

ICLEI – Local Governments for Sustainability USA (ICLEI USA)  
www.icleiusa.org

CACP- Clean Air and Climate Protection Software  
www.cacpsoftware.org

California Climate Action Registry  
www.climateregistry.org

The Climate Registry  
http://www.theclimateregistry.org/

Rocky Mountain Institute’s Community Energy Opportunity Finder  
http://www.energyfinder.org/

U.S. EPA - Clean Energy-Environment Municipal Network  
http://www.epa.gov/cleaneenergy/energy-programs/state-and-local/local.html

Energy Information Administration  
http://www.eia.doe.gov/