



Calculating Carbon Emissions



In the late 20th century, Californians became more than just calorie conscious — we began reading nutrition labels to discover the caloric, fat, trans fat, sodium and vitamin content of food. We also select many of our activities based on the number of calories burned.

In the 21st century, as we become more attuned to addressing climate change, perhaps carbon counting will be the new calorie counting. Just as we want to know how many calories in our lunch come from fat, we are now interested in knowing the amount of carbon emissions associated with various activities and what we can

do to reduce our impact on the environment — our carbon footprint. In fact, many climate change programs suggest “going on a low-carbon diet” for our personal, household, municipal or community activities.

Many daily activities, such as using natural gas to heat buildings or burning gasoline to drive vehicles, release carbon dioxide (CO₂) and other greenhouse gases (GHGs) into the atmosphere. The resulting increased buildup of GHGs in the atmosphere is causing the earth’s climate to change, producing many impacts including higher (and lower) temperatures, less snow and rainfall and rising sea level.

The most abundant GHG in our atmosphere contributing to climate change is CO₂. Other GHGs — methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons and perfluorocarbons — have a much higher global warming potential, which means that they are more potent than CO₂. Many of these GHGs also have a long-lived impact on the environment. Numerous other climate forces contribute to climate change, but climate calculators typically account for emissions of the six GHGs listed here. Climate calculators “count” carbon by converting emissions of GHGs from various activities (such as using natural gas for heat or burning gasoline in vehicles) into what’s known as a carbon dioxide equivalent (CO₂e), as shown in Figure 1.

Weighing the Options

How do we judge the relative carbon reduction benefits of one activity over another? Which generates *less* GHG emissions — replacing a 20-year-old refrigerator with a new energy-efficient one, retrofitting city hall’s 100 fluorescent lamps or purchasing five new hybrid cars for the city fleet? Is it better to invest in high-efficiency fluorescent lamps or a new heating, ventilation and air conditioning (HVAC) system if you can’t do both? One city manager aptly wondered which would be a more effective use of his agency’s funds if the goal is to reduce GHG emissions. Should the city invest \$500,000 in retrofitting city hall to be more energy efficient or in building a grade separation for the railroad

tracks crossing Main Street? These kinds of questions are being asked more frequently as cities evaluate how to reduce their carbon emissions in the most cost-effective manner with limited resources. Figure 2 offers some examples of various carbon-reduction activities and compares their impact in metric tons of CO₂e per year.

Making the analysis somewhat more challenging is the fact that all energy is not equal for the purpose of carbon calculating. For example, one kilowatt-hour (kWh) of electricity produced by a solar photovoltaic system generates *less* GHG emissions than one kWh of electricity generated by a typical power plant. Similarly, the GHG emissions produced by a hybrid vehicle (or a fuel-efficient, gasoline-powered car) are *less* than those produced by a car that gets low gas mileage.

The Local Government Toolkit (available online at www.CoolCalifornia.org) provides guidance and tools that local governments can use to reduce GHG emissions and save money. The toolkit estimates that if each California city replaced 1,000 existing fluorescent lighting systems (T12 lamps with magnetic ballasts) in municipal buildings with high-efficiency systems (Super T8 lamps with electronic ballasts), it would save 48 million kilowatt-hours of electricity — which translates into 19,200 metric tons of CO₂e per year. Each city would emit about 28 to 40 fewer metric tons of CO₂e per year through this type of lighting retrofit activity in a 30,000-square foot municipal building, saving \$13,750 annually. At a cost of \$50 each for 1,000 fixtures, the lighting retrofit would result in a 3.6 year payback or 27 percent return on investment.

The Local Government Toolkit includes information on financial resources as well as a prioritized checklist of no-cost, low-cost and advanced investment options that cities and counties can use to prioritize decisions. In addition, the Institute for Local Government's California Climate Action Network provides numerous related resources for local governments at www.ca-ilg.org/climatechange.

Getting the Most for Taxpayer Dollars

As local agencies take steps to reduce their carbon emissions and evaluate which best practices to use, they can also evaluate which activity will achieve the greatest carbon-reduction bang for their limited buck. Cities and counties are continuing to lead by example in reducing GHG emissions, thus using taxpayer dollars wisely and promoting sustainability at the same time.

Figure 1. How Does Energy Consumption Translate Into GHG Emissions?

Energy Consumption	CO ₂ e (pounds)	CO ₂ e (metric tons)
1 Million BTUs of Natural Gas	117	0.053
1 Gallon of Gasoline	20	0.009
1 kWh of California-Grid Average Electricity	1	0.0004

Source: California Air Resources Board

Figure 2. Greenhouse Gas Emission Reduction Potential of Various Climate Actions

Climate Action	Replace	Better Technology	GHG Emission Reduction Potential (metric tons CO ₂ e) Per Year
Replace five fleet vehicles	Mid-size passenger vehicles	Hybrid vehicles	5
Upgrade 1,000 fluorescent lighting fixtures	T12 lamps with magnetic ballast	SuperT8 lamps with electronic ballast	28
Retrofit a 30,000-sq. ft. municipal building	Varies depending on energy audit	Improve energy efficiency by 25% using a whole-building approach	51
After retrofit, install on-site renewable energy generation at a 30,000-sq. ft. municipal building	Grid-average electricity	On-site solar photovoltaic panels	46

Source: California Air Resources Board

Carbon Calculators: Definitions and Related Resources

Resources for more information

Cool California – www.CoolCalifornia.org and www.coolcalifornia.org/article/climate-calculators

California Climate Action Network (CCAN) – www.ca-ilg.org/climatechange

Definitions of common terms

Greenhouse gas emissions are measured in pounds, metric tons, or, for larger measurements, in million metric tons (MMT) of carbon dioxide equivalent (CO₂e) over some period of time (a year, for example).

A **carbon footprint** is the measurement of total greenhouse gas emissions directly and indirectly contributed by a person, household, business, facility, or community over the course of a year. It takes into account greenhouse gas emissions from stationary combustion of fuel in a fixed location, mobile combustion of fuels from transportation sources and off-road equipment, process emissions from physical or chemical processing, fugitive emissions that are not physically controlled, and indirect emissions from

electricity usage. A life-cycle approach to measuring a carbon footprint also estimates cradle-to-cradle greenhouse gas emissions associated with food choices and goods and services such as clothing, furniture and appliances.

A **carbon calculator** estimates carbon footprints. It measures greenhouse gas emissions for a snapshot in time. Carbon calculators are used to calculate **greenhouse gas inventories** of facilities or operations in order to determine the amount of greenhouse gases produced for a specified year. The results can be used to prepare plans for actions to reduce the amount of greenhouse gas emitted annually or by a target year.

Being **carbon neutral**, or having a net zero carbon footprint, refers to achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount reduced, sequestered or offset emissions.

Greenhouse gas (GHG) emissions are those gaseous constituents of the atmosphere, both natural and anthropogenic (caused by human activity), that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the "greenhouse effect." Water vapor (H₂O), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄) and ozone (O₃) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances. Still other greenhouse gases are sulphur hexafluoride (SF₆), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). (Source: Intergovernmental Panel on Climate Change)

Modeling tools estimate greenhouse gas emissions and potential reductions for various scenarios. They are typically used for climate action planning.

Protocols provide a standardized set of guidelines, methodologies and calculations to quantify and report greenhouse gas emission inventories.

The Climate Registry offers an online reporting tool to report greenhouse gas emission inventories. The report is third-party certified and the public can review verified greenhouse gas emission reports.

Carbon Calculators for Local Governments

Although the field is evolving, new tools are emerging to make the process of calculating carbon emissions from one's home, business trip or city hall easier and more accurate. The following provides an overview to help understand the growing field of carbon calculators and carbon footprints.

Climate Registry Information System (CRIS) – from The Climate Registry

www.theclimateregistry.org/resources/climate-registry-information-system-cris/

Several cities and counties have historically used the California Climate Action Registry's On-Line Tool (CARROT) to calculate and report greenhouse gas emissions. However, the California Climate Action Registry is no longer registering greenhouse gas emission inventories. The California Climate Action Registry formed The Climate Registry, which offers the next generation of online reporting through The Climate Registry Information System (CRIS). Cities and counties can use CRIS to report their greenhouse gas emission inventories, which is third-party certified and available for public review.

Clean Air and Climate Protection (CACP) Software 2009

www.icleiusa.org/cacp

Local governments can use the Clean Air and Climate Protection (CACP) software to determine greenhouse gas emissions and criteria pollutants from government operations and communities. CACP is a downloadable spreadsheet, which ICLEI – Local Governments for Sustainability members can use to input aggregate information about energy usage, waste generation, and vehicle miles traveled (VMT) to calculate a greenhouse gas emission inventory. CACP was updated in April of 2009 to include the calculation methods of the Local Government Operations Protocol (LGOP), adopted in 2008 by the California Air Resources Board.

Local Government Operations Protocol

www.arb.ca.gov/cc/protocols/localgov/localgov.htm

Since both the Climate Registry Information System and Clean Air and Climate Protection calculators require a membership fee, some local governments may be interested in calculating their own greenhouse gas emission inventories. The Local Government Operations Protocol (LGOP) provides a standardized set of guidelines, methodologies and calculations for local governments to quantify and report greenhouse gas emission inventories from municipal operations. While there is not a calculator for the LGOP, it provides the option for a 'free' method to calculate greenhouse gas emissions from municipal operations.

Other Resources**Greenhouse Gas Equivalencies Calculator**

www.epa.gov/cleanenergy/energy-resources/calculator.html

This calculator, developed by the U.S. Climate Technology Cooperation, expresses quantities of greenhouse gases in terms of metrics such as number of cars, gallons of gasoline, acres of forest, and others.

Recycled Content (ReCon) Tool

www.epa.gov/climatechange/wycd/waste/calculators/ReCon_home.html

The Recycled Content (ReCon) Tool calculates greenhouse gas emissions and energy consumption resulting from purchasing recycled products. For example, the tool estimates the greenhouse gas emissions and energy benefits of purchasing office paper with 35 percent recycled content instead of 25 percent recycled content...

Waste Reduction Model (WARM)

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

The WASTE Reduction Model (WARM) calculates and totals greenhouse gas emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling.

Center for Urban Forest Research (CUFR) Tree Carbon Calculator

www.fs.fed.us/ccrc/topics/urban-forests/

The CUFR Tree Carbon Calculator for California climate regions produces carbon storage and sequestration values for a tree plus the associated energy conservation and emission reductions. The CUFR Tree Carbon Calculator is the only tool approved by the California Climate Action Registry's Urban Forest Project Reporting Protocol for quantifying carbon dioxide sequestration from tree planting projects.

Energy Star Portfolio Manager

www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager#manage

Portfolio Manager is an interactive energy management tool that allows users to create an inventory of greenhouse gas emissions from public buildings, set efficiency investment priorities, identify under-performing buildings, verify efficiency improvements, and receive EPA recognition for superior energy performance.

Portfolio Manager generates a Statement of Energy Performance for each building, summarizing important energy information including carbon emissions.

Household Carbon Footprint Calculators

<http://coolcalifornia.org/article/carbon-calculator>

There are many different household carbon footprint calculators available to help individuals gain a better understanding of the greenhouse gas emissions related to personal choices made on a daily basis. The Cool California Carbon Footprint calculator takes a life-cycle approach to measuring carbon footprints, including direct and indirect greenhouse gas emissions from transportation, household energy, food, goods and services. The calculator also acts as a benchmarking tool where individuals can compare their results to typical households in their city or region and the U.S. or global average.

General Information

ICLEI – Local Governments for Sustainability - www.icleiusa.org/

The Climate Registry - www.theclimateregistry.org/

Local Government Commission - www.lgc.org/issues/climatechange.html

CAPCOA - www.capcoa.org/climatechange/

Flex Your Power – www.flexyourpower.com

This article originally appeared in the [July 2009](#) issue of *Western City* magazine. Dana Papke Waters, an air pollution specialist with the Climate Action and Research Planning, Research Division of the California Air Resources Board, co-authored the article.
