Leading by Example Program
Greenhouse Gas Emissions Inventory Guidance

I. INTRODUCTION:

The Leading by Example Program conducts annual greenhouse gas (GHG) emissions inventories to track the sources and amounts of greenhouse gases that are produced as a result of state operations. Governor Deval Patrick's Executive Order 484 requires state government to reduce its GHG emissions 25% by 2012, 40% by 2020, and 80% by 2050. In addition, in July 2008 the Governor signed into law the Global Warming Solutions Act, legislation that requires an 80% emissions reduction (1990 baseline) across the Commonwealth by 2050.

Tracking emission sources and progress toward our goals helps the state target climate action initiatives and implement policies and programs to facilitate and accelerate further greenhouse gas emission reductions. Emissions inventories can also be used to track agency progress in meeting its own targets, as well as measuring progress over time.

This *Greenhouse Gas Emissions Guidance* Sheet provides basic information about the inventory process, how Massachusetts state government GHG inventories are conducted, and what methods are used to calculate carbon emissions. It also lists additional tools and resources.

II. CONDUCTING A GREENHOUSE GAS EMISSIONS INVENTORY:

While the six internationally-recognized categories of greenhouse gases that are tracked for inventory purposes are Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur Hexafluoride (SF6), LBE inventories focus primarily on CO2 as the most easily measurable and the most significant greenhouse gas contributing to climate change.* In an inventory, greenhouse gas emissions from energy usage are converted into the appropriate CO2 equivalent for comparison. The inventory process consists of three major steps:

Step 1: *Compile Energy Data*: Energy data by fuel (e.g. electricity, natural gas, fuel oil, etc. is collected from a variety of sources to determine the annual consumption by agency by fuel total state emissions for the year from both direct (on-site) and indirect (off-site) sources.

Step 2: *Calculate Emissions*: Once energy data has been collected, the CO_2 emissions are derived by multiplying each fuel consumption total by the appropriate conversion factor (see page 3) for each fuel. The CO_2 emissions are then converted to metric tons, the internationally-accepted unit of measure for GHG inventories.

Step 3: *Analyze and Report*: The Leading by Example Program then analyzes the data to determine the primary sources of emissions and current trends by agency and throughout state government facilities. This information is used to target efforts towards reducing emissions where the greatest benefit will be obtained. Annual GHG inventory reports are provided by the LBE Program to participating agencies.

* http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html

III. ENERGY METRICS:

Energy can be measured in a variety of ways and companies use different units of measure to report energy consumption. The most common energy metrics are gallons (for fuel oil, diesel fuel, gasoline, propane), therms (for natural gas), and kilowatt-hours (for electricity). One therm is 100,000 Btus, which is approximately equal to 100 cubic feet of natural gas. A kilowatt-hour (kWh) is a unit of measure equal to 1,000 watts of power consumed for one hour. For example, a 100-watt light bulb that is illuminated for 24 hours has an energy use equivalent to 2.4kWh (100W x 24 hrs. ÷ 1,000W = 2.4 kWh).

When comparing the relative usage between different fuels, data must be converted to the same unit of measure so that accurate comparisons between fuels can be made. The Leading by Example Program converts energy data to BTUs (see chart below), a standard unit of measure for energy. This conversion can allow facilities to compare their own energy usage on a square foot basis with other like facilities (e.g. one community college versus another). It can also be used to evaluate a facility's total energy usage over time, even when different fuels are used (e.g. converting from oil to gas).

British Thermal Units, or BTUs, are used to measure heat-generated energy. One BTU is equal to the quantity of heat required to raise the temperature of one pint of water one degree Fahrenheit. This is an internationally-accepted measurement for energy.

The following table lists the BTU equivalents per volume of fuel used to convert energy data from physical units of measure (such as gallons or cubic feet) into the energy-equivalent measure of BTU.

Table 1: BTU Equivalents for Fuels

FUEL	VOLUME	BTU
Electricity	1 kWh	3412
Distillate Fuel (No. 2 and No. 4 Fuel Oil)	1 gallon	138,874
Residential Fuel (No. 5 and No.6 Fuel Oil)	1 gallon	149,793
Natural Gas	100 ft^3	103,047
Natural Gas	1 therm	100,000
Motor Gasoline	1 gallon	124,884
Diesel	1 gallon	138,874
Kerosene	1 gallon	134,780
Liquefied Petroleum Gasses (LPG)	1 gallon	95,500

Please see the following site for various conversion equivalencies:
http://www.onlineconversion.com/energy.htm

IV. EMISSIONS FACTORS FOR CALCULATING GHG EMISSIONS:

Emissions factors are the average emissions rate of a given pollutant for a given source of energy. Greenhouse Gas emissions factors are used to convert energy usage data into CO_2 lbs. equivalents. Pounds of CO_2 produced from a fuel are then converted into metric tons for the final inventory report. The calculation for converting pounds of CO_2 to metric tons of CO_2 is:

Metric Tons of CO_2 = Pounds of CO_2 ÷ 2204.6

The following table lists the emissions rates (obtained from the U.S. Energy Information Administration at: http://www.eia.doe.gov/oiaf/1605/coefficients.html) used by Leading by Example to calculate carbon emissions and facility carbon footprints.

Table 2: CO_2 Emissions Rates

FUEL	LBS CO_2	METRIC TONS CO_2
Fuel Oil (No. 1, No. 2, No. 4)	22.384 / gallon	0.0102
Residual Fuel Oil (No. 5, No. 6)	26.033 / gallon	0.0118
Natural Gas	12.059 / 100 ft^3	0.0055
Motor Gasoline	19.564 / gallon	0.0089
Diesel	22.384 / gallon	0.0102
Propane	12.669 / gallon	0.0057
Electricity	SEE BELOW	SEE BELOW

V. CO2 EMISSION FACTORS FOR ELECTRICITY

Unlike other fuels, the emissions factor for electricity changes significantly each year as the regional grid fuel mix used to generate electricity changes, getting cleaner when more natural gas and renewables are used, dirtier when fuels such as oil and coal are used. The cleaner the fuels used to provide grid electricity in the future, the lower the corresponding CO_2 emission factors will become.

The following chart shows the total statewide electricity emissions rates from 2001 to 2006 for both fiscal and calendar years. The numbers for the fiscal year (from July 1 to June 30) are found by averaging the numbers from two calendar years that overlap with the corresponding fiscal year. This data is obtained from an annual report issued by the ISO New England, the regional grid operator.

CO_2 emissions data is shown in both lbs/kWh and metric tons/kWh.

Table 3: CO_2 Emissions Rates for Calendar and Fiscal Year								
Lbs CO_2/kWh					Metric Tons CO_2/kWh			
Calendar Year	CO2 Emissions	CO2 Emissions	Fiscal Year		Calendar Year	CO2 Emissions	CO2 Emissions	Fiscal Year
2001	.930				2001	0.000422		
		.919	2002				0.000417	2002
2002	.909				2002	0.000412		
		.939	2003				0.000426	2003
2003	.970				2003	0.000440		
		.923	2004				0.000419	2004
2004	.876				2004	0.000397		
		.897	2005				0.000407	2005
2005	.919				2005	0.000417		
		.863	2006				0.000392	2006
2006	.808				2006	0.000367		
		.856	2007					
2007	.905				2007	0.000410	.000388	2007
2008	*Use the latest data available and update when new data is developed*				2008	*Use the latest data available and update when new data is developed*		
2009					2009			

VI. BIOFUELS, RECs, AND OTHER ISSUES

Due to the complexity of and changing science associated with emission factors of fuels such as bioheat, biodiesel, and biomass, agencies should continue to report the use of these fuels but check with the LBE staff for the latest information on how to calculate associated Greenhouse gas emissions. Renewable Energy Certificates (RECs) should be reported and counted separately using the REC guidance established by the LBE program (see the Resources page at http://www.mass.gov/eea/leadingbyexample).

VII. TOOLS AND RESOURCES:

For more information on greenhouse gas emissions calculations and inventories visit the following websites:

World Resources Institute, Climate Analysis Indicators Tool: http://cait.wri.org/
World Resources Institute, GHG Protocol Initiative: http://www.wri.org/project/ghg-protocol
Clean Air-Cool Planet: http://www.cleanair-coolplanet.org/
The Climate Registry: http://www.theclimateregistry.org/
The Greenhouse Gas Protocol Initiative: http://www.ghgprotocol.org/
U.S. Environmental Protection Agency: http://www.epa.gov/climatechange/emissions/index.html
IPCC – National Greenhouse Gas Inventories Program: http://www.ipcc-nggip.iges.or.jp/
Online Conversions: http://www.onlineconversion.com/energy.htm
Energy Information Administration: http://www.eia.doe.gov/oiaf/1605/coefficients.html

VIII. LEADING BY EXAMPLE CONTACTS:

For more information on this document, State GHG inventories, or the LBE Program, contact:

Eric Friedman, Director, Leading by Example Program, (617) 626-1034, Eric.Friedman@state.ma.us

Janet Curtis, Project Manager, Leading by Example Program, (617) 626-1026, Janet.Curtis@state.ma.us

Charlie Tuttle, Project Manager, Leading by Example Program, (617) 626-1043, Charles.Tuttle@state.ma.us