Greenhouse Gas Inventory and Tracking in Portfolio Manager
October 21, 2008

Introduction:

Energy use in commercial and industrial buildings in the United States contribute 45 percent of our national emissions of the greenhouse gases linked to global climate change.[1] Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the principal greenhouse gases emitted to the atmosphere from the burning of fossil fuels to produce heat and power for these buildings. Electricity consumption in these buildings is responsible for roughly three-quarters of these greenhouse gases (GHG), with the remainder resulting from burning natural gas and petroleum products. Of these three GHGs, CO_2 represents more than 99% of the total greenhouse gas emissions from fuels combusted by commercial, industrial, and electricity production sources, with CH_4 and N_2O together representing less than 1% from the same sources.[2]

The greenhouse gas accounting and tracking function in ENERGY STAR's Portfolio Manager was designed to provide users with the ability to record, track, and communicate the GHG emissions associated with the energy use of their buildings. The methodology for calculating GHG emissions in Portfolio Manager was designed to be consistent with the Greenhouse Gas Protocol[3] developed by the World Resources Institute and World Business Council for Sustainable Development, and as such is compatible with the accounting, inventory and reporting requirements of Environmental Protection Agency's (EPA) Climate Leaders program, as well as other state and NGO registry and reporting programs.

Methodology for Calculating a Building's Total Greenhouse Gas Footprint:

The Portfolio Manager methodology to determine a building's total GHG emissions accounts for all CO_2, CH_4, and N_2O emissions associated with the building's energy use. This inventory includes GHG emissions from both fossil fuel consumed on-site (referred to as direct emissions), as well as GHG emissions generated off-site at power plants that deliver heat, cooling or electricity to the building (referred to as indirect emissions). To determine the direct emissions from on-site combusted fuels, Portfolio Manager utilizes a default fuel analysis approach. This simplifies calculation for the user by providing fuel-specific factors for heating value, carbon content, and carbon oxidation factor. Indirect emissions from district energy consumption (heating and cooling) use a similar approach. Indirect emissions from electricity consumption are determined through direct measurement by utility owners and operators reporting continuous emissions monitoring system data to EPA under several regulatory programs. This information is available in U.S. EPA's Emissions & Generation Resource Integrated Database (eGRID)[4].

While a default fuel analysis approach provides a straightforward estimation of direct CO_2 emissions, estimating direct emissions of CH_4, and N_2O is much more complicated. Unlike CO_2 emissions, CH_4, and N_2O emissions depend not only upon fuel characteristics, but also on combustion technology (size, vintage, maintenance, and operation), combustion characteristics, usage of pollution control equipment, and ambient environmental conditions. Fortunately, as these direct emissions comprise a small percentage of the total GHG footprint of a building, fuel-specific, commercial sector factors are considered adequate to estimate CH_4, and N_2O emissions associated with on-site fuel consumption.

To provide consistency in reporting total GHG emissions, the quantity of each GHG is multiplied by its global warming potential, and expressed in CO_2-equivalents (CO_2e)[5]. A building's total GHG emissions are associated with the fuel consumption at the building only; any precombustion emissions associated with the energy used to extract, process, or deliver fuel to the building are not included.

Calculating Direct GHG Emissions:

For ***direct*** greenhouse gas emissions in CO_2e, each fuel is assigned a heating content, carbon content, a carbon oxidation factor, and a standard carbon to CO_2 ratio to arrive at an emissions factor expressed in mass of CO_2 per unit of fuel energy. CH_4 and N_2O emissions factors are estimates derived for each fuel type using commercial end-use sector combustion technology, characteristics, controls. Measured (billed or metered) site energy consumption is then multiplied by the following factors shown in **Table 1**.

Table 1. Direct Greenhouse Gas Emission Factors[6]

Fuel Type	kg CO_2/MBtu	kg CH_4/MBtu	kg N_2O/MBtu	kg e /MBtu
Natural Gas	53.0567	0.0052709	0.0001054	53.200036
Fuel Oil (No. 2)	73.1500	0.0105419	0.0006325	73.567457
Wood	93.8667	0.3162555	0.0042167	101.815222
Propane	63.0667	0.0105419	0.0006325	63.484124
Liquid Propane	63.1620	0.0105419	0.0006325	63.579457
Kerosene	72.3067	0.0105419	0.0006325	72.724124
Fuel Oil (No. 1)	73.1500	0.0105419	0.0006325	73.567457
Fuel Oil (No. 5 & No. 6)	78.7967	0.0105419	0.0006325	79.214124
Coal (anthracite)	103.6200	0.0105419	0.0015813	104.331575
Coal (bituminous)	93.4633	0.0105419	0.0015813	94.174908
Coke	113.6667	0.0105419	0.0015813	114.378242
Fuel Oil (No. 4)	73.1500	0.0105419	0.0006325	73.567457
Diesel	73.1500	0.0105419	0.0006325	73.567457

Calculating Indirect GHG Emissions:

Similarly, Portfolio Manager uses default emission factor values to determine ***indirect*** GHG emissions from purchased electricity or district energy. For purchased district steam, use of a default emissions factor does not require the user to obtain boiler efficiency, fuel mix, or fuel emissions factor values from their energy supplier. For purchased district chilled water, the user must obtain the chilled water production method from their energy supplier. For indirect emissions resulting from the consumption of district energy, measured site energy consumption is multiplied by the following factors shown in **Table 2**.

Table 2. Indirect Greenhouse Gas Emission Factors (District Energy)[7]

Fuel Type	kg CO_2e /MBtu
District Steam	78.95
District Chilled Water – Electric Driven Chiller	0.238095*eGRID Subregion Rate
District Chilled Water – Absorption Chiller using Natural Gas	66.50
District Chilled Water - Engine-Driven Chiller using Natural Gas	44.33

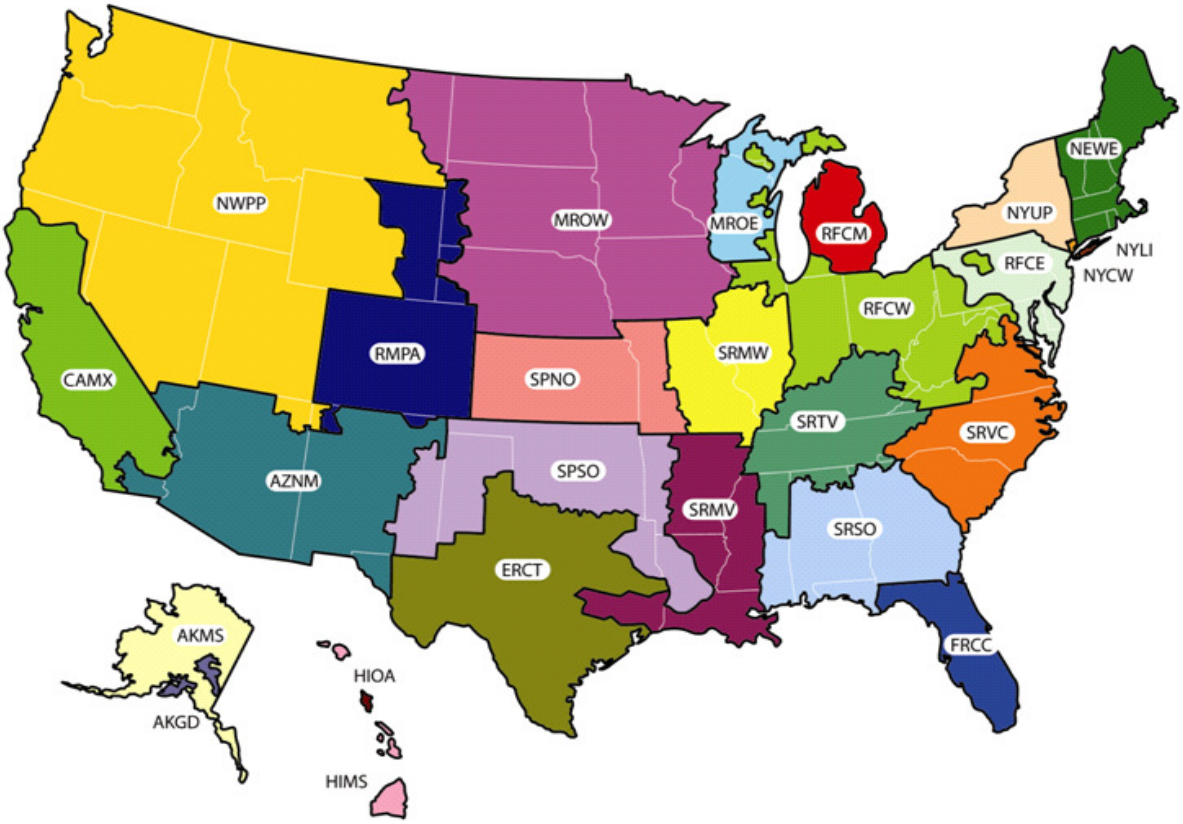
For indirect emissions resulting from the consumption of purchased electricity, site electricity consumption is multiplied by the average electricity production output emission rates of the electricity grid serving the building, according to its eGRID subregion. These factors represent the average emissions from the all grid connected electricity generation units (baseload, intermediate, and peaking), and are appropriate for developing a carbon footprint or emissions inventory. In order to estimate reductions in GHG emissions from reduced electricity use, annual non-baseload output emissions rates also available from eGRID should be used. The annual output

emissions rate factors are shown in **Table 3** and the location of these eGRID subregions are shown in **Figure 1** below.

Table 3. Indirect Emission Factors (purchased electricity)[8]

Electricity Grid by eGRID Subregion	kg CO_2/MBtu	kg CH_4/MBtu	kg N_2O/MBtu	kg CO_2e/MBtu
NEWE (New England)	110.26	0.0115	0.0023	111.1998
NYCW (New York City)	103.84	0.0048	0.0007	104.1627
NYLI (Long Island, NY)	179.92	0.0153	0.0024	180.9885
NYUP (Upstate NY)	93.01	0.0033	0.0015	93.5360
RFCE (Mid Atlantic)	145.63	0.0037	0.0023	146.4199
SRVC (Virginia/Carolina)	148.67	0.0032	0.0026	149.5563
SRTV (Tennessee Valley)	200.72	0.0027	0.0034	201.8366
SRMV(Lower Mississippi)	135.26	0.0032	0.0016	135.8106
SRSO (SE US, Gulf Coast)	196.34	0.0035	0.0034	197.4664
FRCC (Most of Florida)	168.10	0.0061	0.0023	168.9224
RFCM (Most of Michigan)	205.16	0.0045	0.0036	206.3762
RFCW (Ohio Valley)	204.32	0.0024	0.0034	205.4303
MROE (Eastern WI)	241.00	0.0037	0.0040	242.3268
SRMW (Middle Mississippi)	243.31	0.0028	0.0041	244.6227
MROW (Upper Midwest)	240.67	0.0037	0.0041	242.0177
SPNO (KS-Western MO)	260.68	0.0032	0.0043	262.0664
SPSO (TX Panhandle-OK)	220.04	0.0033	0.0030	221.0419
ERCT (Most of TX)	176.05	0.0025	0.0020	176.7271
RMPA (CO-Eastern WY)	248.61	0.0030	0.0038	249.8624
AZNM (Southwest US)	174.28	0.0023	0.0024	175.0721
NWPP (Northwest US)	119.38	0.0025	0.0020	120.0487
CAMX (Southwest Coast)	94.78	0.0040	0.0011	95.1978
HIMS (HI excluding Oahu)	188.20	0.0418	0.0062	191.0109
HIOA (Oahu Island)	230.96	0.0146	0.0031	232.2375
AKMS (Most of Alaska)	66.32	0.0028	0.0005	66.5416
AKGD (So/Central Alaska)	161.32	0.0034	0.0009	161.6548
National Average	174.61	0.0036	0.0027	175.5362

Figure 1. Electricity Grid by eGRID Subregions



Mapping a Building to an eGRID Subregion:

Given the interconnected nature of the electric transmission and distribution system and the resulting inability to identify the generation source for the electricity used, eGRID subregions were selected as a practical resolution of electricity origin to determine electricity emissions factors. An eGRID subregion, as defined by the U.S. EPA's Emissions & Generation Resource Integrated Database (eGRID), represents a portion of the U.S. power grid that is contained within a single North America Electric Reliability Council (NERC) region, which have similar emissions and resource mix characteristics, and may be partially isolated by transmission constraints. A building is located inside an eGRID subregion by mapping its zip code to its eGRID subregion. In many cases, a zip code is not confined within one eGRID subregion. In these instances, the user is asked to identify his/her electric distribution utility in order to locate that building within an eGRID subregion.[9] When a building has been mapped to an eGRID subregion, Portfolio Manager will also compare the grid fuel mix and the emissions factors for that building against the national averages. Finally, the user may also specify an individual power generation plant when the building is making a direct purchase of electricity from that plant. In some instances, a user may have a direct purchasing agreement or contract with a specific electric utility plant. The power purchase agreement specifies the terms and conditions under which electric power will be generated and purchased.

[1] Table 2-16: U.S. Greenhouse Gas Emissions by Economic Sector and Gas with Electricity-Related Emissions, from *Inventory of U.S. Greenhouse Gas and Sinks: 1990-2005*. "USEPA #430-R-07-002, April 2007.

[2] Tables 3-3, 3-14, & 3-15, from *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*.
[3] World Resources Institute and the World Business Council for Sustainable Development, *The Greenhouse Gas Protocol; A Corporate Accounting and Reporting Standard*. Revised Edition.
http://www.ghgprotocol.org/DocRoot/7e9ttsv1gVKekh7BFhqo/ghg-protocol-revised.pdf
[4] U.S. EPA's Emissions & Generation Resource Integrated Database (eGRID). eGRID2007 Version 1 contains the complete release of year 2005 data. The data are organized to reflect the owner, operator and electric grid configuration as of October 1, 2007.
www.epa.gov/cleanenergy/egrid
[5] The 100 year global warming potential (GWP) of each greenhouse gas (CO_2=1, CH_4=21, and N_2O= 310) compares the radiative forcing ability of each gas relative to CO_2, which serves as the reference gas. Intergovernmental Panel on Climate Change, Climate Change 1995: The Science of Climate Change (Cambridge, UK; Cambridge University Press, 1995),
http://www.ipcc.ch/ipccreports/assessments-reports.htm
[6] U.S. Environmental Protection Agency, Climate Leaders Program, Direct Emissions from Stationary Combustion Sources, Appendix B, May 2008. http://www.epa.gov/climateleaders/documents/resources/stationarycombustionguidance.pdf
[7] Instructions for Form EIA-1605, Voluntary Reporting of Greenhouse Gases, Energy Information Administration, Department of Energy. October 15, 2007. Appendix N; Emissions Benchmarks for Purchased Steam and Chilled/Hot Water. Values do not include transmission losses.
http://www.eia.doe.gov/oiaf/1605/pdf/EIA1605_Instructions_10-23-07.pdf
[8] U.S. EPA's Emissions & Generation Resource Integrated Database (eGRID). eGRID2007 Version 1 contains the complete release of year 2005 data. The data are organized to reflect the owner, operator and electric grid configuration as of October 1, 2007.
www.epa.gov/cleanenergy/egrid
[9] Zip code mapping accomplished through the InteliMap Inc.'s Utility Boundaries software product, also utilized by EPA's Power Profiler. Buildings located outside the continental United States are assigned the US national average emission factor.