Middlebury Institute of International Studies
Annual Greenhouse Gas Inventory
Fiscal Year 2008-2009

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Summary Data

Color Code

Annual Dependent Variable I: Factor susceptible to change that must be updated from primary sources with each inventory.
Annual Dependent Variable II: Factor susceptible to change that must be updated each fiscal year, regardless of inventory completion date.
A MIIS-specific number that will need to be updated, but not necessarily annually.
National statistical data that should be updated or checked each year.
Totals
Dynamic factors and coefficients used

Comprehensive Summary: Fiscal Year 2008-2009

Sub-Scope	**MTCDEs**		
S1S Natural Gas	240.8	**W/o travel or commute**	**599.3**
S1M Gas	6.7		
S2 Electricity	294.1		
S3 Travel	2184.6		
S3 Landfill CH4	57.7		
S3 Employee Commute	785.0		
Offsets	0.0		
Total	**2,783.9**	**With Commute**	**3,568.88**

Percent

S1S Natural Gas	8.6%	6.75%
S1M Gas	0.2%	0.19%
S2 Electricity	10.6%	8.24%
S3 Travel	78.5%	61.21%
S3 Landfill CH4	2.1%	1.62%
S3 Employee Commute		22.00%
Offsets	-	
Total	**100%**	

Sub-scope Total

MTCDEs	
Scope 1: Stationary	241
Scope 1: Mobile	7
Scope 2: Electricity	294
Scope 3: Travel	2,185
Scope 3: Landfill CH4	58
Scope 3: Employee Commute	
Total	**2,783.9**

Percent

S1S	9%

S1M	0%
S2	11%
S3 Trav	78%
S3 LF CH4	2%
S3 Commute	0%
Total	**100%**

Scope Total

MTCDEs	
Scope 1	248
Scope 2	294
Scope 3	3,027
Total	**3,568.9**
Percent	
Scope 1	7%
Scope 2	8%
Scope 3	85%
Total	**100%**

MTCDEs by gas

GHG	**MTCDE**
CO2	2363.5
CH4	70.7
N2O	156.0
Total	**2590.2**
Percent	
CO2	91.2%
CH4	2.7%
N2O	6.0%
Total	**100.0%**

Symbols and Glossary

Symbols Indicating Data Provider

*	Collected annually by Sustainability Graduate Assistant from the PG&E bills. Access given by Barbara Burke. [RB & CS 09]
†	Collected annually from receipts of campus vehicle provided by accounting. Information received from Barbara Burke. [CS & RB 09]
‡	On campus solar
□	Collected annually by the Sustainability Graduate Student. Estimated from travel numbers provided by accounting. Information received from Barbara Burke. [NB 08] (We are currently developing a new system of data collection for this.)
▲	Collected annually by Sustainability Graduate Assistant from Waste management bills. [NB 08]
∞	Collected annually by Sustainability Graduate Assistant from Facilities. Information received from Barbara Burke [NB 08]
●	Calculated from employee zip codes, percentage of full-time and part-time employees, number of working days, and average number of vacation days. Information provided by Barbara Burke [NL 10]

Glossary

BBL	Barrels of liquid hydrocarbons
BTU (British Thermal Unit)	The amount of heat required to increase the temperature of a pint of water (which weighs exactly sixteen ounces) by one degree Fahrenheit. For example, 3412.14 BTUs = 1 kWh, and 1 BTU = 1,055.06 joules. One Million BTU's can be expressed as MBTU or MMBTU. Middlebury College facilities publications typically use MMBTU to express this quantity.
CCC (Carbon Content Coefficient)	The mass to energy ratio of a fuel source. i.e., the mass of carbon atoms per million BTU's (MMBTU or MBTU).
EF (Emissions Factor)	General name for conversion factors that are calculated experimentally and can change over time. These need to be updated regularly for the monitoring and reporting system to retain its accuracy.
GWP (Global Warming Potential)	Value based on the amount that a given GHG contributes to Global Warming. All GWP's are typically based on a 100-year time horizon, which is somewhat putative, given the 5–200-year atmospheric life span of a CO2 molecule (IPCC, 2001, "Observed Changes in Globally Well-Mixed Greenhouse Gas Concentrations and Radiative Forcing." http://www.grida.no/climate/ipcc_tar/wg1/016.htm). For examples of GWP's see: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." http://www.epa.gov/nonco2/econ-inv/table.html.
GHG (Greenhouse Gas)	Greenhouse gases are gases in an atmosphere that absorb and emit radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect.
HC (Heat Content)	The amount of energy (in this case heat) contained in a given mass or volume. E.g., MMBTU/bbl. of #6 Fuel oil = 6.287 MMBTU/bbl.
Therms	100,000 BTUs
ΣMTCDE (Metric Tons of Carbon Dioxide Equivalent)	Unit of measure that is used in this GHG audit

Source: IPCC — Intergovernmental Panel on Climate Change

Scope 1, Part A: Direct Emissions from Stationary Combustion

This section includes emissions from all stationary combustion of fossil fuels purchased by the institution and combusted within the geographic and control boundaries established in the introduction.

Summary Data: Fiscal Year 2008-2009

Sources	**MTCDEs**
Natural Gas	240.8
TOTAL	**240.8**

Value/EF	
Natural Gas (therm)	39,407
MMBTUs of fuel	4,050.0
Metric Tonnes CO2	240.6
tonnes CH4	0.004
MTCDE from CH4	0.08
tonnes N2O	0.00038
MTCDE from N2O	0.12
ΣMTCDE from natural gas	**240.8**

Formulaic Numbers

Standard Coefficients	
barrels/gallon (1/42)	0.02381
tonne/gram (1/1x106)	0.000001
Tonne/kg (1/1,000)	0.001
CH4 GWP	21
N2O GWP	310

#6 Fuel Oil

MMBTU/gal #6 EF	0.1497
Tonnes CO2/gal #6 EF	0.011669382
HC (MMBTU/bbl)	6.287
CCC (kg C/ MMBTU)	21.49
Fraction Oxidized	0.99000
MW ratio (kg CO2/kg C)	3.664
CH4 EF (g gas/MMBTU)	2.00
N2O EF (g gas/MMBTU)	0.601

Natural Gas

MMBTU/therm natural gas EF	0.1027
Tonnes CO2/therm natural gas EF	0.006105
HC (MMBTU/therm)	0.1027
CCC (kg C/ MMBTU)	14.47
Fraction Oxidized	0.995
CH4 EF (g gas/MMBTU)	0.95
N2O EF (g gas/MMBTU)	0.095

Sources for Scope 1, Part A Data

This section includes emissions from all stationary combustion of fossil fuels purchased by the institution and combusted within the geographic and control boundaries established in the introduction.

Formulaic Numbers

HC (MMBTU/bbl)	Higher heating values (HHV) are used. FY01/02-FY05/06: EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 22. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [BB 07]
CCC (kg C/ MMBTU)	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 22. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [BB 07]
Fraction Oxidized	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 22. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [BB 07]
MW ratio (kg CO2/kg C)	Molecular Weights are accepted as chemical standards. Value = ((12.011+2*16.000)/12.011) [BB 07]
CH4 EF (g gas/MMBTU)	Based on HHV and residential/commercial efficiency. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 20. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [BB 07]
CH4 GWP	Global Warming Potential (GWP) based on 100 yr time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
N2O EF (g gas/MMBTU)	Based on HHV and industrial efficiency. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 20. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [BB 07]
CH4 EF (g gas/MMBTU)	Based on HHV and industrial efficiency. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 20. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [BB 07]
N2O GWP	Global Warming Potential (GWP) based on 100 yr time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
Tonne/kg (1/1,000)	Unit Conversion
Barrels/gallon (1/42)	Unit Conversion

#6 Fuel Oil

#6 Fuel Oil (gal)	Collected by Noah Lichtenstein, Clayton Snyder from the PG&E bills
MMBTU/gal #6 EF	Calculated from sourced data
Tonnes CO2/gal #6 EF	Calculated from sourced data

#2 Fuel Oil / Off Road Diesel

Straight #2 Fuel Oil (gal)	Collected by Clayton Snyder and Noah Lichtenstein from the PG&E bills
B-5 Bioheat (gal)	N/A
B-20 Bioheat (gal)	N/A
Off-Road Diesel (inc. blends)	N/A
MMBTU/gal #2 EF	Calculated from sourced data
Tonnes CO2/gal #2 EF	Calculated from sourced data

Propane

Propane (gal)	N/A
MMBTU/gal propane EF	Calculated from sourced data
Tonnes CO2/gal propane EF	Calculated from sourced data

Notes on Source Reproduction

For #6, #2, and Diesel:

HC values were originally published in U.S. Department of Energy, Energy Information Administration. 2003. "Annual Energy Review 2002," DOE/EIA 0384(2002), Washington, DC, October 2003.

Carbon Content Coefficients and Fractions Oxidized were found in US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.

For Propane:

HC and Carbon Content Coefficients values were originally published in Guthrie, V.B. (ed.). 1960 Characteristics of Compounds, Petroleum Products Handbook. New York, NY: McGraw Hill. pp 3.

Carbon Content Coefficient values and Fractions Oxidized were calculated based on the findings of US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.

Scope 1, Part B: Direct Emissions from Mobile Combustion

This section includes emissions from all mobile combustion of fossil fuels purchased by the institution combusted within all vehicles owned and controlled by the institution as established in the introduction.

Summary Data: Fiscal Year 2008-2009

Sources	**MTCDEs**
Gas	6.7
TOTAL	**6.70**

Gasoline Fueled Vehicles

ΣScope 1Gas = campus gas + off campus gas

Factors determining off campus gas calculations:	
Car tank size (gal)	19.5
Car average miles/gal	20.0
15/11-pass. van tank size (gal)	0.0
15/11-pass. van average miles/gal	0.0
Mini-van tank size (gal)	0.0
Mini-van average miles/gal	0.0
Off Campus Gasoline (gal) †	672.0
Σ Scope 1 Gas (gal)	672
MMBTUs of fuel	84.0
Metric Tonnes CO2	5.9
Putative Vehicle mi/gal	23.0
Gas Vehicle Activity miles	15,456
tonnes CH4	0.003
MTCDE from CH4	0.06
tonnes N2O	0.002
MTCDE from N2O	0.7
ΣMTCDE from Gasoline	**6.7**

Formulaic Numbers

Standard Coefficients	
Barrels/gallon (1/42)	0.02381
Tonne/kg (1/1,000)	0.001
Tonne/gram (1/1x106)	0.000001
CH4 GWP	21
N2O GWP	310

Gasoline Fueled Vehicles

MMBTU/gal gas EF	0.1251
Tonnes CO2/gal gas EF	0.009
CH4 EF (g gas/mile)	0.1984
N2O EF (g gas/mile)	0.1517
HC (MMBTU/bbl)	5.253
CCC (kg C/ MMBTU)	19.34

Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664

Diesel Fueled Vehicles

MMBTU/gal diesel EF	0.1387
Tonnes CO2/gal diesel EF	0.0100371
CH4 EF (g gas/mile)	0.0966
N2O EF (g gas/mile)	0.0483
HC (MMBTU/bbl)	5.825
CCC (kg C/ MMBTU)	19.95
Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664

Sources for Scope 1, Part B Data

This section includes emissions from all mobile combustion of fossil fuels purchased by the institution combusted within all vehicles owned and controlled by the institution as established in the introduction.

Formulaic Numbers

HC (MMBTU/bbl)	Higher heating values (HHV) are used. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [BB 07]
CCC (kg C/ MMBTU)	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [BB 07]
Fraction Oxidized	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [BB 07]
MW ratio (kg CO2/kg C)	Molecular Weights are accepted as chemical standards. Value = ((12.011+2*16.000)/12.011) [BB 07]
CH4 EF (g gas/MMBTU)	Based on 1985-1986 EFs for heavy duty vehicles (most conservative values). EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 9. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [BB 07]
CH4 GWP	Global Warming Potential (GWP) based on 100-year time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
N2O EF (g gas/MMBTU)	Based on 1996 EFs for heavy duty vehicles (most conservative values). EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 9. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [BB 07]
N2O GWP	Global Warming Potential (GWP) based on 100-year time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
barrels/gallon (1/42)	Unit Conversion
Tonne/kg (1/1,000)	Unit Conversion

Gasoline Fueled Vehicles

ΣScope 1Gas = campus gas + off campus gas

Factors determining off campus gas calculations:	
Truck tank size (gal)	2005-2007 Toyota Camrys used as case studies (6 cyl 3 L): <http://www.fueleconomy.gov/feg/noframes/20932.shtml> Estimated by the number given by Middlebury [NB 08]
Truck avg miles/gal	Given to us from Facilities [NB 08]
15/11-pass. van tank size (gal)	N/A
15/11-pass. van ave miles/gal	N/A
Mini-van tank size (gal)	N/A
Mini-van ave miles/gal	N/A
Off Campus Gasoline (gal)	Calculated from number of gallons purchased on the Union 76 card. $2016 spent on gasoline divided by average of $3/gal gas. Given by Barbara Burke [NL 10]
On- Campus Gasoline (gal)	N/A
MMBTU/gal gas EF	Calculated from sourced data
Tonnes CO2/gal gas EF	Calculated from sourced data

Putative Vehicle mi/gal	2005-07 Toyota Camrys used as case studies (6 cyl 3 L): <http://www.fueleconomy.gov/feg/noframes/20932.shtml> Estimated from the Middlebury numbers [NB 08]
Gas Vehicle Activity miles	Calculated from sourced data

Diesel Fueled Vehicles

Straight on-road diesel (gal)	I removed this from the calculation because MIIS does not own a diesel fueled vehicle [NB08]
B-5 Biodiesel (gal)	N/A
B-20 Biodiesel (gal)	N/A
MMBTU/gal diesel EF	Calculated from sourced data
Tonnes CO2/gal diesel EF	Calculated from sourced data
Putative Vehicle mi/gal	N/A
Gas Vehicle Activity miles	Calculated from sourced data

Notes on Source Reproduction

Methane and Nitrous oxide EFs are based on highway vehicle EFs taken directly from US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004, as are CCC's and FO factors. FO values of .99 are also recommended by IPCC guidelines.

For #6, #2, and Diesel:

HC values were originally published in U.S. Department of Energy, Energy Information Administration. 2003. "Annual Energy Review 2002," DOE/EIA 0384(2002), , Washington, DC, October 2003.

Carbon Content Coefficients and Fractions Oxidized were found in US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.

For Propane:

HC and Carbon Content Coefficients values were originally published in Guthrie, V.B. (ed.). 1960 Characteristics of Compounds, Petroleum Products Handbook. New York, NY: McGraw Hill. pp 3.

Carbon Content Coefficient values and Fractions Oxidized were calculated based on the findings of US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.

Scope 2: Indirect Emissions from Electricity Purchases

This section includes emissions from all stationary combustion of fossil fuels done in direct proportion to an energy source purchased by the institution, i.e., purchased electricity and steam generated outside the geographic/control boundaries set in the introduction, yet consumed within them.

Summary Data: Fiscal Year 2008-2009

Source	MTCDEs
ΣMTCDE from Natural Gas	277.50
ΣMTCDE from Coal	16.59
ΣMTCDE from Electricity Use	**294.08**

kWh Used by On-Campus Sources

Value/EF	
On-campus solar kWh ‡	2,014
Total kWh from PG&E *	1,332,876
Total kWh used w/in boundaries	**1334890**

PG&E Sources as Percents

% Biomass	4.00
% Large Hydro	16.00
% Nuclear	20.00
% Natural Gas	47.00
% Coal	2.00
% Geothermal	4.00*
% Small Hydo	4.00**
% Wind	3.00
% Solar	1.00
% Other	1.00
Total	102***

MIIS Net kWh by Source

Solar	15,343
Biomass	53,315
Large Hydro	213,260
Nuclear	266,575
Natural Gas	626,452
Coal	26,658
Geothermal	53,315
Small Hydro	53,315
Wind	39,986
Other	13,329
Total kWh:	**1,361,548****

MIIS Electricity Sources by Percent

Solar	1.1%

Biomass	3.9%
Hydro	15.7%
Nuclear	19.6%
Natural Gas	46.0%
Coal	2.0%
Geothermal	3.9%
Small Hydro	3.9%
Wind	2.9%
Other	1.0%
Total:	**100.0%**

*% #1, 2, & 4 Fuel Oil

**% #5 & 6 Fuel Oil

***More than one hundred due to rounding conventions

**** Larger than in-boundary kWh b/c of PG&E rounding conventions

CO2 Emissions Calculations: Natural Gas

Value/EF	Total	Units	Notes
kWh from Natural Gas	626,452		
MMBTUs of electricity	2,137.5		
Metric Tonnes CO2	274.4		
tonnes CH4	0.00203		
MTCDE from CH4	0.043		
tonnes N2O	0.00020		
MTCDE from N2O	0.063		
ΣMTCDE from Natural Gas Excluding Losses	274.5		

Accounting for Losses (Natural Gas)

Value/EF	Total	Units	Notes
kWh consumed at MIIS from Natural Gas	626,452		
T&D loss factor	1.10%		from PG&E
kWh at generator	633,318		
Generation efficiency (heat rate)	8250	Btu/kWh	PG&E avg
MBtu natural gas consumed at generator	5225	MBtu	
Metric Tonnes CO2	277.24	tonnes	CO2
tonnes CH4	0.00496	tonnes	CH4
MTCDE from CH4	0.104	tonnes	CO2-eq
tonnes N2O	0.00050	tonnes	N2O
MTCDE from N2O	0.15387	tonnes	CO2-eq
ΣMTCDE from Natural Gas	277.50	tonnes	CO2-eq

CO2 Emissions Calculations: Coal

Value/EF	Total	Units	Notes
kWh from Coal	26,658		
MMBTUs of electricity	91.0		
Metric Tonnes CO2	29.3		
tonnes CH4	0.00009		
MTCDE from CH4	0.002		

tonnes N2O	0.00013		
MTCDE from N2O	0.039494		
ΣMTCDE from Coal Excluding Losses	29.3		

Accounting for Losses (Coal)

Value/EF	Total	Units	Notes
kWh consumed at MIIS from Coal	26,658	kWh	
T&D loss factor	1.10%		from PG&E
kWh at generator	26,950	kWh	
Generation efficiency (heat rate)	11,500	Btu/kWh	PG&E avg
MBtu natural gas consumed at generator	310	MBtu	
Metric Tonnes CO2	16.44	tonnes	CO2
Tonnes CH4	0.00029	tonnes	CH4
MTCDE from CH4	0.006	tonnes	CO2-eq
Tonnes N2O	0.00043	tonnes	N2O
MTCDE from N2O	0.13451	tonnes	CO2-eq
ΣMTCDE from Coal	16.59	tonnes	CO2-eq
ΣMTCDE from Electricity Use	294.08	tonnes	CO2-eq

MTCDEs by Electricity Source

Solar	0
Biomass	0
Hydro	0
Nuclear	0
Natural Gas	277
Coal	17
Geothermal	0
Small Hydro	0
Wind	0
ΣMTCDE from electricity:	**294**

MTCDE Sources by Percent

Solar	0%
Biomass	0%
Hydro	0%
Nuclear	0%
Natural Gas	94%
Coal	6%
Geothermal	0%
Small Hydro	0%
Wind	0%
Should be 100%	100%

Formulaic Numbers

Standard Coefficients	
MWh/kWh (1/1000)	0.001
MMBTU/kWh	0.003412

Tonne/kg (1/1,000)	0.001
Tonne/gram (1/1x106)	0.000001
Tonne/lb (1/2,204.6)	0.000454
CH4 GWP	21
N2O GWP	310

Natural Gas

Tonnes CO2/kWh NG EF	0.000438
lbs CO2/MMBtu	117
CH4 EF (g gas/MMBTU)	0.95
N2O EF (g gas/MMBTU)	0.095
CCC (kg C/ MMBTU)	14.47
Fraction Oxidized	0.995
MW ratio (kg CO2/kg C)	3.664

Coal

Tonnes CO2/kWh Coal EF	0.001100
lbs CO2/MMBtu	210
CH4 EF (g gas/MMBTU)	1.00
N2O EF (g gas/MMBTU)	1.40
CCC (kg C/ MMBTU)	25.49
Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664

Sources for Scope 2 Data

This section includes emissions from all stationary combustion of fossil fuels done in direct proportion to an energy source purchased by the institution, i.e., purchased electricity and steam generated outside the geographic/control boundaries set in the introduction, yet consumed within them.

Formulaic Numbers

CCC (kg C/ MMBTU)	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 22. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [JK 06]
Fraction Oxidized	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 22. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [JK 06]
MW ratio (kg CO2/kg C)	Molecular Weights are accepted as chemical standards. Value = ((12.011+2*16.000)/12.011) [JK 06]
CH4 EF (g gas/MMBTU)	Based on HHV and residential/commercial efficiency. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 20. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [JK 06]
CH4 GWP	Global Warming Potential (GWP) based on 100 yr time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
N2O EF (g gas/MMBTU)	Based on HHV and industrial efficiency. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 20. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [JK 06]
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MWh/kWh (1/1000)	Unit Conversion
MMBTU/kWh	Unit Conversion
Tonne/gram (1/1x106)	Unit Conversion
Tonne/lb. (1/2,204.6)	Unit Conversion
Tonne/kg (1/1,000)	Unit Conversion

Calculating kWH of Carbon Emitting Electricity Sources

Total kWh from PG&E	Collected Annually from PG&E bills [NB 08]
PG&E kWh from CH4 dig.	N/A [NB 08]
on-campus co-gen kWH	N/A [NB 08]
on-campus wind kWH	N/A [RB 09]
on-campus solar kWH	.converter reading on 4/30/10: 16,561 kWh since installation on 9/22/2001 Solar -18575 = Approximate FY09-10 kWh generated = kWh / year since installation [kWh] NL 10 2014=16561

PG&E Sources as Percents

% Coal	http://www.pge.com/myhome/myaccount/explanationofbill/billinserts/previous/2009/feb.shtml [RB 09] *Spoke to PG&E rep, this info is most recent as of 7/21/09
% Large Hydro	Same as above
% Natural Gas	Same as above
% Nuclear	Same as above
% Biomass	Same as above

% Geothermal	Same as above
% Small Hydro	Same as above
% Solar	Same as above
% Wind	Same as above
% Other	Same as above

Natural Gas	Tonnes CO2/kWh NG EF	Calculated from sourced data
Coal	Tonnes CO2/kWh Coal EF	Calculated from sourced data
#1, 2, & 4 Fuel Oil	Tonnes CO2/kWh Dis Oil EF	Calculated from sourced data
#5 & 6 Fuel Oil	Tonnes CO2/kWh Res Oil EF	Calculated from sourced data

Notes on Source Reproduction

For Natural Gas #6, #2, and Diesel:

HC values were originally published in U.S. Department of Energy, Energy Information Administration. 2003. “Annual Energy Review 2002,” DOE/EIA 0384(2002), , Washington, DC, October 2003.

Carbon Content Coefficients and Fractions Oxidized were found in US EPA. 2004. “Inventory of U.S. Greenhouse Gas Emissions and Sinks:” 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.

For Coal:

Carbon Content Coefficients and HC were found in DOE/EIA. 2002. "Documentation for Emissions of Greenhouse Gasses in the United States 2002," DOE/EIA-0638(2002), Energy Information Administration, Office of Integrated Analysis and Forecasting, U.S. Department of Energy, January 2004.

Fractions Oxidized were found in U.S. Department of Energy, Energy Information Administration. 2003. “Annual Energy Review 2002,” DOE/EIA 0384(2002), , Washington, DC, October 2003.

**Jim Williams strongly recommended that we add conversion efficiency and transmission losses to our calculations for the electricity. Instead of replacing the original formula from Middlebury, Professor William's calculations are found on the previous sheet. The numbers calculated from his formulas are tied to our final GHG number [NB 08]

Scope 3, Part A: Indirect Emissions from Outsourced Travel

This section includes emissions from all mobile combustion of fossil fuels used in vehicles not owned by the institution, but whose services are directly solicited by the institution.

Summary Data: Fiscal Year 2008-2009

Total Amount Spent on Travel		
Type of Expenditure	**% of Total**	**Amount ($)**
Rental Cars	10.00%	118,900
Gasoline	15.00%	178,350
Taxis	5.00%	59,450
Bus	0.00%	0
Airplanes	30.00%	356,700
Trains	0.00%	0
Conference Fees	15.00%	178,350
Lodging	25.00%	297,250
Total	**100.00%**	**1,189,000**

Sources	**MTCDEs**	**Percentage**
Rental Cars	434.08	19.87%
Gasoline	651.1	29.8%
Taxis	7.6	0.3%
Bus	0	0.0%
Airplanes	1,091.8	50.0%
Trains	0.0	0.0%
TOTAL:	**2,185**	**100.0%**

Gasoline and Rental Cars

Value/EF	
Total Reimbursement $	$297,250*
Annual avg cents/gal	258.7**
Total Reimbursement Gas (gal)	114,901
MMBTUs of fuel	14,370.9
Metric Tonnes CO2	1,008.2
Putative Vehicle mi/gal	20.0
Gas Vehicle Activity miles	2,298,029
tonnes CH4	0.263
MTCDE from CH4	5.52
tonnes N2O	0.230
MTCDE from N2O	71.5
ΣMTCDE from Mile Reimb.	**1,085.2**

*15% of Total Travel for Gasoline Reimbursement + 10% of Travel for Car Rental

**316.85 - Number Used by Billy Borden and in previous audits

Taxi Emissions (Gasoline)

Value/EF	
Total Taxi $	$59,450

Average $/person	$25.00
Average people/trip	6
Average $/trip	$25
Mode trip distance (mi)	5
Total Taxi Miles	11,890
Van mi/gal	15
Total Taxi Gas (gal)	793
MMBTUs of fuel	99.1
Metric Tonnes CO2	7.0
tonnes CH4	0.002
MTCDE from CH4	0.05
tonnes N2O	0.002
MTCDE from N2O	0.6
ΣMTCDE from Taxi Gasoline	**7.6**

Bus Emissions (Diesel)

Value/EF	
Total Bus $ □	$0*
Mode Bus Size (by capacity)	$55
Base hourly fee ($/hr)	$101
Live Mile charge/mile ($/mi)	$3.55
Dead Mile charge/mile ($/mi)	$3.55
High Emissions/$ Scenario: Midd=>Colby for a 4 Hour Event	
Live Speed	56.18
Dead Speed	40.43
Total Cost	$4,129
Total Gal Diesel Combusted	99.6
Gal/$ Given the High Em. Scenario	0.0241
Total diesel (gal)	0
MMBTUs of fuel	0.0
Metric Tonnes CO2	**0.0**
Gas Vehicle Activity miles	0
tonnes CH4	0.000
MTCDE from CH4	**0.000**
tonnes N2O	0.000
MTCDE from N2O	**0.00**
ΣMTCDE from Bus Travel:	**0.0**

*0% of Misc. Travel

Air Travel Emissions

Value/EF	
Total Airline $ □	$356,700
% of $ spent on dom travel □	20%
San Jose to LAX RT price	$220
San Jose to LAX RT miles	388
San Jose to LAX $/pass-mile	$0.567
SFO to Burlington RT price	$388

SFO to Burlington RT miles	3,043
SFO to Burlington $/pass-mile	$0.127
SFO to Tokyo price	$1,075
SFO to Tokyo miles	5,180
SFO to Tokyo $/pass-mile	$0.208
Domestic $/passenger mi	$0.347
International $/passenger mi	$0.208
Domestic passenger mi	210,000
International passenger mi	1,380,000
Total Passenger mi	1,590,000
Dom BTU jet fuel/pass. mi.	3,098
Int BTU jet fuel/pass. mi.	3,691
MMBTU/airfare $ EF	0.0161
Tonnes CO2/airfare $ EF	0.0011
MMBTUs of fuel	5,744.2
Metric Tonnes CO2	402.8
Radiative Forcing Index (RFI)	2.7
MTCDEs Adj. for RFI	1,087.6
Gallons of Jet Fuel Consumed	42,550
tonnes CH4	0.011
MTCDE from CH4	0.23
tonnes N2O	0.013
MTCDE from N2O	4.0
ΣMTCDE from Air Travel:	**1,091.8**

Train Travel Emissions (Assume diesel fueled trains)

Value/EF	
Total Train $ □	$0*
Salinas to San Franscisco RT price	$14
Salinas to San Francisco RT mileage	106.0
Burlington to St. Albans $/pass-mi	$0.132
Salinas. to LA RT price	$100
Salinas. to LA RT mileage	304.7
Burl. to NYC $/pass-mi	$0.328
Burl. to DC RT price	$142
Burl. to DC RT mileage	1,052.0
Burl. to Washington DC $/pass-mi	$0.135
Average $/passenger-mile	$0.198
Total train passenger -miles	1
Amtrak BTU/pass. mi.	2,100
MMBTU/airfare $ EF	0
Tonnes CO2/train $ EF	0
MMBTUs of fuel	0.0
Metric Tonnes CO2	0.0
Gallons of Diesel Fuel Consumed	0
MTCDE from CH4	0.000
Tonnes N2O	0.00000

MTCDE from N2O	0.000
ΣMTCDE from Train Travel:	**0.0**

*0% of Misc Travel

Formulaic Numbers

Standard Coefficients	
MMBTU/BTU (1/1 million)	0.000001
barrels/gallon (1/42)	0.02381
Tonne/kg (1/1,000)	0.0
tonne/gram (1/1x106)	0.000001
US Dollars/cent (1/100)	0.01
kg/tonne (1,000/1)	1,000
CH4 GWP	21
N2O GWP	310

Mileage Reimbursement for use of Personal and Rental Cars (Gasoline)

MMBTU/gal gas EF	0.1251
Tonnes CO2/gal gas EF	0.008774691
CH4 EF (g gas/mile)	0.1143
N2O EF (g gas/mile)	0.1003
HC (MMBTU/bbl)	5.253
CCC (kg C/ MMBTU)	19.34
Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664

Taxi Emissions (Gasoline)

MMBTU/gal gas EF	0.1251
Tonnes CO2/gal gas EF	0.008774691
CH4 EF (g gas/mile)	0.1984
N2O EF (g gas/mile)	0.1517
HC (MMBTU/bbl)	5.253
CCC (kg C/ MMBTU)	19.34
Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664

Bus Emissions (Diesel)

MMBTU/gal diesel EF	0.1387
Tonnes CO2/gal diesel EF	0.01004
CH4 EF (g gas/mile)	0.0966
N2O EF (g gas/mile)	0.0483
HC (MMBTU/bbl)	5.8
CCC (kg C/ MMBTU)	19.95
Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664
Live RT Distance (mi)	618
Dead RT Distance (mi)	69

Live Time (hr)	11.00
Dead Time (hr)	1.72
Stationary Time (hr)	4.00
Gallons per Mile (diesel)	0.1449
Bus Miles per Gal	6.90

Air Travel Emissions

CH4 EF (g gas/kg fuel)	0.087
N2O EF (g gas/kg fuel)	0.10
HC (MMBTU/bbl)	5.670
CCC (kg C/ MMBTU)	19.33
Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664
Jet Fuel Density (tonne/bbl)	0.126

Train Travel Emissions (Assume diesel fueled trains)

Fuel Density (kg/gal)	3.19
CH4 EF (g gas/kg fuel)	0.25
N2O EF (g gas/kg fuel)	0.08
HC (MMBTU/bbll)	5.825
CCC (kg C/ MMBTU)	19.33
Fraction Oxidized	1
MW ratio (kg CO2/kg C)	3.664

Sources for Scope 3, Part A Data

This section includes emissions from all mobile combustion of fossil fuels used in vehicles not owned by the institution, but whose services are directly solicited by the institution.

Formulaic Numbers

HC (MMBTU/bbl)	Higher heating values (HHV) are used. FY01/02-FY05/06: EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 22. <http://www.epa.gov/climateleaders/docs/stationarycombustionguidance.pdf > [JK 06]
CCC (kg C/ MMBTU)	Higher heating values (HHV) are used. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [JK 06]
Fraction Oxidized	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [BB 07]
MW ratio (kg CO2/kg C)	Molecular Weights are accepted as chemical standards. Value = ((12.011+2*16.000)/12.011) [BB 07]
CH4 EF (g gas/MMBTU)	Based on 1987-1993 EFs for vans, pickups, and SUVs (most conservative light-duty values),1985-1986 EFs for heavy duty vehicles (most conservative values), 1966-1982 EFs for heavy duty vehicles (most conservative values), values for locomotive diesel fuel. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." p 9 and 25. http://www.epa.gov/climateleaders/docs/mobilesourceguid, and Jet Fuel Specific EFs. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 (April 2003) EPA 430-R-03-004; Annex E [JK 06]
CH4 GWP	Global Warming Potential (GWP) based on 100-year time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
N2O EF (g gas/MMBTU)	Based on 1987-1993 EFs for vans, pickups, and SUVs (most conservative light-duty values),1985-1986 EFs for heavy duty vehicles (most conservative values), 1966-1982 EFs for heavy duty vehicles (most conservative values), values for locomotive diesel fuel. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." p 9 and 25. http://www.epa.gov/climateleaders/docs/mobilesourceguid, and Jet Fuel Specific EFs. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 (April 2003) EPA 430-R-03-004; Annex E [JK 06]
N2O GWP	Global Warming Potential (GWP) based on 100 yr time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
N2O EF (g gas/mile)	Based on 1987-1993 EFs for vans, pickups, and SUVs (most conservative light-duty values),1985-1986 EFs for heavy duty vehicles (most conservative values), 1966-1982 EFs for heavy duty vehicles (most conservative values), values for locomotive diesel fuel. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." p 9 and 25. http://www.epa.gov/climateleaders/docs/mobilesourceguid, and Jet Fuel Specific EFs. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 (April 2003) EPA 430-R-03-004; Annex E [JK 06]
CH4 EF (g gas/mile)	Based on 1987-1993 EFs for vans, pickups, and SUVs (most conservative light-duty values). EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." p 9. http://www.epa.gov/climateleaders/docs/mobilesourceguid [JK 06]

barrels/gallon (1/42)	Unit Conversion
US Dollars/cent (1/100)	Unit Conversion
Tonne/kg (1/1,000)	Unit Conversion
tonne/gram (1/1x106)	Unit Conversion
Bus Miles per Gal	Calculated from sourced data
Bus mi/gal	See Above
MMBTU/BTU (1/1 million)	Unit Conversion

Milage Reimbursement for use of Personal and Rental Cars (Gasoline)

Value/EF	**Sources**
Total Reimbursement $	Total travel expenditure given by Barbara Burke [NL 10]
Annual average cents/gal	U.S. Department of Energy, Energy Information Administration. "WHAT WE PAY FOR IN A GALLON OF REGULAR GASOLINE", http://www.eia.gov/oog/info/gdu/gaspump.html, site last updated 04/10/10. [NL 10]
Total Reimbursement Gas (gal)	Calculated from sourced data
MMBTU/gal gas EF	Calculated from sourced data
Tonnes CO2/gal gas EF	Calculated from sourced data
Putative Vehicle mi/gal	Mileage rate used by Monterey Institute of International Studies in determining $ reimbursements. Taken From Middlebury College CCAL Gas Mileage Chart by Charlotte Chase. [JK 06]
Gas Vehicle Activity miles	Calculated from sourced data

Taxi Emissions (Gasoline)

Value/EF	**Sources**
Total Taxi $	Estimated as 5% of Total travel, from Barbara Burke (CS & RB 09)
Average $/person	Totally Estimated [NB 2008]
Average people/trip	Totally Estimated [NB 2008]
Average $/trip	Totally Estimated [NB 2008]
Mode trip distance (mi)	
Total Taxi Miles	Calculated from sourced data
Van mi/gal	N/A [NB 08]
Tot Taxi Gas (gal)	Calculated from sourced data
MMBTU/gal gas EF	Calculated from sourced data
Tonnes CO2/gal gas EF	Calculated from sourced data

Bus Emissions (Diesel)

Value/EF	**Sources**
Total Bus $	Estimated as 0% of Total travel, from Barbara Burke (CS & RB 09)
Mode Bus Size (by capacity)	N/A [NB 08]
Base hourly fee ($/hr)	N/A [NB 08]
Live Mile charge/mile ($/mi)	N/A [NB 08]
Dead Mile charge/mile ($/mi)	N/A [NB 08]
Gallons per Mile (diesel)	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 12. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [BB 07]
Live RT Distance (mi)	MapQuest Queries End point: 460 Pierce Street, Monterey, CA 93940: <http://www.mapquest.com/directions/main.adp?bCTsettings=1>

Dead RT Distance (mi)	MapQuest Queries End point:460 Pierce Street, Monterey, CA 93940: <http://www.mapquest.com/directions/main.adp?bCTsettings=1>
Live Time (hour)	MapQuest Queries End point: 460 Pierce Street, Monterey, CA 93940: <http://www.mapquest.com/directions/main.adp?bCTsettings=1>
Dead Time (hr)	MapQuest Queries by End point: 460 Pierce Street, Monterey, CA 93940: <http://www.mapquest.com/directions/main.adp?bCTsettings=1>
Stationary Time (hr)	Putatively small in order to remain conservative
Live Speed	Calculated from sourced data
Dead Speed	Calculated from sourced data
Total Cost	Calculated from sourced data
Total Gal Diesel Combusted	Calculated from sourced data
Gal/$ Given the High Em. Scenario	Calculated from sourced data
MMBTU/gal diesel EF	Calculated from sourced data
Tonnes CO2/gal diesel EF	Calculated from sourced data
Gas Vehicle Activity miles	Calculated from sourced data

Air Travel Emissions

Value/EF	**Sources**
Total Airline $	Estimated as 30% of Total travel, from Barbara Burke (CS & RB 09)
% of $ spent on dom travel	Estimated by Natalie Berland confirmed by Jim Williams [NB 08]
San Jose to LAX RT price	Average price of non-weekend travel and weekend travel two months from booking date <www.kayak.com> [NL]
San Jose to LAX RT milage	Mileage data collected via MapQuest <http://www.mapquest.com> [NB 08]
SFO to Burlington RT price	Average price of non-weekend travel and weekend travel two months from booking date <www.kayak.com> [NL]
SFO to Burlington RT milage	Mileage data collected via MapQuest <http://www.mapquest.com> [NB 08]
SFO to Tokyo RT price	Average price of non-weekend travel and weekend travel two months from booking date <www.kayak.com> [NL]
SFO to Tokyo RT milage	Mileage data collected via MapQuest <http://www.mapcrow.info/> [NB 08]
Dom BTU jet fuel/pass. mi.	Energy Intensity of Passenger Modes (BTU per passenger miles), Bureau of Transportation Statistics, National Transportation Statistics 2007, (Table 4-20), pp 286: <http://www.bts.gov/publications/national_transportation_statistics/pdf/entire.pdf> [BB 07]
Int BTU jet fuel/pass. mi.	Energy Intensity of Passenger Modes (BTU per passenger miles), Bureau of Transportation Statistics, National Transportation Statistics 2007, (Table 4-20), pp 286: http://www.bts.gov/publications/national_transportation_statistics/pdf/entire.pdf [BB 07]
MMBTU/airfare $ EF	Calculated from sourced data (given the % domestic travel given)
Tonnes CO2/airfare $ EF	Calculated from sourced data (given the % domestic travel given)
Radiative Forcing Index (RFI)	1992 Global RFI as set by the IPCC. This is one of the more concrete RFI numbers in circulation and is higher than that used by Native Energy and the Carbon Exchange. <http://www.grida.no/climate/ipcc/aviation/064.htm> [BB 07] "In 1992, the RFI for aircraft is 2.7; it evolves to 2.6 in 2050 for the Fa1 scenario."

Train Travel Emissions (Assume diesel fueled trains)

Value/EF	**Sources**
Total Train $	Estimated as 0% of Total travel, from Barbara Burke (CS & RB 09)
Short Haul Price	Price of non-weekend travel 2 months from booking date <http://www.orbitz.com>
Short Haul Mileage	Mileage data collected via MapQuest <http://www.mapquest.com>

Medium Haul Price	Price of non-weekend travel 2 months from booking date <http://www.orbitz.com>
Medium Haul Mileage	Mileage data collected via MapQuest <http://www.mapquest.com>
Long Haul Price	Price of non-weekend travel 2 months from booking date <http://www.orbitz.com>
Long Haul Mileage	Mileage data collected via MapQuest <http://www.mapquest.com>
Amtrack BTU/pass. mi.	Energy Intensity of Passenger Modes (BTU per passenger miles), Bureau of Transportation Statistics, National Transportation Statistics 2007, (Table 4-20), pp 286: <http://www.bts.gov/publications/national_transportation_statistics/pdf/entire.pdf> [BB 07]
MMBTU/airfare $ EF	Calculated from sourced data (given the % domestic travel given)
Tonnes CO2/airfare $ EF	Calculated from sourced data (given the % domestic travel given)

Notes on Source Reproduction

Methane and Nitrous oxide EFs are based on highway vehicle EFs that were taken directly from US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004, as were CCC's and FO factors. FO values of .99 are also recommended by IPCC guidelines.

Miscellaneous Travel Estimates

30%	Airfare
15%	Lodging
15%	Gas
5%	Taxi
25%	Conference fees
10%	Car rental

Scope 3, Part B: Indirect Emissions from Landfill Waste

This section includes emissions from methane produced by the institutional waste stream.

Primary Assumption: That the institution is responsible for the lifetime effect of the methane emitted during the reporting period during that reporting period only.

Summary Data: Fiscal Year 2008-2009

Source	MTCDEs
MTCDEs from Landfill CH4	**57.70**

Assessing the Split Between Landfills

Value/EF	
Total Solid Waste (lbs.) ▲	94,146
% Taken to MRWMD	100%
MRWMD Landfill Emissions	
Straight Landfill	25.0%
CH4 Recovery/Flaring w/o LFGE? (%)	0.0%
Electricity Generation (%)	75.0%
Short Tons Solid Waste	47.07
CH4 EF (tonnes gas/ton waste)	0.058
Tonnes MRWMD LF CH4	2.75

Net Methane + Emissions Factor Calculations

Value/EF	
CH4 EF w/out Recovery (MTCE/ton)	0.52
CH4 EF w/ Recovery (MTCE/ton)	0.40
CH4 EF w/ LFGE (MTCE/ton)	0.27
Tonnes CH4	2.75
MTCDEs from Landfill CH4	**57.70**

Formulaic Numbers

Standard Coefficients	
Short tons/lb. (1/2000)	0.0005
CH4 GWP	21
MTCDE/MTCE (tonne CO2/tonne C)	3.664

Landfill Emissions

CH4 EF w/out Recovery (tonne gas/ton)	0.091
CH4 EF w/ Recovery (tonne gas/ton)	0.070
CH4 EF w/ LFGE (tonne gas/ton)	0.047

Sources for Scope 3, Part B Data

This section includes emissions from methane produced by the institutional waste stream.

Directly proportional to: Total amounts of waste, Diversion rates, Methane processing technology

Primary Assumption: That the institution is responsible for the lifetime effect of the methane emitted during the reporting period during that reporting period only.

Formulaic Numbers

Short tons/lb. (1/2000)	Unit Conversion
CH4 EF w/out Recovery (tonne gas/ton)	*** (see note below)
CH4 EF w/ Recovery (tonne gas/ton)	*** (see note below)
CH4 EF w/ LFGE (tonne gas/ton)	*** (see note below)
MTCDE/MTCE (tonne CO2/tonne C)	Molecular Weights are accepted as chemical standards. Value = ((12.011+2*16.000)/12.011)
CH4 GWP	Global Warming Potential (GWP) based on 100 yr time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html>

Assessing the Split Between Landfills

Value/EF	**Sources**
Total Solid Waste (lbs)	Waste Audit Document [NL 10]
MRWMD Landfill Emissions	
Straight LF	**25% as calculated from EPA " Solid Waste Management and Greenhouse Gases, a Lifecycle Assessment of Emissions and Sinks" 3rd Ed. September 2006 (p.89) [JW 08]
CH4 Recovery/Flaring w/o LFGE? (%)	**0% (see note above) [JW 08]
Electricity Generation? (%)	**75% (see note above) [JW 08]

Indirect Emissions from Regular Commuting (Potentially Scope 3)

This section includes emissions from all mobile combustion of fossil fuels used in vehicles not owned by the institution, but whose operations are indirectly solicited by the institution, i.e., regular employee and off-campus student commuting.

Summary Data: Fiscal Year 2008-2009

Source	MTCDEs
ΣMTCDE from Commuting	**785.0**

Gasoline Fueled Vehicles

Σ Commuting Miles = Σ (daily miles x annual working days x vacation factor x ft%)

Employee City	Zip Code	Avg Miles	# of Employees	Miles driven one-way per day by number of employees at this zip code
Aptos	95003	35.59	2	71.18
Berkeley	94707	120.82	2	241.64
Boulder Creek	95006	55.20	1	55.2
Capitola	95010	38.20	2	76.4
Carmel	93921	4.21	2	8.42
Carmel	93921	4.10	1	4.1
Carmel	93923	8.15	9	73.35
Carmel Valley	93924	21.60	3	64.8
Castro Valley	94546	103.44	1	103.44
Castroville	95012	16.20	1	16.2
Corral de Tierra, Salinas	93908	17.77	5	88.85
Cupertino	95014	71.28	1	71.28
Fair Oaks	95628	202.00	1	202
Folsom	95630	207.00	1	207
Gilroy	95020	42.59	1	42.59
Hollister	95023	45.21	2	90.42
La Selva Beach, Royal Oaks	95076	30.54	2	61.08
Marina	93933	11.01	19	209.19
Menlo Park	94025	85.30	1	85.3
Monterey	93940	1.60	69	110.4
Monterey	93940	0.30	1	0.3
Monterey	93942	1.33	3	3.99
Monterey	93942	1.10	1	1.1
Moraga	94556	122.22	1	122.22
Morgan Hill	95037	51.29	1	51.29
Oakland	94611	114.00	1	114
Pacific Grove	93950	3.20	27	86.4
Pebble Beach	93953	5.60	1	5.6
Pebble Beach	93953	5.60	1	5.6
Pebble Beach	93953	5.60	1	5.6
Salinas	93901	18.90	2	37.8
Salinas	93905	23.90	3	71.7

Salinas	93906	28.00	2	56
Salinas	93907	24.20	2	48.4
San Francisco	94107	112.00	1	112
San Francisco	94122	113.00	2	226
Santa Clara	95050	72.50	1	72.5
Santa Cruz	95062	40.60	1	40.6
Santa Cruz	95065	45.10	1	45.1
Scotts Valley	95066	46.40	1	46.4
Seaside	93955	5.90	15	88.5
Spreckles	93962	17.40	1	17.4
Vacaville	95688	153.00	1	153
Walnut Creek	94598	116.00	1	116
Watsonville	95076	27.10	1	27.1
Average Daily Commute	**34.55**	**Total**	**199**	**3437.44**

Yearly Miles Full-Time Employees	1,475,853.64
Yearly Miles Part-Time Employees	204,979.67
Commuting miles ●	1,680,833.31
Ave Mi/Gal of emp vehicles	21.1
Σ Commuter Gas (gal)	79,660.3
MMBTUs of fuel	9,963.2
Metric Tonnes CO2	**699.0**
Gas Vehicle Activity miles	1,680,833
tonnes CH4	0.333
MTCDE from CH4	**7.00**
tonnes N2O	0.255
MTCDE from N2O	**79.0**
ΣMTCDE from Commuting	**785.0**

Formulaic Numbers

Standard Coefficients	
barrels/gallon (1/42)	0.02381
Tonne/kg (1/1,000)	0.001
Tonne/gram (1/1x106)	0.000001
CH4 GWP	21
N2O GWP	310

Gasoline Fueled Vehicles

MMBTU/gal gas EF	0.1251
Tonnes CO2/gal gas EF	0.008774691
CH4 EF (g gas/mile)	0.1984
N2O EF (g gas/mile)	0.1517
HC (MMBTU/bbl)	5.253
CCC (kg C/ MMBTU)	19.34
Fraction Oxidized	0.99
MW ratio (kg CO2/kg C)	3.664

Factors Determining Commuting Miles

Days/yr	365
weekend days/yr.	104
Regular holiday days/yr	8.0
Base commuting days/yr	253
Vacation for full time staff 1-2 yrs	12
Vacation for full time staff 3-4 yrs	15
Vacation for full time staff 5+ yrs	20
Avg. vacation days	15.67
Avg. Days for Full-Time Employee	237.3333333
Number of Full-time Employees	180
Number of Part-time Employees	50
Total	230
% Full-time	78.26%
% Part-time	21.74%

Sources for Indirect Emissions from Regular Commuting

This section includes emissions from all mobile combustion of fossil fuels used in vehicles not owned by the institution, but whose operations are indirectly solicited by the institution, i.e., regular employee and off-campus student commuting.

Formulaic Numbers

HC (MMBTU/bbl)	Higher heating values (HHV) are used. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [JK 06]
CCC (kg C/ MMBTU)	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [JK 06]
Fraction Oxidized	EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 26. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance.pdf> [JK 06]
MW ratio (kg CO2/kg C)	Molecular Weights are accepted as chemical standards. Value = ((12.011+2*16.000)/12.011) [BB 07]
CH4 EF (g gas/mile)	Based on 1985-1986 EFs for heavy duty vehicles (most conservative values). EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 9. <http://www.epa.gov/climateleaders/docs/mobilesourceguid
Tonne/gram (1/1x106)	Unit Conversion
CH4 GWP	Global Warming Potential (GWP) based on 100 yr time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
N2O EF (g gas/mile)	Based on 1996 EFs for heavy duty vehicles (most conservative values). EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 9. <http://www.epa.gov/climateleaders/docs/mobilesourceguidance. [JK 06]
N2O GWP	Global Warming Potential (GWP) based on 100 yr time horizon: US EPA. 2006. "Non-CO2 Gasses Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." <http://www.epa.gov/nonco2/econ-inv/table.html> [BB 07]
Barrels/gallon (1/42)	Unit Conversion
Tonne/kg (1/1,000)	Unit Conversion
Tonne/gram (1/10E6)	Unit Conversion

Factors Determining Commuting Miles

Days/year	Accepted
Weekend days/year	Accepted
Regular holiday days/year	Monterey Institute Employee Handbook. Page 25: Vacation <http://www.miis.edu/media/view/13801/original/employee_handbook.pdf> [NL 10]
Vacation for full time staff 0-1 years	[NL 10]
Vacation for full time staff 1-2 years	Monterey Institute Employee Handbook. Page 25: Vacation <http://www.miis.edu/media/view/13801/original/employee_handbook.pdf> [NL 10]
Vacation for full time staff 3-4 years	Monterey Institute Employee Handbook. Page 25: Vacation <http://www.miis.edu/docs/hr/employee_handbook_2007.pdf> [NL 10]
Vacation for full time staff 5+	Monterey Institute Employee Handbook. Page 25: Vacation <http://www.miis.edu/docs/hr/employee_handbook_2007.pdf> [NL 10]

Gasoline Fueled Vehicles

Average Commute (mi) for Employes: Σ Commuting Miles = Σ (daily miles x annual working days x nh factor x ft%)		
Town	**Zip Code**	**Mileage from Google Maps End Point: 460 Pierce Street, Monterey, CA 93940**
Aptos	95003	35.59
Berkeley	94707	120.82
Boulder Creek	95006	55.2
Capitola	95010	38.2
Carmel	93921	4.21
Carmel	93921-7235	4.1
Carmel	93923	8.15
Carmel Valley	93924	21.6
Castro Valley	94546	103.44
Castroville	95012	16.2
Corral de Tierra, Salinas	93908	17.77
Cupertino	95014	71.28
Fair Oaks	95628	202
Folsom	95630	207
Gilroy	95020	42.59
Hollister	95023	45.21
La Selva Beach, Royal Oaks	95076	30.54
Marina	93933	11.01
Menlo Park	94025	85.3
Monterey	93940	1.6
Monterey	93940-1951	0.3
Monterey	93942	1.33
Monterey	93942-1405	1.1
Moraga	94556	122.22
Morgan Hill	95037	51.29
Oakland	94611	114
Pacific Grove	93950	3.2
Pebble Beach	93953	5.6
Pebble Beach	93953-2625	5.6
Pebble Beach	93953-3077	5.6
Salinas	93901	18.9
Salinas	93905	23.9
Salinas	93906	28
Salinas	93907	24.2
San Francisco	94107	112
San Francisco	94122	113
Santa Clara	95050	72.5
Santa Cruz	95062	40.6
Santa Cruz	95065	45.1
Scotts Valley	95066-3301	46.4
Seaside	93955	5.9
Spreckles	93962	17.4
Vacaville	95688	153

Walnut Creek	94598	116
Watsonville	95076-1860	27.1

Commuting miles	Determined by using city and zip code for each entry above as a starting point and 460 Pierce Street, Monterey, CA 93940 as an end point [NL]
Average Mile/Gal of emp vehicles	Average on-road US mi/gal based on 55/44 highway/city driving habits as set by the EPA in: US EPA. 2006. Light Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2006. Executive Summary. EPA420-S-06-003, July 2006. Retrieved from: <http://www.epa.gov/otaq/cert/mpg/fetrends/420s06003.htm> [JK 06]
Σ Commuter Gas (gal)	Calculated from sourced data
MMBTU/gal gas EF	Calculated from sourced data
Tonnes CO2/gal gas EF	Calculated from sourced data

Notes on Source Reproduction

Methane and Nitrous oxide EFs are based on highway vehicle EFs taken directly from US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004, as are CCC's and FO factors. FO values of .99 are also recommended by IPCC guidelines.

For #6, #2, and Diesel:
HC values were originally published in U.S. Department of Energy, Energy Information Administration. 2003. "Annual Energy Review 2002," DOE/EIA 0384(2002), , Washington, DC, October 2003.

Carbon Content Coefficients and Fractions Oxidized: US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004. US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.

For Propane:
HC and Carbon Content Coefficients values were originally published in: Guthrie, V.B. (ed.). 1960 Characteristics of Compounds, Petroleum Products Handbook. New York, NY: McGraw Hill. pp 3.

Carbon Content Coefficient values and Fractions Oxidized were calculated based on the findings of: US EPA. 2004. "Inventory of U.S. Greenhouse Gas Emissions and Sinks:" 1990-2002, EPA430-R-04-003, U.S. EPA, Washington, DC, April 2004.

Employee Zip Codes: Spreadsheet acquired from Barbara Burke detailing zip codes associated with each individual employee (Edited in 2023 to take out repeated zip codes, from the original version of one zip code per employee.)				
22302	95012	93933	93905	93955
22314	91711	94025	93901	93962
48104	93908	93940	93907	95688
95003	95014	93942	93906	22182
94707	95628	93950	94107	94598
95006	95630	94556	94122	20009
95010	95020	95037	95050	20002
93923	89074	94611	95065	20005
93921	95023	93953	95062	20016
93924	95076	18944	95060	20037
94546	90024	20852	95066	60091

Direct Sequestration, Renewable Energy Certificates, and Offsets

This section catalogues all carbon sinks, and verifiable third-party investments in renewable energy.

Summary Data: Fiscal Year 2008-2009

	MTCDEs by year (FY08/09)
Contributing Internal Offsets	0.00
Contributing External Offsets	0.00
TOTAL	**0.00**

Contributing Internal Offsets

Value/EF	**MTCDEs by year (FY08/09)**
Waste Composted (lbs.)	0
Tonnes CO2 sequestered	**0.00**

Contributing External Offsets: All values are to be entered in metric tonnes.

Group Categories	**MTCDEs by year (FY08/09)**
Athletics	
Academic Departments	
Administration	
Student Organizations	0*
Commons	
Total	**0.00**
Combined Reported Footprints	
Athletics	
Academic Departments	
Administration	
Student Organizations	
Commons	
Total	**0**

*ETF Happy Hour

Non-contributing External Offsets: All values are to be entered in metric tonnes.

Group Categories	**MTCDEs by year (FY08/09)**
Athletics	
Academic Departments	
Administration	
Student Organizations	
Commons	
Total	**0.0**

Formulaic Numbers

MTCDE seq/ton composted	0.03
Short tons/lb. (1/2000)	0.0005

Sources for Direct Sequestration, Renewable Energy Certificates, and Offsets

This section catalogues all carbon sinks and verifiable third-party reductions directly produced by the institution in hopes of reducing its environmental impact on a global scale.

Formulaic Numbers

Short tons/lb. (1/2000)	Unit Conversion

Contributing Internal Offsets

Value/EF	**Sources**
Waste Composted (lbs.)	n/a

Contributing External Offsets

Administration	n/a
Student Organizations	ETF?
Commons	n/a

Non-Contributing External Offsets

Student Organizations	ETF Purchased carbon offsets for the Carbon Neutral happy hour. However, we do not know if these credits were calculated to offset the electricity used during the event. We believe that the offsets were used to offset the food and alcohol, and the transportation of the people to come to happy hour. Therefore, it is debatable whether or not these credits are applicable to the GHG audit. In addition, we are not sure as to the location of the certificate for the offsets (therefore the number of offsets purchased), or whether they were bought in MIIS' name. This is something that needs to be addressed when ETF purchases offsets in the future.
Academic Departments	n/a
Administration	n/a
Commons	n/a

Normalization Factors

This section includes information that relates to institutional growth between reporting periods. By normalizing emissions data, emissions can be displayed in the context of organic growth.

Total Students	722
Total Employees	199

This information is from the campus community census report to the City of Monterey Planning Department (June 25, 2007). Represents total MIIS community members for fall 2006 and spring 2007. [NB 08]