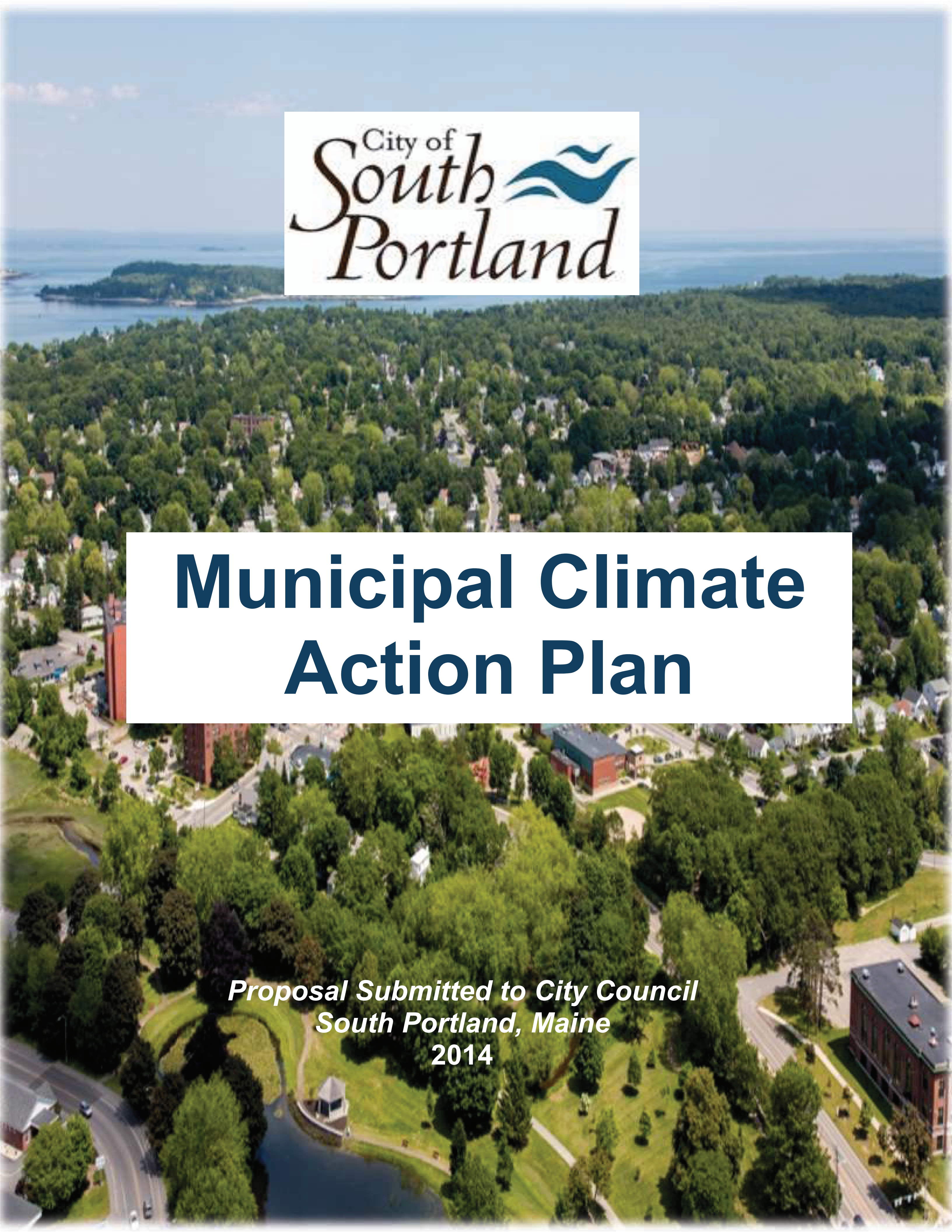

City of South Portland

Municipal Climate Action Plan

Proposal Submitted to City Council
South Portland, Maine
2014

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

> *"If not addressed, [climate change] will consume our national resources and threaten the well-being of future generations, and volatile energy prices and more extreme weather will devastate our economy." – Former White House Chief of Staff John D. Podesta (speech to National Association of State Treasurers, 2007).*

Global warming is a documented and present threat to the planet—the combustion of fossil fuels releases greenhouse gases (GHG) into the atmosphere, causing global surface temperatures to increase. Scientific evidence continues to support the theory that carbon dioxide ($CO_{2)}$ and other GHGs that have been released into the atmosphere since the beginning of the industrial era are having a profound effect on the Earth's climate.

These documented and observed impacts are not only affecting the Earth's climate, but are also increasing costs for municipal governments. Predicted changes in Maine's climate over the next century include diminished snow pack, topsoil loss from rainfall events, declines in local ecosystem health, increased coastal flooding and demand on wastewater infrastructure, and less economic growth in core local industries such as tourism, fishing, and forestry.[1]

The City of South Portland signed the U.S. Mayors' Climate Protection Agreement in 2007, which called for municipalities to address "global warming pollutants through programs that provide economic and quality of life benefits, such as reduced energy bills in residential, commercial and public buildings, green space preservation, air quality improvements, reduced traffic congestion, improved transportation choices, and economic development and job creation through energy conservation and new energy technologies." This agreement sets a specific goal for all participating municipalities— to reduce GHG emissions by **17 percent** (based on 2007 emissions) by the year **2017,** or **"17 by '17"**.

GHG emissions from "municipal activities" include those emissions occurring from municipal functions within the City of South Portland's jurisdictional boundary, and this Climate Action Plan addresses emissions that are under the City's influence or control. Through adopting and implementing this Climate Action Plan, the City intends to meet or exceed the goal of 17% emissions reduction by 2017.

South Portland's Climate Action Plan (CAP) discusses the findings of a 2007 Inventory of Municipal Greenhouse Gas Emissions, and identifies emission reduction strategies for the municipality. The City's Climate Action Plan is divided into three phases: Phase 1, "City Department Actions for Reducing Energy Consumption"; Phase 2, "Business Energy Consumption Reduction"; and Phase 3, "Residential Opportunities for Energy Use Reduction". Phase 1 is included in this document; Phases 2 and 3 are currently under development.

[1] Jacobson, G.L., I.J. Fernandez, P.A. Mayewski, and C.V. Schmitt (editors). 2009. Maine's Climate Future: An Initial Assessment. Orono, ME: University of Maine. http://www.climatechange.umaine.edu/mainesclimatefuture/.

INTRODUCTION

Development of the Climate Action Plan (CAP)

An inventory of 2007 municipal greenhouse gas emissions was completed in 2011 (See Appendix B). South Portland produced **10,100 metric tonnes of GHGs** (CO_{2e}) in 2007 and aims to cut **1,700 metric tonnes** of CO_2 Equivalent (CO_{2E}) to meet the goal set by the Mayors' Agreement. The City's target is a 17% reduction in greenhouse gas emissions by 2017.

It is the vision of the City of South Portland to create a sustainable city that benefits the lives of all citizens through energy savings, preservation of the environment, economic opportunity, and improvement of the health and welfare of the employees and people of the City. This vision and its accomplishment will create a "Legacy of leadership [that is] taking action on climate change [to provide] tangible benefits for citizens today – and ensures that future generations will have access to the resources that support healthy, prosperous, and livable communities."[2]

This CAP was envisioned to identify attainable goals for the following: using energy more efficiently to keep municipal operating costs low, harnessing renewable energy to power City buildings, enhancing access to sustainable transportation modes, and recycling local waste, in order to keep dollars in the local economy, support local green jobs, and improve community quality of life.

The strategies and actions in this plan are based on local ideas, and similar plans developed by other cities and states. Currently, over 1,000 cities have signed the U.S. Mayors' Climate Protection Agreement established by Seattle Mayor Greg Nickels in February 2005. Under the Agreement, participating cities must strive to meet or beat the Kyoto Protocol targets in their own communities, as well as urge the state and federal government to enact policies and programs to reduce greenhouse gas emissions.

Similarly, over 1,200 international cities, including many U.S. cities, participate in the Cities for Climate Protection program managed by the International Council for Local Environmental Initiatives (ICLEI). One of the milestones set by the program is to develop a local action plan to reduce emissions. Currently, a relatively small percentage of participating cities in one or both of the programs have developed and begun implementation of state, regional and local action plans. A number of Maine municipalities have signed the agreement, including South Portland neighbors Cape Elizabeth, Falmouth, Yarmouth, Portland, Saco, and Biddeford.[3]

In addition, the Maine Department of Environmental Protection (DEP) is working with its partners and regional stakeholders to develop a statewide Climate Action Plan, and the Greater Portland Council of Governments (GPCOG), in partnership with Clean Air – Cool Planet (CA-CP), formed EmPowerMe, a local Energy Working Group, in early 2010. The mission of the Working Group is:

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[2] U.S. Mayors' Climate Protection Agreement, Climate Action Handbook, 2008.

[3] http://www.usmayors.org/climateprotection/list.asp

> "To reduce energy use and greenhouse gas emissions through strategic energy planning, public outreach and the provision of resources and technical support to municipalities and local energy committees."

In 2008, the City Council created the standing Energy and Recycling Committee (ERC) and empowered it to define the City's approach toward achieving the Mayors' Agreement in Chapter 2, Section 2-134 of the City's Code of Ordinances. In 2010, at the recommendation of the ERC, the City Council adopted the first Sustainability Resolve (#1-10/11), specifically calling for energy and other resource conservation practices to be put in place and carried out by all City departments.

The Climate Action Plan is the result of the ERC's work and establishes Phase 1 as the foundation for the implementation of GHG- and resource- reduction measures at the municipal level to be carried out immediately upon acceptance by City Council. Currently under development, Phase 2 will address the roles of commercial and industrial opportunities and demands while Phase 3, not nearly least in importance, will address residential opportunities for resource conservation, and dovetail these actions with the City's Comprehensive Plan.

The Climate Action Plan is a living document which continues to be updated by the ERC and City staff. Many goals have been achieved to date, and many new measures have been identified and incorporated.

Commitment to the CAP

Budgets for investing in energy efficiency measures are being evaluated on an ongoing basis, and will be greatly impacted by the language in the Climate Action Plan and targeted savings in future energy bills achieved through GHG-reducing activities, such as upgrading building systems, using renewable energy supplies, reducing miles traveled, and reducing consumption of water and other non-renewable resources.

With the support of the City Manager's Office, the Comprehensive Plan Committee, and all the City departments, South Portland can meet its goal to be the foundation of environmental stewardship from which residents and neighbors can build. To this end, and through the adoption of the City's Sustainability Resolve, the City will invest significant time, energy, resources, and capital to achieve the goals set forth in this document.

Greenhouse Gas Emissions Baseline (2007)

To ensure that the municipality stays on course to meet its aggressive GHG reduction target, it is necessary to track its progress by conducting regular, community-wide GHG emissions inventories. It helps to think of the inventory as a "snapshot" of South Portland's GHG emissions for a given year. The 2007 base inventory for the municipality was completed in 2011. This study identifies the major sources and quantity of GHG emissions produced by residents, businesses, and public institutions. The complete 2007 Inventory Report is attached to this CAP as Appendix B.

Municipal Emissions

In 2007, South Portland's government operations emitted approximately 10,100 metric tonnes of GHG emissions, at a direct cost of over $3 million. Table 2 of the Inventory, shown below, displays municipal energy-use categories, sorted by GHG output as CO_{2e} (metric tonnes emitted). Table 5 of the Inventory shows the emissions associated with each City building.

Table 2: 2007 South Portland government emissions, energy costs, and energy output by sector.

South Portland: GHG Emissions Inventory Overview (2007)						
Sector	**Cost ($)**	**Cost (%)**	**Energy Output (MMBtu)**	**Energy Output (%)**	**CO2e (tonnes)**	**CO2e (%)**
Buildings: Heat & Hot Water	894,294.45	29.4%	54,539.1	48.1%	3,766.6	37.3%
Buildings: Electricity	794,822.04	26.2%	17,665.0	15.6%	2,194.6	21.7%
Total Buildings	**1,689,116.49**	**55.6%**	**72,204.1**	**63.6%**	**5,961.2**	**59.1%**
Wastewater	399,039.96	13.1%	12,454.2	11.0%	1,833.6	18.2%
Vehicle Fleet*	446,291.94	14.7%	19,086.4	16.8%	1,380.1	13.7%
Lights & Traffic Signals	357,525.72	11.8%	3,993.2	3.5%	496.1	4.9%
Transit Fleet*	143,877.30	4.7%	5,602.7	4.9%	409.9	4.1%
Water Delivery	1715.84	0.06%	95.2	0.08%	11.8	0.12%
Port Facilities	1193.16	0.04%	16.9	0.01%	2.1	0.02%
GRAND TOTALS	**3,038,760.41**		**113,452.8**		**10,094.9**	
*Fuel usage data for the vehicle and transit fleets was not available for 2007; fuel usage data for calendar year 2008 was used for the 2007 base year inventory.						

Table 5: 2007 government buildings' analysis including energy cost per square foot, energy intensity (kBtu/s.f.), and GHG intensity. Buildings preceded by a superscript number indicate instances where energy usage is split between two or three separate line items; these buildings had different square footage values for electricity and heated space or, as in the case of the Cash Corner Fire Station, the discernment between building sections found in data collection were maintained for data analysis.

Buildings (2007): Cost, Energy, GHG Emissions, & Square Footage Analysis							
Department / Building Name* (Year Built) (Fuel Type)	Square Footage	Cost ($)	Energy Cost per Sq. Ft. ($)	Energy Output (MMBtu)	Energy Intensity (kBtu** / s.f.)	CO2e (tonnes)	GHG Intensity (tonnes CO2e /1,000 s.f)
Rec, Pool (1978) (#2)	3,690	63,230.23	17.14	3,909.44	1,059.47	287.61	77.94
[1] Fire, Cash Corner/Rear (1971?) (Prop, Elec)	896	7,993.73	8.92	211.02	235.51	22.82	25.47
Maine Military Museum (1940) (#2, Elec)	704	3,912.80	5.56	231.82	329.28	17.10	24.29
Parks, Greenhouse (1968) (#2, Elec)	960	4,757.23	4.96	269.64	280.88	20.31	21.15
Police Garage (1972?) (#2)	1,000	3,547.54	3.55	218.05	218.05	16.04	16.04
Bus Service, Office (1982) (Kero, Elec)	480	1,770.00	3.69	73.55	153.23	7.40	15.42
[2] Schools, School Bus Building (1984) (#2, Kero)	6,925	23,929.15	3.46	1,379.17	199.16	101.02	14.59
[3] Public Safety (Police/Fire Admin) (1972/1998) (Elec)	6,814	30,519.00	4.48	784.21	115.09	97.43	14.30
[4] PW, Admin Office & Gar. Bay 1 (1930) (#2, NatGas)	6,600	20,295.12	3.08	1,354.85	205.28	89.13	13.50
City Hall (1898) (#2, NatGas, Elec)	8,500	32,572.33	3.83	1,183.22	139.20	113.15	13.31
Parks, Maintenance Bldng (1968) (#2, Elec)	2,800	8,803.47	3.14	436.64	155.94	35.28	12.60
PW, Transfer Station Entrance Shed (1998) (Elec)	400	1,541.99	3.85	40.17	100.42	4.99	12.48
Schools, Hamlin (1961) (#2, Elec)	7,858	25,423.14	3.24	1,214.08	154.50	95.63	12.17
Schools, Memorial (1960) (#2, Elec)	77,074	205,533.09	2.67	10,286.69	133.47	826.21	10.72
Parks, Wainwright Field, CmmBldng (2002) (Prop, Elec)	2,504	8,394.93	3.35	268.98	107.42	25.37	10.13
[3] Police/Public Safety Furnaces (1972/1998) (#2)	12,975	26,950.70	2.08	1,669.88	128.70	122.85	9.47
Assessing (1955) (NatGas, Elec)	1,444	4,396.43	3.04	172.83	119.69	13.24	9.17
Schools, SPHS (1950/1960) (#2, NatGas, Elec)	189,349	452,698.38	2.39	18,764.67	99.10	1,615.81	8.53
Bus-Service, Garage (1945) (NatGas, Elec)	6,251	15,670.88	2.51	788.89	126.20	51.64	8.26
Water Resources, Sewer Maint. Gar. (1980) (Prop, Elec)	2,600	9,285.56	3.57	287.99	110.77	21.47	8.26
Library, Branch, Wescott (1978) (Prop, Elec)	4,642	13,868.90	2.99	452.28	97.43	37.96	8.18
Fire, Central (1940) (#2, NatGas, Elec)	14,288	28,921.63	2.02	1,427.98	99.94	114.41	8.01
Fire, West End Station (2003) (NatGas, Elec)	10,698	26,222.97	2.45	1,096.59	102.50	84.00	7.85
Schools, Robotics (One Clsrm Prgrm Bldng) (#2)	1,920	3,067.63	1.60	188.49	98.17	13.87	7.22
Library, Public, Broadway (1970) (#2, Elec)	12,300	27,503.08	2.24	900.57	73.22	88.60	7.20
Fire, Ferry Village Station (1920)(#2, NatGas, Elec)	1,760	3,177.94	1.81	157.24	89.34	12.28	6.98

Buildings (2007): Cost, Energy, GHG Emissions, & Square Footage Analysis							
Department / Building Name* (Year Built) (Fuel Type)	Square Footage	Cost ($)	Energy Cost per Sq. Ft. ($)	Energy Output (MMBtu)	Energy Intensity (kBtu** / s.f.)	CO2e (tonnes)	GHG Intensity (tonnes CO2e /1,000 s.f)
Schools, Brown (1940) (NatGas, Elec)	31,774	74,963.00	2.36	3,079.83	96.93	219.06	6.89
[3] Police (1972) (Elec)	6,161	12,596.70	2.04	316.00	51.29	39.26	6.37
Schools, Dyer (1971) (NatGas, Elec)	29,278	66,455.00	2.27	2,492.81	85.14	185.91	6.35
Rec, Wilkinson Function Hall (1950) (#2, Elec)	2,748	4,325.97	1.57	217.74	79.23	17.35	6.31
Schools, Small (2003) (NatGas, Elec)	30,728	67,085.00	2.18	2,401.53	78.15	186.41	6.07
Schools, Skillin (1940) (#2, Elec)	50,290	82,444.77	1.64	3,481.61	69.23	300.10	5.97
Fire, Thornton Heights (1939) (#2, Prop, Elec)	1,628	3,636.34	2.23	122.31	75.13	9.58	5.88
Planning & Development (1961) (NatGas, Elec)	4,546	8,214.66	1.81	383.00	84.25	26.24	5.77
[1] Fire, Cash Corner/Front (1971) (#2, Elec)	7,250	9,025.94	1.24	539.50	74.41	40.01	5.52
Schools, Mahoney Jr HS (1940) (#2, NatGas, Elec)	62,060	90,404.18	1.46	4,085.78	65.84	340.07	5.48
Schools, Kaler (2003) (NatGas, Elec)	30,728	59,343.00	1.93	1,997.23	65.00	165.48	5.39
Fire, Willard Square Station (1940) (#2, Elec)	4,576	5,762.10	1.26	283.06	61.86	24.12	5.27
Rec, Redbank Gym (1997) (NatGas, Elec)	11,674	19,479.83	1.67	777.45	66.60	61.23	5.25
PW, Dugout & Sign Shop (1950) (#2, Elec)	4,262	5,448.73	1.28	250.02	58.66	20.93	4.91
Rec, Community Center (2000) (NatGas, Elec)	49,888	76,049.61	1.52	2,782.95	55.78	243.25	4.88
[4] PW, Admin & Gar. Bays 1 & 2 (1930/1950) (Elec)	11,400	13,601.60	1.19	307.78	27.00	38.24	3.35
Police Garage (Elec)	1,600	1,785.59	1.12	40.10	25.06	4.98	3.11
Water Resources, Office (2007) (Prop)	1,360	1,786.46	1.31	63.93	47.00	4.06	2.98
[2] Schools, School Bus Building (1984) (Elec)	42,528	26,283.71	0.62	661.84	15.56	82.22	1.93
PW, Engineer's Bldng (1950) (#2, Elec)	1,664	943.79	0.57	38.02	22.85	3.20	1.92
Golf Course Maint. Bldng (1979) (Elec)	1,664	873.55	0.52	18.21	10.94	2.26	1.36
PW, Salt Shed (1985) (Elec)	5,026	873.55	0.17	18.21	3.62	2.26	0.45
Parks, Willard Beach Beach House (1973) (Elec)	1,408	338.09	0.24	5.34	3.79	0.66	0.47
Armory (1941) (Elec)	24,904	653.09	0.03	10.92	0.44	1.36	0.05
[4] PW, Gar. Bay 2 (1950) (Nat Gas)	4,800	125.41	0.03	1.13	0.23	0.06	0.01
Parks, Mill Creek Park Pumphouse (Elec)	N/A	3,005.00	N/A	67.97	N/A	8.44	N/A

*Buildings which shared an electricity meter, but not a furnace/boiler –or- vice versa –or- buildings in which the entire square footage did use electricity, but was not heated were split in this table to enable greater transparency. Buildings preceded by a superscript number indicate instances where energy usage is split between two or three separate line items.
**kBtu = one thousand "British thermal units." A BTU is a measurement of energy equivalent to approximately 1,055 joules.

Municipal Fuel Usage

The graph below, Figure 6 of the Inventory, displays fuel use by sector as a percentage of CO_{2e} emissions.

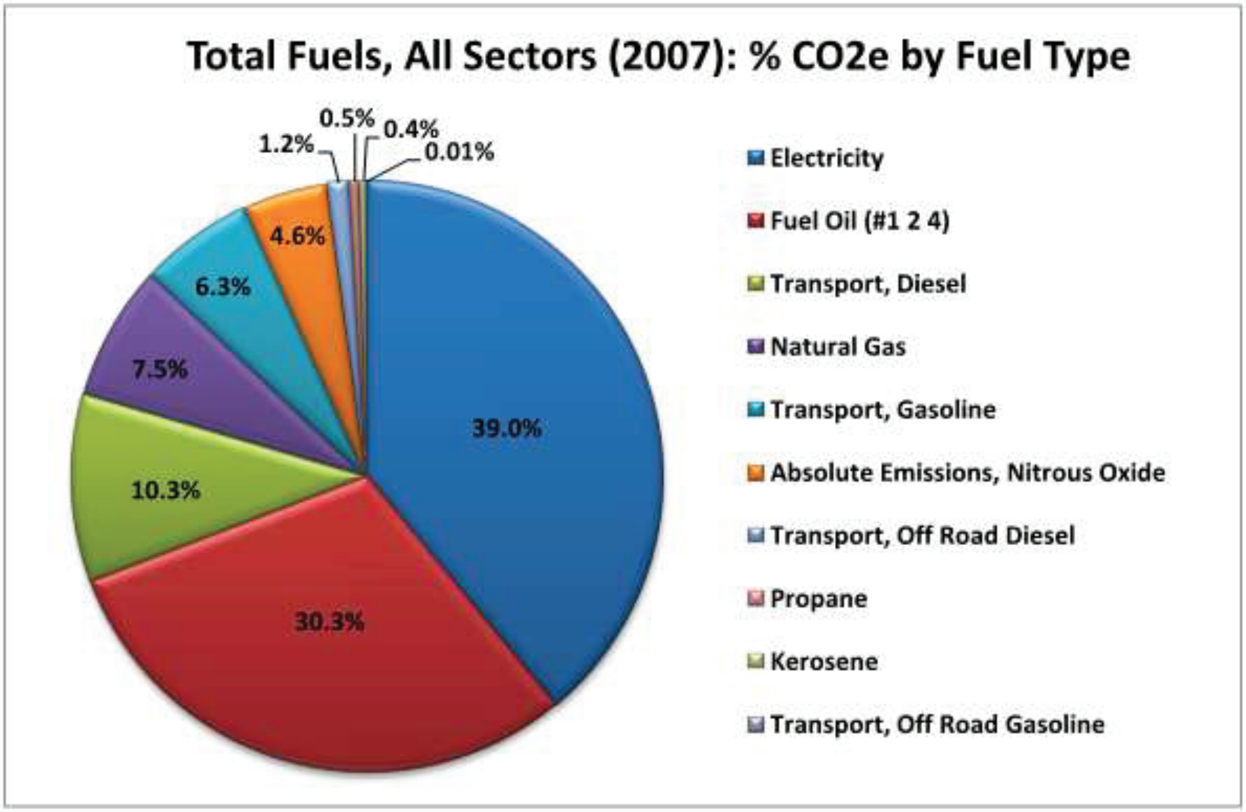

Figure 6: Energy usage by fuel type across all sectors. Percentages represent actual CO_2e emissions resulting from specific fuel usages.

ACTION RECOMMENDATIONS

A successful Climate Action Plan addresses all the GHG-producing activities of a community. As defined in the City's 2010 Sustainability Resolve, Resolve #1-10/11 (included as Appendix A), which established goals and guidelines for sustainability initiatives and emissions reductions strategies, the ERC will continue to update this plan, address changes to the GHG inventory, compile budgeting and investment strategy information, and otherwise assist in the evolution of the Climate Action Plan toward its goal of achieving the Mayors' Agreement target of 17% reduction in GHGs and reaching the City's goals of reducing costs and becoming more energy independent.

The Climate Action Plan is the result of the ERC's work and establishes a 3-phase plan of action. Phase 1 is the foundation for the implementation of GHG- and resource-reducing measures at the municipal level. Some of these measures are already being carried out in municipal buildings and departments, while others will be adopted soon after approval by City Council. Phase 2 addresses the roles of commercial and industrial opportunities and demands. Phase 3, not nearly least in importance, addresses residential opportunities for resource conservation and the continued dovetailing of these actions with the goals of the City's Comprehensive Plan, which was adopted in 2012.

Beginning in 2011, the City followed the recommendation of the ERC to act on Phase 1 immediately and aggressively. Although the Climate Action Plan will address GHG reduction and resource conservation for the entire City, at this juncture and with time of the essence, this Plan is predominately focused on immediate action items and implementation strategies for municipal buildings and infrastructure, including the South Portland School Department.

Methodology

Recognizing that there was no method in place to measure and verify GHG reductions from projects already completed, the ERC began to assemble the data for a base inventory for the municipal infrastructure in 2009. The result of this effort was the 2007 Emissions Inventory included in Appendix B. These data form the basis for evaluating emissions reduction projects, and allow the Municipality to measure its progress toward the 2017 GHG emissions reduction goal. The inventory will be updated regularly in order to form the basis for further reduction goals.

Following the completion of the inventory, the ERC, in conjunction with the City Manager's in-house team, examined a range of action strategies to reach the stated goal. The initial list of action items compiled by the committee in 2011 had 51 items. Through careful discussion and evaluation, the ERC established a manageable list of project-related action items and behavior/policy changes. These items are specific to Phase 1 - Municipal Opportunities.

PHASE 1—MUNICIPAL OPPORTUNITIES FOR REDUCING ENERGY CONSUMPTION

To reach the goal of 17% GHG emissions reduction from 2007 levels by 2017 ("17 by '17") the City must reduce annual emissions by 1,700 metric tonnes. Savings in both costs and GHG emissions from these projects will result in a reduction of GHG from the 2007 Base Inventory, which will be tracked once projects are completed.

The action steps in this Climate Action Plan incorporate the guidance of the US EPA EnergyStar™ Building Upgrade Manual[4]. This manual recommends a five-stage process and a staged approach to building upgrades. This CAP includes these EPA steps and supplemental actions as well.

These Phase 1 municipal action items are divided into three subcategories: General, Facility-Related Projects, and Behavior/Policy Changes. As the Phase 2 and Phase 3 revisions of the Climate Action Plan are completed, they will also include these subcategories. This Plan identifies all strategies adopted since 2011, and provides a progress report for each recommended action. As of fall 2013, many of these strategies have been adopted and are in progress, others have been analyzed for feasibility, and some have been successfully completed.

Category 1: General Recommendations for Municipal Energy Consumption Reduction

1. Change data tracking so that energy usage can be tracked for all municipal infrastructure, including schools.

    - The first step towards identifying the issues that make tracking energy usage difficult began in spring, 2011. A new method of capturing energy use by building is currently being developed. The School Department is now in the process of starting to use the EPA Portfolio Manager to track the carbon footprint of the school buildings.

[4] US EPA EnergyStar™ Building Upgrade Manual, p. 4.

2. Compile and complete the FY 2012 Emissions Inventory when the required data becomes available (there is a current lag in data availability), and prepare reports to determine the City's movement toward the goal of this plan.

3. Management of energy usage, costs, and managing technical energy systems is a specialized field, which should be addressed through the creation of new City positions focused on facilities management and sustainability.

   - While the School Department has a facilities director, the Municipality does not. Furthermore, the school position is spread too thinly for effective management of all City buildings, schools, and fleets.

   - One of the most cost-effective investments for the City would be the creation of a facilities manager/sustainability coordinator that manages the operation, maintenance, and upgrades to all municipal buildings.

   - ICLEI USA provides evidence that energy offices or staff positions have been shown to finance themselves within two years through energy cost savings, and are often eligible for federal grants which are worth many times the operating costs of the office.[5]

   - In the same way, a vehicle and equipment operations and maintenance department in a central garage for both the municipality and the school district could consolidate both costs and maintenance schedules to achieve efficiencies and, presumably, cost savings. A new, centralized municipal services facility was approved by voters in November 2013 for this purpose.

4. Continue to monitor and revise the City/School procurement policies to build in specific language ensuring all purchases of equipment, vehicles, and building upgrades meet the highest energy standards possible at the time. The City's Purchasing Ordinance was updated in 2012 to include Sec. 2-160: "Environmentally Preferable Products and Services"[6], but should be reviewed continually to reinforce the City's commitment to reducing GHG emissions. The policy does not currently address energy standards at this time.

5. The City and its schools should strive to document all the energy reduction projects or initiatives that have been completed after 2007 above and beyond those resulting from the respective Siemens contracts. Many of the initiatives completed to date

[5] http://www.icleiusa.org/library/documents/Energy%20Office%20One%20Pager.pdf

[6] SECTION 2-160: The City supports the purchase of environmentally preferable products and services as evidenced by its commitment to sustainability set forth in City Council Resolve #1-10/11. Where practicable, City departments should endeavor to ensure that specifications do not discriminate against environmentally preferable products and services; evaluate environmentally preferable products and services to determine the extent to which they may be used by the department; and review and revise specifications to include environmentally preferable products and services.

(Ord. No. 22-89/90, 6-4-90, Ord. 15-98/99, 4/21/99, [Fiscal note less than $1000]; Ord. No. 7-11/12, 1/4/12 [Fiscal Note: Less than $1000]) have been included in this document, but others have not yet been tracked and summarized. A City sustainability coordinator or facilities manager would be useful in this capacity.

- This analysis shall be completed for each building so that a comparison can be made with current energy usage rates, in order to accurately measure usage reductions.

- The City in-house team is currently investigating the costs and benefits of membership in the ULI Greenprint program, which is a software program operated by a non-profit geared towards improving the environmental performance of member properties. If cost-effective, this program would allow a sustainability/facilities manager to easily enter data at any frequency (annual, monthly, weekly) on energy consumption, waste generation, water usage, emissions, at both the asset and meter level. Greenprint's software also generates reports on-demand, lessening the technical reporting burden on City staff.

6. Encourage department or building initiatives initiated by staff, such as participation in the State-wide program "Zero Waste" at the Memorial School. Ensure all City buildings and schools have adequate recycling containers and storage to support increased recycling efforts.

7. Continue advocacy for energy efficient policies at the Maine State Legislature level. In 2013, City staff was successful in drafting and advocating for LD 1251, a bill which would require electricity utilities to provide three options for municipal street light programs.[7] These different ownership or lease structures will allow Maine municipalities to choose the most cost-effective and energy-efficient option each year. In other New England states, municipalities' total costs for street lighting have declined 30% to 40% through efficiency upgrades.[8]

Category 2: Municipal Facility-Related Actions

Energy Efficiency Actions

Action: **Replace existing refrigerators with ENERGY STAR models that are rated as at least 30% more efficient than the current Federal standard. Replace compact refrigerators with one standard size in each department.**

[7] http://www.mainelegislature.org/legis/bills/bills_126th/billtexts/HP088501.asp

[8] Town of Falmouth, Resolution to Support LD 1251. Retrieved from: http://www.town.falmouth.me.us/Pages/FalmouthME_CouncilAgendas/2013/04082013/S03E8960F.1/912013_Resolution_LD1251.pdf

Responsible Department	All departments with refrigerators.
GHG Emissions Reduction	40% less CO_{2e} each year per refrigerator unit.[9]
Annual Cost Savings	$85-$1,000 over five years, depending on the size and age of refrigerator replaced with an Energy Star model.[10] The Energy Star Refrigerator Calculator, available online, can be used to determine annual costs savings per refrigerator replaced.
Challenges	Behavior change for staff, who are accustomed to compact refrigerators in several offices.
Benefits	Health and social benefits from the use of larger, communal refrigerators. All ENERGY STAR models use at least 40% less energy than conventional models. Many models replaced will pay for themselves in energy cost savings in one to two years.
Action Status	Ongoing. Each City Hall Department has replaced their aging refrigerators with communal Energy Star-rated models. The Library, Police Department, Public Works, Fire Department, and Water Resources have not yet begun to phase out refrigerators.

This change involves replacing as many municipal refrigerators as possible with more energy-efficient models, and consolidating multiple smaller refrigerators into larger, communal refrigerators. Due to the nature of this change, it would have to be on a case-by-case implementation. While consolidating refrigerators may be appropriate in some facilities, it may not be in others. In selecting upgrades, models with top-mounted freezers and without automatic ice makers would be favored, as they are more efficient.

Action: Replace individual air conditioners with central systems where cost-efficient, or individual EnergyStar units.

Responsible Department	All departments with individual air conditioners.
GHG Emissions Reduction	15% less CO_{2e} each year per air conditioning unit.
Annual Cost Savings	$90 per each individual unit replaced.
Challenges	Behavior change for staff, who are accustomed to having control over individual air conditioning units. Central cooling systems are difficult and very expensive to install in older City buildings, due to the duct and sealing work needed.

[9] http://www.energystar.gov/ia/business/EPA_BUM_Full.pdf, Ch. 7, p. 6.

[10] http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator&

Benefits	Cost-savings from the use of central cooling systems in new City buildings, and from replacing older individual units already in City buildings. Energy Star individual room models use at least 15% less energy than conventional models, and save $90 in energy costs over the life of each unit.
Action Status	Ongoing. City Hall has also begun the process of replacing outdated air conditioners with more efficient Energy Star-rated models. To date, approximately 11 air conditioners have been replaced with Energy Star. The Library, Police Department, Public Works, Fire Department, and Water Resources have not yet begun to phase out older air conditioners.

A majority of City buildings have air conditioners, but most are small, residential-purpose units. Many of the units in City Hall were over 20 years old before replacement began in 2013. The US EPA recommends replacing heating and cooling equipment (residential) over the age of ten years with Energy Star models.[11] Energy Star-certified room air conditioners use 15% less energy than older models, which can equate to $90 in energy cost savings over the lifetime of the replaced unit.[12]

The ERC recommends purchasing individual units with timers, which use the minimum amount of energy necessary to cool an individual office. The ERC also recommends that any new buildings or buildings under significant renovations investigate the costs and benefits of central heating and cooling systems, including the new Public Works facility.

Action: Separate heat and hot water where the systems are combined, and install an energy-efficient hot water heater with an Energy Star-rating. Continue boiler efficiency improvements through upgrades or replacement with Energy Star-rated models. Prepare and implement a schedule of retro-commissioning of all municipal buildings.

Responsible Department	All buildings that have never been commissioned. The schedule can be prioritized for any of the following reasons: high or unexplained changes in energy consumption; persistent failure of building equipment, control systems, or both; or excessive occupant complaints about temperature, airflow, and/or comfort.
GHG Emissions Reduction	Reduction depends on the size and energy usage of the building.
Annual Cost Savings	Up to a 15% annual cost savings.
Challenges	Maintenance of the retro-commissioned systems so that they continue to perform at the optimum level.
Benefits	Immediate energy use reductions when recommendations are implemented and maintained, immediate health and comfort benefits for occupants of the building.

[11] http://www.energystar.gov/ia/partners/publications/pubdocs/HeatingCoolingGuide%20FINAL_9-4-09.pdf?8802-84fc

[12] http://www.energystar.gov/certified-products/detail/air_conditioning_room

Action Status	Ongoing. See the detailed “Siemens Energy Performance Contract: Performance Assurance Report”, attached as Appendix C, for a full list of upgrades completed to date and the resulting emissions reductions after 1 year of installation.

The US EPA Building Upgrade Manual identifies “retro-commissioning” as its first stage to reduce building energy usage. Retro-commissioning helps to identify heating and cooling systems that need to be replaced, and equipment which is not functioning properly. Retro-commissioning can also be used to identify opportunities to increase the operational efficiency of existing municipal systems.

To forward its GHG emissions reduction goal, the City has negotiated two “paid through savings/ performance” contracts with Siemens Industries. As a result of these contracts, Siemens completes energy upgrades and retrofits in municipal buildings and the cost is paid for over time by the amount of money the City saves on energy bills over the next 5 to 20 years, depending on the upgrade/retrofit scenario and the technology installed. The first contract resulted in energy upgrades for all of the schools in the City, and completed in the fall of 2010. The second contract was for energy upgrades at 14 municipal buildings. Construction for these projects started in June 2011 and completed in 2012. A progress report of these savings and resulting GHG reductions is provided annually by Siemens (see Appendix C for the impressive Performance Year 1 results). As a result of the Siemens Contract, the City’s single-year realized energy savings amounted to the equivalent of the removal of 73.4 cars from the road for a year. **The total one-year reduction of 883,594.7 pounds of CO_{2e} equated to approximately 400 metric tonnes of CO_{2e}, or almost 24% of the City’s overall goal of 1,700 metric tonnes.**

The goal of the retro-commissioning stage in a building upgrade effort is to ensure that the building operates as intended and meets current operational needs, despite its age. Doing so can be cost effective, with the EPA reporting typical costs for existing buildings at about \$0.27/ ft^2, energy savings of 15 percent, and a payback period of 0.7 years.[13]

According to the 2007 Inventory, the building with the highest GHG intensity (that is, tonnes CO_{2e} per thousand square feet) is the South Portland Community Center Pool building, followed by the police headquarters. As such, it was suggested that the priority for retro-commissioning should start with these buildings. The oil boilers in the pool building were replaced with natural gas boilers as part of the 2011-12 Siemens projects. At current rates, energy costs should now be lower with the change from #2 heating oil to natural gas.

As of 2013, all City buildings have been converted to natural gas or propane with the exception of the Police Department and Public Safety Building, Cash Corner and Western Avenue fire stations, the Fire Garage, and Police Garage. The Fire and Police Garages do have new waste oil burners, however.

In addition to the Siemens Contract upgrades, HVAC systems have also been upgraded at the Branch Library and Redbank Community Center.

[13] http://www.energystar.gov/ia/business/EPA_BUM_Full.pdf, Ch. 5, p. 3.

Action: Install energy efficient LED exit signs

Responsible Department	All buildings that have exit signs.
GHG Emissions Reduction	Roughly 158 pounds of CO_{2e}/year for each sign (fluorescent to LED conversion), which equates to 0.07 metric tonnes CO_{2e} per sign, or 3.5 metric tonnes per year if 50 signs were replaced.
Annual Cost Savings	$7.00 per sign, per year (fluorescent to LED). Roughly $1,400/year (based on 50 replaced signs).
Challenges	None – ROI 1.4 years, simple replacement
Benefits	Longer-lasting, brighter, and, therefore, safer exit signs for municipal buildings
Action Status	TBD.

The EPA recommends lighting upgrades as the second stage of building upgrades, as lighting has a substantial impact on electrical use. Lighting upgrades range from new light fixtures to new control systems.

Replacement of older exit signs with incandescent bulbs saves on electricity and maintenance costs. A conventional exit sign with incandescent bulbs will go one year without needing bulb replacement; a new LED sign will last 25. LED bulbs are also brighter, and provide better visibility, improving workplace safety.[14]

Action: Install lighting occupancy sensors in appropriate, intermittently-used rooms in all buildings, and install efficient lighting retrofits in buildings that have not already received this upgrade.

Responsible Department	Municipality – priority for any un-upgraded fixtures.
GHG Emissions Reduction	83% energy savings per year.
Annual Cost Savings	TBD. A combination of sensors, lighting upgrades, and daylight dimming has a payback period of 3.3 years, and reduces energy use by 83%.[15]
Challenges	Initial cost of conversion/replacement of existing systems.
Benefits	Choice of lighting affects energy loads, occupant comfort and productivity.
Action Status	Ongoing.

[14] http://www.energystar.gov/ia/business/EPA_BUM_Full.pdf, Ch. 10, p. 9.
[15] http://www.energystar.gov/ia/business/EPA_BUM_Full.pdf, Ch. 6, p. 8.

According to EPA's Building Upgrade Manual, "lighting consumes close to 35 percent of the electricity used in commercial buildings in the United States and affects other building systems through its electrical requirements and the waste heat that it produces. Upgrading lighting systems with efficient light sources, fixtures, and controls can reduce lighting energy use, improve the visual environment, and affect the sizing of HVAC and electrical systems."

The payback of investment in these two measures is between 4.5 and 8.5 years, according to the City's Siemens contract (see Appendix C). Completing these retrofits in all appropriate buildings is highly recommended.

Action: Creation of a "Green CIP" budget for yearly efficiency improvements of City facilities and infrastructure.

Responsible Department	All City Departments submitting yearly Capital Improvement Plans.
GHG Emissions Reduction	TBD.
Annual Cost Savings	TBD.
Challenges	Cost. Many efficiency improvements are not included in the annual Capital Improvement Program (CIP) because of high cost and lower priority than other vital department needs.
Benefits	Eliminates purchasing silos, and identifies department-specific efficiency improvements that could be made if funds allowed. The Green CIP will help to identify worthwhile efficiency improvements that could be made, but might otherwise not be included in a department's request due to lower priority.
Action Status	New policy for 2014. Green CIP submissions will begin prior to the 2015-16 budget cycle.

The City Sustainability Committee and ERC recommend the creation of a "Green CIP", an annual plan for energy efficiency-related capital improvements needed at the various department buildings. The City's current Capital Improvement Program (CIP) focuses on priorities for funding of capital infrastructure investment in the City.

While the ERC strongly recommends that City departments consider all facility upgrades as an opportunity to install more energy efficient equipment and infrastructure (such as boiler upgrades and new windows), it recognizes the value in establishing a secondary, "Green", CIP which could allow City departments to identify worthwhile, department-specific energy-efficiency improvement needs (such as centralized air conditioning, or new LED outdoor lighting), that might otherwise not be considered high enough priority to be included in their annual CIP request. This Green CIP would also help to eliminate purchasing silos by identifying needs that span departments (for example, purchasing new LED lighting in bulk for outdoor lighting upgrades at all City buildings, rather than hiring electricians to buy and replace a few lights at a time, over an extended period).

The Green CIP will function as a yearly list of priority sustainability upgrades, which could be managed by the City's Sustainability Coordinator. The ERC recommends that the Sustainability Coordinator endeavor to research and apply for grant funding to cover all or some of these improvements.

Transportation Actions

Action: Replace existing municipal vehicles with better fuel economy models, and establish MPG purchasing standards.

Responsible Department	Each department with non-emergency vehicles.
GHG Emissions Reduction	1.66 metric tonnes of CO_{2e} per vehicle per year, if the MPG standards rose from 20 MPG to 29 MPG.[16]
Annual Cost Savings	Roughly $654 per vehicle per year[17].
Challenges	For many vehicles, serviceability versus sustainability, and the cost to upgrade the City's fleets.
Benefits	Fosters a culture of energy consciousness; reduces or eliminates emissions from City's non-emergency fleet. Increased MPG also decreases the costs for fueling each vehicle.
Action Status	The City applied for a 2013 Central Maine Power grant for funding towards the lease of a 2014 Nissan Leaf, a plug-in Hybrid Electric Vehicle (PHEV). If this grant is awarded, the City intends to evaluate the functionality/practicality of the PHEV as the new two-wheel drive non-emergency fleet vehicle. The City is also updating the RTA software program, which tracks the City's vehicle inventory, and includes information on fuel consumption, age, and mileage, to better be able to identify opportunities to phase out and upgrade inefficient, older vehicles.

The City currently has vehicle efficiency standards, but these standards have not been updated in many years. Opportunity exists to raise these standards. The ERC recommends that the City adopt the vehicle fuel efficiency ratings published by the Massachusetts Department of Energy Resources' Green Communities Division.[18] These standards were developed using 2010 EPA data on combined city and highway MPG ratings, and have been successfully adopted in many Massachusetts cities and towns.

The standards recommended are:

- 2 wheel drive cars: 29 MPG
- 4 wheel drive cars: 24 MPG

[16] http://www.epa.gov/otaq/climate/documents/420f11041.pdf, p. 2.

[17] The annual cost savings and emissions reduction estimates are based on the following assumptions: Cost of gasoline: $3.50/gallon; Fuel efficiency of new vehicle: 29 mpg; Fuel efficiency of replaced vehicle: 20 mpg; Average annual miles: 12,042 per vehicle. Sources: Fuel Economy.gov (find a car): http://www.fueleconomy.gov/feg/findacar.htm.

[18] http://www.mass.gov/eea/docs/doer/green-communities/grant-program/criterion-4-guidance.pdf

- 2 wheel drive SUVs: 21 MPG
- 4 wheel drive SUVs: 18 MPG
- 2 wheel drive small trucks: 21 MPG
- 4 wheel drive small trucks: 19 MPG
- 2 wheel drive standard trucks: 17 MPG
- 4 wheel drive standard trucks: 16 MPG

Heavy-duty vehicles (those with a manufacturer's gross vehicle weight rating of more than 8,500 pounds) and all emergency vehicles will remain exempt from these purchasing standards. (However, some emergency vehicles have already voluntarily been replaced with Flex Fuel models with "Active Fuel Management" systems, allowing employees to save fuel during light load conditions, while still driving a vehicle with the required power and acceleration of a V-8 engine.) At current tally, the City has 97 vehicles that could eventually be replaced with new models meeting the above standards.

The ERC also recommends that City departments begin to identify fuel-efficiency as a consideration when replacing their smaller vehicles as well, such as commercial lawn mowers. The U.S. Department of Energy offers a *"Clean Cities" Guide to Alternative Fuel Commercial Lawn Equipment*, which lists options for fuel efficient and alternative energy-powered commercial equipment.[19]

Action: Re-examine the purchase of alternative fuels, such as biodiesel from a renewable source, for all appropriate vehicles and equipment. This item might include the installation of a fueling station for the municipality.

Responsible Department	Public works - maintenance and fueling; Transportation/Bus Department.
GHG Emissions Reduction	The use of B20 reduces CO_{2e} by 15%. B100 reduces emissions by 75% when compared to petroleum diesel.[20]
Annual Cost Savings	TBD.
Challenges	Getting municipal staff behind the change in light of a previously "unsatisfactory" trial with biodiesel; high costs for mandated safety measures at storage facilities if fleet converted to natural gas.
Benefits	Dramatically decreased emissions, no engine modifications required for biodiesel. Biodiesel is also non-toxic, and less combustible than traditional diesel.

[19] http://www.afdc.energy.gov/pdfs/52423.pdf

[20] http://www.afdc.energy.gov/fuels/biodiesel_benefits.html

Action Status	Ongoing. On November 5, 2013, citizens of South Portland voted to approve a bond to finance a new municipal services facility on Highland Avenue. This new facility will house a central fueling station for the municipality. The City has also attended multiple workshops as a stakeholder in the Maine Clean Communities Program on biodiesel and compressed natural gas for municipal fleets. These 2013 workshops included presentations and Q & A with fleet managers who utilize alternative energy sources (such as Oakhurst Dairy and Casella/Pine Tree Waste), and representatives from Maine Standard Biofuel and Advanced Fuel Solutions, Inc.

The City performed a trial-run of bio-fuels in 2008. While that trial was unsuccessful, the City hopes to re-examine the use of biofuels and take advantage of new technologies and lower per-gallon costs. Other New England municipalities and businesses are now using biodiesel for their fleets, with great success through improved technology and different mixtures of biodiesel. The most commonly used grade of biodiesel is B20 (i.e. 20% bio-fuel, 80% petroleum-based diesel, by volume). This fuel, in general, requires no changes to engines to run effectively. The City of Keene, New Hampshire has been using B20 for multiple years in all of their municipal fleet and equipment, including police and fire trucks, construction equipment, and all vehicles with no problems,[21] and Cape Elizabeth and Falmouth have recently started using B20 as well. L.L. Bean has been using B20 biodiesel in their fleets since 2003. A number of local businesses and municipalities are also experimenting with using a higher mix of biodiesel during the warmer months and B20 in the winter.

Workshops through Maine Clean Communities have provided the City with contacts from local biodiesel suppliers, who spoke to their production, availability, and potential contract potential for local fleets. Representatives from local Oakhurst Dairy and Casella/Pine Tree Waste, whose fleets both run on biodiesel, recommended its usage by other area fleets, and did not report any major issues. Casella’s fleets in Vermont are also using compressed natural gas (CNG) successfully.

(The ERC does recommend, however, that any shift to biodiesel should be using fuel for which the plant basis is a local Maine or New England source. This caveat is based on the enormous GHG emissions and costs of using plant-based sources that must be transported long distances to Maine for use.)

[21] http://www.ci.keene.nh.us/departments/public-works/fleet-services

Action: Purchase, as they become available, systems that reduce the energy usage of add-on equipment vehicles such as police and fire vehicles without sacrificing operational efficiency.

Responsible Department	Police and fire departments.
GHG Emissions Reduction	A reduction of five minutes of daily idling time for a single vehicle can save 250 pounds of CO_{2e} per year.[22]
Annual Cost Savings	Depends upon technologies that become available for purchase.
Challenges	Initial cost due to the size of the City's fleet. IdleRight2 Fuel Management Systems, for example, can cost upwards of $550 per vehicle for purchase and installation. IdleRight2 systems are also best-suited for detail vehicles, not regular patrol cars, as they do not allow for heat and AC to remain on when the engine is off.
Benefits	Allows the engines of emergency vehicles to be turned off, while still maintaining battery power to operate lights.
Action Status	Ongoing. The City of Portland tested "IdleRight" System on police cars in 2011, and passed their findings on to South Portland. The system has been installed for a "trial-run" on one South Portland police detail vehicle, which is predominately used at construction sites.

The ERC recommends that the City investigate the purchase of a system that reduces the energy usage of add-on equipment vehicles like police, fire, and construction, without sacrificing operational efficiency such as the IdleRight™ system used in police cars in Portland and Falmouth.

IdleRight™ is compatible with virtually any vehicle with an automatic transmission and electronic fuel injection, and it allows a vehicle to be turned off while emergency lights are flashing without fear of killing the battery. Produced by Havis, Inc., it detects the voltage in the battery and automatically turns on the ignition when the battery needs to be charged. After the battery charges, the vehicle automatically turns off. Havis estimates fuel savings as high as 80% depending on the application and the efficiency of the emergency equipment. Havis offers a "Return on Investment" Calculator for its new "IdleRight2" system here: http://idleright.havis.com/savings.html. Newer IdleRight2 systems also track and report idling hours saved, providing an easy way for the City to track cost and energy savings associated with the technology. However, IdleRight2 systems require vehicles to have remote starters, which can increase the costs associated with installation by as much as $400.

The City currently has one system installed and working successfully, but the Police Department lacks the funds to install the system in every vehicle.

[22] Town of Falmouth Energy and Climate Protection Plan, p. 46.

Action: Strengthen and enforce existing City policy to reduce idling of both heavy and light duty vehicles.

Responsible Department	Public Works, Transit, Parks and Recreation, and Sewer Maintenance departments.
GHG Emissions Reduction	A reduction of five minutes of daily idling time for a single vehicle can save 250 pounds of CO_{2e} per year.[23]
Annual Cost Savings	A vehicle idling gets zero miles per gallon.
Challenges	Enforcement and the number of exceptions (transit buses with passengers, emergency vehicles, and etc.) required.
Benefits	Improved air quality at City facilities, reduced consumption of diesel and gasoline by City vehicles, and a reduction in pounds of $CO_{2e.}$
Action Status	Ongoing. City policy is in place, but is not actively enforced at this time.

The City is required to use cars and trucks for the general conduct of government. However, opportunities exist to minimize emissions and gasoline consumption.

Idling vehicle engines contributes to greenhouse gas emissions and air pollution. Idling a single vehicle for 5 minutes a day contributes almost 250 pounds of CO_{2e} per year. The State of Maine passed a commercial vehicle "no idling" law in 2008. The City followed suit by adopting an amended "Anti-Idling Policy" effective August 1, 2008. This City policy prohibits unnecessary idling when the ambient temperature exceeds 35 degrees F; limits idling to under five minutes when the temperature is 32 to 35 degrees, and under ten minutes when the temperature is below 32 degrees to ensure the operator has a safe level of heat. All vehicles are limited to five minutes of idling time for air conditioning when the temperature exceeds 80 degrees F.

This City policy is not actively enforced by City staff. The ERC recommends that the City routinely remind employees to not idle vehicles unnecessarily, and encourage department heads to monitor vehicle operators to identify and correct violations of City policy.

The City of Burlington, Vermont has limited idling to three minutes per hour. The ERC strongly recommends that the City follow Burlington's example and limit idling from five minutes to three in temperatures above freezing.[24]

[23] Town of Falmouth Energy and Climate Protection Plan, p. 46.

[24] http://www.burlingtonfreepress.com/article/20100112/NEWS02/100111014/.

Renewable Energy Actions

As rebates and incentives become available at the municipal level, all opportunities to include renewable energy in the City's energy portfolio will be considered.

Action: Power Purchase Agreements for the purchase and installation of solar panels for municipal buildings.

Responsible Department	City Hall; Planning; School Department; Community Center
GHG Emissions Reduction	TBD; first project savings are being tracked by Planning Department.
Annual Cost Savings	Under the current Power Purchase Agreement, a savings to the City of $0.02 for every kilowatt purchased from SoPo Solar.
Challenges	Suitability of buildings for solar installation; varied cost-savings associated with each project site.
Benefits	Zero-emission solar power is sold to the City at reduced cost. Panels can later be purchased by the City at a steep (75%) discount.
Action Status	Ongoing. The City Planning Office has installed solar panels, but some City buildings have been ruled out of the SoPo Solar program due to cost reasons. However, some buildings have installed solar panels, such as the new high school, to heat hot water systems, rather than for the purpose of electricity generation. Once these new panels are up and running, the City will be able to evaluate the cost/benefit of using panels for this purpose as well. The City's Wastewater Treatment Plant is also examining solar panels as an option for pre-heating makeup air for larger HVAC systems in the development of their facilities plan.

On November 5, 2012, the South Portland City Council passed Order #60-12/13, authorizing the City Manager to sign a Power Purchase Agreement (PPA) with SoPo Solar, LLC, a subsidiary of ReVision Energy, LLC. This agreement permitted ReVision Energy to construct, operate, and maintain a solar powered electric generation project at the Planning and Development Department on 496 Ocean Street, previously the site of Hamlin School.

This PPA authorized SoPo Solar to sell power that comes from solar panels on the current Planning Department building to the City. SoPo Solar was created to enable ReVision Energy to benefit from the Federal Investment Tax Credit, Renewable Energy Credits, and other State solar rebates and incentives. Power is to be sold to the City for two cents under current energy supply cost, and after seven years the City will have the option to buy the panels at approximately one-quarter of their original cost.

The solar orientation and resulting output is less favorable on City Hall than on the Hamlin School, causing the discount for installing solar panels on City Hall to be only one cent under supply cost.

As such, the City Council does not currently believe that City Hall building should be included as a future five panel host site in the PPA.

The Community Center was also considered as a possible panel site, but due to the larger size of the facility reducing the rate paid for electricity, the savings would not be enough to justify a project. However, the old Hamlin School, being a relatively small electricity user, pays a higher rate and was found to expect more savings. The building was chosen due to the slope, orientation, and height (which affects installation costs) of the roof.

The impact of this project on greenhouse gases will be determined by Planning Officials, who are documenting energy use, respective savings, and monitoring performance of the solar panels over time. The City hopes that by quantifying and documenting benefits and savings, local businesses and taxpayers will be more inclined to expand their renewable energy portfolios as well.

Action: Complete a feasibility analysis and construct a South Portland Landfill Solar Array.

Responsible Department	Executive & Planning Departments.
GHG Emissions Reduction	TBD by ReVision Energy Feasibility Study.
Annual Cost Savings	TBD by ReVision Energy Feasibility Study.
Challenges	Potential site limitations, financial feasibility.
Benefits	Energy production by solar array will produce emissions-free solar power on a capped landfill, which can be sold to the City and residents.
Action Status	The City Council has allocated $12,500 for a solar farm feasibility study, expected spring 2014.

The City Executive and Planning Departments have requested a solar Site Feasibility Study[25] for the South Portland Landfill located off Highland Avenue. The City has asked ReVision Energy, LLC to propose a methodology to determine the feasibility of installing a utility scale solar array on top of the capped landfill—a “brightfield” project, as these projects have been coined.[26]

According to ReVision’s proposal, this three-part study will determine the site feasibility of the project from an electrical engineering perspective, a solar suitability perspective, and a financial perspective. The electrical engineering study will determine the “feasibility of interconnecting a solar array to the utility grid, including an evaluation of the existing electrical infrastructure provided by the utility both on site and in the vicinity; to determine limitations of the existing electrical

[25] Proposal to Provide Services, City of South Portland, South Portland Landfill Solar Array Site Feasibility Study”, ReVision Energy, LLC. November. 22, 2013.

[26] “A Blue-Collar Town Goes Green”, Bloomberg Businessweek, Aug. 27-Sept. 2, 2012.

infrastructure, if any; to quantify service upgrades that may be required and the costs of such upgrades."

The solar suitability study will determine the feasibility of designing a solar array that maximizes energy production, and will include an evaluation of the existing landfill site to determine any production or cost limitations.

The financial study will include an evaluation of ownership structure options, available state and federal incentives and energy off-taker options, and a discussion of the advantages and disadvantages of these various options.

If the result of the initial three-part feasibility study by ReVision indicates that the landfill is a suitable site for a solar array, then the City will proceed with site-specific geotechnical analysis by a qualified engineering firm with related landfill experience in advance of any construction.

Category 3: Behavior Change and Policy Recommendations

The EPA recommends "supplemental load reductions" as a necessary step to reduce facility energy usage. Supplemental sources are building occupants and electronic equipment. The City and ERC recognize that policies in the workplace need to be established to reduce energy consumption. These policies cost nothing, however, they involve behavior changes at all levels of the City staff and reduce a significant amount of energy. In return, the amount of money saved can ultimately benefit the City and staff.

Action: Establish purchase and use policies to reduce solid waste.

Responsible Department	All City Departments.
GHG Emissions Reduction	TBD.
Annual Cost Savings	TBD.
Challenges	Competitive procurement is largely governed by price.
Benefits	Lower replacement and disposal costs for goods purchased by the City.
Action Status	To be implemented.

The ERC recommends that the City amend its purchasing policy to place emphasis on the durability of goods, and consider useful life along with cost. The City Sustainability Committee and Purchasing Department can work together to draft a new purchasing policy that includes language on the durability and lifespan of purchased goods.

Action: Establish and/or expand recycling at all facilities. Encourage employees to utilize the City's single sort-recycling program.

Responsible Department	All City Departments.
GHG Emissions Reduction	Measuring waste prevention is difficult, but the US EPA offers a web program[27] to track any reductions in waste disposal, and provides estimates for: 1) The quantity and composition of waste generated, 2) Waste removal costs avoided, 3) Waste prevention and recycling revenues, and 4) GHG emission reductions. The City is also researching the ULI Greenprint software program, which generates reports for members that import their waste generation data.
Annual Cost Savings	TBD.
Challenges	Most buildings only have recycling bins by photocopiers, while trash cans exist at every employee desk. It is often more convenient to throw something away than to recycle it, and confusion does exist on what can or cannot be recycled.
Benefits	Increased recycling of waste paper and other recyclable materials that would otherwise be thrown away, saving waste disposal costs for the City.
Action Status	The City now provides recycling bins for paper next to all printers and photocopiers. The provision of more recycling bins at employee desks, break rooms, and in community centers for the public is now underway.

It is important to educate employees on what can be recycled and what must be thrown away in order to increase proper recycling and reduce waste.

The City now provides recycling bins for paper next to all printers and photocopiers, and endeavors to provide recycling bins next to every City trash can in the future. Savings associated with increased recycling and waste reduction can be tracked with the EPA's "Waste Reduction and Buy Recycled Tracking Sheet", or with the ULI Greenprint software.

The ERC recommends that the City follow the example of the University of Southern Maine, which has recently introduced the "Tiny Trash Reduction Initiative."[28] USM issued all staff and faculty members a small desktop trash can to replace any larger desk side trash cans. Recycling bins were placed next to every desk to encourage increased recycling. The ERC recommends the City adopt a similar policy, and remove large trash cans from under the desks of employees.

[27] http://www.epa.gov/smm/wastewise/measure-progress.htm.

[28] http://usm.maine.edu/sustainability/tiny-trash

Action: Establish and encourage a "lights out" at night policy.

The City will encourage all employees to embrace a "lights out" at night policy. Lighting is usually the largest electricity user in City buildings. A "lights out at night" or "while not in use" policy is an effective and easy way to save electricity, reduce pollution and save municipal money.

The ERC recommends the City overcome barriers by providing education to all employees and by installing motion sensors in rooms, as mentioned in a prior action step. Sensors can save between 20%-50% of the lighting energy used.

Action: Establish and encourage the policy of turning off all office equipment at night and on weekends, and pursue new technologies which minimize electricity use by City equipment which must remain turned on or plugged in at night.

Encourage all employees to turn off all office equipment at night and on weekends where possible. Toasters, coffee makers, space heaters, and air conditioners should also remain unplugged when not in use. This benefits the City by reducing the electricity drawn by equipment that is not regularly in use.

Power management of computers and monitors can significantly reduce energy consumption and save electricity costs. Information Technology (IT) management and policies are a way to ensure computers, monitors, appliances, and lights are turned off or drawing minimal energy possible when not in use.

The City Information Technology (IT) Department is currently researching new technologies, such as those in place at Maine Medical Center, which allow for computers and other equipment to be turned off for most of the night, automatically powered on briefly for necessary security and software updates, then powered off again when not in use. The ERC recommends that the City IT Department and City Sustainability Committee actively pursue any new technologies which allow for effective management of electricity by all City electronic equipment.

Action: Promote car/van pooling, public transit, and bicycling as a means of transportation for employees.

Responsible Department	All municipal staff.
GHG Emissions Reduction	Roughly 12 tonnes of CO_2 per year (0.25 tonnes per person per year)[29].
Annual Cost Savings	Roughly $4,685/year.

[29] This estimate is based on the number of 2010 employees residing in Portland or South Portland. If 50 of these employees car-pooled to work there would be a significant reduction in GHG emissions and costs for the City employee. The example is based on the following parameters - $ 3.60/gal; 15 mpg of vehicles removed from the highway; average one-way commute 8 miles.

Challenges	Behavioral change, convenience, ability of employees to respond to an emergency, coordination of commuters.
Benefits	Reduced congestion and reduced municipal parking needs.
Action Status	The City has installed bicycle racks at all staffed municipal buildings. City Hall and the South Portland Recreation Center have shower facilities and lockers available for staff use in order to promote more active lifestyles through walking/biking and reduce vehicular commuting.

In 2010, the City staff consisted on approximately 290 full and part-time people from 43 municipalities. If eventually 150 of these folks commute another way, including car pooling and bicycling, the impact on GHG emissions in the City and the surrounding area will be substantial, saving staff money.

Total estimated emissions from the transportation sector were 89,712 tonnes CO_{2e} in 2007. Gasoline-powered passenger cars and light trucks contributed 48.4% (43,456 tonnes CO_{2e}) and 35.5% (31,819 tonnes CO_{2e}), respectively, of total transportation emissions according to the 2007 Inventory Report.

A City/School car pooling program can set an example to the larger community about the City's commitment to reducing GHG emissions.

Initially, incentives may be needed to start this program. For example, Hillsborough County, FL offers a $20 monthly subsidy to each vanpool rider and a 50 percent subsidy on bus passes to employees, resulting in 67,200 fewer miles being traveled by commuters.[30] South Portland could offer free bus passes to employees who live locally, and stipends for carpooling or choosing to ride a bicycle.

Eventually, incentives to employees who commute another way could be paid through charges for parking for staff that does not commute another way. However, this charge should be avoided if possible.

Action: Eliminate desktop printers.

Desktop printers are expensive to maintain and are not durable. Only a small few City positions need to retain a private printer.

To date, City Hall and the School Department have replaced most desktop printers with Department printers/copiers that are shared by all employees.

[30] Hillsborough County, Florida vanpool program, http://www.gohart.org/ride_guide/vanpool/hart-vanpool.html.

IMPLEMENTATION PLAN

Policy Implementation

The ERC recommends that the City begin to implement or complete the Action Steps outlined in this document: Phase 1 - Municipal Opportunities, immediately upon adoption by the City Council. The combined efforts of the City Sustainability Committee, citizen-staffed Energy and Recycling Committee, and a City Sustainability Coordinator will take this document from plan to reality, and establish the City of South Portland as a positive example of green leadership for the public, local businesses, and the region.

The Renewable Energy, Efficiency, and Transportation action items in this CAP will be addressed and implemented through the day-to-day functions of City staff. The behavioral items will require a new program designed to educate and motivate all employees to work towards sustainability goals.

As a fun jumpstart to this new initiative, employees could be presented with the current carbon footprint of their building from the GHG inventory. Next, employees can set a goal that they can all work at together so there is a measurable change so they are able to see the success they have created. This will create a team environment where workers can encourage each other to make behavioral changes that will help them reach a goal. This pilot plan was used in Portland, Oregon and garnered positive reviews. Portland called the program a “low carbon diet”, which functioned like a weight loss challenge. Many work places established “Eco-teams” and encouraged friendly competition between teams to increase the reduction in their carbon footprint. The University of Maine Orono has also established this same practice by creating dormitory “Eco Reps” and holding multiple competitions to reduce student electric use between dormitories.[31]

Webinars and educational meeting could be incorporated into the workday that educate employees how to reduce their carbon footprint. Selected individuals from the Eco-teams could be chosen to present ideas and encourage employees to make changes.

Ideas to support policy and change:

- Teaming up with other organizations and business that are encouraging sustainable practices;
- Making sure that management is trained and aware of the importance of encouraging sustainable practices in the workplace;
- Creating a life-long education program about sustainability in the workplace; and
- Using local, state, and national policies that encourage sustainable practices.

Behavioral changes can be difficult to accomplish because they require a change in existing, entrenched habits. However, with proper education from their supervisors, people can develop new habits that can make a difference to their workplace and community. Proper education includes awareness of need and benefits from the change, and encouragement/reward.

[31] http://umaine.edu/news/blog/2011/08/02/princeton-review-fiske-guides-list-umaine-among-nations-best-university-named-to-green-honor-roll/

Municipal leaders and department managers should ask themselves:

- *“What can I do to make a difference?”*
- *“How can I help my staff follow examples?” and*
- *“How can our example as a municipality help the residents we serve?”*

City leaders should establish a program that encourages employees to commute to work in ways that create no or low carbon (walk, bike ride, carpool, bus, rideshare). Incentives could be established that encourage employees to change the way they get to work. Initial investment would be incredible small and has the ability to make a large difference in the carbon footprint.

1. Increase municipal employee bus ridership. Note: The case for this action is very similar to that of car/van pooling, especially for staff that live within the South Portland and Metro systems’ area.
2. In this case, there are greater savings because a larger number of vehicles are removed from the road with the full use of each municipal bus.
3. In addition, as there is more usage of the existing transit system, investments in additional routes or more buses on existing routes can be justified.

The City’s in-house Sustainability Committee will be instrumental in the implementation of Phase 1. The action items specifically outlined in this plan have been restricted to those which are attainable and realistic, and will help the City achieve its goal of 17% emissions reductions by 2017. However, there are many additional items that have been identified that are also being pursued by City staff. The ERC recommends incorporating new items into this living document as they become feasible and cost-effective.

PHASE 1 CONCLUSION

Phase 1 of the City’s Climate Action Plan is an ambitious endeavor to meet a lofty goal: 17% emissions reduction by 2017. However, the ERC believes strongly that through both large and small City actions, that goal can be met or even surpassed.

Phase 1 identifies work being done by the South Portland municipal government. It is the firm belief of the ERC that these proposed actions—many of which are currently in progress, or soon to be adopted by City departments—will establish a solid foundation for future energy use reductions.

APPENDICES

APPENDIX A

SOUTH PORTLAND SUSTAINABILITY RESOLVE

City of South Portland Sustainability Resolve
IN CITY COUNCIL
RESOLVE #1-10/11

WHEREAS, the Council for the City of South Portland has expressed a desire to lead by supporting initiatives that reinforce the goal of creating a sustainable South Portland that benefits all people in the City through energy savings, cost benefits, and improving the health and welfare of the employees and people of the City; and

WHEREAS, the City of South Portland signed the U.S. Mayors' Climate Protection Agreement in 2007 that calls for focusing on "reducing global warming pollutants through programs that provide economic and quality of life benefits such as reduced energy bills [in residential, commercial and public buildings], green space preservation, air quality improvements, reduced traffic congestion, improved transportation choices, and economic development and job creation through energy conservation and new energy technologies"; and

WHEREAS, following the Council's guidance in passing the Resolve #3-07/08 in 2007 that resulted in the signing of the U.S. Mayors' Climate Protection Agreement, the City Manager and City staff, in conjunction with citizen committees, have begun work on framing the tenets of sustainability as they can be applied in South Portland; and

WHEREAS, the City of South Portland, as a member of the Greater Portland Council of Governments, strongly endorses the Sustainability Principles adopted in 2008 by the GPCOG Executive Committee; and WHEREAS, buildings are the major source of demand for energy and materials that produce by-product greenhouse gases (GHG), slowing the growth rate of GHG emissions and then reversing it over the next ten years is the key to keeping global warming under one degree centigrade (°C) above today's level; and

WHEREAS, the City recognizes and celebrates the initiatives that have already occurred that raise the level of awareness throughout the City for a sustainable approach to improving the quality of life for all of our citizens, while encouraging continued business vitality and economic development; and

WHEREAS, the Planning Department, in collaboration with a citizen committee, is in the process of updating the 1992 Comprehensive Plan, which will provide an opportunity for the City to incorporate and embed sustainable principles into an action plan for the City for the next five to ten years and beyond.

WHEREAS, the Executive Department initiated a department wide strategic planning process that includes sustainability principles and action steps; and

WHEREAS, City staff is working with the School Department on a sustainable procurement policy that will govern all purchases of supplies and equipment for the City. The City of South Portland is committed to policies that are fiscally sustainable for the City; and

WHEREAS, through a U.S. Department of Energy grant, the City has hired an Energy and Sustainability Coordinator to help move the City towards its sustainability goals. The City recognizes that the organizational commitment to more complex steps toward the evolution of a sustainable City requires the focus of a dedicated position or office and will seek funding to continue support of this process; and

WHEREAS, the City has engaged the services of an Energy Service Company first to perform a baseline audit of a number of municipal buildings, and then to make recommendations for energy improvements to reduce greenhouse gas emissions, to reduce energy usage, and to avoid additional expenditures from the General Fund, all of which will inform decisions on City facility planning; and

WHEREAS, a citizen-based Energy and Recycling Committee has begun a green house gas inventory that will form the basis for a Climate Action Plan that can be integrated into the Comprehensive Plan; and

WHEREAS, the Economic Development office, through a public/private partnership, is seeking to develop combined heat and power facilities in a number of locations that would reduce energy use and costs; and

WHEREAS, the Mill Creek Transit Hub project and associated planned Transit Tax Increment Financing district illustrate the use of a creative multiple stakeholder process that is the foundation of achieving a sustainable transportation system in the City. This project is emblematic of the kind of efficiency of operations, incorporation of low impact stormwater design features, efficient energy use through realignment of transit schedules and routes to encourage greater use, and provide the public with an example of municipal leadership through accomplishment of cross-organizational goals; and

WHEREAS, in advance of the development of a PACE (Property Assessed Clean Energy) Program, staff has begun discussion with the Efficiency Maine Trust, to develop a plan that will provide property owners with access to low-interest loans to allow residential and business energy upgrades; and

WHEREAS, the South Portland Bus Service has negotiated an agreement with Southern Maine Community College that will provide incentives for students during the 2010-2011 school year to ride public transportation. This goals of this program are to reduce vehicle emissions with fewer single occupancy vehicles, reduce congestion on Broadway and other roadways, and increase ridership on public transportation; and

WHEREAS, automated curbside recycling, for residential solid waste customers, begun in 2008, in South Portland and now accounts for approximately 28% of residential waste. The Energy and Recycling committee is currently working on steps to move the recycling program to the next level. Recycling and Waste Reduction will also be part of the Climate Action Plan; and a goal will be set as part of the plan; and

WHEREAS, the City of South Portland has implemented various other initiatives throughout the City to reduce costs and to demonstrate the City's commitment to sustainability, such as, for example, replacing standard bulbs with 8,800 LED Christmas lights, installing LED lights in City traffic signals, redesigning motors and equipment at the wastewater treatment plant and pump stations to run more efficiently, thereby reducing the energy load from 2.7 million KWh/year to 1.9 million KWh/year; and

WHEREAS, the LEED (Leadership in Energy and Environmental Design) rating systems, developed by the U.S. Green Building Council to encourage market transformation of the process for building design and construction, are not intended for use as a municipal code, and there are also numerous standards, usually in the form of allied building codes that, if they are added to existing codes, can result in confusion and conflicts, adding to the complexity of meeting the goals and metrics to reduce Greenhouse Gases, energy consumption, and reliance on fossil fuels. The City will continue to explore ways to encourage and support the use of LEED criteria in renovation and construction of both municipal and private sector projects.

NOW THEREFORE BE IT RESOLVED, that the City Council, City Manager, Staff and stakeholders of the City of South Portland pledge themselves to complete the implementation of policies and actions that will meet the goals for greenhouse gas reduction initially set by the U.S. Mayors' Climate Protection Agreement and the completed South Portland Climate Action Plan; and

BE IT FURTHER RESOLVED, that an in-house team, consisting of at least one City Counselor, representatives of City Departments, in conjunction with established municipal committees, shall serve as the municipal sustainability champions to develop and implement policies for all City projects; and

BE IT FURTHER RESOLVED, that the City will develop stakeholders' groups of residents, business owners, school officials, and other interested parties to implement the action agenda provided by the Climate Action Plan in the following building sectors – municipal, schools, residential, commercial, and industrial; and

BE IT FURTHER RESOLVED, that once the Climate Action Plan is completed, steps will be taken by the In-house Team and stakeholders' groups to develop implementation strategies to meet the goals recommended in the Climate Action Plan, in conjunction with the ongoing Comprehensive Plan process, in the following areas – Land Use, Transportation Planning, Renewable Energy, Energy Efficiency, Sustainable Building Practices, Water and Wastewater Management, Recycling and Waste Reduction, and Education and Outreach; and

BE IT FURTHER RESOLVED, that by the time the current City electrical supply contracts begin to expire in 2012, the City will have in place the legal and operational framework for a nonprofit Municipal energy supply company or an equivalent vehicle. The goals of this action are to reduce the power costs for the residents, businesses, and the municipality, and to provide funding outside of the General Fund for future municipal projects; and

BE IT FURTHER RESOLVED, that education of the citizens of the City is a critical component of the increasingly complex actions that will be necessary to keep moving toward a sustainable and resilient South Portland. After providing education in the techniques of sustainable thinking with municipal staff and departments, the City will expand the education process to the residents and business owners to ensure the public is receiving sufficient information, guidance, and support to provide the incentives for all to act with a sustainable intent. Over time the goal is that citizens will educate each other about the latest thinking and the effect of the myriad decisions that we each make in our lives; and

BE IT FURTHER RESOLVED, the City of South Portland will accomplish the aforesaid goals according to the following schedule.

- Late Fall, 2010 – Implement an Environmentally Preferable Purchasing Policy for all City departments.

- Fall, 2010 –Establish the In-house team with the charge of achieving three interdepartmental projects by the middle of 2012, in addition to the Environmentally Preferable Purchasing Policy, that are outside the scope of the Energy Services company audit and Climate Action Plan, but are creative solutions to existing issues in the City that inhibit the City's ability to move in sustainable directions.

- Late Fall, 2010 – Energy Services Company audit completed to provide the basis for prioritization of projects in City buildings.

- Spring, 2011 – Prioritize and begin implementation of the projects that have been identified through the audit by the Energy Services Company.

- Spring, 2011 – Completion of the first phase (i.e. municipal buildings, infrastructure and fleets) of the Climate Action Plan for the City. Once this plan is completed, the stakeholder groups will be activated to assist the City in the implementation of the initial action steps. This will include a timeline for implementing or achieving the steps.

- Fall, 2011 – Implement a plan, developed by the City staff (the In-house team and others), and led by the City Council members and executive staff, to provide incentives for all City employees to commute another way at least two days per week, as an example of the City's commitment to reducing single occupant vehicles on South Portland roads. The plan will be based on the assumption that with creative, sustainable thinking, ways to accomplish this goal can be found.

- Spring, 2012 – Develop procedures and parameters for on-going data collection to evaluate the success of the program and policies and to develop the next set of action items as an ongoing process to keep moving South Portland to an ever more sustainable level of operation. This will be the work of the City Council, the Energy and Recycling Committee, the In-house team and the stakeholder groups; and

BE IT FURTHER RESOLVED, that the City Manager or his/her designee shall prepare quarterly/semi-annual progress reports for City Council. These reports will identify project implementation and emission reductions.

APPENDIX B

2007 CITY OF SOUTH PORTLAND EMISSIONS INVENTORY

See digital attachment.

APPENDIX C

SIEMENS YEAR 1 PERFORMANCE REPORT

See digital attachment.

CITY OF SOUTH PORTLAND, MAINE

GHG Emissions Inventory for Base Year 2007

South Portland, Maine

Prepared by Michelle DeBartolo-Stone for South Portland's Energy & Recycling Committee

5/23/2011

Contents

INTRODUCTION: Why conduct a Greenhouse Gas Emissions Inventory?

Overview of the Earth's Climate System

Climate Change: Climate versus Weather

Although weather and climate are related, they differ in what they are describing. Weather is the local and present state of the atmosphere while climate is the statistical collection of average weather conditions at a given place, typically defined over a 30-year time period. The meteorological variables which make up weather are quantified by measurements of temperature, precipitation, humidity, pressure, winds, and cloudiness. Thus, climate is the mean and variability of each of these variables over a defined time period at a given place. Climate can also be viewed as "concerning the status of the entire Earth system, including the atmosphere, land, oceans, snow, ice, and living things that serve as the global background conditions that determine weather patterns" (IPCC, 2007, p. FAQ 1.2).

Climate change refers to the global trend of significant changes in climate since the industrial era (year 1750), especially as related to anthropogenic (human-related) causes. Climate patterns can be traced as far back as 10,000 years ago which means that the climate trends of the past 250 years can be put into the larger context of the planet's climate history. Although predicting weather beyond a few days is limited by the dynamic properties of the atmosphere, predicting climate change is a much more manageable problem; the comparison is analogous to predicting the outcome of a single roll of the dice versus predicting the statistical behavior of a large number of trials, i.e. many rolls of the dice (IPCC, 2007).

The Greenhouse Effect and Radiative Forcing

Greenhouse Effect

The Earth's climate system is powered by solar radiation. The amount of shortwave solar radiation that is absorbed by the Earth's atmosphere and surface, approximately 240 watts per square meter (W m^{-2}), must be counter balanced by the longwave (infrared or thermal) radiation that is emitted from every surface on Earth (IPCC, 2007). To maintain this balance, the temperature in the troposphere[1] needs to be -19°C. The global mean of the Earth's surface temperature, 14°C, is much warmer than the troposphere because of the natural greenhouse effect. The greenhouse effect occurs because thermal radiation emitted from the surface is absorbed by the atmosphere, including atmospheric clouds, and reradiated back to Earth. An increase of the greenhouse effect means that more heat is being reradiated back to the Earth's surface and warming the climate. The amount of warming is impacted by various feedback mechanisms especially water vapor mechanisms and mechanisms involving clouds.

The two most important greenhouse gases (GHG) are water vapor and carbon dioxide (CO_2)[2]. Water vapor is considered the most important GHG by the Intergovrnmental Panel on Climate Change (IPCC) because it is the most abundant GHG and because, in tandem with CO_2, results in feedback mechanisms that substantially increase the greenhouse effect of CO_2; water vapor almost doubles the effect of CO_2 on climate change than that of CO_2 alone (IPCC, 2007). Human activity does not directly affect the quantity of atmospheric water vapor[3], but, since warmer atmospheres contain more water vapor than cooler atmospheres, climate change stemming from human activity indirectly increases water vapor substantially.

CO_2 is the second most important GHG because it is the most abundant GHG stemming from human activities; it is also long-lived, remaining in the atmosphere on average for 120 years. More importantly, changes to the Earth's climate system set into effect by atmospheric CO_2 are irreversible for at least 1,000 years after the cessation of all CO_2 emissions (net zero emissions) (Solomon, Plattner, Knutti, & Friedlingstein, 2009).

Methane (CH_4), nitrous oxide (N_2O), ozone, halocarbons, and aerosols (small particles) also increase the greenhouse effect to various degrees (see *Global Warming Potential* below). The Global Warming Potential (GWP) of these other GHGs is higher than CO_2, but they are lower in abundance than CO_2. The atmospheric persistence of GHGs other than CO_2 varies from, for example, approximately 12 years

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[1] The troposphere is approximately 5 km above the Earth's surface.
[2] The two dominant gases in the atmosphere, nitrogen (78%) and oxygen (21%), have almost no greenhouse effect (IPCC, 2007).
[3] Human activity resulting in increased methane, CH_4, can exert a small increase in water vapor due to atmospheric processes involving CH_4 (IPCC, 2007).

for methane to 260 years for HFC-23 (which has a GWP of over 11,000 times greater than CO_2) (EPA, 2010).

Radiative Forcing

Radiative forcing (RF) is the measure of how the energy balance of the Earth-atmosphere system is influenced when factors that affect climate (such as greenhouse gases) are changed. RF can be both natural, e.g. volcanic eruptions, as well as human induced. RF is measured in W m^{-}2 and can be negative, resulting in a cooling trend, or positive, resulting in a warming trend. The impact of RF is seen in relation to the 240 W m^{-2} of infrared energy needed to maintain the Earth's energy balance.

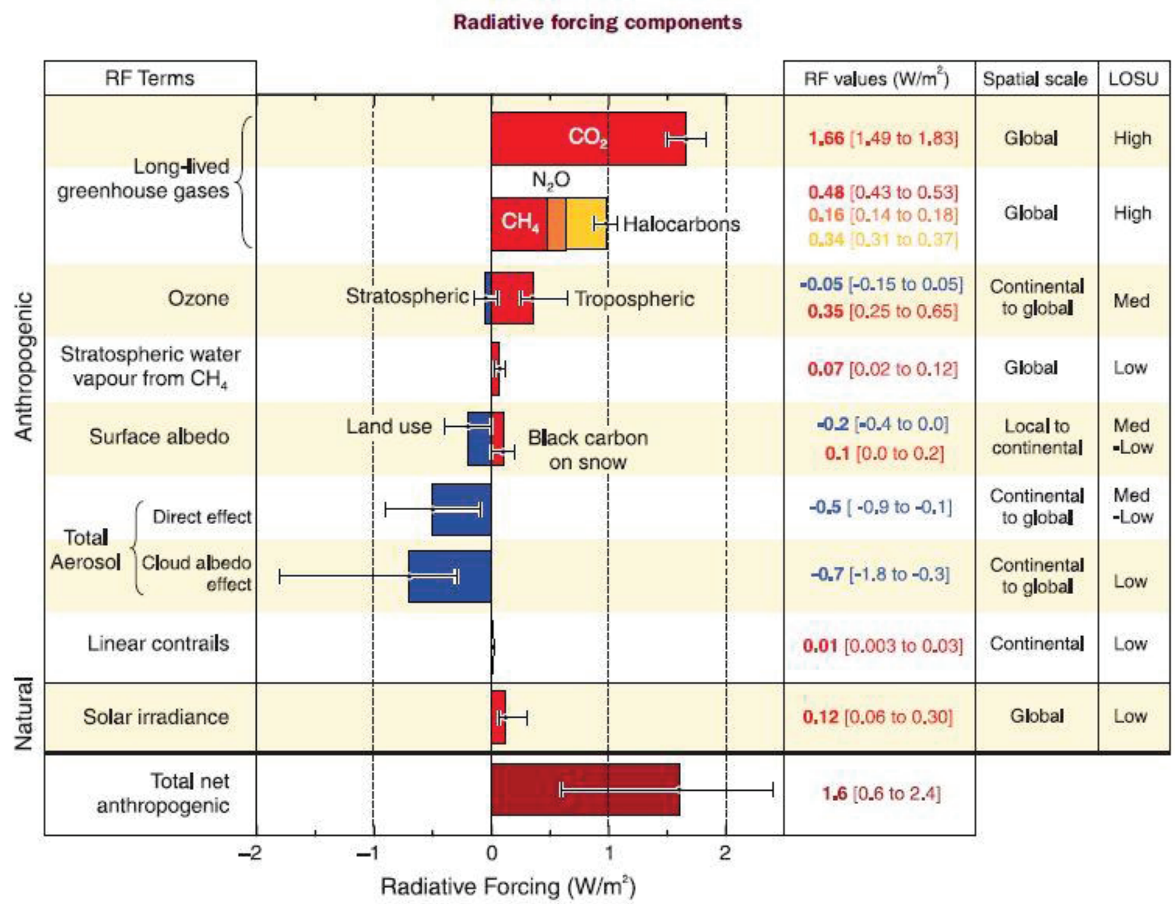

Figure 2.4. *Global average radiative forcing (RF) in 2005 (best estimates and 5 to 95% uncertainty ranges) with respect to 1750 for CO_2, CH_4, N_2O and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). Aerosols from explosive volcanic eruptions contribute an additional episodic cooling term for a few years following an eruption. The range for linear contrails does not include other possible effects of aviation on cloudiness. {WGI Figure SPM.2}*

Figure 1: Global average radiative forcing (RF) in 2005. Image copied from IPCC's *Climate Change 2007: Synthesis Report* (2007, p. 39).

According to the IPCC (2007), anthropogenic RF is estimated to be +1.6 [-1.0, +0.8][2] W m^{-2} (2005 levels relative to 1750 levels). CO_2 RF is estimated at +1.66 [1.49 to 1.83] W m^{-2} while CH_4 RF is estimated at +0.48 [0.43 to 0.53] W m^{-2} (Figure 1).

Global Warming Potentials
(100 Year Time Horizon)

Gas	GWP SAR[a]	GWP AR4[b]
Carbon dioxide (CO_2)	1	1
Methane (CH_4)*	21	25
Nitrous oxide (N_2O)	310	298
HFC-23	11,700	14,800
HFC-125	2,800	3,500
HFC-134a	1,300	1,430
HFC-143a	3,800	4,470
HFC-152a	140	124
HFC-227ea	2,900	3,220
HFC-236fa	6,300	9,810
HFC-4310mee	1,300	1,640
CF_4	6,500	7,390
C_2F_6	9,200	12,200
C_4F_{10}	7,000	8,860
C_6F_{14}	7,400	9,300
SF_6	23,900	22,800

[a] *IPCC Second Assessment Report* (1996)
[b] *IPPC Fourth Assessment Report* (2007)
* The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

Note: GWP values from the *IPCC Second Assessment Report* are used in accordance with UNFCCC guidelines.

Figure 2: Global warming potentials from the IPCC's Second Assessment Report (SAR) and Fourth Assessment Report (A4R). Image copied from EPA's Fast Facts, *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2008.*

Global Warming Potential and CO_2 Equivalent

Global warming potential (GWP) is defined by the US Environmental Protection Agency (EPA) as (EPA, 2010):

> … a quantified measure of the globally averaged relative radiative forcing impacts of a particular greenhouse gas. It is defined as the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kilogram (kg) of a trace substance relative to that of 1 kg of a reference gas (p. 1-6).

The reference gas used in determining GWP is CO_2 thus the GWP of CO_2 itself is "1." The GWP of a GHG is dependent on the time horizon over which it is being measured. The time horizon for measuring GWP agreed upon by parties to the United Nations Framework Convention on Climate Change (UNFCC) is 100 years; the EPA also uses the 100 year time horizon in accordance with UNFCC recommendations (EPA, 2010). Figure 2, Global Warming Potentials, lists the GWPs for many GHGs according to the IPCC's Second Assessment Report (SAR, 1996) and Fourth Assessment Report (AR4, 2007) (EPA, 2010). The EPA (2010) points out that GWPs typically have an uncertainty of $\pm$ 35%.

CO_2 equivalent (CO_2e) is a standard metric used to enable direct comparisons of the impacts of the different GHGs in terms of their GWPs. By convention, CO_2

equivalent is expressed in terms of metric tons (tonnes)[4]. GHGs with higher GWPs will result in more tonnes CO_2e if the absolute quantity of each GHG is the same. For example, 1 tonne of CO_2 equates to 1 tonne CO_2e, 1 tonne of CH_4 equates to approximately 21 tonnes CO_2e, and 1 tonne of N_2O equates to approximately 310 tonnes CO_2e. The total impacts of different GHGs can be determined by expressing quantities of each gas in terms of its CO_2e and then adding the results.

Evidence of Climate Change

Global Climate Change

Most of what is known about climate change has emanated from the IPCC. The IPCC was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) and is the leading scientific body for the assessment of climate change. The IPCC reviews and assesses the most recent scientific, technical, and socio-economic information produced worldwide relevant to the understanding of climate change. Multiple scientific models, representing different scenarios, are used to project the amount of warming due to greenhouse gases and aerosols, degree of climate change, and effects of climate change.

Working Group I (WG I)[5] of the IPCC (2007), report that as a result of human activities, particularly the burning of fossil fuels, deforestation, agriculture, fertilizer use, and industrial activities, the rate of increase of greenhouse gases is very likely (>90% certainty) to have been unprecedented in more than 10,000 years. As stated above, anthropogenic RF is estimated by WG I to be +1.6 [-1.0, +0.8][2] W m^{-2} (2005 levels relative to 1750 levels).

The global atmospheric concentration of CO_2, the most important anthropogenic greenhouse gas, was 379 parts per million (ppm) in 2005; this exceeds the natural range of CO_2 (180 – 300 ppm) seen over the past 650,000 years as determined from ice cores (IPCC, 2007). CO_2 emissions have increased from an average of 6.4 gigatons of carbon (GtC) per year in the 1990s to 7.2 GtC per year in 2000 – 2005. This increase is a result of increasing fossil fuel use as well as land use changes such as deforestation which results in less available biomass to serve as a carbon sink.

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[4] A metric tons (tonne) differs from a U.S., or *short*, ton; one U.S. short ton = 0.9072 metric tonnes or conversely 1 tonne = 1.10231 short tons.

[5] Working Group I of the IPCC assesses materials from the natural sciences.

RF resulting from methane (CH_4) is +0.48 W m^{-2} with a range of 0.43 – 0.53 W m^{-2}. The global atmospheric concentration of CH_4 was 1,774 parts per billion (ppb) in 2005; this exceeds the natural range of CH_4 (320 – 790 ppb) seen over the past 650,000 years as determined from ice cores. WG I of the IPCC (2007) reports that it is very likely (>90% certainty) that the observed increase in CH_4 is due to anthropogenic activities such as agriculture and fossil fuel use.

WG I of the IPCC (2007) reports that warming of the climate system is "unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (WG I, Summary, p. 5). Estimates of global average surface temperatures are derived by combining thermometer measurements taken every day at several thousand stations over land areas and thousands of measurements of sea surface temperatures taken from ships moving over oceans. Surface temperatures have increased by approximately 0.74°C over the past hundred years. Eleven of the twelve warmest years on record occurred between 1995–2006 (a twelve year span). Average arctic temperatures increased at almost twice the global average rate in the past 100 years.

Balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates that are slightly greater than those of the surface temperature record (IPCC, 2007). The stratosphere has cooled markedly since 1979 in accordance with most model results; ozone depletion caused by the recent widespread use of chlorofluorocarbons is a significant contributor to stratospheric cooling.

Global average sea level rose at an average rate of 1.8 millimeters (mm) per year over 1961-2003 with the fastest rate, about 3.1 mm, occurring over 1993-2003 (IPCC, 2007). There is high confidence (8 out of 10 chance of being correct) that the rate of observed sea level rise increased from the 19^{th} to the 20^{th} century. Ocean warming and glacial and ice cap melting both contribute to sea level rise. Observations since 1961 show that the average temperature of the ocean has increased to depths of at least 3,000 meters (m) and that the ocean has been absorbing more than 80% of the heat added to the climate system. Loses from the ice sheets of Greenland and Antarctica have very likely (>90% certainty) contributed to sea level rise over 1993-2003. Satellite data since 1978 show that annual average arctic sea ice extent has shrunk by 2.7% per decade (IPCC, 2007).

Future projections of sea level rise do not include uncertainties in climate-carbon cycle feedback or the full effects of changes in ice sheet flow due to a lack of basis in the published scientific literature (IPCC, 2007). Current projections of sea level rise during 2090-2099 relative to 1980-1999 levels range from 0.18m – 0.59m depending on the scenario (amount of radiative forcing due to anthropogenic causes) used in the models. The upper ranges of sea level rise for each scenario would increase by 0.1 to 0.2m if the amount of melting (flow rates) from the Greenland and Antarctica ice sheets were to grow linearly with global average temperature change; however, these effects are not used in the models since scientific understanding is too limited to assess their likelihood or provide a best estimate for sea level rise.

A warmer climate increases the risk of both droughts and floods. Warmer climate, "owing to increased water vapor, leads to more intense precipitation events even when the total annual precipitation is reduced slightly, and with prospects for even stronger events when the overall precipitation amounts increase" (WG I, 2007, FAQ, 3.2). More intense and longer droughts have been observed over wider areas since the 1970s and it is likely (>66% certainty) that this trend will increase in the future. The frequency of heavy precipitation has increased over most land areas and it is very likely (>90% certainty) that this trend will increase in the future. It is very likely (>90% certainty) that hot extremes, heat waves and heavy precipitation events will continue to become more frequent.

The IPCC Special Report on Emission Scenarios (SRES) reports that a warming of about 0.2°C per decade for the next two decades is projected for a range of emission scenarios and that even if concentrations of all greenhouse gases and aerosols were kept constant at year 2000 levels, a warming of 0.1°C per decade would still be expected. Furthermore, it is indicated that decadal warming over each inhabited continent by the year 2030 is very likely (>90% certainty) to be at least twice as large as corresponding model-estimated natural variability during the 20th century.

Climate Change in Maine

Historical Changes and Future Predictions

While public opinion polls show a general awareness among Americans of the scientific consensus that the Earth's climate is changing and that anthropogenic (human) causes are a significant factor in these changes, most Americans regard the environment and climate change as relatively low national priorities (Leiserowitz, 2005). Furthermore, most Americans rated local risks (risks that would impact themselves) of climate change as unlikely to occur (Leiserowitz, 2005). This is reinforced by research findings that report most Americans don't associate extreme weather events with climate change.

The overall climactic trend in Maine is a warmer and wetter climate over all four seasons (Jacobson, G.L., Fernandez, P.A., Mayewski, P.A., & Schmitt C.V. [editors]., 2009; Wake, et al., 2009). Analsyis of data collected from four meteorological stations in southern and central Maine (Farmington, Lewiston, Portland, and Rumford) shows a regional warming of 1.5 to 3.0° F since 1965 "with the greatest warming occurring in winter (1.6 to 4.9° F)" (Wake, et al., 2009, p. 2).

Precipitation in Portland has increased by 0.88 inches per decade between 1891 and 2006 due primarily to strong increases occurring in fall (Nov. – Dec) and spring (March- May); changes in quantity of winter precipitation has not been observed although the number of snow-covered days has decreased in Portland at a rate of -7.9 days per decade (1965-2005) (Wake, et al., 2009). The number of extreme precipitation events (>2" in 48 hours) between 1949 and 2006 increased by +4.1 (Wake, et al., 2009).

Sea surface temperature in the Gulf of Maine has warmed at a rate of approximately 0.06° F per decade since 1854 for a total warming of 1.0° F during the same period (Wake, et al., 2009). Sea level rise has been occurring at a rate of approximately 0.7" per decade (1912-2007) for a total rise of 12" between 1912-2007 (Wake, et al., 2009).

Another important indicator of climate change is lake ice-out dates. The ice-out countdown starts on January 1st and ends once the lake is condisdered ice-free; ice-out on Sebago Lake is when the Great Basin, or Big Bay, is ice-free. Ice out dates on Sebago Lake are occuring 23 days earlier than when ice-out dates were first recorded in 1807 (Wake, et al., 2009).

Future predictions for climate change in Southern Maine were estimated by Wake, et al. (2009) based on the highest (A1 Fi) and lowest (B1) IPCC emissions scenarios in order to get a plausible range of climatic impacts depending on such things as population, technology, demographics, and energy use. Statistical downscaling of four global model simulations provide predictions for mid-century (2050) and end-of –century 2099 (Table 1). Temperature is predicted to increase by 2.0° – 6.0° F by mid-century and 3.0° - 8.0° F by end-of-century. Precipitation by mid-century and end-of-century will increase by 5% and 10% respectively.

Table 1: Climate predictions for Southern Maine: mid- and end-of-century. Data from Wake, et al. (2009).

CLIMATE PREDICTIONS: SOUTHERN MAINE			
Time Horizon	**Temperature Increase (F)**	**Precipitation**	**Sea Level Rise (Feet)**
By mid-century	2.0° to 6.0°	Increase by 5%	9.5 – 10.3
By end-of-century	3.0° to 8.0°	Increase by 10%	11.1 – 14.3

The range of sea level rise is predicted at 9.5 - 10.3 feet by mid-century and 11.1 – 14.3 feet by end-of-century. This prediction takes into account climate related causes of sea level rise, namely thermal expansion of sea water (direct cause) and melting of glaciers and ice-caps (indirect cause), as well as a regional non-climatic influence known as “subsidence.” Subsidence is the sinking of the Earth’s crust following a post-glacial rebound (rising) of the crust. The Earth’s crust in the Gulf of Maine is sinking at a rate of approximately 0.1mm per year (0.04 inches per decade) (Wake, et al., 2009).

Consequences of Climate Change in Maine

Impacts of climate change vary from location to location and are already being felt in the state of Maine. Below are some excerpts from *Maine’s Climate Future: An Initial Assessment* (2009)[6] on some of these impacts.

[6] An electronic copy of *Maine’s Climate Future: An Initial Assessment* (2009) is available online from the Maine State Planning Office’s (SPO) “Planning for Climate Change” website,

Warming ocean temperatures can lead to the replacement of sub-arctic species that reside on the coast of Maine by more temperate species that will be able to out-compete Maine's native species. These changes in species compositions can impact our fisheries directly and indirectly. Due to warming temperatures on the ocean floor, Atlantic cod numbers are predicted to decline in the Gulf of Maine by 2100. Maine fishermen have noticed significant changes in the lobster fishery, including altered growth and migration behavior. Shift in species compositions can also impact other organisms that rely on certain species as a food source. Other effects of ocean warming include increased harmful algal blooms and the arrival and/or proliferation of invasive species such as the Asian shore crab.

Freshwater ecosystems are affected by changes in temperature, precipitation, and timing of significant aquatic events. Changes in stream flow as a result of climate change have already been documented in the state of Maine; peak flows have shifted to earlier in spring and flows later in the season are lower than what has been observed historically. Freezing dates and evaporation are also changing resulting in an advancement of lake "ice-out" dates by up to two weeks since the 1800s. This has a direct negative impact on traditional Maine recreational activities such as ice-fishing, skate, skiing, and snowmobiling with implications for the tourism economy.

Other expected changes include decreased snow depth, greater lake level fluctuations, and saline intrusion of coastal aquifers. These effects will impact water-dependent wildlife such as obligate vernal pool species, insects, sea-run fish, and birds that feed on these species. Societal costs of climate change on freshwater ecosystems include threats to water quality resulting from more frequent or more intense algal blooms and salt water intrusion as well as damage to water front property resulting from increased severity of storms.

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http://www.maine.gov/spo/landuse/techassist/climatechange.htm, or from the University of Maine's Climate Change Institute at http://climatechange.umaine.edu/research/publications/climate-future.

SECTION 2: OVERVIEW OF THE GHG EMISSIONS INVENTORY PROCESS

Program Utilized: ICLEI

In 2007, the South Portland City Council issued a resolve (Resolve #3-07/08) that authorized the Mayor of South Portland to sign the *U.S. Mayors Climate Protection Agreement;* the resolve calls for the need to conserve energy, reduce energy bills, improve air quality, conserve green space, reduce traffic congestion, and improve transportation choices. Toward this end, South Portland committed resources to developing and implementing a Climate Action Plan (CAP) and in 2010 joined *ICLEI-Local Governments for Sustainability*[7], heretofore known as ICLEI. ICLEI is "a membership association of local governments committed to advancing climate protection and sustainable development" with more than 600 member cities within the US and 1,100 member cities worldwide (ICLEI, n.d.). In addition to South Portland, member communities in Maine listed on ICLEI's website are Belfast, Biddeford, Cumberland, Falmouth, Portland, Yarmouth, and York; the Greater Portland Council of Governments (GPCOG) has also used ICLEI tools to conduct a regional GHG emissions inventory. Benefits of membership include access to proprietary emissions inventory software, emission reduction estimation and prioritization programs, centralized access to supporting documents and examples of actions taken by other US communities, and a forum in which to interact with other ICLEI member communities.

ICLEI's programs fall into three related, but distinct, categories: Sustainable Development, Climate Adaptation, and Climate Mitigation. The climate mitigation program is based on an iterative, five milestone methodology of which the cornerstone is the recognition of the need for, and commitment towards developing, a CAP by public officials and other community leaders. Once leadership commitment is secured, the first step towards developing a CAP is conducting a baseline, emissions inventory for a given year (Figure 3). Each milestone involves multiple steps. For instance, milestone two, establish an emissions target, involves identifying a target year by which emission reductions will be achieved, estimating a business-as-usual (BAU) scenario for emissions in that target year[8], and then

[7] ICLEI-USA's website: http://www.icleiusa.org/. ICLEI was initially established in 1990 as the "International Council for Local Environmental Initiatives," but is now officially ICLEI-Local Governments for Sustainability.
[8] A business-as-usual (BAU) scenario is an estimate of emissions assuming no actions are taken to reduce emissions.

determining the level of emission reductions that are desired and possible given the opportunities and constraints within a specific community.

Figure 3: ICLEI- Five Milestone Methodology for Climate Mitigation.
Figure from ICLEI: http://www.icleiusa.org/programs/climate/mitigation

CACP Software

Foremost amongst ICLEI's resources and tools is its Clean Air Climate Protection (CACP) software developed by ICLEI in partnership with the National Association of Clean Air Agencies (NACAA)[9]. South Portland's GHG and criteria air pollutant emissions inventory was conducted using the CACP software, version 2.2.1b. Including GHG emissions accounting, the CACP software can aid communities in four broad tasks (ICLEI & NACAA, 2003):

1. Create an inventory of greenhouse gas and criteria air pollutant emissions for a base year.
2. Forecast emissions growth to create an inventory of predicted emissions for a future year.
3. Evaluate measures to reduce emissions of these [emissions and] pollutants
4. Prepare emissions reduction action plans (p. 6).

[9] The NACAA was formerly the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO).

The primary GHGs estimated by the CACP are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The criteria air pollutants estimated by the CACP are nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), volatile organic compounds (VOC), particulate matter 10 microns (PM_{10}), and particulate matter 2.5 microns ($PM_{2.5}$).

The CACP software includes two modules used for conducting an emissions inventory: (1) government analysis module and (2) community analysis module. The government analysis module looks at emissions stemming from government operations and is organized by sectors. The sectors included in the government analysis module are:

- Buildings and Other Facilities
- Streetlights and Traffic Signals
- Port Facilities
- Airport Facilities
- Water Delivery Facilities
- Wastewater Facilities
- Solid Waste Facilities
- Vehicle Fleet
- Transit Fleet
- Employee Commute
- Electric Power (Generated by government)
- Other Process and Fugitive Emissions
- Refrigerants

The second module within the CACP software used for conducting an emissions inventory is the community analysis module. The community analysis module is organized by much broader sectors: residential, commercial, industrial, transportation, waste, and "other. The "other" sector is used to enter absolute amounts of GHGs or criteria air pollutants that are not accounted for in any of the other community sectors. Government emissions calculated in the government analysis module are included under the "community" umbrella so should not be directly entered in the community analysis module as this would result in double counting of emissions.

An essential companion to the CACP software was the *Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions Inventories* (LGOP)[10], V1.1 (2010). The

[10] The LGOP uses principles and guidelines set forth by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) in the *GHG Protocol Corporate Standard:* http://www.ghgprotocol.org/standards/corporate-standard.

LGOP was developed by ICLEI in partnership with the California Air Resources Board (ARB), California Climate Action Registry (CCAR), and the Climate Registry and includes comprehensive methodology for GHG emissions accounting including determination of organizational and operational boundaries. The LGOP provides the written methodology on best use of the CACP software as well as the background formulas and models used within the CACP software. The LGOP is not directed towards conducting a community wide GHG emissions inventory, but some of its broad principles can apply at the community level.

Organizational and Operational Boundaries

Before beginning a GHG emissions inventory, a community must first define its organizational and operational boundaries in order to determine how and what emissions should be counted. Organizational boundaries are based on one of two control approaches: operational control or financial control. The LGOP strongly recommends that communities use the operational control approach. Operational control is established if the community "wholly owns an operation, facility, or source" and/or has the "full authority to introduce and implement operational and health, safety and environmental policies" (LGOP, 2010, p. 14). An emissions inventory organized by operational control would count emissions from sources that meet one or both of these logical tests.

Financial control is established if one of more of the following criteria is met (LGOP, 2010):

- An operation, facility, or source is wholly owned.
- An operation considered, for the purposes of financial accounting, a group company or subsidiary, and whose financial accounts are consolidated within the financial statements of the organization conducting the inventory.
- An operation governing the financial policies of a joint venture under a statute, agreement, or contract.
- An operation or facility that is part of a joint venture or partnership for which the majority of the economic benefits and/or financial risks are retained.

Operational boundaries of an emissions inventory are the emission sources to be included in the inventory based on the type of organizational control set above, i.e. operational or financial control. Anthropogenic source categories for GHG emissions include stationary combustion, mobile combustion, process emissions, and fugitive emissions (WRI & WBCSD, 2004):

- Stationary combustion: combustion of fuels in stationary equipment such as boilers, furnaces, burners, turbines, heaters, incinerators, engines, flares, etc.
- Mobile combustion: combustion of fuels in transportation devices such as automobiles, trucks, buses, trains, airplanes, boats, ships, barges, vessels, etc.
- Process emissions: emissions from physical or chemical processes such as CO_2 from the calcination step in cement manufacturing, CO_2 from catalytic cracking in petrochemical processing, PFC emissions from aluminum smelting, etc.
- Fugitive emissions: intentional and unintentional releases such as equipment leaks from joints, seals, packing, gaskets, as well as fugitive emissions from coal piles, wastewater treatment, pits, cooling towers, gas processing facilities, etc. (p. 41).

Setting of operational boundaries also includes categorizing emissions as direct or indirect emissions and assigning the "scope of accounting" (LGOP, 2010, p. 22). Scopes are used in order to avoid double counting emissions by two or more organizations. Scope 1 emissions are direct emissions occurring within the set organizational boundaries. Examples of scope 1 emissions are fuel combustion in city owned furnaces or boilers. Scope 2 emissions are indirect emissions resulting from electricity purchased from a facility outside of the organizational boundary, and often outside of the geographic area in which scope 1 emissions are occurring. Scope 3 emissions are indirect emissions other than those stemming from purchased electricity. Examples of scope 3 emissions are outsourced activities such as waste disposal; emissions stemming from EcoMaine's waste incineration plant in Portland would be counted as scope 3 emissions.

Emission Factors

Since direct monitoring of emissions is cost prohibitive and not feasible for many communities, emissions are instead estimated using fuel use data and emissions factors. The CACP software converts activity data into GHG and criteria pollutant emissions using default[11] emissions factors. A generalized formula illustrating this operation is as follows (LGOP, 2010):

$$Activity\ Data\ \times Emission\ Factor\ = Emissions$$

Activity data includes the type and quantity of fuel used in stationary and mobile sources and metered electricity usage. CO_2 emissions stemming from stationary and mobile sources are directly related to the quantity of fuel combusted; however, CH_4 and N_2O emissions are more dependent on "technology type

[11] Customized emission factors can be used within the CACP software.

and combustion characteristics, pollution/emission control technologies, and maintenance and operational practices" and so are more uncertain than CO_2 emissions estimates (LGOP, 2010, pp. 41, 64). Activity data for mobile combustion CH_4 and N_2O emissions also includes vehicle miles traveled (VMT) or vehicle type (size class) and model year in order to capture differences in emissions stemming from specific technology. Differences in CH_4 and N_2O emissions in stationary sources are estimated by use of average emission factors specific to residential, commercial, and industrial sectors.

Emission factors are defined by WRI & WBCSD (2004) as "calculated ratios relating GHG emissions to a proxy measure of activity at an emissions source" (p. 42). An emission factor is usually expressed in terms of quantity emissions generated per quantity energy used, e.g. lbs of CO_2 / kWh or kg CO_2/gallon). The CACP analyses modules uses four sets of emission factors:

1. Average GRID electricity coefficients:
    a. Regional specific electric grid coefficients taken from EPA's Emissions and Generation Resource Integrated Database (eGRID)[12]. These coefficients include emission factors for CO_2, CH_4, and N_2O and take into account fuel mix used by regional electric power plants. The year of the eGRID coefficients chosen should be as close to the inventory year as possible[13].
        i. Maine's eGRID region is "NEWE."
    b. North American Electric Reliability Corporation (NERC) regional coefficients for criteria air pollutants (NO_x, SO_x, CO, VOC, PM_{10})[14]. The year of the NERC region coefficients chosen should again be as close to the inventory year as possible[15].
        i. Maine's NERC region is "07: Northeast Power Coordinating Council/New England."
2. Fuel CO_2 emissions coefficients:

[12] Information on EPA's eGRID tool, as well as emission factors by electric grid region can be accessed online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.
[13] 2005 was the closest available eGRID year, to the 2007 base year inventory, at the time the inventory was conducted (Summer 2010).
[14] Additional information about NERC and a map of the NERC region can be accessed online at: http://www.eia.doe.gov/glossary/index.cfm?id=N#nerc.
[15] 2005 was the closest available NERC year, to the 2007 base year inventory, at the time the inventory was conducted (Summer 2010).

CO_2 emissions factors for 64 different fuel types. CO_2 emissions factors are separate from other GHG emissions and criteria pollutants because CO_2 emissions are not dependent on technology types.

3. Transport average coefficients:

   CH_4, N_2O, and criteria air pollutant emission factors for mobile sources. These coefficients are used when vehicle miles traveled (VMT) by vehicle and fuel type is not known. Emission factors are given for 14 fuel types based on the type of vehicle (e.g. on-road/off-road), size class (e.g. passenger car, light duty, heavy duty), and average fuel efficiencies:

   > For each vehicle/fuel combination, the software contains distance-based emission factors and fuel economy associated with each vehicle class. For each vehicle/fuel combination, the software contains historical and projected emission factors and fuel efficiency values for the years 1990-2020. This accounts for changes in the average on-road vehicle fleet over time (e.g. aging of the fleet) (ICLEI & NACAA, 2003, p. 18).

4. RCI (Residential, Commercial, and Industrial) average coefficients:

   CH_4, N_2O, and criteria air pollutant emission factors for 23 fuels commonly used in the residential, commercial, and industrial sectors.

Default emissions factors and eGRID/NERC region emissions factors used for South Portland's base year inventory are included in *Appendix I: Emissions Factors*. The default emissions factors (Fuel CO_2, Transport Average, and RCI Average) included in the *Appendix I* were exported from the CACP 2009 software, V2.2.1b, and were the default emissions factors used for South Portland's 2007 base year inventory. The eGRID/NERC region emissions factors are excerpted from tables provided by ICLEI[16], but in the case of eGRID can also be accessed from the US EPA's *Clean Energy Resources* website provided above.

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[16] eGRID and NERC tables can be found within ICLEI's online 2009 CACP User Guide, Appendix A at http://www.icleiusa.org/action-center/tools/cacp-software/user-guide/appendix-a-electricity-emissions-factors (password required).

SECTION 3: 2007 SOUTH PORTLAND GHG EMISSIONS INVENTORY

Government Analysis: Methodology

Inventory Boundaries

The base year chosen by South Portland officials and the Energy and Recycling Committee was calendar[17] year 2007 (Jan 2007 – December 2007). Data for calendar year 2007 was not available for the transit and vehicle fleet so calendar year 2008 (Jan 2008 – December 2008) data was used instead. Wastewater treatment N_2O emissions were for fiscal year 2007 – 2008 (July 2007 – June 2008), but wastewater treatment emissions are estimated using formulas, i.e. they are not absolute emissions from direct monitoring, so a six month shift will have no effect on reported emissions.

The government organizational boundary used by South Portland was determined by operational control rather than financial control. This approach ensured that most government emission sources were included in the inventory. The operational control test is also the approach recommended by the LGOP (2010).

Operational boundaries for the government analysis were broadly defined by the sectors within the CACP software. The sectors included in the 2007 inventory were:

- Buildings and Other Facilities
- Streetlights and Traffic Signals
- Vehicle Fleet
- Transit Fleet
- Wastewater Facilities
- Water Deliver Facilities (irrigation and sprinkler electricity use only)

The sources included within each of these sectors are detailed under the *Government Analysis: Inventory Results* heading below. Emissions from fuel combustion at stationary sources (e.g. boilers, furnaces, waste water pump stations[18], and generators) were included in the inventory and counted as scope 1 emissions. Emissions from government owned mobile sources (e.g. gasoline and diesel for the transit

[17] Calendar years are commonly used by most international and national emission inventory standards; the LGOP strongly recommends using calendar year rather than fiscal year for consistency between communities.
[18] Fuel data was not available for all pump stations for base year 2007. For more information see details under the Government Analysis section of the report.

and vehicle fleet) were also counted as scope 1 emissions. Purchased electricity for government operations (e.g. buildings, waste water pump stations, street lights and traffic signals) were included in the inventory and counted as scope 2 emissions. Finally, N_2O emissions from the wastewater treatment plant were also included in the inventory and counted as scope 1 emissions.

South Portland does not have operational control over Portland Water District (PWD) facilities (water delivery) or EcoMaine facilities (solid waste disposal). Thus, government emissions from these sectors were counted as scope 3 emissions and included in the *Community Analysis* module. Within the community analysis module, government emissions from water usage could be estimated (See *Water Delivery* under *Community Analysis: Inventory Results*); however, emissions from solid waste were provided on the community level and so an estimation of government emissions from solid waste was not broken out.

2007 Inventory Data Sources

A comprehensive list of on-site fuel combustion (e.g. furnaces, boilers, and generators) and electricity usage for buildings and facilities was not available for the 2007 inventory. South Portland's Accounts Payable and Finance departments provided billing information for stationary sources' energy use categorized by department and address or, sometimes, by building name. Often multiple sources of information had to be used to associate fuel usage with the correct building or facility. Except as noted below, billing information provided the inventory data for locations of energy use, fuel types, quantities, and costs. When necessary, hard copies of supplier bills found in house were referenced for fuel quantities; this was the case for almost all natural gas usage with the exception of schools' natural gas usage.

While it would appear most billing is handled through the accounts payable office, with the notable exception of schools' electricity and natural gas usage, some minor usage billed directly to, and paid by, individual departments was found. To ensure that the emissions inventory was as complete as possible, an inventory of energy consuming buildings/facilities along with the types of fuels being consumed was created while the inventory was being conducted based on financial records. Each department was asked by South Portland's Assistant City Manager, Erik Carson, and Sustainability Coordinator, Ann Archinhowe, to review the buildings/energy sources list for corrections, additions, and comments. The

Water Resources department provided information on the existence of two diesel generators at the wastewater treatment plan, propane usage at seven pump stations, and diesel usage at one pump station that wasn't captured from accounts payable financial records; unfortunately records from 2007 were not available for these sources. The Transportation & Waterfront Department provided information on average annual kerosene (K-1) usage at the Bus Service's office located at the 42 O'Neill St complex; records for kerosene usage were not available so the average usage (250 glns) was used for the 2007 inventory.

As noted above, electricity and natural gas is billed directly to the South Portland School Department. Hard copies of annual summaries of electricity and natural gas usage were obtained from the school department. The summaries included quantity of fuel/electricity only, not costs. Cost data was subsequently obtained from South Portland School Department's Director of Buildings and Grounds, Scott McKernan. Usage was categorized by schools. Only one meter each for natural gas and electricity was listed for each school; no indication was given in the usage reports of the existence of additional meters at each school, e.g. for secondary buildings or outbuildings. City employees familiar with the schools indicated that, most likely, the only missing usage would have been for school crosswalks which would have incurred minimal usage. An important note regarding schools is that South Portland's Community Center and the South Portland High School share a Central Maine Power (CMP) electricity meter. Based on historical usage patterns, it was assumed that the provided electricity data for the high school included community center usage; a break out was obtained by Ann Archinohowe and usage was separated between the high school and community center for the 2007 inventory.

Outside sources of data were required and obtained for the following buildings from each respective supplier:

- Water Resources, office and garage on Highland Ave: Propane usage from Maingas, Inc.
- Branch Library/Golf Clubhouse on Wescott Ave: Propane usage from Dead River and Downeast Energy.
- Fire Dept, Cash Corner Station: Propane usage from Royal River/Broadway Industries Corp.
- Fire Dept, Thornton Heights Station: Propane usage from Downeast Energy.

Fuel use data by mobile sources, i.e. vehicle and transit fleets, was provided by South Portland's Public Works department. Transit gasoline and diesel records were organized by department, i.e. fuel account numbers, and then by fuel key numbers and vehicle name/number. Public Works' data included dates of usage, fuel type, quantity, and cost. Odometer readings were included on the reports, but were generally viewed as unreliable for the 2008[19] year. Vehicle type, e.g. size class and model year, was obtained from most departments including Public Works, Parks and Recreation, Schools, Fire Department, Water Resources, and the Bus Service (transit fleet). Fuel key/vehicle numbers from each department's vehicle inventory list was matched to the fuel key/vehicle number on the fuel usage reports. The Finance Department also provided a comprehensive list of vehicles including make, model, and year; however, the Finance Department list did not include fuel key/vehicle numbers in most instances. Vehicle types were not available for all vehicles on the fuel usage reports. Emissions from vehicles of unknown size class and model years were calculated for CO_2 only; CH_4, N_2O, and criteria pollutants could not be estimated.

Fugitive wastewater treatment emissions were estimated using an ICLEI Microsoft Excel workbook containing formulas for estimation of methane and nitrous oxide from wastewater treatment processes. Positive entries within the workbook were population served, utilization of aerobic or anaerobic processes, utilization of nitrification/denitrification, and whether lagoons and/or septic systems were used. James Jones, the Treatment Systems Manager, for South Portland filled out the workbook for fiscal year 2007-2008.

Government Analysis: Inventory Results

Overview: All Sectors

South Portland's total 2007 GHG emissions were 10,095 tonnes CO_2e (Table 2). Total energy usage for the same period was 113,453 million Btu (MMBtu). Costs were approximately $3.039 million.

[19] Mobile sources' fuel data was not available for calendar year 2007.

Table 2: 2007 South Portland government emissions, energy costs, and energy output by sector.

South Portland: GHG Emissions Inventory Overview (2007)						
Sector	**Cost ($)**	**Cost (%)**	**Energy Output (MMBtu)**	**Energy Output (%)**	**CO2e (tonnes)**	**CO2e (%)**
Buildings: Heat & Hot Water	894,294.45	29.4%	54,539.1	48.1%	3,766.6	37.3%
Buildings: Electricity	794,822.04	26.2%	17,665.0	15.6%	2,194.6	21.7%
Total Buildings	**1,689,116.49**	**55.6%**	**72,204.1**	**63.6%**	**5,961.2**	**59.1%**
Wastewater	399,039.96	13.1%	12,454.2	11.0%	1,833.6	18.2%
Vehicle Fleet*	446,291.94	14.7%	19,086.4	16.8%	1,380.1	13.7%
Lights & Traffic Signals	357,525.72	11.8%	3,993.2	3.5%	496.1	4.9%
Transit Fleet*	143,877.30	4.7%	5,602.7	4.9%	409.9	4.1%
Water Delivery	1715.84	0.06%	95.2	0.08%	11.8	0.12%
Port Facilities	1193.16	0.04%	16.9	0.01%	2.1	0.02%
GRAND TOTALS	**3,038,760.41**		**113,452.8**		**10,094.9**	
*Fuel usage data for the vehicle and transit fleets was not available for 2007; fuel usage data for calendar year 2008 was used for the 2007 base year inventory.						

Included sectors in the government inventory were buildings, streetlights and traffic signals (including holiday lights and park lights), wastewater facilities, vehicle fleet, transit fleet, water delivery (minimal electricity use for sprinklers/irrigation only), and port facilities (minimal electricity use at two piers and boat ramps). The buildings sector was the largest contributor of CO_2e with 5,961 tonnes CO_2e (59% of total government emissions) (Figure 4). Within the buildings sector on-site fuel combustion contributed 3,767 tonnes CO_2e (37% of government total) and purchased electricity contributed 2,195 tonnes CO_2e (21.7% of government total) (Figure 4). Wastewater facilities were the second largest contributor at 1,834 tonnes CO_2e (18.2%) followed by the vehicle fleet with 1,380 tonnes CO_2e (13.7%). The remaining sectors, transit fleet, lights and traffic signals, water deliver, and port facilities all contributed less than 5% each with port facilities contributing the least CO_2e at 2.1 tonnes (0.02%).

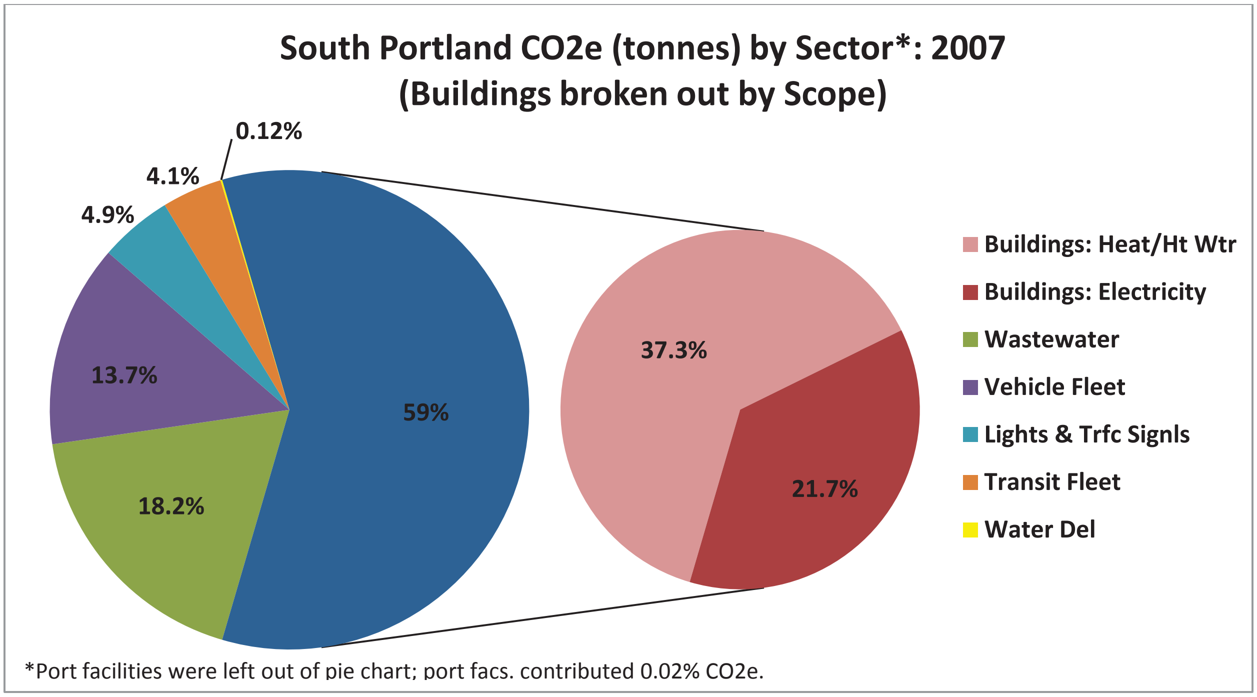

Figure 4: Contribution of 2007 emissions by government sector including a breakout of scope 1 and 2 emissions in the buildings sector.

Costs were highest in the buildings sector, representing approximately 56% ($1.69 million) of total governmental costs (Table 2). Second highest costs were incurred by the vehicle fleet at $0.45 million (15%) and then wastewater facilities at $0.4 million (13%).

Energy output by sector follows the same pattern as emissions (largest energy use to smaller energy use) with the exception that the transit fleet used more energy than lights and traffic signals and the vehicle fleet used more energy than the wastewater sector (Figure 5). This latter point is primarily due to absolute N_2O emissions stemming from wastewater treatment processes.

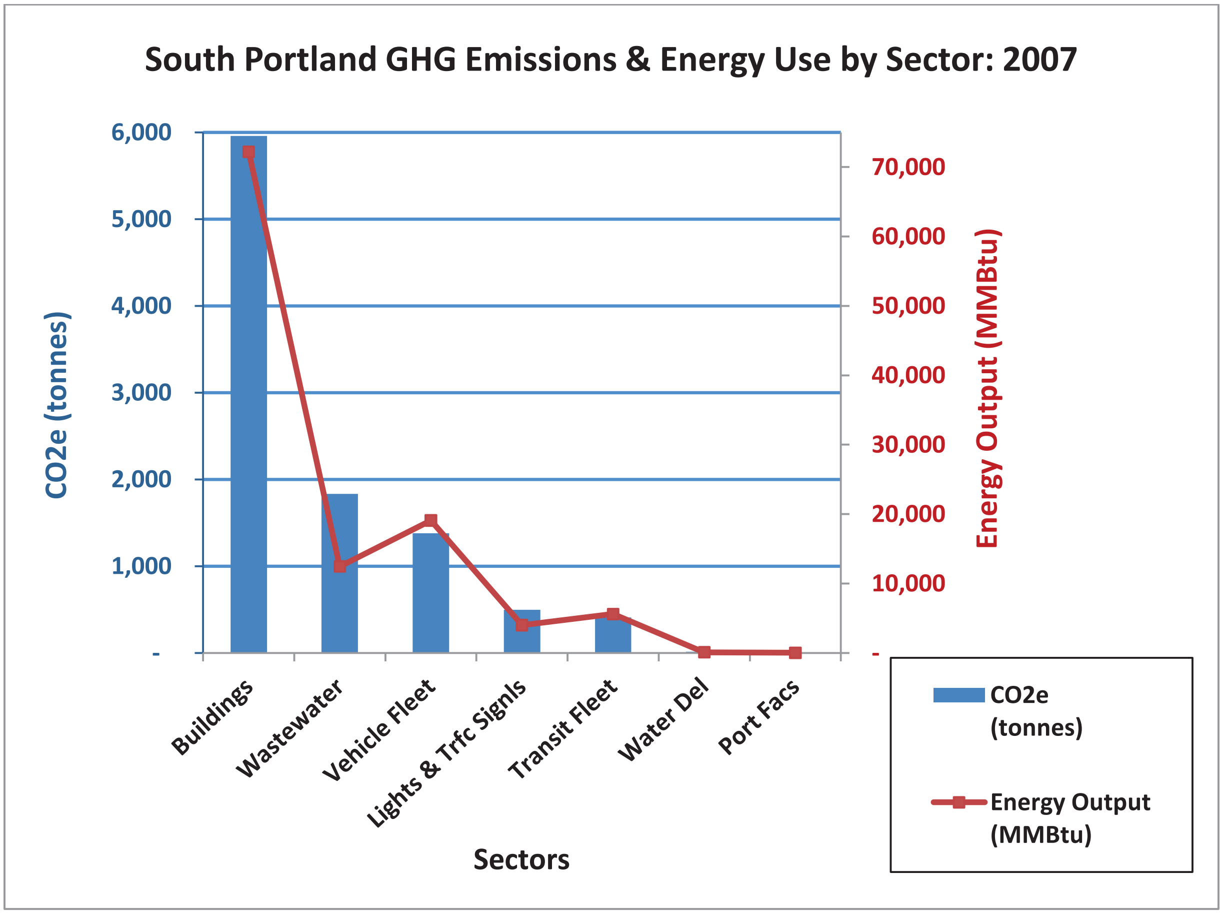

Figure 5: Emissions and energy output by sector. Emissions (tonnes CO_2e) are shown on the primary vertical axis (left side of graph) and are represented by the blue bars while energy output (MMBtu) is shown on the secondary vertical axis (right side of graph) and is represented by the red line.

Although it may be less meaningful to look at absolute quantities of fuel types, along with each fuel type's associated emissions, it does provide another perspective of the data and is informative in broad terms. As can be gleaned from the above information, purchased electricity accounts for the majority of emissions (39%) (Figure 6). On-site combustion of fuel oil was the second largest emitter of CO_2e (30%) and along with electricity account for 69% of all CO_2e emissions.

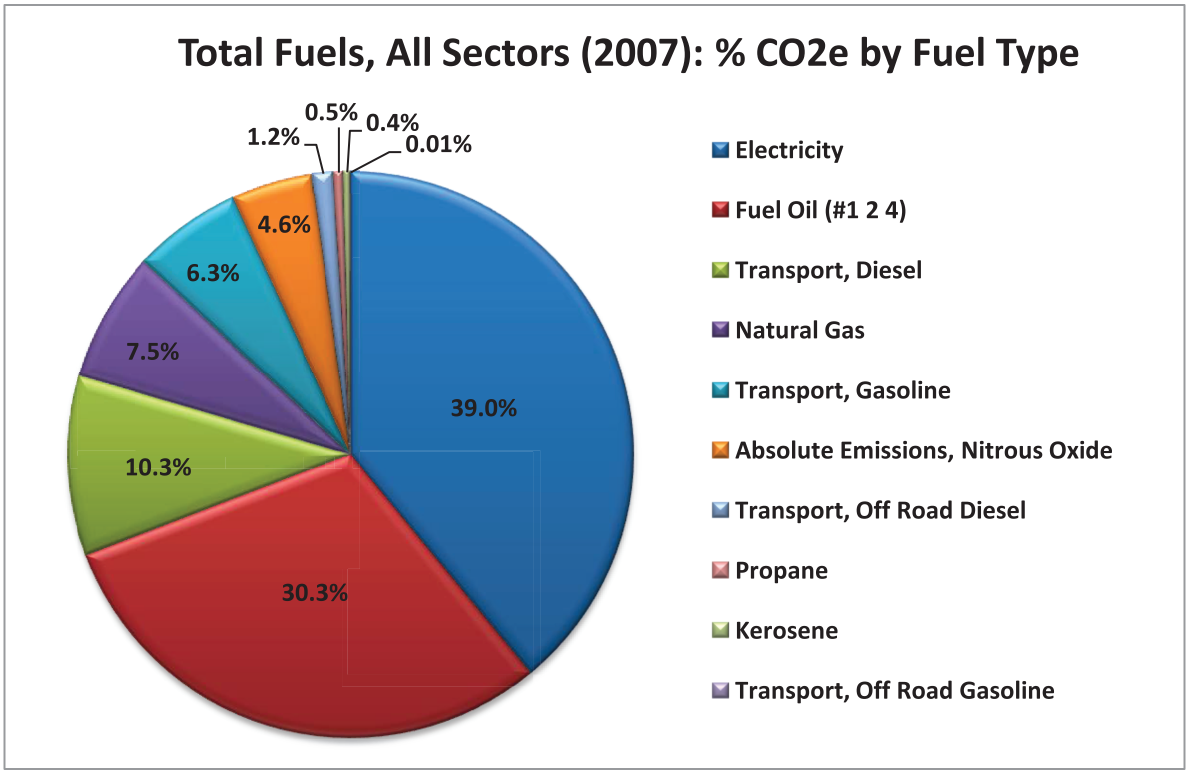

Figure 6: Energy usage by fuel type across all sectors. Percentages represent actual CO_2e emissions resulting from specific fuel usages.

The relationship between energy output (MMBtu) and resultant GHG emissions (tonnes CO_2e) differs between different fuel types; given the same energy output some fuels, e.g. #2 heating fuel, will result in more GHG emissions than, for example, natural gas. The relationship between energy output and emissions can be referred to as "GHG intensity" with a lower number indicating less GHG emissions for an equivalent energy output or, simply speaking, a "cleaner" burning fuel. Based on the inventory results for South Portland's government operations, the GHG intensity was 0.07 for most fuels except for the high of 0.12 for electricity and the low of 0.05 for natural gas (Table 4).

Table 3: Quantities, costs, energy output, CO2e, and GHG intensity of fuels used by South Portland government operations in 2007 (stationary sources) and 2008 (mobile sources).

Total Fuels, All Sectors (2007): Absolute Quantities, Energy Output, & Emissions						
Fuel	Quantity (Unit)	Cost ($)	Energy Usage (MMBtu)	CO2e (tonnes)	CO2e: % of Total (absolute#)	GHG Intensity (CO2e /Energy Use)
Electricity	9,280,712.0 (kWh)	1,516,262	31,674.8	3,935.1	39.0%	0.12
Fuel Oil (#1 2 4)	299,334.0 (US Glns)	674,545	41,510.3	3,053.8	30.3%	0.07
Transport, Diesel	101,995.3 (US Glns)	358,620	14,144.3	1,035.5	10.3%	0.07
Natural Gas	141,595.4 (therms)	226,219	14,159.5	753.2	7.5%	0.05
Transport, Gasoline	71,477.0 (US Glns)	190,189	8,879.2	632.2	6.3%	0.07
Absolute Emissions, Nitrous Oxide	1.5 (tonnes)			467.5	4.6%	
Transport, Off Road Diesel	11,904.4 (US Glns)	41,005	1,650.8	121.2	1.2%	0.07
Propane	9,432.8 (US Glns)	21,381	858.7	54.5	0.5%	0.06
Kerosene	4,151.0 (US Glns)	10,183	560.3	40.8	0.4%	0.07
Transport, Off Road Gasoline	119.3 (US Glns)	359	14.8	1.1	0.01%	0.07
TOTALS		**3,038,763**	**113,452.8**	**10,094.9**		

CO_2e tracked with energy output for most fuel types except for electricity and fugitive nitrous oxide emissions from the wastewater treatment plant (Figure 7). The nitrous oxide resulted from wastewater treatment processes and so was not associated with any energy output. Electricity usage resulted in higher CO_2e emissions for an equivalent energy output relative to other fuels. As stated in the *Emissions Factors* section of this document, the electricity emissions factors used for this inventory were not tailored to reflect the energy mix (fossil fuels vs. renewable energy) or technology used by Maine electricity generating power plants in 2007, but are an estimation based on the region-wide energy mix and technology in use by all New England power plants in 2005.

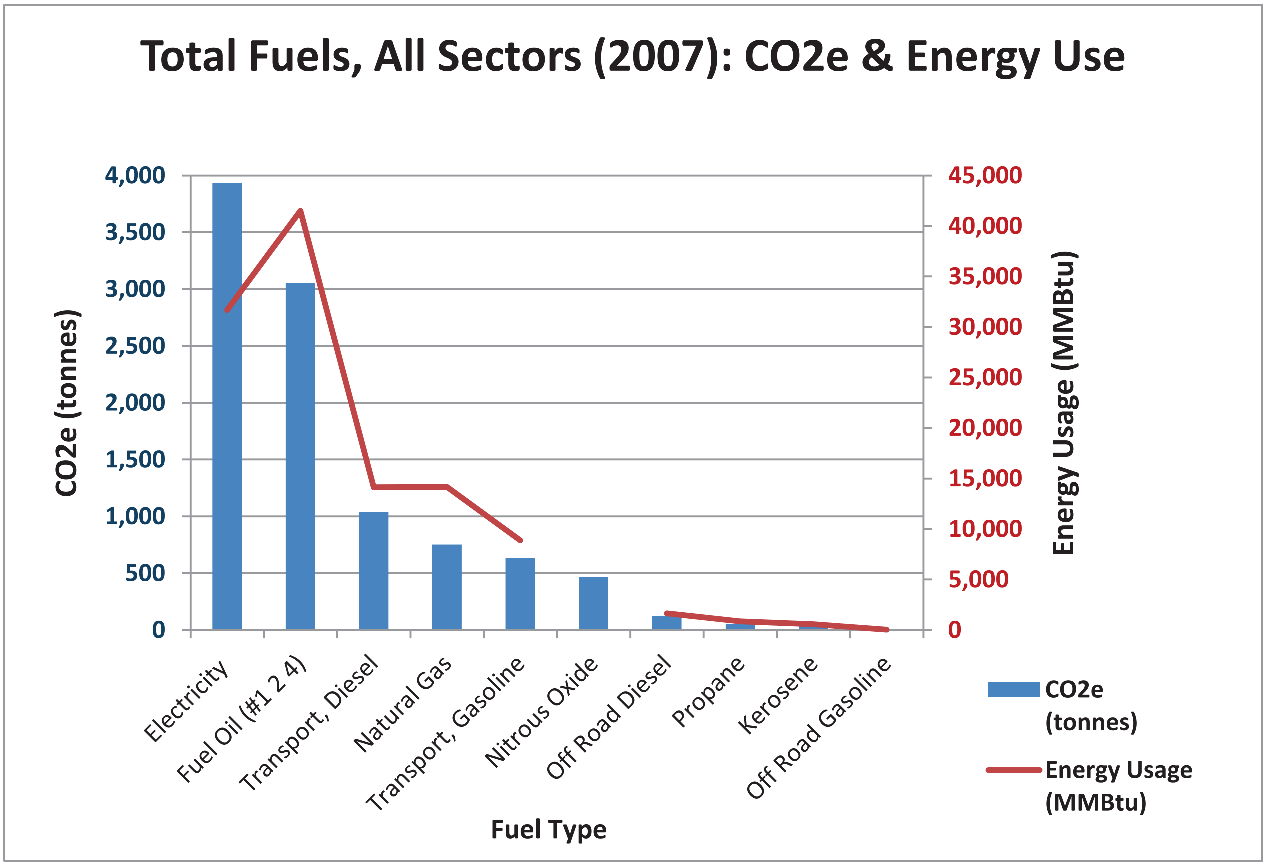

Figure 7: CO2e (tonnes) and energy usage (MMBtu) by fuel type. Emissions (tonnes CO_2e) are shown on the primary vertical axis (left side of graph) and are represented by the blue bars while energy output (MMBtu) is shown on the secondary vertical axis (right side of graph) and is represented by the red line. Note the break in the energy output line graph (red line) at nitrous oxide-this is because nitrous oxide is a fugitive emission stemming from wastewater treatment processes.

Buildings & Facilities

Forty-five buildings, ranging in size from 189,349 square feet (s.f.) to 400 s.f., were assessed for the GHG emissions inventory. Energy usage in buildings resulted in 5,961 tonnes CO_2e in 2007 with 63.2% (3,767 tonnes) of emissions stemming from fuel usage by heating plants and 36.8% (2,195 tonnes) stemming from electricity usage (Table 4). The South Portland High School (SPHS) on Highland Ave had the highest level of absolute emissions at 1,616 tonnes CO_2e. Memorial Middle School on

Table 4: Buildings' energy summary by scope: Scope 1 (heating plant) and scope 2 (electricity usage).

Buildings & Facilities (2007): CO2e Emissions by Scope						
Sector & Scope	**Cost ($)**	**Cost (%)**	**Energy Output (MMBtu)**	**Energy Output (%)**	**CO_2e (tonnes)**	**CO_2e (%)**
Buildings: Heat & Hot Water (Scope 1)	894,294.45	52.9%	54,539.1	75.5%	3,766.6	63.2%
Buildings: Electricity (Scope 2)	794,822.04	47.1%	17,665.0	24.5%	2,194.6	36.8%
Total Buildings	**1,689,116.49**		**72,204.1**		**5,961.2**	

Wescott Rd had the second highest GHG emissions in absolute terms at 826 tonnes CO_2e. In terms of size, the SPHS and Memorial Middle School are also the largest municipal buildings at 189,349 square feet (s.f.) and 77,074 s.f. respectively. GHG intensity, i.e. tonnes CO_2e per a consistent quantity of s.f., takes into account the size of the buildings being assessed and so provides a useful means of comparing the relative GHG emissions of all buildings. In terms of GHG intensity, the SPHS ranked 18^{th} (8.53 tonnes CO_2e /1,000 s.f.) out of all South Portland municipal buildings and Memorial Middle School ranked 14^{th} (10.72 tonnes CO_2e/1,000 s.f.).

The range of GHG intensity was 77.88 tonnes CO_2e. The pool, located in the Community Center on Nelson Rd, had the maximum GHG intensity at 77.94 tonnes CO_2e /1,000 s.f. while the Armory on Broadway had the minimum GHG intensity at 0.05 tonnes CO_2e /1,000 s.f. (Figures 8 and 9). The light GHG intensity at the Armory is most likely a function of very light use of the building while the GHG intensity at the pool is a function of heavy usage in terms of the amount (in gallons) of #2 heating fuel used to heat the pool space. Looking at the GHG intensity of all facilities, the pool GHG intensity was an outlier; the second strongest observed GHG intensity was at the Police and Public Safety building which was 61.3% lower than the pool at 30.1 tonnes CO_2e / 1,000 s.f.

The median GHG intensity was 7.2 tonnes CO_2e /1,000 s.f. at the "One Classroom" building (formerly known as the "Robotics" buildings) located on the SPHS campus. About half (24/45 or 53%) of the assessed municipal buildings fell within a range of 4.3 tonnes CO_2e /1,000 s.f. The low-end of this range was 4.88 tonnes CO_2e/1,000 s.f. seen at the Community Center (not including the pool). The high-end of this range was 9.17 tonnes CO_2e /1,000 s.f. seen at the Assessor's Office located at 41 Thomas St (City Hall Annex). 13% (6/45) of assessed buildings were below 3.0 tonnes CO_2e /1,000 s.f. The remainder of the buildings (14/45 or 31% - not including the pool) had a GHG intensity ranging from 10.13 tonnes CO_2e /1,000 s.f. (Wainwright Sports Complex building) to 30.14 tonnes CO_2e /1,000 s.f. (Police & Public Safety building)- a range of 20.0 tonnes CO_2e/ 1,000 s.f.

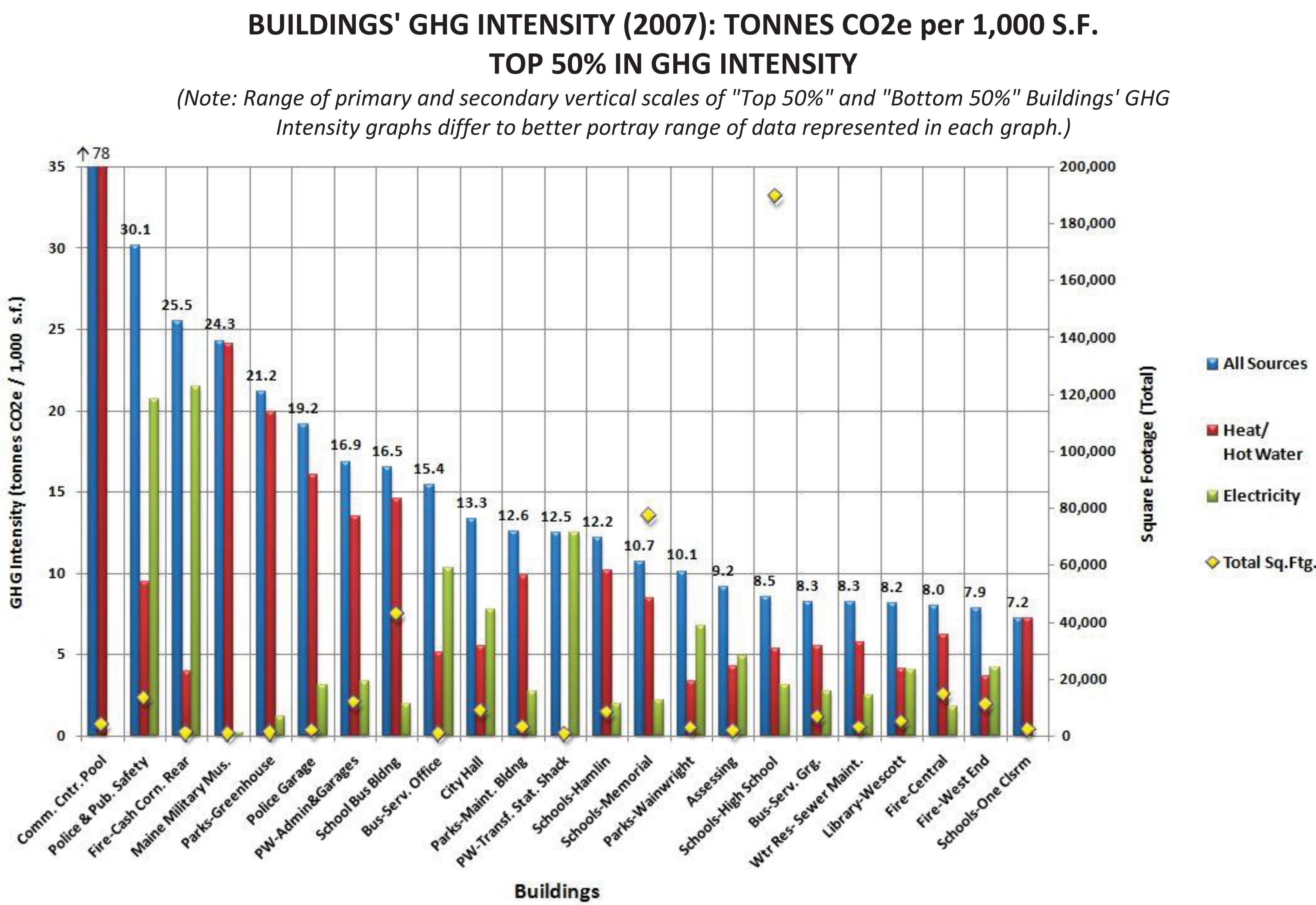

Figure 8: GHG intensity (tonnes CO_2e per 1,000 s.f.) of government buildings in 2008 and total square footage of government buildings (1 of 2). GHG intensity (tonnes CO2e per 1,000 s.f.) is shown on the primary vertical axis (left side of graph) and is represented by blue bars (total GHG intensity), red bars (GHG intensity stemming from heating plants), and green bars (GHG intensity stemming from electricity usage. Total square footage of each building is shown on the secondary vertical axis (right side of graph) and is represented by the yellow diamonds. The "Schools-One Clsrm" was the median in GHG intensity. Approximately 53% of assessed buildings were between 4.8 and 9.2 tonnes CO_2e/1,000 s.f.- a range of 4.3 tonnes CO_2e. The GHG intensity observed at the Community Center pool was an outlier at 77.9 tonnes CO_2/1,000 s.f. and was 61% higher than the next highest value.

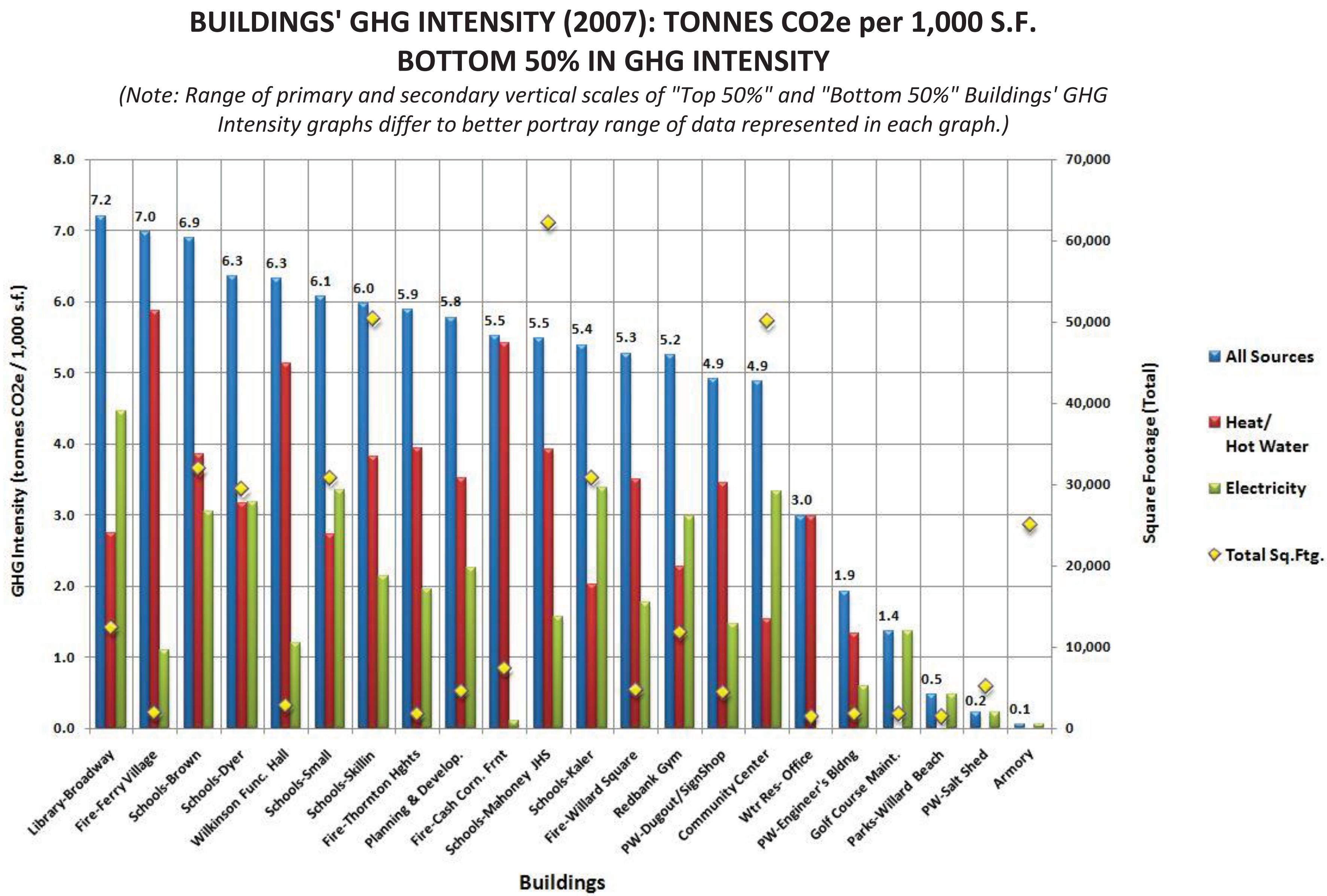

Figure 9: GHG intensity (tonnes CO_2e per 1,000 s.f.) of government buildings in 2008 and total square footage of government buildings (2 of 2). GHG intensity (tonnes CO2e per 1,000 s.f.) is shown on the primary vertical axis (left side of graph) and is represented by blue bars (total GHG intensity), red bars (GHG intensity stemming from heating plants), and green bars (GHG intensity stemming from electricity usage. Total square footage of each building is shown on the secondary vertical axis (right side of graph) and is represented by the yellow diamonds. Approximately 53% of assessed buildings were between 4.8 and 9.2 tonnes CO_2e/1,000 s.f.- a range of 4.3 tonnes CO_2e.

Table 5: 2007 government buildings' analysis including energy cost per square foot, energy intensity (kBtu/s.f.), and GHG intensity. Buildings preceded by a superscript number indicate instances where energy usage is split between two or three separate line items; these buildings had different square footage values for electricity and heated space or, as in the case of the Cash Corner Fire Station, the discernment between building sections found in data collection were maintained for data analysis.

Buildings (2007): Cost, Energy, GHG Emissions, & Square Footage Analysis							
Department / Building Name* (Year Built) (Fuel Type)	Square Footage	Cost ($)	Energy Cost per Sq. Ft. ($)	Energy Output (MMBtu)	Energy Intensity (kBtu** / s.f.)	CO2e (tonnes)	GHG Intensity (tonnes CO2e /1,000 s.f)
Rec, Pool (1978) (#2)	3,690	63,230.23	17.14	3,909.44	1,059.47	287.61	77.94
[1] Fire, Cash Corner/Rear (1971?) (Prop, Elec)	896	7,993.73	8.92	211.02	235.51	22.82	25.47
Maine Military Museum (1940) (#2, Elec)	704	3,912.80	5.56	231.82	329.28	17.10	24.29
Parks, Greenhouse (1968) (#2, Elec)	960	4,757.23	4.96	269.64	280.88	20.31	21.15
Police Garage (1972?) (#2)	1,000	3,547.54	3.55	218.05	218.05	16.04	16.04
Bus Service, Office (1982) (Kero, Elec)	480	1,770.00	3.69	73.55	153.23	7.40	15.42
[2] Schools, School Bus Building (1984) (#2, Kero)	6,925	23,929.15	3.46	1,379.17	199.16	101.02	14.59
[3] Public Safety (Police/Fire Admin) (1972/1998) (Elec)	6,814	30,519.00	4.48	784.21	115.09	97.43	14.30
[4] PW, Admin Office & Gar. Bay 1 (1930) (#2, NatGas)	6,600	20,295.12	3.08	1,354.85	205.28	89.13	13.50
City Hall (1898) (#2, NatGas, Elec)	8,500	32,572.33	3.83	1,183.22	139.20	113.15	13.31
Parks, Maintenance Bldng (1968) (#2, Elec)	2,800	8,803.47	3.14	436.64	155.94	35.28	12.60
PW, Transfer Station Entrance Shed (1998) (Elec)	400	1,541.99	3.85	40.17	100.42	4.99	12.48
Schools, Hamlin (1961) (#2, Elec)	7,858	25,423.14	3.24	1,214.08	154.50	95.63	12.17
Schools, Memorial (1960) (#2, Elec)	77,074	205,533.09	2.67	10,286.69	133.47	826.21	10.72
Parks, Wainwright Field, CmmBldng (2002) (Prop, Elec)	2,504	8,394.93	3.35	268.98	107.42	25.37	10.13
[3] Police/Public Safety Furnaces (1972/1998) (#2)	12,975	26,950.70	2.08	1,669.88	128.70	122.85	9.47
Assessing (1955) (NatGas, Elec)	1,444	4,396.43	3.04	172.83	119.69	13.24	9.17
Schools, SPHS (1950/1960) (#2, NatGas, Elec)	189,349	452,698.38	2.39	18,764.67	99.10	1,615.81	8.53
Bus-Service, Garage (1945) (NatGas, Elec)	6,251	15,670.88	2.51	788.89	126.20	51.64	8.26
Water Resources, Sewer Maint. Gar. (1980) (Prop, Elec)	2,600	9,285.56	3.57	287.99	110.77	21.47	8.26
Library, Branch, Wescott (1978) (Prop, Elec)	4,642	13,868.90	2.99	452.28	97.43	37.96	8.18
Fire, Central (1940) (#2, NatGas, Elec)	14,288	28,921.63	2.02	1,427.98	99.94	114.41	8.01
Fire, West End Station (2003) (NatGas, Elec)	10,698	26,222.97	2.45	1,096.59	102.50	84.00	7.85
Schools, Robotics (One Clsrm Prgrm Bldng) (#2)	1,920	3,067.63	1.60	188.49	98.17	13.87	7.22
Library, Public, Broadway (1970) (#2, Elec)	12,300	27,503.08	2.24	900.57	73.22	88.60	7.20
Fire, Ferry Village Station (1920)(#2, NatGas, Elec)	1,760	3,177.94	1.81	157.24	89.34	12.28	6.98

Buildings (2007): Cost, Energy, GHG Emissions, & Square Footage Analysis

Department / Building Name* (Year Built) (Fuel Type)	Square Footage	Cost ($)	Energy Cost per Sq. Ft. ($)	Energy Output (MMBtu)	Energy Intensity (kBtu** / s.f.)	CO2e (tonnes)	GHG Intensity (tonnes CO2e /1,000 s.f)
Schools, Brown (1940) (NatGas, Elec)	31,774	74,963.00	2.36	3,079.83	96.93	219.06	6.89
[3] Police (1972) (Elec)	6,161	12,596.70	2.04	316.00	51.29	39.26	6.37
Schools, Dyer (1971) (NatGas, Elec)	29,278	66,455.00	2.27	2,492.81	85.14	185.91	6.35
Rec, Wilkinson Function Hall (1950) (#2, Elec)	2,748	4,325.97	1.57	217.74	79.23	17.35	6.31
Schools, Small (2003) (NatGas, Elec)	30,728	67,085.00	2.18	2,401.53	78.15	186.41	6.07
Schools, Skillin (1940) (#2, Elec)	50,290	82,444.77	1.64	3,481.61	69.23	300.10	5.97
Fire, Thornton Heights (1939) (#2, Prop, Elec)	1,628	3,636.34	2.23	122.31	75.13	9.58	5.88
Planning & Development (1961) (NatGas, Elec)	4,546	8,214.66	1.81	383.00	84.25	26.24	5.77
[1] Fire, Cash Corner/Front (1971) (#2, Elec)	7,250	9,025.94	1.24	539.50	74.41	40.01	5.52
Schools, Mahoney Jr HS (1940) (#2, NatGas, Elec)	62,060	90,404.18	1.46	4,085.78	65.84	340.07	5.48
Schools, Kaler (2003) (NatGas, Elec)	30,728	59,343.00	1.93	1,997.23	65.00	165.48	5.39
Fire, Willard Square Station (1940) (#2, Elec)	4,576	5,762.10	1.26	283.06	61.86	24.12	5.27
Rec, Redbank Gym (1997) (NatGas, Elec)	11,674	19,479.83	1.67	777.45	66.60	61.23	5.25
PW, Dugout & Sign Shop (1950) (#2, Elec)	4,262	5,448.73	1.28	250.02	58.66	20.93	4.91
Rec, Community Center (2000) (NatGas, Elec)	49,888	76,049.61	1.52	2,782.95	55.78	243.25	4.88
[4] PW, Admin & Gar. Bays 1 & 2 (1930/1950) (Elec)	11,400	13,601.60	1.19	307.78	27.00	38.24	3.35
Police Garage (Elec)	1,600	1,785.59	1.12	40.10	25.06	4.98	3.11
Water Resources, Office (2007) (Prop)	1,360	1,786.46	1.31	63.93	47.00	4.06	2.98
[2] Schools, School Bus Building (1984) (Elec)	42,528	26,283.71	0.62	661.84	15.56	82.22	1.93
PW, Engineer's Bldng (1950) (#2, Elec)	1,664	943.79	0.57	38.02	22.85	3.20	1.92
Golf Course Maint. Bldng (1979) (Elec)	1,664	873.55	0.52	18.21	10.94	2.26	1.36
PW, Salt Shed (1985) (Elec)	5,026	873.55	0.17	18.21	3.62	2.26	0.45
Parks, Willard Beach Beach House (1973) (Elec)	1,408	338.09	0.24	5.34	3.79	0.66	0.47
Armory (1941) (Elec)	24,904	653.09	0.03	10.92	0.44	1.36	0.05
[4] PW, Gar. Bay 2 (1950) (Nat Gas)	4,800	125.41	0.03	1.13	0.23	0.06	0.01
Parks, Mill Creek Park Pumphouse (Elec)	N/A	3,005.00	N/A	67.97	N/A	8.44	N/A

*Buildings which shared an electricity meter, but not a furnace/boiler –or- vice versa –or- buildings in which the entire square footage did use electricity, but was not heated were split in this table to enable greater transparency. Buildings preceded by a superscript number indicate instances where energy usage is split between two or three separate line items.

**kBtu = one thousand "British thermal units." A BTU is a measurement of energy equivalent to approximately 1,055 joules.

Wastewater Facilities

Operations within the wastewater facilities sector includes the wastewater treatment complex at 111 Waterman Dr (including the primary pump station located within the complex) and 28 wastewater pump stations located outside of the complex. Absolute emissions of nitrous oxide from the wastewater treatment process itself at 111 Waterman Dr are also included in this sector. Water resources buildings located at 1142 Highland Ave were not included within the wastewater facilities sector, but were instead included in the buildings sector of the inventory. Fuel usage data for eight pump stations (six using propane and one using diesel) was not available for year 2007. Data on diesel fuel for the generators located at the 111 Waterman Drive complex was also not available but most likely any generator usage was minimal.

Emissions stemming from wastewater facilities represented 18.2% of total government emissions. Total energy usage by wastewater facilities was 12,454 MMBtu resulting in 1,834 tonnes CO_2e. Facilities located at 111 Waterman Dive, not including fugitive emissions, resulted in the most emissions (50%/ 914 tonnes CO_2e). The remainder of emissions was divided almost evenly between the fugitive N_2O emissions from treatment processes (25.5%/ 468 tonnes CO_2e) and the energy usage at the pump stations (24.7%/ 452 tonnes CO_2e) (Figure 10).

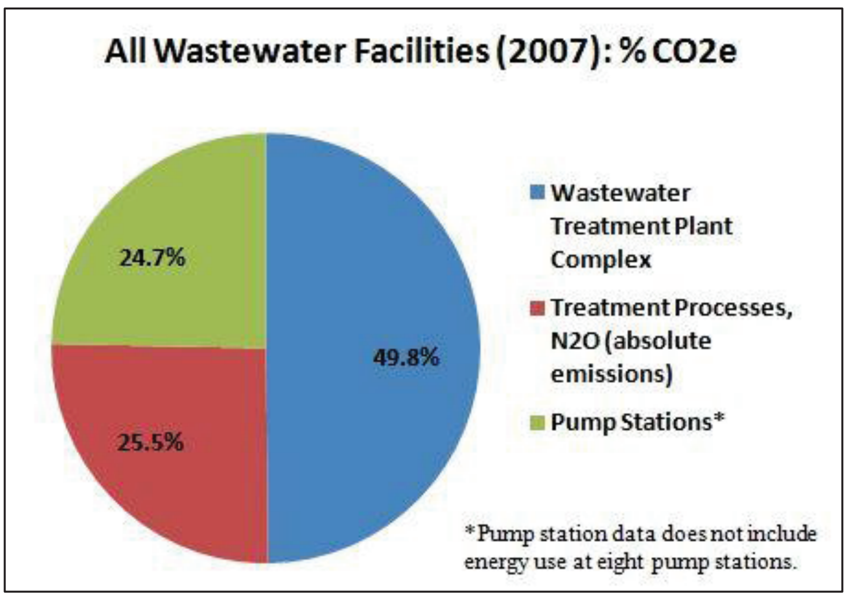

Figure 10: Percent of wastewater facilities CO_2e emissions resulting from energy usage at the wastewater treatment plant complex at 111 Waterman Dr, energy usage at pump stations, and fugitive N_2O emissions at the wastewater treatment complex.

Looking at the wastewater treatment plan at 111 Waterman Dr, most emissions are from electricity usage and N2O emissions at 56.6% (781 tonnes CO_2e) and 33.8% (468 tonnes CO_2e) respectively (Figure 11). The remainder of emissions at the complex is from natural gas usage: 6.7% by operations buildings, 2.6% by the main pump station, 0.11% by the disinfection building, and 0.10% by the biosolids facility.

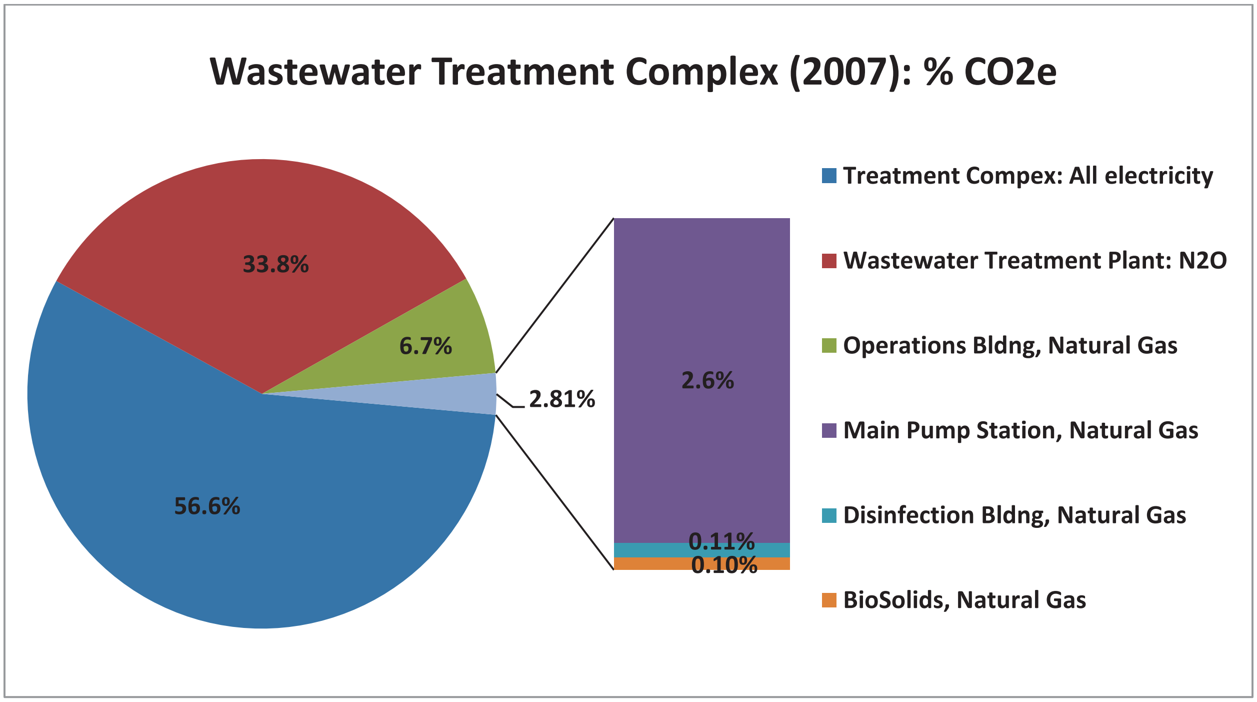

Figure 11: Percent of CO_2e emissions occurring at the wastewater treatment plan complex at 111 Waterman Dr. Emissions are divided by heating plant for each building (all are using natural gas), electricity usage for entire complex, and fugitive N_2O emissions.

See Table 6 for more detailed usage information for wastewater facilities including electricity usage and natural gas usage at pump stations. A complete list of all pump stations and associated energy usage and emissions is provided in *Appendix II: Wastewater Pump Stations*.

Table 6: Energy use, costs, and emissions at wastewater facilities in 2007. First level classification was determined by separating emissions stemming from the wastewater treatment plant complex at 111 Waterman Dr from those stemming from energy usage at pump stations located outside of the treatment complex. Second level classification was determined by fuel type/fugitive emissions and by individual buildings within the treatment complex.

Wastewater Facilities (2007): Energy Use, Costs, and Emissions						
Group Name	**Quantity**	**Cost**	**Energy Output (MMBtu)**	**Energy Output: % of Total**	**CO_2e (tonnes)**	**CO_2e: % of Total**
Treatment Compex: All electricity	1,842,500 kWh	187,107.07	6,288.3958	50.5%	781.2	42.6%
Wastewater Treatment Plant: N2O	1.5 tonnes	N/A	N/A	N/A	467.5	25.5%
Operations Bldng, Natural Gas	17522.4 therms	25,683.35	1,752.2380	14.1%	93.2	5.1%
Main Pump Station, Natural Gas	6815.2 therms	10,240.64	681.5200	5.5%	36.3	2.0%
Disinfection Bldng, Natural Gas	298.3 therms	597.43	29.8300	0.24%	1.6	0.09%
BioSolids, Natural Gas	264.5 therms	550.99	26.4450	0.21%	1.4	0.08%
Sub-Total: Trtmnt Complex, Natural Gas	24,900.3	37,072.41	2,490.03	20.0%	132.5	7.2%
TOTAL: TREATMENT COMPLEX		**224,179.48**	**8,778.43**	**70.5%**	**1,381.2**	**75.3%**
Pump Stations, Electricity	1,059,492 kWh	173,896.74	3,616.01	29.0%	449.2	24.5%
Pump Stations, Natural Gas	597.6 therms	963.74	59.76	0.5%	3.2	0.2%
TOTAL: PUMP STATIONS*		**174,860.48**	**3,675.77**	**29.5%**	**452.4**	**24.7%**
GRAND TOTALS		**399,039.96**	**12,454.20**		**1,833.6**	
***Pump station data does not include propane (6) or diesel (1) usage at eight pump stations.**						

Absolute nitrous oxide (N_2O) emissions resulting from the wastewater treatment process were estimated based on population served, the effluent treatment process, i.e. aerobic versus anaerobic, and whether or not nitrification/denitrification was used[20]. The population served by South Portland's wastewater treatment plant was 23,255, the treatment process was/is aerobic, and nitrification/denitrification wasn't used.

Vehicle Fleet

Fuel data for mobile sources was not available for base year 2007 so fuel usage for calendar year 2008 was used for inclusion in the base year mobile sources inventory. Vehicle fleet emissions represented 13.7% of total government emissions. A total of 190 vehicles were included in the base year inventory.

[20]Wastewater treatment emissions were estimated using a Microsoft Excel workbook designed by ICLEI and filled out by, Jim Jones, the Treatment Systems Manager of the wastewater treatment plant. While methane emissions are possible from aerobic systems that are not well managed, they are generally only calculated for facilities that utilize anaerobic digesters, facultative treatment lagoons, and septic systems (LGOP, 2010).

Twenty-three vehicles used both diesel and gasoline during 2008. Emissions from diesel and gasoline are calculated using different emissions factors necessitating a double listing of vehicles using both types of fuel; the double listing makes it appear as if there were 213 vehicles using fuel during 2008. Taking this latter statement in mind, 111 vehicles using diesel fuel resulted in emissions of 752.6 tonnes CO_2e (54.5%) while 102 gasoline using vehicles resulted in 627.5 tonnes CO_2e (45.5%) (Table 7).

Table 7: 2008 vehicle fleet emissions, energy output, and fuel costs. First level classification was determined by fuel type, i.e. diesel or gasoline. Second level classification was determined by size classification, e.g. heavy duty, light duty,… Refer to *Appendix III: CACP Vehicle Classifications* for an explanation on the CACP vehicle classification process. "CO_2 Only" classification was used for vehicles of unknown size classification.

Vehicle Fleet (2008*): Emissions, Cost, and Energy Use

Vehicle Classification	Number of Vehicles**	Quantity (US Gal)	Ave. Glns/ Per Vehicle	Cost ($)	Cost: % of Total	Energy Output: (MMBtu)	Energy Output: % of Total	CO_2e (tonnes)	CO_2e: % of Total
Diesel, Heavy Duty	60	54,590.0	909.8	189,347.66	42.4%	7,570.3	39.7%	554.3	40.2%
Diesel, Off Road	22	11,904.4	541.1	41,005.17	9.2%	1,650.8	8.6%	121.2	8.8%
Diesel, Light Duty	19	5,183.6	272.8	18,555.34	4.2%	718.8	3.8%	52.6	3.8%
Diesel, CO2 Only	10	2,407.7	240.8	8,507.71	1.9%	333.9	1.7%	24.4***	1.8%
Total Diesel	**111**	**74,085.7**		**257,415.88**	**57.7%**	**10,273.9**	**53.8%**	**752.6**	**54.5%**
Gasoline, CO2 Only	54	41,289.4	764.6	110,723.99	24.8%	5,129.2	26.9%	363.6****	26.3%
Gasoline, Light Duty	42	29,494.3	702.2	77,680.27	17.4%	3,663.9	19.2%	262.6	19.0%
Gasoline, Off Road	3	119.3	39.8	358.86	0.1%	14.8	0.1%	1.1	0.1%
Gasoline, Heavy Duty	3	37.1	12.4	112.94	0.0%	4.6	0.0%	0.3	0.0%
Total Gasoline	**102**	**70,940.1**		**188,876.06**	**42.3%**	**8,812.5**	**46.2%**	**627.5**	**45.5%**
GRAND TOTALS	**213***			**446,291.94**		**19,086.4**		**1,380.1**	

***2007 data was not available for mobile sources emissions; calendar year 2008 data was used for the base year inventory.**
****Vehicles that used both diesel and gasoline (23) were counted twice since emission factors differ based on fuel type. Total vehicle count was actually 190 (213 - 23 = 190).**
*****Total CO2e emissions for vehicles classified as "Diesel, CO2 Only" was as reported; vehicle classification had little/no impact on total CO2e.**
******Total CO2e emissions for vehicles classified as "Gasoline, CO2 Only" may range from 365.6 – 372.7 tonnes depending on size class and model year of vehicles.**

Emissions from mobile sources were calculated based on fuel use and vehicle type (size class and model year)[21]. Vehicle types were not available for 10 vehicles using diesel and 54 vehicles using gasoline. Emissions for these latter vehicles are for CO_2 only; CH4 and N_2O emissions are not included in the CO_2e listed in Table 7. Unclassified vehicles burning gasoline used 41,289 gallons (glns) of gasoline resulting in 363.6 tonnes CO_2 or CO_2e. Actual emissions (tonnes CO_2e) may be approximately 0.5% to 2.5% higher (365.6 – 372.7 tonnes CO_2e) than reported emissions depending on the size class, e.g. light

[21] See Appendix IV for description of CACP (2009) vehicle classifications.

duty truck vs. passenger car, and model year. Unclassified vehicles using diesel burned 2,408 glns of diesel fuel in 2008; differentiation of emissions from vehicles using this quantity of diesel based on vehicle type is negligible.

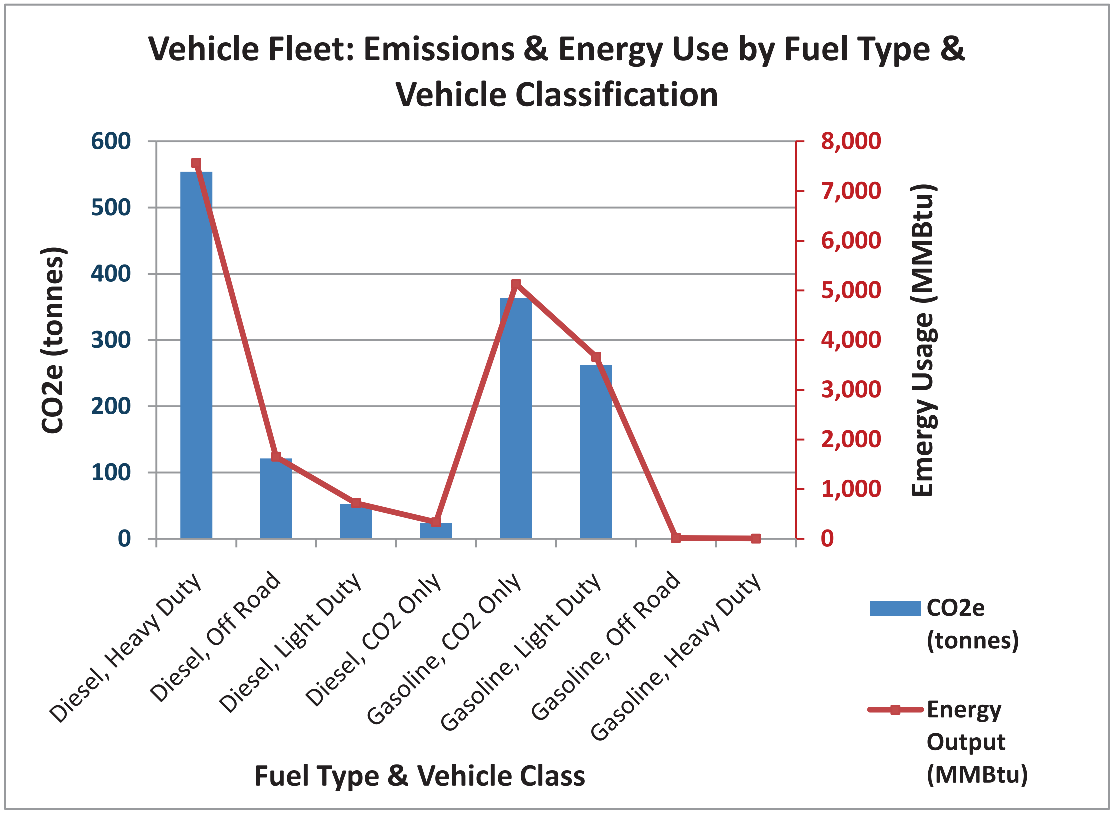

Figure 12: Emissions and energy use by the 2008 vehicle fleet. Emissions (tonnes CO_2e) are shown on the primary vertical axis (left side of graph) and are represented by the blue bars while energy output (MMBtu) is shown on the secondary vertical axis (right side of graph) and is represented by the red line.

Heavy duty trucks burning diesel used the greatest quantity of fuel resulting in 554 tonnes CO_2e (40.2% of total emissions) (Figure 12). Unclassified vehicles burning gasoline resulted in the second highest emissions (364 tonnes CO_2e /26.3% of total emission) emissions. Light duty gasoline burning vehicles emitted 262.6 tonnes CO_2, the third highest emissions (19.0%) of consolidated vehicle classes. *Appendix IV: Vehicle and Transit Fleets (2008)* provides a complete list (vehicle and transit fleets) of unconsolidated vehicles sorted first by fuel type (diesel or gasoline) and then by model year (newest to oldest); *Appendix IV* also includes department, fuel key/vehicle numbers, fuel quantity, and cost for each vehicle.

Lights and Traffic Signals

All emissions within the "Lights and Traffic Signals" sector are scope 2, purchased electricity; purchased electricity in this sector resulted in 4.9% of total government operations' emissions (496 tonnes CO_2e). Street lights make up 87.4% of CO_2e emissions (434 tonnes) in this sector followed distantly by traffic signals at 11.2% total CO_2e emission (56 tonnes) (Table 8). The remaining 1.37% emissions result from minimal usage for holiday and park lights including the annual power usage for the Art-in-the-Park show.

Table 8: Costs, energy usage, and CO_2e emissions in the Lights and Traffic Signals sector. Data reflects electricity usage by street lights, traffic signals, holiday lighting, and park lights paid for by the City of South Portland.

Lights & Traffic Signals (2007): Quantity (kWh), Cost, & CO_2e					
Group Name	Quantity (kWh)	Cost ($)	Energy Output (MMBtu)	CO_2e (tonnes)	CO_2e: % of Total
Streetlights	1,022,759	331,684.00	3,490.6	433.7	87.4%
Traffic Signals	131,230	22,598.25	447.9	55.6	11.2%
Parks, Holiday Lights	12,875	2,327.13	43.9	5.5	1.10%
Parks, Shoreway Path Lights	1,702	359.47	5.8	0.7	0.15%
Parks, Erskine Park Lights	792	230.30	2.7	0.3	0.07%
Parks, Art-in-the-Park Power	638	208.57	2.2	0.3	0.05%
Public Works, Rumery Park Sign	-	118.00	-	-	0.00%
TOTALS	**1,169,996**	**357,525.72**	**3,993.2**	**496.1**	

Transit Fleet

Fuel data for mobile sources was not available for base year 2007 so fuel usage for calendar year 2008 was used for inclusion in the base year mobile sources inventory. Transit fleet emissions represented 4.1% of total government emissions. Total emissions stemming from the transit fleet sector were 410 tonnes CO_2e with 98.6% of those emissions (404 tonnes) from diesel vehicles (Table 9). There were ten vehicles using diesel fuel and two vehicles using gasoline within the fleet for the base year inventory. Emissions for five out of the ten diesel vehicles were calculated for "CO_2 only" due to unknown vehicle classification; however, there was no difference in the amount of CO_2e based on vehicle classification so all diesel vehicles are consolidated for this report. The five classified diesel vehicles were either model year 1996 or 1999[22].

Table 9: 2008 transit fleet emissions, energy output, and fuel costs. First level classification was determined by fuel type, i.e. diesel or gasoline. Second level classification was determined by size classification, e.g. heavy duty, light duty,… Refer to *Appendix III: CACP Vehicle Classifications* for an explanation on the CACP vehicle classification process. "CO_2 Only" classification was used for vehicles of unknown size classification.

Transit Fleet (2008*): Emissions, Cost, & Energy Use						
Vehicle Classification	**Number of Vehicles**	**Quantity (US Glns)**	**Cost ($)**	**Energy Output (MMBtu)**	**CO_2e (tonnes)**	**CO_2e: % of Total**
Diesel, Heavy Duty**	10	39,814.0	142,208.70	5,521.2	404.2	98.6%
Gasoline, CO2 Only	2	656.2	1,668.60	81.5	5.8	1.4%
TOTALS	**12**		**143,877.30**	**5,602.7**	**409.9**	

*2007 data was not available for mobile sources emissions; calendar year 2008 data was used for the base year inventory.
**Emissions for five out of the ten diesel vehicles were calculated for "CO2 only" due to unknown vehicle classification; however, there was no difference in the amount of CO2e based on vehicle classification so all diesel vehicles are consolidated for this report.

Vehicle classification was also not known for either of the two vehicles burning gasoline so emissions were calculated for CO_2 only; however, differentiation of emissions from vehicles using this quantity of gasoline based on vehicle type is less than 0.5 tonne CO_2e.

Water Delivery (Government)

Government operations included in the Water Delivery sector were electricity usage for irrigation pumps located at Wainwright Field and the golf course as well as minimal usage for the Mill Creek Park fountain pump. Total emissions stemming from these three operations represented 0.12% of total government emissions (11.8 tonnes CO_2e) with 98.2% of water delivery emissions (11.6 tonnes CO_2e) stemming from the irrigation pump at Wainwright Field (Table 10).

Energy usage in the delivery of water by Portland Water District (PWD) was considered a scope 3 emission; scope 3 emissions occurred outside of the South Portland government's organizational

[22] See *Appendix V: Vehicle and Transit Fleets (20008)* for an unconsolidated list of vehicles in the transit and vehicle fleets; the transit fleet was "Account# 30/Municipal Bus."

boundaries. Refer to the *Community Analysis* section of this report for an estimation of emissions resulting from government operations' water usage.

Table 10: 2007 costs, energy output, and emissions within the Water Delivery sector. This sector includes electricity usage by irrigation and fountain pumps only. Energy usage in the delivery of water by Portland Water District was considered a scope 3 emission; these emissions were estimated in the *Community Analysis* portion of this report.

Water Delivery (2007): Electricity Usage, Cost, and Emissions					
Group Name	Quantity (kWh)	Cost ($)	Energy Output (MMBtu)	CO_2e: (tonnes)	CO_2e: % of Total
Parks, Wainwright Field Irrigation Pump	27,415	1331.1	93.6	11.6	98.2%
Golf Course Irrigation Pump	483	264.95	1.6	0.2	1.7%
Parks, Mill Creek Park Fountain Pump	10	119.79	0.0	0.0	0.0%
TOTALS	**27,908**	**1715.84**	**95.2**	**11.8**	

Port Facilities

Electricity usage at Thomas Knight Park/Pier at Knightville Landing, the Portland Street Pier, and boat ramps at Madison St resulted in 0.02% of total government emissions (2.1 tonnes CO_2e) (Table 11). Usage for all three operations was minimal; the Thomas Knight Park/Knightville Pier comprised 62.4% of port facility emissions (1.3 tonnes CO_2e). Electricity usage at Portland Street Pier comprises 37.0%

Table 11: 2007 emissions, costs, and energy output within the Port Facilities sector. This sector includes minimal electricity usage at two piers, one of which also included usage for lighting at Thomas Knight Park, and the Madison Street boat ramps.

Port Facilities (2007): Electricity Usage, Energy, Cost, & Emissions					
Group Name	Quantity (kWh)	Cost ($)	Energy Output (MMBtu)	CO_2e: (tonnes)	CO_2e: % of Total
Thomas Knight Park & Pier at Knightville Landing	3,100	557	10.5802	1.314413	62.4%
Portland Street Pier	1,836	396.22	6.2662	0.778472	37.0%
Boat Ramps, Madison St	28	239.94	0.0956	0.011872	0.6%
TOTALS	**4,964**	**1,193.16**	**16.9**	**2.1**	

of port facility emissions (0.78 tonnes CO_2e). Electricity usage at the Portland Street Pier includes usage by lessee, Waterworks Diving Service, as well as any usage at the Portland Street Pier boat ramps. Typically energy usage by a lessee would be outside of the organizational boundary based on operational control; however, since the electricity meter was shared by both the lessee and government operations and because the overall usage was minimal, the usage at the Portland Street Pier was included in the South Portland government inventory.

Community Analysis: Methodology

The base year for the community analysis was calendar year 2007 (Jan 2007 – Dec 2007). Data within the community analysis is necessarily courser grained than data within the government analysis module. Sectors included within the community analysis are:

- Residential
- Commercial
- Industrial
- Transportation
- Waste
- Other

For the 2007 base year, it was decided by South Portland's Energy & Recycling Committee to focus on government operations and to include community data only where it was easily accessible. Data included in the 2007 inventory was purchased electricity usage by residential, commercial, and industrial sectors (scope 2); estimated fuel usage within the transportation sector (scope 1); emissions from municipal solid waste (MSW) disposal (scope 3); and emissions from water delivery listed as absolute emissions in the "other" sector (scope 3). Scope 1 fuel usage by stationary sources was not estimated for the 2007 base year.

Electricity data was provided by Central Maine Power (CMP) by way of ICLEI[23]. Transportation data was provided by the Maine Department of Transportation (MDOT), Bureau of Transportation Systems Planning, Systems Management Division by way of the Greater Portland Council of Governments (GPCOG)[24]. Waste data was obtained from the 2007 South Portland Municipal Solid Waste Annual Report sent to the Maine State Planning Office's (SPO), Waste Management Program[25].

[23] Allison Webster of ICLEI supplied community-wide electricity data; data was originally obtained from CMP by Missy Stults of ICLEI.
[24] MDOT contact was Edward Beckwith, edward.beckwith@maine.gov, 207-624-3302. GPCOG contact was Ben Lake, blake@gpcog.org, 207-774-9891.
[25] The 2007 Solid Waste Annual Report was filled out by Steven S. Johnson (no title listed). The South Portland contact person listed on the report was Dana Anderson, Director and Recycling Coordinator. The Maine State Planning Office (SPO) contact was Lana LaPlant-Ellis, Maine Waste Management Program, Lana.LaPlant-Ellis@maine.gov.

Community Analysis: Inventory Results

Community Overview

The 2007 base year inventory did not include scope 1 emissions from stationary sources, e.g. fuel usage by furnaces and boilers. With the omission of scope 1 emissions from stationary sources, the commercial and transportation sectors each contributed approximately 35% (89,712 and 91,452 tonnes CO_2e respectively) of total community emissions (Table 12). The industrial sector was the third highest contributor to community emissions at approximately 17% (42,333 tonnes CO_2e).

Table 12: Community-wide emissions and energy usage by sector. Scope 1 emissions from stationary sources (fuel for furnaces/boilers,…) was not estimated for the 2007 base year inventory.

2007 Community Overview[1]			
Community Sector	**Energy Output (MMBtu)**	**CO_2e (tonnes)**	**CO_2e (%)**
Commercial: Electricity & Water Delivery[2]	736,398	91,452	35.9%
Transportation[3]	1,236,889	89,712	35.3%
Industrial: Electricity & Water Delivery	341,123	42,333	16.6%
Residential: Electricity & Water Delivery	237,600	29,463	11.6%
Waste (Incinerated & Landfilled)[4]	0	1,518	0.6%
Totals	**2,552,010**	**254,478**	

[1] Data does not include scope 1 emissions from stationary sources.

[2] Commercial sector data includes water delivery for government operations, but not electricity usage by government operations included in the Government Analysis portion of this report.

[3] Road classifications ("Federal Functional Class.") included for this analysis were local, major/urban collectors, minor arterials, and other principal arterials.

[4] According to the Maine State Planning Office (SPO), landfilled tonnage was most likely underestimated by the reporting entity (City of South Portland) and resulted in zero emissions for this report.

Water Delivery (Community)

Introduction

GHG emissions associated with water usage are a function of the fuel types and quantities used in the provision of that water. Energy usage in the provision of water is, in turn, mainly a function of the distance from the water source and the quantity of water provided. Portland Water District (PWD) provides water to eleven Greater Portland communities including South Portland. PWD is a quasi-municipality that is overseen by a publically elected, geographically representational board. South Portland does not have operational control over PWD facilities, and as such, GHG emissions resulting from South Portland water usage are counted as scope 3 emissions[26]. Also, fuel types and quantities used by individual PWD facilities could not be assigned to any particular South Portland sector with confidence so emissions from water delivery for all sectors, including government, are counted in the community analysis. However, water usage by sector was obtained as well as a calculation of total energy usage and CO_2e in the delivery of that water enabling an estimation of energy usage and CO_2e for each sector.

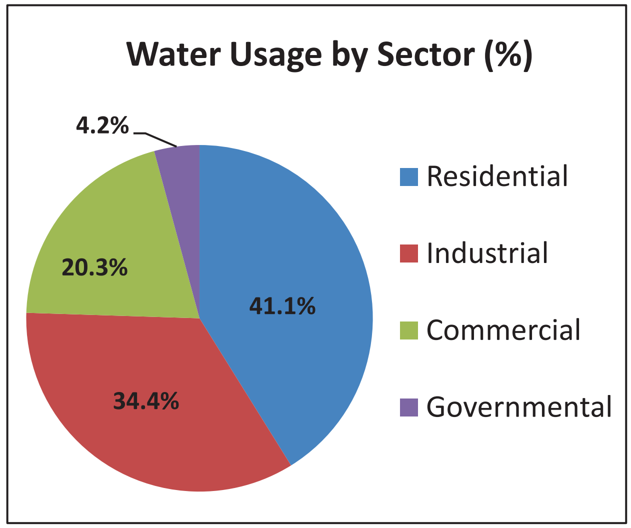

Figure 13: Percent of water delivered to each sector within the South Portland community. Data was obtained from Portland Water District.

Results

Data for the determination of GHG emissions resulting from water delivery was provided by PWD[27]. Data included quantity of water broken down by residential, industrial, commercial, and government sectors. Total water delivered was approximately 1.6 million hundred cubic feet (HCF)[28] (Table 12). The residential sector used the most water (41% / 0.6 million HCF) followed by industry (34% / 0.5

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[26] South Portland operates its own wastewater treatment plant including waste water pump stations; emissions stemming from wastewater treatment are included as scope 1 emissions in the government analysis.
[27] PWD contact was facilities director, Roger Paradis. Contact info: email: rparadis@pwd.org; Tel#: 207-774-5961 x3321
[28] 1 HCF = 748.05 gallons.

million HCF) and commercial businesses (20% / 0.3 million HCF) (Figure 13). Government, including the school district, used approximately 0.07 million HCF (4% / 67 *thousand* HCF).

Percent CO_2e attributable to each sector was estimated by applying the percent of total water quantity used by each sector to total CO_2e generated by PWD facilities' fuel usage (Table 12). Percent energy usage attributable to each sector was estimated in this same way. The residential sector had the highest water usage (41%) and so also had the highest attributable CO2e, 234 tonnes, and energy usage, 2.3 thousand MMBtu, of all

Table 13: 2007 community water usages (HCF/gallons) as reported by Portland Water District. Emissions and energy usage for each sector was estimated using fuel usage data for Portland Water District pump stations associated with the delivery of water to South Portland facilities. See Table 13 for details on fuel types and quantities used by the aforementioned pump stations.

2007 COMMUNITY WATER USAGE: Water Usage by Sector[1]

	Quantity (HCF[2])	Quantity (Glns)	CO2e (tonnes)	Energy Usage (MMBtu)	% of Total
Residential	652,955	488,442,987.75	233.73	2,323.40	41.14
Industrial	545,436	408,013,399.80	195.25	1,940.82	34.37
Commercial	321,783	240,709,773.15	115.19	1,145.00	20.27
Government[3]	66,973	50,099,152.65	23.97	238.31	4.22
Totals	**1,587,147**	**1,187,265,313**	**568.14**	**5,647.53**	

[1]Water quantity data provided by PWD facilities director, Roger Paradis.
[2]HCF is hundred cubic feet; 1 HCF = 748.05 glns
[3]Government figure includes usage for school district.

sectors. CO_2e attributed to the industrial sector was 195 tonnes (1.9 thousand MMBtu). Commercial businesses followed with 115 tonnes CO2e (1.1 thousand MMBtu). Government CO_2e was estimated at 24 tonnes CO_2e (238 MMBtu).

Total energy usage associated with water delivery to South Portland in 2007 was 5,647 MMBtu. Fuel types and quantities associated with water delivery to South Portland in 2007 included electricity (54% / 3,028 MMBtu), stationary gasoline (15% / 830 MMBtu), and #2 fuel (11% / 605 MMBtu) (Table 13). Four remaining fuels (#6 fuel, diesel, propane, and natural gas) all provided less than 10% of energy used with natural gas providing the least amount of energy (0.4% /20 MMBtu).

Table 14: Energy use and resultant emissions (tonnes CO_2e) from water delivery by Portland Water District to South Portland facilities including all sectors: industrial, commercial, residential, and government.

2007 Community Water Usage[1]:
Total Emissions & Energy Usage by Fuel Type[2]

Fuel Type (units)	Fuel Quantity[3]	CO_2 (tonnes)	N_2O (tonnes)	CH_4 (tonnes)	Energy Usage (MMBtu)	Energy Usage (%)	Equiv. CO_2 (tonnes)	Equiv. CO_2 (%)
Electricity (kWh)	887,423	373.42	0.006847	0.034815	3,027.96	53.6%	376.27	66.2%
Gasoline[4] (glns)	6,684	58.85	0.000498	0.002491	830.10	14.7%	59.06	10.4%
#2 (glns)	4,365	44.28	0.000363	0.001816	605.16	10.7%	44.43	7.8%
#6[5] (glns)	3,503	41.32	0.000315	0.001573	524.17	9.3%	41.45	7.3%
Diesel[6] (glns)	3,810	38.65	0.000317	0.001585	528.22	9.4%	38.78	6.8%
Propane (glns)	1,232	7.07	0.000067	0.000336	112.13	2.0%	7.10	1.3%
Nat Gas (therms)	198	1.05	0.000002	0.000020	19.79	0.4%	1.05	0.2%
TOTALS		**564.64**	**0.0084**	**0.0426**	**5,647.53**		**568.14**	

[1]Community water usage includes all sectors including government and schools.
[2]Fuel types and quantities supplied by Portland Water District (PWD) facilities director, Roger Paradis.
[3]Quantity of fuel was to supply 1,587,147 HCF water.
[4]Gasoline was classified as "stationary gasoline" in the CACP software.
[5]#6 fuel is not an option in the CACP software, per ICLEI advisement it was instead classified as "residual fuel oil" which is heavier than #1, 2, or 4 fuel oil.
[6]Diesel is not an option under stationary sources in the CACP software, it was assumed fuel was lighter diesel and under ICLEI advisement it was instead classified as #1, 2, 4 fuel oil.

Total CO2e generated by use of the above fuels was 568 tonnes (Table 13). Electricity usage generated 66% of CO2e (376 tonnes) followed by gasoline at 10% (59 tonnes) and #2 fuel at 8% (44 tonnes). No. 6 fuel and diesel resulted in approximately 7% of CO2e each (41 tonnes and 39 tonnes respectively). Propane and natural gas contributed 1.3% (7 tonnes) and 0.2% (1 tonne) CO2e respectively.

Discussion

Since, in South Portland, emissions stemming from water delivery are defined as scope 3, discussions on reducing these emissions will need to be framed in terms of reducing the quantity of water delivered. Measures employed to conserve water can be evaluated based on reduction in water usage and then related back to the amount of fuel used in the delivery of that water as done above. However, quantity of water will be the absolute determinant of the performance of the conservation measures undertaken since any potential technology or fuel changes implemented by PWD will have a large impact on emissions and energy usage.

Transportation

Total estimated emissions from the transportation sector were 89,712 tonnes CO_2e in 2007. Gasoline powered passenger cars and light trucks contributed 48.4% (43,456 tonnes CO_2e) and 35.5% (31,819 tonnes CO_2e) respectively of total transportation emissions (Table 15).

Table 15: Community-wide transportation emissions, vehicle miles traveled (VMT), and energy output for 2007. VMT for each vehicle classification were based on the default CACP assumptions in the *Transport Assistant* found in the transportation sector of the *Community Analysis* module. VMT data supplied to GPCOG from Edward Beckwith, MDOT, Bureau of Transportation Systems. VMT quantities are based on official 2007 estimates. Refer to *Appendix V* for specific information on included and excluded VMT in the 2007 inventory.

Community Transportation (2007): VMT , Energy Output, and Estimated Emissions						
Vehicle Classification	Fuel	VMT Quantity	VMT %	Energy Output (MMBtu)	CO_2e (tonnes)	CO_2e %
Passenger Cars Alt. Method	Gasoline	91,684,908	60.6%	600,550	43,456	48.4%
Light Trucks Alt. Method	Gasoline	49,019,654	32.4%	439,170	31,819	35.5%
Heavy Duty Vehicles Alt. Method	Diesel	8,169,942	5.4%	179,831	13,168	14.7%
Light Trucks Alt. Method	Diesel	1,966,838	1.3%	14,428	1,056	1.2%
Passenger Cars Alt. Method	Diesel	453,886	0.3%	2,910	213	0.2%
Totals		**151,295,228**		**1,236,889**	**89,712**	

VMT for each vehicle classification were based on the default CACP assumptions in the *Transport Assistant* found in the transportation sector of the *Community Analysis* module. Refer to *Appendix V: Vehicle Miles Traveled by Federal Functional [Road] Classifications (FFC)* for a list of included and omitted road types along with their associated VMTs.

Waste

Emissions from waste management were counted as scope 3 emissions and resulted in 1,518 tonnes CO_2e. Waste data was taken from the 2007 South Portland Municipal Solid Waste Annual Report sent to the Maine SPO's, Waste Management Program. According to the SPO, landfilled tonnage was most likely underestimated by the reporting entity (City of South Portland) and resulted in zero emissions for this report. Controlled incineration took place at Ecomaine. South Portland is one of twenty-one "owner/members" of Ecomaine, an integrated waste management facility comprised of a waste-to-energy facility and a single-stream recycling facility located in the greater Portland area.

Table 16: 2007 community waste tonnage and resultant emissions. Waste emissions were counted as "scope 3" emissions.

Community Waste: 2007 Emissions & Waste Production			
Disposal Technology	Waste Production (tons)	CH4 (kg)	CO2e (tonnes)
Controlled Incineration	7678.81	72,269	1,518
Managed Landfill*	26.68	0	0
Totals	**7705.49**	**72,269**	**1,518**

*According to the Maine State Planning Office (SPO), landfilled tonnage was most likely underestimated by the City of South Portland.

Types of waste and their respective shares had to be assigned in order to estimate emissions within the waste sector. Waste shares for the "controlled incineration" disposal technology were based on a Connecticut Department of Environmental Protection report[29] per the recommendation of Lana LaPlant-Ellis from the Maine SPO (Table 17). The SPO advised that, because both Connecticut and Maine have bottle/can recycling laws, Connecticut's waste shares would be more accurate than national averages in describing Maine's waste shares. Waste shares were further delineated by the waste type groupings found in the CACP software which were paper products, food waste, plant debris, wood/textiles, and "all other." 100% of waste shares for the "managed landfill" technology were categorized as waste type "all other."

[29] *Connecticut State-Wide Solid Waste Composition and Characterization Study, Final Report* (May 26, 2010). The report is available online at: http://www.ct.gov/dep/cwp/view.asp?A=2718&Q=439264.

Table 17: 2007 South Portland waste shares (% and tonnage) used to estimate emissions resulting from controlled incineration of municipal solid waste (MSW).

2007 South Portland Waste Shares: Controlled Incineration		
	Waste Share	**Tonnage**
Paper Products	25.2%	1,935
Food Waste	13.7%	1,052
Plant Debris	18.4%	1,413
Wood and Textiles	8.7%	668
All Other (e.g. glass, plastic, metal)	34.0%	2,611
	Total Tonnage	**7,679**

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Online Resources

California Department of Environmental Protection (CDEP), Air Resources Board (ARB):

- *Local Government Operations Protocol* (LGOP): http://www.arb.ca.gov/cc/protocols/localgov/localgov.htm

Casco Bay Estuary Partnership (CBEP):

- *Climate Change in the Casco Bay Watershed: Past, Present, and Future* (2009): http://www.cascobay.usm.maine.edu/pdfs/Climate_Change_in_Casco_Bay.pdf
- Additional Publications: http://www.cascobay.usm.maine.edu/publications.html

Department of Energy (DOE), U.S. Energy Information Administration (EIA):

- Environment (US Emissions Data/GHG Reporting): http://www.eia.doe.gov/environment.html

Environmental Protection Agency (US EPA):

- Climate Change: http://www.epa.gov/climatechange/index.html
- eGRID: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
- Greenhouse Gas Emissions: http://www.epa.gov/climatechange/emissions/index.html

ICLEI USA-Local Governments for Sustainability:

- Home Page: http://www.icleiusa.org/
- CACP Software User Guide (Requires Password): http://www.icleiusa.org/action-center/tools/cacp-software/user-guide

Intergovernmental Panel on Climate Change (IPCC):

- Home Page: http://www.ipcc.ch/
- Fourth Assessment Report (AR4): http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

Greater Portland Council of Governments (GPCOG):

- Sustainability Initiative: Energy Use and GHG Emissions: http://www.gpcog.org/forums/sustainability.php#Energy.
- GPCOG & Clean Air/Cool Planet: *The Maine Energy Handbook: A Comprehensive Guide to Municipal Energy Efficiency and Sustainable Energy*: http://www.pactsplan.org/documents/MaineEnergyHandbook.pdf

Greenhouse Gas Protocol Initiative, The:
- Home Page: http://www.ghgprotocol.org/about-ghgp
- GHG Protocol Corporate Standard: http://www.ghgprotocol.org/standards/corporate-standard

Maine Department of Environmental Protection (MDEP), Bureau of Air Quality (BAQ):
- Emissions Inventory Program: http://www.maine.gov/dep/air/emissions/index.htm
- Maine Climate Action Plan: http://www.maine.gov/dep/air/greenhouse/

Maine State Planning Office (SPO):
- Planning for Climate Change: http://www.maine.gov/spo/landuse/techassist/climatechange.htm

University of Maine (UM), Climate Change Institute:
- *Maine's Climate Future: An Initial Assessment* (2009): http://climatechange.umaine.edu/research/publications/climate-future

Appendix I: Emissions Factors

eGRID Electricity Emissions

Table 1. eGRID Electricity Emissions Factors by eGRID Subregion for Inventory Years 2004 and 2005

Inventory Year		2004			2005		
eGrid Subregion	eGrid Subregion Name	CO_2 (lb/MWh)	N_2O (lb/MWh)	CH_4 (lb/MWh)	CO_2 (lb/MWh)	N_2O (lb/MWh)	CH_4 (lb/MWh)
AKGD	ASCC Alaska Grid	1257.188	0.0064	0.0266	1,232.36	0.00651	0.0256
AKMS	ASCC Miscellaneous	480.099	0.0044	0.0239	498.86	0.00408	0.02075
AZMN	WECC Southwest	1254.018	0.0148	0.0175	1,311.05	0.01794	0.01745
CAMX	WECC California	878.707	0.0084	0.0359	724.12	0.00808	0.03024
ERCT	ERCOT All	1420.559	0.0148	0.0214	1,324.35	0.01511	0.01865
FRCC	FRCC All	1327.661	0.0160	0.0541	1,318.57	0.01694	0.04592
HIMS	HICC Miscellaneous	1456.167	0.0183	0.1006	1,514.92	0.04688	0.31468
HIOA	HICC Oahu	1728.121	0.0212	0.0911	1,811.98	0.02362	0.10947
MROE	MRO East	1858.719	0.0303	0.0411	1,834.72	0.03036	0.02759
MROW	MRO West	1813.810	0.0289	0.0275	1,821.84	0.03071	0.028
NEWE	NPCC New England	908.902	0.0153	0.0798	927.68	0.01701	0.08649
NWPP	WECC Northwest	921.104	0.0141	0.0223	902.24	0.0149	0.01913
NYCW	NPCC NYC/Westchester	922.221	0.0060	0.0384	815.45	0.00546	0.03602
NYLI	NPCC Long Island	1412.197	0.0162	0.1020	1,536.8	0.01809	0.11541
NYUP	NPCC Upstate NY	819.684	0.0114	0.0240	720.8	0.01119	0.02482
RFCE	RFC East	1095.533	0.0172	0.0276	1,139.07	0.01871	0.03027
RFCM	RFC Michigan	1641.412	0.0254	0.0348	1,563.28	0.02717	0.03393
RFCW	RFC West	1556.388	0.0244	0.0195	1,537.82	0.02571	0.01823
RMPA	WECC Rockies	2035.813	0.0302	0.0244	1,883.08	0.02875	0.02288
SPNO	SPP North	1971.417	0.0303	0.0236	1,960.94	0.03209	0.02382
SPSO	SPP South	1761.140	0.0230	0.0303	1,658.14	0.02261	0.02498
SRMV	SERC Mississippi Valley	1135.463	0.0133	0.0420	1,019.74	0.01171	0.02431
SRMW	SERC Midwest	1844.344	0.0288	0.0214	1,830.51	0.0305	0.02115
SRSO	SERC South	1490.370	0.0249	0.0395	1,489.54	0.02547	0.02627
SRTV	SERC Tennessee Valley	1494.886	0.0237	0.0233	1,510.44	0.02564	0.02005
SRVC	SERC Virginia/Carolina	1146.386	0.0192	0.0294	1,134.88	0.01979	0.02377
Source		Local Governments Operations Protocol Version 1.0 (September 2008) Table G.7			eGRID2007 Version 1.1 (Year 2005)		

Table from ICLEI: http://www.icleiusa.org/action-center/tools/cacp-software/user-guide/appendix-a-electricity-emissions-factors.

Information is also available directly from the US EPA at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

NERC Electricity Emissions Factors

Table 3. NERC Electricity Emissions Factors for Criteria Air Pollutants for Inventory Years 1990 – 2005.

Map Number	NERC Region	NOx (lb/MWh)	SOx (lb/MWh)	CO (lb/MWh)	VOC (lb/MWh)	PM10 (lb/MWh)
01	East Central Area Reliability Coordination Agreement					
Inventory Year	1990-2003	5.287	16.573	0.2578	0.0294	0.2445
	2004	3.791	10.187	0.2702	0.0304	0.2385
	2005	3.713	9.660	0.2689	0.0302	0.2338
02	Electric Reliability Council of Texas					
Inventory Year	1990-2003	2.523	3.008	0.5110	0.0582	0.4845
	2004	2.460	2.468	0.5251	0.0591	0.4635
	2005	2.352	2.442	0.5202	0.0585	0.4523
03	Mid-Atlantic Area Council					
Inventory Year	1990-2003	2.175	11.687	0.5389	0.0613	0.5110
	2004	1.688	6.725	0.5599	0.0630	0.4943
	2005	1.662	6.371	0.5573	0.0626	0.4846
04	Mid-America Interconnected Network					
Inventory Year	1990-2003	3.499	9.955	0.5753	0.0655	0.5455
	2004	3.146	8.074	0.6001	0.0676	0.5298
	2005	3.159	8.274	0.5969	0.0671	0.5190
05	Mid-Continent Area Power Pool					
Inventory Year	1990-2003	3.708	5.265	0.9013	0.1026	0.8546
	2004	3.973	5.258	0.9457	0.1065	0.8348
	2005	3.971	5.240	0.9435	0.1060	0.8204
06	Northeast Power Coordinating Council/New York					
Inventory Year	1990-2003	1.395	6.325	0.9953	0.1133	0.9437
	2004	1.070	3.379	1.042	0.1173	0.9194
	2005	1.057	3.338	1.038	0.1166	0.9023
07	Northeast Power Coordinating Council/New England					
Inventory Year	1990-2003	0.9331	3.997	1.145	0.1303	1.085
	2004	0.7941	1.702	1.189	0.1339	1.050
	2005	0.7635	1.543	1.185	0.1332	1.030

Table from ICLEI: http://www.icleiusa.org/action-center/tools/cacp-software/user-guide/appendix-a-electricity-emissions-factors

Default Fuel CO2 Emission Factors: CACP 2009 (exported data).

FUEL CO2 EMISSIONS: CACP 2009							
Fuel	**Emissions Unit**	**Per Energy Unit**	**CO2 Coefficient**	**Fuel**	**Emissions Unit**	**Per Energy Unit**	**CO2 Coefficient**
Anthracite Coal	kg	MMBtu	103.62	Special Naphtha	kg	MMBtu	72.82
Bituminous Coal	kg	MMBtu	93.46	Stationary Gasoline	kg	MMBtu	70.88
Coke	kg	MMBtu	113.67	Stationary LPG	kg	MMBtu	63.16
Commercial Coal	kg	MMBtu	95.33	Still Gas	kg	MMBtu	64.2
Crude Oil	kg	US Gal	10.29	Subbituminous Coal	kg	MMBtu	97.09
Electric Utility Coal	kg	MMBtu	94.45	Unfinished Oils	kg	MMBtu	74.54
Ethane	kg	MMBtu	59.58	Waxes	kg	MMBtu	72.64
Fuel Oil (#1 2 4)	kg	MMBtu	73.15	Black Liquor NA hrdwd	kg	MMBtu	0
Fuel Oil (#1 2 4) ULSD	kg	MMBtu	73.15	Black Liquor NA sftwd	kg	MMBtu	0
Industrial Coking Coal	kg	MMBtu	93.73	Cali MSW fossil portion	kg	MMBtu	90.72
Isobutane	kg	MMBtu	65.08	Cali MSW non fossil	kg	MMBtu	0
Kerosene	kg	MMBtu	72.31	Heat Plants	kg	MMBtu	0
Lignite	kg	MMBtu	96.43	Landfill Gas or biogas	kg	MMBtu	0
Lubricants	kg	MMBtu	74.21	US MSW fossil portion	kg	MMBtu	90.72
n Butane	kg	MMBtu	64.97	US MSW non fossil	kg	MMBtu	0
Naphtha lt 401 deg F	kg	MMBtu	66.51	Wood 12 pct moisture	kg	MMBtu	0
Nat Gas 1000 to 1025 Btu per cf	kg	MMBtu	52.91	Green Electricity	kg	kWh	0
Nat Gas 1025 to 1050 Btu per cf	kg	MMBtu	53.06	Biodiesel (B100)	tonnes	US Gal	0
Nat Gas 1050 to 1075 Btu per cf	kg	MMBtu	53.46	Compressed Natural Gas	kg	MMBtu	53.057
Nat Gas 1075 to 1100 Btu per cf	kg	MMBtu	53.72	Diesel	kg	MMBtu	73.15
Nat Gas 975 to 1000 Btu per cf	kg	MMBtu	54.01	Diesel ULSD	kg	MMBtu	73.15
Nat Gas gt 1100 Btu per cf	kg	MMBtu	54.71	Ethanol (E100)	kg	US Gal	0
Natural Gas	kg	MMBtu	53.06	Gasoline	kg	MMBtu	70.88
Natural Gasoline	kg	MMBtu	66.88	Liquefied Natural Gas	kg	US Gal	4.46
Other Industrial Coal	kg	MMBtu	93.98	LPG	kg	MMBtu	63.16
Other Oil gt 401 deg F	kg	MMBtu	78.8	Methanol	kg	US Gal	4.1
Pentanes Plus	kg	MMBtu	66.88	OFF ROAD Aviation Gasoline	kg	US Gal	8.32
Petrochemical Feedstocks	kg	MMBtu	71.02	OFF ROAD Diesel	kg	US Gal	10.15
Petroleum Coke	kg	MMBtu	102.12	OFF ROAD Diesel ULSD	kg	US Gal	10.15
Propane	kg	MMBtu	63.07	OFF ROAD Gasoline	kg	US Gal	8.81
Residential Coal	kg	MMBtu	95.33	OFF ROAD Jet Fuel	kg	US Gal	9.57
Residual Fuel Oil	kg	MMBtu	78.8	OFF ROAD Residual Fuel Oil	kg	US Gal	11.8

Default Transport Average Emissions Factors: CACP 2009 (exported data).

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Buses	0	0.175	1.966	4.8675	0.0648564	11.432	1.9771429	0.0161039	Miles	US Gal Gasoline Eq	6.93
Heavy Duty Vehicles	0	0.175	1.966	4.8675	0.0648564	11.432	1.9771429	0.0161039	Miles	US Gal Gasoline Eq	6.93
Light Duty Vehicles	0	0.05	0.737	0.0855	0.0016916	4.1385	0.071	0.009	Miles	US Gal Gasoline Eq	12.4
Heavy Duty Vehicles All MYs	0	0.0048	0.0051	14.99899	0.48736	9.5636653	1.2271349	0.7445818	Miles	US Gal Gasoline Eq	5.6191162
Heavy Duty Vehicles Alt. Method	1990	0.0048	0.0051	18.447783	2.7574768	10.437884	2.445852	1.8845115	Miles	US Gal Gasoline Eq	5.2384214
Heavy Duty Vehicles Alt. Method	1991	0.0048	0.0051	18.133279	2.5052416	10.340749	2.310439	1.7645609	Miles	US Gal Gasoline Eq	5.3036659
Heavy Duty Vehicles Alt. Method	1992	0.0048	0.0051	17.818775	2.2530064	10.243614	2.175026	1.6446102	Miles	US Gal Gasoline Eq	5.359032
Heavy Duty Vehicles Alt. Method	1993	0.0048	0.0051	17.504271	2.0007712	10.146478	2.039613	1.5246596	Miles	US Gal Gasoline Eq	5.406072
Heavy Duty Vehicles Alt. Method	1994	0.0048	0.0051	17.189767	1.748536	10.049343	1.9042	1.4047089	Miles	US Gal Gasoline Eq	5.4461971
Heavy Duty Vehicles Alt. Method	1995	0.0048	0.0051	16.875263	1.4963008	9.9522072	1.7687869	1.2847583	Miles	US Gal Gasoline Eq	5.4802541
Heavy Duty Vehicles Alt. Method	1996	0.0048	0.0051	16.560759	1.2440656	9.8550717	1.6333739	1.1648076	Miles	US Gal Gasoline Eq	5.5090426
Heavy Duty Vehicles Alt. Method	1997	0.0048	0.0051	16.246254	0.9918304	9.7579362	1.4979609	1.044857	Miles	US Gal Gasoline Eq	5.6021818
Heavy Duty Vehicles Alt. Method	1998	0.0048	0.0051	15.93175	0.7395952	9.6608008	1.3625479	0.9249063	Miles	US Gal Gasoline Eq	5.6087674
Heavy Duty Vehicles Alt. Method	1999	0.0048	0.0051	15.617246	0.48736	9.5636653	1.2271349	0.8049557	Miles	US Gal Gasoline Eq	5.6143651
Heavy Duty Vehicles Alt. Method	2000	0.0048	0.0051	14.99899	0.48736	9.5636653	1.2271349	0.7445818	Miles	US Gal Gasoline Eq	5.6191162
Heavy Duty Vehicles Alt. Method	2001	0.0048	0.0051	14.421066	0.48736	9.5636653	1.2271349	0.6878252	Miles	US Gal Gasoline Eq	5.6231616
Heavy Duty Vehicles Alt. Method	2002	0.0048	0.0051	13.881805	0.48736	9.5636653	1.2271349	0.6345545	Miles	US Gal Gasoline Eq	5.6265955
Heavy Duty Vehicles Alt. Method	2003	0.0048	0.0051	13.379538	0.48736	9.5636653	1.2271349	0.5846383	Miles	US Gal Gasoline Eq	5.629512
Heavy Duty Vehicles Alt. Method	2004	0.0048	0.0051	12.912596	0.48736	9.5636653	1.2271349	0.5379454	Miles	US Gal Gasoline Eq	5.6320051
Heavy Duty Vehicles Alt. Method	2005	0.0048	0.0051	12.479312	0.48736	9.5636653	1.2271349	0.4943444	Miles	US Gal Gasoline Eq	5.6341219
Heavy Duty Vehicles Alt. Method	2006	0.0048	0.0051	12.078015	0.4860215	9.5636653	1.2271349	0.453704	Miles	US Gal Gasoline Eq	5.6359094
Heavy Duty Vehicles Alt. Method	2007	0.0048	0.0051	11.707038	0.4847558	9.5636653	1.2271349	0.4158929	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2008	0.0048	0.0051	11.364711	0.4835605	9.5636653	1.2271349	0.3807796	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2009	0.0048	0.0051	11.049366	0.4824333	9.5636653	1.2271349	0.3482329	Miles	US Gal Gasoline Eq	5.643671

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Heavy Duty Vehicles Alt. Method	2010	0.0048	0.0051	10.759334	0.4813721	9.5636653	1.2271349	0.3181215	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2011	0.0048	0.0051	10.492947	0.4803743	9.5636653	1.2271349	0.290314	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2012	0.0048	0.0051	10.248536	0.4794379	9.5636653	1.2271349	0.2646791	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2013	0.0048	0.0051	10.200063	0.4785604	9.5636653	1.2271349	0.2410855	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2014	0.0048	0.0051	10.155585	0.4777395	9.5636653	1.2271349	0.2194018	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2015	0.0048	0.0051	10.114808	0.4769731	9.5636653	1.2271349	0.1994967	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2016	0.0048	0.0051	10.114808	0.4762586	9.5636653	1.2271349	0.1929733	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2017	0.0048	0.0051	10.114808	0.475594	9.5636653	1.2271349	0.1869874	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2018	0.0048	0.0051	10.114808	0.4749768	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2019	0.0048	0.0051	10.114808	0.4744048	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2020	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2021	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2022	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2023	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2024	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2025	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2026	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2027	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2028	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2029	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2030	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2031	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2032	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2033	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2034	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2035	0.0048	0.0051	10.114808	0.4738756	9.5636653	1.2271349	0.1814996	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt.	2036	0.004	0.005	10.1148	0.47387	9.56366	1.22713	0.18149	Miles	US Gal	5.6436

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Method		8	1	08	56	53	49	96		Gasoline Eq	71
Heavy Duty Vehicles Alt. Method	2037	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2038	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2039	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2040	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2041	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2042	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2043	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2044	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2045	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2046	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2047	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2048	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2049	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Heavy Duty Vehicles Alt. Method	2050	0.004 8	0.005 1	10.1148 08	0.47387 56	9.56366 53	1.22713 49	0.18149 96	Miles	US Gal Gasoline Eq	5.6436 71
Light Trucks Alt. Method	1990	0.001 44	0.000 94	1.88421 83	0.50196 84	1.37066 21	0.68475 94	0.34305 47	Miles	US Gal Gasoline Eq	15.185 006
Light Trucks Alt. Method	1991	0.001 44	0.000 94	1.84303 29	0.46379 11	1.35849 78	0.66482	0.33305 43	Miles	US Gal Gasoline Eq	15.456 027
Light Trucks Alt. Method	1992	0.001 44	0.000 94	1.80184 75	0.42561 38	1.34633 35	0.64488 06	0.32305 39	Miles	US Gal Gasoline Eq	15.687 393
Light Trucks Alt. Method	1993	0.001 44	0.000 94	1.76066 21	0.38743 65	1.33416 92	0.62494 12	0.31305 35	Miles	US Gal Gasoline Eq	15.884 961
Light Trucks Alt. Method	1994	0.001 44	0.000 94	1.71947 68	0.34925 92	1.32200 49	0.60500 19	0.30305 32	Miles	US Gal Gasoline Eq	16.052 894
Light Trucks Alt. Method	1995	0.001 44	0.000 94	1.67829 14	0.31108 19	1.30984 06	0.58506 25	0.29305 28	Miles	US Gal Gasoline Eq	16.196 342
Light Trucks Alt. Method	1996	0.001 44	0.000 94	1.63710 6	0.27290 46	1.29767 64	0.56512 31	0.28305 24	Miles	US Gal Gasoline Eq	16.318 764
Light Trucks Alt. Method	1997	0.001 44	0.000 94	1.59592 06	0.23472 73	1.28551 21	0.54518 37	0.27305 21	Miles	US Gal Gasoline Eq	16.611 941
Light Trucks Alt. Method	1998	0.001 44	0.000 94	1.55473 53	0.19655	1.27334 78	0.52524 43	0.26305 17	Miles	US Gal Gasoline Eq	16.662 038
Light Trucks Alt. Method	1999	0.001 44	0.000 94	1.51354 99	0.15837 27	1.26118 35	0.50530 5	0.25305 13	Miles	US Gal Gasoline Eq	16.704 727
Light Trucks Alt. Method	2000	0.001 45	0.000 95	1.45223 12	0.15837 27	1.26118 35	0.49018 51	0.24434 95	Miles	US Gal Gasoline Eq	16.741 418
Light Trucks Alt. Method	2001	0.001 46	0.000 96	1.39216 46	0.15837 27	1.26118 35	0.47460 77	0.23535 06	Miles	US Gal Gasoline Eq	16.772 818

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Light Trucks Alt. Method	2002	0.00147	0.00097	1.3339532	0.1583727	1.2611835	0.4587255	0.2261438	Miles	US Gal Gasoline Eq	16.79963
Light Trucks Alt. Method	2003	0.00147	0.00097	1.2781998	0.1583727	1.2611835	0.4426908	0.2168183	Miles	US Gal Gasoline Eq	16.822562
Light Trucks Alt. Method	2004	0.00148	0.00098	1.1920537	0.1583727	1.2164262	0.4226567	0.2061984	Miles	US Gal Gasoline Eq	16.841966
Light Trucks Alt. Method	2005	0.00148	0.00098	1.1077163	0.1583727	1.1691871	0.4025534	0.1955679	Miles	US Gal Gasoline Eq	16.858548
Light Trucks Alt. Method	2006	0.00149	0.00099	1.0261616	0.1583727	1.1199624	0.3825775	0.1850297	Miles	US Gal Gasoline Eq	16.87266
Light Trucks Alt. Method	2007	0.00149	0.00099	0.9483634	0.1583727	1.0692485	0.362926	0.1746871	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2008	0.00149	0.00099	0.8752957	0.1583727	1.0175419	0.3437957	0.1646431	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2009	0.00149	0.00099	0.8016599	0.1583727	0.9653389	0.3253834	0.1550009	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2010	0.00149	0.00099	0.7343547	0.1583727	0.9131358	0.3078859	0.1458636	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2011	0.00149	0.00099	0.6744234	0.1583727	0.8499008	0.2902502	0.1373343	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2012	0.00149	0.00099	0.6229096	0.1187796	0.7870193	0.2738537	0.1295161	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2013	0.00149	0.00099	0.5732896	0.1583727	0.7251155	0.2589071	0.1225121	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2014	0.00149	0.00099	0.5260117	0.1583727	0.6648137	0.245621	0.1164256	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2015	0.00149	0.00099	0.4816092	0.1583727	0.606738	0.2342061	0.1113595	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2016	0.00149	0.00099	0.4406154	0.1583727	0.5515128	0.2248731	0.1074171	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2017	0.00149	0.00099	0.4035636	0.1583727	0.4997623	0.2178327	0.1047014	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2018	0.00149	0.00099	0.3709873	0.1583727	0.4521108	0.2132955	0.1033156	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2019	0.00149	0.00099	0.342044	0.1583727	0.4091824	0.2092107	0.1022614	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2020	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2021	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2022	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2023	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2024	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2025	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2026	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2027	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2028	0.001	0.000	0.31715	0.15837	0.37160	0.20561	0.10155	Miles	US Gal	16.934

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	**Year**	**N2O**	**CH4**	**NOx**	**SOx**	**CO**	**VOC**	**PM10**	**Distance Unit**	**Per Energy Unit**	**Fuel Efficiency**
		49	99	86	27	14	11	53		Gasoline Eq	4
Light Trucks Alt. Method	2029	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2030	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2031	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2032	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2033	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2034	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2035	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2036	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2037	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2038	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2039	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2040	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2041	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2042	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2043	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2044	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2045	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2046	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2047	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2048	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2049	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2050	0.00149	0.00099	0.3171586	0.1583727	0.3716014	0.2056111	0.1015553	Miles	US Gal Gasoline Eq	16.9344
Light Trucks MY 1960 to 1982	0	0.0017	0.0011	1.8842183	0.5019684	1.3706621	0.6847594	0.3430547	Miles	US Gal Gasoline Eq	15.185006
Light Trucks MY 1983 to 1995	0	0.0014	0.0009	1.8842183	0.5019684	1.3706621	0.6847594	0.3430547	Miles	US Gal Gasoline Eq	15.185006
Light Trucks MY 1996 to 2004	0	0.0015	0.001	1.4522312	0.1583727	1.2611835	0.4901851	0.2443495	Miles	US Gal Gasoline Eq	16.741418
Passenger Cars Alt. Method	1990	0.001	0.0005	1.6194092	0.5752287	1.3252821	0.5394793	0.3931221	Miles	US Gal Gasoline Eq	17.250732

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Passenger Cars Alt. Method	1991	0.001	0.0005	1.5889613	0.5230457	1.3275021	0.5356822	0.3681864	Miles	US Gal Gasoline Eq	17.60722
Passenger Cars Alt. Method	1992	0.001	0.0005	1.5585133	0.4708627	1.3297221	0.531885	0.3432507	Miles	US Gal Gasoline Eq	17.916376
Passenger Cars Alt. Method	1993	0.001	0.0005	1.5280654	0.4186797	1.3319422	0.5280879	0.318315	Miles	US Gal Gasoline Eq	18.182084
Passenger Cars Alt. Method	1994	0.001	0.0005	1.4976174	0.3664967	1.3341622	0.5242907	0.2933793	Miles	US Gal Gasoline Eq	18.407152
Passenger Cars Alt. Method	1995	0.001	0.0005	1.4671695	0.3143138	1.3363822	0.5204936	0.2684436	Miles	US Gal Gasoline Eq	18.586621
Passenger Cars Alt. Method	1996	0.001	0.0005	1.4367215	0.2621308	1.3386023	0.5166964	0.243508	Miles	US Gal Gasoline Eq	18.782067
Passenger Cars Alt. Method	1997	0.001	0.0005	1.4062736	0.2099478	1.3408223	0.5128993	0.2185723	Miles	US Gal Gasoline Eq	19.006259
Passenger Cars Alt. Method	1998	0.001	0.0005	1.3758256	0.1577648	1.3430424	0.5091021	0.1936366	Miles	US Gal Gasoline Eq	19.141962
Passenger Cars Alt. Method	1999	0.001	0.0005	1.3453777	0.1055818	1.3452624	0.505305	0.1687009	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2000	0.001	0.0005	1.3105345	0.1055818	1.3452624	0.4980645	0.1572875	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2001	0.001	0.0005	1.2737592	0.1055818	1.3452624	0.4906049	0.1460948	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2002	0.001	0.0005	1.2354382	0.1055818	1.3452624	0.4829993	0.1352386	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2003	0.001	0.0005	1.1959579	0.1055818	1.3452624	0.4753207	0.1248347	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2004	0.001	0.0005	1.1365409	0.1055818	1.3452624	0.4610588	0.1143605	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2005	0.001	0.0005	1.0756749	0.1055818	1.3452624	0.4465047	0.1045347	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2006	0.001	0.0005	1.0139587	0.1055818	1.3452624	0.4318047	0.0954801	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2007	0.001	0.0005	0.9519914	0.1055818	1.3452624	0.4171046	0.0873197	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2008	0.001	0.0005	0.8903718	0.1055818	1.3452624	0.4025506	0.0801762	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2009	0.001	0.0005	0.829699	0.1055818	1.3452624	0.3882886	0.0741726	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2010	0.001	0.0005	0.7705719	0.1055818	1.3452624	0.3744647	0.0694316	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2011	0.001	0.0005	0.712428	0.1055818	1.3115675	0.3591676	0.0660762	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2012	0.001	0.0005	0.6569634	0.1055818	1.2760041	0.3444865	0.0629937	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2013	0.001	0.0005	0.6047899	0.1055818	1.238946	0.3305904	0.0602098	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2014	0.001	0.0005	0.5565194	0.1055818	1.2007667	0.317648	0.0577641	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2015	0.001	0.0005	0.5127636	0.1055818	1.1618401	0.3058281	0.055696	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2016	0.001	0.0005	0.4741345	0.1055818	1.1225397	0.2952997	0.0540453	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt.	2017	0.001	0.000	0.44124	0.10558	1.08323	0.28623	0.05285	Miles	US Gal	19.378

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Method			5	39	18	94	16	14		Gasoline Eq	365
Passenger Cars Alt. Method	2018	0.001	0.0005	0.4147037	0.1055818	1.0443127	0.2787926	0.0521539	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2019	0.001	0.0005	0.3951256	0.1055818	1.0061335	0.2720685	0.0516218	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2020	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2021	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2022	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2023	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2024	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2025	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2026	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2027	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2028	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2029	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2030	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2031	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2032	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2033	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2034	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2035	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2036	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2037	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2038	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2039	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2040	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2041	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2042	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2043	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Passenger Cars Alt. Method	2044	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2045	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2046	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2047	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2048	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2049	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2050	0.001	0.0005	0.3831215	0.1055818	0.9690753	0.266143	0.0512653	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars MY 1960 to 1982	0	0.0012	0.0006	1.6194092	0.5752287	1.3252821	0.5394793	0.3931221	Miles	US Gal Gasoline Eq	17.250732
Passenger Cars MY 1983 to 2004	0	0.001	0.0005	1.3105345	0.1055818	1.3452624	0.4980645	0.1572875	Miles	US Gal Gasoline Eq	19.378365
Heavy Duty Vehicles All MYs	0	0.0048	0.0051	14.99899	0.0155955	9.5636653	1.2271349	0.7073527	Miles	US Gal Gasoline Eq	5.6191162
Heavy Duty Vehicles Alt. Method	1990	0.0048	0.0051	18.447783	0.0882393	10.437884	2.445852	1.790286	Miles	US Gal Gasoline Eq	5.2384214
Heavy Duty Vehicles Alt. Method	1991	0.0048	0.0051	18.133279	0.0801677	10.340749	2.310439	1.6763328	Miles	US Gal Gasoline Eq	5.3036659
Heavy Duty Vehicles Alt. Method	1992	0.0048	0.0051	17.818775	0.0720962	10.243614	2.175026	1.5623797	Miles	US Gal Gasoline Eq	5.359032
Heavy Duty Vehicles Alt. Method	1993	0.0048	0.0051	17.504271	0.0640247	10.146478	2.039613	1.4484266	Miles	US Gal Gasoline Eq	5.406072
Heavy Duty Vehicles Alt. Method	1994	0.0048	0.0051	17.189767	0.0559532	10.049343	1.9042	1.3344735	Miles	US Gal Gasoline Eq	5.4461971
Heavy Duty Vehicles Alt. Method	1995	0.0048	0.0051	16.875263	0.0478816	9.9522072	1.7687869	1.2205204	Miles	US Gal Gasoline Eq	5.4802541
Heavy Duty Vehicles Alt. Method	1996	0.0048	0.0051	16.560759	0.0398101	9.8550717	1.6333739	1.1065673	Miles	US Gal Gasoline Eq	5.5090426
Heavy Duty Vehicles Alt. Method	1997	0.0048	0.0051	16.246254	0.0317386	9.7579362	1.4979609	0.9926141	Miles	US Gal Gasoline Eq	5.6021818
Heavy Duty Vehicles Alt. Method	1998	0.0048	0.0051	15.93175	0.023667	9.6608008	1.3625479	0.878661	Miles	US Gal Gasoline Eq	5.6087674
Heavy Duty Vehicles Alt. Method	1999	0.0048	0.0051	15.617246	0.0155955	9.5636653	1.2271349	0.7647079	Miles	US Gal Gasoline Eq	5.6143651
Heavy Duty Vehicles Alt. Method	2000	0.0048	0.0051	14.99899	0.0155955	9.5636653	1.2271349	0.7073527	Miles	US Gal Gasoline Eq	5.6191162
Heavy Duty Vehicles Alt. Method	2001	0.0048	0.0051	14.421066	0.0155955	9.5636653	1.2271349	0.653434	Miles	US Gal Gasoline Eq	5.6231616
Heavy Duty Vehicles Alt. Method	2002	0.0048	0.0051	13.881805	0.0155955	9.5636653	1.2271349	0.6028268	Miles	US Gal Gasoline Eq	5.6265955
Heavy Duty Vehicles Alt. Method	2003	0.0048	0.0051	13.379538	0.0155955	9.5636653	1.2271349	0.5554064	Miles	US Gal Gasoline Eq	5.629512
Heavy Duty Vehicles Alt. Method	2004	0.0048	0.0051	12.912596	0.0155955	9.5636653	1.2271349	0.5110482	Miles	US Gal Gasoline Eq	5.6320051
Heavy Duty Vehicles Alt. Method	2005	0.0048	0.0051	12.479312	0.0155955	9.5636653	1.2271349	0.4696272	Miles	US Gal Gasoline Eq	5.6341219
Heavy Duty Vehicles Alt.	2006	0.004	0.005	12.0780	0.01555	9.56366	1.22713	0.43101	Miles	US Gal	5.6359

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Method		8	1	15	27	53	49	88		Gasoline Eq	094
Heavy Duty Vehicles Alt. Method	2007	0.0048	0.0051	11.707038	0.0155122	9.5636653	1.2271349	0.3950982	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2008	0.0048	0.0051	11.364711	0.0154739	9.5636653	1.2271349	0.3617406	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2009	0.0048	0.0051	11.049366	0.0154379	9.5636653	1.2271349	0.3308213	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2010	0.0048	0.0051	10.759334	0.0154039	9.5636653	1.2271349	0.3022154	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2011	0.0048	0.0051	10.492947	0.015372	9.5636653	1.2271349	0.2757983	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2012	0.0048	0.0051	10.248536	0.015342	9.5636653	1.2271349	0.2514452	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2013	0.0048	0.0051	10.200063	0.0153139	9.5636653	1.2271349	0.2290312	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2014	0.0048	0.0051	10.155585	0.0152877	9.5636653	1.2271349	0.2084317	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2015	0.0048	0.0051	10.114808	0.0152631	9.5636653	1.2271349	0.1895218	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2016	0.0048	0.0051	10.114808	0.0152403	9.5636653	1.2271349	0.1833246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2017	0.0048	0.0051	10.114808	0.015219	9.5636653	1.2271349	0.177638	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2018	0.0048	0.0051	10.114808	0.0151993	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2019	0.0048	0.0051	10.114808	0.015181	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2020	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2021	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2022	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2023	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2024	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2025	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2026	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2027	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2028	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2029	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2030	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2031	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2032	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Heavy Duty Vehicles Alt. Method	2033	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2034	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2035	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2036	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2037	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2038	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2039	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2040	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2041	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2042	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2043	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2044	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2045	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2046	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2047	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2048	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2049	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Heavy Duty Vehicles Alt. Method	2050	0.0048	0.0051	10.114808	0.015164	9.5636653	1.2271349	0.1724246	Miles	US Gal Gasoline Eq	5.643671
Light Trucks Alt. Method	1990	0.00144	0.00094	1.8842183	0.0160663	1.3706621	0.6847594	0.3259019	Miles	US Gal Gasoline Eq	15.185006
Light Trucks Alt. Method	1991	0.00144	0.00094	1.8430329	0.0148413	1.3584978	0.66482	0.3164016	Miles	US Gal Gasoline Eq	15.456027
Light Trucks Alt. Method	1992	0.00144	0.00094	1.8018475	0.0136196	1.3463335	0.6448806	0.3069012	Miles	US Gal Gasoline Eq	15.687393
Light Trucks Alt. Method	1993	0.00144	0.00094	1.7606621	0.012398	1.3341692	0.6249412	0.2974009	Miles	US Gal Gasoline Eq	15.884961
Light Trucks Alt. Method	1994	0.00144	0.00094	1.7194768	0.0111763	1.3220049	0.6050019	0.2879005	Miles	US Gal Gasoline Eq	16.052894
Light Trucks Alt. Method	1995	0.00144	0.00094	1.6782914	0.0099546	1.3098406	0.5850625	0.2784002	Miles	US Gal Gasoline Eq	16.196342
Light Trucks Alt. Method	1996	0.00144	0.00094	1.637106	0.0087329	1.2976764	0.5651231	0.2688998	Miles	US Gal Gasoline Eq	16.318764
Light Trucks Alt. Method	1997	0.00144	0.00094	1.5959206	0.0075113	1.2855121	0.5451837	0.2593995	Miles	US Gal Gasoline Eq	16.611941
Light Trucks Alt. Method	1998	0.001	0.000	1.55473	0.00628	1.27334	0.52524	0.24989	Miles	US Gal	16.662

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
		44	94	53	96	78	43	91		Gasoline Eq	038
Light Trucks Alt. Method	1999	0.00144	0.00094	1.5135499	0.0050679	1.2611835	0.505305	0.2403988	Miles	US Gal Gasoline Eq	16.704727
Light Trucks Alt. Method	2000	0.00145	0.00095	1.4522312	0.0050679	1.2611835	0.4901851	0.232132	Miles	US Gal Gasoline Eq	16.741418
Light Trucks Alt. Method	2001	0.00146	0.00096	1.3921646	0.0050679	1.2611835	0.4746077	0.2235831	Miles	US Gal Gasoline Eq	16.772818
Light Trucks Alt. Method	2002	0.00147	0.00097	1.3339532	0.0050679	1.2611835	0.4587255	0.2148366	Miles	US Gal Gasoline Eq	16.79963
Light Trucks Alt. Method	2003	0.00147	0.00097	1.2781998	0.0050679	1.2611835	0.4426908	0.2059773	Miles	US Gal Gasoline Eq	16.822562
Light Trucks Alt. Method	2004	0.00148	0.00098	1.1920537	0.0050679	1.2164262	0.4226567	0.1958885	Miles	US Gal Gasoline Eq	16.841966
Light Trucks Alt. Method	2005	0.00148	0.00098	1.1077163	0.0050679	1.1691871	0.4025534	0.1857895	Miles	US Gal Gasoline Eq	16.858548
Light Trucks Alt. Method	2006	0.00149	0.00099	1.0261616	0.0050679	1.1199624	0.3825775	0.1757783	Miles	US Gal Gasoline Eq	16.87266
Light Trucks Alt. Method	2007	0.00149	0.00099	0.9483634	0.0050679	1.0692485	0.362926	0.1659528	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2008	0.00149	0.00099	0.8752957	0.0050679	1.0175419	0.3437957	0.156411	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2009	0.00149	0.00099	0.8016599	0.0050679	0.9653389	0.3253834	0.1472509	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2010	0.00149	0.00099	0.7343547	0.0050679	0.9131358	0.3078859	0.1385704	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2011	0.00149	0.00099	0.6744234	0.0050679	0.8499008	0.2902502	0.1304676	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2012	0.00149	0.00099	0.6229096	0.0038009	0.7870193	0.2738537	0.1230403	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2013	0.00149	0.00099	0.5732896	0.0050679	0.7251155	0.2589071	0.1163865	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2014	0.00149	0.00099	0.5260117	0.0050679	0.6648137	0.245621	0.1106043	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2015	0.00149	0.00099	0.4816092	0.0050679	0.606738	0.2342061	0.1057915	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2016	0.00149	0.00099	0.4406154	0.0050679	0.5515128	0.2248731	0.1020462	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2017	0.00149	0.00099	0.4035636	0.0050679	0.4997623	0.2178327	0.0994663	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2018	0.00149	0.00099	0.3709873	0.0050679	0.4521108	0.2132955	0.0981498	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2019	0.00149	0.00099	0.342044	0.0050679	0.4091824	0.2092107	0.0971483	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2020	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2021	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2022	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2023	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2024	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Light Trucks Alt. Method	2025	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2026	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2027	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2028	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2029	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2030	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2031	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2032	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2033	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2034	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2035	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2036	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2037	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2038	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2039	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2040	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2041	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2042	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2043	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2044	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2045	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2046	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2047	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2048	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2049	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks Alt. Method	2050	0.00149	0.00099	0.3171586	0.0050679	0.3716014	0.2056111	0.0964776	Miles	US Gal Gasoline Eq	16.9344
Light Trucks MY 1960 to	0	0.001	0.001	1.88421	0.01606	1.37066	0.68475	0.32590	Miles	US Gal	15.185

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
1982		7	1	83	3	21	94	19		Gasoline Eq	006
Light Trucks MY 1983 to 1995	0	0.0014	0.0009	1.8842183	0.016063	1.3706621	0.6847594	0.3259019	Miles	US Gal Gasoline Eq	15.185006
Light Trucks MY 1996 to 2004	0	0.0015	0.001	1.4522312	0.0050679	1.2611835	0.4901851	0.232132	Miles	US Gal Gasoline Eq	16.741418
Passenger Cars Alt. Method	1990	0.001	0.0005	1.6194092	0.0184073	1.3252821	0.5394793	0.373466	Miles	US Gal Gasoline Eq	17.250732
Passenger Cars Alt. Method	1991	0.001	0.0005	1.5889613	0.0167375	1.3275021	0.5356822	0.3497771	Miles	US Gal Gasoline Eq	17.60722
Passenger Cars Alt. Method	1992	0.001	0.0005	1.5585133	0.0150676	1.3297221	0.531885	0.3260882	Miles	US Gal Gasoline Eq	17.916376
Passenger Cars Alt. Method	1993	0.001	0.0005	1.5280654	0.0133978	1.3319422	0.5280879	0.3023993	Miles	US Gal Gasoline Eq	18.182084
Passenger Cars Alt. Method	1994	0.001	0.0005	1.4976174	0.0117279	1.3341622	0.5242907	0.2787104	Miles	US Gal Gasoline Eq	18.407152
Passenger Cars Alt. Method	1995	0.001	0.0005	1.4671695	0.010058	1.3363822	0.5204936	0.2550215	Miles	US Gal Gasoline Eq	18.586621
Passenger Cars Alt. Method	1996	0.001	0.0005	1.4367215	0.0083882	1.3386023	0.5166964	0.2313326	Miles	US Gal Gasoline Eq	18.782067
Passenger Cars Alt. Method	1997	0.001	0.0005	1.4062736	0.0067183	1.3408223	0.5128993	0.2076437	Miles	US Gal Gasoline Eq	19.006259
Passenger Cars Alt. Method	1998	0.001	0.0005	1.3758256	0.0050485	1.3430424	0.5091021	0.1839548	Miles	US Gal Gasoline Eq	19.141962
Passenger Cars Alt. Method	1999	0.001	0.0005	1.3453777	0.0033786	1.3452624	0.505305	0.1602658	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2000	0.001	0.0005	1.3105345	0.0033786	1.3452624	0.4980645	0.1494231	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2001	0.001	0.0005	1.2737592	0.0033786	1.3452624	0.4906049	0.1387901	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2002	0.001	0.0005	1.2354382	0.0033786	1.3452624	0.4829993	0.1284767	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2003	0.001	0.0005	1.1959579	0.0033786	1.3452624	0.4753207	0.118593	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2004	0.001	0.0005	1.1365409	0.0033786	1.3452624	0.4610588	0.1086424	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2005	0.001	0.0005	1.0756749	0.0033786	1.3452624	0.4465047	0.0993079	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2006	0.001	0.0005	1.0139587	0.0033786	1.3452624	0.4318047	0.0907061	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2007	0.001	0.0005	0.9519914	0.0033786	1.3452624	0.4171046	0.0829537	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2008	0.001	0.0005	0.8903718	0.0033786	1.3452624	0.4025506	0.0761674	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2009	0.001	0.0005	0.829699	0.0033786	1.3452624	0.3882886	0.070464	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2010	0.001	0.0005	0.7705719	0.0033786	1.3452624	0.3744647	0.0659601	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2011	0.001	0.0005	0.712428	0.0033786	1.3115675	0.3591676	0.0627724	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2012	0.001	0.0005	0.6569634	0.0033786	1.2760041	0.3444865	0.059844	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2013	0.001	0.0005	0.6047899	0.0033786	1.238946	0.3305904	0.0571993	Miles	US Gal Gasoline Eq	19.378365

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Passenger Cars Alt. Method	2014	0.001	0.0005	0.5565194	0.0033786	1.2007667	0.317648	0.0548759	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2015	0.001	0.0005	0.5127636	0.0033786	1.1618401	0.3058281	0.0529112	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2016	0.001	0.0005	0.4741345	0.0033786	1.1225397	0.2952997	0.051343	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2017	0.001	0.0005	0.4412439	0.0033786	1.0832394	0.2862316	0.0502088	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2018	0.001	0.0005	0.4147037	0.0033786	1.0443127	0.2787926	0.0495462	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2019	0.001	0.0005	0.3951256	0.0033786	1.0061335	0.2720685	0.0490407	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2020	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2021	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2022	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2023	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2024	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2025	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2026	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2027	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2028	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2029	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2030	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2031	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2032	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2033	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2034	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2035	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2036	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2037	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2038	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2039	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt.	2040	0.001	0.000	0.38312	0.00337	0.96907	0.26614	0.04870	Miles	US Gal	19.378

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Method			5	15	86	53	3	21		Gasoline Eq	365
Passenger Cars Alt. Method	2041	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2042	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2043	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2044	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2045	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2046	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2047	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2048	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2049	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars Alt. Method	2050	0.001	0.0005	0.3831215	0.0033786	0.9690753	0.266143	0.0487021	Miles	US Gal Gasoline Eq	19.378365
Passenger Cars MY 1960 to 1982	0	0.0012	0.0006	1.6194092	0.0184073	1.3252821	0.5394793	0.373466	Miles	US Gal Gasoline Eq	17.250732
Passenger Cars MY 1983 to 2004	0	0.001	0.0005	1.3105345	0.0033786	1.3452624	0.4980645	0.1494231	Miles	US Gal Gasoline Eq	19.378365
Buses	0	0.175	0.197	1.6495276	0.003939	13.69626	1.3552511	0.5465083	Miles	US Gal Gasoline Eq	6.93
Heavy Duty Vehicles	0	0.175	0.197	1.6495276	0.003939	13.69626	1.3552511	0.5465083	Miles	US Gal Gasoline Eq	8.3
Light Duty Vehicles	0	0.067	0.055	0.4142687	0.0179702	3.2322203	0.1952027	0.00261	Miles	US Gal Gasoline Eq	22.804
Heavy Duty Vehicles Alt. Method	1990	0.12126	0.26243	6.5932231	0.2178984	108.46453	8.740201	0.211385	Miles	US Gal Gasoline Eq	4.2038413
Heavy Duty Vehicles Alt. Method	1991	0.12126	0.26243	6.4228611	0.2143532	101.63761	8.2286366	0.2020823	Miles	US Gal Gasoline Eq	4.3069001
Heavy Duty Vehicles Alt. Method	1992	0.12126	0.26243	6.2524991	0.2108079	94.810694	7.7170723	0.1927796	Miles	US Gal Gasoline Eq	4.394271
Heavy Duty Vehicles Alt. Method	1993	0.12126	0.26243	6.0821371	0.2072626	87.983779	7.205508	0.1834769	Miles	US Gal Gasoline Eq	4.469535
Heavy Duty Vehicles Alt. Method	1994	0.12126	0.26243	5.9117751	0.2037174	81.156863	6.6939437	0.1741742	Miles	US Gal Gasoline Eq	4.533968
Heavy Duty Vehicles Alt. Method	1995	0.12126	0.26243	5.7414131	0.2001721	74.329948	6.1823793	0.1648714	Miles	US Gal Gasoline Eq	4.5893753
Heavy Duty Vehicles Alt. Method	1996	0.12126	0.26243	5.5710511	0.1966268	67.503032	5.670815	0.1555687	Miles	US Gal Gasoline Eq	4.6365564
Heavy Duty Vehicles Alt. Method	1997	0.12126	0.26243	5.4006891	0.1930816	60.676117	5.1592507	0.146266	Miles	US Gal Gasoline Eq	4.7393388
Heavy Duty Vehicles Alt. Method	1998	0.12126	0.26243	5.2303271	0.1895363	53.849201	4.6476864	0.1369633	Miles	US Gal Gasoline Eq	4.7602716
Heavy Duty Vehicles Alt. Method	1999	0.12126	0.26243	5.0599652	0.1859911	47.022286	4.136122	0.1276606	Miles	US Gal Gasoline Eq	4.7781821
Heavy Duty Vehicles Alt. Method	2000	0.12262	0.23709	4.8857948	0.1859911	45.741577	4.0939539	0.12309	Miles	US Gal Gasoline Eq	4.7935171

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Heavy Duty Vehicles Alt. Method	2001	0.12546	0.21149	4.7229835	0.1859911	44.547859	4.0546499	0.1186404	Miles	US Gal Gasoline Eq	4.8066001
Heavy Duty Vehicles Alt. Method	2002	0.12721	0.19053	4.5710613	0.1859911	43.43729	4.0180837	0.1143175	Miles	US Gal Gasoline Eq	4.8178192
Heavy Duty Vehicles Alt. Method	2003	0.12685	0.17253	4.4295584	0.1859911	42.406027	3.9841286	0.1101269	Miles	US Gal Gasoline Eq	4.827433
Heavy Duty Vehicles Alt. Method	2004	0.1178	0.15537	4.2980052	0.1859911	41.450229	3.9526584	0.1060742	Miles	US Gal Gasoline Eq	4.835665
Heavy Duty Vehicles Alt. Method	2005	0.10984	0.13826	4.1759317	0.1859911	40.566054	3.9235463	0.102165	Miles	US Gal Gasoline Eq	4.8427445
Heavy Duty Vehicles Alt. Method	2006	0.1031	0.12351	4.0628683	0.180768	39.749661	3.896666	0.0984048	Miles	US Gal Gasoline Eq	4.8496652
Heavy Duty Vehicles Alt. Method	2007	0.1031	0.12351	3.958345	0.1758289	38.997207	3.871891	0.0947994	Miles	US Gal Gasoline Eq	4.8546632
Heavy Duty Vehicles Alt. Method	2008	0.1031	0.12351	3.8618921	0.1711647	38.30485	3.8490947	0.0913543	Miles	US Gal Gasoline Eq	4.8589439
Heavy Duty Vehicles Alt. Method	2009	0.1031	0.12351	3.7730398	0.1667665	37.66875	3.8281506	0.0880752	Miles	US Gal Gasoline Eq	4.8626248
Heavy Duty Vehicles Alt. Method	2010	0.1031	0.12351	3.6913183	0.1626252	37.085062	3.8089324	0.0812281	Miles	US Gal Gasoline Eq	4.8657647
Heavy Duty Vehicles Alt. Method	2011	0.1031	0.12351	3.6162579	0.158732	36.549947	3.7913133	0.07487	Miles	US Gal Gasoline Eq	4.8727795
Heavy Duty Vehicles Alt. Method	2012	0.1031	0.12351	3.5473886	0.1550778	36.549947	3.7913133	0.0689772	Miles	US Gal Gasoline Eq	4.8758724
Heavy Duty Vehicles Alt. Method	2013	0.1031	0.12351	3.5334985	0.1516537	36.549947	3.7913133	0.0635259	Miles	US Gal Gasoline Eq	4.8766486
Heavy Duty Vehicles Alt. Method	2014	0.1031	0.12351	3.520753	0.1484506	36.549947	3.7913133	0.0584925	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2015	0.1031	0.12351	3.509068	0.1454597	36.549947	3.7913133	0.0538534	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2016	0.1031	0.12351	3.509068	0.142672	36.549947	3.7913133	0.0495847	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2017	0.1031	0.12351	3.509068	0.1400784	36.549947	3.7913133	0.0456629	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2018	0.1031	0.12351	3.509068	0.13767	36.549947	3.7913133	0.0420643	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2019	0.1031	0.12351	3.509068	0.1354379	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2020	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2021	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2022	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2023	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2024	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2025	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2026	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt.	2027	0.103	0.123	3.50906	0.13337	36.5499	3.79131	0.03876	Miles	US Gal	4.8799

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Method		1	51	8	31	47	33	51		Gasoline Eq	12
Heavy Duty Vehicles Alt. Method	2028	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2029	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2030	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2031	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2032	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2033	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2034	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2035	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2036	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2037	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2038	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2039	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2040	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2041	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2042	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2043	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2044	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2045	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2046	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2047	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2048	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2049	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles Alt. Method	2050	0.1031	0.12351	3.509068	0.1333731	36.549947	3.7913133	0.0387651	Miles	US Gal Gasoline Eq	4.879912
Heavy Duty Vehicles MY 1985 to 1986	0	0.0515	0.409	6.5932231	0.2178984	108.46453	8.740201	0.211385	Miles	US Gal Gasoline Eq	4.2038413
Heavy Duty Vehicles MY 1987	0	0.0849	0.3675	6.5932231	0.2178984	108.46453	8.740201	0.211385	Miles	US Gal Gasoline Eq	4.2038413
Heavy Duty Vehicles MY 1988 to 1989	0	0.0933	0.3492	6.5932231	0.2178984	108.46453	8.740201	0.211385	Miles	US Gal Gasoline Eq	4.2038413

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Heavy Duty Vehicles MY 1990 to 1995	0	0.1142	0.3246	5.7414131	0.2001721	74.329948	6.1823793	0.1648714	Miles	US Gal Gasoline Eq	4.5893753
Heavy Duty Vehicles MY 1996	0	0.168	0.1278	5.5710511	0.1966268	67.503032	5.670815	0.1555687	Miles	US Gal Gasoline Eq	4.6365564
Heavy Duty Vehicles MY 1997	0	0.1726	0.0924	5.4006891	0.1930816	60.676117	5.1592507	0.146266	Miles	US Gal Gasoline Eq	4.7393388
Heavy Duty Vehicles MY 1998	0	0.1693	0.0641	5.2303271	0.1895363	53.849201	4.6476864	0.1369633	Miles	US Gal Gasoline Eq	4.7602716
Heavy Duty Vehicles MY 1999	0	0.1435	0.0578	5.0599652	0.1859911	47.022286	4.136122	0.1276606	Miles	US Gal Gasoline Eq	4.7781821
Heavy Duty Vehicles MY 2000	0	0.1092	0.0493	4.8857948	0.1859911	45.741577	4.0939539	0.12309	Miles	US Gal Gasoline Eq	4.7935171
Heavy Duty Vehicles MY 2001	0	0.1235	0.0528	4.7229835	0.1859911	44.547859	4.0546499	0.1186404	Miles	US Gal Gasoline Eq	4.8066001
Heavy Duty Vehicles MY 2002	0	0.1307	0.0546	4.5710613	0.1859911	43.43729	4.0180837	0.1143175	Miles	US Gal Gasoline Eq	4.8178192
Heavy Duty Vehicles MY 2003	0	0.124	0.0533	4.4295584	0.1859911	42.406027	3.9841286	0.1101269	Miles	US Gal Gasoline Eq	4.827433
Heavy Duty Vehicles MY 2004	0	0.0285	0.0341	4.2980052	0.1859911	41.450229	3.9526584	0.1060742	Miles	US Gal Gasoline Eq	4.835665
Heavy Duty Vehicles MY 2005	0	0.0177	0.0326	4.1759317	0.1859911	40.566054	3.9235463	0.102165	Miles	US Gal Gasoline Eq	4.8427445
Light Trucks Alt. Method	1990	0.09029	0.06059	2.4727521	0.1102187	27.273672	3.2116433	0.0595609	Miles	US Gal Gasoline Eq	10.851014
Light Trucks Alt. Method	1991	0.09029	0.06059	2.4059981	0.1095833	26.289345	3.0733753	0.0574865	Miles	US Gal Gasoline Eq	10.925899
Light Trucks Alt. Method	1992	0.09029	0.06059	2.339244	0.1089479	25.305017	2.9351073	0.055412	Miles	US Gal Gasoline Eq	10.997336
Light Trucks Alt. Method	1993	0.09029	0.06059	2.2724899	0.1083124	24.32069	2.7968393	0.0533376	Miles	US Gal Gasoline Eq	11.069906
Light Trucks Alt. Method	1994	0.09029	0.06059	2.2057359	0.107677	23.336363	2.6585713	0.0512631	Miles	US Gal Gasoline Eq	11.237428
Light Trucks Alt. Method	1995	0.09029	0.06059	2.1389818	0.1070416	22.352035	2.5203033	0.0491887	Miles	US Gal Gasoline Eq	11.516014
Light Trucks Alt. Method	1996	0.09029	0.06059	2.0722277	0.1064062	21.367708	2.3820353	0.0471142	Miles	US Gal Gasoline Eq	11.847327
Light Trucks Alt. Method	1997	0.09029	0.06059	2.0054737	0.1057708	20.38338	2.2437673	0.0450398	Miles	US Gal Gasoline Eq	12.242719
Light Trucks Alt. Method	1998	0.09029	0.06059	1.9387196	0.1051354	19.399053	2.1054993	0.0429653	Miles	US Gal Gasoline Eq	12.513053
Light Trucks Alt. Method	1999	0.09029	0.06059	1.8719655	0.1045	18.414726	1.9672313	0.0408909	Miles	US Gal Gasoline Eq	12.768675
Light Trucks Alt. Method	2000	0.08665	0.05701	1.7989537	0.1045	18.231607	1.9412608	0.0390007	Miles	US Gal Gasoline Eq	12.986369
Light Trucks Alt. Method	2001	0.07795	0.05158	1.7262847	0.1045	18.042948	1.9145047	0.0370533	Miles	US Gal Gasoline Eq	13.176957
Light Trucks Alt. Method	2002	0.07095	0.047	1.654682	0.1045	17.850596	1.8872248	0.0350678	Miles	US Gal Gasoline Eq	13.344459
Light Trucks Alt. Method	2003	0.06295	0.04236	1.5848692	0.1045	17.656398	1.8596831	0.0330632	Miles	US Gal Gasoline Eq	13.489615
Light Trucks Alt. Method	2004	0.05593	0.03811	1.5107022	0.1045	17.462199	1.8257013	0.0310586	Miles	US Gal Gasoline Eq	13.611943
Light Trucks Alt. Method	2005	0.049	0.034	1.43939	0.1045	17.2698	1.79162	0.02907	Miles	US Gal	13.716

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
		35	51	15		47	43	31		Gasoline Eq	78
Light Trucks Alt. Method	2006	0.04331	0.03146	1.3717368	0.1027583	17.081188	1.7577853	0.0271257	Miles	US Gal Gasoline Eq	13.799512
Light Trucks Alt. Method	2007	0.04331	0.03146	1.3085377	0.1010167	16.898069	1.7245178	0.0252355	Miles	US Gal Gasoline Eq	13.86581
Light Trucks Alt. Method	2008	0.04331	0.03146	1.2505942	0.099275	16.722337	1.6921549	0.0234216	Miles	US Gal Gasoline Eq	13.917933
Light Trucks Alt. Method	2009	0.04331	0.03146	1.1935551	0.0975333	16.526105	1.6599567	0.0217029	Miles	US Gal Gasoline Eq	13.958071
Light Trucks Alt. Method	2010	0.04331	0.03146	1.1430854	0.0957917	16.339304	1.6292704	0.0200986	Miles	US Gal Gasoline Eq	13.988479
Light Trucks Alt. Method	2011	0.04331	0.03146	1.1000419	0.09405	16.16411	1.600441	0.0186278	Miles	US Gal Gasoline Eq	14.011249
Light Trucks Alt. Method	2012	0.04331	0.03146	1.0652815	0.0923083	16.002699	1.5738139	0.0173094	Miles	US Gal Gasoline Eq	14.028515
Light Trucks Alt. Method	2013	0.04331	0.03146	1.0334472	0.0905667	15.857248	1.5497342	0.0161626	Miles	US Gal Gasoline Eq	14.042288
Light Trucks Alt. Method	2014	0.04331	0.03146	1.004907	0.088825	15.729933	1.5285471	0.0152063	Miles	US Gal Gasoline Eq	14.053872
Light Trucks Alt. Method	2015	0.04331	0.03146	0.980099	0.0870833	15.62293	1.510598	0.0144598	Miles	US Gal Gasoline Eq	14.063848
Light Trucks Alt. Method	2016	0.04331	0.03146	0.9594611	0.0853417	15.538416	1.4962319	0.013942	Miles	US Gal Gasoline Eq	14.073216
Light Trucks Alt. Method	2017	0.04331	0.03146	0.9434312	0.0836	15.478567	1.4857941	0.0136719	Miles	US Gal Gasoline Eq	14.081154
Light Trucks Alt. Method	2018	0.04331	0.03146	0.9324474	0.0818583	15.44556	1.4796299	0.0136688	Miles	US Gal Gasoline Eq	14.096146
Light Trucks Alt. Method	2019	0.04331	0.03146	0.9224284	0.0801167	15.414179	1.4741997	0.0136688	Miles	US Gal Gasoline Eq	14.108051
Light Trucks Alt. Method	2020	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2021	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2022	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2023	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2024	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2025	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2026	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2027	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2028	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2029	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2030	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2031	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Light Trucks Alt. Method	2032	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2033	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2034	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2035	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2036	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2037	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2038	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2039	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2040	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2041	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2042	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2043	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2044	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2045	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2046	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2047	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2048	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2049	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks Alt. Method	2050	0.04331	0.03146	0.9134566	0.078375	15.384447	1.4695433	0.0136688	Miles	US Gal Gasoline Eq	14.113411
Light Trucks MY 1987 to 1993	0	0.1035	0.0813	2.4727521	0.1102187	27.273672	3.2116433	0.0595609	Miles	US Gal Gasoline Eq	10.851014
Light Trucks MY 1994	0	0.0982	0.0646	2.2057359	0.107677	23.336363	2.6585713	0.0512631	Miles	US Gal Gasoline Eq	11.237428
Light Trucks MY 1995	0	0.0908	0.0517	2.1389818	0.1070416	22.352035	2.5203033	0.0491887	Miles	US Gal Gasoline Eq	11.516014
Light Trucks MY 1996	0	0.0871	0.0452	2.0722277	0.1064062	21.367708	2.3820353	0.0471142	Miles	US Gal Gasoline Eq	11.847327
Light Trucks MY 1997	0	0.0871	0.0452	2.0054737	0.1057708	20.38338	2.2437673	0.0450398	Miles	US Gal Gasoline Eq	12.242719
Light Trucks MY 1998	0	0.0728	0.0391	1.9387196	0.1051354	19.399053	2.1054993	0.0429653	Miles	US Gal Gasoline Eq	12.513053
Light Trucks MY 1999	0	0.0564	0.0321	1.8719655	0.1045	18.414726	1.9672313	0.0408909	Miles	US Gal Gasoline Eq	12.768675
Light Trucks MY 2000	0	0.062	0.034	1.79895	0.1045	18.2316	1.94126	0.03900	Miles	US Gal	12.986

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
		1	6	37		07	08	07		Gasoline Eq	369
Light Trucks MY 2001	0	0.0164	0.0151	1.7262847	0.1045	18.042948	1.9145047	0.0370533	Miles	US Gal Gasoline Eq	13.176957
Light Trucks MY 2002	0	0.0228	0.0178	1.654682	0.1045	17.850596	1.8872248	0.0350678	Miles	US Gal Gasoline Eq	13.344459
Light Trucks MY 2003	0	0.0114	0.0155	1.5848692	0.1045	17.656398	1.8596831	0.0330632	Miles	US Gal Gasoline Eq	13.489615
Light Trucks MY 2004	0	0.0132	0.0152	1.5107022	0.1045	17.462199	1.8257013	0.0310586	Miles	US Gal Gasoline Eq	13.611943
Light Trucks MY 2005	0	0.0101	0.0157	1.4393915	0.1045	17.269847	1.7916243	0.0290731	Miles	US Gal Gasoline Eq	13.71678
Passenger Cars Alt. Method	1990	0.05372	0.05035	1.9694245	0.0841603	22.877143	2.413177	0.0372738	Miles	US Gal Gasoline Eq	15.944505
Passenger Cars Alt. Method	1991	0.05372	0.05035	1.9341179	0.0835738	22.093049	2.3319486	0.0369142	Miles	US Gal Gasoline Eq	16.268779
Passenger Cars Alt. Method	1992	0.05372	0.05035	1.8988112	0.0829874	21.308955	2.2507202	0.0365545	Miles	US Gal Gasoline Eq	16.54047
Passenger Cars Alt. Method	1993	0.05372	0.05035	1.8635045	0.0824009	20.524861	2.1694918	0.0361949	Miles	US Gal Gasoline Eq	16.76045
Passenger Cars Alt. Method	1994	0.05372	0.05035	1.8281978	0.0818144	19.740767	2.0882634	0.0358353	Miles	US Gal Gasoline Eq	16.951002
Passenger Cars Alt. Method	1995	0.05372	0.05035	1.7928912	0.0812279	18.956673	2.007035	0.0354757	Miles	US Gal Gasoline Eq	17.126179
Passenger Cars Alt. Method	1996	0.05372	0.05035	1.7575845	0.0806415	18.172579	1.9258066	0.0351161	Miles	US Gal Gasoline Eq	17.283599
Passenger Cars Alt. Method	1997	0.05372	0.05035	1.7222778	0.080055	17.388485	1.8445782	0.0347565	Miles	US Gal Gasoline Eq	17.446837
Passenger Cars Alt. Method	1998	0.05372	0.05035	1.6869712	0.0794685	16.604391	1.7633498	0.0343969	Miles	US Gal Gasoline Eq	17.549596
Passenger Cars Alt. Method	1999	0.05372	0.05035	1.6516645	0.0788821	15.820297	1.6821214	0.0340373	Miles	US Gal Gasoline Eq	17.647195
Passenger Cars Alt. Method	2000	0.0508	0.04648	1.6259485	0.0788821	15.820297	1.6746547	0.0340373	Miles	US Gal Gasoline Eq	17.721367
Passenger Cars Alt. Method	2001	0.04711	0.04248	1.5994546	0.0788821	15.820297	1.6669621	0.0340373	Miles	US Gal Gasoline Eq	17.899053
Passenger Cars Alt. Method	2002	0.04364	0.03886	1.572442	0.0788821	15.820297	1.6591189	0.0340373	Miles	US Gal Gasoline Eq	18.076739
Passenger Cars Alt. Method	2003	0.04011	0.03542	1.5451701	0.0788821	15.820297	1.6512004	0.0340373	Miles	US Gal Gasoline Eq	18.254425
Passenger Cars Alt. Method	2004	0.0363	0.03251	1.5101042	0.0788821	15.820297	1.6369172	0.0340373	Miles	US Gal Gasoline Eq	18.432111
Passenger Cars Alt. Method	2005	0.03413	0.0299	1.4748654	0.0788821	15.820297	1.6223563	0.0340373	Miles	US Gal Gasoline Eq	18.609798
Passenger Cars Alt. Method	2006	0.0294	0.0278	1.4397994	0.0775674	15.820297	1.6076637	0.0340373	Miles	US Gal Gasoline Eq	18.787484
Passenger Cars Alt. Method	2007	0.0294	0.0278	1.3994066	0.0762527	15.820297	1.5919244	0.0340373	Miles	US Gal Gasoline Eq	18.96517
Passenger Cars Alt. Method	2008	0.0294	0.0278	1.3595541	0.074938	15.820297	1.5762862	0.0340373	Miles	US Gal Gasoline Eq	19.142856
Passenger Cars Alt. Method	2009	0.0294	0.0278	1.3206524	0.0736233	15.820297	1.5609069	0.0340373	Miles	US Gal Gasoline Eq	19.320542
Passenger Cars Alt. Method	2010	0.0294	0.0278	1.2831121	0.0723086	15.820297	1.5459441	0.0340373	Miles	US Gal Gasoline Eq	19.498228

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Passenger Cars Alt. Method	2011	0.0294	0.0278	1.2473439	0.0709939	15.820297	1.5315553	0.0340373	Miles	US Gal Gasoline Eq	19.675915
Passenger Cars Alt. Method	2012	0.0294	0.0278	1.2137582	0.0696792	15.820297	1.5178984	0.0340373	Miles	US Gal Gasoline Eq	19.853601
Passenger Cars Alt. Method	2013	0.0294	0.0278	1.1827658	0.0683645	15.820297	1.5051309	0.0340373	Miles	US Gal Gasoline Eq	20.031287
Passenger Cars Alt. Method	2014	0.0294	0.0278	1.1547772	0.0670498	15.820297	1.4934104	0.0340373	Miles	US Gal Gasoline Eq	20.208973
Passenger Cars Alt. Method	2015	0.0294	0.0278	1.1302029	0.0657351	15.820297	1.4828946	0.0340373	Miles	US Gal Gasoline Eq	20.386659
Passenger Cars Alt. Method	2016	0.0294	0.0278	1.1094537	0.0644204	15.820297	1.4737412	0.0340373	Miles	US Gal Gasoline Eq	20.564345
Passenger Cars Alt. Method	2017	0.0294	0.0278	1.09294	0.0631057	15.820297	1.4661079	0.0340373	Miles	US Gal Gasoline Eq	20.742032
Passenger Cars Alt. Method	2018	0.0294	0.0278	1.0810724	0.061791	15.820297	1.4601521	0.0340373	Miles	US Gal Gasoline Eq	20.919718
Passenger Cars Alt. Method	2019	0.0294	0.0278	1.0704151	0.0604763	15.820297	1.4549148	0.0340373	Miles	US Gal Gasoline Eq	21.097404
Passenger Cars Alt. Method	2020	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2021	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2022	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2023	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2024	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2025	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2026	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2027	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2028	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2029	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2030	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2031	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2032	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2033	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2034	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2035	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2036	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt.	2037	0.029	0.027	1.06107	0.05916	15.8202	1.45046	0.03403	Miles	US Gal	21.275

Transport Average Emissions Factors: CACP 2009

Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Method		4	8	59	16	97	58	73		Gasoline Eq	09
Passenger Cars Alt. Method	2038	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2039	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2040	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2041	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2042	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2043	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2044	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2045	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2046	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2047	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2048	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2049	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars Alt. Method	2050	0.0294	0.0278	1.0610759	0.0591616	15.820297	1.4504658	0.0340373	Miles	US Gal Gasoline Eq	21.27509
Passenger Cars MY 1984 to 1993	0	0.0647	0.0704	1.9694245	0.0841603	22.877143	2.413177	0.0372738	Miles	US Gal Gasoline Eq	15.944505
Passenger Cars MY 1994	0	0.056	0.0531	1.8281978	0.0818144	19.740767	2.0882634	0.0358353	Miles	US Gal Gasoline Eq	16.951002
Passenger Cars MY 1995	0	0.0473	0.0358	1.7928912	0.0812279	18.956673	2.007035	0.0354757	Miles	US Gal Gasoline Eq	17.126179
Passenger Cars MY 1996	0	0.0426	0.0272	1.7575845	0.0806415	18.172579	1.9258066	0.0351161	Miles	US Gal Gasoline Eq	17.283599
Passenger Cars MY 1997	0	0.0422	0.0268	1.7222778	0.080055	17.388485	1.8445782	0.0347565	Miles	US Gal Gasoline Eq	17.446837
Passenger Cars MY 1998	0	0.0393	0.0249	1.6869712	0.0794685	16.604391	1.7633498	0.0343969	Miles	US Gal Gasoline Eq	17.549596
Passenger Cars MY 1999	0	0.0337	0.0216	1.6516645	0.0788821	15.820297	1.6821214	0.0340373	Miles	US Gal Gasoline Eq	17.647195
Passenger Cars MY 2000	0	0.0273	0.0178	1.6259485	0.0788821	15.820297	1.6746547	0.0340373	Miles	US Gal Gasoline Eq	17.721367
Passenger Cars MY 2001	0	0.0158	0.011	1.5994546	0.0788821	15.820297	1.6669621	0.0340373	Miles	US Gal Gasoline Eq	17.899053
Passenger Cars MY 2002	0	0.0153	0.0107	1.572442	0.0788821	15.820297	1.6591189	0.0340373	Miles	US Gal Gasoline Eq	18.076739
Passenger Cars MY 2003	0	0.0135	0.0114	1.5451701	0.0788821	15.820297	1.6512004	0.0340373	Miles	US Gal Gasoline Eq	18.254425
Passenger Cars MY 2004	0	0.0083	0.0145	1.5101042	0.0788821	15.820297	1.6369172	0.0340373	Miles	US Gal Gasoline Eq	18.432111
Passenger Cars MY 2005	0	0.0079	0.0147	1.4748654	0.0788821	15.820297	1.6223563	0.0340373	Miles	US Gal Gasoline Eq	18.609798

Transport Average Emissions Factors: CACP 2009											
Size Class & Model Year		Emissions Coeffecient Emissions (grams) / Distance (miles)							Fuel Efficiency		
VehicleType	Year	N2O	CH4	NOx	SOx	CO	VOC	PM10	Distance Unit	Per Energy Unit	Fuel Efficiency
Heavy Duty Vehicles	0	0.175	1.966	0	0	0	0	0	Miles	US Gal Gasoline Eq	8.3
Heavy Duty Vehicles	0	0.175	0.066	4.8675	0	11.432	2.4714286	0.0161039	Miles	US Gal Gasoline Eq	8.3
Light Duty Vehicles	0	0.067	0.037	4.8675	0	11.432	2.4714286	0.0161039	Miles	US Gal Gasoline Eq	22.804
Buses	0	0.175	0.066	4.8675	0.0535722	14.29	2.4714286	0.0375758	Miles	US Gal Gasoline Eq	6.93
Heavy Duty Vehicles	0	0.175	0.066	4.8675	0.0535722	14.29	2.4714286	0.0375758	Miles	US Gal Gasoline Eq	8.3
Light Duty Vehicles	0	0.067	0.018	0.0855	0.0080833	4.1385	0.071	0.021	Miles	US Gal Gasoline Eq	22.804
Aircraft	0	0.11	7.04	0	0	0	0	0	Miles	US Gal	1
Agricultural Equipment	0	0.26	1.44	0	0	0	0	0	Miles	US Gal	1
Construction Equipment	0	0.26	0.58	0	0	0	0	0	Miles	US Gal	1
Large Utility Vehicles	0	0.26	0.58	0	0	0	0	0	Miles	US Gal	1
Locomotive	0	0.26	0.8	0	0	0	0	0	Miles	US Gal	1
Ships and Boats	0	0.26	0.74	0	0	0	0	0	Miles	US Gal	1
Agricultural Equipment	0	0.26	1.44	0	0	0	0	0	Miles	US Gal	1
Construction Equipment	0	0.26	0.58	0	0	0	0	0	Miles	US Gal	1
Large Utility Vehicles	0	0.26	0.58	0	0	0	0	0	Miles	US Gal	1
Locomotive	0	0.26	0.8	0	0	0	0	0	Miles	US Gal	1
Ships and Boats	0	0.26	0.74	0	0	0	0	0	Miles	US Gal	1
Agricultural Equipment	0	0.22	1.26	0	0	0	0	0	Miles	US Gal	1
Construction Equipment	0	0.22	0.5	0	0	0	0	0	Miles	US Gal	1
Large Utility Vehicles	0	0.22	0.5	0	0	0	0	0	Miles	US Gal	1
Recreational Including Motorcycles	0	0.22	0.5	0	0	0	0	0	Miles	US Gal	1
Ships and Boats	0	0.22	0.64	0	0	0	0	0	Miles	US Gal	1
Small Utility Vehicles	0	0.22	0.5	0	0	0	0	0	Miles	US Gal	1
Snowmobiles	0	0.22	0.5	0	0	0	0	0	Miles	US Gal	1
Aircraft	0	0.31	0.27	0	0	0	0	0	Miles	US Gal	1
Ships and Boats	0	0.3	0.86	0	0	0	0	0	Miles	US Gal	1

Default RCI (Residential, Commercial, & Industrial) Average Emissions Factors: CACP 2009 Software (exported data)

Default RCI Average Emissions Factors: CACP Software								
Fuel	Sector	Emissions Coefficients Emissions (grams) / Energy (MMBtu)						
		N2O	CH4	NOx	SOx	CO	VOC	PM10
Anthracite Coal	Commercial	1.6	11	502.9599	2692.501	204.7798	12.61833	235.872
Anthracite Coal	Electric Power	1.6	1	282.341	683.6675	56.99123	3.594268	38.5285
Anthracite Coal	Industrial	1.6	11	282.341	683.6675	56.99123	3.594268	38.5285
Anthracite Coal	Residential	1.6	316	502.9599	2692.501	204.7798	12.61833	235.872
Bituminous Coal	Commercial	1.6	11	502.9599	2692.501	204.7798	12.61833	235.872
Bituminous Coal	Electric Power	1.6	1	282.341	683.6675	56.99123	3.594268	38.5285
Bituminous Coal	Industrial	1.6	11	282.341	683.6675	56.99123	3.594268	38.5285
Bituminous Coal	Residential	1.6	316	502.9599	2692.501	204.7798	12.61833	235.872
Coke	Commercial	1.6	11	502.9599	2692.501	204.7798	12.61833	235.872
Coke	Electric Power	1.6	1	282.341	683.6675	56.99123	3.594268	38.5285
Coke	Industrial	1.6	11	282.341	683.6675	56.99123	3.594268	38.5285
Coke	Residential	1.6	316	502.9599	2692.501	204.7798	12.61833	235.872
Commercial Coal		1.6	11	502.9599	2692.501	204.7798	12.61833	235.872
Crude Oil	Commercial	0.6	11	0	0	0	0	0
Crude Oil	Electric Power	0.6	3	0	0	0	0	0
Crude Oil	Industrial	0.6	3	0	0	0	0	0
Crude Oil	Residential	0.6	11	0	0	0	0	0
Electric Utility Coal		1.6	1	282.341	683.6675	56.99123	3.594268	38.5285
Ethane	Commercial	0.6	11	0	0	0	0	0
Ethane	Electric Power	0.6	3	0	0	0	0	0
Ethane	Industrial	0.6	3	0	0	0	0	0

Default RCI Average Emissions Factors: CACP Software								
Fuel	Sector	Emissions Coefficients Emissions (grams) / Energy (MMBtu)						
		N2O	CH4	NOx	SOx	CO	VOC	PM10
Ethane	Residential	0.6	11	0	0	0	0	0
Fuel Oil (#1 2 4)	Commercial	0.6	11	2000.342	131.5418	430.9128	158.7573	140.6136
Fuel Oil (#1 2 4)	Electric Power	0.6	3	2000.342	131.5418	430.9128	158.7573	140.6136
Fuel Oil (#1 2 4)	Industrial	0.6	3	2000.342	131.5418	430.9128	158.7573	140.6136
Fuel Oil (#1 2 4)	Residential	0.6	11	2000.342	131.5418	430.9128	158.7573	140.6136
Fuel Oil (#1 2 4) ULSD	Commercial	0.6	11	0	0	0	0	0
Fuel Oil (#1 2 4) ULSD	Electric Power	0.6	11	0	0	0	0	0
Fuel Oil (#1 2 4) ULSD	Industrial	0.6	11	0	0	0	0	0
Fuel Oil (#1 2 4) ULSD	Residential	0.6	11	0	0	0	0	0
Industrial Coking Coal		1.6	11	282.341	683.6675	56.99123	3.594268	38.5285
Isobutane	Commercial	0.6	11	0	0	0	0	0
Isobutane	Electric Power	0.6	3	0	0	0	0	0
Isobutane	Industrial	0.6	3	0	0	0	0	0
Isobutane	Residential	0.6	11	0	0	0	0	0
Kerosene	Commercial	0.6	11	120.317	374.7836	24.30044	4.094618	14.30291
Kerosene	Electric Power	0.6	3	120.317	374.7836	24.30044	4.094618	14.30291
Kerosene	Industrial	0.6	3	120.317	374.7836	24.30044	4.094618	14.30291
Kerosene	Residential	0.6	11	120.317	374.7836	24.30044	4.094618	14.30291
Lignite	Commercial	1.6	11	502.9599	2692.501	204.7798	12.61833	235.872
Lignite	Electric Power	1.6	1	282.341	683.6675	56.99123	3.594268	38.5285
Lignite	Industrial	1.6	11	282.341	683.6675	56.99123	3.594268	38.5285
Lignite	Residential	1.6	316	502.9599	2692.501	204.7798	12.61833	235.872
Lubricants	Commercial	0.6	11	0	0	0	0	0
Lubricants	Electric Power	0.6	3	0	0	0	0	0
Lubricants	Industrial	0.6	3	0	0	0	0	0
Lubricants	Residential	0.6	11	0	0	0	0	0
n Butane	Commercial	0.6	11	0	0	0	0	0

Default RCI Average Emissions Factors: CACP Software								
Fuel	Sector	Emissions Coefficients Emissions (grams) / Energy (MMBtu)						
		N2 O	CH 4	NOx	SOx	CO	VOC	PM10
n Butane	Electric Power	0.6	3	0	0	0	0	0
n Butane	Industrial	0.6	3	0	0	0	0	0
n Butane	Residential	0.6	11	0	0	0	0	0
Naphtha lt 401 deg F	Commercial	0.6	11	0	0	0	0	0
Naphtha lt 401 deg F	Electric Power	0.6	3	0	0	0	0	0
Naphtha lt 401 deg F	Industrial	0.6	3	0	0	0	0	0
Naphtha lt 401 deg F	Residential	0.6	11	0	0	0	0	0
Nat Gas 1000 to 1025 Btu per cf	Commercial	0.1	5	76.2058 2	3.03593 4	19.6767 6	4.19709 6	2.33012 9
Nat Gas 1000 to 1025 Btu per cf	Electric Power	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1000 to 1025 Btu per cf	Industrial	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1000 to 1025 Btu per cf	Residential	0.1	5	79.6385 2	3.03598 5	19.6770 9	4.19716 6	2.33012 9
Nat Gas 1025 to 1050 Btu per cf	Commercial	0.1	5	76.2058 2	3.03593 4	19.6770 9	4.19716 6	2.33012 9
Nat Gas 1025 to 1050 Btu per cf	Electric Power	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1025 to 1050 Btu per cf	Industrial	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1025 to 1050 Btu per cf	Residential	0.1	5	79.6385 2	3.03598 5	19.6770 9	4.19716 6	2.33012 9
Nat Gas 1050 to 1075 Btu per cf	Commercial	0.1	5	76.2058 2	3.03598 5	19.6770 9	4.19716 6	2.33012 9
Nat Gas 1050 to 1075 Btu per cf	Electric Power	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1050 to 1075 Btu per cf	Industrial	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1050 to 1075 Btu per cf	Residential	0.1	5	79.6385 2	3.03598 5	19.6770 9	4.19716 6	2.33012 9
Nat Gas 1075 to 1100 Btu per cf	Commercial	0.1	5	76.2058 2	3.03598 5	19.6770 9	4.19716 6	2.33012 9
Nat Gas 1075 to 1100 Btu per cf	Electric Power	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1075 to 1100 Btu per cf	Industrial	0.1	1	133.359 2	63.8893 1	37.8196 9	6.68890 4	4.72600 4
Nat Gas 1075 to 1100 Btu per cf	Residential	0.1	5	79.6385 2	3.03598 5	19.6770 9	4.19716 6	2.33012 9
Nat Gas 975 to 1000 Btu per cf	Commercial	0.1	5	76.2058 2	3.03598 5	19.6770 9	4.19716 6	2.33012 9

Default RCI Average Emissions Factors: CACP Software								
Fuel	**Sector**	**Emissions Coefficients Emissions (grams) / Energy (MMBtu)**						
		N2O	**CH4**	**NOx**	**SOx**	**CO**	**VOC**	**PM10**
Nat Gas 975 to 1000 Btu per cf	Electric Power	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Nat Gas 975 to 1000 Btu per cf	Industrial	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Nat Gas 975 to 1000 Btu per cf	Residential	0.1	5	79.63852	3.035985	19.67709	4.197166	2.330129
Nat Gas gt 1100 Btu per cf	Commercial	0.1	5	76.20582	3.035985	19.67709	4.197166	2.330129
Nat Gas gt 1100 Btu per cf	Electric Power	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Nat Gas gt 1100 Btu per cf	Industrial	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Nat Gas gt 1100 Btu per cf	Residential	0.1	5	79.63852	3.035985	19.67709	4.197166	2.330129
Natural Gas	Commercial	0.1	5	76.20582	3.035985	19.67709	4.197166	2.330129
Natural Gas	Electric Power	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Natural Gas	Industrial	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Natural Gas	Residential	0.1	5	79.63852	3.035985	19.67709	4.197166	2.330129
Natural Gasoline	Commercial	0.6	11	0	0	0	0	0
Natural Gasoline	Electric Power	0.6	3	0	0	0	0	0
Natural Gasoline	Industrial	0.6	3	0	0	0	0	0
Natural Gasoline	Residential	0.6	11	0	0	0	0	0
Other Industrial Coal		1.6	11	282.341	683.6675	56.99123	3.594268	38.5285
Other Oil gt 401 deg F	Commercial	0.6	11	0	0	0	0	0
Other Oil gt 401 deg F	Electric Power	0.6	3	0	0	0	0	0
Other Oil gt 401 deg F	Industrial	0.6	3	0	0	0	0	0
Other Oil gt 401 deg F	Residential	0.6	11	0	0	0	0	0
Pentanes Plus	Commercial	0.6	11	0	0	0	0	0
Pentanes Plus	Electric Power	0.6	3	0	0	0	0	0
Pentanes Plus	Industrial	0.6	3	0	0	0	0	0
Pentanes Plus	Residential	0.6	11	0	0	0	0	0
Petrochemical Feedstocks	Commercial	0.6	11	0	0	0	0	0
Petrochemical Feedstocks	Electric Power	0.6	3	0	0	0	0	0
Petrochemical Feedstocks	Industrial	0.6	3	0	0	0	0	0

Default RCI Average Emissions Factors: CACP Software								
Fuel	Sector	Emissions Coefficients Emissions (grams) / Energy (MMBtu)						
		N2O	CH4	NOx	SOx	CO	VOC	PM10
Petrochemical Feedstocks	Residential	0.6	11	0	0	0	0	0
Petroleum Coke	Commercial	0.6	11	0	0	0	0	0
Petroleum Coke	Electric Power	0.6	3	0	0	0	0	0
Petroleum Coke	Industrial	0.6	3	0	0	0	0	0
Petroleum Coke	Residential	0.6	11	0	0	0	0	0
Propane	Commercial	0.6	11	69.40328	7.90E-05	9.419016	2.478689	1.982951
Propane	Electric Power	0.6	3	94.19016	7.90E-05	15.86361	2.478689	2.974426
Propane	Industrial	0.6	3	94.19016	7.90E-05	15.86361	2.478689	2.974426
Propane	Residential	0.6	11	69.40328	7.90E-05	9.419016	2.478689	1.982951
Residential Coal		1.6	316	502.9599	2692.501	204.7798	12.61833	235.872
Residual Fuel Oil	Commercial	0.6	11	413.0202	1960.764	217.4634	34.9398	118.2495
Residual Fuel Oil	Electric Power	0.6	3	413.0202	1960.764	217.4634	34.9398	118.2495
Residual Fuel Oil	Industrial	0.6	3	413.0202	1960.764	217.4634	34.9398	118.2495
Residual Fuel Oil	Residential	0.6	11	413.0202	1960.764	217.4634	34.9398	118.2495
Special Naphtha	Commercial	0.6	11	0	0	0	0	0
Special Naphtha	Electric Power	0.6	3	0	0	0	0	0
Special Naphtha	Industrial	0.6	3	0	0	0	0	0
Special Naphtha	Residential	0.6	11	0	0	0	0	0
Stationary Gasoline	Commercial	0.6	11	739.368	38.1024	28440.72	952.56	45.36
Stationary Gasoline	Electric Power	0.6	3	739.368	38.1024	28440.72	952.56	45.36
Stationary Gasoline	Industrial	0.6	3	739.368	38.1024	28440.72	952.56	45.36
Stationary Gasoline	Residential	0.6	11	739.368	38.1024	28440.72	952.56	45.36
Stationary LPG	Commercial	0.6	11	0	0	0	0	0
Stationary LPG	Electric Power	0.6	3	0	0	0	0	0
Stationary LPG	Industrial	0.6	3	0	0	0	0	0
Stationary LPG	Residential	0.6	11	0	0	0	0	0
Still Gas	Commercial	0.6	11	0	0	0	0	0

Default RCI Average Emissions Factors: CACP Software								
Fuel	Sector	Emissions Coefficients Emissions (grams) / Energy (MMBtu)						
		N2O	CH4	NOx	SOx	CO	VOC	PM10
Still Gas	Electric Power	0.6	3	0	0	0	0	0
Still Gas	Industrial	0.6	3	0	0	0	0	0
Still Gas	Residential	0.6	11	0	0	0	0	0
Subbituminous Coal	Commercial	1.6	11	502.9515	2692.456	204.7763	12.61812	235.868
Subbituminous Coal	Electric Power	1.6	1	282.341	683.6675	56.99123	3.594268	38.5285
Subbituminous Coal	Industrial	1.6	11	282.341	683.6675	56.99123	3.594268	38.5285
Subbituminous Coal	Residential	1.6	316	502.9599	2692.501	204.7798	12.61833	235.872
Unfinished Oils	Commercial	0.6	11	0	0	0	0	0
Unfinished Oils	Electric Power	0.6	3	0	0	0	0	0
Unfinished Oils	Industrial	0.6	3	0	0	0	0	0
Unfinished Oils	Residential	0.6	11	0	0	0	0	0
Waxes	Commercial	0.6	11	0	0	0	0	0
Waxes	Electric Power	0.6	3	0	0	0	0	0
Waxes	Industrial	0.6	3	0	0	0	0	0
Waxes	Residential	0.6	11	0	0	0	0	0
Black Liquor NA hrdwd		2	2.5	0	0	0	0	0
Black Liquor NA sftwd		2	2.5	0	0	0	0	0
Cali MSW fossil portion		0	0	105.4784	4.219135	5273.918	632.8702	149.6855
Cali MSW non fossil		0	0	105.4784	4.219135	5273.918	632.8702	149.6855
Heat Plants		0	0	0	0	0	0	0
Landfill Gas or biogas	Commercial	0.1	5	76.20582	3.035934	19.67676	4.197096	2.33009
Landfill Gas or biogas	Electric Power	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Landfill Gas or biogas	Industrial	0.1	1	133.3592	63.88931	37.81969	6.688904	4.726004
Landfill Gas or biogas	Residential	0.1	5	79.63852	3.035985	19.67709	4.197166	2.330129
US MSW fossil portion		0	0	105.4784	4.219135	5273.918	632.8702	149.6855
US MSW non fossil		0	0	105.4784	4.219135	5273.918	632.8702	149.6855
Wood 12 pct moisture	Commercial	4.2	316	222.264	11.34	272.16	17.2368	149.688

Default RCI Average Emissions Factors: CACP Software								
Fuel	Sector	Emissions Coefficients Emissions (grams) / Energy (MMBtu)						
		N2O	CH4	NOx	SOx	CO	VOC	PM10
Wood 12 pct moisture	Electric Power	4.2	32	222.264	11.34	272.16	17.2368	149.688
Wood 12 pct moisture	Industrial	4.2	32	222.264	11.34	272.16	17.2368	149.688
Wood 12 pct moisture	Residential	4.2	316	222.264	11.34	272.16	17.2368	149.688
Green Electricity		0	0	0	0	0	0	0

USA Default Waste Emissions Factors: CACP 2009 Software (exported data).

USA Default Waste Emissions Factors: CACP 2009 Software					
		Emissions Coefficient Emissions (tonnes) / Waste (tonnes)			
Material (MSW)	Disposal Type	Methane	Seqstrtn: Forest	Upstrm Enrgy	Upstrm Non Enrgy
Paper Products	Open Dump	1.282957721	0	0	0
Food Waste	Open Dump	0.726202484	0	0	0
Plant Debris	Open Dump	0.411514741	0	0	0
Wood/Textiles	Open Dump	0.363101242	0	0	0
All Other Waste	Open Dump	0	0	0	0
Aluminum	Open Dump	0	0	0	0
Cardboard	Open Dump	1.161923974	0	0	0
Food Waste	Open Dump	0.726202484	0	0	0
Glass	Open Dump	0	0	0	0
Mixed MSW	Open Dump	0.629375486	0	0	0
Mixed Recyclables	Open Dump	1.007000777	0	0	0
MSW	Open Dump	0.629375486	0	0	0
Paper - Household	Open Dump	1.186130723	0	0	0
Paper - Mixed General	Open Dump	1.282957721	0	0	0
Paper - Mixed Office	Open Dump	1.403991468	0	0	0
Paper - Newsprint	Open Dump	0.556755237	0	0	0
Paper - Office Paper	Open Dump	2.63853569	0	0	0
Plastic - HDPE	Open Dump	0	0	0	0
Plastic - LDPE	Open Dump	0	0	0	0
Plastic - PET	Open Dump	0	0	0	0
Steel	Open Dump	0	0	0	0
Wood	Open Dump	0.363101242	0	0	0
Yard Waste	Open Dump	0.411514741	0	0	0
Fibreboard	Open Dump	0.363	0	0	0
Magazines	Open Dump	0.629	0	0	0
Phonebooks	Open Dump	0.557	0	0	0
Textbooks	Open Dump	2.639	0	0	0
Paper Products	Open Burning	0.080689165	0	0	0
Food Waste	Open Burning	0.080689165	0	0	0
Plant Debris	Open Burning	0.080689165	0	0	0
Wood/Textiles	Open Burning	0.080689165	0	0	0
All Other Waste	Open Burning	0.484134989	0	0	0
Cardboard	Open Burning	0.080689165	0	0	0
Food Waste	Open Burning	0.080689165	0	0	0

USA Default Waste Emissions Factors: CACP 2009 Software					
		Emissions Coefficient Emissions (tonnes) / Waste (tonnes)			
Material (MSW)	**Disposal Type**	**Methane**	**Seqstrtn: Forest**	**Upstrm Enrgy**	**Upstrm Non Enrgy**
Mixed MSW	Open Burning	0.080689165	0	0	0
Mixed Recyclables	Open Burning	0.484134989	0	0	0
MSW	Open Burning	0.484134989	0	0	0
Paper - Household	Open Burning	0.080689165	0	0	0
Paper - Mixed General	Open Burning	0.080689165	0	0	0
Paper - Mixed Office	Open Burning	0.080689165	0	0	0
Paper - Newsprint	Open Burning	0.080689165	0	0	0
Paper - Office Paper	Open Burning	0.080689165	0	0	0
Plastic - HDPE	Open Burning	3.106532846	0	0	0
Plastic - LDPE	Open Burning	3.106532846	0	0	0
Plastic - PET	Open Burning	2.259296615	0	0	0
Wood	Open Burning	0.080689165	0	0	0
Yard Waste	Open Burning	0.080689165	0	0	0
Fibreboard	Open Burning	0.081	0	0	0
Magazines	Open Burning	0.081	0	0	0
Phonebooks	Open Burning	0.081	0	0	0
Textbooks	Open Burning	0.081	0	0	0
Paper Products	Managed Landfill	2.138262868	0	0	0
Food Waste	Managed Landfill	1.210337473	0	0	0
Plant Debris	Managed Landfill	0.685857901	0	0	0
Wood/Textiles	Managed Landfill	0.605168736	0	0	0
All Other Waste	Managed Landfill	0	0	0	0
Aluminum	Managed Landfill	0	0	0	0
Cardboard	Managed Landfill	1.936539956	0	0	0
Food Waste	Managed Landfill	1.210337473	0	0	0
Glass	Managed Landfill	0	0	0	0
Mixed MSW	Managed Landfill	1.048959143	0	0	0
Mixed Recyclables	Managed Landfill	1.678334629	0	0	0
MSW	Managed Landfill	1.048959143	0	0	0
Paper - Household	Managed Landfill	1.976884538	0	0	0
Paper - Mixed General	Managed Landfill	2.138262868	0	0	0
Paper - Mixed Office	Managed Landfill	2.33998578	0	0	0
Paper - Newsprint	Managed Landfill	0.927925396	0	0	0
Paper - Office Paper	Managed Landfill	4.397559483	0	0	0
Plastic - HDPE	Managed Landfill	0	0	0	0
Plastic - LDPE	Managed Landfill	0	0	0	0
Plastic - PET	Managed Landfill	0	0	0	0
Steel	Managed Landfill	0	0	0	0

USA Default Waste Emissions Factors: CACP 2009 Software					
		Emissions Coefficient Emissions (tonnes) / Waste (tonnes)			
Material (MSW)	**Disposal Type**	**Methane**	**Seqstrtn: Forest**	**Upstrm Enrgy**	**Upstrm Non Enrgy**
Wood	Managed Landfill	0.605168736	0	0	0
Yard Waste	Managed Landfill	0.685857901	0	0	0
Fibreboard	Managed Landfill	0.605	0	0	0
Magazines	Managed Landfill	1.049	0	0	0
Phonebooks	Managed Landfill	0.928	0	0	0
Textbooks	Managed Landfill	4.398	0	0	0
Paper Products	Controlled Incineration	0.080689165	0	0	0
Food Waste	Controlled Incineration	0.080689165	0	0	0
Plant Debris	Controlled Incineration	0.080689165	0	0	0
Wood/Textiles	Controlled Incineration	0.080689165	0	0	0
All Other Waste	Controlled Incineration	0.484134989	0	0	0
Cardboard	Controlled Incineration	0.080689165	0	0	0
Food Waste	Controlled Incineration	0.080689165	0	0	0
Mixed MSW	Controlled Incineration	0.080689165	0	0	0
Mixed Recyclables	Controlled Incineration	0.484134989	0	0	0
MSW	Controlled Incineration	0.484134989	0	0	0
Paper - Household	Controlled Incineration	0.080689165	0	0	0
Paper - Mixed General	Controlled Incineration	0.080689165	0	0	0
Paper - Mixed Office	Controlled Incineration	0.080689165	0	0	0
Paper - Newsprint	Controlled Incineration	0.080689165	0	0	0
Paper - Office Paper	Controlled Incineration	0.080689165	0	0	0
Plastic - HDPE	Controlled Incineration	3.106532846	0	0	0
Plastic - LDPE	Controlled Incineration	3.106532846	0	0	0
Plastic - PET	Controlled Incineration	2.259296615	0	0	0
Wood	Controlled Incineration	0.080689165	0	0	0
Yard Waste	Controlled Incineration	0.080689165	0	0	0
Fibreboard	Controlled Incineration	0.081	0	0	0
Magazines	Controlled Incineration	0.081	0	0	0
Phonebooks	Controlled Incineration	0.081	0	0	0
Textbooks	Controlled Incineration	0.081	0	0	0
Paper Products	Compost	0	0	0	0
Food Waste	Compost	0	0	0	0
Plant Debris	Compost	0	0	0	0
Wood/Textiles	Compost	0	0	0	0
All Other Waste	Compost	0	0	0	0
Food Waste	Compost	0	0	0	0
Yard Waste	Compost	0	0	0	0
Aluminum	Recycling of Waste	0	0	-	-

USA Default Waste Emissions Factors: CACP 2009 Software					
		Emissions Coefficient Emissions (tonnes) / Waste (tonnes)			
Material (MSW)	**Disposal Type**	**Methane**	**Seqstrtn: Forest**	**Upstrm Enrgy**	**Upstrm Non Enrgy**
				13.19267845	4.558937813
Cardboard	Recycling of Waste	0	-2.94515452	0.121033747	0
Glass	Recycling of Waste	0	0	-0.16137833	-0.16137833
Mixed Recyclables	Recycling of Waste	0	-2.54170869	-0.443790407	-0.080689165
Paper - Household	Recycling of Waste	0	-2.94515452	0.443790407	0
Paper - Mixed General	Recycling of Waste	0	-2.94515452	0.443790407	0
Paper - Mixed Office	Recycling of Waste	0	-2.94515452	-0.645513319	0
Paper - Newsprint	Recycling of Waste	0	-2.94515452	-1.00861456	0
Paper - Office Paper	Recycling of Waste	0	-2.94515452	0.403445824	-0.040344582
Plastic - HDPE	Recycling of Waste	0	0	-1.775161626	-0.201722912
Plastic - LDPE	Recycling of Waste	0	0	-2.218952033	-0.201722912
Plastic - PET	Recycling of Waste	0	0	-2.057573703	-0.121033747
Steel	Recycling of Waste	0	0	-2.017229121	0
Wood	Recycling of Waste	0	-2.01722912	0.080689165	0
Fibreboard	Recycling of Waste	0	-2.02	0.08	0
Magazines	Recycling of Waste	0	-2.95	0	0
Phonebooks	Recycling of Waste	0	-2.95	-1.05	0
Textbooks	Recycling of Waste	0	-2.95	-0.08	0
Aluminum	Reduction in Waste	0	0	-7.665470659	-2.380330363
Cardboard	Reduction in Waste	0	-1.21033747	-0.968269978	0
Food Waste	Reduction in Waste	0	0	0	0
Glass	Reduction in Waste	0	0	-0.403445824	-0.121033747
Mixed Recyclables	Reduction in Waste	0	-2.54170869	-0.443790407	-0.080689165
Paper - Household	Reduction in Waste	0	0	-1.533094132	0

USA Default Waste Emissions Factors: CACP 2009 Software					
		Emissions Coefficient Emissions (tonnes) / Waste (tonnes)			
Material (MSW)	**Disposal Type**	**Methane**	**Seqstrtn: Forest**	**Upstrm Enrgy**	**Upstrm Non Enrgy**
Paper - Mixed General	Reduction in Waste	0	0	-1.533094132	0
Paper - Mixed Office	Reduction in Waste	0	0	-3.429289505	0
Paper - Newsprint	Reduction in Waste	0	-1.45240497	-1.855850791	0
Paper - Office Paper	Reduction in Waste	0	-1.97688454	-1.210337473	0
Plastic - HDPE	Reduction in Waste	0	0	-1.775161626	-0.201722912
Plastic - LDPE	Reduction in Waste	0	0	-2.259296615	-0.201722912
Plastic - PET	Reduction in Waste	0	0	-1.855850791	-0.080689165
Steel	Reduction in Waste	0	0	-2.218952033	-0.968269978
Wood	Reduction in Waste	0	-2.01722912	-0.403445824	0
Yard Waste	Reduction in Waste	0	0	0	0
Fibreboard	Reduction in Waste	0	-2.02	-0.4	0
Magazines	Reduction in Waste	0	-2.46	-1.86	0
Phonebooks	Reduction in Waste	0	-2.66	-2.58	0
Textbooks	Reduction in Waste	0	-2.58	-2.38	0

Appendix II: Wastewater Pump Stations, 2007 Energy Use and Emissions

SOUTH PORTLAND PUMP STATIONS: 2007 ENERGY USE, COSTS, AND EMISSIONS						
Pump Station	**Fuel**	**Quantity**	**Units**	**Cost ($)**	**Energy Output (MMBtu)**	**CO2e (tonnes)**
Pearl St, 1	Electricity	294,900	(kWh)	46,898.01	1,006.5	125.0
Westbrook St, 427/Long Creek	Electricity	231,000	(kWh)	33,349.31	788.4	97.9
Willard Beach, 11 Fishermans Ln	Electricity	153,240	(kWh)	25,421.23	523.0	65.0
Front St, 152-Scope 2	Electricity	151,280	(kWh)	27,286.96	516.3	64.1
* Western Ave, 445-Scope 2	Electricity	57,232	(kWh)	9,852.58	195.3	24.3
* Winding Way, 44-Scope 2	Electricity	29,827	(kWh)	4,427.20	101.8	12.6
** Main St, 1-Scope 2	Electricity	29,818	(kWh)	5,940.55	101.8	12.6
High St, 301-Scope 2	Electricity	28,080	(kWh)	6,452.95	95.8	11.9
Bay Rd, 3-Scope 2	Electricity	12,325	(kWh)	1,872.37	42.1	5.2
Westbrook St, 463-Scope 2	Electricity	10,624	(kWh)	1,702.23	36.3	4.5
Gannett Dr, 310-Scope 2	Electricity	9,931	(kWh)	1,609.60	33.9	4.2
Southborough Dr, 350-Scope 2	Electricity	8,718	(kWh)	1,437.00	29.8	3.7
Mechanic St, 16-Scope 2	Electricity	8,430	(kWh)	1,397.04	28.8	3.6
* Appletree Dr, 46-Scope 2	Electricity	8,357	(kWh)	1,302.57	28.5	3.5
* Snowberry Dr, 117-Scope 2	Electricity	6,555	(kWh)	1,047.03	22.4	2.8
* B St, 2-Scope 2	Electricity	6,284	(kWh)	1,011.70	21.4	2.7
Western Ave, 257-Scope 1	Natural Gas	420	(therms)	261.71	42.0	2.2
John Roberts Rd, 100-Scope 2	Electricity	4,085	(kWh)	776.66	13.9	1.7
Western Ave, 257-Scope 2	Electricity	4,027	(kWh)	766.50	13.7	1.7
Mariner Dr, 0-Scope 2	Electricity	2,387	(kWh)	534.26	8.1	1.0
Bay Rd, 3-Scope 1	Natural Gas	107	(therms)	273.68	10.7	0.6
* Crestview Dr,-Scope 2	Electricity	1,192	(kWh)	286.98	4.1	0.5
Elm St, 23-Scope 2	Electricity	894	(kWh)	244.67	3.1	0.4
Southborough Dr, 350-Scope 1	Natural Gas	47	(therms)	146.81	4.7	0.3
E St, 6-Scope 2	Electricity	238	(kWh)	151.73	0.8	0.10
Gannett Dr, 310-Scope 1	Natural Gas	13	(therms)	144.50	1.3	0.07
Westbrook St, 427/Long Creek	Natural Gas	10	(therms)	137.04	1.0	0.05
Stillman St, 121-Scope 2	Electricity	68	(kWh)	127.61	0.23	0.03
TOTALS				**174,860.48**	**3,675.8**	**452.4**

*Pump station has propane usage not captured for 2007 inventory.
**Pump station has diesel usage not captured for 2007 inventory.

Appendix III: CACP (2009) Vehicle Classifications

CACP (2009): Vehicle Classifications

Fuel	Vehicle Type	MY	Weight
Diesel	Heavy Duty Veh.	All MYs (All model years)	Heavy Duty Truck: Trucks with a gross vehicle weight (GVW) over 8,500 lbs
		Alt Method	
	Light Trucks	Alt Method	Light Duty Truck: Trucks with a GVW up to 8,500 lbs (includes sports utility vehicles, pickup trucks and commercial delivery vans and trucks).
		1960-1982	
		1983-1995	
		1996-2004	
	Passenger Cars	Alt Method	
		1960-1982	
		1983-2004	
Gasoline	Heavy Duty Veh.	Alt Method	Heavy Duty Truck: Trucks with a gross vehicle weight (GVW) over 8,500 lbs
		1985-1986	
		1987	
		1988-1989	
		1990-1995	
		1996-2004: Listed individually	
	Light Trucks	Alt Method	Light Duty Truck: Trucks with a GVW up to 8,500 lbs (includes sports utility vehicles, pickup trucks and commercial delivery vans and trucks).
		1987-1993	
		1994-2005:Listed individually	
	Passenger Cars	Alt Method	**Size Class Abbreviations (included in Appendix IV below):** AG = Agricultural Equip (off-road) CE = Construction Equip (off-road) HD = Heavy Duty Trucks LD = Light Duty Trucks PC = Passenger Cars RV = Recreational Vehicles SN = Snowmobiles UVL = Utility Vehicle, Large (off-road) UVS = Utility Vehicles, Small (off-road, gas only)
		1984-1993	
		1994-2005: Listed individually	
OFF ROAD Diesel	Agricultural Equip		
	Construction Equip		
	Large Utility Veh.		
	Locomotive		
	Ships & Boats		
OFF ROAD Gasoline	Agricultural Equip		
	Construction Equip		
	Large Utility Veh.		
	Recreational including motorcycles		
	Ships & Boats		
	Small utility vehicles		
	Snowmobiles		
CNG	Buses		
	Heavy Duty Veh.		
	Light Duty Veh.		

Appendix IV: Vehicle & Transit Fleets (2008)

Vehicle & Transit Fleets (2008): Fuel Key# /Vehicle #, Size Class, Fuel Usage							
Account Name	Account Number	Vehicle Fuel Key# /Veh Name	Gas or Diesel	Size Class*	Model Year	Total Quantity (Glns)	Total Cost ($)
School Transportation-Reg	100	472/B-4	D	LD	2010	1,766.40	6,287.42
School Transport-SPED	101	475/B-18	D	HD	2009	438.40	1,491.32
Parks	80	437/#82	D	LD	2009	172.70	605.79
Public Works- Highways	90	569/#11-2009 INTERNATIONAL	D	HD	2009	305.20	936.66
Public Works-Rubbish	92	578/#20-2009 VOLVO VHD64B	D	HD	2009	3,895.20	13,839.21
School Maintenance	200	455/BT-1	D**	LD	2009	170.30	575.61
Sewer Maintenance	60	490/#11	D**	LD	2008	16.10	58.06
Sewer Maintenance	60	492/#13	D**	HD	2008	96.70	326.85
Public Works- Highways	90	559/#1-2008 INTERNATIONAL	D**	HD	2008	750.50	2,580.56
Public Works- Highways	90	573/#15-2008 INTERNATIONAL	D	HD	2008	731.70	2,384.53
Public Works- Highways	90	574/#16-2008 INTERNATIONAL	D	HD	2008	706.80	2,355.81
Public Works- Highways	90	608/#53-2008 FORD F550	D**	LD	2008	933.30	3,354.05
Public Works-Rubbish	92	586/#28-2008 INTERNATIONAL	D	HD	2008	892.70	3,072.93
Sewer Maintenance	60	489/#10	D**	LD	2007	39.70	134.15
Sewer Maintenance	60	496/#17	D	HD	2007	1,178.90	4,232.43
Fire Department	70	550/PRIMEMOVER2	D	LD	2007	182.20	621.46
Public Works- Highways	90	595/#38-2007 TRACKLESS MT5	D	UVL	2007	562.40	1,840.17
Public Works- Highways	90	607/#52-2007 GMC SIERRA	D**	LD	2007	3.70	13.34
Public Works- Highways	90	613/#58-2007 DODGE RAM	D**	LD	2007	9.30	38.42
School Transportation-Reg	100	471/B-14	D	HD	2007	2,081.00	7,173.64
School Transport-SPED	101	460/B-2	D	HD	2006	2,244.10	7,912.33
Sewer Maintenance	60	488/#9	D	HD	2006	677.30	2,491.69
Fire Department	70	547/R-1	D	HD	2006	1,705.70	6,056.56
Public Works- Highways	90	585/#27-2006 JOHN DEERE	D	CE	2006	1,726.00	5,681.68
Sewer Maintenance	60	493/#14	D	HD	2005	724.80	2,710.23
Fire Department	70	545/E-8	D	HD	2005	1,880.80	6,677.62
Fire Department	70	548/R-2	D	HD	2005	392.80	1,396.76
Public Works- Highways	90	572/#14-2005 GMC C7500	D	HD	2005	275.80	998.47
Public Works- Highways	90	587/#30-2005 TENANT	D	UVL	2005	1,753.10	6,525.00
Public Works- Highways	90	593/#36-2005 TRACKLESS MT5	D	UVL	2005	515.80	1,632.30
Public Works- Highways	90	600/#43-2005 BOBCAT 185	D**	CE	2005	266.60	963.46
School Transportation-Reg	100	458/T-30	D**	LD	2005	21.50	80.36
School Transport-VOC	102	470/B-13	D	HD	2004	2,405.70	8,441.32

Vehicle & Transit Fleets (2008): Fuel Key# /Vehicle #, Size Class, Fuel Usage

Account Name	Account Number	Vehicle Fuel Key# /Veh Name	Gas or Diesel	Size Class*	Model Year	Total Quantity (Glns)	Total Cost ($)
School Transport-VOC	102	474/B-17	D	HD	2004	904.70	3,036.49
Fire Department	70	543/E-5	D	HD	2004	607.30	2,187.08
Public Works- Highways	90	591/#34-2004 KOMATSU	D	CE	2004	728.00	2,323.10
Public Works- Highways	90	594/#37-2004 HOLDER MTC978	D	UVL	2004	188.20	589.77
Public Works- Highways	90	611/#56-2004 FORD F350	D**	LD	2004	1.10	4.12
Public Works- Highways	90	612/#57-2004 FORD F250	D**	LD	2004	4.50	18.59
School Transportation-Reg	100	463-B-6	D	HD	2004	843.50	3,060.20
School Transportation-Reg	100	464/B-7	D	HD	2004	1,342.40	4,731.68
School Transportation-Reg	100	465/B-8	D	HD	2004	1,603.40	5,660.20
School Transportation-Reg	100	466/B-9	D	HD	2004	1,436.60	5,079.63
School Transportation-Reg	100	468/B-11	D	HD	2004	711.70	2,387.33
School Transportation-Reg	100	469/B-12	D	HD	2004	1,802.50	6,363.39
School Transportation-Reg	100	473/B-16	D	HD	2004	1,412.50	4,944.45
School Transport-SPED	101	462/B-5	D	HD	2003	145.20	509.60
Sewer Maintenance	60	483/#4	D**	LD	2003	40.00	144.24
Fire Department	70	554/SQUAD 4	D	UVL	2003	34.40	133.61
Parks	80	432/#77	D**	LD	2003	42.50	177.61
Public Works- Highways	90	561/#3-2003 STERLING L7501	D	HD	2003	1,196.90	4,194.24
Public Works- Highways	90	563/#5-2003 STERLING L7501	D	HD	2003	1,052.80	3,519.02
Public Works- Highways	90	564/#6-2003 STERLING L7501	D	HD	2003	1,062.80	3,436.49
School Transportation-Reg	100	467/B-10	D	HD	2003	763.20	2,767.09
Fire Department	70	544/E-6	D	HD	2002	61.00	186.28
Parks	80	440/#85	D	LD	2002	566.80	2,041.40
Public Works- Highways	90	562/#4-2002 INTERNATIONAL	D	HD	2002	1,032.10	3,315.28
Public Works- Highways	90	566/#8-2002 STERLING SL7500	D	HD	2002	746.90	2,349.57
Public Works- Highways	90	568/#10-2002 INTERNATIONAL	D	HD	2002	758.10	2,362.37
School Transportation-Reg	100	477/B20	D	HD	2002	781.00	2,862.15
School Transport-SPED	101	476/B-19	D	HD	2001	769.40	2,793.92
Public Works- Highways	90	599/#42-2001 BOBCAT 773T	D	CE	2001	225.40	821.37
Public Works- Highways	90	609/#54-2001 FORD F350	D	LD	2001	649.20	2,324.32
Public Works-Transfer Station	93	583/#25-2001 FREIGHTLINER	D	HD	2001	368.50	1,248.14
School Transportation-Reg	100	478/B-21	D	HD	2001	429.00	1,629.55
Sewer Maintenance	60	491/#12	D	HD	2000	1,420.90	5,179.85
Parks	80	434/#79	D**	LD	2000	265.50	1,070.21
Public Works- Highways	90	560/#2-2000 FREIGHTLINER	D	HD	2000	653.40	2,039.61
Public Works- Highways	90	570/#12-2000 FREIGHTLINER	D	HD	2000	746.10	2,382.97
Public Works- Highways	90	584/#26-2000 CATERPILLAR	D	CE	2000	978.70	3,220.91

Vehicle & Transit Fleets (2008): Fuel Key# /Vehicle #, Size Class, Fuel Usage

Account Name	Account Number	Vehicle Fuel Key# /Veh Name	Gas or Diesel	Size Class*	Model Year	Total Quantity (Glns)	Total Cost ($)
Public Works- Highways	90	596/#29-2000 HOLDER C9700	D	UVL	2000	74.10	237.10
Public Works- Highways	90	596/#39-2000 HOLDER C9700	D	UVL	2000	94.10	299.02
Public Works-Rubbish	92	579/#21-2000 FREIGHTLINER	D**	HD	2000	2,302.10	8,321.39
Public Works-Rubbish	92	580/#22-2000 FREIGHTLINER	D	HD	2000	1,460.60	5,098.89
School Transportation-Reg	100	459/B-1	D	HD	2000	856.10	2,946.46
Municipal Bus	30	406/911	D	HD	1999	8,881.00	31,322.68
Municipal Bus	30	407/912	D	HD	1999	8,041.80	28,868.91
Treatment Plant	61	495/#16	D	HD	1999	190.80	679.01
Parks	80	438/#83	D	HD	1999	19.40	65.57
Public Works- Highways	90	571/#13-1999 INTERNATIONAL	D	HD	1999	772.60	2,401.17
Public Works- Highways	90	575/#17-1999 INTERNATIONAL	D	HD	1999	521.10	1,643.98
Public Works- Highways	90	576/#18-1999 INTERNATIONAL	D	HD	1999	527.50	1,662.12
Public Works- Highways	90	597/#40-1999 TRACKLESS	D	UVL	1999	246.90	785.54
School Transportation-Reg	100	461/B-3	D	HD	1999	342.10	1,247.88
Fire Department	70	553/S-12 MAINTEN (ST-10?)	D**	LD	1998	296.80	998.80
Public Works- Highways	90	577/#19-1997 INTERNATIONAL	D	HD	1997	1,019.60	3,352.09
Public Works- Highways	90	582/#24-1997 JOHN DEERE	D	CE	1997	479.70	1,456.46
Public Works- Highways	90	590/#33-1997 CHAMPOIN 710A	D	CE	1997	430.00	1,314.57
Public Works-Transfer Station (42 o'neil st)	93	581/#23-1997 JOHN DEERE	D	CE	1997	269.10	886.53
Municipal Bus	30	403/908	D	HD	1996	3,267.30	11,335.70
Municipal Bus	30	404/909	D	HD	1996	7,100.40	25,384.04
Municipal Bus	30	405/910	D	HD	1996	1,316.50	4,339.36
Fire Department	70	555/T-1	D	UVL	1996	105.30	355.92
Public Works- Highways	90	567/#9-1995 FORD L8000	D	HD	1995	290.50	981.17
Fire Department	70	541/E-2	D	HD	1992	119.60	423.63
Fire Department	70	542/E-3	D	HD	1992	80.70	272.46
Fire Department	70	540/E-1	D	HD	1991	48.30	168.50
Fire Department	70	556/T-2	D	HD	1991	297.40	1,061.79
Fire Department	70	546/E-9	D	HD	1985	38.00	128.44
Municipal Bus	30	394/908	D			2,151.60	8,096.01
Municipal Bus	30	402/SPARE2	D			730.50	2,770.69
Municipal Bus	30	408/913	D			3,455.90	12,642.82
Municipal Bus	30	409/914	D			4,751.10	17,028.83
Municipal Bus	30	411/4	D			117.40	419.66
Sewer Maintenance	60	498/#25,26,30,34, PORT.GEN.	D			1,503.70	5,272.16
Sewer Maintenance	60	499/#19	D			161.10	509.77

Vehicle & Transit Fleets (2008): Fuel Key# /Vehicle #, Size Class, Fuel Usage

Account Name	Account Number	Vehicle Fuel Key# /Veh Name	Gas or Diesel	Size Class*	Model Year	Total Quantity (Glns)	Total Cost ($)
Fire Department	70	397/SERVICE 4	D			148.80	572.43
Parks	80	429/#74	D**			102.90	402.02
Parks	80	435/#80	D**			79.00	325.95
Parks	80	442/#8	D			13.40	50.16
Parks	80	443/#6	D			5.40	21.45
Parks	80	444/#7	D	AG		173.00	655.36
Parks	80	446/#101	D**	AG		659.90	2,458.32
Parks	80	448/#103	D	AG		1,297.70	4,802.64
Parks	80	616/0616	D	AG		169.10	573.07
Public Works- Highways	90	565/#7-INTERNATIONAL	D	HD		1,667.60	5,587.61
Public Works- Highways	90	589/589	D	UVL		915.40	3,411.92
Public Works- Highways	90	614/#54	D**	LD		2.00	7.39
School Transportation-Reg	100	457/M-2	D**			56.10	199.06
Police	130	532/#32	D			161.10	559.15
School Maintenance	200	456/M-1	D**	Spare D?		176.20	595.56
Parks	80	436/#81	G	LD	2009	921.20	2,341.10
Sewer Maintenance	60	490/#11	G**	LD	2008	773.10	2,207.81
Parks	80	430/#75	G	LD	2008	352.50	947.51
Public Works- Highways	90	559/#1-2008 INTERNATIONAL	G	HD	2008	14.30	47.75
Public Works- Highways	90	608/#53-2008 FORD F550	G**	LD	2008	294.20	771.99
Sewer Maintenance	60	480/#1	G**	LD	2007	325.20	900.07
Sewer Maintenance	60	489/#10	G**	LD	2007	882.50	2,413.38
Fire Department	70	538/ CAR 2	G	LD	2007	538.60	1,463.77
Parks	80	435/#80	G**	LD	2007	701.40	1,866.52
Parks	80	439/#84	G	LD	2007	1,067.50	2,768.92
Public Works- Highways	90	607/#52-2007 GMC SIERRA	G**	LD	2007	794.40	2,070.37
Public Works- Highways	90	613/#58-2007 DODGE RAM	G**	LD	2007	1,500.20	3,941.46
Pumping Station	62	482/#3	G	LD	2006	323.80	845.45
Pumping Station	62	485/#6	G	LD	2006	646.70	1,631.55
Parks	80	426/#71	G	LD	2006	337.40	883.22
School Transportation-Reg	100	454/V-3	G	LD	2006	504.70	1,308.73
Public Works- Highways	90	600/#43-2005 BOBCAT 185	G**	CE	2005	12.40	41.60
Public Works-Admin	91	606/#51-2005 CHEVROLET	G	LD	2005	699.40	1,854.81
School Transportation-Reg	100	458/T-30	G**	LD	2005	622.80	1,650.96
Fire Department	70	537/CAR 4	G	LD	2004	794.90	2,054.93
Fire Department	70	552/S-8	G	LD	2004	494.30	1,246.10
Parks	80	427/#72	G	LD	2004	849.10	2,120.62

Vehicle & Transit Fleets (2008): Fuel Key# /Vehicle #, Size Class, Fuel Usage							
Account Name	Account Number	Vehicle Fuel Key# /Veh Name	Gas or Diesel	Size Class*	Model Year	Total Quantity (Glns)	Total Cost ($)
Parks	80	433/#78	G	LD	2004	780.40	2,085.47
Public Works- Highways	90	611/#56-2004 FORD F350	G**	LD	2004	668.40	1,786.58
Public Works- Highways	90	612/#57-2004 FORD F250	G**	LD	2004	1,772.00	4,465.51
School Maintenance	200	453/V-2	G	LD	2004	629.90	1,666.78
Sewer Maintenance	60	483/#4	G**	LD	2003	823.10	2,089.64
Parks	80	432/#77	G**	LD	2003	607.30	1,618.90
Public Works- Highways	90	610/#55-2003 GMC TK2575	G	LD	2003	1,432.00	3,744.77
School Transport-SPED	101	479/B-22	G	LD	2002	1,344.50	3,456.77
Parks	80	441/#86	G	LD	2002	1,202.70	3,027.13
School Transportation-Reg	100	452/V-1	G	LD	2002	643.10	1,722.63
Fire Department	70	539/CAR 3	G	LD	2001	637.40	1,711.93
Parks	80	428/#73	G	LD	2001	236.20	578.73
Parks	80	434/#79	G**	LD	2000	599.40	1,647.86
Public Works- Highways	90	604/#49-2000 GMC SIERRA	G	LD	2000	835.10	2,434.85
Public Works-Rubbish	92	579/#21-2000 FREIGHTLINER	G	HD	2000	6.80	17.68
School Maintenance	200	449/T-1	G	LD	1999	694.60	1,971.13
Fire Department	70	553/S-12 MAINTEN	G**	LD	1998	309.00	834.23
School Maintenance	200	450/T-2	G	LD	1998	538.60	1,465.75
School Maintenance	200	451/T-3	G	LD	1998	521.90	1,362.13
Pumping Station	62	494/#15	G	LD	1997	746.20	2,017.40
Parks	80	431/#76	G	LD	1997	233.90	587.49
Parks	80	429/#74	G**	LD	1995	226.90	751.75
Fire Department	70	557/T-2 GAS	G	HD	1992	16.00	47.51
WRP Engineer	65	619/619	G			176.30	565.54
Assessor's/City Manager	10	617/617	G			154.20	406.48
Planning & Development/Code Enforcement	20	422/PD73	G			217.20	587.14
Planning & Development/Code Enforcement	20	423/PD1	G			341.80	927.57
Planning & Development/Code Enforcement	20	424/PD2	G			22.10	29.10
Planning & Development/Code Enforcement	20	425/PD3	G			139.30	348.60
Municipal Bus	30	401/SPARE1	G			53.00	120.90
Municipal Bus	30	410/3	G			603.20	1,547.70
Sewer Maintenance	60	486/#7	G			935.60	2,353.43
Sewer Maintenance	60	487/Traded 3-17-09	G			928.70	2,377.77

Vehicle & Transit Fleets (2008): Fuel Key# /Vehicle #, Size Class, Fuel Usage

Account Name	Account Number	Vehicle Fuel Key# /Veh Name	Gas or Diesel	Size Class*	Model Year	Total Quantity (Glns)	Total Cost ($)
Sewer Maintenance	60	492/#13	G**			559.50	1,687.85
Treatment Plant	61	484/#5	G			443.00	1,125.07
Treatment Plant	61	497/#20	G	UVS		64.50	169.41
Treatment Plant	61	500/#18	G			150.90	391.94
Industrial Compliance	64	481/#2	G			189.90	519.01
Fire Department	70	558/CENT UTILITY	G			6.30	20.73
Parks	80	446/#101	G**	AG		42.40	147.85
Parks	80	618/618	G			107.20	287.16
Public Works- Highways	90	614/#54	G**	LD		587.80	1,363.57
School Transportation-Reg	100	457/M-2	G**			49.40	102.75
Police	130	395/#34	G			145.40	451.34
Police	130	396/#35	G			218.00	694.13
Police	130	501/#1	G			1,027.60	2,769.99
Police	130	502/#2	G			494.40	1,323.27
Police	130	503/#3	G			1,320.50	3,533.47
Police	130	504/#4	G			4,352.20	11,568.89
Police	130	505/#5	G			2,624.00	7,245.86
Police	130	506/#6	G			3,596.30	9,476.39
Police	130	507/#7	G			3,473.80	9,501.96
Police	130	508/#8	G			2,602.80	6,953.63
Police	130	509/#9	G			3,526.80	9,424.53
Police	130	510/#10	G			999.90	2,462.30
Police	130	511/#11	G			187.60	537.26
Police	130	512/#12	G			238.30	628.78
Police	130	513/#13	G			55.10	143.20
Police	130	514/#14	G			2,542.60	6,508.32
Police	130	515/#15	G			1,330.80	3,506.25
Police	130	516/#16	G			910.90	2,417.72
Police	130	517/#17	G			411.60	1,089.45
Police	130	518/#18	G			316.80	733.90
Police	130	519/#19	G			320.30	888.84
Police	130	520/#20	G			349.30	968.53
Police	130	521/#21	G**			388.30	1,011.51
Police	130	522/#22	G			320.30	839.09
Police	130	523/#23	G			404.70	1,112.58
Police	130	524/324	G			326.40	836.22
Police	130	525/2010 TAHOE	G			487.50	1,352.51

Vehicle & Transit Fleets (2008): Fuel Key# /Vehicle #, Size Class, Fuel Usage							
Account Name	Account Number	Vehicle Fuel Key# /Veh Name	Gas or Diesel	Size Class*	Model Year	Total Quantity (Glns)	Total Cost ($)
Police	130	526/#26	G			869.50	2,504.80
Police	130	527/#27	G			4.60	12.28
Police	130	528/#28	G			176.80	470.48
Police	130	529/#29	G			265.60	836.67
Police	130	530/#30	G			110.50	286.06
Police	130	531/#31	G			832.20	2,203.01
Police	130	533/M1	G**			163.90	449.71
Police	130	534/M2	G			55.60	175.56
Police	130	535/M3	G			84.30	265.25
Police	130	536/M4	G			12.70	39.37
School Maintenance	200	455/BT-1	G**			1,221.80	3,564.97
School Maintenance	200	456/M-1	G	Spare D?		98.30	205.77

***See Appendix III for explanation of Size Class abbreviations.**
****Vehicles listed twice; these vehicles used both diesel and gasoline during base year inventory (2008).**

Appendix V: Vehicle Miles Traveled by Federal Functional [Road] Classifications

2007 Annual Vehicle Miles Traveled (VMT): South Portland, Maine*						
Town Code	Town Name	MPO**	Federal Urban /Rural	Federal Functional Classifications***	Included / Omitted	Annual VMT
5220	South Portland	PACTS	Urban	Local	Included	24,580,500.978
5220	South Portland	PACTS	Urban	Major/Urb Collector	Included	41,834,474.812
5220	South Portland	PACTS	Urban	Minor Arterial	Included	71,275,468.623
5220	South Portland	PACTS	Urban	Other Princ Arterial	Included	13,604,783.468
				Sub-Total: Included VMT		**151,295,227.881**
5220	South Portland	PACTS	Urban	Princ Art Interstate	Omitted	61,350,682.356
5220	South Portland	PACTS	Urban	Princ Art Other F&E	Omitted	23,580,072.537
				Sub-Total: Omitted VMT		**84,930,754.893**
				Total VMT		**236,225,982.774**

***Data supplied to GPCOG by Edward Beckwith, edward.beckwith@maine.gov, MDOT, Bureau of Transportation Systems.**
****Metropolitan Planning Organization**
*****For a decription of Federal Functional Classifications visit:**
http://www.maine.gov/mdot/maines-transportation-systems/classification-highways%20.php

SIEMENS

ENERGY PERFORMANCE CONTRACT

PERFORMANCE ASSURANCE REPORT

FOR THE

City of South Portland

Performance Year 1: April 1, 2012– March 31, 2013

Siemens Industry, Inc.
Canton, MA

SIEMENS

PERFORMANCE SOLUTIONS AGREEMENT OVERVIEW

Client ....City of South Portland

Effective Contract Date...April 15, 2011

Customer Contact..James Galey, City Manager

Siemens Contact.....................Colleen Fissette, Performance Assurance Engineer

Baseline Period...May 2009 – April 2010

Performance Guarantee Period........................... April 1, 2012 to March 31, 2027

Contract Term .... 15 Years

Table of Contents

1. Executive Summary

Performance Year 1: April 2012 – March 2013

Siemens Industry (Siemens) is pleased to provide the City of South Portland with this Year-1 energy savings guarantee report. This report details the energy performance of the implemented project by comparing realized energy and cost savings for this annual period to the contract guaranteed savings. Your Energy Performance Contract with Siemens guaranteed **$127,796** in annual cost savings, including both construction and Year 1 savings. Total Year-1 cost savings for this annual period amounted to **$176,096** and consisted of **$57,414** in Construction Savings, **$83,996** in Measured and Verified Savings, **$25,996** in Stipulated Energy Savings, and **$8,720** in Stipulated Operational Savings. Total Year-1 savings are **$48,300** in excess of the guaranteed savings for this performance period.

Table 1. Summary of annual guaranteed and verified savings for the City of South Portland

Performance Year	Measured and Verified Savings	Stipulated Savings	Operational Savings	Total Realized Year-1 Savings	Annual Guaranteed Savings	Deviation from Plan
Construction				**$57,414**	**$15,000**	**$42,414**
1	**$83,966**	**$25,996**	**$8,720**	**$118,683**	**$112,796**	**$5,887**
2			$8,982		$117,221	
3			$9,251		$121,819	
4			$9,529		$126,600	
5			$9,814		$131,568	
6			$0		$126,624	
7			$0		$131,689	
8			$0		$136,957	
9			$0		$143,435	
10			$0		$148,132	
11			$0		$154,057	
12			$0		$160,220	
13			$0		$166,629	
14			$0		$173,294	
15			$0		$180,225	
YTD Totals	**$83,966**	**$25,996**	**$46,296**	**$176,096**	**$2,146,266**	**$48,300**

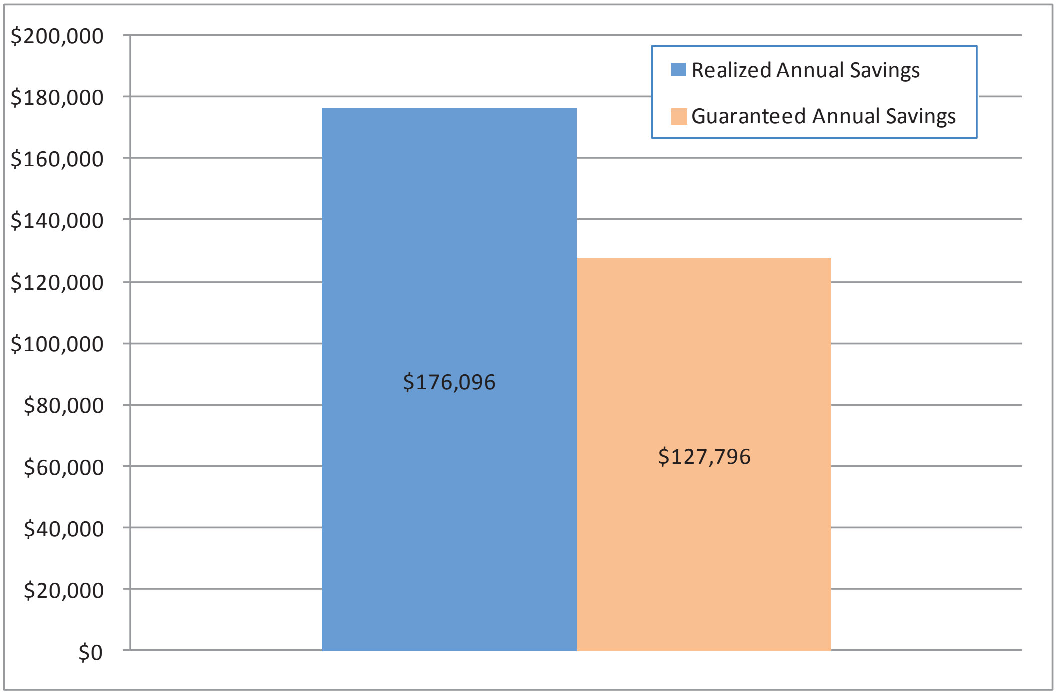


Figure 1. Year 1 Savings Comparison

Table 2. Year-to-Date Energy Savings (Units)

Energy Savings	Electric Energy Saved (kWh/yr)	Natural Gas Saved (Therms/yr)	#2 Fuel Oil Saved (gal/yr)	Propane Savings (Gal)	Water Savings (kGal)	Sewer Savings (kGal)
Guaranteed	398,831	(19,708)	27,443	1,509	327	327
Year-1	431,238	(22,509)	28,838	1,521	327	327

Table 3. Realized Energy Savings by FIM (Units)

Facility Improvement Measure	Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	Fuel Oil Savings (Gal/Yr)	Water Savings (kGal/yr)	Sewer Savings (kGal/yr)
Lighting & Controls	370,806	(602)	(39)	(201)		
Water Conservation		448		61	327	327
Boiler Replacement		(26,171)		22,416		
Burner Replacement		(5,197)		3,883		
Demand Control Ventilation	575	2,324		439		
EMS-Occupied/Unoccupied Setback	18,843	448				
Building Envelope	25,245	4,964	1,560	1,645		
Insulate Store Windows				594		
Vending Misers	15,768					
Steam Trap Replacement		1,277				
TOTALS	**431,238**	**(22,509)**	**1,521**	**28,838**	**327**	**327**

2. Performance Assurance Overview

This section of the report provides an overview of the methodology and parameters used to measure and verify savings for this report and are based on the signed contract between the City of South Portland and Siemens Industry, Inc.

2.1 Measurement and Verification Methods

Realized savings were calculated using the methodology described in Exhibit C of the energy performance. There are four guarantee options to measure and verify savings: Option A – Retrofit Isolation: Key Parameter Measurement, Option B – Retrofit Isolation: All Parameter Measurement, Option C – Whole Facility, Option D – Calibrated Simulation, and Option E - Stipulated.

Option A – Retrofit Isolation: Key Parameter Measurement. Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the FIM's affected system(s) and/or the success of the Project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement is evaluated. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option B – Retrofit Isolation: All Parameter Measurement. Savings are determined by field measurement of the energy use of the FIM-affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option C – Whole Facility: Savings are determined by measuring energy use at the whole Facility of sub-Facility level. Continuous measurements of the entire Facility's energy use are taken throughout the reporting period. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option D – Calibrated Simulation: Savings are determined through simulation of the energy use of the whole Facility, or of a sub-Facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the Facility. This option usually requires considerable skill in calibrated simulation. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option E – Stipulated: This option is the method of measurement and verification applicable to FIMS consisting either of Operation Savings or where the end use capacity or operation efficiency; demand, energy consumption or power level; or manufacturer's measurements, industry standard efficiencies or operating hours are known in advance, and used in a calculation or analysis method that will stipulate the outcome. Both CLIENT and SIEMENS agree to the stipulated inputs and outcome(s) of the analysis methodology. Based on the established analytical methodology the Savings stipulated will be achieved upon completion of the FIM and no further measurements or calculations will be performed during the Performance Guarantee Period. If applicable, the methodology and calculations to establish Savings value will be defined in Section 4.6 of Exhibit C.

2.2 Guaranteed Savings

Guaranteed cost savings are shown below in Table 4.

Table 4. Realized and Guaranteed Annual Cost Savings.

FIM Description	M&V Option	Guaranteed Energy Savings
Lighting & Controls	A	$64,606
Water Conservation	E	$3,052
Boiler Replacement	B	$12,677
Burner Replacement	B	$1,463
Demand Control Ventilation	B	$4,973
EMS-Occupied/Unoccupied Setback	B	$3,081
Building Envelope	E	$17,676
Insulate Store Windows	E	$1,194
Vending Misers	E	$2,580
Steam Trap Replacement	E	$1,494
Total		**$112,796**

2.3 Utility Rate Structures and Escalation Rates

Utility rates used to calculate dollar savings for this report are based on the baseline year unit rates shown in Table 5. As per contract, an escalation rate of 4% will be applied to the baseline rate for each utility.

Table 5. Summary of Contract Utility Rates for Performance Year-1

Location	#2 Fuel Oil ($/gal)	Natural Gas ($/Therm)	Propane ($/Gal)	Electric Demand ($/kW)	Electric Consumption ($/kWh)	Water ($/kGal)	Sewer ($/kGal)
Wastewater Treatment Plant		$1.24			$0.163	$2.05	$5.31
Western Ave Fire Station		$1.19			$0.163		
Wainwright Farms			$2.13		$0.163		
Main Library	$2.02	$1.20			$0.183		
Police and Public Safety Building	$1.98	$1.17			$0.163	$2.05	$5.31
Redbank Community Center		$1.26			$0.225	$2.05	$5.31
Sewer Maint Station			$3.05		$0.150		
City Hall	$2.00	$1.14			$0.166	$2.05	$5.31
Community Center/Pool Building	$2.05	$1.23		$0.163	$0.163	$2.05	$5.31
Golf Course Maintenance			$2.13		$0.167	$1.53	$3.97
Central Fire	$2.05	$1.17			$0.195	$2.05	$5.31
Branch Library			$2.13		$0.149		
Cash Corner Fire Station	$2.01	$1.17			$0.190	$2.05	$5.31
Hamlin School	$1.89		$2.13		$0.163		

2.4 Baseline Utility Data

The annual period selected as the Baseline period starts May 2009 and ends April 2010. Tables 6 outline the utility consumption that occurred during the Baseline period.

Table 6. Electric Baseline Consumption (May 2009 - April 2010)

Location	Electricity (kWh)	Natural Gas (Therms)	Propane (Gal)	Fuel Oil (Gal)
Wastewater Treatment Plant	81,649			
Western Ave Fire Station	81,649	7,421		
Main Library	89,240			4,058
Redbank Community Center	35,021	3,984		
Sewer Maint Station	10,898		2,782	
City Hall	108,320	68		3,883
Police Department	63,548			9,642
Golf Course Maintenance	22,862		851	
Hamlin School	803			12,376
Assessor's Office	12,172	1,193		
Branch Library	37,320		2,243	
Cash Corner Fire Station	27,518			2,924
Community Center/Pool Bldg	379,471	15,716		22,583
Central Fire Department	36,396			7,339
Public Safety	408			
Operations Buidling		8,591		
Main Pump Station		4,228		
Total	**987,275**	**41,201**	**5,876**	**62,806**

2.5 Baseline Operating Data

The operating practices during the Baseline period are used to determine the guaranteed savings based on the efficiency improvements after implementing the facility improvement measures, these parameters are shown in Table 7.

Table 7. Baseline Operating Schedules, West Ave Fire House

Units	Heating		Cooling	
	Occupied	Unoccupied	Occupied	Unoccupied
Western Ave Fire House - Living Area	74	74	68	70
Western Ave Fire House - Garage	74	74	68	70

2.6 Contracted Baseline Operating Data

The guaranteed savings from the facility improvement measures provided under this contract are based on implementation of the following schedules and set points shown in Tables 8.

Table 8. Post Implementation schedule, West Ave Fire House

Units	Heating		Cooling	
	Occupied	Unoccupied	Occupied	Unoccupied
Western Ave Fire House - Living Area	70	68	72	74
Western Ave Fire House - Garage	70	68	72	74

3. Performance Assurance Results

3.1. Summary of Guaranteed and Verified Energy Savings

Total realized annual energy savings for this performance year were **$179,726** and were comprised of **$57,414** in Construction Savings, **$61,006** of Option A, **$22,960** in Option B, **$25,996** in Option E savings, and **$8,720** in stipulated Operational Savings respectively. Total realized annual savings are in excess of the annual guaranteed energy savings of **$127,796** by **$48,300.** The following sections detail the Option A, B, and E savings.

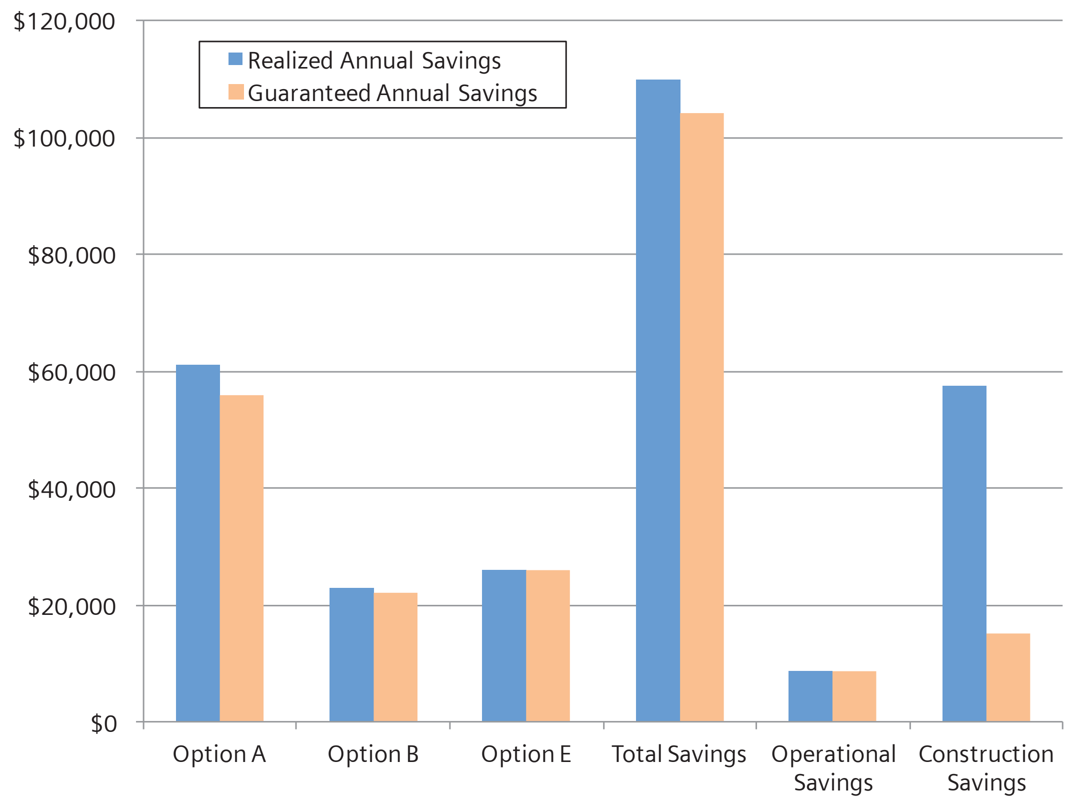


Figure 2. Realized and Guaranteed Annual Cost Savings for Year-1.

3.2. Option A Savings

3.2.1. Performance Year Savings

Option A savings are verified based on one-time measurements taken after substantial completion of each facility improvement measure and the estimated savings are included as ongoing realized savings in each subsequent performance year. The table below summarizes Option A savings realized during the current performance year and shows that total Option A savings amount to **$61,006** which is **$5,120** above the guaranteed Option A savings (**$55,886**).

Table 9. Summary of Option A Savings for Performance Year-1

Description of FIM	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	Fuel Oil Savings (Gal/Yr)	Verified $ Saved per year	Guaranteed $ per year	Excess/ Shortfall $
Lighting & Controls	370,806	(602)	(39)	(201)	**$61,006**	$55,886	$5,120

3.2.2. Results by Measure

3.2.2.1. Lighting & Controls Retrofit

Energy savings resulting from the lighting retrofit were verified based upon a one-time measurement of the lighting power capacity under existing conditions, a one-time measurement of the lighting power capacity upon completion of the lighting retrofit project and agreed-upon annual operating hours. A representative sample of each lighting-fixture type was used to determine pre-retrofit and post-retrofit kW. The following tables detail the savings results from the lighting and controls retrofit.

Table 10. Annual Savings Associated with the Lighting and Controls Retrofit

Lighting & Controls	
Guaranteed Electric Savings (kWh)	339,942
Realized Electric Savings (kWh)	**370,806**
Heating Penalty:	
Guaranteed Natural Gas Savings (Therms)	(510)
Realized Natural Gas Savings (Therms)	**(602)**
Guaranteed Propane Savings (Gal)	(51)
Realized Propane Savings (Gal)	**(39)**
Guaranteed Fuel Oil Savings (Gal)	(199)
Realized Fuel Oil Savings (Gal)	**(201)**
Total Guranteed Savings	**$55,886**
Total Realized Savings	**$61,006**
Excess/Shortfall in Savings	**$5,120**

Table 11. Annual Savings Associated with the Lighting and Controls Retrofit per location.

Description of FIM	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	Fuel Oil Savings (Gal/Yr)	Verified $ Saved per year	Guaranteed $ per year	Excess/ Shortfall $
Lighting & Controls	370,806	(602)	(39)	(201)	**$61,006**	**$55,886**	**$5,120**
City Hall	25,521	(61)			$4,156	$3,570	$586
Assessors Bldg	2,957	(7)			$430	$463	($33)
Hamlin School	11,457			(31)	$1,809	$1,567	$242
West End Fire House	30,218	(74)			$4,844	$3,871	$973
Golf Course Maint	2,663			(7)	$429	$443	($14)
Wainwright Farms	7,890		(21)		$1,241	$1,897	($656)
Redbank Community	16,498	(39)			$3,670	$2,885	$785
Branch Library/ GC	6,771		(18)		$968	$994	($26)
Main Library	17,627			(31)	$3,164	$2,955	$209
Community Ceter/Pool	111,767	(267)			$17,839	$14,959	$2,880
Sewer Maintenance Bldg	11,124	(27)			$2,142	$2,352	($210)
Central Fire/Dispatch/Police	68,285			(121)	$10,859	$11,270	($411)
Waste Water Treatment Pl	52,028	(128)			$8,335	$7,509	$826
Cash Corner Fire House	5,999			(11)	$1,120	$1,152	($32)

Overall the verified cost savings for this measure was higher than expected. Some buildings resulted in higher or lower than expected kW savings due to a difference between expected and actual measured kW per fixture (Table 12), although overall for the project, the verified lighting savings exceeded the guarantee.

Table 12. Measured energy savings per fixture type.

Fixture Type	Expected Savings/Fixture	Realized Savings/Fixture	Deviation from Expected
HB400MH/HIF4LT5HO-50W-WG-MS-NF	0.242	0.274	0.032
I2L8HO/RI6L4-8F-25-N-KIT	0.109	0.199	0.090
I4L4-8F-T8-25-L	0.038	0.042	0.004
P2L4-T8/VR2L4-T8-25-L	0.020	0.021	0.001
P3L4-T8-AB/VR2L4-T8-25-BL-KIT	0.045	0.024	-0.021
P4L4-T8/VR2L4-T8-25-N-KIT	0.069	0.081	0.012
PM3L4-T8-AB-25-L	0.031	0.024	-0.007
PM6L4-8F-T8-25-L	0.000	0.072	0.072
PM8L4-8F-T8/W6L4-8F-25-N-NF	0.096	0.092	-0.004
S2L4-T8-25-L	0.023	0.015	-0.008
SB250MH/200-P	0.063	0.056	-0.007
SB400MH/320-P	0.115	0.059	-0.056
SM2L2U6-T8/RK3L2-15-L-KIT	0.027	0.023	-0.004
SM2L4-T8/VR2L4-T8-25-L-KIT	0.023	0.032	0.009
SM2L4-T8-25-L	0.023	0.021	-0.002
SM6L3-T8-22-L	0.032	0.032	0.000
T2L2U6-T8/RK3L2-15-L-KIT	0.027	0.023	-0.004
T3L4-T8/VR2L4-T8-25-L-KIT	0.051	0.052	0.001
T3L4-T8/VR2L4-T8-25-N-KIT	0.045	0.043	-0.002
T4L4-AB/VR2L4-T8-25-BL-KIT	0.117	0.024	-0.093
T4L4-T8/VR2L4-T8-25-N-KIT	0.069	0.065	-0.004
TR17CFR30/LED8-PAR20-NL	0.009	0.018	0.009
VT2L4-T8-D-25-L	0.023	0.026	0.003
VT4L4-8F/Remain	0.038	0.000	-0.038
W2L2-T8-15-L	0.015	0.013	-0.002
W2L4-25-L	0.043	0.045	0.002
W2L4-T8-25-L	0.023	0.015	-0.008
W4L4-25-L	0.086	0.015	-0.071
W4L4-8F-T8/EW4L4-8F-25-L-NF	0.038	0.027	-0.011
W4L4-T8/W3L4-T8-25-L-NF	0.055	0.028	-0.027

3.3. Option B Savings

3.3.1. Performance Year Savings

Realized Option B savings amounted to **$22,960** which is **$766** in excess of Year-1 guaranteed Option B savings of **$22,194**. These realized savings are calculated each year based on measurements and methods outlined in Exhibit C of the performance contract.

Table 14. Summary of Option B Savings for Performance Year-1

Description of FIM	Electric Savings (kwh/yr)	Fuel Oil Saved (Gal/yr)	Natural Gas Saved (Therms/yr)	Verified $ Saved per year	Guaranteed $ per year	Excess/Shortfall in Savings
Boiler Replacement		**22,416**	**(26,171)**	**$13,763**	**$12,677**	**$1,086**
Community Center/Pool Building						
Demand Control Ventilation	**575**	**439**	**2,324**	**$3,751**	**$4,973**	**($1,222)**
Community Center/Pool Building	10		38	$48		
Western Ave Fire Station	422		2,286	$2,789		
Main Library	143	439		$914		
EMS-Occupied/Unoccupied Setback	**18,843**		**448**	**$3,605**	**$3,081**	**$524**
Western Ave Fire Station						
Burner Replacement		**3,883**	**(5,197)**	**$1,842**	**$1,463**	**$379**
City Hall						
Total Option B Savings	**19,418**	**26,739**	**(28,596)**	**$22,960**	**$22,194**	**$766**

3.3.2. Results by Measure

3.3.2.1. Boiler Replacement

Siemens replaced three existing oil-fired boilers at the South Portland Community Center/Pool with three high efficiency natural gas boilers and natural gas burners. Energy savings was achieved by converting from Fuel Oil to Natural Gas and increased combustion efficiency. Savings was verified through the results of a combustion efficiency test performed on all boilers at high and low fire resulting in an average efficiency of **89.1%**.

Table 15. Savings Associated with the Boiler Replacement

Boiler Replacement	
Existing Combustion Efficiency	75%
Verified Combustion Efficiency	**89%**
Guaranteed Fuel Oil Savings (Gal)	20,174
Realized Fuel Oil Savings (Gal)	**22,416**
Cost per Gal	$2.05
Realized Fuel Oil Savings ($)	**$45,953**
Guaranteed Natural Gas Savings (Therms)	(23,318)
Realized Natural Gas Savings (Therms)	**(26,171)**
Cost per Therm	$1.23
Realized Natural Gas Savings ($)	**($32,190)**
Total Guaranteed Savings	**$12,677**
Total Realized Savings	**$13,763**
Excess/Shortfall in Savings	**$1,086**

3.3.2.2 EMS Occupied/Unoccupied Scheduling

Location: Western Ave Fire Station

Units as described in Article 2.6 of this document will be automatically shut down during unoccupied periods by the EMS system. The occupied/unoccupied scheduling will reduce electrical energy consumption by replacing or eliminating operation of the supply and exhaust fans when areas are unoccupied. A one month trend analysis was done of the Western Ave Fire Station heating temperature set points for the living area and garage. Heating temperature set points were found to be lower than proposed resulting in an excess from the guaranteed natural gas and electric savings.

Table 16. Actual Heating Temperature Set points

Units	Heating Occupied	Heating Unoccupied
Western Ave Fire House - Living Area	70	67
Western Ave Fire House - Garage	68	68

Table 17. Actual Savings Associated with the EMS

EMS: Occ/Unocc Setback	
Guaranteed Electric Savings (kWh)	16,952
Realized Electric Savings (kWh)	**18,843**
Cost per kWh	$0.1630
Realized Electric Savings ($)	**$3,071**
Guaranteed Natural Gas Savings (Therms)	267
Realized Natural Gas Savings (Therms)	**448**
Cost per Therm	$1.19
Realized Natural Gas Savings ($)	**$533**
Total Guaranteed Savings	**$3,081**
Total Realized Savings	**$3,605**
Excess/Shortfall in Savings	**$524**

3.3.2.3. Demand Control Ventilation

Location: Community Center/Pool Building, Main Library, and Western Ave Fire Station

Demand control ventilation (DCV) adjusts the outdoor air damper position based on occupancy at any given time instead of at a fixed position for full occupancy. Carbon dioxide (CO2) sensors monitor the CO2 level to estimate activity level in the space which intern signals the HVAC system to adjust the amount of outside air to be conditioned for the space. The CO2 levels in the applicable areas will be monitored annually for a two-week period and reported, as per contract, in conjunction with the outdoor air damper position to prove the system is working properly.

The Main Library has an existing Barber Coleman DDC system in which trending is not possible. A third party mechanical service company installed and integrated the DCV control and the system was commissioned by them.

Table 18. Savings Associated with DCV

Demand Control Ventilation	
Guaranteed Electric Savings (kWh)	923
Realized Electric Savings (kWh)	**575**
Guaranteed Fuel Oil Savings (Gal)	395
Realized Fuel Oil Savings (Gal)	439
Guaranteed Natural Gas Savings (Therms)	3,289
Realized Natural Gas Savings (Therms)	**2,324**
Total Guaranteed Savings	**$4,973**
Total Realized Savings	**$3,751**
Excess/Shortfall in Savings	**($1,222)**

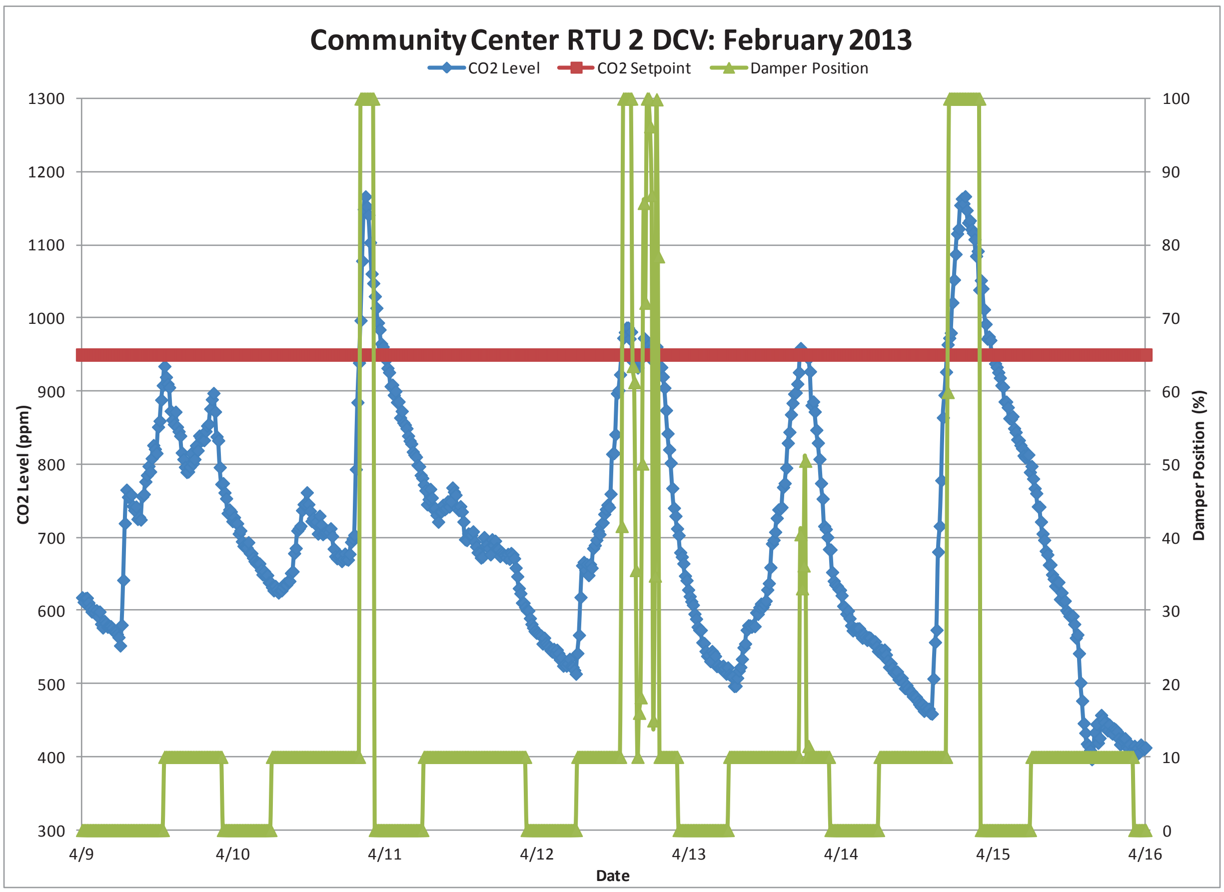


Figure 3. Demand Control Ventilation, Community Center/Pool Building

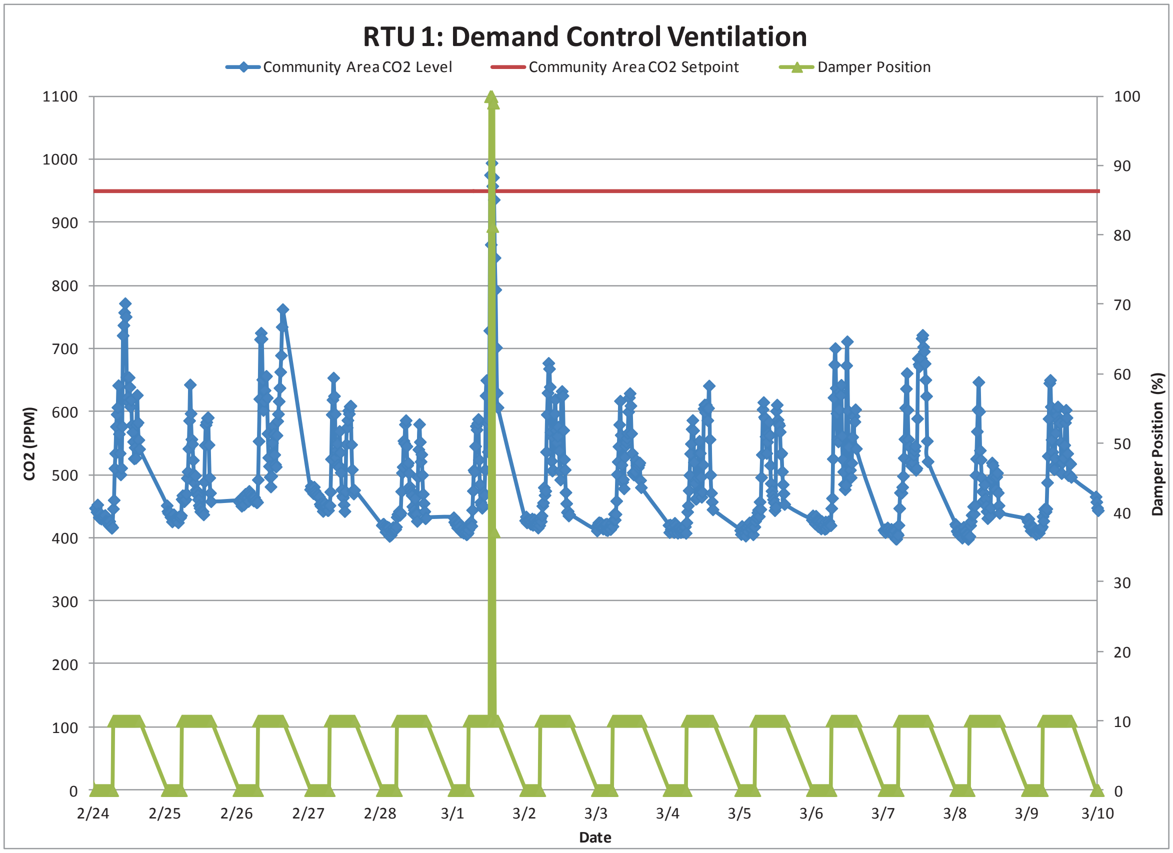


Figure 4. Demand Control Ventilation, Western Ave Fire Station

The M&V results suggest that the demand control ventilation (DCV) strategies at the Community Center and Western Ave Fire Station need to be optimized. Because DCV savings result from minimizing the amount conditioned ventilation air, the outside air damper should remain closed unless the CO_2 level for the spaces served rise above set point. Currently the dampers are maintained at a minimum of 10% open during occupancy, regardless of CO_2 level. Siemens is working with our service team to optimize the DCV sequence for the Fire Station and Community Center units to ensure future savings are realized.

3.3.2.3 Burner Replacement

Siemens replaced two existing oil-fired boiler burners at the City Hall with two new natural gas burners.

Table 19. Savings Associated with the Burner Replacement

Burner Replacement	
Proposed Combustion Efficiency	81%
Verified Combustion Efficiency	**84%**
Guaranteed Fuel Oil Savings (Gal)	3,495
Realized Fuel Oil Savings (Gal)	**3,883**
Cost per Gal	$2.00
Realized Fuel Oil Savings ($)	**$7,767**
Guaranteed Natural Gas Savings (Therms)	(4,847)
Realized Natural Gas Savings (Therms)	**(5,197)**
Cost per Therm	$1.14
Realized Natural Gas Savings ($)	**($5,925)**
Total Guaranteed Savings	**$1,463**
Total Realized Savings	**$1,842**
Excess/Shortfall in Savings	**$379**

3.4. Option E Stipulated Savings

Realized Option E savings amounted to **$25,996** and are based on the predicted savings calculated in the detailed energy audit as agreed upon in the performance contract.

3.4.1. Performance Year Savings

Table 20. Summary of Option D Stipulated Savings.

Description of FIM	Electric Energy Savings (kWh/yr)	Fuel Oil Savings (Gal/yr)	Natural GasSavings (Therms/yr)	Propane Savings (Gal/yr)	Water Savings (kGal/yr)	Sewer Savings (kGal/yr)	Verified $ Saved per year	Guaranteed $ per year	Excess/Shortfall in Savings
Water Conservation		**61**	**448**		**327**	**327**	**$3,052**	**$3,052**	$0
Wastewater Treatment Plant			33		7	7	$92		
Central Fire Station			251		118	118	$1,162		
City Hall			100		149	149	$1,212		
Police Station & Public Safety		61			34	34	$375		
Redbank Community Center			14		3	3	$41		
Community Center/Pool Bldg.			50		15	15	$172		
Building Envelope	**25,245**	**1,645**	**4,964**	**1,560**			**$17,676**	**$17,676**	$0
Branch Library	322			229			$535		
Cash Corner Fire Station	1,117	456					$1,129		
Central Fire Station	456		220				$346		
City Hall	1,506		672				$1,016		
Community Center/Pool Bldg.	8,339		1,903				$3,700		
Hamlin School				204			$386		
Main Library	2,787	596					$1,714		
Police Station & Public Safety	4,137	593					$1,848		
Redbank Community Center			622				$784		
Sewer Maint. Station	1,642			921			$3,056		
Wainwright Farms				205			$438		
Wastewater Treatment Plant	4,939		1,548				$2,724		
Insulate Store Windows		**594**					**$1,194**	**$1,194**	$0
Cash Corner Fire Station									
Vending Misers	**15,768**						**$2,580**	**$2,580**	$0
Police Station & Public Safety	1,332						$217		
Branch Library	5,571						$830		
Cash Corner Fire Station	1,927						$366		
Central Fire Station	1,156						$225		
Community Center/Pool Bldg.	3,854						$628		
Western Ave Fire Station	1,927						$314		
Steam Trap Replacement			**1,277**				**$1,494**	**$1,494**	$0
Central Fire Station									
Total Option D Savings	**41,013**	**2,300**	**6,689**	**1,560**	**327**	**327**	**$25,996**	**$25,996**	**$0**

3.4.2. Results by Measure

3.4.2.1 Water Conservation

Siemens did a bathroom survey and identified several high flow fixtures to retrofit with low flow fixtures. Tables 18 and 19 identify the existing and retrofit flow rates, locations, and quantity of fixtures that were replaced.

Table 21. Water conservation fixture locations and quantities

Buildig Location	Toilets	Urinals	Sinks	Showers
Central Fire	5	1	7	3
City Hall	5	0	7	0
Wastewater Treatment Plant	0	0	4	1
Cash Corner	3	1	2	1
Redbank Community Center	0	2	4	0
Community Center	1	0	15	0
Police Station & Public Safety	3	4	7	0
Totals	**17**	**8**	**46**	**5**

Table 22. Water Conservation Pre & Post Retrofit Flow Rates

Fixture Type	Existing Flow Rate	Proposed Flow Rate
Toilets	3.5	1.28
Urinals	1.5	1
Snks	2.2	0.5
Shower	2.5	1.5

3.4.2.2 Building Envelope

To control air leakage Siemens' sealed gaps, cracks, and holes using appropriate materials and systems in doors, windows, and roofs as described in Exhibit A of the performance contract.

3.4.2.3 Insulate Store Windows

Siemens replaced windows at the Cash Corner Fire Station on the West side with new energy star rated windows and fitted with trapezoidal windows on the North Side with insulated panels.

3.4.2.4. Vending Misers

Siemens installed PlugMiser® vending machine occupancy controllers (VMOC) to manage power consumption of the vending machines. Utilizing a Passive Infrared (PIR) sensor, the VMOC completely powers down the vending machine when the area surrounding it is unoccupied. One powered down, the VMOC will monitor the room's temperature and use this information to automatically re-power the vending machine at one to three hour intervals, independent of occupancy, to ensure that the vended product stays cold. These were installed on soda machines at the following locations.

Table 23. PlugMiser® locations

Location	Soda Machines	Snack Machines
Community Center	2	0
Western Fire House	1	0
Cash Corner Fire House	1	0
Golf/Branch Library	2	0
Central Fire House	1	0
Central Police/Dispatch	2	1

3.4.2.5. Steam Trap Replacement

Siemens conducted a survey of the steam traps at the Central Fire Station. The survey revealed 4 distribution line steam traps in the school mechanical rooms as well as 22 thermostatic radiator traps. The 4 distribution line traps were replaced with new steam traps and the 22 thermostatic radiator traps were rebuilt using Tunstall steam trap kits and covers.

4. Construction Savings

Construction savings is calculated by prorating the Year-1 realized savings by the number of days between when Substantial completion and Final completion were signed. Total construction savings amount to **$57,414** which is **$42,414** in excess of the guaranteed **$15,000**.

Table 24. Construction Savings

FIM Name	Individual FIM Substantial Completion	Start of Performance Period 1	Days	Year 1 Savings	Construction Period Savings ($)
Lighting & Controls	9/1/2011	4/1/2012	213	$61,006	$35,601
Water Conservation	9/30/2011	4/1/2012	184	$3,052	$1,539
Boiler Replacement	10/10/2011	4/1/2012	174	$13,763	$6,561
Burner Replacement	12/21/2011	4/1/2012	102	$1,842	$515
Demand Control Ventilation	2/8/2012	4/1/2012	53	$3,751	$545
EMS-Occupied/Unoccupied Setback	3/26/2012	4/1/2012	6	$3,605	$59
Building Envelope	9/13/2011	4/1/2012	201	$17,676	$9,734
Insulate Store Windows	09/30/11	4/1/2012	184	$1,194	$602
Vending Misers	09/01/11	4/1/2012	213	$2,580	$1,506
Steam Trap Replacement	09/30/11	4/1/2012	184	$1,494	$753
TOTAL					$57,414

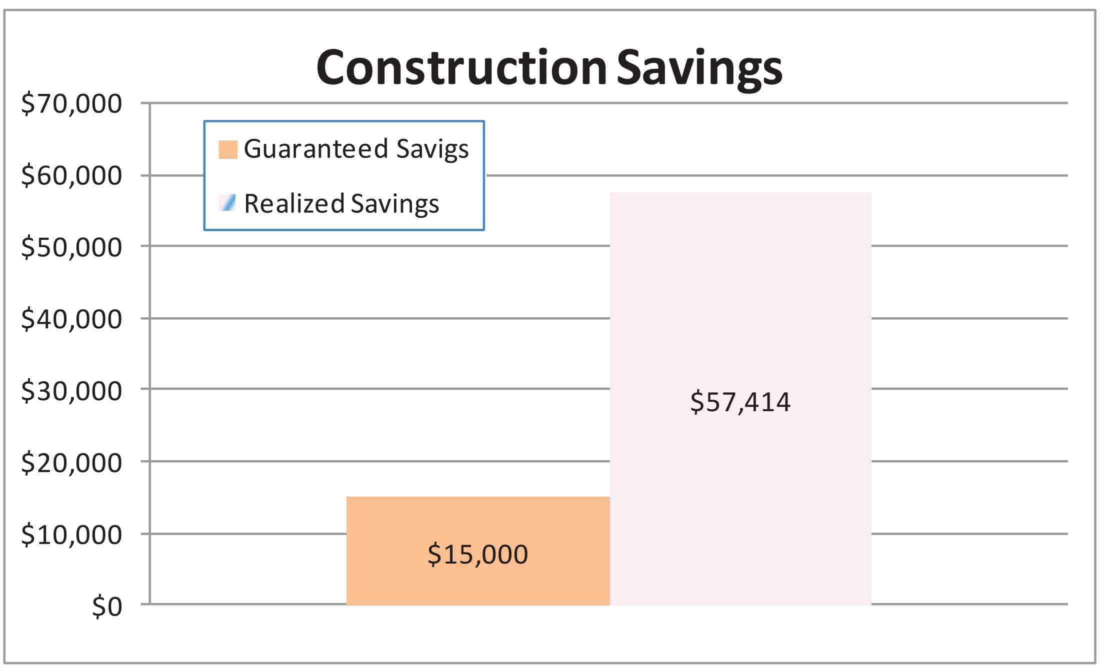


Figure 6. Guaranteed vs. Realized Construction Savings

5. Emissions Reduction

The following table converts the energy savings (electric, fuel oil, propane, etc.) into pounds of carbon dioxide that would have been released into the atmosphere if this project was not performed. These values are then converted into everyday examples to illustrate how this performance contract has decreased the carbon footprint of Waterbury Hospital. For example, from the table below, the realized energy savings avoided the equivalent of the **carbon dioxide emission of 73.4 cars in Year 1**.

Annual Reduction

CO2e Reductions

Electricity	501,620.3
Natural Gas	-263,535.3
#1, #2, #4 Fuel Oil	645,509.7
#5, #6 Fuel Oil	0.0
Total	883,594.7

in pounds

Other Pollutants

NOx	521.0
SO2	1,123.4

in pounds

Equivalencies

Project Term Reduction

CO2e Reductions

Electricity	7,524,305.3
Natural Gas	-3,953,030.5
#1, #2, #4 Fuel Oil	9,682,646.8
#5, #6 Fuel Oil	0.0
Total	13,253,921.6

in pounds

Other Pollutants

NOx	7,815.5
SO2	16,851.8

in pounds

Equivalencies

6. Appendix

6.1 Combustion Efficiency Test Results, City Hall

#1 Boiler
SoPo City Hall

testo 327-1
V1.17 02121791/USA

12/22/2011 15:49:44

Fuel	Nat Gas
CO2 max	11.7 %

Flue gas

376.2	°F	T stack
8.52	%	CO2
83.8	%	EFF
33.3	%	ExAir
5.7	%	Oxygen
8	ppm	CO
11	ppm	CO AirFree
---	inH2O	Draft
80.8	°F	Ambient temp
86.0	°F	Instrum temp
---	°F	Diff. temp.
---	inH2O	Diff. Press
0	ppm	CO Ambient

#2 Boiler
SoPo City Hall

testo 327-1
V1.17 02121791/USA

12/22/2011 15:19:12

Fuel	Nat Gas
CO2 max	11.7 %

Flue gas

408.6	°F	T stack
10.25	%	CO2
84.3	%	EFF
12.6	%	ExAir
2.6	%	Oxygen
---	ppm	CO
---	ppm	CO AirFree
---	inH2O	Draft
82.0	°F	Ambient temp
85.6	°F	Instrum temp
---	°F	Diff. temp.
---	inH2O	Diff. Press
0	ppm	CO Ambient

6.2 Combustion Efficiency Test Results, Community Center

Low Fire

```
testo 330-1
V1.21          01295757/USA
SITE
10/07/2011         16:44:10
Fuel:           Natural gas
O2ref.:                3.0%
CO2max:               11.7%
110.7     °F  T stack
 8.74      %  CO2
 69.6      %  EFF
 30.2      %  ExAir
  5.3      %  Oxygen
   17    ppm  CO
   23    ppm  Undiluted CO
-----  inH2O  Draft
 74.3     °F  Ambient temp
 65.9     °F  Instr. temp.
-----     °F  Diff. temp.
-----   mbar  Diff. Press.
-----    ppm  CO2amb
-----    ppm  aCo
Heat transf.°F: ----- °F
```

MASTER High Fire

```
testo 330-1
V1.21          01295757/USA
SITE
10/07/2011         16:49:28
Fuel:           Natural gas
O2ref.:                3.0%
CO2max:               11.7%
157.3     °F  T stack
 8.96      %  CO2
 88.6      %  EFF
 27.2      %  ExAir
  4.9      %  Oxygen
  126    ppm  CO
  164    ppm  Undiluted CO
-----  inH2O  Draft
 75.0     °F  Ambient temp
 70.1     °F  Instr. temp.
-----     °F  Diff. temp.
-----   mbar  Diff. Press.
-----    ppm  CO2amb
-----    ppm  aCo
Heat transf.°F: ----- °F
```

So. Po. Rec Center

Boiler #1 Low Fire

```
testo 330-1
V1.21          01295757/USA
SITE
10/07/2011         16:34:53
Fuel:           Natural gas
O2ref.:                3.0%
CO2max:               11.7%
145.5     °F  T stack
 8.96      %  CO2
 88.7      %  EFF
 27.2      %  ExAir
  4.9      %  Oxygen
  131    ppm  CO
  171    ppm  Undiluted CO
-----  inH2O  Draft
 67.7     °F  Ambient temp
 56.5     °F  Instr. temp.
-----     °F  Diff. temp.
-----   mbar  Diff. Press.
-----    ppm  CO2amb
-----    ppm  aCo
Heat transf.°F: ----- °F
```

So. Po. Rec. Center
Boiler #1 High Fire

```
testo 330-1
V1.21          01295757/USA
SITE
10/07/2011         16:39:00
Fuel:           Natural gas
O2ref.:                3.0%
CO2max:               11.7%
117.3     °F  T stack
 9.08      %  CO2
 89.3      %  EFF
 25.8      %  ExAir
  4.7      %  Oxygen
   17    ppm  CO
   22    ppm  Undiluted CO
-----  inH2O  Draft
 68.7     °F  Ambient temp
 61.0     °F  Instr. temp.
-----     °F  Diff. temp.
-----   mbar  Diff. Press.
-----    ppm  CO2amb
-----    ppm  aCo
Heat transf.°F: ----- °F
```

Low Fire

```
testo 330-1
V1.21          01295757/USA
SITE
10/07/2011         17:01:40
Fuel:           Natural gas
O2ref.:                3.0%
CO2max:               11.7%
110.6     °F  T stack
 8.91      %  CO2
 89.6      %  EFF
 28.0      %  ExAir
  5.0      %  Oxygen
   17    ppm  CO
   22    ppm  Undiluted CO
-----  inH2O  Draft
 77.9     °F  Ambient temp
 77.1     °F  Instr. temp.
-----     °F  Diff. temp.
-----   mbar  Diff. Press.
-----    ppm  CO2amb
-----    ppm  aCo
Heat transf.°F: ----- °F
```

Boiler #2 High Fire

```
testo 330-1
V1.21          01295757/USA
SITE
10/07/2011         17:05:09
Fuel:           Natural gas
O2ref.:                3.0%
CO2max:               11.7%
152.4     °F  T stack
 9.02      %  CO2
 88.8      %  EFF
 26.5      %  ExAir
  4.8      %  Oxygen
  130    ppm  CO
  169    ppm  Undiluted CO
-----  inH2O  Draft
 79.3     °F  Ambient temp
 78.6     °F  Instr. temp.
-----     °F  Diff. temp.
-----   mbar  Diff. Press.
-----    ppm  CO2amb
-----    ppm  aCo
Heat transf.°F: ----- °F
```

So. Po. Rec Center

SIEMENS

ENERGY PERFORMANCE CONTRACT

PERFORMANCE ASSURANCE REPORT

FOR THE

City of South Portland

Performance Year 2: April 1, 2012– March 31, 2013

Siemens Industry, Inc.
Scarborough, ME

SIEMENS

PERFORMANCE SOLUTIONS AGREEMENT OVERVIEW

Client:	City of South Portland
Client Contact:	James Gailey, City Manager
Contract Date:	April 15, 2011
Siemens Contacts:	Colleen Fissette, Performance Assurance Specialist Email: colleen.fissette@siemens.com Thomas Seekins, Account Executive Email: thomas.seekins@siemens.com Siemens Industry, Inc. 66 Mussey Road Scarborough, ME 04074 Phone: (207) 885 - 4115
Performance Guarantee Period:	April 1, 2012 – March 31, 2027
Contract Term Length:	15 Years

Table of Contents

1. Executive Summary

Performance Year 2: April 2013 – March 2014

Siemens Industry (Siemens) is pleased to provide the City of South Portland with this Year 2 energy savings guarantee report. This report details the energy performance of the implemented project by comparing realized energy and cost savings for this annual period to the contract guaranteed savings. Your Energy Performance Contract with Siemens guaranteed $117,221 in annual cost savings. Total Year 2 cost savings for this annual period amounted to $118,742 and consisted of $82,724 in Measured and Verified Savings, $27,036 in Stipulated Energy Savings, and $8,982 in Stipulated Operational Savings. Total Year 2 savings are $1,521 in excess of the guaranteed savings for this performance period.

Table 1. Summary of annual guaranteed and verified savings for the City of South Portland

Performance Year	Measured and Verified Savings	Stipulated Savings	Total Realized Savings	Operational Savings	Total Annual Realized Savings	Annual Guaranteed Savings	Deviation from Plan
Construction					$57,414	$15,000	$42,414
1	$83,966	$25,996	$109,963	$8,720	$118,683	$112,796	$5,887
2	$82,724	$27,036	$109,760	$8,982	$118,742	$117,221	$1,521
3				$9,251		$121,819	
4				$9,529		$126,600	
5				$9,814		$131,568	
6				$0		$126,624	
7				$0		$131,689	
8				$0		$136,957	
9				$0		$142,435	
10				$0		$148,132	
11				$0		$154,057	
12				$0		$160,220	
13				$0		$166,629	
14				$0		$173,294	
15				$0		$180,225	
Total	$166,690	$53,032	$219,722	$17,702	$237,424	$230,017	$7,407

Table 2. Year-to-Date Energy Savings (Units)

Energy Saving	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	#2 Fuel Oil Savings (Gal/yr)	Water Savings (kGal/yr)	Sewer Savings (kGal/yr)
Guaranteed	398,831	(19,708)	1,509	27,443	327	327
Year-1	431,238	(22,509)	1,521	28,838	327	327
Year-2	430,080	(26,052)	1,521	28,838	327	327
Total	861,318	(48,561)	3,042	57,677	653	653

Table 3. Realized Energy Savings by FIM (Units)

Facility Improvement Measure	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	#2 Fuel Oil Savings (Gal/yr)	Water Savings (kGal/yr)	Sewer Savings (kGal/yr)
Lighting & Controls	370,806	(602)	(39)	(201)		
Boiler Replacement		(25,909)		22,416		
Demand Control Ventilation	(412)	(1,990)		439		
EMS-Occupied/Unoccupied Setback	18,673	813				
Burner Replacement		(5,053)		3,883		
Water Conservation		448		61	327	327
Building Envelope	25,245	4,964	1,560	1,645		
Insulate Store Windows				594		
Vending Misers	15,768					
Steam Trap Replacement		1,277				
Total	430,080	(26,052)	1,521	28,838	327	327

2. Performance Assurance Overview

This section of the report provides an overview of the methodology and parameters used to measure and verify savings for this report and are based on the signed contract between the City of South Portland and Siemens Industry, Inc.

2.1 Measurement and Verification Methods

Realized savings were calculated using the methodology described in Exhibit C of the energy performance. There are four guarantee options to measure and verify savings: Option A – Retrofit Isolation: Key Parameter Measurement, Option B – Retrofit Isolation: All Parameter Measurement, Option C – Whole Facility, Option D – Calibrated Simulation, and Option E - Stipulated.

Option A – Retrofit Isolation: Key Parameter Measurement. Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the FIM's affected system(s) and/or the success of the Project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement is evaluated. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option B – Retrofit Isolation: All Parameter Measurement. Savings are determined by field measurement of the energy use of the FIM-affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option C – Whole Facility: Savings are determined by measuring energy use at the whole Facility of sub-Facility level. Continuous measurements of the entire Facility's energy use are taken throughout the reporting period. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option D – Calibrated Simulation: Savings are determined through simulation of the energy use of the whole Facility, or of a sub-Facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the Facility. This option usually requires considerable skill in calibrated simulation. If applicable, the predetermined schedule for data collection, evaluation, and reporting is defined in Exhibit A, Article 3-Performance Assurance Service Program.

Option E – Stipulated: This option is the method of measurement and verification applicable to FIMS consisting either of Operation Savings or where the end use capacity or operation efficiency; demand, energy consumption or power level; or manufacturer's measurements, industry standard efficiencies or operating hours are known in advance, and used in a calculation or analysis method that will stipulate the outcome. Both CLIENT and SIEMENS agree to the stipulated inputs and outcome(s) of the analysis methodology. Based on the established analytical methodology the Savings stipulated will be achieved upon completion of the FIM and no further measurements or calculations will be performed during the Performance Guarantee Period. If applicable, the methodology and calculations to establish Savings value will be defined in Section 4.6 of Exhibit C.

2.2 Guaranteed Savings

Guaranteed cost and energy savings are shown below in Table 4 and 5.

Table 4. Guaranteed Annual Cost Savings

FIM	Option Type	Total Guaranteed Cost Savings ($)
Lighting & Controls	A	$67,103
Boiler Replacement	B	$13,184
Demand Control Ventilation	B	$5,172
EMS-Occupied/Unoccupied Setback	B	$3,204
Burner Replacement	B	$1,522
Water Conservation	D	$3,174
Building Envelope	D	$18,383
Insulate Store Windows	D	$1,242
Vending Misers	D	$2,683
Steam Trap Replacement	D	$1,554
Total		$117,221

Table 5. Guaranteed Annual Energy Savings (Units)

Facility Improvement Measure	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	#2 Fuel Oil Savings (Gal/yr)	Water Savings (kGal/yr)	Sewer Savings (kGal/yr)
Lighting & Controls	339,942	(510)	(51)	(199)		
Boiler Replacement		(23,318)		20,174		
Demand Control Ventilation	923	3,289		395		
EMS-Occupied/Unoccupied Setback	16,952	267				
Burner Replacement		(4,847)		3,495		
Water Conservation		448		61	327	327
Building Envelope	25,245	4,964	1,560	1,645		
Insulate Store Windows				594		
Vending Misers	15,768					
Steam Trap Replacement				1,277		
Total	398,831	(19,708)	1,509	27,443	327	327

2.3 Utility Rate Structures and Escalation Rates

Utility rates used to calculate dollar savings for this report are based on the baseline year unit rates shown in Table 6. As per contract, an escalation rate of 4% will be applied to the baseline rate for each utility.

Table 6. Summary of Contract Utility Rates for Performance Year 2

Location	Electricity ($/kWh)	Natural Gas ($/Therm)	Propane ($/Gal)	#2 Fuel Oil ($/Gal)	Water ($/kGal)	Sewer ($/kGal)
Wastewater Treatment Plant	$0.1695	$1.29			$2.13	$5.52
Western Ave Fire Station	$0.1695	$1.24				
Wainwright Farms	$0.1695		$2.22			
Main Library	$0.1903	$1.25		$2.10		
Police Station & Public Safety Building	$0.1695	$1.22		$2.06	$2.13	$5.52
Redbank Community Center	$0.2340	$1.31			$2.13	$5.52
Sewer Maint Station	$0.1560		$3.17			
City Hall	$0.1726	$1.19		$2.08	$2.13	$5.52
Community Center/Pool Building	$0.1695	$1.28		$2.13	$2.13	$5.52
Golf Course Maintenance	$0.1737		$2.22		$1.59	$4.13
Central Fire Station	$0.2028	$1.22		$2.13	$2.13	$5.52
Branch Library	$0.1550		$2.22			
Cash Corner Fire Station	$0.1976	$1.22		$2.09	$2.13	$5.52
Hamlin School	$0.1695		$2.22	$1.97		

2.4 Baseline Utility Data

The annual period selected as the Baseline period starts May 2009 and ends April 2010. Tables 7 outline the utility consumption that occurred during the Baseline period.

Table 7. Electric Baseline Consumption (May 2009 - April 2010)

Location	Electricity (kWh)	Natural Gas (Therms)	Propane (Gal)	Fuel Oil (Gal)
Wastewater Treatment Plant	81,649			
Western Ave Fire Station	81,649	7,421		
Main Library	89,240			4,058
Redbank Community Center	35,021	3,984		
Sewer Maint Station	10,898		2,782	
City Hall	108,320	68		3,883
Police Department	63,548			9,642
Golf Course Maintenance	22,862		851	
Hamlin School	803			12,376
Assessor's Office	12,172	1,193		
Branch Library	37,320		2,243	
Cash Corner Fire Station	27,518			2,924
Community Center/Pool Bldg	379,471	15,716		22,583
Central Fire Department	36,396			7,339
Public Safety	408			
Operations Buidling		8,591		
Main Pump Station		4,228		
Total	987,275	41,201	5,876	62,806

2.5 Baseline Operating Data

The operating practices during the Baseline period are used to determine the guaranteed savings based on the efficiency improvements after implementing the facility improvement measures, these parameters are shown in Table 8.

Table 8. Baseline Operating Schedules, West Ave Fire House

	Heating		Cooling	
Units	Occupied	Unoccupied	Occupied	Unoccupied
Western Ave Fire House - Living Area	74	74	68	70
Western Ave Fire House - Garage	74	74	68	70

2.6 Contracted Baseline Operating Data

The guaranteed savings from the facility improvement measures provided under this contract are based on implementation of the following schedules and set points shown in Tables 9.

Table 9. Post Implementation schedule, West Ave Fire House

	Heating		Cooling	
Units	Occupied	Unoccupied	Occupied	Unoccupied
Western Ave Fire House - Living Area	70	68	72	74
Western Ave Fire House - Garage	70	68	72	74

3. Performance Assurance Results

3.1. Summary of Guaranteed and Verified Energy Savings

Total realized annual energy savings for this performance year were $118,742 and were comprised of $63,536 of Option A, $19,188 in Option B, $27,036 in Option D savings, and $8,982 in stipulated Operational Savings respectively. Total realized annual savings are in excess of the annual guaranteed energy savings of $117,221 by $1,521. The following sections detail the Option A, B, and D savings.

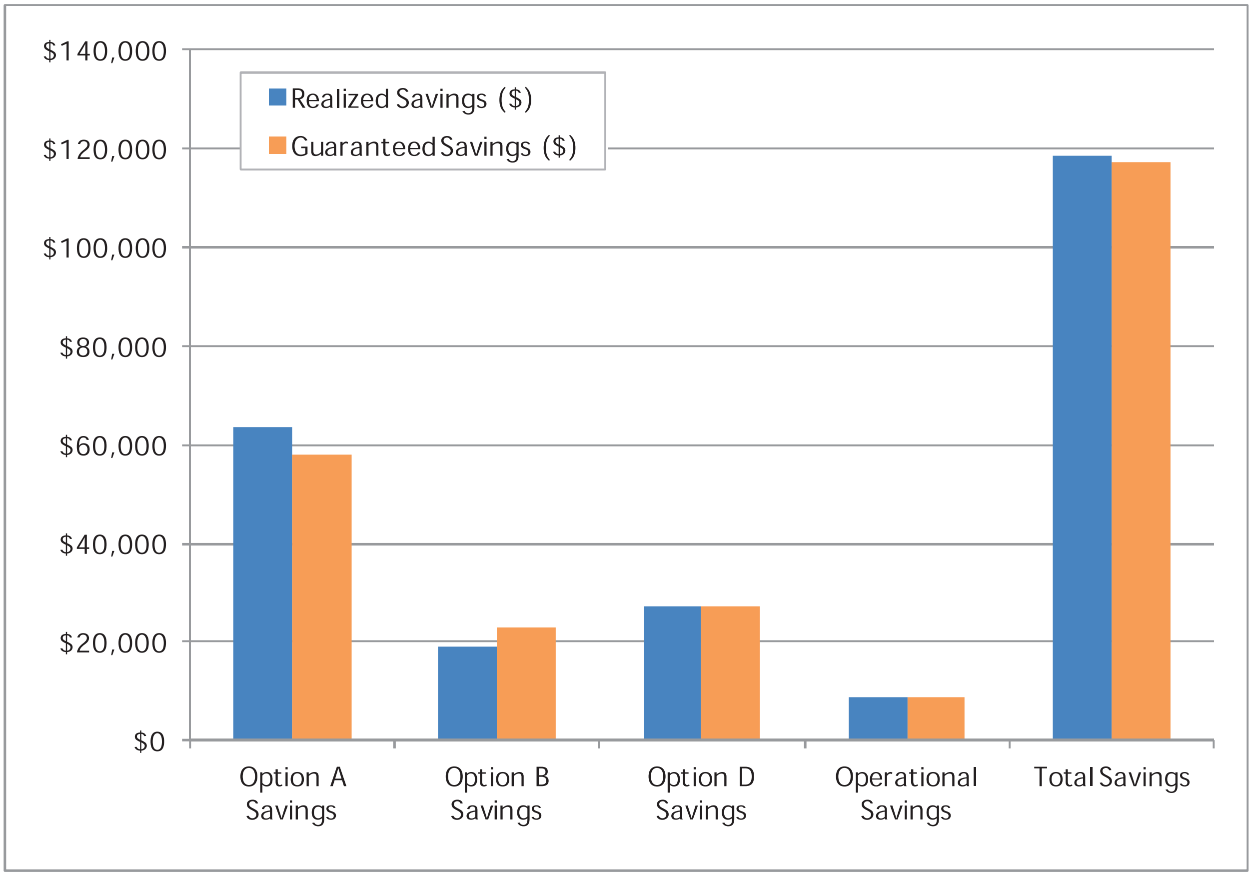


Figure 1. Realized and Guaranteed Annual Cost Savings for Year 2.

3.2. Option A Savings

3.2.1. Performance Year Savings

Option A savings are verified based on one-time measurements taken after substantial completion of each facility improvement measure and the estimated savings are included as ongoing realized savings in each subsequent performance year. The table below summarizes Option A savings realized during the current performance year and shows that total Option A savings amount to $63,526 which is $5,415 above the guaranteed Option A savings ($58,121).

Table 10. Summary of Option A Savings for Performance Year 2

Facility Improvement Measure	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	#2 Fuel Oil Savings (Gal/yr)	Realized Annual Cost Savings	Guaranteed Annual Cost Savings	Excess/Shortfall in Savings ($)
Lighting & Controls	370,806	(602)	(39)	(201)	$63,536	$58,121	$5,415

3.2.2. Results by Measure

3.2.2.1. Lighting & Controls Retrofit

Energy savings resulting from the lighting retrofit were verified based upon a one-time measurement of the lighting power capacity under existing conditions, a one-time measurement of the lighting power capacity upon completion of the lighting retrofit project and agreed-upon annual operating hours. A representative sample of each lighting-fixture type was used to determine pre-retrofit and post-retrofit kW. The following tables detail the savings results from the lighting and controls retrofit.

Table 11. Annual Savings Associated with the Lighting and Controls Retrofit

Lighting & Controls	
Guaranteed Electric Savings (kWh)	339,942
Realized Electric Savings (kWh)	370,806
Heating Penalty:	
Guaranteed Natural Gas Savings (Therms)	(510)
Realized Natural Gas Savings (Therms)	(602)
Guaranteed Propane Savings (Gal)	(51)
Realized Propane Savings (Gal)	(39)
Guaranteed Fuel Oil Savings (Gal)	(199)
Realized Fuel Oil Savings (Gal)	(201)
Total Guranteed Savings	$58,121
Total Realized Savings	$63,536
Excess/Shortfall in Savings	$5,415

Table 12. Annual Savings Associated with the Lighting and Controls Retrofit per location.

Facility Improvement Measure	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	#2 Fuel Oil Savings (Gal/yr)	Realized Annual Cost Savings	Guaranteed Annual Cost Savings	Excess/Shortfall in Savings ($)
Lighting & Controls	370,806	(602)	(39)	(201)	$63,536	$58,121	$5,415
City Hall	25,521	(61)			$4,334	$3,713	$621
Assessors Bldg	2,957	(7)			$448	$482	($34)
Hamlin School	11,457			(31)	$1,882	$1,630	$252
West End Fire House	30,218	(74)			$5,038	$4,026	$1,012
Golf Course Maintenance	2,663			(7)	$462	$461	$2
Wainwright Farms	7,890		(21)		$1,291	$1,973	($682)
Redbank Community Center	16,498	(39)			$3,809	$3,000	$809
Branch Library	6,771		(18)		$1,009	$1,034	($25)
Main Library	17,627			(31)	$3,289	$3,073	$216
Community Center/Pool Building	111,767	(267)			$18,606	$15,557	$3,048
Central Fire Station	11,124	(27)			$2,224	$2,446	($222)
Police Station & Public Safety Building	68,285			(121)	$11,327	$11,721	($394)
Wastewater Treatment Plant	52,028	(128)			$8,655	$7,809	$846
Cash Corner Fire Station	5,999			(11)	$1,163	$1,198	($35)

Overall the verified cost savings for this measure was higher than expected. Some buildings resulted in higher or lower than expected kW savings due to a difference between expected and actual measured kW per fixture (Table 13), although overall for the project, the verified lighting savings exceeded the guarantee.

Table 13. Measured energy savings per fixture type.

Fixture Type	Expected Savings/Fixture	Realized Savings/Fixture	Deviation from Expected
HB400MH/HIF4LT5HO-50W-WG-MS-NF	0.242	0.274	0.032
I2L8HO/RI6L4-8F-25-N-KIT	0.109	0.199	0.090
I4L4-8F-T8-25-L	0.038	0.042	0.004
P2L4-T8/VR2L4-T8-25-L	0.020	0.021	0.001
P3L4-T8-AB/VR2L4-T8-25-BL-KIT	0.045	0.024	-0.021
P4L4-T8/VR2L4-T8-25-N-KIT	0.069	0.081	0.012
PM3L4-T8-AB-25-L	0.031	0.024	-0.007
PM6L4-8F-T8-25-L	0.000	0.072	0.072
PM8L4-8F-T8/W6L4-8F-25-N-NF	0.096	0.092	-0.004
S2L4-T8-25-L	0.023	0.015	-0.008
SB250MH/200-P	0.063	0.056	-0.007
SB400MH/320-P	0.115	0.059	-0.056
SM2L2U6-T8/RK3L2-15-L-KIT	0.027	0.023	-0.004
SM2L4-T8/VR2L4-T8-25-L-KIT	0.023	0.032	0.009
SM2L4-T8-25-L	0.023	0.021	-0.002
SM6L3-T8-22-L	0.032	0.032	0.000
T2L2U6-T8/RK3L2-15-L-KIT	0.027	0.023	-0.004
T3L4-T8/VR2L4-T8-25-L-KIT	0.051	0.052	0.001
T3L4-T8/VR2L4-T8-25-N-KIT	0.045	0.043	-0.002
T4L4-AB/VR2L4-T8-25-BL-KIT	0.117	0.024	-0.093
T4L4-T8/VR2L4-T8-25-N-KIT	0.069	0.065	-0.004
TR17CFR30/LED8-PAR20-NL	0.009	0.018	0.009
VT2L4-T8-D-25-L	0.023	0.026	0.003
VT4L4-8F/Remain	0.038	0.000	-0.038
W2L2-T8-15-L	0.015	0.013	-0.002
W2L4-25-L	0.043	0.045	0.002
W2L4-T8-25-L	0.023	0.015	-0.008
W4L4-25-L	0.086	0.015	-0.071
W4L4-8F-T8/EW4L4-8F-25-L-NF	0.038	0.027	-0.011
W4L4-T8/W3L4-T8-25-L-NF	0.055	0.028	-0.027

3.3. Option B Savings

3.3.1. Performance Year Savings

Realized Option B savings amounted to $19,188 which is $3,894 short of Year 2 guaranteed Option B savings of $23,082. These realized savings are calculated each year based on measurements and methods outlined in Exhibit C of the performance contract.

Table 14. Summary of Option B Savings for Performance Year 2

Facility Improvement Measure	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	#2 Fuel Oil Savings (Gal/yr)	Realized Annual Cost Savings	Guaranteed Annual Cost Savings	Excess/Shortfall in Savings ($)
Boiler Replacement		(25,909)	22,416	$14,648	$13,184	$1,464
Community Center/Pool Building		(25,909)	22,416	$14,648	$13,184	$1,464
Demand Control Ventilation	(412)	(1,990)	439	($1,719)	$5,172	($6,891)
Community Center/Pool Building	-684	-2,687		($3,553)	$3,536	($7,089)
Western Ave Fire Station	129	696		$884	$780	$104
Main Library	143		439	$950	$855	$96
EMS-Occupied/Unoccupied Setback	18,673	813		$4,172	$3,204	$967
Western Ave Fire Station	18,673	813		$4,172	$3,204	$967
Burner Replacement		-5,053	3,883	$2,087	$1,522	$566
City Hall		-5,053	3,883	$2,087	$1,522	$566
Total	18,260	(32,139)	26,739	$19,188	$23,082	($3,894)

3.3.2. Results by Measure

3.3.2.1. Boiler Replacement

Siemens replaced three existing oil-fired boilers at the South Portland Community Center/Pool with three high efficiency natural gas boilers and natural gas burners. Energy savings was achieved by converting from Fuel Oil to Natural Gas and increased combustion efficiency. Savings was verified through the results of a combustion efficiency test performed on all boilers resulting in an average efficiency of 90%. Combustion test results are shown in the Appendix.

Table 15. Savings Associated with the Boiler Replacement

Boiler Replacement	
Existing Combustion Efficiency	75%
Verified Combustion Efficiency	90%
Guaranteed Fuel Oil Savings (Gal)	20,174
Realized Fuel Oil Savings (Gal)	22,416
Cost per Gal	$2.13
Realized Fuel Oil Savings ($)	$47,791
Guaranteed Natural Gas Savings (Therms)	(23,318)
Realized Natural Gas Savings (Therms)	(25,909)
Cost per Therm	$1.28
Realized Natural Gas Savings ($)	($33,143)
Total Guaranteed Savings	$13,184
Total Realized Savings	$14,648
Excess/Shortfall in Savings	$1,464

3.3.2.2 EMS Occupied/Unoccupied Scheduling

Location: Western Ave Fire Station

The roof top units serving the Living Area and Garage of the Fire Station are automatically "setback" during unoccupied periods by the EMS. The setbacks reduce electrical energy consumption by reducing and eliminating operating of the applicable supply and return fans when areas are unoccupied. Heating and cooling savings is also achieved during the setbacks as space temperatures are automatically setback during the winter (and "set forward" during the summer) therefore reducing the heat transfer losses through the building envelope. Trend analysis was done of the heating and cooling temperature set points for the living area and garage. As a result the occupied and unoccupied heating temperature set points in the living area (69°F/65°F) and

(65°F/65°F) in the garage were found to be lower than the proposed (70°F/68°F). Also, cooling set points were found to be lower than expected during the occupied periods in the living area (68°F) than the proposed 72°F. Overall an excess in savings of $967 resulted from the change in set points from contracted. Trend results are shown in Tables 16 and 17.

Table 16. Average monthly occupied and unoccupied set points in the living area and garage of the Western Ave Fire Station.

Month	Living Area						Garage	
	RTU 1		RTU 2		Living Area		MAU 1	
	Day	Night	Day	Night	Day	Night	Day	Night
Apr-13	70	65	69	65	69	65	67	65
May-13	70	65	69	65	69	65	64	65
Jun-13	70	80	68	80	69	80	64	65
Jul-13	69	80	68	80	68	80	64	65
Aug-13	69	80	68	80	68	80	64	65
Sep-13	69	80	68	80	68	80	64	65
Oct-13	69	80	68	80	69	80	64	65
Nov-13	69	65	69	65	69	65	64	65
Dec-13	69	65	70	65	70	65	67	65
Jan-14	70	65	70	65	70	65	68	65
Avg Heating	70	65	69	65	69	65	65	65
Avg Cooling	69	80	68	80	68	80		

Table 17. Actual and Proposed Heating and Cooling Temperature Set points at the Western Ave Fire House.

Location		Heating		Cooling	
		Occupied	Unoccupied	Occupied	Unoccupied
Western Ave Fire House - Living Area	Actual	69	65	68	80
	Proposed	70	68	72	74
Western Ave Fire House - Garage	Actual	65	65	N/A	N/A
	Proposed	70	68	N/A	N/A

Table 18. Actual Savings Associated with the EMS

EMS: Occ/Unocc Setback	
Guaranteed Electric Savings (kWh)	16,952
Realized Electric Savings (kWh)	18,673
Cost per kWh	$0.1695
Realized Electric Savings ($)	$3,165
Guaranteed Natural Gas Savings (Therms)	267
Realized Natural Gas Savings (Therms)	813
Cost per Therm	$1.28
Realized Natural Gas Savings ($)	$1,040
Total Guaranteed Savings	$3,204
Total Realized Savings	$4,172
Excess/Shortfall in Savings	$967

3.3.2.3. Demand Control Ventilation

Location: Community Center/Pool Building, Main Library, and Western Ave Fire Station

Demand control ventilation (DCV) adjusts the outdoor air damper position based on occupancy at any given time instead of at a fixed position for full occupancy. Carbon dioxide (CO2) sensors monitor the CO2 level to estimate activity level in the space which intern signals the HVAC system to adjust the amount of outside air to be conditioned for the space. The CO2 levels in the applicable areas were monitored in conjunction with the outdoor air damper position.

The Main Library has an existing Barber Coleman DDC system in which trending is not possible. A third party mechanical service company installed and integrated the DCV control and the system was commissioned by them.

Table 19. Savings Associated with DCV

Demand Control Ventilation	
Guaranteed Electric Savings (kWh)	923
Realized Electric Savings (kWh)	(412)
Guaranteed Fuel Oil Savings (Gal)	395
Realized Fuel Oil Savings (Gal)	439
Guaranteed Natural Gas Savings (Therms)	3,289
Realized Natural Gas Savings (Therms)	(1,990)
Total Guaranteed Savings	$5,172
Total Realized Savings	($1,719)
Excess/Shortfall in Savings	($6,891)

In an attempt to optimize the programming, after a deficit in DCV savings was identified in last year's performance assurance report, the Siemens service team modified the control strategy June 2013. A review of the trend data after this DCV reprogramming shows that this measure is still not performing to expectations, resulting in overventilation and reduced energy savings (Figures 2 and 3).

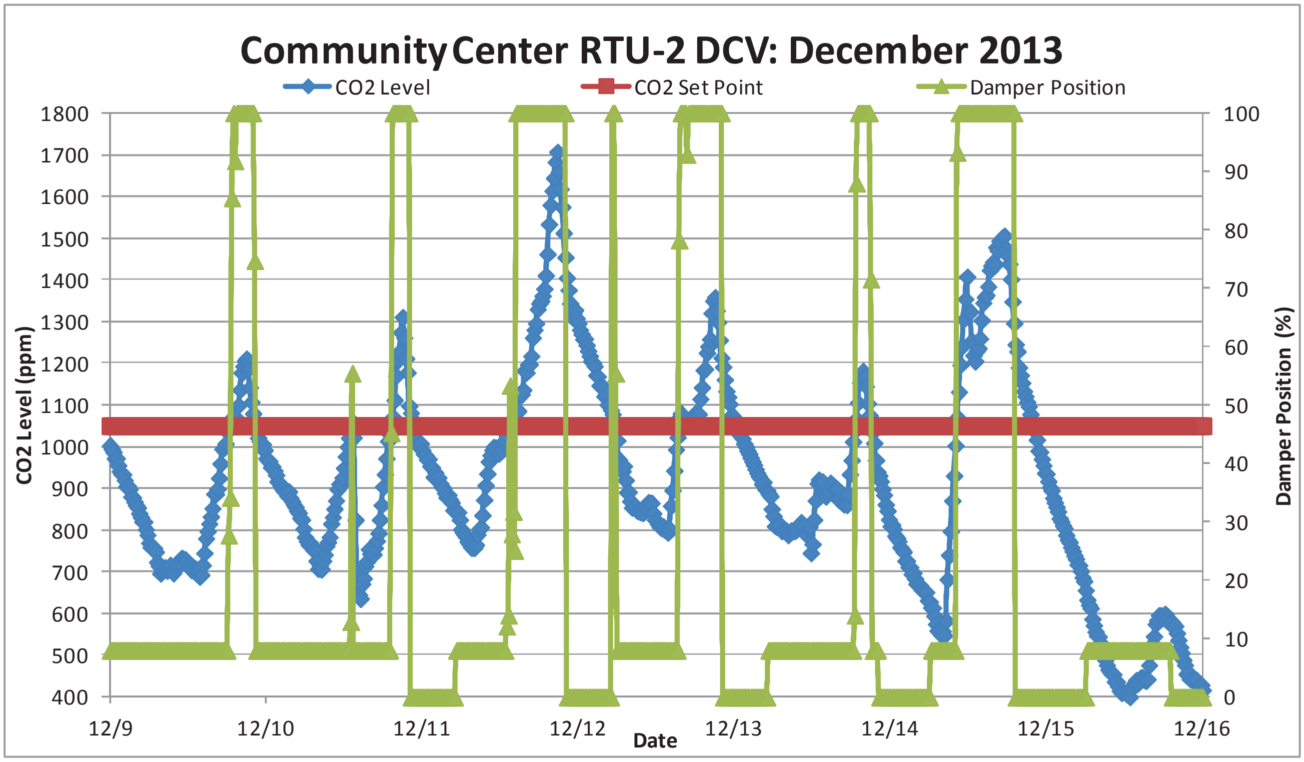


Figure 2. Modified Programming, RTU-2 Community Center/Pool Building

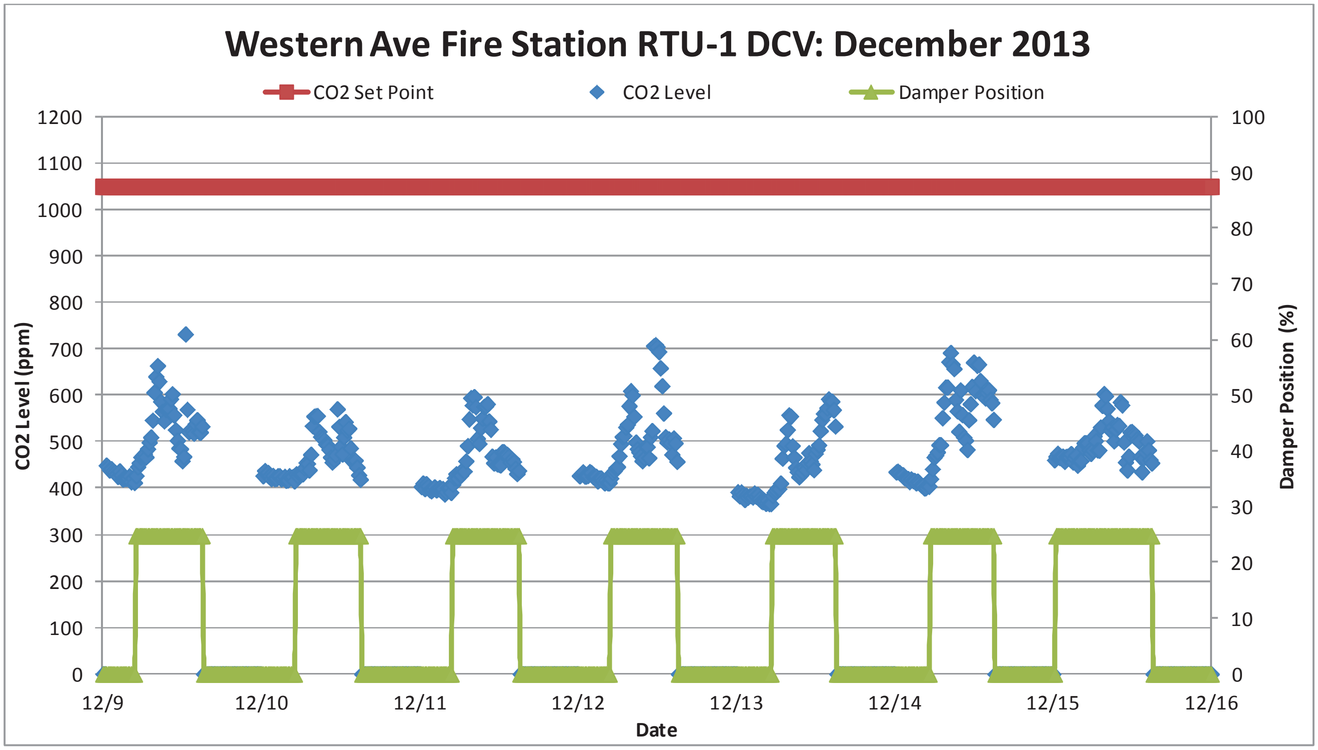


Figure 3. Modified Programming, RTU-1 Western Ave Fire Station

The M&V results indicate that the demand control ventilation (DCV) strategies at the Community Center and Western Ave Fire Station need additional optimization. DCV savings result from minimizing the amount conditioned ventilation air, the outside air damper should remain closed unless the CO_2 level for the spaces served rise above set point. Currently the dampers are maintained at a minimum of 8% (Community Center RTU-1 & 2), 25% (WEFS RTU-1), and 11% (WEFS RTU-2) open during occupancy and modulating to 100% when the CO2 level is above set point. The trend results for average damper position are shown below (Tables 20 and 21). For the Community Center 15.9% was inputted into the energy savings calculation. The average position of 14.22% was inputted into the savings calculation for the Fire Station. Siemens is working with our service team to optimize the DCV sequence for the Fire Station and Community Center units to ensure future savings are realized.

Table 20. Community Center Trend Results

Month	Occupied Damper Position (%)			Average CO2 Level	CO2 Set Point	Average CO2 Level	CO2 Set Point
	RTU-1	RTU-2	Average	RTU-1		RTU-2	
Apr-13	No Data	No Data	No Data	No Data	950	665	950
May-13	10.00%	10.00%	10.00%	No Data	950	587	950
Jun-13	24.54%	8.12%	16.33%	871	1,050	600	1,050
Jul-13	10.54%	5.94%	8.24%	871	1,050	626	1,050
Aug-13	6.62%	6.65%	6.64%	845	1,050	650	1,050
Sep-13	10.08%	7.11%	8.60%	860	1,050	631	1,050
Oct-13	20.67%	3.49%	12.08%	988	1,050	754	1,050
Nov-13	32.45%	27.64%	30.04%	1,222	1,300	1,063	1,300
Dec-13	0.02%	48.32%	24.17%	986	1,300	986	1,050
Jan-14	0.19%	53.28%	26.73%	1,115	1,300	1,120	1,050
Average	12.8%	18.9%	15.9%	970	1,105	768	1,055

Table 21. Western Ave Fire Station Trend Results

Month	Occupied Damper Position (%)			Average CO2 Level	CO2 Set Point	Average CO2 Level	CO2 Set Point
	RTU-1	RTU-2	Average	RTU-1		RTU-2	
Apr-13	10.00%	10.00%	10.00%	477	950	476	950
May-13	10.00%	10.00%	10.00%	474	950	480	950
Jun-13	11.67%	10.53%	11.10%	496	1,050	505	1,050
Jul-13	25.15%	10.49%	17.82%	503	1,050	499	1,050
Aug-13	24.80%	10.80%	17.80%	508	1,050	499	1,050
Sep-13	24.80%	10.80%	17.80%	507	1,050	494	1,050
Oct-13	24.80%	10.80%	17.80%	500	1,050	491	1,050
Nov-13	24.80%	10.80%	17.80%	492	1,050	478	1,050
Dec-13	24.33%	10.46%	17.40%	495	1,050	485	1,050
Jan-14	1.74%	7.57%	4.65%	483	1,050	471	1,050
Average	18.21%	10.23%	14.22%	494	1,030	488	1,030

3.3.2.3 Burner Replacement

Siemens replaced two existing oil-fired boiler burners at the City Hall with two new natural gas burners. Combustion efficiency for this annual period averaged 86%. Printouts from the combustion efficiency tests for this period are shown in the Appendix of this report.

Table 22. Savings Associated with the Burner Replacement

Burner Replacement	
Proposed Combustion Efficiency	81%
Verified Combustion Efficiency	86%
Guaranteed Fuel Oil Savings (Gal)	3,495
Realized Fuel Oil Savings (Gal)	3,883
Cost per Gal	$2.08
Realized Fuel Oil Savings ($)	$8,077
Guaranteed Natural Gas Savings (Therms)	(4,847)
Realized Natural Gas Savings (Therms)	(5,053)
Cost per Therm	$1.19
Realized Natural Gas Savings ($)	($5,990)
Total Guaranteed Savings	$1,522
Total Realized Savings	$2,087
Excess/Shortfall in Savings	$566

3.4. Option D Stipulated Savings

Realized Option E savings amounted to $27,036 and are based on the predicted savings calculated in the detailed energy audit as agreed upon in the performance contract.

3.4.1. Performance Year Savings

Table 23. Summary of Option D Stipulated Savings.

Facility Improvement Measure	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms/yr)	Propane Savings (Gal/yr)	#2 Fuel Oil Savings (Gal/yr)	Water Savings (kGal/yr)	Sewer Savings (kGal/yr)	Realized Annual Cost Savings	Guaranteed Annual Cost Savings	Excess/ Shortfall in Savings ($)
Water Conservation		448		61	327	327	$3,174	$3,174	$0
Wastewater Treatment Plant		33			7	7	$96	$96	$0
Central Fire Station		251			118	118	$1,208	$1,208	$0
City Hall		100			149	149	$1,260	$1,260	$0
Police Station & Public Safety Building				61	34	34	$390	$390	$0
Redbank Community Center		14			3	3	$43	$43	$0
Community Center/Pool Building		50			15	15	$179	$179	$0
Building Envelope	25,245	4,964	1,560	1,645			$18,383	$18,383	$0
Branch Library	322		229				$557	$557	$0
Cash Corner Fire Station	1,117			456			$1,174	$1,174	$0
Central Fire Station	456	220					$360	$360	$0
City Hall	1,506	672					$1,057	$1,057	$0
Community Center/Pool Building	8,339	1,903					$3,848	$3,848	$0
Hamlin School			204				$402	$402	$0
Main Library	2,787			596			$1,783	$1,783	$0
Police Station & Public Safety Building	4,137			593			$1,922	$1,922	$0
Redbank Community Center		622					$815	$815	$0
Sewer Maint Station	1,642		921				$3,179	$3,179	$0
Wainwright Farms			205				$455	$455	$0
Wastewater Treatment Plant	4,939	1,548					$2,833	$2,833	$0
Insulate Store Windows				594			$1,242	$1,242	$0
Cash Corner Fire Station				594			$1,242	$1,242	$0
Vending Misers	15,768						$2,683	$2,683	$0
Police Station & Public Safety Building	1,332						$226	$226	$0
Branch Library	5,571						$863	$863	$0
Cash Corner Fire Station	1,927						$381	$381	$0
Central Fire Station	1,156						$235	$235	$0
Community Center/Pool Building	3,854						$653	$653	$0
Western Ave Fire Station	1,927						$327	$327	$0
Steam Trap Replacement		1,277					$1,554	$1,554	$0
Central Fire Station		1,277					$1,554	$1,554	$0
Total	41,013	6,689	1,560	2,300	327	327	$27,036	$27,036	$0

3.4.2. Results by Measure

3.4.2.1 Water Conservation

Siemens did a bathroom survey and identified several high flow fixtures to retrofit with low flow fixtures. Tables 24 and 25 identify the existing and retrofit flow rates, locations, and quantity of fixtures that were replaced.

Table 24. Water conservation fixture locations and quantities

Buildig Location	Toilets	Urinals	Sinks	Showers
Central Fire	5	1	7	3
City Hall	5	0	7	0
Wastewater Treatment Plant	0	0	4	1
Cash Corner	3	1	2	1
Redbank Community Center	0	2	4	0
Community Center	1	0	15	0
Police Station & Public Safety	3	4	7	0
Totals	17	8	46	5

Table 25. Water Conservation Pre & Post Retrofit Flow Rates

Fixture Type	Existing Flow Rate	Proposed Flow Rate
Toilets	3.5	1.28
Urinals	1.5	1
Snks	2.2	0.5
Shower	2.5	1.5

3.4.2.2 Building Envelope

To control air leakage Siemens' sealed gaps, cracks, and holes using appropriate materials and systems in doors, windows, and roofs as described in Exhibit A of the performance contract.

3.4.2.3 Insulate Store Windows

Siemens replaced windows at the Cash Corner Fire Station on the West side with new energy star rated windows and fitted with trapezoidal windows on the North Side with insulated panels.

3.4.2.4. Vending Misers

Siemens installed PlugMiser® vending machine occupancy controllers (VMOC) to manage power consumption of the vending machines. Utilizing a Passive Infrared (PIR) sensor, the VMOC completely powers down the vending machine when the area surrounding it is unoccupied. One powered down, the VMOC will monitor the room's temperature and use this information to automatically re-power the vending machine at one to three hour intervals, independent of occupancy, to ensure that the vended product stays cold. These were installed on soda machines at the following locations.

Table 26. PlugMiser® locations

Location	Soda Machines	Snack Machines
Community Center	2	0
Western Fire House	1	0
Cash Corner Fire House	1	0
Golf/Branch Library	2	0
Central Fire House	1	0
Central Police/Dispatch	2	1

3.4.2.5. Steam Trap Replacement

Siemens conducted a survey of the steam traps at the Central Fire Station. The survey revealed 4 distribution line steam traps in the school mechanical rooms as well as 22 thermostatic radiator traps. The 4 distribution line traps were replaced with new steam traps and the 22 thermostatic radiator traps were rebuilt using Tunstall steam trap kits and covers.

4. Emissions Reduction

The following table converts the energy savings (electric, fuel oil, propane, etc.) into pounds of carbon dioxide that would have been released into the atmosphere if this project was not performed. These values are then converted into everyday examples to illustrate how this performance contract has decreased the carbon footprint of Waterbury Hospital. For example, from the table below, the realized energy savings avoided the equivalent of the carbon dioxide emission of 73.4 cars in Year 2.

Annual Reduction

CO2e Reductions

Electricity	500,273.3
Natural Gas	-305,016.8
#1, #2, #4 Fuel Oil	635,325.0
#5, #6 Fuel Oil	0.0
Total	830,581.6

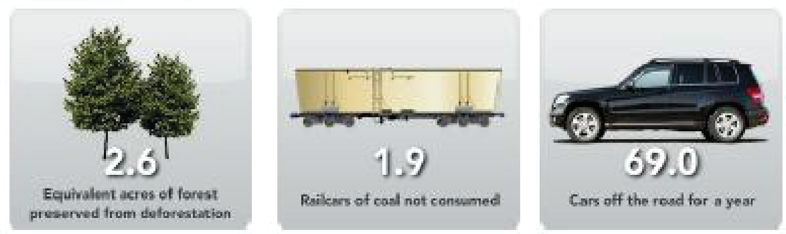
in pounds

Other Pollutants

NOx	458.0
SO2	1,117.5

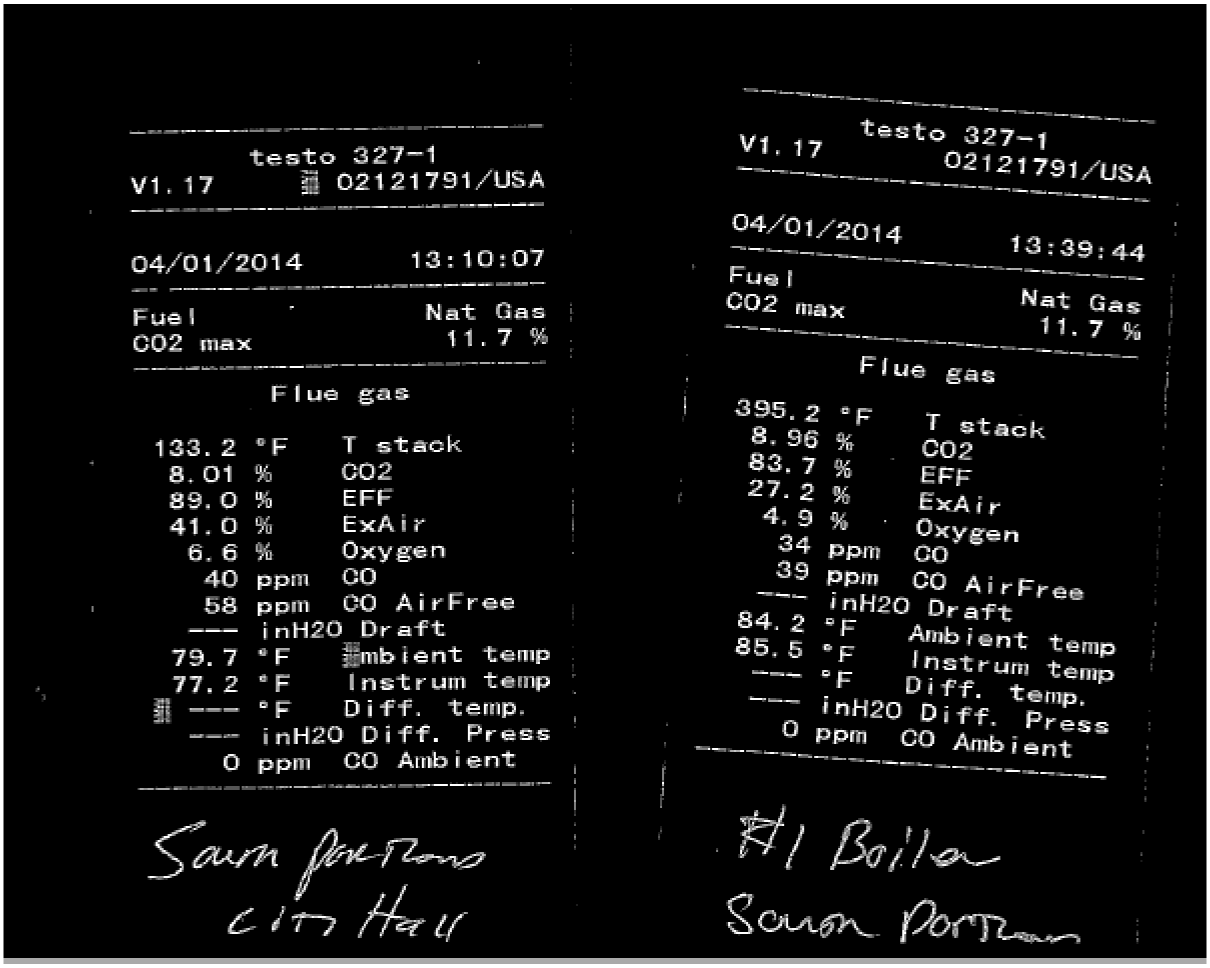
in pounds

Equivalencies



5. Appendix

5.1 Combustion Efficiency Test Results, City Hall



testo 327-1
V1.17 02121791/USA

04/01/2014 13:10:07

Fuel Nat Gas
CO2 max 11.7 %

Flue gas

133.2 °F T stack
8.01 % CO2
89.0 % EFF
41.0 % ExAir
6.6 % Oxygen
40 ppm CO
58 ppm CO AirFree
--- inH2O Draft
79.7 °F Ambient temp
77.2 °F Instrum temp
--- °F Diff. temp.
--- inH2O Diff. Press
0 ppm CO Ambient

Sowth Portland
City Hall

testo 327-1
V1.17 02121791/USA

04/01/2014 13:39:44

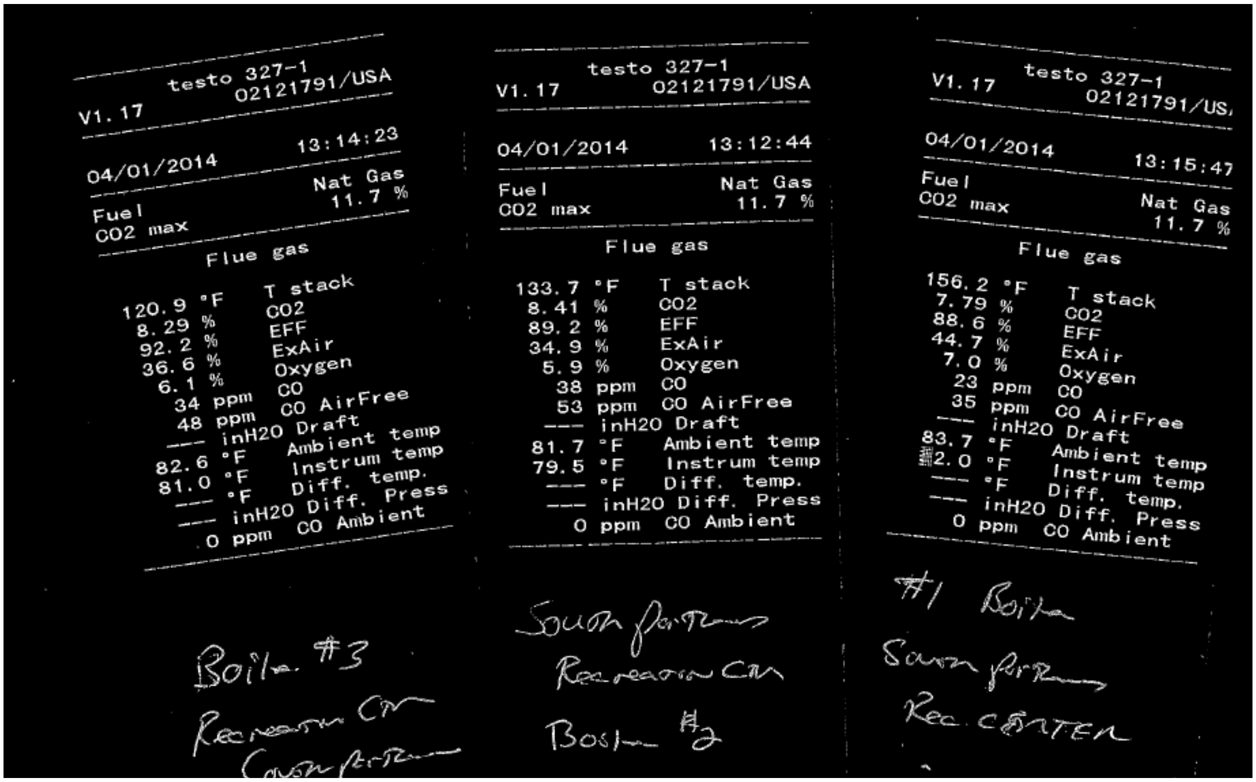
Fuel Nat Gas
CO2 max 11.7 %

Flue gas

395.2 °F T stack
8.96 % CO2
83.7 % EFF
27.2 % ExAir
4.9 % Oxygen
34 ppm CO
39 ppm CO AirFree
--- inH2O Draft
84.2 °F Ambient temp
85.5 °F Instrum temp
--- °F Diff. temp.
--- inH2O Diff. Press
0 ppm CO Ambient

#1 Boiler
South Portland

5.2 Combustion Efficiency Test Results, Community Center



testo 327-1
V1.17 02121791/USA
04/01/2014 13:14:23
Fuel Nat Gas
CO2 max 11.7 %
Flue gas
120.9 °F T stack
8.29 % CO2
92.2 % EFF
36.6 % ExAir
6.1 % Oxygen
34 ppm CO
48 ppm CO AirFree
--- inH2O Draft
82.6 °F Ambient temp
81.0 °F Instrum temp
--- °F Diff. temp.
--- inH2O Diff. Press
0 ppm CO Ambient

Boiler #3
Recreation Ctr
South Portland

testo 327-1
V1.17 02121791/USA
04/01/2014 13:12:44
Fuel Nat Gas
CO2 max 11.7 %
Flue gas
133.7 °F T stack
8.41 % CO2
89.2 % EFF
34.9 % ExAir
5.9 % Oxygen
38 ppm CO
53 ppm CO AirFree
--- inH2O Draft
81.7 °F Ambient temp
79.5 °F Instrum temp
--- °F Diff. temp.
--- inH2O Diff. Press
0 ppm CO Ambient

South Portland
Recreation Ctr
Boiler #2

testo 327-1
V1.17 02121791/USA
04/01/2014 13:15:47
Fuel Nat Gas
CO2 max 11.7 %
Flue gas
156.2 °F T stack
7.79 % CO2
88.6 % EFF
44.7 % ExAir
7.0 % Oxygen
23 ppm CO
35 ppm CO AirFree
--- inH2O Draft
83.7 °F Ambient temp
82.0 °F Instrum temp
--- °F Diff. temp.
--- inH2O Diff. Press
0 ppm CO Ambient

#1 Boiler
South Portland
Rec. CENTER