



# GREENHOUSE GAS EMISSIONS REPORT FOR 2005-2013

CITY OF NAPERVILLE



**Naperville**



## Contents

Acknowledgments.....	2
About The Author.....	2
List of Tables and Figures .....	3
Sources of Information .....	4
Executive Summary .....	6
Emissions Inventory .....	11
Boundaries .....	11
Geographic Boundaries.....	11
Greenhouse Gases .....	11
Baseline Year .....	12
Adjustments to Base Year Emissions .....	12
Organizational Boundaries.....	13
Impact of 2010 Sustainability Plan Recommendations on GHG .....	14
Ice Bear.....	14
Upgrading Streetlights and Traffic Signals .....	15
Renewable Energy Program.....	15
Water Conservation Program .....	16
Sustainable Procurement Guidelines.....	16
Appendix 1 - Electricity Usage Data .....	17
Appendix 2 - Natural Gas Usage Data .....	18
Appendix 3 - Solid Waste Calculations.....	19
Appendix 4 - Distillate Fuel Calculations.....	22
Appendix 5 - Mobile Sources of Emission Calculations.....	23
Appendix 6 - Population Data .....	25
Appendix 7 - Renewable Energy Program Participation .....	26
Appendix 8 - Change of Source Mix for Electricity Generation.....	27
Acronyms.....	29
Glossary (from the Greenhouse Gas Protocol, WRI).....	30
References.....	33

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**Neuqua Valley High School students** for their efforts to collect, calculate and report 2007, 2009 and 2011 data under the direction of science teacher Adrienne O’Neal.

**Stephanie Hastings**, president of Naperville for Clean Energy and Conservation, for the group’s efforts to initiate this project.

**The Naperville EnviroTeam** for its project oversight and final report preparation efforts:

- Katie Delaney
- Amy Emery
- Jan Fischer
- Jim Holzapfel
- Veronica Kloff
- Beth Lang
- Patricia Lord
- Shebnem Ozkaptan
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- Kate Schultz
- Jonathan Stelle
- Tom Urbas

## About The Author

Vikas Chandola has been a resident of Naperville since December 2003. This report was prepared in conjunction with his studies toward a Master of Liberal Arts (MLA) with a concentration in Sustainability and Environmental Management from Harvard University Extension School. Mr. Chandola holds a Master’s Degree in Business Administration and Bachelor of Technology in Chemical Engineering.

# List of Tables and Figures

## List of Tables

- Table 1, Summary of Results
- Table 2, City of Naperville – City Operations, Emissions Data
- Table 3, Sources of Data
- Table 4, CDD Analysis with 2012 Data
- Table 5, CDD Analysis with 2013 Data

## List of Figures

- Fig 1, Emissions in MT CO<sub>2</sub>e
- Fig 2, Emissions in MT CO<sub>2</sub>e Per Capita
- Fig 3, Emissions in MT CO<sub>2</sub>e Per Square Mile
- Fig 4, City Operations, Electricity, MT CO<sub>2</sub>e

## Sources of Information

As part of its sustainability efforts, in 2005 the City of Naperville commissioned environmental consulting firm Camp Dresser and McKee Inc., now known as CDM Smith, to conduct a baseline Greenhouse Gas (GHG) Emissions Inventory. The original study followed the Local Government Operations Protocol (LGOP) (California Air, 2010) in determining the annual GHG emissions for the baseline inventory. The original study was followed by additional studies in 2007, 2009 and 2011 by Neuqua Valley High School students. In the course of the discussions with various stakeholders, it was determined that there were limitations with the 2007, 2009 and 2011 studies due to:

1. Data assumptions made for several emission sources;
2. Emissions factors used were based on Climate Research Institute, 2005 standards;
3. Outputs of these studies were not independently verified for accuracy; and
4. There was missing data so the studies were not complete.

Notwithstanding the above, there were some parts of information from surveys for the years 2007, 2009 and 2011 that have been included in the present report for the following reasons:

1. Natural Gas usage data – 2007 and 2009 numbers were verified to be the data provided by Nicor (Appendix 2).
2. Plug gaps in current study data for in-between years where information was unavailable. The report highlights such assumptions at appropriate places.

For this report, information and data was collected from the following City of Naperville departments:

1. Transportation, Engineering and Development Services Business Group (T.E.D.)
2. Department of Public Utilities – Electric – electricity usage data (Appendix 1)
3. Department of Public Utilities – Water - water usage data
4. Department of Public Works – fleet data

The following organizations were also approached for additional data:

1. Science Department, Neuqua Valley High School GOLD Campus, to understand the data collation and analysis from the 2007, 2009 and 2011 studies.

2. Nicor Gas – to obtain natural gas usage data (Appendix 2).
3. Chicago Metropolitan Agency for Planning – annual vehicle miles traveled (AVMT) data (Appendix 5).

The City's sustainability efforts are coordinated by the EnviroTeam, a committee with representatives from every department that meets quarterly to oversee implementation of the *2010 Naperville Sustainability Plan*. Recommendations contained in the 2010 plan include several actions that may reduce GHGs, such as energy audits and improvements to City facilities, upgraded streetlights and traffic signals that will be initiated in FY15, ongoing energy audit and weatherization programs, ordinance updates initiated in FY12 and more. Members of the EnviroTeam were instrumental in the final review and release of this report.

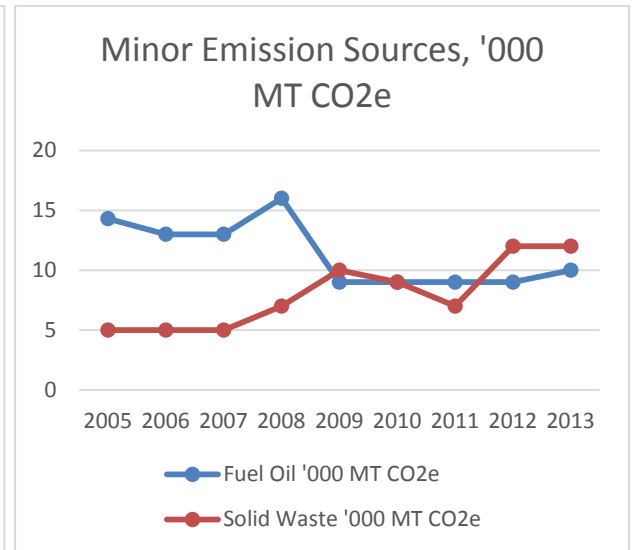
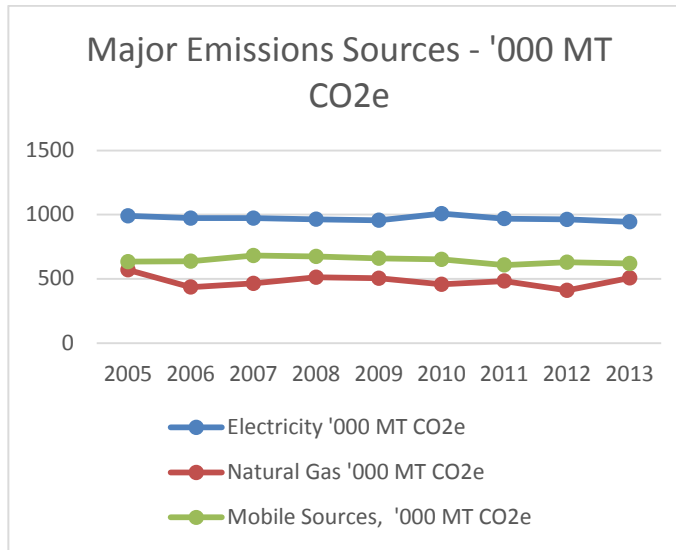
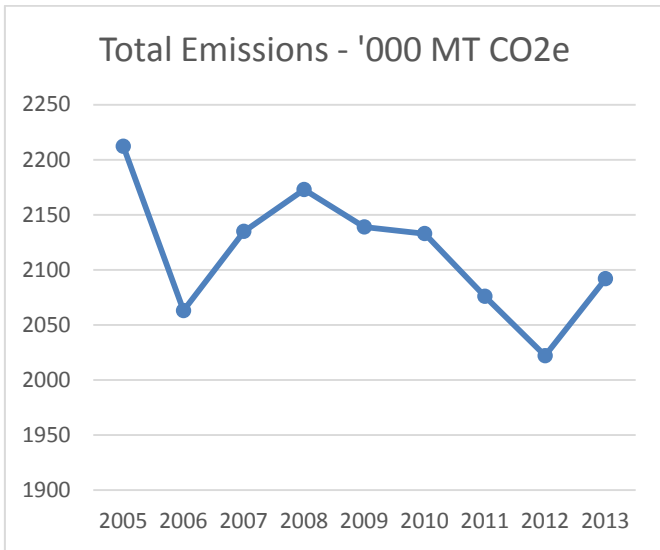
# Executive Summary

The total Metric Tons of Carbon Dioxide Equivalent (MT CO2e) for the City of Naperville has showed a downward trend between 2005 and 2013, on absolute totals, on total per capita and on total per square mile basis. A similar trend is seen for the major emission sources that contribute to greenhouse gases, including electricity, natural gas and mobile sources (e.g. vehicles). The sum of all emissions from the City of Naperville operations is likely 1.2 - 1.4% of the total emission sources generated from within the City as a whole. The table below summarizes the GHG emissions for community-wide emissions for the City of Naperville.

**Table 1, Summary of Results**

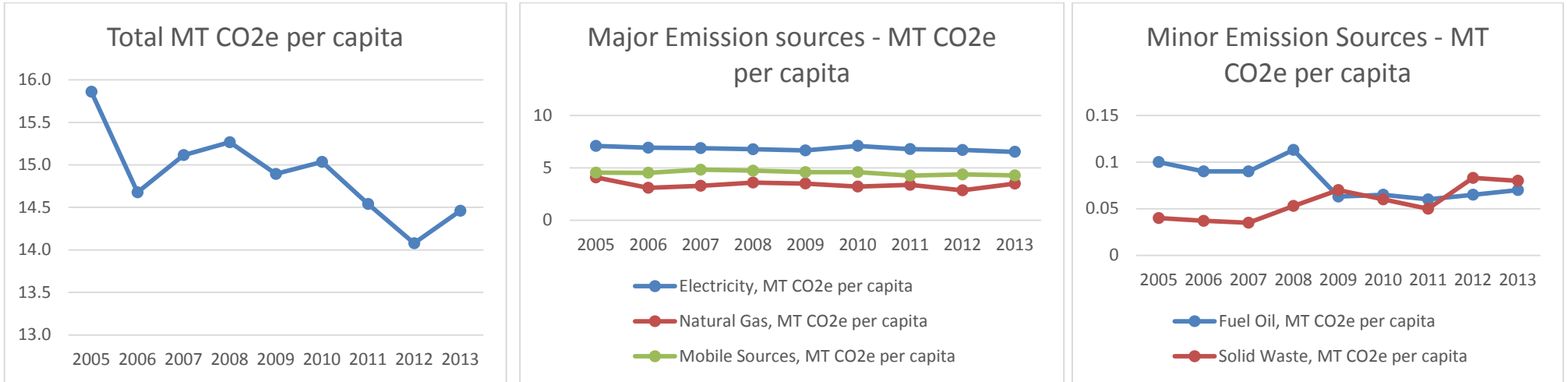
Emission Factors	Year																										
	2005			2006			2007			2008			2009			2010			2011			2012			2013		
	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile	In '000 Metric Tons CO2e	Metric Tons CO2e per capita	In '000 Metric Tons CO2e per sq. mile
Electricity	990	7.09	25.5	972	6.92	25.1	972	6.88	25.1	964	6.77	24.9	956	6.66	24.7	1007	7.1	26	969	6.79	25	962	6.7	24.8	944	6.53	24.4
Natural Gas	570	4.09	14.7	436	3.1	11.2	464	3.29	12	512	3.60	13.2	504	3.51	13	457	3.22	11.8	483	3.38	12.45	410	2.86	10.58	507	3.5	13.07
Fuel Oil	14.3	0.10	.368	13	.090	.328	13	.09	.328	16	.113	.416	9	.063	.233	9	.065	.239	9	.06	.24	9	.065	.242	10	.07	.249
Mobile Sources	633	4.54	16.3	637	4.53	16.4	681	4.82	17.6	674	4.73	17.4	660	4.59	17	651	4.59	16.8	608	4.26	15.7	629	4.37	16.2	619	4.28	16
Solid Waste	5	0.04	.137	5	.037	.133	5	.035	.128	7	.053	.193	10	.07	.258	9	.06	.219	7	.05	.18	12	.083	.31	12	.08	.315
Community Total	2212	15.9	57	2063	14.7	53.2	2136	15.1	55.1	2174	15.3	56.1	2139	14.9	55.2	2133	15	55.06	2076	14.5	53.57	2022	14.1	52.13	2092	14.5	54.03

**Figure 1, Emissions in MT CO2e (Metric Tons of Carbon Dioxide Equivalent)**

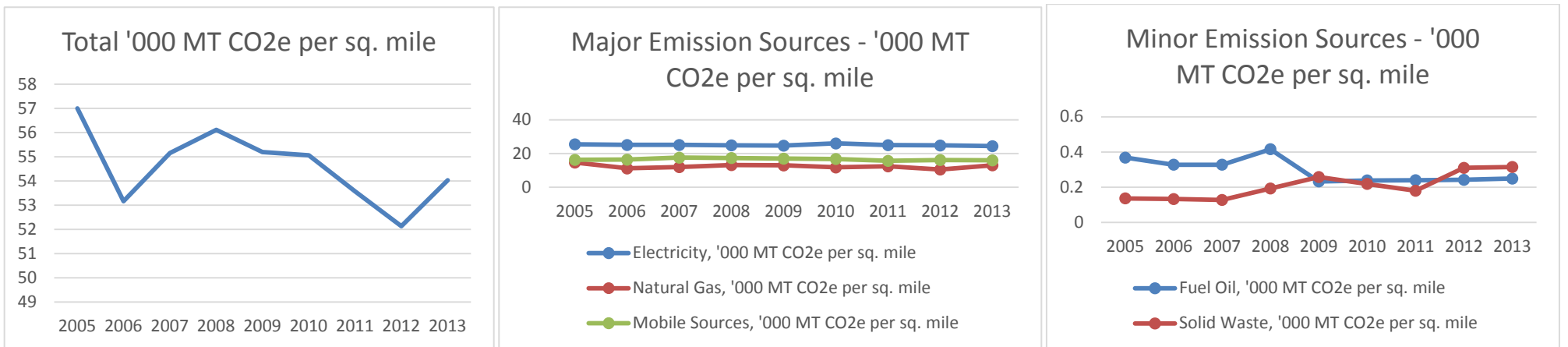




**Figure2, Emissions in MT CO2e (Metric Tons of Carbon Dioxide Equivalent) per capita**



**Figure 3, Emissions in MT CO2e (Metric Tons of Carbon Dioxide Equivalent) per square mile**



## Notes:

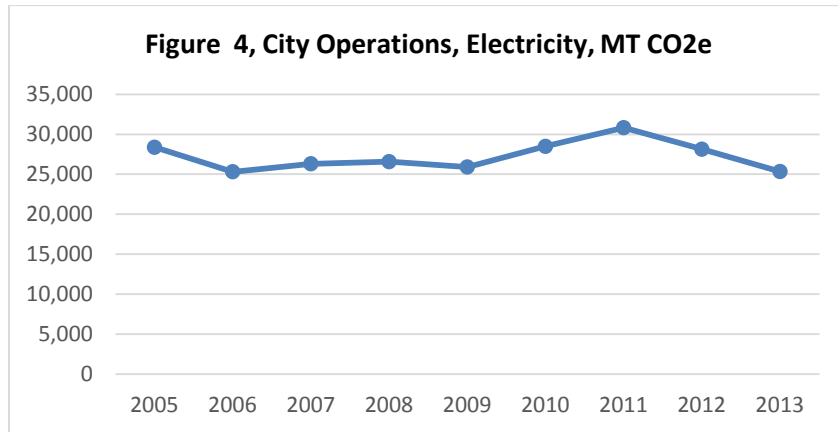
- The electricity emission numbers are based on actual usage numbers in KWH obtained from the City of Naperville. The City purchases electricity from the Illinois Municipal Electric Agency (IMEA). In a later section the fuel mix of sources in IMEA's portfolio is discussed. There are zero-emission sources of electricity in the mix, such as wind and nuclear. The mix of renewables in the electricity consumption for the period 2005 to 2013 is not known. However, it is presumed that the renewable energy portion of utility is already accounted for in the region's eGRID factor (p.47, California Air, 2010).
- Though the calculations for electricity usage generated GHG has assumed ReliabilityFirst Corporation (RFC) West eGRID sub-region (EPA, 2014) for Naperville, the actual fuel based percentages shows a very high skew towards coal (90.26% versus 68.6%). Therefore the estimates for electricity usage GHG emissions in this section are almost certainly lower than the actual emissions. As mentioned at the beginning of this section, and as illustrated in Figures 1, 2, and 3, Naperville has experienced a downward CO<sub>2</sub>e trend over the last eight years. The total emissions of about 2.2 million tons of CO<sub>2</sub>e in 2005 has dropped to 2.1 million tons of CO<sub>2</sub>e in 2013 - a drop of about 4.7%. This can be attributed to reduction in electricity emissions from .99 million MT to .944 million MT (a drop of about 4.6%), a natural gas emissions drop from .57 million MT to .507 million MT (an about 11% reduction), and mobile sources emissions drop from .633 million MT to .619 million MT (down about 2.2%). This downward trend is also seen in the per capita drop from 15.9 MT CO<sub>2</sub>e to 14.5 MT CO<sub>2</sub>e (a drop of 8.8%). A similar trend is seen for per square mile of MT CO<sub>2</sub>e emissions especially between 2008 and 2012.

It is important to point out that these numbers are based on certain assumptions defined later in this report. There are also certain mitigation approaches stated in this report which could potentially reduce the numbers quite substantially.

For the City of Naperville's operations, electricity data in KWH was provided by the Department of Public Utilities-Electric. Data was also provided for fleet usage by the City of Naperville Public Works Department for 2013. Data for stationary source (Natural Gas) was provided by Nicor, Inc. (AGL Resources). Based on available information, the City operations GHG footprint was determined as shown in Table 2 and Figure 4.

**Table 2, City of Naperville – City Operations, emissions data**

Year	Electricity usage (MT CO2e)	Mobile Sources (MT CO2e)	Stationary Sources (Natural Gas) (MT CO2e)
2005	28,373	3,780*	1,291*
2006	25,317	N/A	N/A
2007	26,310	N/A	N/A
2008	26,573	N/A	N/A
2009	25,910	N/A	N/A
2010	28,487	N/A	N/A
2011	30,820	N/A	N/A
2012	28,130	N/A	N/A
2013	25,340	3,424**	N/A



**Notes:**

- The electricity data usage in Table 2 is based on actual usage data for City operations provided by the City and using the conversion factors from Climate Registry published 01/10/2014 (The Climate Registry, 2014), assuming RFCW sub grid region (EPA, 2014). Therefore, the year 2005 numbers stated in Table 2 are different than the electricity usage emission numbers reported in GHG inventory report (CDM, 2009). This report had noted 2005 emissions as 32,378 MT CO2e.
- \* The mobile source and stationary data for 2005 are from the GHG inventory report (CDM, 2009). Mobile sources include fire trucks, police vehicles and utility vehicles.
- \*\* The mobile sources emission number for 2013 is based on actual usage numbers of gasoline and diesel for 2013 provided by the City of Naperville for its operations and using the

conversion factors of Climate Registry (The Climate Registry, 2014).

The City operations GHG footprint from electricity sources is included in the number for overall Naperville City GHG emission numbers and is about 1.2 - 1.4% of this total. Though the data for stationary and mobile sources are not available for all the years, based on the data that is available for 2005 and 2013, the percentages of these emissions is likely less than .3% of the total City of Naperville emission numbers.

## **Emissions Inventory**

Based on data from the State of Illinois (EIA, 2014), discussions with City of Naperville staff, Local Government Operations Protocol covering stationary combustion (p.30, California Air, 2010), and electricity usage (p. 38, California Air, 2010), the following are determined to be the most relevant emissions sources for the entire City of Naperville by meeting the significance threshold for reporting emissions of 5% (p.172, California Air, 2010): electricity usage, natural gas usage, distillate fuel oil usage, solid waste, and mobile sources (e.g. vehicles).

Looking only at the City of Naperville's operations that can be controlled by the City as a municipal government, as explained later in this report, electricity usage constituted more than 85% of the energy usage, followed by stationary sources (e.g. natural gas).

## **Boundaries**

### **Geographic Boundaries**

The geographic boundary assumed for the purposes of this report is the incorporated limits of the City of Naperville, which covers an area of approximately 40 square miles. This includes portions of two counties in the State of Illinois, Will and DuPage.

### **Greenhouse Gases**

The GHG's assessed in this study are carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O) and methane (CH<sub>4</sub>). The study used Global Warming Potential (GWP) conversion factors of 21 and 310 for CH<sub>4</sub> and N<sub>2</sub>O per the Climate Change Registry (The Climate Registry, 2014) to determine Million Ton (MT) CO<sub>2</sub>e totals. Data in the form of fugitive emissions and emission sources for hydrofluorocarbons (HFCs),

perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrous hexafluoride (NF3) greenhouse gases are not available. No additional data was available to determine HFC, PFC, and SF6 emissions. Naperville does not have production facilities for aluminum or semiconductors, two major sources of PFCs (What’s Your Impact, 2014); therefore, it is likely PFC emissions are negligible. The City provided data on the number of refrigerators and freezers recycled as part of the Illinois Municipal Electric Agency’s (IMEA’s) “Recycle My Fridge” program it participates in (Arca, 2014). This is covered in some detail later in this report.

## Baseline Year

The original baseline for emissions was the year 2005. This has been stated in the 2005 Greenhouse Gas Emissions report for the City of Naperville by Camp Dresser and McKee Inc., now called CDM Smith Inc. (CDM Smith, 2014). Using data provided from various sources as listed in Table 3 and making certain calculation assumptions stated elsewhere in this report at appropriate places, the inventory was determined on a calendar year basis. The emission calculations have been done for every year from 2006 to 2013.

**Table 3, Sources of Data**

Resource	Source of Data
Electricity	City of Naperville
Natural Gas	Nicor, Inc.
Water	City of Naperville
Solid Waste Collection	City of Naperville
Fuel Oil	Direct – Industrial, Commercial and Residential from EIA website
Mobile Sources	Chicago Metropolitan Agency for Planning

## Adjustments to Base Year Emissions

The following adjustments were made to baseline year calculations:

- In order to maintain consistency in calculations for the distillate fuel oil, the 2005 numbers were recalculated to align the estimation methods used for this emission source for the other years with the baseline year 2005. This became essential since the difference between reported emissions in the original 2005 report (CDM, 2009) and the emissions calculated using the calculation process adopted for subsequent studies in 2007, 2009, and 2011 as well as the current study was large - 101,047 MT CO2e per the original 2005 report versus 14,276 MT CO2e per the calculations in the current study. Information on the method adopted for

calculating 2005 numbers in the 2005 report was not available.

- The 2007, 2009, and 2011 calculations were based on previously defined emission factors by the Climate Registry. These were recalculated using the emission factors from the latest Climate Registry published on 01/10/2014 (The Climate Registry, 2014). After making the changes in the emission factors, the difference in the numbers of MT CO<sub>2</sub>e for the various emission sources was found to be less than 5%.

## **Organizational Boundaries**

The organizational boundaries for the City Of Naperville, as an entire community, were not feasible due to the nature of the entity being studied (e.g. a myriad of independent households, businesses, visitors, etc.). However, the organizational boundaries could be determined for the City of Naperville municipal operations using the Control Approach. The City of Naperville government was able to provide documentation of 100% of its electricity usage for all City of Naperville government building operations for all years from 2006 to 2013. The City of Naperville government also provided mobile source data for one year, 2013, for its municipal fleet in the form of fleet miles and diesel and gasoline usage in gallons. Data for stationary sources and employee travel were not provided. These data were presented in the previous summary section along with analysis of each emission source. As mentioned previously, the sum of all emissions from City government operations is likely 1.2 - 1.4% of the total emission sources from within the City of Naperville. The sources of all City of Naperville government emissions include all departments within the City. Since the entity had 100% control on each department, a Control Approach can be adopted.

Based on Table 2, it should be noted that electricity usage constitutes the single largest source of emissions for the City of Naperville's municipal operations, which is almost 85% of the total. This will constitute Scope 2 for the City Operations. Scope 1 emissions are from mobile sources used by the City in its operations, such as fire trucks, police vehicles, utility vehicles, etc. These constitute about 11% of the emissions. The 4% balance is from Scope 1 stationary sources, e.g. Natural Gas. This analysis is based on 2005 numbers. Presuming no significant change in usage patterns between 2005 and 2013, a similar split is likely between the two scopes (85:15) for City operations for the remaining years as well. Though an effort was made to collect data on Scope 3 emissions (e.g. indirect emissions from sources such as purchased goods and services, construction projects, upstream transportation, employee business travel, and employee commuting), this data was unavailable.

## Impact of 2010 Sustainability Plan Recommendations on GHG

### Ice Bear

In May 2013, the City of Naperville completed a project intended to conserve electricity during summer peak periods using ice conversion technology. Dubbed the Ice Bear Demonstration Project, this technology was implemented at the Water Service Center, 120 W. Ogden Ave. The effort was consistent with the 2010 Sustainability Plan recommendation to pursue energy efficient improvements in City-owned facilities. The electricity usage data in KWH provided by the City of Naperville and Cooling Degree Days (CDD) analysis data is provided in Table 4 and Table 5.

**Table 4, CDD Analysis with 2012 Data**

	<b>CDD</b>	<b>KWH</b>	<b>KWH/CDD</b>
June	310	12,400	40
July	490	10,145	21
August	281	9,568	34
September	120	8,042	67
October	13	4,940	380

**Table 5, CDD Analysis with 2013 Data**

	<b>CDD</b>	<b>KWH</b>	<b>KWH/CDD</b>
June	184	5,508	30
July	280	6,843	24
August	254	5,147	20
September	166	6,187	37
October	30	4,590	153

Linear regression analysis shows that the linear regression line for 2013 is flatter than for 2012 and the KWH/CDD for 2013 was 53 as compared to 108 for 2012. This sizable reduction numerically demonstrates that the project was a success in helping save energy. The approximate energy savings is more than 37% in KWHs of electricity usage during the summer months. Expanded use of this (or similar) technology by other City-owned or private locations could result in substantial energy savings. Assuming that 60% of the energy use is in the summer months, it would potentially mean saving 60% of 37% of 732,558 MWH, which is about 162,628 MWH annually. This is a substantial energy savings and potential impact on the GHG footprint of the City of about 112,771 MT CO<sub>2</sub>e.

## **Upgrading Streetlights and Traffic Signals**

Camp Dresser and McKee, now CDK Smith (CDM Smith, 2014), had previously made certain recommendations for GHG savings in 2005. One of these was to upgrade the City's streetlights and traffic signals to light emitting diode (LED) lights. A similar recommendation was included in the 2010 Naperville Sustainability Plan. Installation of LEDs has proved largely cost prohibitive since 2010; however, budgetary allocations have recently been made to replace the current high pressure sodium (HPS) bulbs. With 10,199 fixtures at an estimated 2,195,041 watts replaced with a rating of 1,021,147 watts, and assuming 4,380 hours usage (light hours only) in a year, and converting calculations to KWH, the math translates to  $(2195041 - 1021147) \times 4380 / 1000 = 5,141,656$  KWH or 5,142 MWH, which translates to approximately 3,500 MT in annual savings of CO<sub>2</sub>e emissions.

## **Renewable Energy Program**

For calendar year 2013, Renewable Energy Credits (RECS) amounting to 1.09% of the total retail electricity sales to customers (see Appendix 7) was purchased by Naperville in the form of voluntary contributions on monthly electric bills for the renewable energy credit. 99% were wind credits and 1% was solar credits. This program is available to Naperville utility customers (City of Naperville, Renewable, 2014). Unfortunately, as seen from Appendix 7, there is a reduction in the number of customers participating in the program. The City could consider improving the percentage of RECs of the total retail sales through incentives, knowledge seminars, and aggressive marketing. A doubling of the percentage to more than 2% could translate to almost 30,000 MWH per information provided by the City of Naperville. While these RECs cannot be applied to Scope 1 and Scope 2, these could be applied against Scope 3 emissions. (Refer to glossary for definition of each Scope.)



## **Water Conservation Program**

From information received from the City of Naperville, the City has conducted leak detection surveys to locate leaks in the public water supply system. These leaks occur through water main breaks, service line leaks, and hydrant losses. The City's losses used to average above the national average and were in between the range of 10% and 20%. This was brought down to between 3.51% and 5.78% between Fiscal Year (FY) 09 and FY11. This came down further to 3.1% in the first six months of 2013. However, on an annualized basis the number has risen to around 9.7%. Per information from the City of Naperville, every 1% of water loss equates to \$200,000 in purchased water costs. An increase in percentage loss implies a substantial loss for the City's revenues. This is based on more than 1.5 million gallons of water usage per day across the City. A comprehensive water leakage detection survey is therefore required at this time to determine the location and causes for such losses. The project will be completed in FY15.

## **Sustainable Procurement Guidelines**

The City of Naperville is a large purchaser of services and goods and also sets policies that impact the City's residents, businesses and industries (City Of Naperville, Financial, 2013). By developing an environmentally preferable procurement plan for goods and services such as buildings and construction and influencing suppliers to adopt an environmentally conscious approach to products and services, these actions can have a strong ripple effect in the community at large. It will lead to cost savings in procurement in the long run and also lead to significant GHG savings. Some examples have been quoted in the 2005 GHG report (CDM, 2009). The City completed these guidelines in 2012 in accordance with the recommendations of the Greenhouse Gas Inventory.

## Appendix 1 - Electricity Usage Data

Year	Electricity usage Residential MWH	Electricity usage Commercial MWH	Electricity usage Industrial MWH	Total MWH
2006	529,574	613,001	259,852	873,383
2007	529,574	613,001	259,852	1,402,427
2008	540,605	634,274	215,430	1,390,309
2009	551,636	656,447	171,007	1,379,090
2010	605,642	665,190	181,547	1,452,379
2011	550,806	602,532	244,647	1,397,985
2012	588,351	629,980	169,290	1,387,621
2013	526,181	600,941	234,630	1,361,752

Notes:

- 2007, 2009, 2010, 2011, 2012, and 2013 data was received from the City of Naperville
- 2006 data assumed to be same as 2007 data
- 2008 data taken as average of 2007 and 2009 data

## Appendix 2 - Natural Gas Usage Data

Year	Natural Gas Usage Data – Residential Therms	Natural Gas Usage Data – Commercial Therms	Natural Gas Usage Data – Industrial Therms
2006	47,447,344	29,040,608	5,473,366
2007	51,595,625	30,076,901	5,682,590
2008	56,717,127	34,300,559	5,369,654
2009	54,706,242	35,774,149	4,320,530
2010	50,034,405	31,932,264	4,102,212
2011	52,685,238	33,921,407	4,224,755
2012	43,473,300	29,747,257	3,971,486
2013	55,738,130	35,644,368	3,937,752

Notes:

- a. The numbers from 2010 to 2013 are those of the City of Naperville’s annual natural gas usage, including Franchise Gas. Franchise Gas is the amount of natural gas provided to the City at no charge under the franchise agreement. (Source: AGL Resources)
- b. Data for 2007 and 2009 was received from the City of Naperville.
- c. Data for 2010, 2011, 2012, and 2013 was received from Nicor Gas (AGL Resources).
- d. Data for 2008 based on natural gas usage numbers for Illinois is as follows:
  - Collected MMCF natural gas usage data for IL (EIA, 2014) for Residential, Commercial, and Industrial for all years from 2007 to 2009.
  - Converted MMCF numbers to Therms using the conversion 1 MMCF = 10,000 Therms.
  - Since the data in Therms for 2007 and 2009 for Naperville was available, we could determine the ratio of Naperville usage for these years as a percentage of the IL numbers. Thus, we arrived at two sets of ratios for 2007 and 2009 for Naperville usage numbers of Residential, Commercial, and Industrial as a ratio of Illinois usage numbers.
  - For 2008, we determined the ratio of Naperville usage numbers to Illinois usage numbers by taking averages of the numbers arrived at for 2007 and 2009. Once the ratios of the Naperville usage numbers to Illinois usage numbers were determined for 2008, we multiplied these ratios to Illinois usage numbers to arrive at Naperville usage numbers for 2008.

## Appendix 3 - Solid Waste Calculations

The Solid waste Calculations used the following data:

Year	Methane Flow Rate cfm	Minutes per year	Annual Naperville landfilled waste MT	Annual landfill waste accepted at Livingston Landfill MT	Source of Data
2007	3,444.6	525,600	43,264	1,391,345	City of Naperville
2009	4,595.69	525,600	44,132	943,071	City of Naperville
2011	4,916.35	525,600	36,002	1,172,502	City of Naperville
2012	7,200	525,600	37,040	1,040,000	Methane flow rate determined from data on 14 MW power plant at the facility using methane gas; Naperville landfill waste – City of Naperville; annual landfill waste based on information that 4,000 MT per day for 260 days in a year gets collected (Hoosier, 2014)
2013	7,200	525,600	37,965	1,040,000	Methane flow rate determined from data on 14 MW power plant at the facility using methane gas; Naperville landfill waste – City of Naperville; annual landfill waste based on information that 4,600 MT per day for 260 days in a year gets collected (Hoosier, 2014)

- 2008 data was taken as the average of the numbers calculated for 2007 and 2009.
- 2010 data was taken as the average of the numbers calculated for 2009 and 2011.

Sample calculation for 2013 (format from Local Government Operations Protocol - California Air, 2010)

Input data		
Methane flow rate <sup>1</sup>	7200	scfm
Minutes per year	525600	minutes
Annual Landfill gas collected	3784.32	mmscf
Fraction of CH <sub>4</sub> in LFG	0.50	(default)
Collection Efficiency (CE)	0.75	(default)
Oxidation Factor (OX)	0.10	(default)
CH <sub>4</sub> Destruction Efficiency (DE)	0.99	(default)
1 mmscf CH <sub>4</sub> =	19.125	metric tons CH <sub>4</sub>
GWP of CH <sub>4</sub>	21	

Methane Emissions <sup>2</sup>		
<i>Fugitive emissions = LFG collected x % CH<sub>4</sub> x [(1 - CE) / CE] x (1-OX)] x unit conversion</i>		
Annual Fugitive CH <sub>4</sub> emitted	10,856.27	metric tons CH <sub>4</sub>
<i>Flare/Combusted emissions = LFG collected x % CH<sub>4</sub> x (1 - DE) x unit conversion</i>		
Annual CH <sub>4</sub> flared	361.88	metric tons CH <sub>4</sub>
<i>Total Annual CH<sub>4</sub> Emissions = Fugitive emissions + Flare/Combusted emissions</i>		
<b>Total Annual CH<sub>4</sub> Emissions</b>	<b>11,218.14</b>	<b>metric tons CH<sub>4</sub></b>

Carbon Dioxide emissions <sup>3</sup>		
<i>Annual LFG combusted = Annual LFG collected</i>		
Annual landfill gas combusted	3,784,320,000	scf
Emission Factor <sup>4</sup>	0.0262	kg CO <sub>2</sub> / scf
<b>Annual CO<sub>2</sub> emissions</b>	99,149,184	kg CO <sub>2</sub>
	<b>99,149.18</b>	<b>metric tons of CO<sub>2</sub></b>

Annual Livingston Landfill GHG Emissions		
<i>Landfill GHG Emissions = (CH<sub>4</sub> Emissions x GWP) + CO<sub>2</sub> Emissions</i>		
Annual CH <sub>4</sub> Emissions	235,581	metric tons CO <sub>2</sub> e
Annual CO <sub>2</sub> emissions	99,149.18	metric tons CO <sub>2</sub> e
<b>Annual Landfill Emissions</b>	<b>334,730.20</b>	<b>metric tons CO<sub>2</sub>e</b>

Solid Waste Data		
Annual Naperville landfilled waste	37,965	tons
Annual waste accepted at Livingston Landfill <sup>1</sup>	1,040,000	tons
Percentage of Naperville waste of Livingston's total	4%	

Solid Waste GHG emissions		
Annual Livingston Landfill Emissions	334,730	metric tons CO <sub>2</sub> e
<b>Annual Naperville-caused Landfill Emissions</b>	<b>12,219</b>	<b>metric tons CO<sub>2</sub>e</b>

## Appendix 4 - Distillate Fuel Calculations

The calculations were based on the following:

- a. Collecting data for each year between 2005 and 2013 for the state of Illinois (EIA, 2014) usage in gallons for residential distillate fuel no. 2, commercial residential distillate fuel no. 2, and industrial distillate fuel no. 2; commercial residual fuel no. 5 and no. 6; industrial residual fuel oil no. 5 and 6; and taking averages for no. 5 and no. 6.
- b. Using the ratio of the Naperville population to Illinois' population to determine usage in gallons of each of the fuel oils.
- c. Determining the CO<sub>2</sub>e using emission factors (The Climate Registry, 2014) for CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O.

Note that distillate fuel data from the City of Naperville indicated use of fuel no. 2. For residual fuel this was not clear; therefore, an average for the no. 5 and no. 6 emission factor was used in the residual fuel GHG calculations.

The Naperville population numbers and Illinois population numbers used are in Appendix 6.

Year	IL state Residential – Distillate Fuel Oil in gallons	IL state Commercial – Distillate Fuel Oil in gallons	IL state Industrial – Distillate Fuel Oil in gallons	IL state Commercial – Residual Fuel Oil in gallons	IL state Industrial – Residual Fuel Oil in gallons
2005	8,891,000	34,959,000	65,259,000	2,359,000	11,838,000
2006	7,326,000	37,623,000	58,065,000	43,000	7,189,000
2007	6,382,000	30,674,000	70,444,000	0	3,396,000
2008	8,714,000	52,589,000	72,721,000	117,000	5,126,000
2009	4,755,000	34,621,000	38,223,000	0	460,000
2010	4,728,000	36,036,000	39,583,000	783,000	137,000
2011	4,407,000	37,494,000	37,214,000	722,000	387,000
2012	2,722,000	41,966,000	36,050,000	0	553,000
2013	2,232,000	44,772,000	35,383,000	376,000	384,000

Source of data - [http://www.eia.gov/dnav/pet/pet\\_cons\\_821use\\_dcu\\_sil\\_a.htm](http://www.eia.gov/dnav/pet/pet_cons_821use_dcu_sil_a.htm)

## Appendix 5 - Mobile Sources of Emission Calculations

The mobile sources data was calculated as follows:

- a. Determined the VMT (vehicle miles traveled) for Will and DuPage counties for each year from 2006 to 2013. This data was collected from Illinois Travel Statistics reports (IL Department of Transportation, 2014). This data was available for seven functional classes of roads, including Interstate, Freeways, Principal Arterials, Minor Arterials, Collectors, Minor Collectors, Local Roads and Streets.
- b. Based on the percentage of Naperville's population in each of the two counties, Naperville's VMT was calculated (Appendix 6).
- c. Using the following parameters, the conversion for grams per mile was determined for each year from 2006 to 2013:
  - Percentage of energy consumption in petajoules by mode of transport from US Department of Transportation, split between light duty vehicles and trucks + buses at a national level;
  - Average age of automobiles and trucks in the US at a national level;
  - Fuel economy data for light transport at a national level and assuming a miles per gallon (mpg) of 6 for trucks;
  - Grams CO<sub>2</sub> per gallon for gasoline and diesel (The Climate Registry, 2014).

Based on the above data, the grams per mile arrived at for each year is as follows:

2005 - 504.31  
2006 - 502.30  
2007 - 531.26  
2008 - 532.89  
2009 - 521.86  
2010 - 515.77  
2011 - 499.78  
2012 - 491.41  
2013 - 482.44

- d. The VMT data for Naperville multiplied with the grams per mile provided the CO<sub>2</sub>e from mobile sources for a year.



Sample VMT calculations for 2013 are given below (format from Local Government Operations Protocol - California Air, 2010)

County	County Population	Naperville Population	Naperville Percent of County Population
DuPage County	932,126	96,369	10.34%
Will County	682,829	48,239	7.06%

144,608

Functional Class	DuPage County Annual VMT	Will County Annual VMT	Naperville Annual VMT	Naperville Daily VMT
Interstate	2,617,608,000	2,013,414,000	412,863,882	1,131,134
Freeways	62,941,000	0	6,507,233	
Principal Arterials	2,212,108,000	1,235,033,000	315,951,416	865,620
Minor Arterials	1,622,376,000	930,286,000	233,452,148	639,595
Collectors	608,716,000	463,050,000	95,645,394	262,042
Minor collectors	0	6,105,000	431,293	1,182
Local Roads and Streets	1,300,513,000	1,188,564,000	218,422,199	598,417
<b>Total Roadway Network</b>	<b>8,424,262,000</b>	<b>5,836,452,000</b>	<b>1,283,273,564</b>	<b>3,515,818</b>
<b>City of Naperville - Local Trip VMT</b>	n/a	n/a	<b>870,409,682</b>	2,384,684

## Appendix 6 - Population Data

Year	DuPage County population	Will County population	Naperville City DuPage County	Naperville City Will County	Naperville Total Population	IL State Population
2006	922,190	656,075	96,028	44,491	140,519	12,640,000
2007	922,948	670,013	95,969	45,341	141,310	12,700,000
2008	927,382	679,069	96,166	46,323	142,489	12,750,000
2009	932,541	685,251	96,347	47,314	143,661	12,800,000
2010	918,186	678,883	94,533	47,320	141,853	12,840,000
2011	924,336	680,584	95,213	47,660	142,873	12,870,000
2012	927,987	682,518	95,753	47,931	143,684	12,880,000
2013	932,126	682,829	96,369	48,239	144,608	12,882,100

Sources of data: US Census Bureau

## Appendix 7 - Renewable Energy Program Participation

	2010	2011	2012	2013
Number of Participants	4,446	4,534	4,392	4049
% Change	n/a	1.94%	-3.23%	-8.47%
Amount of Energy ( MWh)	16,741	17,555	17,014	14,299
As a % of all energy purchased	1.15%	1.26%	1.23%	1.05%

Source – City of Naperville

## Appendix 8 - Change of Source Mix for Electricity Generation

The table below provides the fuel mix by source in the Illinois Municipal Electric Agency's (IMEA's) portfolio of fuel. The City purchases its electricity from IMEA to meet the needs of its customers. This mix in these percentages may not be exactly what is purchased by Naperville to meet its power needs. This data is for FY14, year to date.

**Breakdown of fuel mix percentage for electricity usage**

Source	% of Fuel Mix
Coal	90.26%
Wind	4.57%
Misc.	2.44%
Natural Gas	1.84%
Nuclear	0.89%
<b>Total</b>	<b>100.00%</b>

Actual generation data by fuel source across the US (EIA, 2014) shows use of coal as a resource has been going down from 2005 to 2013. From a high of almost 50%, coal as a source has dropped to about 39% in 2013, whereas natural gas use has been going up from almost 19% in 2005 to about 27% in 2013. Nuclear has remained stable at about 19%. The use of renewables has more than doubled from 3.6% to 8% between 2005 and 2013. Renewables include wind, solar, geothermal, biomass, wood and wood-derived fuels, other biomass, hydro-electric pumped storage, and others. Even for the region RFCW West based on the eGRID sub-region derived from zip codes, (EIA, 2014) the electricity generated using coal as a percentage is 68.6%, natural gas is 4.2%, nuclear is 23.8% and renewables is 1.9%. If we were to use the regional numbers as a benchmark, the City could impact emissions in a major way. The calculations are listed below based on 2013 annual electricity usage in the City of Naperville of 1,361,752 MWH (Appendix 1).

**Calculations of emissions for electricity usage source wise**

<b>Source</b>	<b>Current MWHR</b>	<b>Emissions in MT CO2e based on current numbers</b>	<b>Hypothetical MWH based on RFCW West eGRID Sub-region percentages</b>	<b>Emissions in MT CO2e based on RFCW West eGRID Sub-region numbers</b>
Coal	1,229,117	2,290,831	939,609	1,751,244
Natural Gas	25,056	18,889	57,194	26,571
Total MT CO2e emissions	-	2,309,720	-	1,777,815

Thus, by changing the current fuel source mix to match the RFCW West eGRID sub-region fuel mix, it will result in savings of 513,905 MT CO2e per annum (2,309,720-1,777,815). If the mix is moved closer to the US averages, the emission reductions will be even more substantial.

## Acronyms

CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> e	Carbon Dioxide Equivalent
GHG	Greenhouse Gas
HFCs	Hydrofluorocarbons
N <sub>2</sub> O	Nitrous Oxide
PFCs	Perfluorocarbons
RFC	Reliability First Corporation
SF <sub>6</sub>	Sulfur Hexafluoride
WRI	World Resources Institute

## Glossary (from the Greenhouse Gas Protocol, WRI)

Base year (Baseline Year)	A historic datum (a specific year or an average over multiple years) against which a company's emissions are tracked over time.
Boundaries	GHG accounting and reporting boundaries can have several dimensions, e.g. organizational, operational, geographic, business unit, and target boundaries. The inventory boundary determines which emissions are accounted and reported by the company.
CO2 equivalent (CO2e)	The universal unit of measurement to indicate the global warming potential (GWP) of each of the six greenhouse gases, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate releasing (or avoiding releasing) different greenhouse gases against a common basis.
Direct GHG emissions	Emissions from sources that are owned or controlled by the reporting company.
Emissions	The release of GHG into the atmosphere.
Emission factor	A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g. tons of fuel consumed, tons of product produced) and absolute GHG emissions.
Fugitive emissions	Emissions that are not physically controlled but result from the intentional or unintentional releases of GHGs. They commonly arise from the production, processing, transmission, storage, and use of fuels and other chemicals, often through joints, seals, packing, gaskets, etc.
Greenhouse gases (GHG)	For the purposes of this standard, GHGs are the six gases listed in the Kyoto Protocol: carbon dioxide (CO <sub>2</sub> ); methane (CH <sub>4</sub> ); nitrous oxide (N <sub>2</sub> O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF <sub>6</sub> ).
Global Warming Potential (GWP)	A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one

	unit of CO <sub>2</sub> . In the calculations N <sub>2</sub> O's GWP is 310 and CH <sub>4</sub> is 21.
Indirect GHG emissions	Emissions that are a consequence of the operations of the reporting company, but occur at sources owned or controlled by another company.
Intergovernmental Panel on Climate Change (IPCC)	International body of climate change scientists. The role of the IPCC is to assess the scientific, technical and socio-economic information relevant to the understanding of the risk of human-induced climate change ( <a href="http://www.ipcc.ch">www.ipcc.ch</a> ).
Inventory	A quantified list of an organization's GHG emissions and sources.
Inventory boundary	An imaginary line that encompasses the direct and indirect emissions that are included in the inventory. It results from the chosen organizational and operational boundaries.
Kyoto Protocol	A protocol to the United Nations Framework Convention on Climate Change (UNFCCC). Once entered into force it will require countries (developed nations) to meet reduction targets of GHG emissions relative to their 1990 levels during the period of 2008–12.
Life Cycle Analysis	Assessment of the sum of a product's effects (e.g. GHG emissions) at each step in its lifecycle, including resource extraction, production, use, and waste disposal.
Operational boundaries	The boundaries that determine the direct and indirect emissions associated with operations owned or controlled by the reporting company. This assessment allows a company to establish which operations and sources cause direct and indirect emissions, and to decide which indirect emissions to include that are a consequence of its operations.
Organizational boundaries	The boundaries that determine the operations owned or controlled by the reporting company, depending on the consolidation approach taken (equity or control approach).



ReliabilityFirst Corporation (RFC)	<p>ReliabilityFirst is a not-for-profit company certified as the Electric Reliability Organization (ERO) in the United States, pursuant to Section 215 of the Federal Power Act of 2005. Included in this certification was a provision for the ERO to delegate authority for the purpose of proposing and enforcing reliability standards by entering into delegation agreements with regional entities. ReliabilityFirst is one of the eight approved Regional Entities in North America, under the North American Electric Reliability Corporation (NERC).</p> <p>ReliabilityFirst's primary responsibilities include developing reliability standards and monitoring compliance to those reliability standards for all owners, operators and users of the bulk electric system and providing seasonal and long-term assessments of bulk electric system reliability within the Region.</p>
Renewable energy	Energy taken from sources that are inexhaustible, e.g. wind, water, solar, geothermal energy, and biofuels.
Reporting	Presenting data to internal management and external users such as regulators, shareholders, the general public or specific stakeholder groups.
Scope	Defines the operational boundaries in relation to indirect and direct GHG emissions.
Scope 1 inventory	A reporting organization's direct GHG emissions.
Scope 2 inventory	A reporting organization's emissions associated with the generation of electricity, heating/cooling, or steam purchased for own consumption.
Scope 3 inventory	A reporting organization's indirect emissions other than those covered in Scope 2.

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