Chicago 2010 Regional Greenhouse Gas Emissions Inventory

ICF INTERNATIONAL

CHICAGO CLIMATE ACTION PLAN

CMAP

Chicago Metropolitan Agency for Planning

GLOBAL PHILANTHROPY PARTNERSHIP

Prepared for:
Global Philanthropy Partnership with the City of Chicago and the Chicago Metropolitan Agency for Planning

Chicago 2010 Regional Greenhouse Gas Emissions Inventory

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Acronyms and Abbreviations

AAR	Association of American Railroads
AEO	Annual Energy Outlook
BAU	business-as-usual
BTS	Bureau of Transportation Statistics
CAFE	Corporate Average Fuel Economy
CAR	Climate Action Reserve
CARB	California Air Resources Board
CBECS	Commercial Building Energy Consumption Survey
CCAP	Chicago Climate Action Plan
CCX	Chicago Climate Exchange
CDD	Cooling Degree Days
CEMS	Continuous Emission Monitoring System
CH_4	methane
city	city of Chicago
CMAP	Chicago Metropolitan Agency for Planning
CNT	Center for Neighborhood Technology
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPS	Chicago Public Schools
CREATE	Chicago Regional Environmental and Transportation Efficiency Program
CT	Current Trends
CTA	Chicago Transit Authority
CW	Chicago Wilderness
DOE	Chicago Department of Environment
DWM	Chicago Department of Water Management
EIA	U.S. Energy Information Administration
FOD	first order decay
GDP	Gross Domestic Product
GHG	greenhouse gas
GIS	geographic information systems
GPP	Global Philanthropy Partnership
GRID	Generation Resource Integrated Database
GWh	gigawatt hour

GWP	global warming potential
HFCs	halogenated fluorocarbons
HDD	heating degree days
ICF	ICF International
ICLEI	ICLEI–Local Governments for Sustainability
Illinois EPA	Illinois Environmental Protection Agency
IPCC	Intergovernmental Panel on Climate Change
ISWS	Illinois State Water Survey
kwh	kilowatt hour
LGOP	Local Government Operations Protocol
LRI	Less Resource Intensive
MA	Morton Arboretum
MGD	million gallons per day
MMBtu	million metric British thermal units
MT	metric tons
MMT	million metric tons
$MMTCO_2e$	million metric tons of carbon dioxide equivalent
MOVES	Motor Vehicle Emission Simulator
MRI	More Resource Intensive
MRR	Mandatory Reporting Rule
MTC	metric tons of carbon
MSA	Metropolitan Statistical Area
MWh	megawatt hour
MWRD	Metropolitan Water Reclamation District
N_2O	nitrous oxide
NAICS	North American Industry Classification System
NASS	National Agricultural Statistics Service
NERC	North American Electric Reliability Corporation
NONROAD	USEPA's model (Nonroad Engines, Equiment, and Vehicles)
NTAD	National Transportation Atlas Database
ODS	ozone depleting substances
PFCs	Perfluorocarbons
RFC	Reliability First Compliance

RTA	Regional Transportation Authority
SF_6	Sulfur hexafluoride
SNL	SNL Financial
SOCCR	First State of the Carbon Cycle Report
TCR	the Climate Registry
TRUs	transportation refrigeration units
U.S. BEA	U.S. Bureau of Economic Analysis
USEPA	U.S. Environmental Protection Agency
USCCSP	U.S. Climate Change Science Program
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
VMT	vehicle miles traveled
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute
WRP	wastewater reclamation plant
WWTP	wastewater treatment plant

Executive Summary

Executive Summary

Study Purpose

The purpose of this study is to develop a regional, community-wide greenhouse gas (GHG) emissions inventory for 2010 (referred to throughout this report as the "2010 Regional GHG Inventory"). The 2010 Regional GHG Inventory includes the city of Chicago (city) and the seven counties in the Chicago Metropolitan Area (Cook, Will, DuPage, Kane, Kendall, McHenry, and Lake Counties). Throughout this report, these collective jurisdictions (and the associated geographical area) are referred to as the "Chicago Region" or "Region" (and also listed as "7-County Region" in tables and figures). This study is intended to: 1) develop a comprehensive GHG inventory for 2010 using current practices and protocols and an updated forecast of emissions out to 2050; 2) demonstrate how the city of Chicago and the Chicago Region's GHG emissions have changed from 2000 to 2010, based on a comparison to the results of prior emissions inventories conducted for the years 2000 and 2005 by the Center for Neighborhood Technology (CNT) (Center for Neighborhood Technology 2009, 2010); 3) elucidate the drivers for these emissions changes (for each inventory sector) so as to inform current and future local policy aimed at reducing GHG emissions; and 4) improve upon and update earlier methodologies in order to enhance the accuracy of inventory data and to reduce uncertainties in the emissions calculations.

This Report

The 2010 Regional GHG Inventory includes GHG emissions occurring *within* the geographic boundaries of the city of Chicago and each of the seven counties listed above that result from community activities. It also includes emissions that occur *outside* of a jurisdiction that result from community activities *within* the geographic boundaries of the jurisdiction. For example, emissions from electricity consumed by the community in a particular jurisdiction are included, even though these emissions often occur outside of the jurisdiction (at a power plant that provides electricity to the jurisdiction).

The 2010 Regional GHG Inventory results are described in detail in this Report. Specifically, this report includes:

- 2010 Regional GHG Inventory results, including methodology and data sources employed to develop the 2010 GHG Regional Inventory as well as a comparison to methods utilized for the prior 2000 and 2005 inventories.
- An analysis of emissions trends for Chicago and the Chicago Region from 2000 to 2010.
- A comparison of Chicago and the Region's 2010 emissions to that of other jurisdictions and regions in the U.S.
- A forecast of the 2010 Regional GHG Inventory emissions for ten-year increments beyond 2010 and up to 2050.
- A carbon stock and sequestration analysis and methodology for 2010.

Regional Emissions

In 2010, the Chicago Region emitted a total of approximately 126.3 million metric tons of carbon dioxide equivalent ($MMTCO_2e$). As shown in Figure ES-1 below, the city of Chicago emissions represent a considerable portion (27%) of the total Chicago Region emissions (or 33.5 $MMTCO_2e$). Excluding the city of Chicago, Cook County has the greatest emissions of the counties in this study. The next largest counties in order of emissions are DuPage, Will, and Lake. All jurisdictions' 2010 emissions are anticipated to grow substantially between 2010 and 2020, based upon socioeconomic and demographic projections included in the Chicago Metropolitan Agency for Planning (CMAP) GOTO2040 Plan (Chicago Metropolitan Agency for Planning 2011).

On a per capita basis, as shown in Figure ES-2, the city of Chicago had the lowest per capita emissions and Will County had the highest per capita emissions.

Emissions by Sector

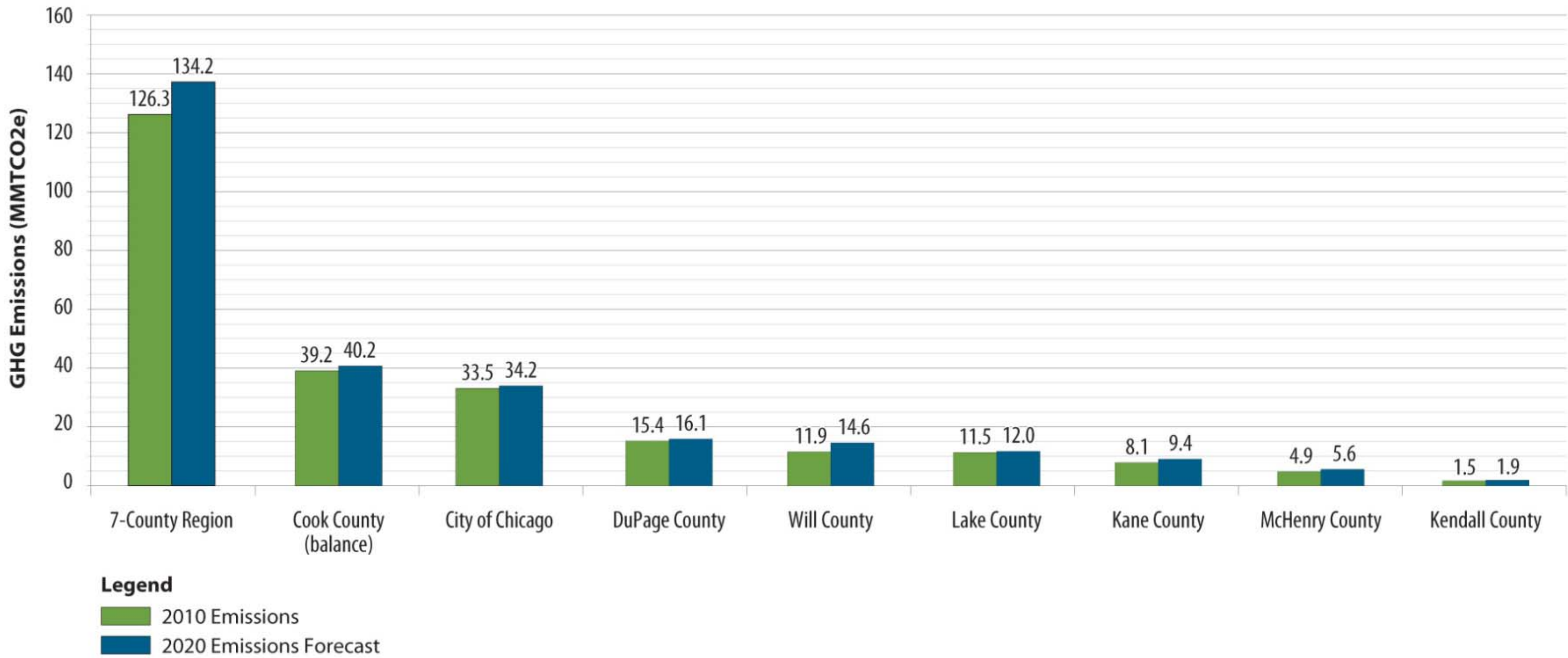
The Chicago Region's primary emissions sources in 2010 include the building energy and on-road transportation sectors, which comprise approximately 64% and 26% respectively of the Chicago Region's total emissions. The 2010 city of Chicago emissions are shown in Table ES-1 and the Region's emissions are shown in Table ES-2, by jurisdiction. The emissions sectors included in the 2010 Regional GHG Inventory include the following: building energy; transportation; stationary, industrial, and product use; solid waste; wastewater; water; and agriculture. Each sector is broken out into further sub-sectors, as applicable.

The following protocols and standards were used to estimate GHG emissions for this inventory: the Local Government Operations Protocol (LGOP) developed by ICLEI–Local Governments for Sustainability (ICLEI), Climate Action Reserve (CAR), the Climate Registry (TCR) and the California Air Resources Board (CARB) (CARB 2010); the U.S. Environmental Protection Agency (USEPA) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007 (U.S. Environmental Protection Agency 2009a); the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (Intergovernmental Panel on Climate Change 2006a); and the GHG Protocol Corporate Standard developed World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) (World Resources Institute 2004).

Emissions are commonly divided into three categories or "scopes: as follows (World Resources Institute 2004):

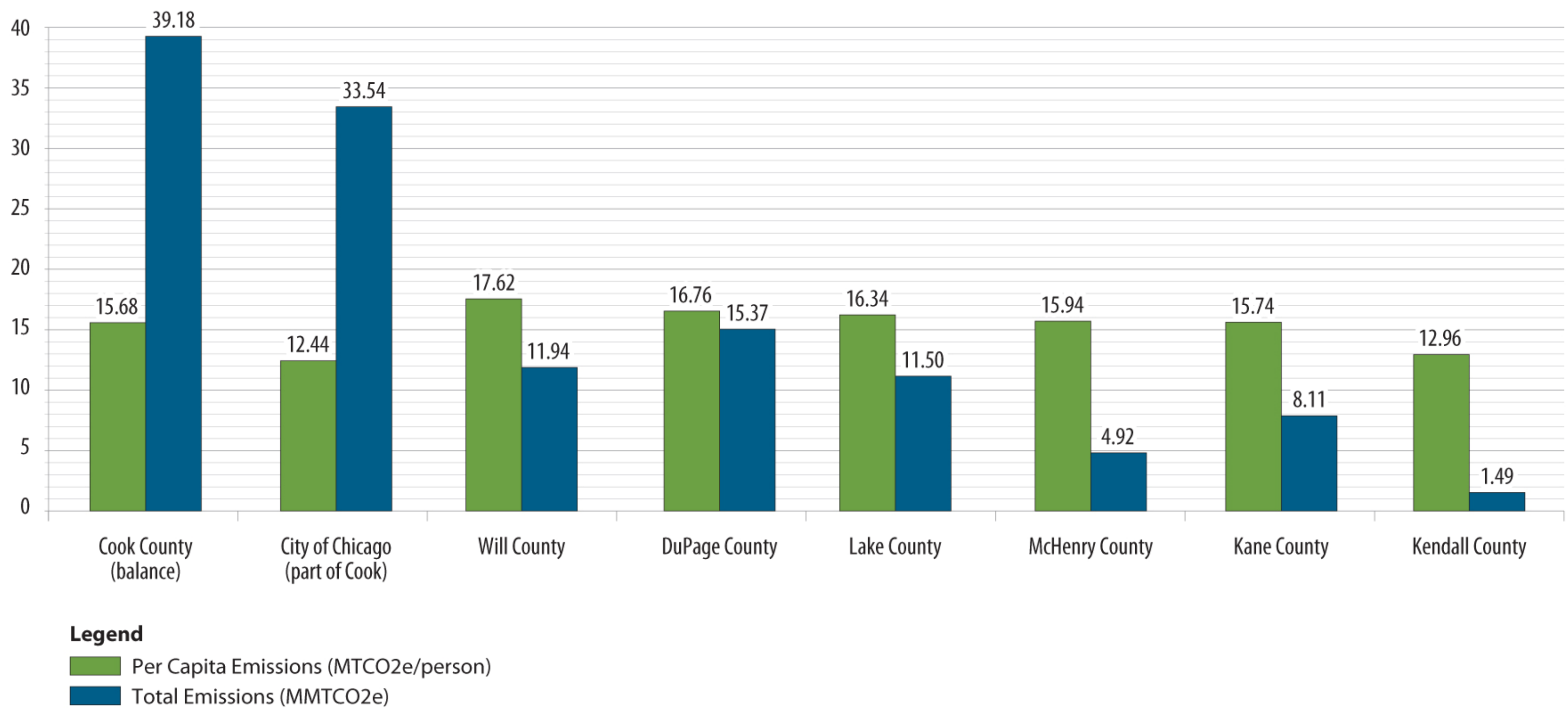
- **Scope 1:** Direct GHG emissions, such as emissions from combustion of natural gas or in vehicles, where the emissions occur directly at the activity causing the emission.
- **Scope 2:** Indirect GHG emissions, such as emissions associate with the consumption of electricity due to power plant emissions or methane emissions at a landfill that receives waste, where the emissions occur at a location separate from the activity causing the emission.
- **Scope 3:** All other indirect emissions not covered in Scope 2 that are not owned or controlled by the reporting jurisdiction, such as the emissions resulting from the extraction and production of purchased materials and fuels.

Figure ES-1. City of Chicago and Chicago Region GHG Emissions for 2010 and 2020 Forecast[1]



[1] As discussed in text below, Figure ES-1 does not display *unallocated* emissions in the inventory that could not be attributed to a specific jurisdiction due to data or methods limitations. These unallocated emissions consist of off-road transportation emissions for Chicago Transit Authority (CTA) and Metra and constitute a minor portion of the Chicago Region total emissions.

Figure ES-2. Chicago Region 2010 Absolute and Per Capita Emissions



The 2010 Regional GHG Inventory includes Scope 1 and 2 emissions (World Resources Institute 2004), including all direct and indirect emissions. Scope 3 emissions are not included. Additional discussion of each of the 2010 Regional GHG Inventory sectors, including data sources, emissions calculations and methodologies, and data or methodology gaps, is included in Chapter 4 of this report.

A separate category was included for *unallocated* emissions in the inventory that could not be attributed to a specific jurisdiction due to data or methods limitations. These *unallocated* emissions consist of off-road transportation emissions for Chicago Transit Authority (CTA) and Metra. Adjustments to the inventory were made to ensure that overlaps in inventoried emissions were avoided.

Table ES-1. City of Chicago 2010 Emissions by Sector

Sector	Subsector	2010 GHG Emissions ($MTCO_2e$)	Percent of Total Inventory
Building Energy	Electricity Use	14,587,504	43.5%
	Natural Gas	9,342,068	27.8%
	SF6	2,365	0.01%
Transportation	On-Road	6,783,031	20.2%
	Off-Road	953,100	2.8%
Solid Waste	Waste	1,291,449	3.8%
Stationary, Industrial, and Product Use	Stationary/Industrial	53,738	0.2%
	Product Use[a]	191,176	0.6%
Wastewater	Wastewater	205,899	0.6%
Water	Water Pumping and Treatment	135,246	0.4%
Agriculture	Agriculture	NA	NA
Total		33,545,577	100%

a. Refrigerant emissions are included in the product use category.

Table ES-2. Chicago Region 2010 GHG Emissions by Sector

		GHG Emissions ($MTCO_2e$)									
Sector	Subsector	City of Chicago	Cook County (balance)	DuPage County	Kane County	Kendall County	Lake County	McHenry County	Will County	7-County Unallocated	7-County Total
Building Energy	Electricity Use	14,587,504	15,395,896	6,535,167	3,324,066	398,403	4,304,964	1,743,557	4,145,713	---	50,435,270
	Natural Gas	9,342,068	9,469,453	3,233,067	1,567,372	330,032	2,418,875	993,302	2,823,532	---	30,177,702
	SF_6	2,365	2,528	1,072	553	67	697	283	724	---	8,288
Transportation	On-Road	6,783,031	10,522,625	4,500,825	2,219,259	449,721	3,953,831	1,573,716	3,223,644	---	33,226,651
	Off-Road	953,100	1,718,000	735,782	505,792	211,486	526,180	372,077	515,312	198,193[a]	5,735,920
Solid Waste	Waste	1,291,449	1,304,286	227,610	121,482	16,468	183,620	82,293	132,156	---	3,359,365
Stationary, Industrial, and Product Use	Stationary/ Industrial	53,738	71,193	---[c]	---[c]	---[c]	---[c]	---[c]	261,769	---	386,700
	Product Use[c]	191,176	166,670	61,565	30,193	6,159	42,831	19,278	40,120	---	557,992
Wastewater	Wastewater	205,899	171,601	39,739	20,455	3,849	25,297	7,258	25,804	---	499,903
Water	Water Pumping and Treatment	135,246	358,410	35,002	218,537	9,776	30,720	15,679	716,814	---	1,520,185
Agriculture	Agriculture	---[b]	282	1,558	102,374	60,596	8,977	115,360	54,357	---	343,505
Total		33,545,577	39,180,944	15,371,387	8,110,085	1,486,556	11,495,991	4,922,803	11,939,945	198,192	126,251,482

Notes:

a. This amount represents transportation emissions from rail system (Amtrak and Metra) emissions that could not be readily assigned by separate jurisdiction.

b. "---" No emissions estimated for this category. For agriculture, no large-scale agricultural activity is reported within Chicago, so no emissions are estimated for this sector. For stationary/industrial emissions, the Mandatory Reporting Rule (MRR) data did not have relevant stationary emissions for DuPage, Kane, Kendall, Lake, and McHenry Counties, so emissions are not reported for these counties.

c. Refrigerant emissions are included in the product use category.

Figure ES-3 provides a summary of the Chicago Region's emissions by sector, for both 2010 emissions and the 2020 emissions forecast. The largest emissions sources for both the city of Chicago and the Region are building electricity use, on-road transportation, building natural gas use, and off-road transportation.

Emissions Trends

A comparison of 2010 GHG emissions for both the city of Chicago and the Chicago Region to prior inventory results for 2000 and 2005 (Center for Neighborhood Technology 2009, 2010) yields the following overall emissions trends.

- Total GHG emissions for the city of Chicago increased by 4% from 2000 to 2005, decreased by 7% from 2005 to 2010, with a net decrease of 3% between 2000 and 2010.[2] Per capita emissions for the city of Chicago increased by 7% from 2000 to 2005, decreased by 3% from 2005 to 2010, for a net increase of 4% from 2000 to 2010..
- Total emissions for the Chicago Region rose by 11% from 2000 to 2005, decreased by 4% from 2005 to 2010, with a net increase of 6% from 2000 to 2010. Per capita emissions increased by 8% from 2000 to 2005 for the Chicago Region, decreased by 4% from 2005 to 2010, for a net increase of 3% from 2000 to 2010.

GHG emissions and rates of energy use in the city of Chicago and the Chicago Region for 2000, 2005, and 2010 were paired with parameters such as population, number of households, employment and weather data to yield useful metrics from which to evaluate these trends. Socioeconomic parameters utilized in this analysis were obtained from sources such as the CMAP and the 2010 U.S. Census.

City of Chicago Emissions Trends

From 2000 to 2005, the city of Chicago's emissions increased by 1.5 $MMTCO_2e$, primarily as a result of a net increase in building-related energy emissions. The building energy emissions increase is due to a large rise in electricity-related emissions. From 2005 to 2010, in contrast, the city of Chicago's emissions declined by 2.7 $MMTCO_2e$, primarily due to lower building energy emissions in 2010 with reductions in both electricity and natural gas emissions. The overall emissions trend from 2000 to 2010 is a decrease of greenhouse gas emissions of approximately 1.2 $MMTCO_2e$.

Figure ES-4 compares total GHG emissions for the city of Chicago for the years 2000, 2005, and 2010, by emissions sector.

[2] For reference, total U.S. GHG emissions decreased by 6.7% from 2000 to 2009 (U.S. Environmental Protection Agency 2011c)

Figure ES-3. Chicago Region GHG Emissions by Sector for 2010 and 2020 Forecast

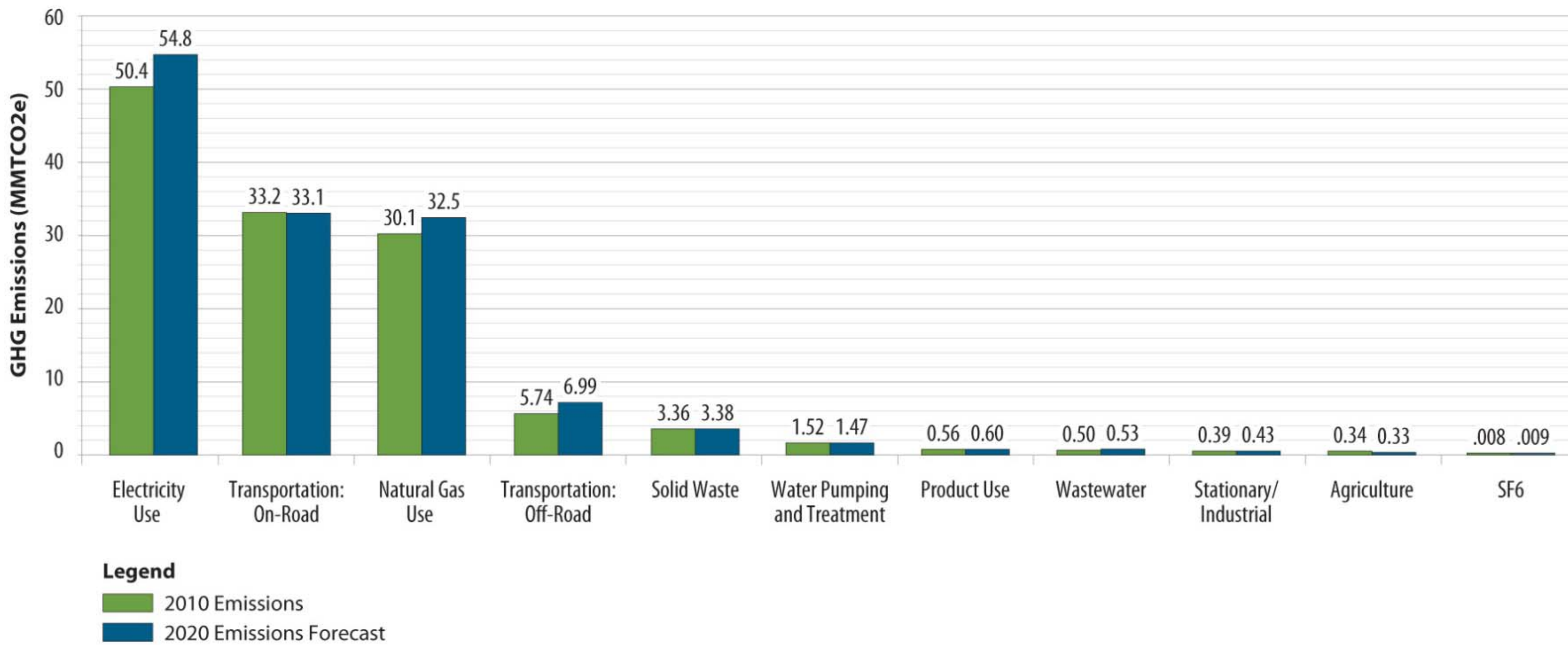
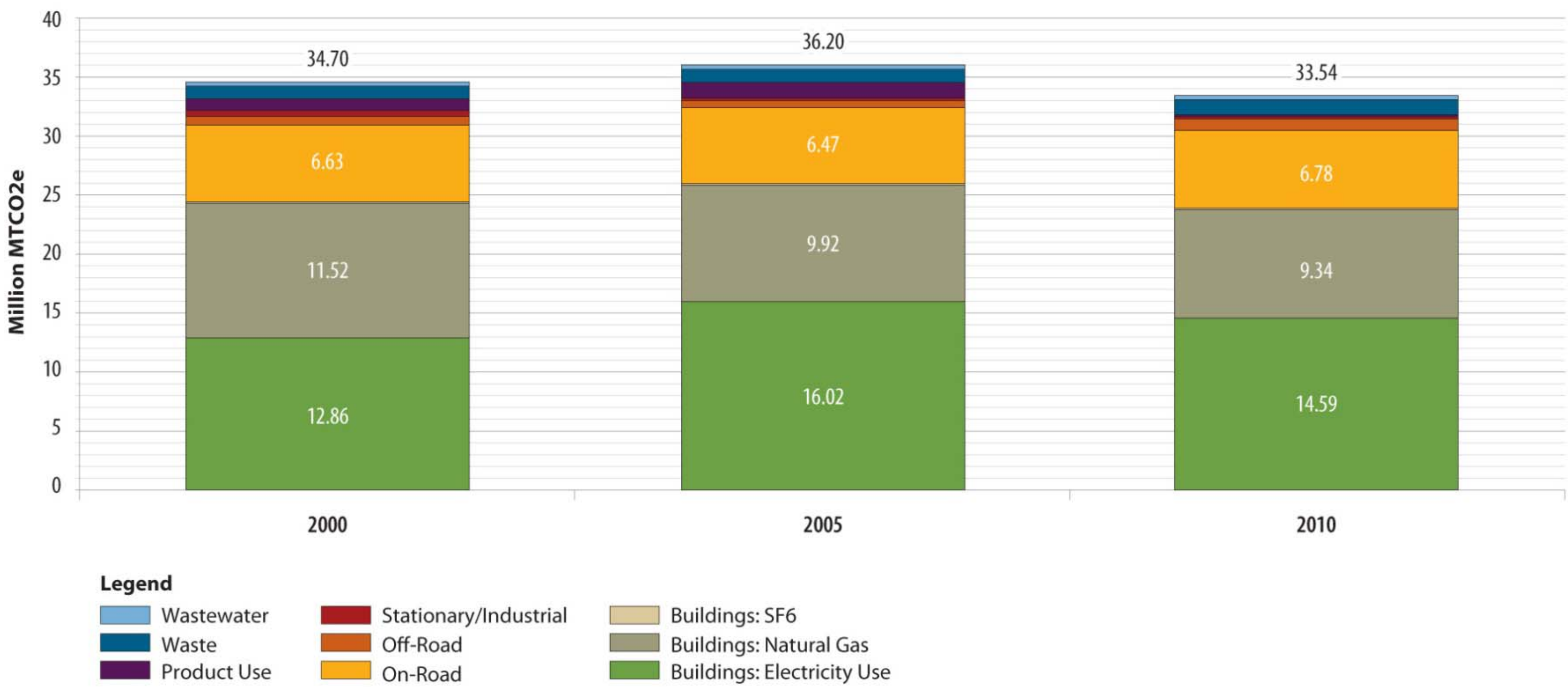


Figure ES-4. Chicago Emissions by Sector for 2000, 2005, and 2010



City of Chicago Overall Trends from 2000 to 2010

The key causes of lower emissions in 2010 relative to 2000, excluding changes in inventory methodology, include a decrease in natural gas sector emissions, correlated with a decrease in residential natural gas consumption; population and employment decreases resulting in reduction in energy consumption; and minor weather differences between the two years. Changes in inventory calculation methodologies for SF_6, stationary, industrial and product use, and wastewater emissions also contributed to a lower inventory in 2010 than in 2000. The overall decrease in emissions for the city of Chicago from 2000 to 2010 occurred despite increases in emissions from the building electricity, on-road transportation, off-road transportation, and waste sectors over this period, some of which were influenced by changes in inventory methodology. Population declined in the city of Chicago from 2000 to 2010 at a rate greater than the reduction in GHG emissions, resulting in a net increase from 2000 to 2010 in per capita greenhouse emissions.

City of Chicago Overall Trends from 2005 to 2010

The key causes of lower emissions in 2010 compared to 2005, excluding changes in inventory methodology, are as follows: increase use of relatively cleaner sources of electricity; a decrease in population; a long-term decline in residential natural gas use (due to combination of more efficient use, housing turnover and long-term price trends), residential and commercial building retrofits; minor weather differences between the two years; and a small decline in employment.

The overall lower emissions for the city of Chicago in the 2010 inventory compared to the 2005 inventory occurred for similar primary causes as that noted above for 2000 to 2010 in regards to declining natural gas consumption and population and employment decreases. In addition, building energy emissions also declined from 2005 to 2010, due to a change in the resource mix used to generate electricity in the region that serves Chicago to relatively cleaner sources[4] and a small decrease in electricity consumption. Changes in inventory methodology for stationary/industrial sources and product use, and wastewater also contributed to lower emissions in 2010 than 2005. The overall decrease in emissions for the city of Chicago from 2005 to 2010 occurred despite increases in emissions from the on-road transportation, off-road transportation and waste sectors, all of which were influenced by changes in methodology. Population declined in the city of Chicago from 2005 to 2010 although not as quickly as the emissions decline, resulting in a decrease from 2005 to 2010 in per capita greenhouse gas emissions.

A sensitivity analysis was done for the city of Chicago 2005 inventory to examine whether the overall trend of decreasing emissions from 2005 to 2010 is real or is due to methodological changes in specific inventory sectors. The conclusion of the sensitivity analysis is that the 2005 inventory would likely be slightly higher than currently estimated if the 2010 methodologies were used to update the 2005 inventory. Excluding methodology changes, 2010 emissions would be approximately 8% lower than 2005 estimated emissions (compared to a 7% decrease comparing the actual 2005 CNT inventory and the 2010 inventory). The following key trends can be identified when comparing the estimated 2005 inventory (adjusted to exclude methodological differences) to the 2010 inventory:

[4] The resource mix used to generate electricity changed from 2005 to 2010 with less coal and more natural gas, nuclear and renewable used to generate electricity in the region that supplies Chicago.

- Electricity emissions (3.8% of overall decrease) - Emission decreased primarily due to an increase in use of relatively cleaner electricity generation sources in combination with a limited decrease in electricity consumption. The decrease of consumption was due to, in order of importance, the following: population decrease, building retrofits, a slightly warmer summer, and a slight decrease in employment.
- Natural gas emissions (3.0% of decrease) - Emissions decreased due to a reduction in natural gas consumption, which was due to, in order of importance, the following : a long-term decline in residential gas use (due to combination of more efficient use, housing turnover and long-term price trends), population decrease, building retrofits, a slightly warmer winter and a slight decrease in employment.
- Onroad emissions (0.7% of decrease) - Emissions decreased due to a reduction in vehicle-miles travelled (VMT) likely due to, in order of importance, the following: population decrease, an increase in rail transit use, and a slight decrease in employment.
- Landfill emissions (0.7% of decrease) - Emission decreased due to a reduction of waste disposal due to increased methane capture and reduced landfill methane generation. Landfill methane generation decreased due to a combination of population and employment decreases, increased waste diversion efforts, aging of existing landfill waste.

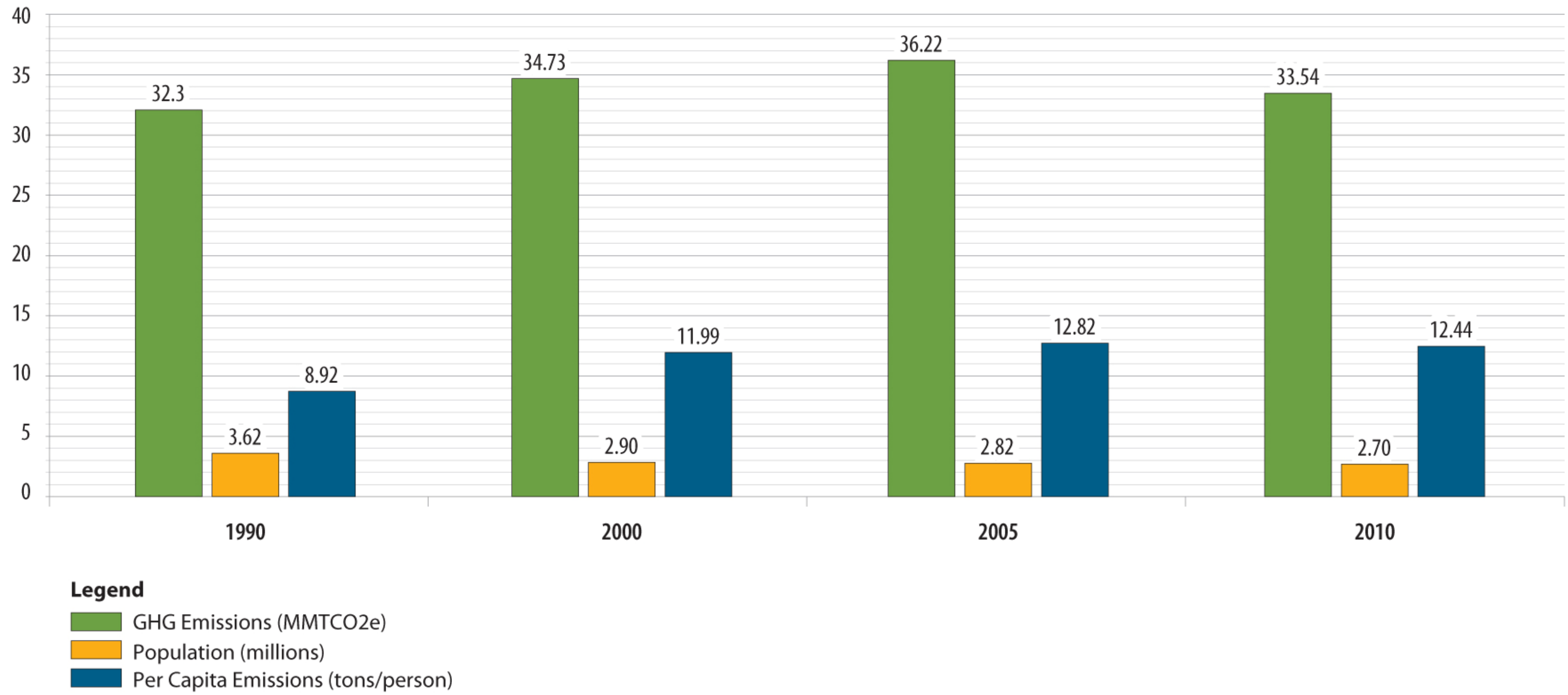
Figure ES-5 illustrates how total and per capita emissions have changed from 1990 to 2010 for the city of Chicago.

Contribution of the Chicago Climate Plan to Chicago Trends from 2005 to 2010

The Chicago Climate Action Plan (CCAP) was adopted in September 2008. The plan focuses on five primary strategies to reduce greenhouse gas emissions and prepare for climate change impacts. These five strategies areas were reviewed in terms of the actions taken to date and their relation to the recent trends identified in this report. Actions taken to date under CCAP are based on information contained in the CCAP Progress Report (City of Chicago 2010) as well as information provided by the city.

- *CCAP Strategy 1: Energy Efficient Buildings*. From 2008 through the third-quarter of 2011, there have been approximately 73,000 residential retrofit projects and over 3,500 commercial and industrial building retrofit projects for energy efficiency that are estimated to have saved nearly 134,000 $MTCO_2e$ of greenhouse gas emissions.
- *CCAP Strategy 2: Clean and Renewable Energy Sources.* Recent initiatives by the City of Chicago supporting renewable energy have included installation of solar and wind energy projects and purchases of renewable energy. The urban solar plant (a partnership of the City, Exelon, and Sunpower) and CPS renewable energy purchase initiatives by Chicago Public Schools could be offsetting approximately 79,000 $MTCO_2e$/year.

Figure ES-5. City of Chicago GHG Emissions, Population, and Per Capita Emissions (1990–2010)[5]



[5] City of Chicago 1990 data is provided in Center for Neighborhood Technology 2010, and estimated based on a "back-cast" of current emissions levels as opposed to an actual inventory of emissions as has been done for 2000, 2005, and 2010. Comparison between inventories and a back-cast is subject to some uncertainty.

- *CCAP Strategy 3: Improved Transportation Options.* From 2005 to 2010, CTA ridership increased by approximately 5% contributing to an overall vehicle miles traveled (VMT) decrease from 2005 to 2010. In addition, the City is promoting alternative fuel vehicles and infrastructure. Although transit ridership declined in 2010 relative to 2008 (due to service cutbacks resultant from the economic downturn), the ongoing effort to support transit, transit-oriented development, and alternative fuel use is helping to limit and reduce transportation emissions overall.
- *CCAP Strategy 4: Reduce Waste and Industrial Pollution.* The City has been promoting waste reduction, reuse and recycle options for many years and the CCAP strategy builds on those prior efforts. Partnerships with local businesses and other entities helped to divert over 160,000 tons of waste in 2008 and 2009 and the City substantially increased the amount of recyclables collected through the Blue Cart Program in 2008 and 2009. Increased diversion of municipal solid waste from landfills due to these programs contributes to the overall reduction of landfill methane emissions.
- *CCAP Strategy 5: Adaptation.* The City has been promoting improved stormwater management which reduces the amount of wastewater treatment and associated emissions. The City has also launched the Urban Forest Agenda in partnership with the Chicago Trees Initiative to expand the urban forest which is increasing the amount of carbon sequestration in the city.

Regional Emissions Trends

Figure ES-6 illustrates the changes in total Chicago Region emissions by sector for 2000, 2005, and 2010. Figure ES-7 illustrates how total and per capita emissions have changed from 2000 to 2010.

Over the past 10 years, the Chicago Region's total emissions have increased at a faster rate than that of population, resulting in a 3% increase in the Chicago Region's per capita emissions between 2000 and 2010. However, per capita emissions decreased between 2005 and 2010.

Chicago Regional Overall Trends from 2000 to 2010

The Chicago Region's total emissions increased by approximately 7.7 $MMTCO_2e$ from 2000 to 2010, primarily due to an increase in building electricity emissions (5.0 $MMTCO_2e$, including water pumping electricity emissions), an increase in on-road transportation emissions (1.9 $MMTCO_2e$), and an increase in off-road transportation emissions (4.2 $MMTCO_2e$). These increases were partially offset by large decreases in the stationary, industrial and product use sectors due to inventory methodology changes. The emissions increases were also offset by decreases in emissions from several minor sectors (including wastewater and agriculture emissions) and due to elimination of the propane and fuel heating sector from the 2010 inventory.

The increase in building electricity emissions from 2000 to 2010 is positively correlated with an increase in the number of households and the population in the Chicago Region over the same time period. The on-road transportation emissions increase is due to both an increase in VMT from 2000 to 2010 and due to changes in modeling methodology to more accurately reflect vehicle types and congestion effects in the Chicago Region. The large increase in off-road transportation emissions is due to a change in inventory methodology to include off-road equipment (in addition to rail) in the 2010 inventory, which was not included in the 2000 inventory.

Figure ES-6. Total Chicago Region GHG Emissions by Sector in 2000, 2005, and 2010

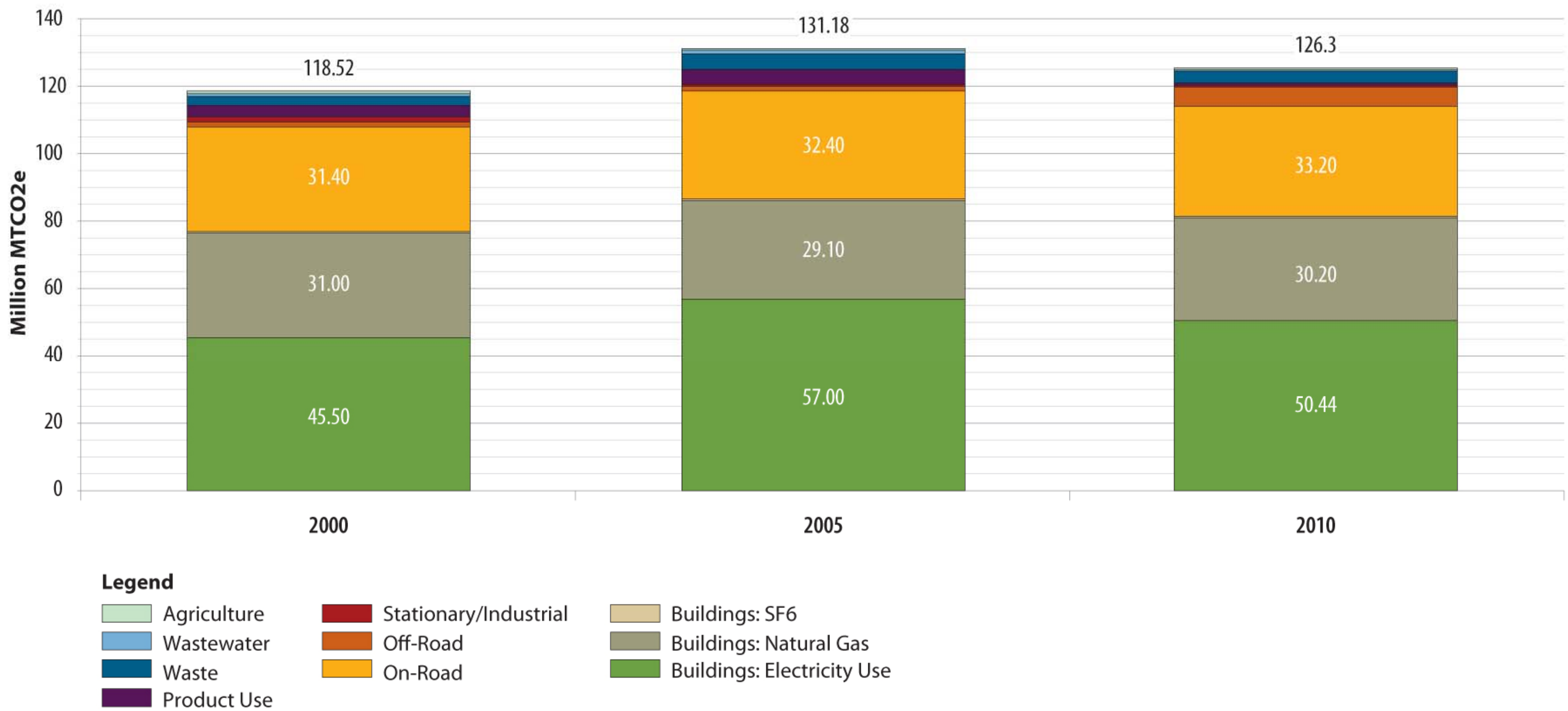
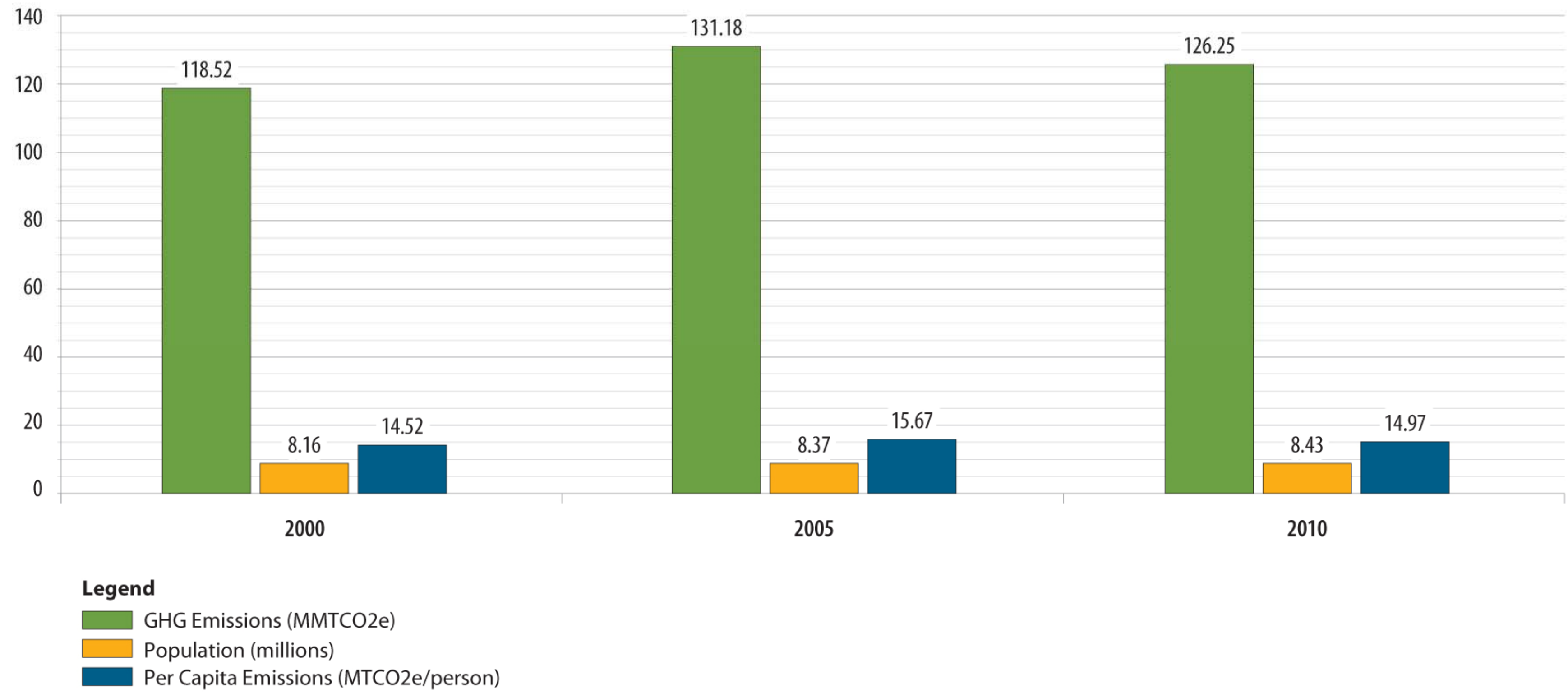


Figure ES-7. Chicago Region GHG Emissions, Population, and Per Capita Emissions (2000–2010)



Emissions for all counties except for Cook County increased from 2000 to 2010. Cook County emissions decreased approximately 2% from 2000 to 2010. Emissions in Kendall County increased the most (53%) of all other counties, while emissions in DuPage County increased the least (5%) of all other counties. These changes appear to be correlated with changes in population. Specifically, Kendall County's population increased the most of all counties during these years, while DuPage County population increased the least of all counties.

Total Chicago Region per capita GHG emissions also increased from 2000 to 2010. This increase is correlated with a rise in per capita building electricity emissions and per capita on-road transportation emissions. The per capita building electricity emissions increase is correlated with a per capita increase in building electricity consumption. As noted above, increasing per capita on-road transportation emissions is due to a combination of an increase in VMT as well as a change in modeling methodology.

Chicago Regional Overall Trends from 2005 to 2010

In contrast to the 2000 to 2010 trend, the Chicago Region's total emissions decreased by approximately 5.7 $MMTCO_2e$ (4%) from 2000 to 2010. This is primarily due to an 11% decrease in building energy electricity emissions. This decrease in building electricity emissions is due to a 4% decrease in electricity consumption and an 8% decrease due to a change in the electricity generation resource mix (as noted above). In addition, there were large decreases in the emissions estimates for the stationary, industrial and product use sectors due to changes in inventory methodology. These decreases were offset partially by increases in the on-road and off-road transportation emissions, both of which are due in large part to changes in inventory methodology. Other changes included decreases in emissions from several minor sectors (including wastewater and agriculture emissions) and elimination of the propane and fuel heating sector from the 2010 inventory.

Forecasts

In order to establish the "business as usual" future emissions trajectory of the city of Chicago and each county in the Chicago Region, in the absence of new policy to reduce GHG emissions, GHG emissions for these jurisdictions were forecast in 10-year increments from the 2010 base year to 20202, 2030, 2040, and2050 and by emissions sector (Figure ES-8 and ES-9). Emissions forecasts for each sector are based primarily on socioeconomic and demographic projections data from the CMAP GOTO2040 Plan (Chicago Metropolitan Agency for Planning 2011), specific to the city and each county.

The Chicago Region's total emissions are forecasted to grow by 28% from 2010 to 2050, with an annual average growth rate of 0.9%. Total emissions growth in the Chicago Region is correlated with an increase in regional population, employment, and housing over this time period. The regional emissions sector expected to grow the most between 2010 and 2050 is building energy. Regional emissions from off-road transportation, solid waste, wastewater treatment, and water consumption are also predicted to increase, as these sectors are correlated with socioeconomic growth, which is projected to increase. In contrast, on-road transportation emissions are predicted to decrease, as vehicle fuel efficiency is anticipated to outpace growth of VMT. Agricultural emissions are anticipated to decline as agricultural acreage decreases in the Chicago Region.

Figure ES-8. City of Chicago and Chicago Region (by County) GHG Emissions Forecasts for 2020, 2030, 2040, and 2050

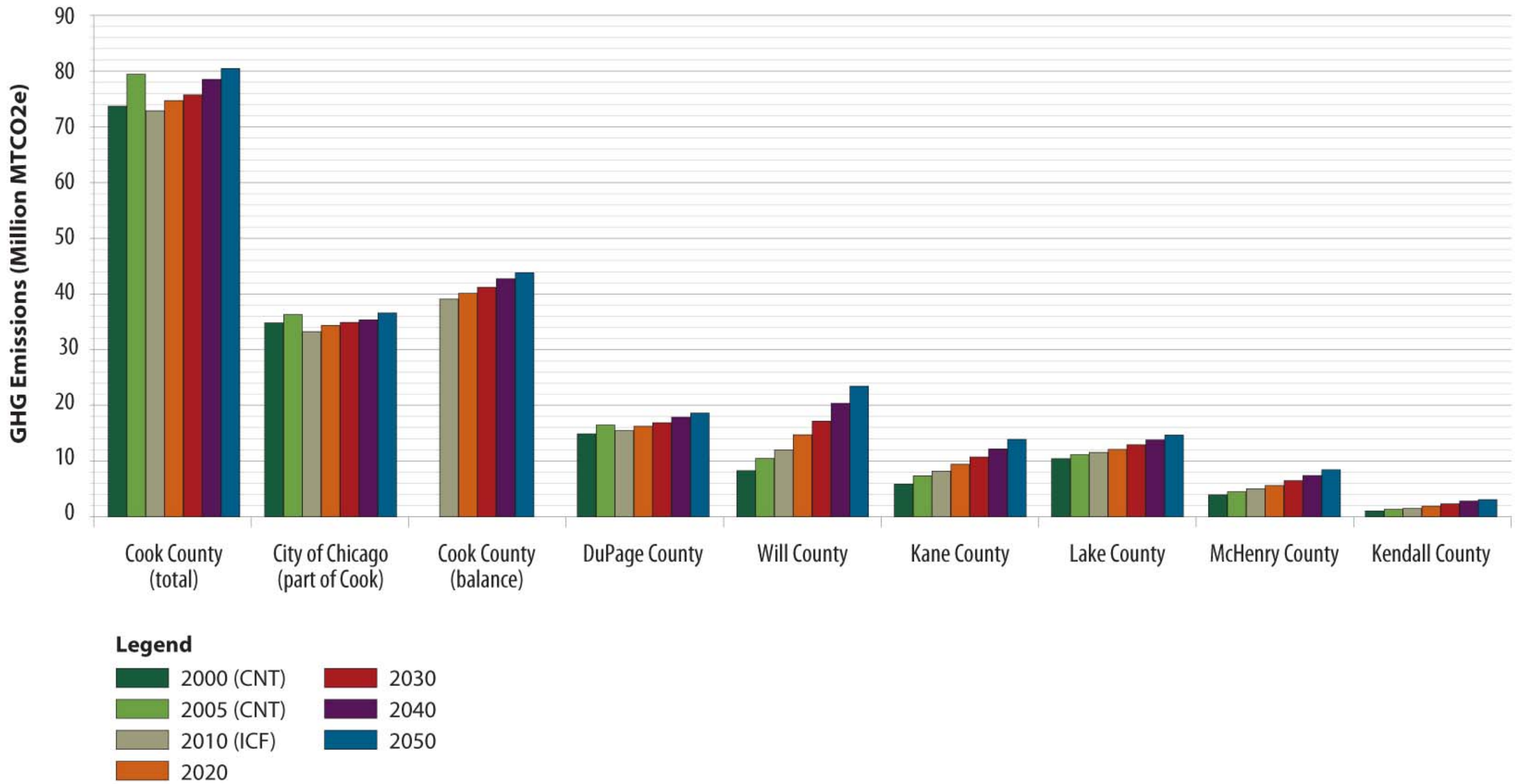
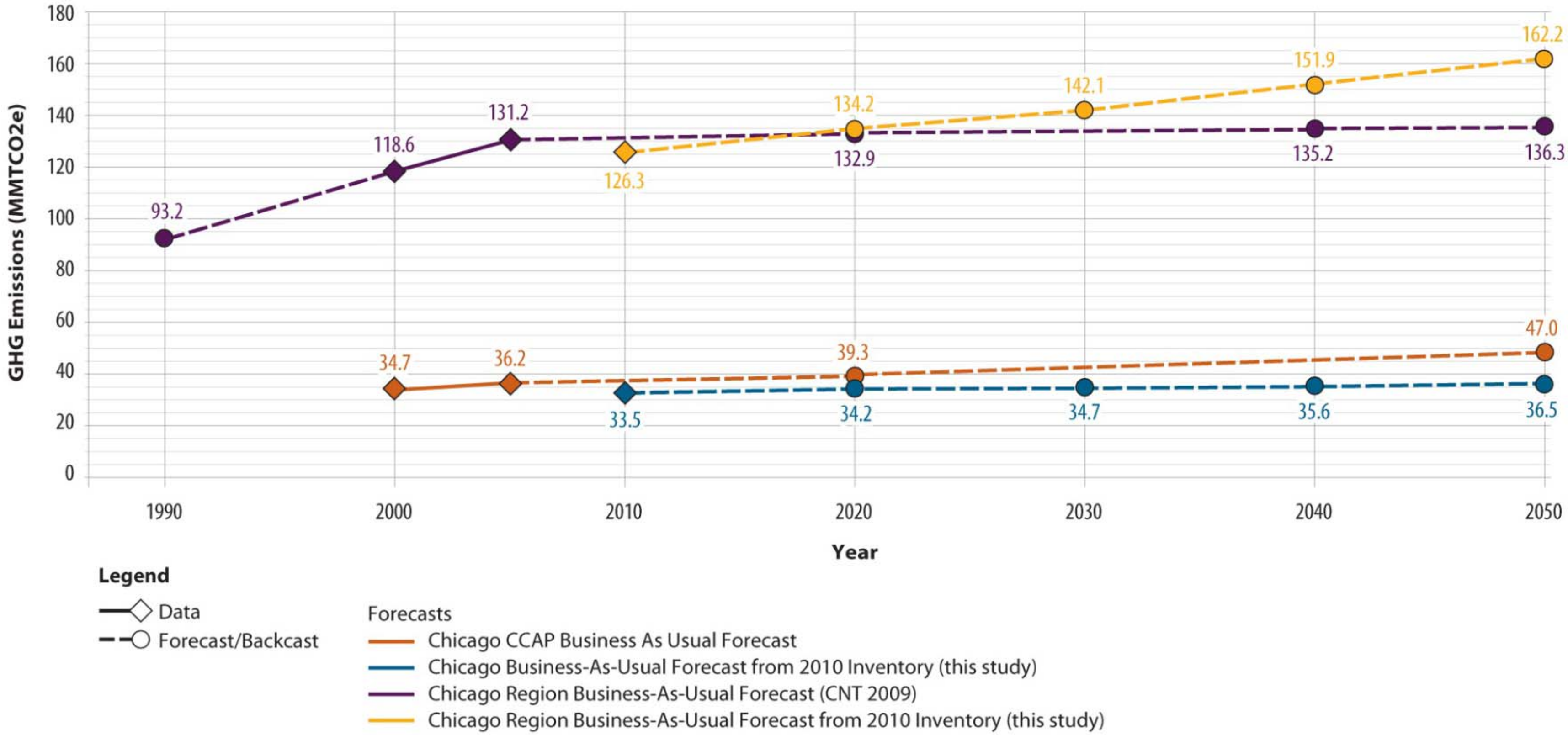


Figure ES-9. City of Chicago and Chicago Region GHG Emissions Forecasts for 2020, 2030, 2040, and 2050



Comparative Analysis of Emissions

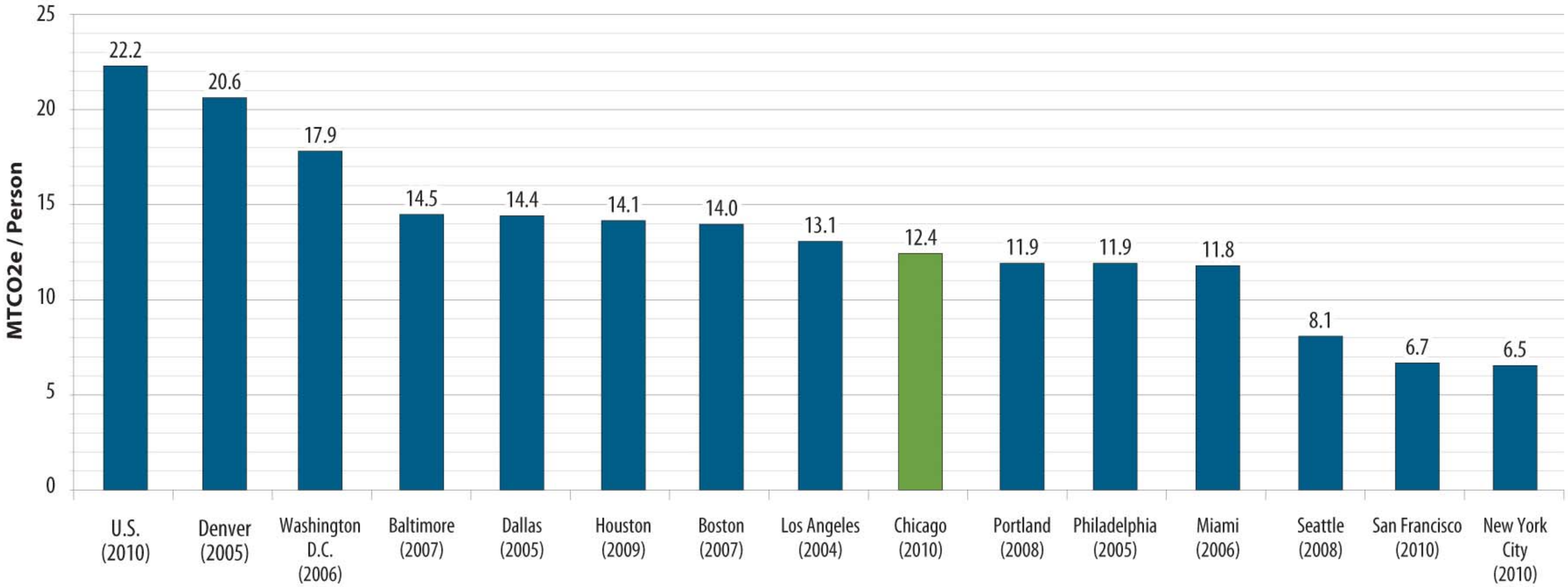
Emissions results for the city of Chicago and the Chicago Region in 2010 were compared to other similar cities and counties, regions, and the U.S. average in regard to per capita emissions and electricity and natural gas consumption. Qualitative comparisons were also made in regards to relative differences in transportation activity. As methods for estimating emissions may differ between these inventories, this comparative analysis may be used to establish only overall rough differences between the geographic entities.

The comparative analysis yields the following conclusions, which are discussed in greater detail in Chapter 6 of this report.

- Per capita GHG emissions for the city of Chicago are lower than statewide and national per capita emissions, and represent a midpoint among other large cities included in this analysis.
- Per capita GHG emissions for the Chicago Region are lower than statewide and national per capita emissions, and are similar to other large regions included in this analysis.
- Per capita electricity use for the city of Chicago is lower than national per capita electricity use and is lower than the midpoint of comparable large U.S. cities.
- Chicago's use of alternative transportation other than personal automobiles is greater than national levels and at approximately the midpoint of comparable large U.S. cities.
- Between 2005 and 2010, Chicago's emissions decreased faster than national emissions, while Chicago per capita emissions decreased at a rate approximately half than of the national per capita emissions because Chicago had a decrease in population over this period while the national population grew.

As shown in Figure ES-10, Chicago's 2010 per capita emissions value is lower than that of several other large U.S. cities (of various inventory years), including: Los Angeles, Boston, Houston and Denver, slightly higher than Philadelphia, Miami, and Portland, and higher than New York city, San Francisco, and Seattle.

Figure ES-10. City of Chicago GHG Emissions per Capita Compared to Other Cities



Carbon Stock and Sequestration Analysis

ICF prepared estimates of carbon stored and annually sequestered by different land covers in the Chicago Region in 2010. Land covers included in this analysis are forests (urban and natural), grassland, shrub/scrub land, wetlands, and agriculture. ICF utilized multiple data sets to estimate carbon stock and sequestration in trees and other land covers, including the results of a recent tree census prepared by the Morton Arboretum, Chicago Region land use mapping, national land cover mapping data for the region, and stock and sequestration factors.

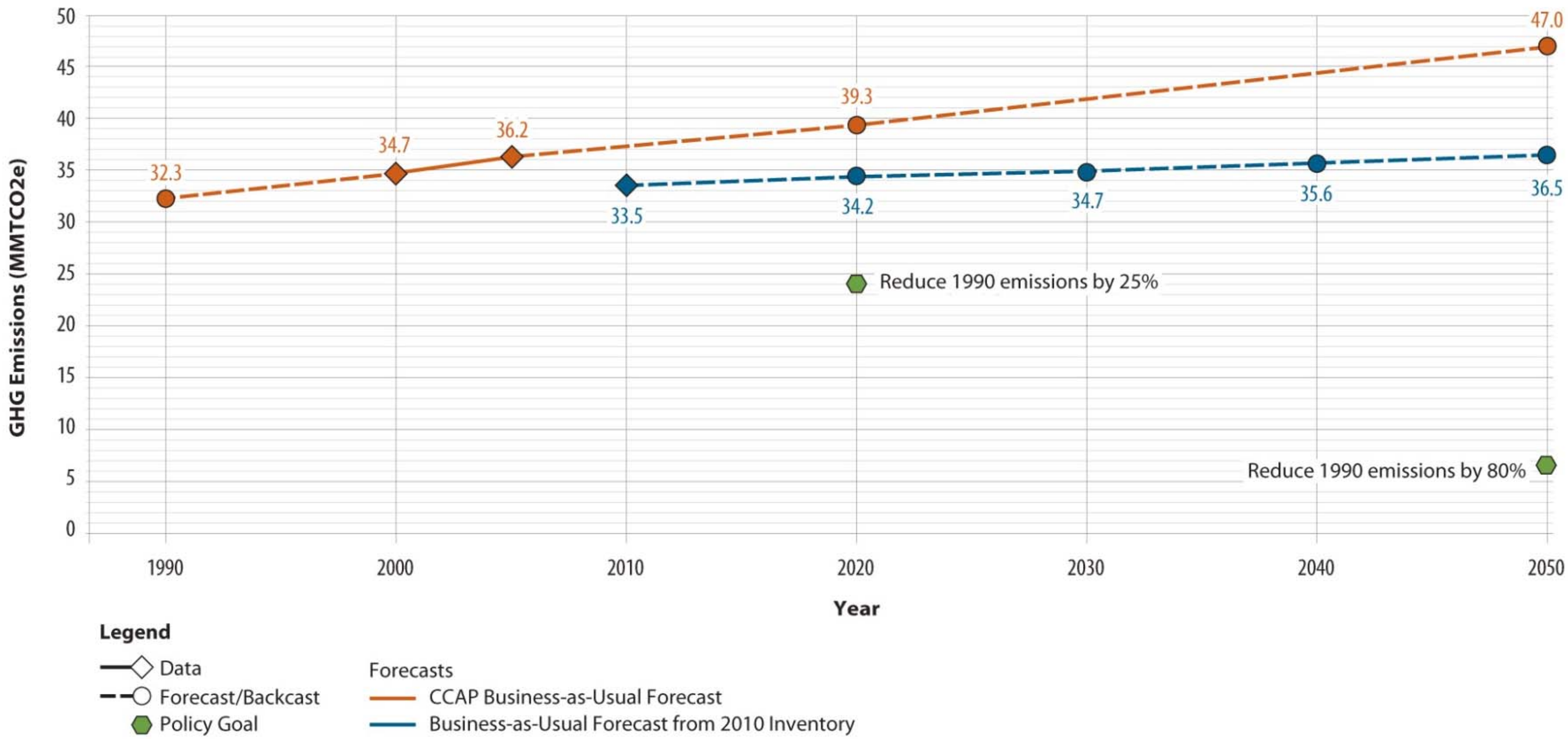
The sequestration analysis conducted for the Chicago Region indicates that there is an estimated 49 million metric tons of carbon stored in vegetation within the Region (equivalent to approximately 180 $MMTCO_2$ in the atmosphere). Further, annual carbon uptake by vegetation in the Chicago Region is approximately 430,000 metric tons of carbon (equivalent to approximately 1.6 $MMTCO_2$ in the atmosphere). On an annual basis, the amount of carbon sequestered by vegetation represents approximately 1.3% of total Chicago Region GHG emissions by all sectors.

GHG Inventory Efforts and Climate Planning in the Chicago Region

The first step in reducing GHG emissions is to understand the scope, scale, and source of the emissions. Consequently, the Global Philanthropy Partnership (GPP) commissioned a study in 2007–2008 to the CNT to develop the GHG emissions inventory for Chicago and the Chicago Region for 2000 and 2005. The results of this study are documented in two separate inventory reports (Center for Neighborhood Technology 2009, 2010), as referenced above and throughout this Report. The CNT inventory reports also included a "business-as-usual" (BAU) emission forecast to 2020 and an emission back-cast to 1990 (Center for Neighborhood Technology 2010). The City of Chicago has made a commitment to reduce its emissions in its 2008 CCAP (City of Chicago 2008). The CCAP provides a "road-map" of the City's goals and plans with regards to achieving GHG reductions by 2020, including climate mitigation and adaptation measures. Specifically, the City's CCAP sets a target or goal of reducing the city's community-wide GHG emissions by 25% below 1990 levels by 2020 (as well as interim targets and a 2050 target). GHG emissions were approximately 32.3 $MMTCO_2e$ in 1990 (Center for Neighborhood Technology 2010); the 2020 target is approximately 30% below 2000 emissions levels (34.7 $MMTCO_2e$), 33% below 2005 emissions levels (36.2 $MMTCO_2e$), and 28% below 2010 emissions levels (33.5 $MMTCO_2e$). The Progress Report for the CCAP summarizes the achievements the City has made in the first 2 years of implementing the CCAP (City of Chicago 2010).

The City has made considerable progress towards achieving its emissions target for 2020, since emissions levels have declined overall since 2000. However, if the city's emissions continue to increase from 2010 emissions levels, as estimated in this report, approximately 10 MMTCO_2e additional reductions would be needed to achieve the CCAP 2020 emissions goal (this is approximately 5 MMTCO_2e lower than that estimated in Center for Neighborhood Technology 2010). In other words, by 2020, if Chicago were to implement no additional mitigation actions after 2010, it will have met approximately 34% of its 2020 reduction target. Figure ES-9 illustrates the City's emissions reduction progress achieved and the additional reductions needed to meet the CCAP targets. Specifically, Figure ES-11 shows the BAU emissions forecast for the city (as prepared by CNT) and the emissions forecast conducted by ICF for this study (based on 2010 emissions levels), and the City's CCAP targets.

Figure ES-11. City of Chicago CCAP Reduction Goal Compared to Business-As-Usual Forecast and Revised Emissions Forecasts



Chapter 1
Background

Chapter 1
Background

Greenhouse Gases, the Greenhouse Effect and Climate Change

The Earth's temperature is regulated by a system commonly known as the greenhouse effect. GHGs absorb heat radiated from Earth's surface. As the atmosphere warms, it in turn radiates heat back to the surface to create the greenhouse effect. According to the USEPA, a GHG is any gas that absorbs infrared radiation and traps heat in the atmosphere (U.S. Environmental Protection Agency 2011c).

The Kyoto Protocols defines the following six GHGs:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Sulfur hexafluoride (SF_6)
- Halogenated fluorocarbons (HFCs)
- Perfluorocarbons (PFCs)

GHGs are both naturally occurring and anthropogenic (i.e., human-made). Once emitted, GHGs remain in the atmosphere for decades or centuries and therefore can mix globally. Natural sources of GHGs include decomposition of organic matter and wildfires. Many human activities add to the levels of naturally occurring gases. CO_2 is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned. N_2O is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.

Atmospheric carbon dioxide concentrations have increased by 35% over the last two centuries.

The largest global accumulation of GHGs historically (and expected to continue into the future) is CO_2. CO_2 and N_2O are the two GHGs released in the greatest quantities from mobile sources burning gasoline and diesel fuel. CH_4, a highly potent GHG, results from off-gassing associated with agricultural practices and landfills, among other sources. HFCs and PFCs are families of synthetic chemicals that are used as substitutes for ozone depleting substances (ODS) being phased out under the Montreal Protocol. SF_6 is used in the electric transmission and distribution systems, as well as various industrial manufacturing processes.

As the global, national, and statewide population and economy continue to grow, anthropogenic emissions of GHGs continue to increase largely as a result of the increase in burning of fossil fuels. The associated increase in atmospheric concentrations of GHGs will cause a variety of adverse environmental impacts related to large-scale changes in the climate system. According to the CCAP, climate change impacts of greatest concern for Chicago could include: hotter summers, more frequent and intense heat waves, heavy rains and snow, and reduced plant hardiness zone (City of

Chicago 2008). Higher temperatures could boost demand for electricity and put stress on power plants. Increased intensity of downpours could make travel more dangerous, flood basements, pollute bodies of water, damage crops, stress infrastructure and disrupt transportation. During summer, rains may fall more heavily but less frequently, translating to more dry spells. Chicago's native ecosystems could change as well. Chicago's present plant hardiness zone has already shifted to that of central Illinois in 1990 correlated to a changing climate. Plants could diminish in number, and new plant and insect pests could survive in the Chicago Region's climate.

Overview of the Chicago Metropolitan Region

For inventory purposes, current and projected GHG emissions are correlated with activity within a particular jurisdictional boundary. As such, emissions reflect the unique geography, climate, demographics, economy, and character of a jurisdiction's community. Further, future projections of GHG emissions reflect how the community plans to grow with respect to housing, jobs and infrastructure. A relevant description of the Chicago Metropolitan 7-County region (referred to in this report as Chicago Region) follows below.

The Chicago Region covers more than 3,900 square miles on the flat Central Lowlands area of the Mid-West and includes Cook, DuPage, Kane, Kendall, Lake, McHenry and Will Counties (U.S. Census Bureau 2010a). The city of Chicago sits on a flat plain that has relatively little topographical relief. North of the city of Chicago, there are steep bluffs and ravines that run along Lake Michigan. The area south of the city of Chicago is marked by sand dunes, while a series of hilly moraines is located further inland. Chicago's climate is typically continental with cold winters, warm summers, and frequent short fluctuations in temperature, humidity, cloudiness, and wind direction. Lake Michigan provides a moderating influence on temperature while boosting the amount of snowfall received in the city of Chicago. The Chicago Region receives a wide variety of types and amounts of precipitation.

The Chicago Region is home to 55 incorporated cities and 227 incorporated villages. As shown in Table 1-1, Cook County is the most populous county in Illinois, as it includes Chicago (2.9 million residents in 2000). The Chicago Region had a population of 8.1 million as of 2000, with Chicago residents comprising 36% of that total. According to the U.S Census (U.S. Census Bureau 2011), the Chicago Region's population grew 4% between 2000 and 2010, from 8.1 to 8.4 million, while Chicago's population fell by 7% over that same period (from 2.9 to 2.7 million), such that Chicago's population represented 32% of the Chicago Region's population in 2010. CMAP's population projection for the Chicago Region estimates that Chicago's population will fall to approximately 30% of the Chicago Region's total population in 2040 (Chicago Metropolitan Agency for Planning 2011).

Table 1-1. Demographic Data for the Region (2000, 2010, and 2040)

	Population			Households		
County	U.S. Census 2000	U.S. Census 2010	CMAP Projected 2040	U.S. Census 2000	U.S. Census 2010	CMAP Projected 2040
City of Chicago	2,896,016	2,695,598	3,247,621	1,061,928	1,045,560	1,212,328
Cook (w/Chicago)	5,376,861	5,194,675	6,001,375	1,974,181	1,966,356	2,240,052
DuPage	906,576	916,924	1,131,072	325,601	337,132	409,958
Kane	407,511	515,269	824,129	133,901	170,479	278,026
Kendall	55,217	114,736	201,398	18,798	38,022	69,979
Lake	648,116	703,462	975,409	216,297	241,712	333,207
McHenry	261,887	308,760	542,734	89,403	109,199	186,978
Will	508,038	677,560	1,243,728	167,542	225,256	417,241
7 County Region	8,164,206	8,431,386	10,919,845	2,925,723	3,088,156	3,935,441

Source: U.S. Census Bureau 2011; Chicago Metropolitan Agency for Planning 2011

The Chicago metropolitan area is home to the corporate headquarters of 57 Fortune 1000 companies, including Boeing, McDonald's, Motorola, Discover Financial Services and United Airlines, representing a diverse group of industries. The area is a major financial center in North America, and is home to the largest futures exchange in the United States, the CME Group.

Objectives of this Study

As part of the process of implementing and measuring the progress of the CCAP, the City of Chicago and CMAP believe it is important to regularly evaluate the Chicago Region's scope, scale and source of GHG emissions. Conducting the community-wide 2010 GHG inventory for the city of Chicago and the Chicago Region presents an opportunity to improve upon earlier methodologies in order to enhance the accuracy of inventory data and to reduce uncertainties in the emissions calculations.

The main purpose of this study is to develop an emissions inventory for 2010 for both the city of Chicago and the Chicago Region. This study is intended to demonstrate how Chicago and the Chicago Region's GHG emissions have changed from 2000 to 2010 as well as to gain insight as to the drivers of these changes so as to inform current and future policy aimed at reducing GHG emissions. The 2010 Regional GHG Inventory incorporates the data, metrics, and methodologies utilized to develop a comprehensive community inventory for Chicago and the Chicago Region.

Study Description

The community-wide 2010 GHG inventory for the city of Chicago and the Chicago Region (referred to throughout this report as the"2010 Regional GHG Inventory") includes the following jurisdictions: the city of Chicago and Cook, Will, DuPage, Kane, Kendall, McHenry, and Lake Counties. The 2010

Regional GHG Inventory includes GHG emissions occurring *within* the geographic boundaries of the city of Chicago and each of these seven counties in the Chicago Region. It also includes emissions that occur *outside* of these counties that result from community activities *within* the geographic boundaries. For example, emissions are included if the activity resulting in emissions occurs within the jurisdiction, such as electricity consumption or waste generation, even though the emissions associated with these activities typically occur outside of the jurisdiction.

The 2010 Regional GHG Inventory results are described in detail in this report. Specifically, this report includes:

- 2010 Regional GHG Inventory results, including methodology and data sources employed to develop the 2010 GHG Regional Inventory as well as a comparison to methods utilized for the 2000 and 2005 inventories.
- An analysis of emissions trends for Chicago and the Chicago Region from 2000 to 2010.
- A comparison of Chicago and the Region's 2010 emissions to that of other jurisdictions and regions in the United States.
- A forecast of the 2010 Regional GHG Inventory emissions for ten-year increments beyond 2010 and up to 2050.
- A carbon stock and sequestration analysis and methodology for 2010.

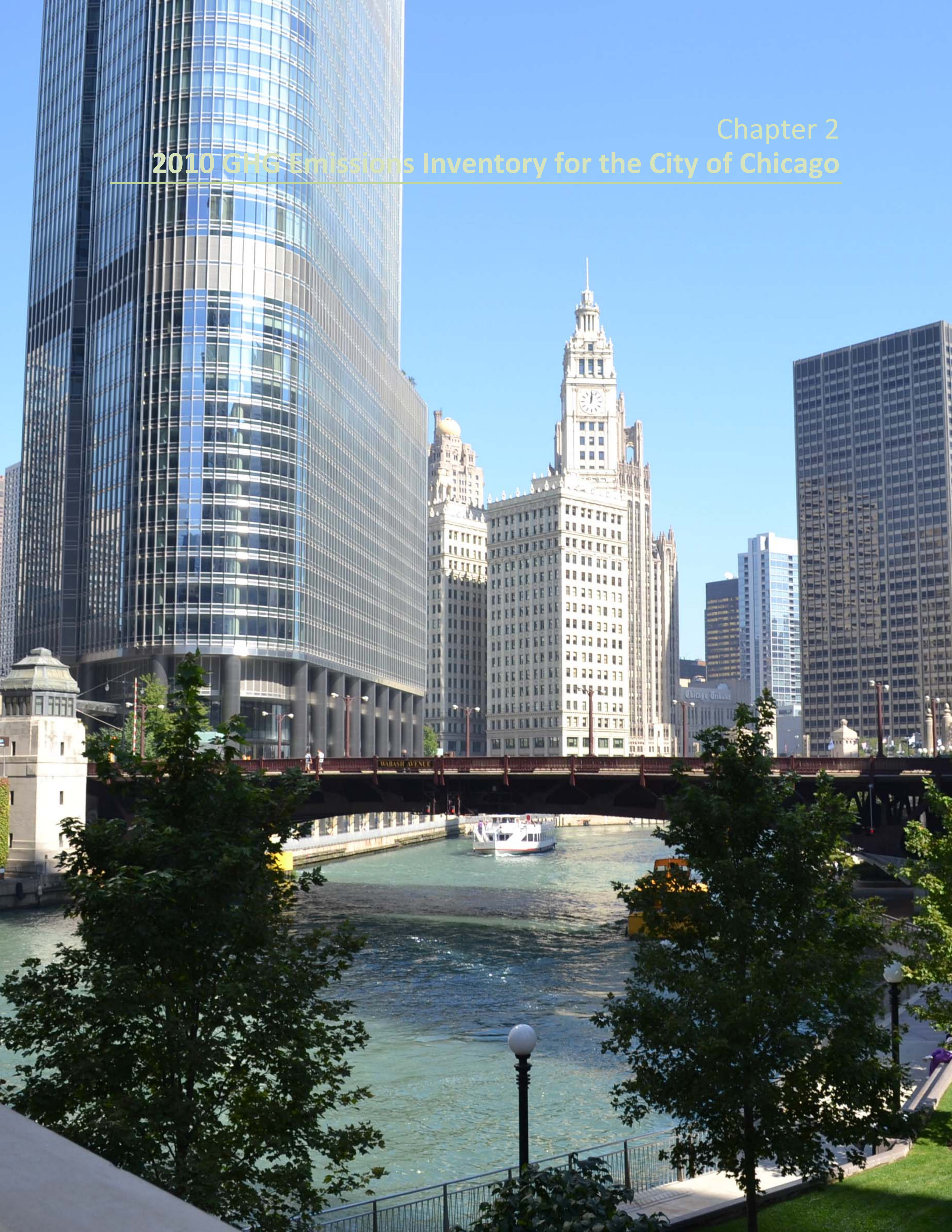
The following is a list of the emissions sectors included in the 2010 Regional GHG Inventory, including a brief definition of each sector.

Table 1-2. 2010 Regional GHG Inventory Emissions Sectors and Definition

Sector	Definition of Sector Emissions
Building Energy	Direct emissions from natural gas consumption and indirect emissions from electricity consumption, relevant to residential, commercial, and industrial buildings or facilities. Indirect emissions from electricity consumption occur as a result of combustion of fossil fuels at power plants. SF_6 leakage from electrical transmission and distribution lines.
On-Road Transportation	Emissions in this sector are due to the combustion of fossil fuels (such as diesel and gasoline) used to power on-road vehicles, including on-road public transit vehicles (e.g., buses).
Off-Road Transportation	Emissions from rail and off-road vehicles and equipment operating in the Chicago Region. Rail sources include the "L" elevated heavy rail operated by CTA, commuter rail operated by Metra, intercity passenger rail operated by Amtrak, and freight rail operated by multiple rail companies. Off-road equipment types include residential (e.g., lawn and garden), commercial (e.g., transportation refrigeration units), and industrial (e.g., construction, agriculture, and mining) categories.
Solid Waste	Methane emissions that result from the decomposition of waste in landfills, due to waste generated by the communities in the Chicago Region.
Stationary, Industrial and Product Use	This emissions sector includes the following components: 1) emissions from stationary (typically industrial) combustion of fossil fuels of any type (except natural gas, which is included in the building energy use sector), 2) refrigerant emissions from commercial and residential buildings, and 3) emissions from consumer product use.

Sector	Definition of Sector Emissions
Wastewater	Emissions are associated with the treatment of industrial, residential, and commercial wastewater produced by community activities in the city of Chicago and the counties in the Chicago Region. These emissions result from the energy consumed to operate each wastewater reclamation plant (WRP) serving each community (indirect emissions) as well as fugitive emissions of CH_4 and N_2O that occur during wastewater treatment and processing (direct emissions).
Water	Emissions from water consumption result from the energy associated with the city of Chicago and the Chicago Region's local water treatment and distribution system. Water consumption emissions also result from energy used to transport, treat, and pump water from *outside* each jurisdiction in the Chicago Region for use *within* the particular jurisdiction.
Agriculture	Emissions from agricultural activities associated with the following processes: fugitive emissions of methane and nitrous oxide from manure management, fugitive emissions of methane from enteric fermentation, and fugitive emissions of nitrous oxide from fertilizer use.

Chapter 2
2010 GHG Emissions Inventory for the City of Chicago

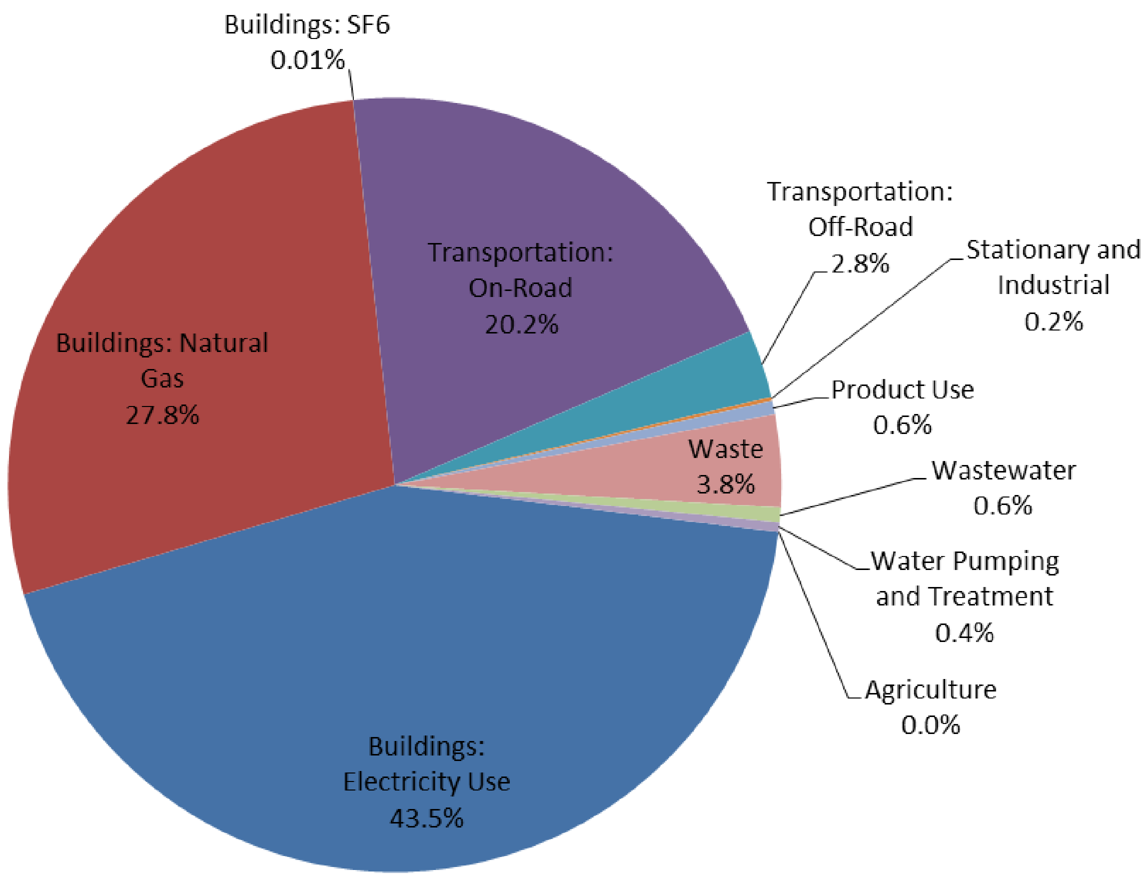


Chapter 2
2010 GHG Emissions Inventory for the City of Chicago

Summary of Emissions

In 2010, the city of Chicago emitted 33.5 $MMTCO_2e$. This is approximately 7.4% less than that emitted in 2005, as reported by CNT, and -3.4% different from that emitted in 2000 (Center for Neighborhood Technology 2009). Similar to the 2000 and 2005 emissions inventories for Chicago, Chicago's primary emissions sources in 2010 include the building energy (including emissions from both natural gas and electricity use) and on-road transportation sectors, approximately 71% and 20% respectively of city-wide emissions. Figure 2-1 provides a summary of the 2010 emissions, by inventory sector, for the city of Chicago.

Figure 2-1. Chicago 2010 GHG Emissions by Sector[6,7]



[6] Sector emissions listed as 0% are less than 1%. Actual percentages are listed Table 2-1.

[7] For consistency with the 2000 and 2005 inventories, refrigerant emissions are included in the product use category, although these emissions are calculated separately.

Emissions by Sector

This section presents the city of Chicago's 2010 GHG Inventory emissions for each sector included in the inventory. As shown in Table 2-1, these emissions sectors include: building energy; transportation; stationary, industrial, and product use; solid waste; wastewater; water; and agriculture. As listed, each sector is broken out into further sub-sectors, and provided with relevant data sources, as well as the percent contribution of each to the total inventory. Building energy emissions from electricity use contributes 43.5% of emissions in 2010, followed by building energy emissions from natural gas use (27.8%) and on-road transportation (20.2%). The next largest sources are solid waste emissions (3.8%) and off-road transportation[8] emissions (2.8%). A comparison of the 2010 emissions to 2005 is listed, indicating some significant differences for the majority of sectors. These differences are discussed in more detail in Chapter 5(regarding emissions trends). Additional discussion of each of the 2010 emissions sectors, including data sources, emissions calculations and methodologies, and data or methodology gaps is included in Chapter 4.

Local Government Emissions

The City of Chicago has been a member of the Chicago Climate Exchange (CCX), a voluntary, legally binding emissions reduction and trading program. The City has reported to CCX GHG emissions associated with its local government (or municipal) operations each year. These local government emissions (to the extent that they occur within the city's geographic boundaries) are presumed to be included in Chicago's community emissions, although these emissions are not listed in the community inventory as a separate sector. The CCX reporting program ended in 2010 due to the diminished U.S. carbon market, which is primarily due to lack of a federal cap and trade system and the unlikelihood of such a system being adopted in the near future.

In 2010, Chicago reported a total of 0.975 $MMTCO_2e$ for its local government emissions (Mazza pers. comm.). These emissions include 0.317 $MMTCO_2e$ of direct emissions (comprised of emissions from natural gas in city buildings and emissions from gasoline and diesel combustion from city transportation activities). Further, 0.658 $MMTCO_2e$ are reported as indirect emissions (such as emissions from electricity consumption). For comparison purposes, given that different methodologies and data sources were used to develop the local government and community emissions inventories for the city, total local government emissions represent approximately 3% of the community-wide GHG emissions total of 33.5 $MMTCO_2e$ for the city of Chicago in 2010. In 2000 (0.922 $MMTCO_2e$) and 2005 (1.07 $MMTCO_2e$), Chicago's local government emissions were a roughly similar share of overall community emissions (McGraw et al. 2008).

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[8] For this inventory, "off-road transportation emissions" includes emissions associated with rail, off-road residential (e.g., lawn and garden), commercial (e.g., transportation refrigeration units—TRUs), and industrial (e.g., construction and mining) equipment. Although TRUs are part of on-road trucks, associated emissions are accounted separately.

Table 2-1. City of Chicago 2010 Emissions by Sector

Sector	Subsector	Primary Data Sources for 2010 Chicago Inventory	2010 GHG Emissions ($MTCO_2e$)	Percent of Total Inventory
Building Energy	Electricity Use	Electricity use from utility billing data	14,587,504	43.5%
	Natural Gas	Natural gas use from utility billing data	9,342,068	27.8%
	SF_6	Leakage from electrical transmission and distribution (ComEd)	2,365	0.01%
Transportation	On-Road	Vehicle travel statistics (including VMT) for city	6,783,031	20.2%
	Off-Road	Regional Transportation Authority data (unpublished study for 2008), NONROAD inputs, National transit database, commuter rail fuel use, Amtrak passenger rail energy use	953,100	2.8%
Solid Waste	Waste	City annual solid waste disposal data	1,291,449	3.8%
Stationary, Industrial and Product Use	Industrial Processes	USEPA Mandatory Reporting Rule (MRR) database	53,738	0.2%
	Product Use[a]	Refrigerant data (refrigerant survey and building square footage); National emissions inventory, U.S. Census	191,176	0.6%
Wastewater	Wastewater	Emissions report from regional wastewater treatment agency	205,899	0.6%
Water	Water Pumping and Treatment	Metropolitan Water Reclamation District; Illinois Environmental Protection Agency	135,246	0.4%
Agriculture	Agriculture	U.S. Department of Agriculture, Agricultural Census, 2007	0	0.0%
Total			33,545,577	100%

[a] Refrigerant emissions are included in the product use category

Chapter 3

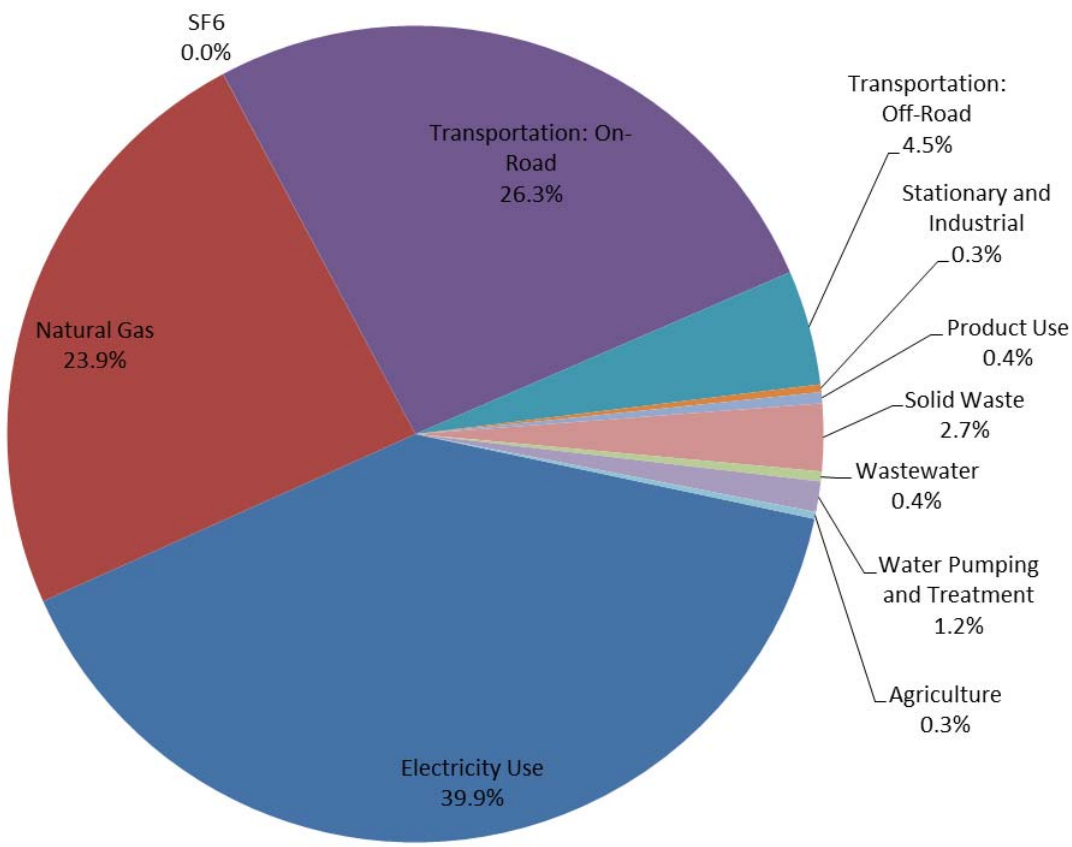
2010 GHG Emissions Inventory for the Chicago Region

Chapter 3
2010 GHG Emissions Inventory for the Chicago Region

Overall Results

In 2010, the Chicago Region emitted an estimated total of 126.3 $MMTCO_2e$. This total is approximately 3.7% less than the amount the Chicago Region emitted in 2005, but approximately 6.5% more than that emitted in 2000 (Center for Neighborhood Technology 2009). Similar to inventory results for 2000 and 2005, the Chicago Region's primary emissions sources in 2010 include the building energy (including emissions from both natural gas and electricity use) and on-road transportation sectors, approximately 64% and 26% respectively of the Chicago Region's total emissions. Figure 3-1 presents the breakdown of total emissions by inventory sector.

Figure 3-1. 2010 Regional GHG Emissions



Emissions by Sector

The following sections present the 2010 Regional GHG Inventory emissions results for each inventory sector. Each sector's results are provided for the separate jurisdictions (i.e., Chicago and each of the seven counties) as well as for the Chicago Region as a whole and further disaggregated by sub-sector.

Table 3-1 provides a summary of the 2010 Regional GHG Inventory. This table lists each emissions sector included in the 2010 Regional GHG Inventory for the city of Chicago and each of the seven counties, as well as the Chicago Region emissions total. Cook County's emissions represent the largest county emissions (approximately 7,373 $MMTCO_2e$), nearly half of which are due to the city of Chicago's emissions, followed by DuPage, Will, and Lake Counties.

The emissions sectors listed in Table 3-1 include: building energy; transportation; stationary, industrial, and product use; solid waste; wastewater; water; and agriculture. Each sector is broken out into further sub-sectors, as applicable.

A separate category was included for unallocated emissions that could not be attributed to a specific jurisdiction. The unallocated emissions consist of off-road transportation emissions for Metra and Amtrak that could not readily be allocated to individual jurisdictions. Some of these emissions are electricity emissions that are already included in utility data provided by jurisdiction, but not separated out on a line item. As a result, a reduction is shown as a negative emission in the unallocated column to avoid double-counting of rail electricity emissions.

Additional discussion of each of the 2010 emissions sectors, including data sources, emissions calculations and methodologies, and data or methodology gaps is included in Chapter 4.

Building Energy

Emissions from building energy use are the largest sector in the 2010 Regional GHG Inventory, accounting for 64% of total emissions in the Chicago Region. Of this 64%, the majority of emissions are from electricity use (40%), while the remaining emissions are from natural gas use (24%) and a very small fraction from SF_6 emissions. Table 3-2 shows building energy emissions for the city and each county by subsector: electricity use, natural gas use, and SF_6 emissions. Electricity use contributes the majority of emissions to the building energy sector (63%), and natural gas use contributes the remaining amount (37%). SF_6 emissions represent a very small portion of the Regional total (0.01%).

Table 3-1. Chicago Region 2010 GHG Emissions by Sector

		GHG Emissions ($MTCO_2e$)									
Sector	Subsector	City of Chicago	Cook County (balance)	DuPage County	Kane County	Kendall County	Lake County	McHenry County	Will County	7-County Unallocated	7-County Total
Building Energy	Electricity Use	14,587,504	15,395,896	6,535,167	3,324,066	398,403	4,304,964	1,743,557	4,145,713	---	50,435,270
	Natural Gas	9,342,068	9,469,453	3,233,067	1,567,372	330,032	2,418,875	993,302	2,823,532	---	30,177,702
	SF_6	2,365	2,528	1,072	553	67	697	283	724	---	8,288
Transportation	On-Road	6,783,031	10,522,625	4,500,825	2,219,259	449,721	3,953,831	1,573,716	3,223,644	---	33,226,651
	Off-Road	953,100	1,718,000	735,782	505,792	211,486	526,180	372,077	515,312	198,193[a]	5,735,920
Solid Waste	Waste	1,291,449	1,304,286	227,610	121,482	16,468	183,620	82,293	132,156	---	3,359,365
Stationary, Industrial, and Product Use	Stationary/ Industrial	53,738	71,193	---[b]	---[b]	---[b]	---[b]	---[b]	261,769	---	386,700
	Product Use[d]	191,176	166,670	61,565	30,193	6,159	42,831	19,278	40,120	---	557,992
Wastewater	Waste-water	205,899	171,601	39,739	20,455	3,849	25,297	7,258	25,804	---	499,903
Water	Water Pumping and Treatment	135,246	358,410	35,002	218,537	9,776	30,720	15,679	716,814	---	1,520,185
Agriculture	Agriculture	---[c]	282	1,558	102,374	60,596	8,977	115,360	54,357	---	343,505
Total		33,545,577	39,180,944	15,371,387	8,110,085	1,486,556	11,495,991	4,922,803	11,939,946	198,193	126,251,482

Notes:

a. This amount represents transportation emissions from rail system (Amtrak and Metra) emissions that could not be readily assigned by separate jurisdiction. Includes electricity and other fuel use for rail systems as well.

b. "---" No emissions estimated for this category. For agriculture, no large-scale agricultural activity is reported within Chicago, so no emissions are estimated. For stationary and industrial emissions, the Mandatory Reporting Rule (MRR) data did not have relevant stationary emissions for DuPage, Kane, Kendall, Lake, and McHenry Counties, after accounting for double-counting of electricity, natural gas and transportation fuels, so emissions are not reported.

c. Refrigerant emissions are included in the product use category.

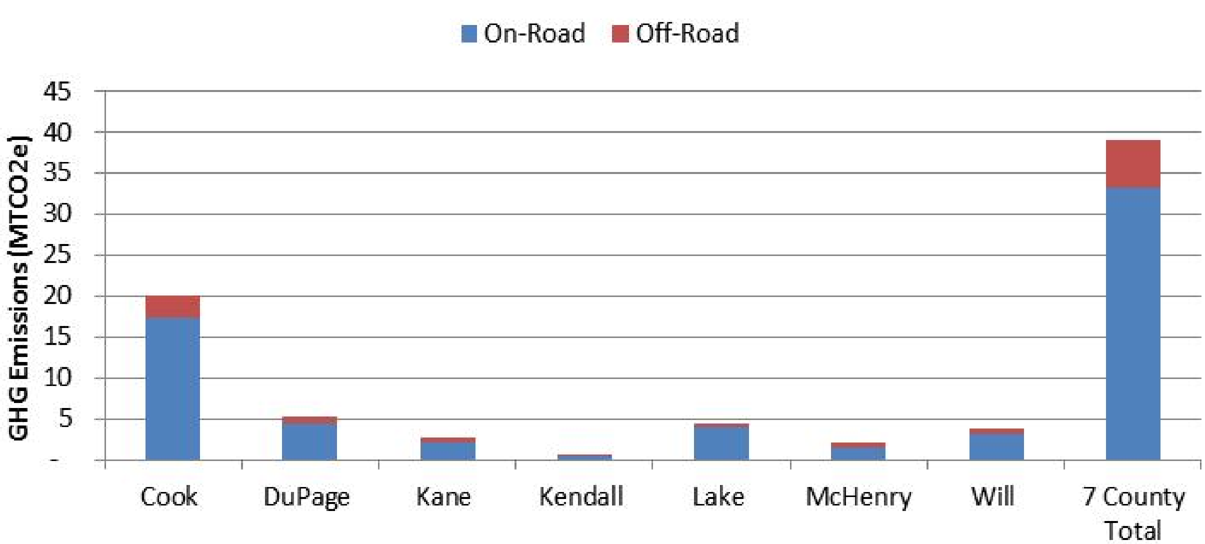
Table 3-2. Building Energy Emissions by Jurisdiction and Sub-Sector for 2010

	GHG Emissions ($MTCO_2e$)			
County	Electricity Use	Natural Gas Use	SF_6 Emissions	Total
City of Chicago	14,587,504	9,342,068	2,365	23,931,937
Cook (balance)	15,395,896	9,469,453	2,528	24,867,878
DuPage	6,535,167	3,233,067	1,072	9,769,306
Kane	3,324,066	1,567,372	553	4,891,991
Kendall	398,403	330,032	67	728,502
Lake	4,304,964	2,418,875	697	6,724,536
McHenry	1,743,557	993,302	283	2,737,142
Will	4,145,713	2,823,532	724	6,969,970
Chicago Region (7-County) Total	50,435,270	30,177,702	8,288	80,621,261

Transportation (On- and Off-Road)

Transportation, including both on-road and off-road sources, is the second largest sector in the 2010 Regional GHG Inventory. On-road and off-road transportation emissions account for 31% of total emissions. Figure 3-2 shows the breakdown of the Region's 2010 transportation emissions by county and by sub-sector. Cook County is responsible for 51% of the Chicago Region's total transportation emissions, followed by DuPage (13%) and Lake (11%). Transportation-related emissions are dominated by on-road source, accounting for 85% of transportation emissions at an aggregate 7-County regional level, with off-road comprising the remaining 15%. This break-out is generally consistent at an individual county level as well.

Figure 3-2. Transportation Emissions by County for 2010



On-Road Transportation

Emissions from on-road vehicles represent 26% of total emissions in the Chicago Region; on-road transportation is the second largest emissions source behind electricity use. Table 3-3 shows on-road transportation emissions by vehicle type for the city and each county. Autos represent 66% of the Chicago Region's on-road transportation emissions, while heavy-duty and B-plate trucks (i.e., truck weighing > 8,000 lbs.) account for 24%, and medium-duty and light-duty trucks represent 9.5%. Bus vehicle emissions represent a very small portion of the Chicago Region's total emissions (0.3%). Based on data provided by CMAP for vehicle trips in the Chicago Region, ICF estimates that GHG emissions from pass-through trips comprise approximately 19% of total emissions for on-road transportation for the Chicago Region.

Table 3-3. On-Road Transportation Emissions by County and Vehicle Type for 2010

	GHG Emissions ($MTCO_2e$)						
County	Auto	B-Plate Truck	Light-Duty Truck	Medium-Duty Truck	Heavy-Duty Truck	Bus	Total
City of Chicago	4,929,217	507,623	150,700	281,664	835,761	78,065	6,783,031
Cook (balance)	6,663,756	1,265,085	371,425	687,412	1,510,215	24,732	10,522,625
DuPage	2,976,265	623,575	183,305	338,171	374,660	4,848	4,500,825
Kane	1,488,652	270,108	77,023	137,822	243,356	2,298	2,219,259
Kendall	310,696	58,008	16,723	28,381	35,845	67	449,721
Lake	2,550,803	491,724	141,174	255,418	511,409	3,302	3,953,831
McHenry	1,027,778	209,498	58,648	103,583	173,303	906	1,573,716
Will	2,095,577	394,676	111,888	203,228	416,957	1,318	3,223,644
Chicago Region (7-County) Total	22,040,218	3,825,091	1,112,232	2,037,991	4,096,357	114,762	33,226,651

Off-Road Transportation

Off-road transportation accounts for 5% of total Chicago Region emissions, and ranks third among all emissions sources (behind building energy and on-road transportation). Table 3-4 illustrates the breakdown of off-road emissions by source for 2010 for the Chicago Region. Nonroad equipment emissions account for the majority of emissions in this sector, or 76% of the Chicago Region emissions in this sector. CTA electrified heavy rail represents 5% and freight rail represents 14% of the Chicago Region's emissions in this sector.

Table 3-4. Off-Road Transportation Emissions by County and Source for 2010

County	GHG Emissions ($MTCO_2e$)					
	Rail-Freight	Passenger Rail-Amtrak	Commuter Rail–Metra	Heavy Rail–CTA (Electrified)	Nonroad Equipment	Total
City of Chicago	---	---	62,587	251,556	638,957	953,100
Cook (balance)	205,128	8,792	---	57,836	1,446,243	1,718,000
DuPage	132,424	1,085	---	---	602,272	735,782
Kane	112,508	1,097	---	---	392,186	505,792
Kendall	112,637	---	---	---	98,848	211,486
Lake	57,980	2,823			465,376	526,180
McHenry	113,754	---			258,323	372,077
Will	47,530	3,045	---	6,081	458,656	515,312
Regional Unallocated	---	---	198,193[a]	---	---	198,193
Chicago Region (7-County) Total	781,963	16,843	260,780	315,473	4,360,861	5,735,920

a. This amount represents transportation emissions from rail systems (Amtrak and Metra) that could not be readily assigned by separate jurisdiction. Includes electricity and other fuel use for rail systems as well.

Solid Waste

Solid waste is the fourth largest emissions source in the Chicago Region, responsible for 3% of total regional emissions. Table 3-5 shows solid waste emissions of methane and total waste disposal for 2010 for each county in the Chicago Region. Waste disposal and resulting methane emissions are closely correlated, and trend with each jurisdiction's population.

Table 3-5. Solid Waste Emissions and Waste Disposal by County for 2010

County	Methane Emissions ($MTCO_2e$)	Waste Disposal (tons)
City of Chicago	1,291,449	2,901,689
Cook (balance)	1,304,286	3,212,169
DuPage	227,610	703,196
Kane	121,482	416,522
Kendall	16,468	79,514
Lake	183,620	556,210
McHenry	82,293	272,495
Will	132,156	472,833
Chicago Region (7-County) Total	3,359,365	8,614,627

Wastewater Treatment

Wastewater treatment emissions account for 0.4% of total emissions in the Chicago Region, and are the seventh largest sector of emissions. Table 3-6 shows wastewater treatment emissions for each jurisdiction in the Chicago Region by emissions source. Electricity use contributes the majority of emissions in this sector, accounting for 80% of the total. Fugitive emissions contribute 17% of total wastewater treatment emissions in the Region, while natural gas contributes the remaining 3%. Fugitive emissions comprise a small fraction of the total wastewater-related GHG emissions.

Table 3-6. Wastewater Treatment Emissions by County and Source for 2010

	GHG Emissions ($MTCO_2e$)			
County	Fugitive	Electricity Use	Natural Gas Use	Total
City of Chicago	35,214	164,438	6,248	205,899
Cook (balance)	29,348	137,046	5,207	171,601
DuPage	6,796	31,737	1,206	39,739
Kane	3,498	16,336	621	20,455
Kendall	658	3,074	117	3,849
Lake	4,326	20,203	768	25,297
McHenry	1,241	5,797	220	7,258
Will	4,413	20,608	783	25,804
Chicago Region (7-County) Total	85,495	399,239	15,169	499,903

Water Consumption

Emissions in the water sector result from the energy consumed by pumps that transport water from the source to the water user as well as the energy consumed in water treatment. Water sources in the Chicago Region include Lake Michigan, inland rivers, and groundwater. Water is used for residential, commercial, and industrial consumptive use, as well as for irrigation, agriculture, and for power plant makeup water and cooling. Cook, Kane and Will Counties have higher water use compared to the other counties in the Chicago Region because of the large amount of water used by power plants located in these counties. In the Chicago Region, nearly 73% of all urban water uses are attributed to power plants, approximately 23% is for public supply (residential, commercial and industrial), 5% is self-supplied (residential, commercial and industrial), and 1% is for irrigation and agriculture.

Emissions related to water consumption represent 1.2% of total Chicago Region emissions, as the 5th largest emissions source. Table 3-7 shows the fuel source composition of water-related GHG emissions for each county in 2010. Natural gas (49.6%) and electricity (50%) were the dominant Regional fuel sources for water pumping and treatment. Fuel oil comprised the remaining 0.4% of emissions in this sector. As Cook, DuPage, and Will Counties are the largest water users (due to power plant water use), these three counties also have the highest GHG emissions associated with the water sector.

Table 3-7. Water-related GHG Emissions by County and Fuel Source for 2010

	GHG Emissions ($MTCO_2e$)			
County	Electricity Use	Natural Gas Use	Fuel Oil	Total
City of Chicago	58,163	76,703	381	135,246
Cook (balance)	173,729	183,413	1,269	358,410
DuPage	23,672	11,279	51	35,002
Kane	111,348	106,459	730	218,537
Kendall	8,774	995	7	9,776
Lake	18,686	11,950	83	30,720
McHenry	12,931	2,728	20	15,679
Will	353,095	361,242	2,477	716,814
Chicago Region (7-County) Total	760,399	754,769	5,017	1,520,185

Stationary, Industrial, and Product Use

Stationary, industrial, and product use emissions account for 0.3% of total Chicago Region emissions. This sector is the eighth largest sector of emissions. Table 3-8 presents stationary, industrial process, and product use emissions for the city and each county. Refrigerants account for the majority of emissions in this sector (56%), followed by industrial processes (41%) and product use (13%).

Table 3-8. Stationary, Industrial, and Product Use Emissions by County in 2010

	GHG Emissions ($MTCO_2e$)			
County	Stationary/Industrial	Refrigerants	Product Use	Total
City of Chicago	53,738	150,797	40,378	244,914
Cook (balance)	71,193	133,017	33,652	237,863
DuPage	-	48,498	13,067	61,565
Kane	-	22,850	7,343	30,193
Kendall	-	4,524	1,635	6,159
Lake	-	32,806	10,025	42,831
McHenry	-	14,878	4,400	19,278
Will	261,769	30,463	9,656	301,888
Chicago Region (7-County) Total	386,700	437,834	120,158	944,692

Agriculture

Agriculture is the smallest sector of the 2010 Regional GHG Inventory and accounts for 0.3% of total emissions in the region. Table 3-9 shows agriculture emissions for the city and each county broken down by source. Fertilizer represents 44.2% of emissions, followed by manure management (44.2%) and enteric fermentation (12.3%). No agricultural emissions are reported for the city of

Chicago (due to a lack of large-scale agricultural activity), while Cook County and DuPage County have limited agricultural emissions. Kane, Kendall, and McHenry Counties have relatively large emissions (compared to population), because there is more agricultural activity in these counties than others.

Table 3-9. Agriculture Emissions by County and Type for 2010

	GHG Emissions ($MTCO_2e$)			
County	Enteric Fermentation	Manure Management	Fertilizer Inputs	Total
City of Chicago	---	---	---	---
Cook (balance)	25	258	---	283
DuPage	20	33	1,505	1,558
Kane	12,326	49,309	40,739	102,374
Kendall	1,996	22,912	35,687	60,596
Lake	2,213	3,917	2,847	8,977
McHenry	20,962	54,209	40,189	115,360
Will	4,582	18,819	30,956	54,357
Chicago Region (7-County) Total	42,125	149,456	151,924	343,505

Chapter 4
Inventory Methods

Chapter 4
Inventory Methods

Introduction

This chapter provides details of the methods employed to estimate emission for each sector included in the 2010 Regional GHG Inventory. A brief introduction to the methods and data sources used to estimate each emissions sector in the 2010 Regional GHG Inventory is listed below, followed by a list of inventory protocols applied. A detailed description each inventory sector's analysis methods and data sources is included, as well as a summary of limitations and recommendations for future improvement of each sector's emissions estimation. Emissions calculations, source data, and detailed references are included in the accompanying technical documentation (provided by ICF to the Global Philanthropy Partnership in January, 2012). This chapter also includes a comparison of methods differences for each emissions sector between the 2010 Regional GHG Inventory and that of the 2000 and 2005 inventories for the Chicago Region.

- **Building-related energy emissions** are estimated for each county in the Chicago Region, as well as for the city of Chicago, based on electricity and natural gas data specific to each jurisdiction, as provided by the utilities that serve the Chicago Region.
- **On-road transportation emissions** are based on VMT and speed class data by transportation mode and vehicle type in the Chicago Region, and estimated for each county in the Chicago Region as well as for the city of Chicago.
- **Off-road transportation emissions** are estimated for each county in the Chicago Region (or as a regional line item where noted), and in some cases for the city of Chicago, by apportioning rail, off-road vehicle, and off-road equipment emissions from several sources, including: the Regional Transportation Authority (RTA) Inventory of passenger rail data (unpublished study for 2008), USEPA NONROAD model, CMAP, the Chicago Regional Environmental and Transportation Efficiency Program (CREATE), the National Transportation Atlas Database (NTAD), and Amtrak (for each of the seven counties but not for Chicago).
- **Solid waste emissions** are based on waste generation data collected from the city of Chicago and Illinois Environmental Protection Agency (Illinois EPA), and apportioned to each county in the Chicago Region. This data is supplemented with locally-specific information on waste generation, waste profile, and waste destination for the city of Chicago.
- **Wastewater emissions** are based on fugitive emissions and energy use (electricity, natural gas) rates for Metropolitan Water Reclamation District (MWRD) treatment plants, and scaled to each county based on the amount of wastewater generated within each county. Emissions for the city of Chicago are based on a population scaling approach.
- **Water consumption emissions** are based on the CMAP Regional Water Demand Scenarios report for water consumption quantities for each county in the Chicago Region. In addition, the Chicago Department of Water Management provided water-related energy consumption data for the city of Chicago.
- **Stationary, Industrial, and Product Use** emissions include the following components: 1) emissions from stationary (typically industrial) combustion of fossil fuels of any type (except

natural gas, which is included in the building energy use sector), 2) refrigerant emissions from commercial and residential buildings, and 3) emissions from consumer product use. Stationary/industrial emissions are based on USEPA's Mandatory Reporting Rule (MRR) database). For refrigerant emissions, ICF used the Chicago Department of Environment (DOE) refrigerant survey data as the basis for city of Chicago refrigerant leakage in buildings and scaled these emissions to the Chicago Region, using building square footage estimates from the City's CoStar database. Last, emissions from consumer product use are based on national inventory data, and scaled to the Chicago Region by population.

- **Agriculture emissions** are based on national data sources of livestock population and agricultural acres (e.g., U.S. Department of Agriculture [USDA] Agricultural Census, U.S. Forest Service [USFS]), and calculated with IPCC and CARB methodologies.

In developing the 2010 Regional GHG Inventory, ICF reviewed community inventory reports prepared by CNT for the 2000 and 2005 inventories. To the extent possible, the data collection process (and resulting emissions estimation methods) for the 2010 Regional GHG Inventory attempted to improve upon existing data sources utilized for the 2000 and 2005 inventories, through the use of more locally-specific or comprehensive datasets, so as to improve upon the accuracy of each inventory sector. Specifically, ICF was able to obtain improved or more locally-specific data sets for the following sectors: on-road transportation; off-road transportation; water consumption; solid waste; and stationary, industrial, and product use. These improvements and other data or methods differences from the 2000 and 2005 inventories are described in each sector's discussion below.

Protocols

Several protocols for estimating GHG emissions were used to prepare the 2010 Regional GHG Inventory, as no standard protocol for the development of local or regional community-wide inventories currently exists. ICLEI is expected to release a community inventory protocol in 2012, however, and may be utilized for future updates to the Chicago Region's emissions inventory. These GHG protocols used in the 2010 Regional GHG Inventory are listed below, and were applied to each sector, as relevant and as discussed below for each emissions sector.

- The **LGOP for Greenhouse Gas Assessments** developed by ICLEI, CAR, TCR and CARB (California Air Resources Board 2010a): This protocol includes methods for estimating emissions resulting from government buildings and facilities, government fleet vehicles, wastewater treatment and potable water treatment facilities, landfill and composting facilities, and other operations. This protocol was developed primarily for use by California local governments; although it contains methodologies for estimating emissions pertinent to community emissions sources. Further, this protocol can be modified for use outside of California, although in some cases, data sources or other references may need to be modified accordingly to local conditions or constraints.
- The **USEPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007** (U.S. Environmental Protection Agency 2009a): The national inventory documentation includes standard methodology and emission factors for nationwide GHG emissions inventorying.
- The **IPCC Guidelines for National Greenhouse Gas Inventories** (Intergovernmental Panel on Climate Change 2006a): This document is the international standard for inventories and

provides much of the baseline methodology used in the national and statewide emission inventories.

- The **GHG Protocol Corporate Standard** developed by WRI and the WBCSD (World Resources Institute 2004): Although this is a protocol designed for use primarily by private corporations, it was one of the first documents to establish the principles and steps to developing a GHG inventory. This document has influenced the development of other types of GHG protocols, including those for municipal, government, and community-wide emissions.

Emissions are commonly divided into three categories or "scopes", as follows (World Resources Institute 2004):

- **Scope 1:** Direct GHG emissions, such as emissions from combustion of natural gas or in vehicles, where the emission occurs directly at the activity causing the emission.
- **Scope 2:** Indirect GHG emissions, such as emissions associate with the consumption of electricity due to power plant emissions or methane emissions at a landfill that receives waste , where the emissions occur at a location separate from the activity causing the emission.
- **Scope 3:** All other indirect emissions not covered in Scope 2 that are not owned or controlled by the reporting jurisdiction, such as the emissions resulting from the extraction and production of purchased materials and fuels.

The 2010 Regional GHG Inventory includes Scope 1 and 2 emissions (World Resources Institute 2004), including all direct and indirect emissions; Scope 3 emissions are not included.

Analysis Methods and Data Sources

The following sections describe the data sources and methods for estimating emissions for each inventory sector. For some sectors, as appropriate, we indicate whether the emissions estimation methods includes a "top-down" (i.e., using data that relies on state, national, or other regional sources), a "bottom-up" (i.e., data collected and aggregated from local sources, such as utilities), or a "hybrid" approach (i.e., a combination of top-down and bottom-up approaches).

Building Energy

Building energy emissions include both direct emissions from natural gas consumption and indirect emissions from electricity consumption, relevant to residential, commercial, and industrial buildings or facilities. Indirect emissions from electricity consumption occur as a result of combustion of fossil fuels at power plants.

GHG emissions from the use of heating fuels (e.g., propane, fuel oil) could not be accommodated as part of this study but are expected to be a minor component of both the city of Chicago and the Chicago Region's total emissions. For reference, these emissions comprise only 0.1% of the Chicago Region emissions total in 2005.

Emissions Estimation Methodology

To estimate building energy emissions, ICF collected electricity and natural gas data from utilities serving the city and the seven counties. These utilities include: Commonwealth Edison, Illinois Municipal Electric Agency, Nicor Gas, and Peoples Gas. The consumption data was typically categorized by building type (i.e., residential single-family, residential multi-family, commercial, and industrial, or commercial plus industrial if the two could not be separated). Several utilities provided the following additional categories: municipal, unspecified, and regional. ICF calculated electricity emissions by applying a 2010 CO_2 emission factor for the North American Electric Reliability Corporation (NERC) Reliability First Compliance (RFC) Region[9] and derived CH_4 and N_2O factors to the electricity consumption data. ICF developed the 2010 CO_2 emissions factor by updating USEPA's eGRID 2007 CO_2 emissions factor for the RFC region. Additional details regarding ICF's derivation of the 2010 CO_2 emissions factor are provided in Appendix A. The 2010 CH_4 and N_2O emissions factors were derived by applying the relative weights of each chemical's 2007 eGRID factor to that of the 2007 eGRID 2007 CO_2 factor (U.S. Environmental Protection Agency 2010b).

ICF calculated natural gas emissions by applying utility-specific CO_2 and CH_4 emission factors to the natural gas consumption data. These factors are based on gas composition information supplied by the Nicor and Peoples Gas utilities. N_2O emission factors for natural gas are from the Climate Action Registry (The Climate Registry 2012).

Electricity and natural gas consumption associated with water and wastewater processes were removed from the building energy sector to avoid double-counting, as this consumption is included in the water and wastewater sectors. Transportation electricity use (electric usage by railways, primarily CTA) from ComEd was not included in the building energy sector but instead applied to the on-road transportation sector

Summary of Methods Changes from Previous Inventories

ICF developed utility-specific 2010 emission factors for natural gas and a 2010 electricity emission factor for the RFC region. For 2000 and 2005, CNT applied the IPCC default factor for natural gas and used a regional eGRID factor for electricity (Center for Neighborhood Technology 2009, 2010), corresponding to each inventory year. The 2010 methods include more refined categories of energy use (e.g., residential, industrial, etc.) than those included in the 2000 and 2005 inventories. Last, the 2010 inventory includes SF_6 emissions from electricity transmission; these emissions are not included in the 2000 and 2005 inventories.

[9] The RFC Region is situated within the Eastern Interconnection and covers territory stretching from the Eastern United States to the lower Great Lakes, including all or portions of New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Ohio, Michigan, Kentucky, Tennessee, Indiana, Illinois, Wisconsin, and the District of Columbia. ICF derived a RFC electricity emissions factor from the average of power generation facilities in the region that provides power to the Chicago region. RFC refers to the Reliability First Corporation which is a regional reliability organization responsible for ensuring reliability of the bulk power system.

On-Road Transportation

This sector includes emissions from on-road transportation in the Chicago Region. Emissions for this sector are due to the combustion of fossil fuels (such as diesel and gasoline) used to power on-road vehicles, including on-road public transit (e.g., buses).

Emissions Estimation Methodology

ICF obtained VMT data for each county in the Chicago Region from CMAP, including pass-through and in-region trips, as well as vehicle type, population, and age distribution data. ICF estimated on-road transportation emissions for each county in the Chicago Region, as well as the city of Chicago, using the USEPA's Motor Vehicle Emission Simulator (MOVES) model (U.S. Environmental Protection Agency 2010c). Data on vehicle and emissions characteristics utilized in this analysis was based on the MOVES model; specifically, the 2025 input files for MOVES. This data includes age distribution of vehicle types, a breakdown of diesel versus gasoline vehicles, and vehicle speed distribution. A separate analysis of on-road transportation alternative fuel emissions was also included in this sector, and was based on data from the Transportation Energy Data Book (U.S. Department of Energy 2011), as well as vehicle population data provided by CMAP.

ICF also estimated emissions from congestion of on-road transportation vehicles in the Chicago Region. Since vehicles are much more efficient at faster speeds, the emissions will be higher at slower congested speeds. This congestion analysis included evaluation of the speed distribution of vehicles on highways and arterial roads, as provided by CMAP. ICF used the MOVES model to quantify vehicle fuel economy at different speeds and applied emissions factors to estimate emissions under this baseline, which includes the effects of congestion. The results of this analysis were compared to emissions that would have resulted from the same vehicles traveling at uncongested "free flow" speeds. ICF's analysis indicates that congestion in the Chicago Region increases on-road GHG emissions by 4.7-6.9%, depending on the speed parameters utilized for *free flow* speeds, similar to that estimated by CNT (approximately 8%) for the 2005 inventory (McGraw et al. 2008).

Summary of Methods Changes from Previous Inventories

ICF's 2010 analysis of on-road transportation emissions is based on VMT data specific to the city of Chicago and each of the seven counties in the Chicago Region, as provided by CMAP. This included not only the aggregate estimates of VMT, but also a breakdown of VMT by speed on freeways and arterials. The result is a specific emissions calculation for each county, which reflects the traffic patterns in each jurisdiction. In contrast, the 2000 and 2005 inventories used nationwide estimates of emissions per vehicle mile, and apportioned these emissions to each county based on total VMT estimates. The prior inventory could not analyze the unique patterns of traffic in each jurisdiction, and roadway congestion effects by different jurisdictions. Prior analysis of emissions due to congestion appears limited, and the methodology was not described in CNT's reports (Center for Neighborhood Technology 2009, 2010). In ICF 2010 work, congestion was calculated as described above, using county-specific data and USEPA MOVES modeling.

The USEPA MOVES modeling done for the 2010 inventory used a more detailed characterization of the vehicle fleet, with 13 different vehicle categories compared to 4 categories used for the 2000 and

2005 inventories. The use of a more detailed breakdown of the vehicle fleet allows for a more precise use of emission factors for different types of vehicles.

For the alternative fuels analysis, emission reductions for alternative fuel use were calculated and included in the inventory. The 2000 and 2005 inventories did not apply MOVES, but instead relied on data from LADCO and other methods of analysis (Center for Neighborhood Technology 2009, 2010).

Off-Road Transportation

This sector includes emissions from rail, as well as emissions from off-road vehicles and equipment operating in the city. Rail sources include the “L” elevated heavy rail operated by CTA, commuter rail operated by Metra, intercity passenger rail operated by Amtrak, and freight rail operated by multiple rail companies. Off-road vehicles and equipment types include residential (e.g., lawn and garden), commercial (e.g., transportation refrigeration units), and industrial (e.g., construction and mining) categories.

Emissions Estimation Methodology

Non-freight Rail

Emissions for this sub-sector were estimated based on application of appropriate emissions factors to rail activity data in the Chicago Region, for each of the various data sources as listed below, and in the case of Metra diesel locomotives, scaled RTA emissions estimates were used. Diesel-related GHG emissions data for Metra’s diesel locomotives was provided by transit agency sources such as the Regional Transit Authority (Minor pers. comm.), based on an unpublished RTA study for 2008 and scaled to 2010 and the National Transit Database (Federal Transit Administration 2011). Electricity usage for CTA as well as Metra’s electric multiple units were extracted from ComEd consumption data for the railroad class category. Electricity emissions were then calculated using the updated 2010 CO_2e emission factor for electricity in the RFC region, as used in the building energy sector. This electricity use was for this electric rail movement was excluded from the building energy sector to avoid double-counting. Electricity use at rail stations appears in the building energy sector as it was not possible to extract that usage from other consumption classes and categorize it separately under off-road transportation.

Rail emissions for Amtrak were not calculated separately for the city of Chicago, as the data from these sources is provided at the county level only. It was not possible to disaggregate Cook County data further into city and non-city components.

Freight Rail

Freight rail emissions were calculated for each county in the 2010 Regional GHG Inventory by collecting data on freight volumes along the rail mainlines throughout the Chicago Region, separated by each county in the Chicago Region. Accordingly, similar to passenger rail, freight rail emissions were not calculated separately for the city of Chicago, but are estimated for each county in the Chicago Region. This data was obtained from CREATE and NTAD, maintained by the Bureau of Transportation Statistics (BTS). The CREATE and NTAD data was combined with fuel economy factors from Association of American Railroads (AAR) to calculate total fuel consumed by freight rail in the Chicago Region. A geographic information systems (GIS) analysis of regional rail lines was undertaken to determine annual ton-miles of rail freight in the Chicago Region. The annual ton-miles was converted to the quantity of fuel consumed within the Region (based on a factor of 875 gross ton-miles per gallon of diesel per a report from Union Pacific), and then to GHG emissions using standard emission factors for diesel (tons CO_2/gallon, tons CH_4/gallon and tons N_2O/gallon) from the USEPA. Since this approach is segment-based, rather than trip-based, the locomotive calculations include both local traffic and pass-through trips.

Off-Road Equipment

For off-road equipment, ICF applied USEPA's NONROAD model to the county scale (U.S. Environmental Protection Agency 2008); Cook County emissions were apportioned between the city and the remainder of the county using land cover, land use, retail sales, or similar factors appropriate to each equipment type.

Summary of Methods Changes from Previous Inventories

The rail emissions approach for the 2010 Regional GHG Inventory is more detailed than or the 2000 or 2005 inventory years, as this data is broken out by both freight and non-freight rail, as well as by county. In addition, for the 2010 Regional GHG Inventory, off-road equipment other than rail was included. This source was not included in the 2000 and 2005 inventories.

For rail projections, ICF was able to allocate a portion of rail emissions to the city of Chicago (aside from Amtrak and freight rail). In addition, instead of using default grid electricity factors, ICF developed utility-specific 2010 emissions factors for electricity based on the utility energy generator in mix for electric rail emissions.

Solid Waste

This sector includes methane emissions that result from the decomposition of waste in landfills, due to waste generated by the communities in the Chicago Region. Although landfills emit CO_2, these emissions are not considered in this analysis because they are considered biogenic in origin.

Emissions Estimation Methodology

ICF evaluated emissions from solid waste using a population-based methodology that accounts for waste generated and disposed of in landfills by each jurisdiction in the 2010 Regional GHG Inventory, accounting for historical waste generation. This approach is often termed a "waste-in-place" approach, as current year emissions are estimated based on historical waste generation. In addition, this methodology includes estimation of indirect emissions from waste generated in the Chicago Region, regardless of where that waste is disposed (i.e., *inside* or *outside* of the Chicago Region). ICF used the IPCC first order decay (FOD) model to estimate emissions from waste landfilling (Intergovernmental Panel on Climate Change 2006b), to estimate solid waste emissions in the 2010 Regional GHG Inventory.

The following parameters in the IPCC FOD model were adjusted to account for specific conditions in the Chicago Region:

- Landfill characteristics for open and closed landfills that have or continue to accept waste from the Chicago Region, including mass of waste disposed, opening/closing of landfill, and percent methane recovery (U.S. Environmental Protection Agency 2009b; Illinois Environmental Protection Agency 2011)
- An "average" methane capture rate of 75% for all landfills with methane capture (Illinois Environmental Protection Agency 2011)

To account for historical waste generation where no data was available (i.e., years prior to 1995), ICF extrapolated the relevant data from years with available data (i.e., post 1995) to estimate waste tonnages and the destination landfill in these prior years.

Summary of Methods Changes from Previous Inventories

The 2010 methodology differs fundamentally from the prior methodology for the 2000 and 2005 inventories. ICF utilized a "waste-in-place" approach whereas the prior inventories applied a "methane commitment" approach to estimating emissions. As described above, the "waste-in-place" approach estimates current year waste emissions, based on historical waste generation. In contrast, the "methane commitment approach" estimates future year emissions due to current waste generation (Illinois Environmental Protection Agency 2011; Center for Neighborhood Technology 2009, 2010). These approaches are fundamentally different such that the results of each should not be compared on an absolute basis.

Wastewater Treatment

These emissions are associated with the treatment of industrial, residential, and commercial wastewater produced by community activities in the city of Chicago and the counties in the Chicago Region. These emissions result from the energy consumed to operate each wastewater reclamation plant (WRP) serving each community (indirect emissions) as well as fugitive emissions of CH_4 and N_2O that occur during wastewater treatment and processing (direct emissions).

Emissions Estimation Methodology

The emissions estimation methodology for wastewater treatment emissions includes a *hybrid* approach, combining regional databases and plant-specific data. Specifically, ICF obtained emissions and energy use data (associated with electricity, natural gas, and biogas combustion, as well as fugitive emissions) for the MWRD seven water reclamation plants that serve the more than five million residents of Cook County. ICF used this MWRD data as a *proxy* for the wastewater treatment profile of the other (132) reclamation plants that serve the Chicago Region. Specifically, ICF obtained plant water flow data for 2010 from USEPA Integrated Compliance Information System–National Pollutant Discharge Elimination System (U.S. Environmental Protection Agency 2011a) for these other 132 plants and combined that plant water flow data with the MWRD profile data to estimate wastewater treatment emissions for the entire Chicago Region for these other 132 plants. ICF then apportioned total wastewater treatment emissions from all 139 plants to each county in the Chicago Region using the total wastewater flow to each plant from each county in the Chicago Region. To estimate emissions for the city of Chicago, ICF used a population-based approach to apportion Cook County emissions to the city of Chicago (Kozak pers. comm.).

Electricity and natural gas consumption for the wastewater treatment sector were removed from the building energy sector to avoid double-counting, because the utility data for the building energy sector also includes this energy consumption.

Summary of Methods Changes from Previous Inventories

The 2010 inventory used MWRD plant profile data for energy use and emissions and USEPA wastewater flow data for the other treatment plants in the Chicago Region, and then scaled these emissions to Chicago using population and to the Chicago Region using flow data. In contrast, the 2000 and 2005 inventories scaled wastewater GHG emissions from MWRD estimates directly to Chicago and to the Chicago Region using population data.

Water Consumption

Emissions from water consumption were estimated based on the energy associated with the city of Chicago and the Chicago Region's local water treatment and distribution system. Water consumption emissions were also estimated from energy used to transport, treat, and pump water from *outside* each jurisdiction in the Chicago Region for use *within* the particular jurisdiction.

Emissions Estimation Methodology

According to CMAP's 2010 Northeastern Illinois Regional Water Supply/Demand Plan, water supplies in the Chicago Region are provided by Lake Michigan, inland surface water (Fox River and Kankakee River), and groundwater sources (Chicago Metropolitan Agency for Planning 2010). The majority of the Chicago Region's water (75-80%) results from Lake Michigan water allocations to approximately 200 communities, including the city of Chicago (Chicago Metropolitan Agency for Planning 2010).

To estimate emissions associated with electricity used to consume water, ICF obtained total water withdrawals and demands, as well as water pumping data, for each county in the Chicago Region (Chicago Metropolitan Agency for Planning 2010; Southern Illinois University Carbondale 2008; Putz pers. comm.). Universal electricity intensities for local groundwater pumping in the Chicago Region were obtained from the California Energy Commission-500-2006-118 report (California Energy Commission 2006). Emissions from electricity were estimated using the updated CO_2 emission factor for 2010 for the eGRID RFC region, described above for the building energy sector. Natural gas emission factors were obtained from Chicago Department of Water Management (DWM). ICF applied emission factors from DWM for calculating emissions for fuel oil and natural gas consumed at pumping stations and treatment plants. Electricity and natural gas consumption in the water sector was removed from the building energy sector to avoid double-counting, because the utility data for the building energy sector also includes this energy consumption.

Summary of Methods Changes from Previous Inventories

The 2000 and 2005 emissions inventories did not include a break-out of water consumption emissions, although emissions associated with the electricity used to consume water are presumed to be included in those inventories' building energy sector[10].

Stationary, Industrial, and Product Use

This emissions sector includes the following components: 1) emissions from stationary (typically industrial) combustion of fossil fuels of any type (except natural gas, which is included in the building energy use sector) and industrial process emissions, 2) refrigerant emissions from commercial and residential buildings, and 3) emissions from consumer product use. Electricity generation is not included in this sector to avoid double-counting of emissions, as these emissions are accounted for in the building energy sector.

Emissions Estimation Methodology

Stationary/Industrial Fuel Combustion and Process Emissions

The 2010 stationary/industrial emissions are included in the USEPA's MRR report for stationary and industrial sources in 2010, which includes specific emissions sources within the Chicago Region (U.S. Environmental Protection Agency 2011b). Emissions reported under MRR subparts AA, NN, D, C, HH, GG, OO and P for the Chicago Region (except cement plants or steel manufacturing) are included. Emissions included in these subparts cover all stationary and industrial sources. Emissions reported under MRR Subparts NN, D, C, HH were excluded because these subparts cover other sectors such as transportation, building energy, and solid waste that are captured elsewhere in the 2010 Regional GHG Inventory. Facility locations and names were determined using a list of zip codes in the Chicago Region. The MRR data did not include stationary emissions for DuPage, Kane, Kendall, Lake, and McHenry Counties, so emissions for these counties are not included in this sector of the 2010 Regional GHG Inventory.

Refrigerant Emissions from Commercial and Residential Building

Refrigerant emissions are produced by air conditioning use and other refrigerant applications in commercial and residential buildings. ICF used a *hybrid* approach to estimate refrigerant emissions in the Chicago Region for the city of Chicago and each county. This approach uses data from the Chicago Central Business District Refrigerant inventory to develop region-specific refrigerants considered to have global warming potential. It takes into account the most commonly used blend of refrigerants used in the city of Chicago, weighted by system capacity and use. Specifically, ICF extrapolated the results of a refrigerant survey conducted for the city of Chicago to the Chicago Region. The survey included estimates of average refrigerant leakage rates, based on building square footage data for the city of Chicago (Bell 2008). Refrigerant emissions estimated for each county are based on a combination of the city of Chicago's commercial refrigerant leakage data and

[10] A separate water sector was not included in the 2000 and 2005 emissions inventories. Since water pumping and treatment require electricity, ICFICF presumes that water-related GHG emissions are at least partially captured in the building energy sector.

building square footage by county from the CoStar database, a privately maintained real estate database.

Consumer Product Use

Consumer product use emissions result from the use of cleaning solvents, aerosols, and other products. These products generally release only N_2O. To calculate emissions from consumer product use in the Chicago Region, a population-based scaling factor (from the U.S. Census) was applied to total product-related N_2O emissions from the USEPA National Inventory (U.S. Census Bureau 2010b; U.S. Environmental Protection Agency 2006) to estimate emissions for the city of Chicago and each county in the Chicago Region.

Summary of Methods Changes from Previous Inventories

Stationary/Industrial Fuel Combustion

Stationary and industrial emissions in the 2000 and 2005 inventories were estimated for the city of Chicago and each county using a *top-down* pro rata share of each jurisdiction's population (to the total U.S. population), multiplied by U.S. national inventory stationary and industrial emissions (Center for Neighborhood Technology 2009, 2010). In addition, the 2000 and 2005 inventories included SF_6 emissions in this sector, while the 2010 inventory includes SF_6 in the building energy sector. In contrast, the 2010 Regional GHG Inventory utilizes a *bottom up* approach to estimating emissions for this sub-sector, based on facility data reported for the Chicago Region.

Refrigerant Emissions from Industrial Processes

In the 2000 and 2005 inventories, refrigerant emissions were calculated using a *top down* approach based on nation-wide refrigerant survey data from the USEPA National Inventory (U.S. Environmental Protection Agency 2006) and scaled to the Chicago Region based on population. In the 2010 Regional GHG Inventory, ICF employed a regionally-specific refrigerant use derivative to estimate emissions in the Chicago Region. This methodology is provides estimates associated the size and intensity of the building stock in the Chicago Region.

Consumer Product Use

The methodologies used in the 2000 and 2005 inventories are similar to that used in the 2010 Regional GHG Inventory. Lubricants and paraffin emissions were not included in the 2010 inventory, although these emissions were included in the 2000 and 2005 inventories, because the US National Inventory 2010 did not seem to include these emissions as a separate category (U.S. Environmental Protection Agency 2010a).

Agriculture

This sector includes emissions from agricultural activities associated with the following processes: fugitive emissions of methane and nitrous oxide from manure management, fugitive emissions of methane from enteric fermentation[11], and fugitive emissions of nitrous oxide from fertilizer use.

Emissions Estimation Methodology

Fuel Combustion Emissions from Agricultural Vehicles

Agricultural vehicles include tractors, pumps, small farm equipment, and other vehicles used for agricultural purposes. Emissions from agricultural vehicles were calculated using the NONROAD model, as described above for the Off-Road Transportation sector (U.S. Environmental Protection Agency 2008), and included in that sector. Emissions were estimated for each county in the Chicago Region.

Emissions from Manure Management, Enteric Fermentation, and Fertilizer Use

To estimate emissions in these agricultural sub-sectors of the 2010 Regional GHG Inventory, livestock numbers and acres of agricultural land types within each county in the Chicago Region were obtained from the USDA Agriculture Census. This data includes population of milk cows, beef cows, other cattle, hogs/pigs, poultry, and fertilizer application for each county for 2002 and 2007 (U.S. Department of Agriculture 2007). A linear regression was used to estimate 2010 population and acreage, which assumes that the annual growth for years between 2007 and 2010 is the same as the annual growth for years 2002–2007. Manure management and enteric fermentation emissions were calculated using livestock population numbers and standard emissions factors from the IPCC (Intergovernmental Panel on Climate Change 2006a). Emissions resulting from fertilizer use were calculated using the number of acres treated with fertilizers found in the USDA's Agriculture Census and CARB equations and protocol for nitrogen applied in synthetic fertilizers for direct and indirect N_2O emissions from fertilizer application (U.S. Department of Agriculture 2007; California Air Resources Board 2010b). The city of Chicago has no livestock or agricultural land and therefore there are no emissions for these sub-sectors included for the city of Chicago.

Summary of Methods Changes from Previous Inventories

CNT used national level agricultural emissions and apportioned to these to the Chicago Region, based on agriculture land and livestock population in the Chicago Region, for the 2000 and 2005 inventories (Center for Neighborhood Technology 2009, 2010). In contrast, ICF calculated emissions based on actual livestock and fertilizer application in the Chicago Region.

[11] Enteric fermentation is a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream of an animal.

Limitations and Recommendations

Methods or data limitations are presented for each inventory sector included in the 2010 Regional GHG Inventory. Also provided are recommendations for improving the accuracy of the 2010 Regional GHG Inventory, in subsequent updates.

Building Energy

Limitations

- Commercial and industrial breakout of electricity use for ComEd was not available. Further, the distinction between the commercial and industrial categories of energy use obtained from the utilities was not always adequate to ensure that overlap issues were avoided or consistency maintained across the various datasets.
- Municipal energy use was only available from Peoples Gas (and not from other utilities). For other utilities, ICF assumed that municipal energy use was included in the commercial category.
- Certain categories of energy use that overlap with other sections of the inventory (including water pumping and wastewater treatment) were not available from the utilities as separate categories. ICF calculated energy use for these categories separately, and then subtracted this energy use from the building energy sector data.

Recommendations for improvement

- Collect utility data for more specific customer classes, perhaps by North American Industry Classification System (NAICS) code, to obtain electricity use for commercial and industrial activities separately.
- Break out municipal emissions separately in order to more accurately track local government emissions.

On-Road Transportation

Limitations

- There was some uncertainty in connecting the five vehicle types used by the Chicago travel demand model with the thirteen vehicle types included in the MOVES model. This was accomplished using ICF's professional judgment.
- Limited information was available regarding penetration of alternative fuel vehicle fleet in the Chicago market.

Recommendations for Improvement

- Obtain transportation data at the local level, if possible, including the speed distribution of vehicles traveling on freeways and local roads.
- Consider alternative methods for estimating emissions, such as activity-based approaches.
- Obtain accurate market penetration data on alternative fuel use, including future forecasts, to improve the alternative fuels analysis.

Off-Road Transportation

Limitations

- The *split* of GHG emissions between the city and Cook County for Metra's diesel locomotives could perhaps be more precise if information was available to split these rail emissions by actual rail miles or rail VMT. Route miles were initially used to establish this "split", as this data provides an approximation, and then adjusted based on direction from RTA. Similarly, for non-road equipment emissions, geographic (such as portion of land or water area), economic (such as retail sales between the city and county), and other metrics were selected to allocate emissions between the city of Chicago and Cook County. Metrics that are expected to have high correlation with the emissions sector analyzed were selected, though these metrics introduce some uncertainty into the analysis.
- The transit emissions estimate for 2010 is based on estimates from 2008 (which were scaled to the year 2010) in the absence of actual 2010 data.
- Transit emissions only include revenue vehicle operations and exclude the operation of non-revenue vehicles such as service trucks.
- USEPA's NONROAD model was published in April 2009. No data beyond that date is included in the underlying database.

Recommendations for Improvement

- Obtain the following data:
  - Separate rail miles or rail VMT for the city and Cook County.
  - Actual 2010 data for transit activity.
  - Data for non-revenue vehicle operations.

Solid Waste

Limitations

- Waste data including disposal tonnages, destination landfill, waste profile, recycled and diverted amounts, could not be obtained for all years utilized in the analysis.
- For the counties, there was no data available for the actual destination of the waste that each county landfilled; only the amount of waste that each county generated and the amount of waste that each landfill accepted was available. As a result, the amounts that went to different landfills were interpolated based on these weights.
- Actual methane capture rates for each landfill were not known, so a widely-accepted default rate of 75% was used.

Recommendations for Improvement

- Obtain total annual waste landfilled, recycled, and composted; the destination facility of that waste; and the waste composition profile of that waste.

- Obtain actual methane capture monitoring and capture data for each landfill serving the Chicago Region (or at least the major landfills).

Water Consumption

Limitations

- Energy use (electricity, natural gas, and fuel oil) per million gallons per day (MGD) pumped and treated at DWM water pumping stations (12 stations) and treatment plants (2 plants) were used as a proxy for all water pumping and treatment in the Chicago Region.
- Flow for each treatment plant serving the city of Chicago and each of the counties was not available, so energy intensities for treatment represent total energy used by both treatment plants divided by the total flow for all pumping stations.
- It was assumed that the emissions intensity of pumping and treating one million gallons of water is the same for each county in the Chicago Region (and is equal to the intensity of the DWM facilities).

Recommendations for improvement

- Collect data for all pumping stations and plants and create separate emission factors for each.
- Consider assigning water-related emissions for power plants by electricity use, rather than power plant location.

Wastewater Treatment

Limitations

- MWRD treatment plants (seven plants) were used as a proxy for all 139 plants serving the region.
- LGOP emission factors (as prepared by MWRD) were used instead of plant-specific factors. The use of LGOP emission factors may over- or under- estimate emissions as compared to plant-specific data.
- The accuracy of the plant flow distribution data (as provided by the City of Chicago) may require improvement.
- It was assumed that the emissions intensity of treating 1 million gallons of wastewater is the same for each county in the Chicago Region (and is equal to the intensity of the MWRD plants).

Recommendations for Improvement

- Collect specific data and emissions factors (as available) for all wastewater treatment plants in the Chicago Region or establish *proxy* data that is more representative of each county's actual wastewater service.

Stationary, Industrial, and Product Use

Limitations

- Paraffin and lubricant data was not available from the 2010 US National Inventory and could not be included in the consumer products emissions estimate. In the absence of more precise data sets for scaling emissions, consumer product use emissions were apportioned to each county based on population.
- Efforts were made to avoid double-counting between the MRR emissions data and the building energy sector. Emissions from the MRR database include fuel combustion at power plants (which was already accounted for in the electricity emission factors used in the building energy sector), along with natural gas combustion (which was already accounted for in the building energy sector). As a result, many emissions sources included in the MRR data for the Chicago Region were not included in the 2010 Regional GHG Inventory.
- The MRR database may not have been complete at the time of data collection (August–November 2011).
- Some source categories in the MRR have minimum thresholds, typically starting at 25,000 $MTCO_2e$ (e.g. Subparts Q—Iron and Steel Production), and do not include data from smaller facilities.
- For refrigerant emissions estimations, ICF relied on the CoStar database for building square footage numbers in the region; these numbers were used for the refrigerant GHG emissions estimates. However, the CoStar database may not capture all the building square footage in Chicago and the seven counties.

Recommendations for Improvement

- Collect emissions data for stationary sources that do not report emissions under the MRR, including smaller facilities.
- In the absence of any refrigerant data from the seven counties, the refrigerant survey for the Chicago Business District was applied not only for the city of Chicago but also for the seven counties. The types and uses of refrigerants may vary between Chicago and the seven counties; there may also be variations within the seven counties. ICF suggests that a similar type of survey to that for the city of Chicago be carried out in each of the seven counties (as possible) to identify the types of refrigerants being used in buildings, system capacities, and end uses.
- ICF applied “proxy” leakage rate factors for air conditioning and refrigeration systems in the absence of any actual data for these parameters. More specific data for the city of Chicago would enhance the accuracy of the refrigerant emissions estimations.
- Collect actual data on product use in the city and each county.

Agriculture

Limitations

- Data from the USDA was available only for 2002 and 2007, so 2010 livestock population and fertilizer acres contain some degree of uncertainty.

Recommendations for Improvement

- Obtain livestock population and agricultural acre data for 2010 for the Chicago Region (preferably by county).
- Obtain region- and crop-specific fertilizer types and rates of application for the Chicago Region (preferably by county).

Chapter 5
Emissions Trends

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Emissions Trends

Introduction

This chapter discusses trends in emissions from 2000 to 2010 for the city of Chicago and the Chicago Region. It also includes emissions trends by sector for this time period. These trends are based on comparison of the 2010 Regional GHG Inventory results to that of prior inventories developed by CNT for 2000 and 2005. Where possible, this chapter also describes the underlying factors that have contributed to these emissions trends, including changes in population, employment, weather, and other external changes, and attempts to distinguish these changes from inventory methodology differences between the current (2010) and prior inventory methods. For some sectors, as discussed below, emissions inventory methodologies differ between the different inventory years such that identification of clear emissions trends for these sectors is not possible. For the city of Chicago, this section also identifies where CCAP initiatives are contributing to reductions in greenhouse gas emissions, particularly over the 2005 to 2010 period.

Overall Emissions Trends

A comparison of 2010 GHG emissions for both the city and the Chicago Regional totals to prior inventory results for 2000 and 2005 yields the following overall emissions trends. [12]

- Total GHG emissions for the city of Chicago decreased by 3% from 2000 to 2010, with a greater decline of 7% between 2005 and 2010. Per capita emissions for the city of Chicago increased by 4% from 2000 to 2010 but decreased by 3% from 2005 to 2010.
- Total emissions for the Region rose by 6% from 2000 to 2010 but decreased by 4% from 2005 to 2010. Per capita emissions increased by 3% from 2000 to 2010 for the Region but decreased by 4% from 2005 to 2010.

Methods

GHG emissions and rates of energy use in the city of Chicago and the Chicago Region for 2000, 2005, and 2010 were paired with parameters such as population, number of households, cooling and heating degree days to yield useful metrics from which to evaluate these trends. Socioeconomic parameters utilized in this analysis were obtained from sources such as the CMAP and the 2010 U.S. Census.

The 2010 inventory separated electricity and natural gas-related emissions associated with water transport and treatment from other building energy emissions whereas the prior inventories did not. In order to make fair comparisons for the trends analysis, the 2010 electricity and natural gas emissions associated with the water sector have been added to the building energy electricity and

[12] For reference, total U.S. GHG emissions decreased by 5% from 2000 to 2010 and by 4% from 2005 to 2010 (U.S. Environmental Protection Agency 2012)

natural gas sectors. Thus the total below for building energy, for both electricity and natural gas consumption, will differ from that presented for the inventory in prior chapters.

City of Chicago Overall Emissions Trends

From 2000 to 2005, the city of Chicago's emissions increased by 1.5 $MMTCO_2e$, primarily as a result of an increase in building-related energy emissions due to a large rise in electricity-related emissions. From 2005 to 2010, in contrast, the city of Chicago's emissions declined by 2.9 $MMTCO_2e$, primarily due to lower building energy emissions in 2010 with reductions in both electricity and natural gas emissions. The overall trend from 2000 to 2010 is a decrease of greenhouse gas emissions of approximately 1.2 $MMTCO_2e$.

As discussed in Chapter 4, methodological changes were made for the 2010 inventory compared to the 2000 and 2005 inventories in the natural gas, on road transportation, solid waste, product use, stationary/industrial, off-road, and wastewater sectors. Changes in the inventory totals due to methodology are noted below.

A sensitivity analysis was done for the city of Chicago 2005 inventory to examine whether the overall trend of decreasing emissions from 2005 to 2010 is real or is due to these methodological changes. The conclusion of the sensitivity analysis is that the 2005 inventory would be slightly higher than currently estimated if the 2010 methodologies were used to update the 2005 inventory. Thus, the decrease in emissions from 2005 to 2010 would be slightly higher than a comparison of the current 2005 inventory and the 2010 inventory would reveal. The sensitivity analysis was also use to identify more clearly the non-methodology causes of change between 2005 and 2010. This analysis is presented at the end of this chapter.

Overall Trends from 2000 to 2010

The city of Chicago's absolute emissions are lower in the 2010 inventory relative to the 2000 inventory, due primarily to the following reasons (exclusive of changes in methodology): a decrease in natural gas sector emissions, correlated with a long-term decrease in residential natural gas consumption; population and employment decreases resulting in lower energy consumption and onroad emissions; and minor differences in weather in the two years. Changes in inventory methodologies for SF6, stationary, industrial and product use, and wastewater emissions also contributed to lower emissions in 2010 compared to 2000. The overall decrease in emissions for the city of Chicago from 2000 to 2010 occurred despite increases in emissions from building electricity, on-road, off-road, and waste sectors.

Population declined in the city of Chicago from 2000 to 2010 at a rate greater than the reduction in GHG emissions, resulting in a net increase in per capita emissions.

In 2010, the summer and winter were both somewhat warmer than in 2000. The differences in weather resulted in a small increase in electricity demand due to a warmer summer and an offsetting small decrease in natural gas demand for heating due to a warmer winter in 2010 compared to 2000. The net influence of these offsetting demands only had a minor net effect on overall greenhouse gas emissions over this period.

Overall Trends from 2005 to 2010

The key causes of lower emissions in 2010 compared to 2005, excluding changes in inventory methodology, are as follows: changes to relatively cleaner sources of electricity; a decrease in population; a long-term decline in residential natural gas use (due to combination of more efficient use, housing turnover and long-term price trends), residential and commercial building retrofits; minor weather differences between the two years; and a small decline in employment.

The overall lower emissions for the city of Chicago in the 2010 inventory compared to the 2005 inventory occurred for similar primary causes as that noted above for 2000 to 2010 in regards to declining natural gas consumption and population and employment decreases. In addition, building energy emissions also declined from 2005 to 2010, due to a change in the resource mix used to generate electricity in the region that serves Chicago to relatively cleaner sources[14] and a small decrease in electricity consumption. Changes in inventory methodology for stationary, industrial sources and product use, and wastewater also contributed to lower emissions in 2010 than 2005. The overall decrease in emissions for the city of Chicago from 2005 to 2010 occurred despite increases in emissions from the on-road transportation, off-road transportation and waste sectors, all of which were influenced by changes in methodology.

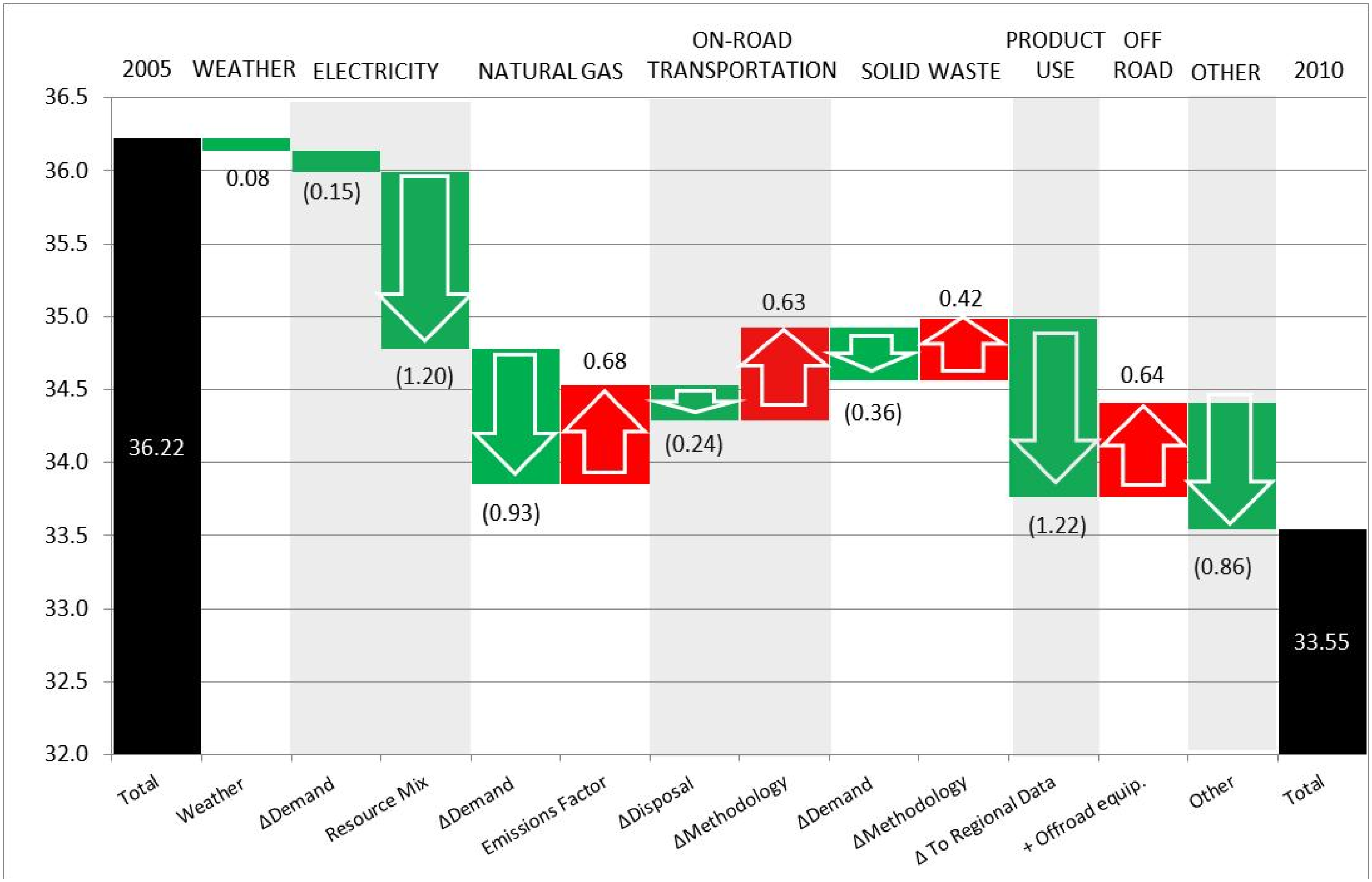
Population declined in the city of Chicago from 2005 to 2010, although not as quickly as the emissions decline, resulting in a decrease from 2005 to 2010 in per capita greenhouse gas emissions.

In 2010, the summer and winter were both somewhat warmer than in 2005. The differences in weather resulted in a small increase in electricity demand due to a slightly warmer summer and an offsetting decrease in natural gas demand for heating due to a slightly warmer winter in 2010 compared to 2005. The net influence of these offsetting demands only had a minor effect on overall greenhouse gas emissions.

The overall emissions trends and primary causes of emission changes between 2005 and 2010 are shown in Figure 5-1 below. Further details of the emissions trends and reasons for their changes are described below.

[14] The resource mix used to generate electricity changed from 2005 to 2010 with less coal and more natural gas, nuclear and renewable used to generate electricity in the region that supplies Chicago.

Figure 5-1. Chicago Greenhouse Gas Inventory, Trends and Causes of Change, 2005 to 2010 ($MMTCO_2e$)



Region-wide Overall Emissions Trends

Overall Trends from 2000 to 2010

The Chicago Region's total emissions increased by approximately 7.7 $MMTCO_2e$ from 2000 to 2010, primarily due to an increase in building electricity emissions (5.0 $MMTCO_2e$, including water pumping electricity), an increase in on-road transportation emissions (1.9 $MMTCO_2e$) and an increase in off-road transportation emissions (4.2 $MMTCO_2e$). These increases were partially offset by large decreases in the stationary, industrial and product use sectors due to change in inventory methodology and smaller decreases in emissions from several minor sectors (including wastewater and agriculture emissions) and due to elimination of the propane and fuel heating sector from the 2010 inventory. The increase in building electricity emissions from 2000 to 2010 is positively correlated with an increase in the number of households and the population in the Chicago Region over the same time period. The on-road transportation emissions increase is due to both an increase in VMT from 2000 to 2010 and due to change in modeling methodology to more accurately reflect vehicle types and congestion effects. The large increase in off-road transportation emissions is due to a change in methodology to include off-road equipment (other than rail) in the 2010 inventory, which was not included in the 2000 inventory.

As noted above, in 2010, the summer and winter were both somewhat warmer than in 2000. The differences in weather resulted in an increase in electricity demand due to a warmer summer and an offsetting decrease in natural gas demand for heating due to a warmer winter in 2010 compared to 2000. The net influence of these offsetting demands only had a minor effect on overall greenhouse gas emissions.

Emissions for all counties except for Cook County increased from 2000 to 2010. Cook County emissions decreased approximately 2% from 2000 to 2010. Emissions in Kendall County increased the most (53%) of all other counties, while emissions in DuPage County increased the least (5%) of all other counties. These changes appear to be correlated with changes in population. Specifically, Kendall County's population increased the most of all counties during these years, while DuPage County population increased the least of all counties.

Total Chicago Region per capita GHG emissions also increased from 2000 to 2010. This increase is correlated with a rise in per capita building electricity emissions and per capita on-road transportation emissions. The per capita building electricity emissions increase is correlated with a per capita increase in building electricity consumption. The latter trend of increasing on-road transportation emissions is likely due to a combination of an increase in vehicle miles travelled as well as a change in methodology to use the MOVES model to more accurately represent different vehicle types and take into account congestion effects. Table 5-1 illustrates how total and per capita emissions have changed from 2000 to 2010. Over the past ten years, the Chicago Region's total emissions have increased at a faster rate than that of population, resulting in an increase in the Chicago Region's per capita emissions between 2000 and 2010.

Overall Trends from 2005 to 2010

In contrast to the 2000 to 2010 trend, the Chicago Region's total emissions *decreased* by approximately 4.9 MMTCO_2e (4%) from 2005 to 2010, This is primarily due to a 11% decrease in building energy electricity emissions. This decrease in electricity emissions is due to a 4% decrease in electricity consumption and an 8% decrease due to a change in the electricity generation resource mix (as noted above). In addition, there were large decreases in the emissions estimates for the stationary, industrial and product use sectors due to changes from using national data to using more regionally specific data. These decreases were offset partially by increases in the on-road and off-road transportation emissions both of which are due in large part to changes in methodology. Other changes included decreases in emissions from several minor sectors (including wastewater and agriculture emissions) and due to elimination of the propane and fuel heating sector from the 2010 inventory.

In 2010, the summer and winter were both slightly warmer than in 2005. The differences in weather resulted in a slight increase in electricity demand due to a warmer summer and an offsetting decrease in natural gas demand for heating due to a warmer winter in 2010 compared to 2005. The net influence of these offsetting demands only had a minor effect on overall greenhouse gas emissions.

The overall emissions trends and causes between 2005 and 2010 are shown in Figure 5-2 below. Further details of the emissions trends and possible reasons for their changes are described below.

Figure 5-2. Chicago Region Greenhouse Gas Inventory, Trends and Causes of Change, 2005 to 2010 ($MMTCO_2e$)

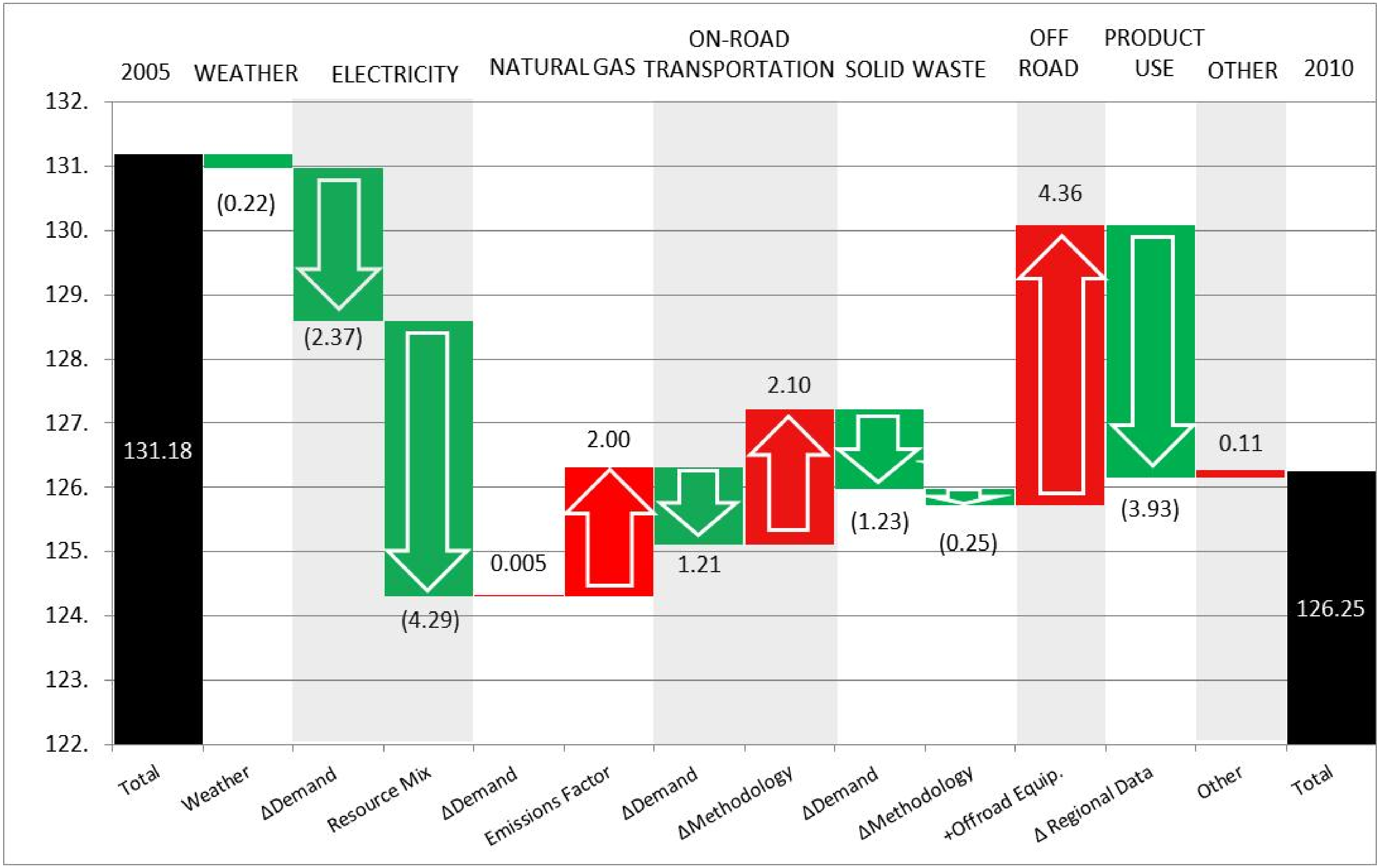


Table 5-1. Total and Per-Capita Emissions by County (2000, 2005, and 2010)

	Total Emissions ($MTCO_2e$)			Population			Per-Capita Emissions ($MTCO_2e$)		
Jurisdiction	2000	2005	2010	2000	2005	2010	2000	2005	2010
City of Chicago	34,700,000	36,200,000	33,545,577	2,896,016	2,824,584	2,695,598	12.0	12.8	12.4
Cook (all)	73,850,000	79,700,000	72,726,521	5,376,861	5,268,513	5,194,675	13.7	15.1	14.0
DuPage	14,690,000	16,540,000	15,371,387	906,576	922,589	916,924	16.2	17.9	16.8
Kane	5,750,000	7,400,000	8,110,085	407,511	475,350	515,269	14.1	15.6	15.7
Kendall	970,000	1,280,000	1,486,556	55,217	79,054	114,736	17.6	16.2	13.0
Lake	10,230,000	11,180,000	11,495,991	648,116	691,815	703,462	15.8	16.2	16.3
McHenry	3,740,000	4,390,000	4,922,803	261,887	301,741	308,760	14.3	14.5	15.9
Will	8,080,000	10,510,000	11,939,945	508,038	631,397	677,560	15.9	16.6	17.6
Unallocated	980,000[a]		198,193						
Chicago Region (7-County) Total	118,520,000[b]	131,180,000[2]	126,251,482	8,164,206	8,370,459	8,431,386	14.5	15.7	15.0

Sources: Center for Neighborhood Technology 2009 (for 2000 and 2005 emissions); U.S. Census 2010 for population numbers; ICF for 2010 emissions.

Notes:

a. Center for Neighborhood Technology 2009 did not report wastewater emissions by jurisdiction.

b. Total reported from Center for Neighborhood Technology 2009. Column totals don't match overall total due to rounding in CNT report.

Emissions Trends by Sector

Both the city of Chicago and Chicago Region 2010 inventories are dominated by building energy emissions from electricity and natural gas use, as well as on-road transportation emissions, similar to 2000 and 2005. Similarly, these sectors are the most GHG-intensive on a per-capita basis for the 2000, 2005, and 2010 inventory years. Table 5-2 summarizes the changes in each inventory sector's absolute emissions, between 2000 and 2010, for both the city of Chicago and the Chicago Region. For the majority of sectors, absolute emissions have increased between 2000 and 2010. Two exceptions are the building energy (natural gas) and wastewater treatment sectors. The data in Table 5-2 is for comparison purposes and does not account for any minor changes in the emissions estimation methodology included in each year's inventory, or any other changes that may have influenced emissions in each inventory year. However, given the considerable methodology changes employed for the off-road transportation, stationary, industrial, product use and wastewater sectors in the 2010 Regional GHG Inventory, these sectors have been excluded from this comparison.

Table 5-2. Percent Change in Emissions by Sector for Chicago and the Chicago Region (2000 vs. 2010)

Sector[a]	Chicago (2010 vs. 2000)	Chicago Region (2010 vs. 2000)
Building Energy—Electricity	14%	12%
Building Energy—Natural Gas	-18%	-0.2%
On-Road Transportation	2%	6%
Water Consumption[b]	N/A	N/A
Agriculture	N/A	-43%
All Sectors	-3%	6%

Notes:

a. Off-Road Transportation, Solid Waste, Stationary, Industrial, Product Use and Wastewater sectors: The 2010 Regional GHG Inventory included substantially different methods/data sources for these sectors than those included in the 2000 inventory. As a result, these sectors have been excluded from this comparison.

b. Water: The 2000 inventory did not include a break-out of water consumption emissions, so a comparison cannot be made for this sector. However, it is assumed that the electricity and natural gas consumption associated with water transportation and treatment were included in the 2000 inventory building energy sector. The electricity and natural gas consumption associated with water transportation and treatment in the 2010 inventory have been included in the electricity and natural gas sectors for the purpose of comparison.

City of Chicago Emissions Trends by Sector

This section describes each inventory sector's trends for the city of Chicago and compares the 2010 inventory results to that of the 2000 and 2005 inventories. To the extent possible, a discussion of the correlative or causal factors that may influence or drive the emissions trends are included for each sector.

The CCAP was adopted in September 2008. The plan focuses on five primary strategies to reduce greenhouse gas emissions and prepare for climate change impacts. These five strategies areas were reviewed in terms of the actions taken to date and their relation to the recent trends identified in this report. Actions taken to date under CCAP are based on information contained in the CCAP Progress Report (City of Chicago 2010) as well as direct information from the city. The influence of the five strategies is discussed below in the electricity, natural gas, on-road transportation, solid waste, and wastewater emissions sectors.

Data on Gross Domestic Product (GDP) is only available at the regional level and thus the analysis for the city below does not reference changes in regional GDP, which is instead discussed in the regional trends analysis. However, economic changes are likely also influencing trends in the city as well. Employment data has been included in the city trends analysis as a proxy for economic growth.

Building Energy

Building energy emission trends are discussed separately for electricity and natural gas consumption emissions.

Electricity

Electricity-related emissions in the city of Chicago increased by 25% between 2000 and 2005, decreased by approximately 9% from 2005 to 2010, for a net increase of 14% from 2000 to 2010 (see Table 5-3). The GHG emissions estimates are derived from electricity consumption and the electricity emissions factor(s), both of which influence changes.

Between 2000 and 2005, electricity emission increased primarily due to a large increase in consumption combined with an increase in the emissions factor due to the use of relatively more carbon-intensive sources of electricity. The increase in consumption was due to a substantially warmer summer resulting in an increase in electricity used for cooling and possible increased use of residential and commercial electronics. These increases are partially offset by declining demand due to population and employment decreases over the period.

Between 2005 and 2010, electricity emission decreased primarily due to an increase in use of relatively cleaner electricity generation sources in combination with a smaller decrease in electricity consumption. The decrease of consumption was due to, in order of importance, the following: population decrease, building retrofits, a slightly warmer summer, and a slight decrease in employment.

Table 5-3 summarizes the changes in various parameters discussed below.

1. **Electricity Consumption:** Building electricity consumption increased by 14% from 2000 to 2005 and decreased by 1% between 2005 and 2010 for a net increase of 13% overall between 2000 and 2010. Below is an analysis of several factors that may have influenced these trends.

The majority of electricity consumption is non-residential (commercial, industrial and municipal) with the remaining amount attributed to residential sources. Residential electricity consumption increased by 23% from 2000 to 2005, compared to an 11% increase in non-residential consumption over the same period. Residential electricity consumption decreased by 3% from 2005 to 2010, compared to a 0.1% increase in non-residential consumption over the same period. The residential share of total consumption did not substantially change from 2000 to 2010.

Population declined from 2000 to 2005 and from 2005 to 2010 however per capita electricity consumption increased over both periods (increasing by 17% from 2000 to 2005 and by 4% from 2005 to 2010).

In 2010 and 2005, there were substantially more cooling degree days (CDD) than in 2000. A regression analysis was done to establish the relationship between electricity consumption and CDD using the 2010 inventory data. The results of the regression analysis indicated the weather differences resulted in an estimated 2.0% increase in electricity demand in 2010 compared to 2000. Cooling degree days for 2005 and 2010 were nearly the same and thus the regression analysis only estimated a 0.07% increase in electricity demand in 2010 compared to 2005 due to weather differences. This increased demand was estimated to have resulted in an increase in electricity GHG emissions of 0.26 $MMTCO_2e$ between 2000 and 2010 and an increase of 0.01 $MMTCO_2e$ between 2005 and 2010.

CCAP Strategy 1 (Energy Efficient Buildings) seeks to reduce energy use through promotion of building retrofit projects. From 2008 through the third-quarter of 2011, there have been approximately 73,000 residential retrofit projects and over 3,500 commercial and industrial building retrofit projects for energy efficiency with a savings of approximately 163 million kilowatt-hours of electricity (Jacks, pers. comm. 2012). Of this total savings, residential retrofit projects account for approximately 11 million kwh saved; commercial and industrial building retrofit projects account for approximately 152 million kwh saved. Using the emissions factors in this inventory, the total retrofit projects are estimated to be reducing approximately 100,000 $MTCO_2e$ of greenhouse gas emissions annually. As noted in Table 5-3 below, residential electricity consumption in the city decreased from 2005 to 2010 and residential retrofit projects implemented as part of the CCAP are definitely contributing to that overall consumption decrease. Nonresidential electricity consumption in the city increased from 2005 to 2010 but the commercial and industrial retrofit projects implemented as part of the CCAP helped to keep the overall consumption level to a level lower than it would have been under business as usual conditions.

Additional factors that also contribute to changes in electricity consumption include energy efficiency measures, energy price changes, and economic activity.

2. **Emissions Factors:** The electricity emissions factor increased from 2000 to 2005 by 9.1% but then decreased by 7.5% from 2005 to 2010. Between 2000 and 2010, the electricity emissions factor slightly increased (0.9%).

   Changes in the electricity emissions factor reflect the estimated changes in the resource mix in electricity generation in the RFC region. Between 2005 and 2010, the change in the emissions factor was due to a decline in coal share (by 6%) and an increase in nuclear and renewable share (by 2%).

CCAP Strategy 2 (Clean and Renewable Energy Sources) seeks to increase the share of renewable energy utilized in the city (City of Chicago 2010). The Chicago Park District is incorporating 25% renewable energy into its electricity purchase and installing pilot solar/wind lighting projects in parks and solar thermal energy for park facilities (City of Chicago 2010). The Rosa Parks Apartments affordable housing development has included geothermal and solar thermal energy elements in its design. The city partnered with Exelon and Sunpower to produce 14,000 megawatt-hours (MWh) of electricity from an urban solar plant and Chicago Public Schools (CPS) is purchasing 20 percent of its electricity from renewable sources and has purchased 342,000 MWh of renewable energy over 3 years (or average of 114,000 MWh/year). Using the RFC emissions factor data used in this inventory, the urban solar plant and CPS renewable energy purchase initiatives could be offsetting approximately 79,000 MTCO2e/year. As described below, the electricity generation resource mix in the multi-state region that supplies Chicago increased its renewable energy share from 2005 to 2010, resulting in reduction of electricity emissions by perhaps 1.2 million MTCO2e. Although the local contributions to that share of renewable energy are small at present, they nonetheless contributed to the increasing share of renewable energy and thus to the associated reductions in greenhouse gas emissions.

3. **Overall Analysis:** Between 2000 and 2010, increases in per capita electricity demand, combined with smaller contributions due to weather changes appear to be driving electricity consumption increases, despite population and employment decreases while the emissions factor was roughly the same in 2000 and 2010. However, between 2005 and 2010, the emissions factor change (due to relatively cleaner sources of electricity generation in 2010 compared to 2005) is the key factor driving lowering emissions with additional contributions from lowered electricity consumption due to population and employment decreases, increased energy efficiency retrofits due to offset. These decreased are slightly offset by higher cooling emissions due to a slightly warmer summer in 2010 compared to 2005.

Table 5-3. Electricity Emissions and Relevant Parameters and Comparators for the City of Chicago (2000-2010)

Parameters	2000 Value	2005 Value	2010 Value	2000–2005 % Change	2005–2010 % Change	2000–2010 % Change
Total GHG Emissions ($MMTCO_2e$)	12.86	16.02	14.65	24.6%	-8.6%	13.9%
1. Electricity Usage (billion kWh)	*21.03*	*24.03*	*23.82*	*14.3%*	*-0.9%*	*13.2%*
Residential (billion kWh)	5.54	6.82	6.59	23.1%	-3.4%	18.9%
Non-Residential (billion kWh)	15.49	17.21	17.23	11.1%	0.1%	11.2%
Per-Capita Electricity Usage (kWh/person)	7,262	8,506	8,835	17.1%	3.9%	21.7%
Per-Capita Residential Electricity Usage (kWh/person)	1,913	2,415	2,444	26.3%	1.2%	27.8%
Change in Electricity Demand due to weather (from regression analysis)				N/A	+0.07%	+2.0%
1. *Emissions Factor (lbs CO_2/MWh)*	*1,347*	*1,470*	*1,360*	*9.1%*	*-7.5%*	*0.9%*
Comparators						
Population	2,896,016	2,824,584	2,695,598	-2.5%	-4.6%	-6.9%
Households	1,061,928	1,063,047	1,045,560	-6%	-1.6%	-1.5%
Employment	1,220,040	1,197,749	1,196,022	-1.8%	-0.1%	-2.0%
Cooling Degree Days	780	1,166	1,811	52.0%	1.3%	54.0%

Note: Water-related electricity emissions for 2010 are included in the building energy sector to allow for fair comparisons to prior inventories

Natural Gas

The GHG emissions related from natural gas consumption were 6% lower in 2010 than in 2005 and and 18% lower in 2010 compared to 2000.

Between 2000 and 2005, emissions decreased due to a reduction in natural gas consumption, which was due to, in order of importance, the following: a long-term decline in residential gas use (due to combination of more efficient use, housing turnover and long-term price trends), population and employment decrease, and a slightly warmer winter.

Between 2005 and 2010, emissions decreased due to a reduction in natural gas consumption, which was due to, in order of importance, the following: a long-term decline in residential gas use (due to combination of more efficient use, housing turnover and long-term price trends), population decrease, CCAP building retrofits, a slightly warmer winter and a slight decrease in employment.

Table 5-4 summarizes the changes in various parameters discussed below.

1. **Natural Gas Consumption:** Overall consumption declined significantly (23%) between 2000 to 2010. Residential natural gas usage decreased while nonresidential gas increased slightly over this time period. Declines in population and, households from 2000 to 2010 contributed to the drop in residential consumption. Per-capita natural gas usage and per capita residential natural gas usage also declined from 2000 to 2010. The long-term decrease in natural gas consumption parallels a regional and national trend. According to the Energy Information Administration (EIA), the national decreasee in residential natural gas consumption per capita is due to the following: 1) increased efficiency in space-heating equipment and other natural gas appliances; 2) turnover in housing stock; 3) long-term increase in natural gas costs 4) population migration to warmer climate 5) decrease in percentage of customers using natural gas as their primary fuel (EIA 2010). These factors are likely what is underlying the bulk of large decreases in residential per capitagas use in the City of Chicago (except for population migration, which is accounted for in population change within the City). The other key cause of decreased natural gas consumption is decline in population and employment between 2000 and 2010.

   In 2010, the winter was slightly warmer than in 2000 and 2005 resulting in a decrease in natural gas demand for winter hearing. A regression analysis was done to establish the relationship between natural gas consumption and heating degree days (HDD) using the 2010 inventory data. The results of the analysis indicate that weather differences resulted in an estimated 2.5 % decrease in natural gas demand in 2010 compared to 2000 and an estimated 0.095% decrease in natural gas demand in 2010 compared to 2000. This decreased demand is estimated to have resulted in a decrease in natural gas GHG emissions of 0.29 $MMTCO_2e$ between 2000 and 2010 and a decrease of 0.09 $MMTCO_2e$ between 2005 and 2010.

   CCAP Strategy 1 (Energy Efficient Buildings) supports reductions in energy use through building retrofit projects. From 2008 through the third-quarter of 2011, the retrofit projects described above have resulted in reduction of approximately 6 million therms of natural gas (Jacks, pers. comm. 2012). Of this total savings, residential retrofit projects account for approximately 5 million therms saved; commercial and industrial building retrofit projects account for approximately 1 million therms saved. Using the emissions factors in this inventory, the total retrofit projects result in an estimated reduction of over 33,000 $MTCO_2e$ of natural gas-related greenhouse gas emissions. As noted above, residential natural gas consumption in the city decreased from 2005 to 2010 and residential retrofit projects implemented as part of the CCAP are definitely contributing to that overall consumption decrease. Nonresidential natural gas consumption in the city increased from 2005 to 2010 but the commercial and industrial retrofit projects implemented as part of the CCAP helped to keep the overall consumption level to a level lower than it would have been under business as usual conditions.

2. **Emissions factors:** A default national factors (5.32 kg CO_2/therm) for natural gas was used in 2000 and 2005. For the 2010 Regional GHG Inventory, ICF derived emisions factors for People's Gas and Nicor Gas, based on gas composition, and then weighted them accordingly to yield a slightly higher factor of 5.69 kg CO_2/therm (an increase of 6.9%).

3. **Overall Analysis:** For 2000 to 2010 and from 2005 to 2010, the natural gas emissions decrease is dominated by the decrease in natural gas consumption due to decreases in residential per capita consumption levels (due to the combination of long-term natural gas consumption trends and in part due to a substantial expansion of energy efficency retrofits), decreases in population

and employment and due to milder winter conditions in 2010 compared to the two prior years. The increase in the emissions factor partially offsets the decrease in consumption.

Table 5-4. Natural Gas-related Emissions and Relevant Parameters and Comparators for the City of Chicago (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2000-2005 % Change	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions ($MMTCO_2e$)	11.52	9.92	9.43	-13.9%	-5.0%	-18.2%
1. Natural Gas Usage (billion therms)	*2.17*	*1.85*	*1.66*	*-14.0%*	*-10.1%*	*-22.6%*
Residential (billion therms)	1.50	1.30	1.00	-13.3%	-23.2%	-33.5%
Non-Residential (billion therms)	0.65	0.55	0.67	-15.4%	21.0%	2.4%
Per-Capita Natural Gas Usage (therms/person)	742	655	617	-11.8%	-5.8%	-16.9%
Change in Natural Gas Demand due to weather (from regression analysis)				N/A	-0.95%	-2.5%
2. Emissions Factor (kg CO_2/therm)	*5.32*	*5.32*	*5.69*[a]	*0%*	*6.9%*	*6.9%*
<u>*Comparators*</u>						
Population	2,896,016	2,824,584	2,695,598	-2.5%	-4.6%	-6.9%
Households	1,061,928	1,063,047	1,045,560	-0.1%	-1.6%	-1.5%
Employment	1,220,040	1,197,749	1,196,022	-1.8%	-0.1%	-2.0%
Heating Degree Days	6,240	6,080	5,991	-2.5%	-1.5%	-4.0%

Note:
Water-related natural gas emissions for 2010 are included in the building energy sector to allow for fair comparisons to prior inventories
a. Weighted average of People's Gas and Nicor Gas emissions factors

On-Road Transportation

On-road transportation emissions in 2010 have increased by 2% from 2000 and by 5% from 2005, as shown in Table 5-5 below.

VMT increased from 2000 to 2005 (+3%), then decreased from 2005 to 2010 (-4%) resulting in an overall slight net decrease from 2000 to 2010 (0.7%).[15] Methodology changes in the 2010 Regional GHG Inventory include the use of USEPA's MOVES model, which departs from previous

[15] VMT data identified for the 2000 and 2005 inventories is labeled as draft.

methodologies as discussed in Chapter 4 (and summarized below), as well as the inclusion of emissions from alternative fuel vehicles. Aside from VMT and methodology changes, on-road GHG emissions are also influenced by fuel economy and emissions factors fuel emission factors.

The MOVES model deviates from the prior inventory methods in the following major ways: 1) The MOVES model uses more categories of vehicles than that used for the prior inventories. 2) The MOVES model examines congestion on a roadway specific basis. The prior inventories used single emissions factors for each vehicle type whereas the 2010 inventory took into account congestion effects on emission factors. It appears that the USEPA MOVES model may account for more congestion effects on vehicle efficiency (and related emissions) than in the prior inventories, which is likely to be driving the overall increase in on-road transportation emissions, given that VMT appears to be declining.

CCAP Strategy 3 (Improved Transportation Options) includes initiatives that build on the City's ongoing role in working with regional transit providers in increasing transit alternatives to automobile use as well as in promoting alternative fuels and alternative fuel vehicles for transportation (City of Chicago 2010). From 2000 to 2010, CTA ridership increased by approximately 8% and from 2005 to 2010 increased by approximately 5%. However, due to financial limitations resultant from the economic downturn, transit service had to be limited in 2010 and from 2008 to 2010 ridership decreased by slightly less than 2%. As the economy recovers from the last recession, it is expected that ridership will approach and then exceed prior levels. Overall VMT and passenger vehicle VMT both decreased from 2005 to 2010 and passenger vehicle VMT capita also decreased from 2005 to 2010; increased use of transit over this period is an important factor in promoting VMT decreases. CTA has been introducing hundreds of hybrid buses that are more fuel-efficient and have lower emissions and the Chicago Area Alternative Fuel Deployment Project is implementing a federal grant to expand alternative fuel infrastructure and increase the alternative fuel fleet. While the exact contribution of alternative fuel vehicles since 2008 could not be identified as part of this study, the increase in alternative fuel vehicles over time will also help to reduce transportation GHG emissions. Thus, the ongoing role of the City in promoting transit is contributing to the overall trend of reductions in VMT.

Per capita on-road emissions are higher in 2010 than for the earlier years of 2000 and 2005. Per capita emissions increased because the Chicago population declined between 2000 and 2010, while absolute transportation emissions increased. Given this population decline, it is likely that VMT (which is usually associated with population) has been decreasing as a result of population changes and changes in transit use over time, and not due to methods or data differences between the inventory years. Further, this suggests that the increase in on-road transportation emissions estimates is likely due to the combination of changes in fuel economy, fuel emissions factors, and methodology changes noted above which is outweighing the reduction in VMT overall.

Table 5-5. On-Road-Per Capita Emissions and Relevant Parameters and Comparators for the City of Chicago (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions ($MMTCO_2e$)	6.63	6.47	6.78	4.9%	2.2%
GHG Emissions/ Capita ($MTCO_2e$)	2.29	2.29	2.52	9.9%	9.8%
1. Vehicle Miles Travelled[a]					
All vehicles	12.21	12.60	12.13	-3.8%	-0.7%
Passenger (billion miles)	5.81	5.99	4.46	-25.6%	-23.2%
Light Duty (billion miles)	5.31	5.49	6.71	22.2%	26.4%
Heavy Duty (billion miles)	1.04	1.07	0.89	-17.0%	-14.6%
Passenger miles/capita	2,006	2,121	1,655	-22.0%	-17.5%
2. Emissions Intensity[b] *(MT CO_2/thousand miles)*	*0.54*	*0.51*	*0.56*	*9.0%*	*2.9%*
Comparators					
Population	2,896,016	2,824,584	2,695,598	-4.6%	-6.9%
Households	1,061,928	1,063,047	1,045,560	-1.6%	-1.5%
Employment	1,220,040	1,197,749	1,196,022	-0.1%	-2.0%

a. The USEPA MOVES model uses 13 different vehicle categories (compared to 4 in prior inventory) and thus vehicles may not be categorized in the same way in the two inventories.

b. This number was calculated by dividing the total GHG emissions by VMT and indicates the relative GHG intensity per mile in the different inventories. Comparisons between 2000/2005 and 2010 are hampered by the change in modeling method.

Off-Road Transportation

Total off-road transportation emissions estimates have increased by 45% in the 2010 inventory compared to the 2005 inventory and by 40% since 2000 (Table 5-6). The primary reason for this large increase is the inclusion of off-road equipment (such as construction equipment and yard equipment) in the 2010 inventory as these sources were not included in the prior inventories. The additional off-road equipment emissions for 2010 were responsible for 0.64 $MMTCO_2e$ or 67% of the total off-road emissions.

Both inventories included railroad vehicle emissions but the 2010 inventory used several different methodologies from the prior inventories. Specifically, ICF allocated a portion of regional rail emissions to the city of Chicago (except for Amtrak and freight rail emissions). In addition, instead of using default grid electricity factors, ICF developed utility-specific 2010 emissions factors for electricity based on the utility energy generator in mix for electric rail emissions. The result of these methodology changes is that rail-related emissions were substantially lower in the 2010 inventory than in the prior inventories.

Table 5-6 Off-Road-related Transportation Emissions and Relevant Parameters and Comparators for the City of Chicago (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions ($MMTCO_2e$)	0.68	0.66	0.95	45.0%	39.6%
1. Rail Emissions[a]	*0.68*	*0.66*	*0.31*	*-52.2%*	*-69.0%*
2. Other Off-Road Equipment	--	--	*0.64*	*100%*	*100%*
Comparators					
Employment	1,220,040	1,197,749	1,196,022	-0.1%	-2.0%

[a] See discussion of methodology changes in the text.

Solid Waste

The total estimated emissions from waste generation in Chicago in the 2010 inventory are 5% more than those estimated in the 2005 inventory and 22% more than those estimated for 2000. Waste disposed in landfills annually has actually declined between 2000 and 2010 and between 2005 and 2010. The primary reason that the emissions estimate in 2010 is larger than the prior inventories is due to a change in methodology between the current and prior inventories.

CCAP Strategy 4 (Reduce Waste and Industrial Pollution) seeks to build on prior City efforts to promote waste reduction, reuse and recycling options. Partnerships with local businesses and other entities helped to divert over 160,000 tons of waste in 2008 and 2009. The City substantially increased the amount of recyclables collected through the Blue Cart Program in 2008 and 2009. Overall, from 2005 to 2010, municipal solid waste from the city disposed in landfills decreased by slightly less than 900,000 tons. While some of that recent decrease is due to the substantial slowdown in the construction industry and the decrease in construction and demolition waste over this period, some of the decrease is also due to the increased diversion of waste to reuse and recycling resultant from City diversion programs and partnerships.

Despite the overall decrease in waste generation from 2000 to 2010, methodology changes appear to drive the changes between the 2010 and 2000/2005 inventories. Specifically, the 2010 emissions estimation methodology accounts for current year landfill methane emissions whereas the prior 2000 and 2005 inventories estimated the *future* landfill methane emissions from disposal of current year solid waste (also known as the "methane commitment" method). The 2010 inventory identified historical waste disposal (including waste generated as far back as 1950) that have resulted in the current amount of waste in place at landfills used by the city of Chicago. ICF's analysis indicates that only 40% of the GHG emissions attributable to the year 2010 from solid waste are sourced from waste disposed in the 2000-2010 period and that the remaining 60% comes from years prior to 2000 (from 1950–2000).

In order to examine the trend in solid-waste related emissions, ICF calculated emissions using both the 2010 inventory method as well as the 2005 inventory method. The results are shown in Table 5-7 and show that solid waste emissions are actually decreasing. For the 2010 inventory method, which is measuring current landfill emissions, a contributing factor to the decrease is the increasing amount of methane capture over time and the long term reduction in new waste being disposed in landfills. For the 2000/2005 inventory method, which measures the landfill "methane commitment" of current year waste disposal, the decrease in waste disposal is a driving factor.

Using the sensitivity analysis results (see discussion later in this section), the key drivers of change between 2005 and 2010 are the increase in methane capture and the reduction in methane generation due to increased diversion of waste, decrease in population and employment, and aging of landfill waste.

Table 5-7. Solid Waste-related Emissions and Relevant Parameters and Comparators for the City of Chicago (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions in Inventory Estimates ($MMTCO_2e$)	1.06	1.23	1.29	5.0%	21.8%
GHG Emissions Using 2010 Methodology ($MMTCO_2e$)	2.15	1.56	1.29	-17.3%	-39.8%
GHG Emissions Using 2000/2005 Methodology ($MMTCO_2e$)	1.06	1.23	0.85	-31.0%	-19.8%
Municipal Solid Waste Disposed in Landfills (million tons)	*2.49*	*3.04*	*2.15*	*-29.3%*	*-14.9%*
Average Weighted Methane Capture	*62%*	*69%*	*73%*	*5.2%*	*17.7%*
Comparators					
Population	2,896,016	2,824,584	2,695,598	-4.6%	-6.9%
Households	1,061,928	1,063,047	1,045,560	-1.6%	-1.5%
Employment	1,220,040	1,197,749	1,196,022	-0.1%	-2.0%

Wastewater Treatment

Total wastewater emissions have decreased approximately 40% since 2005 and 2000 (emissions in 2000 were nearly identical to emissions in 2005). The precise reason for the large change in emissions between the different inventories is difficult to precisely identify in the absence of data on quantity of wastewater treated and utilized in the 2000 and 2005 inventories (which was not provided in the prior inventory report).

CCAP Strategy 5 (Adaptation) is mostly focused on preparing Chicago and its residents in creating community resiliency to changes in the climate that will occur over time. However, within this strategy area, the City has been promoting improved stormwater management to reduce the need for wastewater treatment (City of Chicago 2010), which is also a factor in reductions in the electricity, natural gas, and fugitive emissions from the wastewater sector.

Thus, the reduction in wastewater emissions is likely due to the combination of the following factors: 1) improved efficiency at wastewater plants; 2) a decline in wastewater generation as a result of the city of Chicago's population decline and improved stormwater management; and 3) inventory methodology changes.

Table 5-8. Wastewater-related Emissions and Relevant Parameters and Comparators for the City of Chicago (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions ($MMTCO_2e$)	0.35	0.34	0.20	-40.5%	-41.6%
GHG Emissions /capita ($MTCO_2e$)	0.12	0.12	0.08	-37.7%	-37.3%
Comparators					
Population	2,896,016	2,824,584	2,695,598	-4.6%	-6.9%
Households	1,061,928	1,063,047	1,045,560	-1.6%	-1.5%
Employment	1,220,040	1,197,749	1,196,022	-0.1%	-2.0%

Water Consumption

Water pumping and treatment activities in the city of Chicago emitted a total of 0.135 $MMTCO_2e$ in 2010 and accounted for approximately 0.4% of the city's total GHG emissions. These emissions were not included as a separate category in the 2000 and 2005 inventories, although they are presumed to be included in the building energy electricity and natural gas emissions total. As such, a comparison of emissions between 2000 and 2010 from water consumption is not possible.

Stationary, Industrial, and Product Use

Estimated emissions from stationary and industrial combustion and processes increased 21% from 2005 to 2010 but decreased by 88% between 2000 and 2010. Emissions from product use (including refrigerant emissions) decreased 88% from 2005 to 2010 and by 84% between 2000 and 2010. The main reason for the change in emissions from 2000 to 2010 is due to the vastly different methodologies used to calculate emissions in 2010. As described in Chapter 4, the 2010 inventory generally includes regionally specific data, as opposed to scaling of national emissions data (as utilized in the 2000 and 2005 inventories).

Table 5-9. Stationary, Industrial, and Product Use Per-Capita Emissions and Relevant Parameters and Comparators for the City of Chicago (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Stationary/Industrial GHG Emissions ($MMTCO_2e$)	0.431	0.044	0.054	20.7%	-87.6%
Product Use GHG Emissions ($MMTCO_2e$)	1.056	1.408	0.191	-86.4%	-81.9%
					Comparators
Population	2,896,016	2,824,584	2,695,598	-4.6%	-6.9%
Households	1,061,928	1,063,047	1,045,560	-1.6%	-1.5%
Employment	1,220,040	1,197,749	1,196,022	-0.1%	-2.0%

Agriculture

The city of Chicago has no livestock and no farmland and therefore there are no agricultural emissions included in the 2010 inventory. Agriculture was also not included in the 2000 or 2005 inventories for Chicago. While there are community gardens in various parts of the city, these areas were not included in this inventory due to the relatively limited areas in such use (compared to large-scale farming in other parts of the CMAP region) and limited emissions associated with such activity.

Regional Emissions Trends by Sector

This section describes the emissions trends for each sector in the Chicago Region, including comparison of 2010 total regional emissions to that of the 2000 and 2005 inventories. A discussion of the correlative and causal factors that are influencing or driving the emissions increases or decreases are outlined per sector (to the extent possible).

Building Energy

Building energy emission trends are discussed separately below for electricity and natural gas emissions.

Electricity

The Chicago Region electricity emissions total shows an increase of 13% from 2000 to 2010 and a decrease of 10% from 2005 to 2010 (Table 5-10).

Specifically:

- The **2000 to 2010** increase is primarily due to an increase (10%) in electricity consumption over this period, rather than due to changes in the emissions factor (which only increased by 0.9% over this period). The 2000 to 2010 electricity emissions trend change appears to correlate with demographic changes (increases in population, per capita emissions, and households), economic growth (reflected in growth in Gross Domestic Product) as well as weather. As noted above, in 2010, the summer was somewhat warmer than in 2000. The differences in weather resulted in an increased electricity demand (estimated as 2.4%) due to increased air conditioning in 2010 compared to 2000. This increased demand is estimated to have resulted in an increase in electricity GHG emissions of 1.1 $MMTCO_2e$ between 2000 and 2010. Overall, the emissions factor change has a very small role in raising emissions from electricity from 2000 to 2010; the changes in electricity consumption emissions appear to be primarily due to the changes in the electricity consumption.
- From **2005 to 2010**, the emissions decrease is correlated with lower electricity consumption (a 4% decrease over this time period) as well as a decrease in the emission factor (of 8%). Economic growth over this period was very modest due to the effects of the recession in the later part of the period. The emissions factor change has larger role in decreasing emissions from electricity in this period than does the decrease in electricity consumption. In 2010, the summer was slightly warmer than in 2005. The differences in weather resulted in an increased electricity demand (estimated as 0.09%) due to increased

air conditioning in 2010 compared to 2005. This increased demand is estimated to have resulted in an increase in electricity GHG emissions of 0.05 $MMTCO_2e$ between 2005 and 2010.

Table 5-10. Electricity Emissions and Relevant Parameters and Comparators for the Chicago Region (2000–2010)

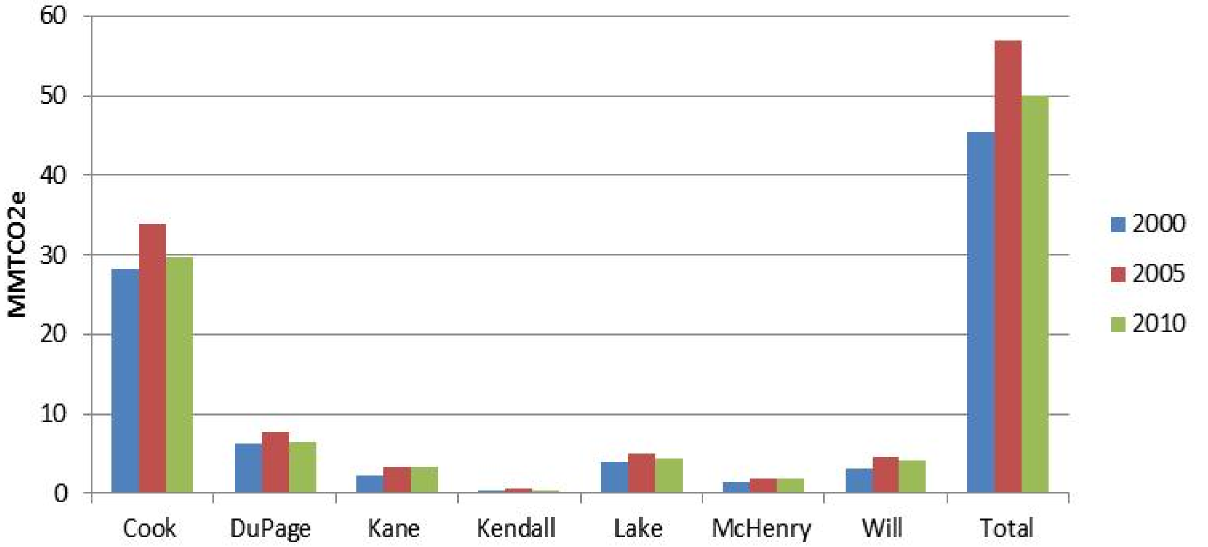
Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions[a] ($MMTCO_2e$)	45.47	57.00	51.20	-10.2%	12.6%
1. Electricity Usage[a] (billion kWh)	*74.65*	*85.84*	*82.34*	*-4.1%*	*10.3%*
Per-Capita Electricity Usage (kWh/person)	9,144	10,254	9,766	-4.8%	6.8%
Change in Electricity Demand due to weather (from regression analysis)				+0.09%	+2.4%
2. Emissions Factor (lbs CO_2/MWh)	*1,347*	*1,470*	*1,360*	*-7.5%*	*0.9%*
<u>Comparators</u>					
Population	8,164,264	8,370,459	8,431,386	0.7%	3.3%
Households	2,925,723	3,024,683	3,088,156	2.1%	5.6%
Cooling Degree Days	780	1,166	1,181	1.3%	54.0%
Scaled GDP ($2005 million)[b]	396,892	421,713	424,591	0.7%	7.0%

a. Water-related electricity and electricity emissions for 2010 are included in the building energy sector to allow for fair comparisons to prior inventories

b. Gross Domestic Product (GDP) was scaled to the CMAP 7-County Region from the GDP for the Joliet-Chicago – Naperville Metropolitan Statistical Area (MSA) using population.

As shown in Figure 5-3, electricity emissions increased from 2000 to 2010 (largely due to increases in electricity consumption) for each of the seven counties, but decreased from 2005 for all counties except Kane County (largely due to a decrease in the electricity emissions factor). The largest relative percentage increases from 2000 to 2010 in electricity consumption by county occurs in the smaller counties, notably Kane, Kendall, McHenry, and Will Counties. These counties have exhibited the largest population percentage increases over this time period, suggesting that demographic factors likely influence the increase in electricity consumption over this time period.

Figure 5-3. Electricity Emissions by County from 2000–2010



Natural Gas

The Chicago Region exhibits an overall decrease of 3% in natural gas emissions from 2000 to 2010, and an increase of 6% from 2005 to 2010 (Table 5-11 and Figure 5-4).

Specifically:

- The **2000 to 2010** decrease in natural gas emissions appears to be primarily due to a decline of 7% in natural gas consumption over this period. Demographic and economic changes, however, do not appear to be aligned with this natural gas consumption change as population was increasing and there was economic expansion over this period while natural gas consumption was declining. As described above for the city of Chicago, there is a long-term trend of declining residential natural gas use due to increased household efficiency, housing turnover, and declining use of natural gas a primary household fuel. The emissions factor increased by 7% over this period which partially offset the decrease in natural gas consumption.[16] As noted above, in 2010, the winter was somewhat warmer than in 2000. The differences in weather resulted in a decrease in natural gas demand (estimated as 2.5 %) for heating in 2010 compared to 2000. This decreased natural gas demand is estimated to have resulted in decrease of 0.78 $MMTCO_2e$ in greenhouse gas emissions.

- From **2005 to 2010**, in spite of the drop in natural gas consumption over this period, the increase in natural gas emissions appears to be correlated to an increase in the emissions factor value. Economic growth over this period was modest and thus had a more limited effect on consumption. In 2010, the winter was slightly warmer than in 2005. The differences in weather resulted in an increase in a decrease in natural gas demand (estimated as 0.9%) for heating in 2010 compared to 2000. This decreased natural gas

[16] An updated utility-specific natural gas emissions factor was also introduced to the 2010 inventory and is more carbon intensive than the default IPCC value that was used in prior inventories.

demand is estimated to have resulted in decrease of 0.27 $MMTCO_2e$ in greenhouse gas emissions.

- As shown in Figure 5-4, the largest relative changes in natural gas consumption between 2000 and 2010 occurred in both large counties (notably Cook County) as well as smaller counties (notably Lake County). In contrast, Will County shows a substantial increase in natural gas consumption between 2000 and 2010.

Table 5-11. Natural Gas-related Emissions and Relevant Parameters and Comparators for the Chicago Region (2000–2010)

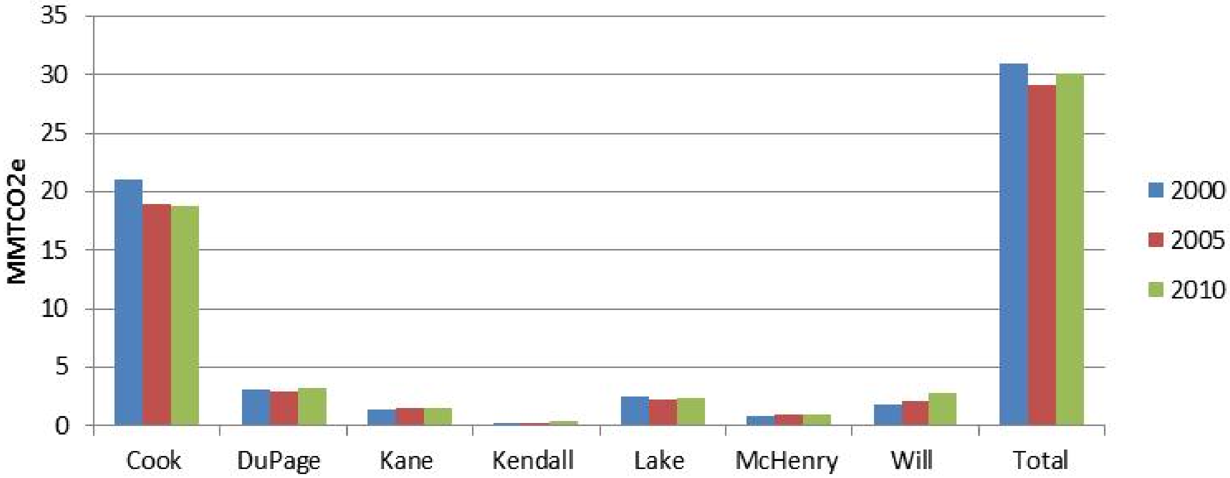
Parameters	2000 Value	2005 Value	2010 Value	2005–2010 % Change	2000–2010 % Change
Total GHG Emissions[a] ($MMTCO_2e$)	30.98	29.05	30.93	6.5%	-0.2%
1. Natural Gas Usage[a] (billion therms)	*5.82*	*5.46*	*5.41*	*-1.0%*	*-7.1%*
Per-Capita Natural Gas Usage (therms/person)	712	652	641	-1.7%	-10.1%
Change in Natural Gas Demand due to weather (from regression analysis)				-0.9%	-2.5%
2. Emissions Factor (kg CO_2/therm[b]	*5.32*	*5.32*	*5.69[a]*	*6.9%*	*6.9%*
Comparators					
Population	8,164,264	8,370,459	8,431,386	0.7%	3.3%
Households	2,925,723	3,024,683	3,088,156	2.1%	5.6%
Heating Degree Days	6,240	6,080	5,991	-1.5%	-4.0%
Scaled Gross Domestic Project ($2005 million)[c]	396,892	421,713	424,591	0.7%	7.0%

a. Water-related natural gas emissions for 2010 are included in the building energy sector to allow for fair comparisons to prior inventories

b. Weighted average of People's Gas and Nicor Gas

c. Gross Domestic Product (GDP) was scaled to the CMAP 7-County Region from the GDP for the Joliet-Chicago – Naperville Metropolitan Statistical Area (MSA) using population.

Figure 5-4. Natural Gas Emissions by County from 2000–2010



On-Road Transportation

On-road emissions in the Chicago Region increased by 6% from 2000 to 2010 and by 2.5% from 2005 to 2010 (Table 5-12). VMT increased by 4% from 2000 to 2010, but declined by about 4% from 2005 to 2010. Per capita on-road emissions increased slightly from 2000 to 2010 but declined by 4% from 2005 to 2010. Population and economic growth from 2000 to 2010 appear to be driving VMT growth. From 2005 to 2010, both population and economic growth were relatively limited and are less a driver of VMT over this period.

As mentioned in the city of Chicago discussion above, the 2010 inventory employed the use of the USEPA's MOVES model, which is a significant departure from the methods employed in the 2000 and 2005 inventories. As noted above, the MOVES model uses more categories of vehicles than the prior inventory approaches and also examines congestion on a roadway specific basis, and appears to be contributing to a higher estimate of on-road emissions than the prior inventories. Aside from VMT and methodology changes, on-road GHG emissions are also influenced by fuel economy and emissions factors for fuels.

At the county level, the increases in emissions between 2000 and 2010 occur primarily in smaller counties (i.e., Kane, Kendall, Lake, McHenry and Will Counties). This increase is positively correlated with increases in population in these counties over this timeframe.

Table 5-12. On-Road-Per Capita Emissions and Relevant Parameters and Comparators for the Chicago Region (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions ($MMTCO_2e$)	31.35	32.41	33.23	2.5%	6.0%
GHG Emissions/ Capita ($MTCO_2e$)	3.8	3.9	3.9	1.8%	2.6%
1. Vehicle Miles Travelled[a]					

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
VMT (All vehicles, billion miles))	56.00	60.53	58.28	-3.7%	4.1%
VMT/capita	6,859	7,231	6,912	-4.4%	0.8%
2. Emissions Intensity[b] (MT CO_2/thousand miles)	*0.56*	*0.54*	*0.57*	*6.5%*	*1.8%*
Comparators					
Population	8,164,264	8,370,459	8,431,386	0.7%	3.3%
Households	2,925,723	3,024,683	3,088,156	2.1%	5.6%
Employment	3,814,581	3,959,141	3,925,127	-0.9%	2.9%
Scaled Gross Domestic Project ($2005 million)[c]	396,892	421,713	424,591	0.7%	7.0%

a. The USEPA MOVES model uses 13 different vehicle categories (compared to 4 in prior inventory) and thus vehicles may not be categorized in the same way in the two inventories.

b. This number was calculated by dividing the total GHG emissions by VMT and indicates the relative GHG intensity per mile in the different inventories. Comparisons between 2000/2005 and 2010 are hampered by the change in modeling method.

c. Gross Domestic Product (GDP) was scaled to the CMAP 7-County Region from the GDP for the Joliet-Chicago – Naperville Metropolitan Statistical Area (MSA) using population.

Off-Road Transportation

Off-road transportation emissions increased from 1.56 $MMTCO_2$ in 2000 to 5.75 $MMTCO_2e$ in 2010, or 266% (Table 5-13). The inclusion of off-road equipment other than rail (approximately 4.4 $MMTCO_2e$) contributes to the majority of the emissions increase from 2000 to 2010. This increase if partially offset by a decrease in rail emissions which is most likely due to changes in methodology for estimating rail emissions in 2010 compared to prior inventories.

Table 5-13 Off-Road-related Transportation Emissions and Relevant Parameters and Comparators for the Chicago Region (2000 – 2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions ($MMTCO_2e$)	1.56	1.62	5.75	255.0%	268.6%
1. Rail Emissions[a]	*1.56*	*1.62*	*1.38*	*-14.8%*	*-11.5%*
2. Other Off-Road Equipment	--	--	*4.36*	*100%*	*100%*
Comparators					
Employment	3,814,581	3,959,141	3,925,127	-0.9%	2.9%

a. See discussion of methodology changes in the text.

Solid Waste

The Chicago Region's solid waste generation emitted a total of 3.4 $MMTCO_2e$ in 2010. Between 2000 and 2010, waste disposed in landfills decreased by 14%. The decrease in landfilled waste from 2000 to 2010 occurred despite population and economic growth over the period. Between 2005 and 2010, waste disposed in landfills declined by 29%, likely reflecting the downturn in the construction industry and reduction in construction and demolition waste. Population and economic growth between 2005 and 2010 were more modest and less of an influence.

As discussed above for the city of Chicago, the 2010 inventory used a different approach to estimating solid waste emissions based on the "waste in place" method whereas the prior inventories used what is often referred to as a "methane commitment" approach. These two approaches are measuring different things; 1) the 2010 method estimated landfill emissions today based on evaluation of the historic waste places in the landfill; 2) the prior 2000/2005 method estimated the future emissions associated with current year waste disposal. ICF's analysis indicates that approximately 50% of the GHG landfill emissions attributable to the year 2010 from solid waste are sourced from waste disposed in the 2000–2010 period, such that the remaining 50% comes from years prior to 2000 (from 1950 to 2000). Since the 2000 and 2005 inventories do not account for the historical waste, there are considerable differences in the solid waste emissions associated with each inventory year.

In addition, the waste sector in the 2010 inventory accounts for methane capture systems in place at both open and closed landfills, whereas the 2000 and 2005 inventories do not address closed landfills. Landfills closed prior to 2010 include 18 out of 28 landfills that serve the Chicago Region.

Since these two measures examine different things, in order to examine trends, 2000 to 2010 emissions for the solid waste sector were estimated using the 2010 methodology and the 2000/2005 methodology. As shown in Table 5-14 below, consistent use of either method would result in an identification of a downward trend in solid waste related emissions.

Table 5-14. Solid Waste-Related Emissions and Relevant Parameters and Comparators for the Chicago Region (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions In Inventory Estimates ($MMTCO_2e$)	2.63	4.84	3.36	-30.6%	27.7%
GHG Emissions Using 2010 Methodology ($MMTCO_2e$) [a]	2.15	1.56	1.29	-17.3%	-39.8%
GHG Emissions Using 2000/2005 Methodology ($MMTCO_2e$) [a]	1.06	1.23	0.85	-31.0%	-19.8%
1. Municipal Solid Waste Disposed in Landfills (million tons)	*2.49*	*3.04*	*2.15*	*-29.3%*	*-13.9%*
2. Average Weighted Methane Capture	*63%*	*68%*	*69%*	*2,6%*	*9.2%*
Comparators					

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Population	8,164,264	8,370,459	8,431,386	0.7%	3.3%
Households	2,925,723	3,024,683	3,088,156	2.1%	5.6%
Employment	3,814,581	3,959,141	3,925,127	-0.9%	2.9%
Scaled Gross Domestic Project ($2005 million)[c]	396,892	421,713	424,591	0.7%	7.0%

a. See discussion of methodology changes in the text.

b. Gross Domestic Product (GDP) was scaled to the CMAP 7-County Region from the GDP for the Joliet-Chicago – Naperville Metropolitan Statistical Area (MSA) using population.

Wastewater Treatment

The Chicago Region's wastewater treatment sector emitted a total of 0.50 $MMTCO_2e$ in 2010. On a regional level, total wastewater emissions have decreased by 50% since 2005 and 51% since 2000 (Table 5-15).

The precise reason for the large change in emissions is difficult to determine in the absence of data on quantity of wastewater treated and utilized in the 2000 and 2005 inventories (which was not provided in the prior inventory report). The reduction may be due to one or more of the following factors: 1) improved efficiency at the wastewater plants; 2) a decline in wastewater generation as a result of the city of Chicago's population decline; and/or 3) methodology changes.

Table 5-15. Wastewater-related Emissions and Relevant Parameters and Comparators for the Chicago Region (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Total GHG Emissions ($MMTCO_2e$)	0.98	0.99	0.50	-49.5%	-49.0%
GHG Emissions /capita ($MTCO_2e$)	0.12	0.12	0.06	-49.9%	-50.6%
Comparators					
Population	8,164,264	8,370,459	8,431,386	0.7%	3.3%
Households	2,925,723	3,024,683	3,088,156	2.1%	5.6%
Employment	3,814,581	3,959,141	3,925,127	-0.9%	2.9%

Water Consumption

The Chicago Region's water consumption sector emitted a total of 1.5 $MMTCO_2e$ in 2010, approximately 1.2% of the Chicago Region's total GHG emissions. As water consumption was not provided as a separate sector in the 2000 and 2005 inventories, a comparison to these inventory years is not possible.

Stationary, Industrial, and Product Use

Stationary and industrial emissions increased by 287% from 2005 to 2010, while emissions from product use (including refrigerant emissions) decreased 88% over this same timeframe. Emissions declined by 80% for both stationary/industrial and product use from 2000 to 2010. Table 5-16 shows emissions trends in the Chicago Region.

The main reason for the change in emissions between the 2010 and the prior inventories is the use of different emissions estimation methodologies for each sub-sector in this emissions sector in the 2010 Regional GHG Inventory. The methods differences are significant and likely outweigh any changes in actual activity data in this sector. Methodology changes are discussed in Chapter 4.

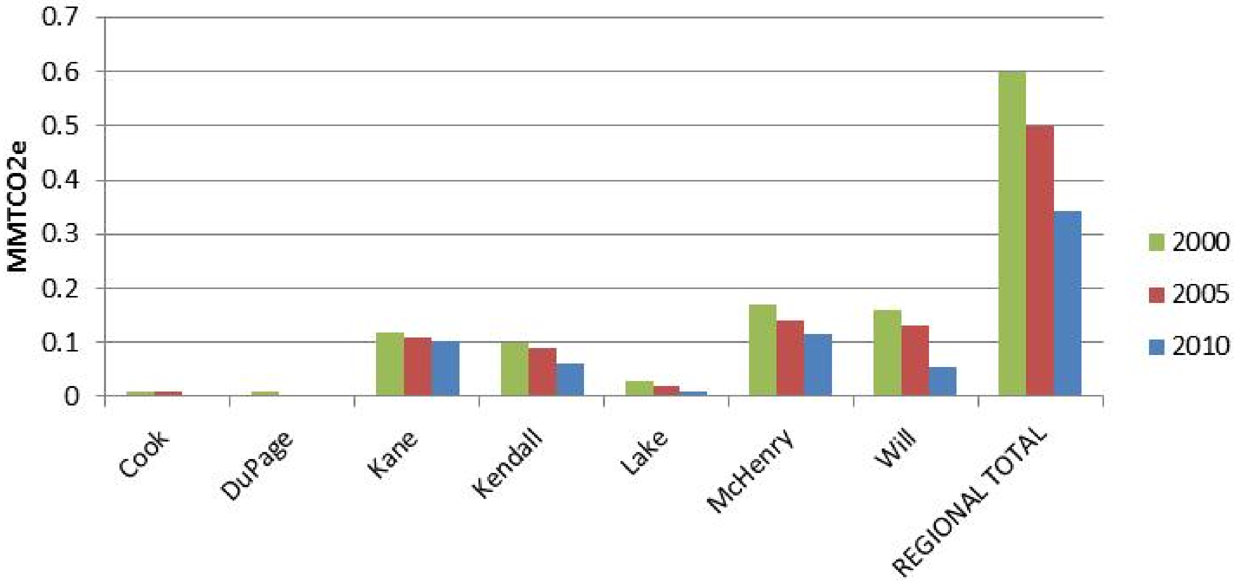
Table 5-16. Stationary/, Industrial, and Product Use Per-Capita Emissions and Relevant Parameters and Comparators for the Chicago Region (2000–2010)

Parameters	2000 Value	2005 Value	2010 Value	2005-2010 % Change	2000-2010 % Change
Stationary/Industrial GHG Emissions (MMTCO$_2$e)	1.39	0.10	0.39	286.7%	-72.2%
Product Use GHG Emissions (MMTCO$_2$e)	3.36	4.49	0.56	-87.6%	-83.4%
Comparators					
Population	8,164,264	8,370,459	8,431,386	0.7%	3.3%
Households	2,925,723	3,024,683	3,088,156	2.1%	5.6%
Employment	3,814,581	3,959,141	3,925,127	-0.9%	2.9%

Agriculture

Agriculture emissions in the Chicago Region (and for most counties) decreased 33% from 2005 to 2010 and 43% from 2000 to 2010 (Figure 5-5). Methods changes are the major contributor to emissions differences between 2010 and 2000/2005, as the 2010 emissions were calculated using actual livestock numbers and agricultural acres in the Chicago Region whereas the 2000/2005 inventories applied national level agricultural emissions and apportioned these emissions to the Region based on agricultural land and livestock.

Figure 5-5. Chicago Region: Agriculture Emissions for 2000–2010



Sensitivity Analysis of City of Chicago 2005 Inventory

As discussed in Chapter 4, methodological changes were made for the 2010 inventory compared to the 2000 and 2005 inventories in the natural gas, on road transportation, solid waste, product use, stationary/industrial, off-road, and wastewater sectors. A sensitivity analysis was done for the city of Chicago 2005 inventory to examine whether the overall trend of decreasing emissions from 2005 to 2010 is real or is due to these methodological changes. An "estimated" 2005 inventory was developed using the 2010 methodologies and/or by scaling changes from the 2010 inventory. The purpose of this analysis is to attempt to remove the influence of methodology changes between the 2005 and 2010 inventories, and to isolate real emissions trends. The conclusion of the sensitivity analysis is that the 2005 inventory would likely be slightly higher than estimated if the 2010 inventory methodologies were used to update the 2005 inventory and thus the decrease in emissions from 2005 to 2010 would likely be even greater than the comparison of the inventories reveals.

Table 5-17 presents an estimate of 2005 GHG emissions using the methods indicated in the table. Since scaling was used to roughly estimate potential 2005 emissions for many sectors, the resultant profile of 2005 emissions is provided for comparison purposes only and should not be considered a formal update to the 2005 inventory. The conclusions that can be drawn from this sensitivity analysis are limited to validating whether or not the macro trends between 2005 and 2010 are reasonable.

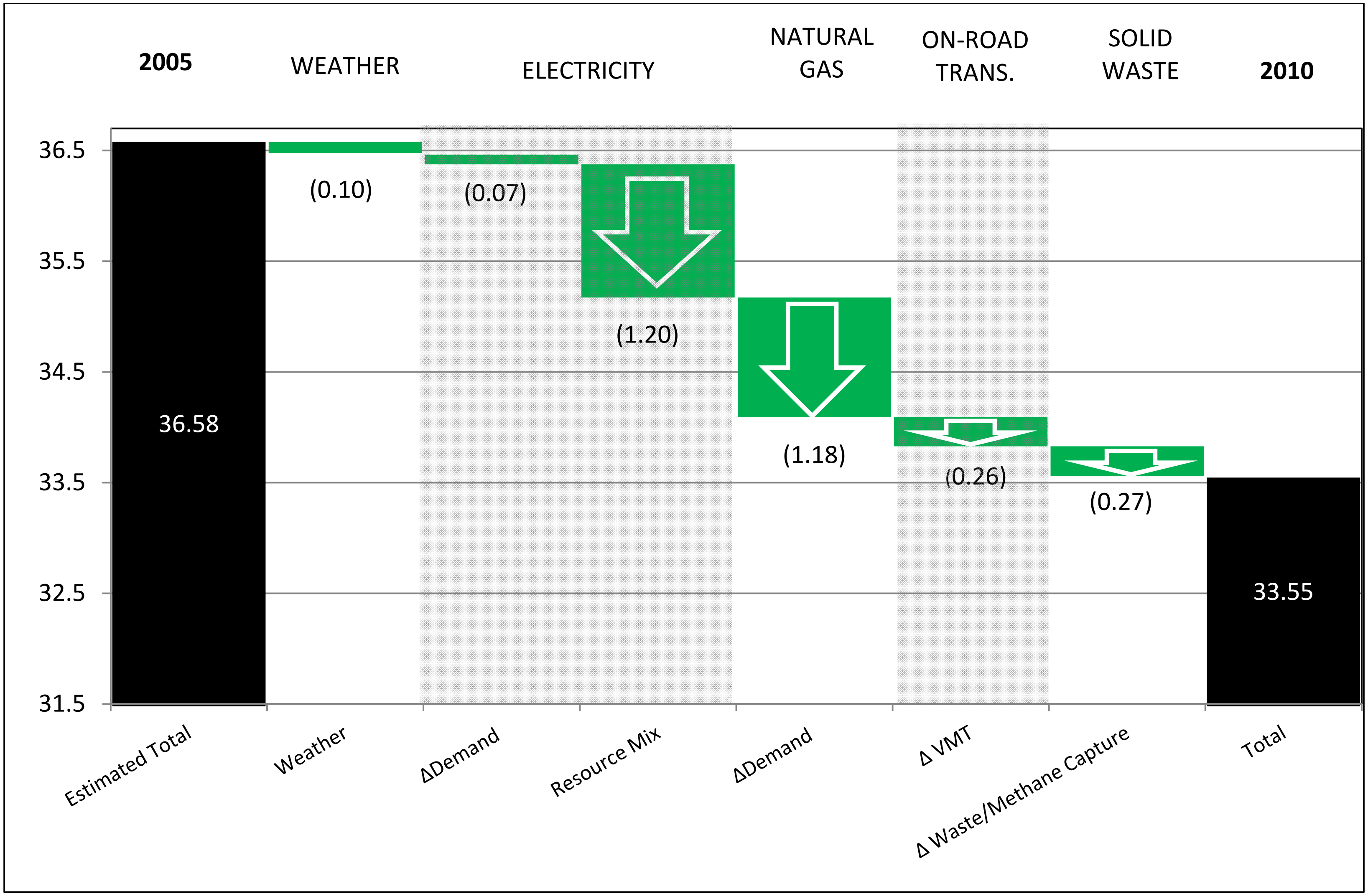
Figure 5-6 shows the causes and trends in the changes in GHG emissions from 2005 to 2010 when comparing the 2005 and 2010 inventories.

Table 5-17. City of Chicago, Estimated Revised 2005 Inventory (for comparison purposes only)

Sector	2005 (CNT 2009)	2005 Estimate (ICF)	Change (CNT to Estimated)	Method	2010	2010 per capita or job
Electricity GHG	16,020,387	16,020,387	0	*No change*	14,645,667	
Natural Gas GHG	9,915,876	10,526,500	610,624		9,418,771	
Natural Gas (Billion therms)	*1.85*	*1.85*	*0.00*	*No change*	*1.64*	
Natural Gas Emissions factor	*5.32*	*5.69*	*0.37*	*Used 2010 factor*	*5.69*	
On-Road GHG	6,467,034	7,056,000	588,966		6,783,031	
Billion VMT	*12.60*	*12.60*	*0.00*	*No change*	*12.13*	
GHG/VMT	0.51	0.56	0.05	Used GHG/VMT factor from 2010	0.56	
Waste GHG	1,233,559	*1,561,508*	327,949	Used "Waste in Place" method	1,291,449	
Off-Road GHG - Rail	657,162	300,644	-356,518	Calculated by scaling 2010 rail emissions using 2010/2005 transit trip data from TRAMS.	314,143	
Off-Road GHG - other	0	639,880	639,880	Calculated using 2010 per job factor and scaled to 2005 employment.	638,957	0.534
Stationary and Industrial GHG	44,525	53,816	9,291	Calculated using 2010 per job factor and scaled to 2005 employment.	53,738	0.045
Product Use GHG	1,407,657	200,324	-1,207,333	Calculated using 2010 per capita factor and scaled to 2005 population.	191,176	0.071
SF6 GHG	127,695	2,376	-125,319	Calculated using 2010 SF6 and scaled to 2005 based on 2010/2005 electricity consumption	2,365	
Wastewater GHG	346,230	215,752	-130,478	Calculated using 2010 per capita factor and scaled to 2005 population.	205,899	0.076
Water Pumping/Treatment (other than elec./natural gas)	--	--	--	Included in 2005 building energy inventory	381	
TOTAL	**36,220,125**	**36,577,188**	**357,063**		**33,545,577**	

Note: In this analysis, water-related electricity and natural gas emissions for 2010 are included in the building energy sector to allow for more exact comparison to prior inventories.

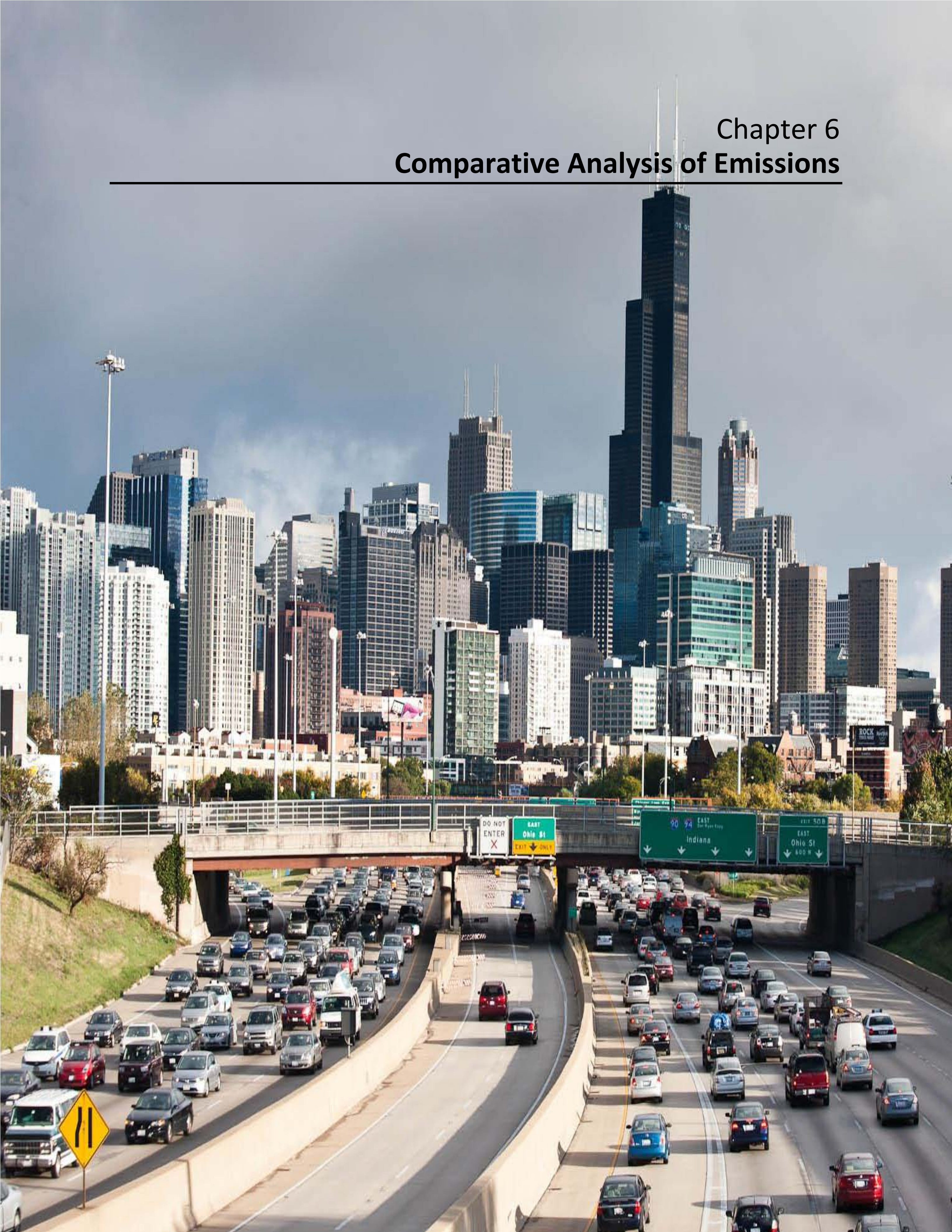
Figure 5-6. City of Chicago, Trends and Causes of Change from Estimated Revised 2005 Inventory and 2010 Inventory (MMTCO$_2$e)



The key reasons that GHG emissions in Chicago in 2010 were 8% lower by comparison to the estimated 2005 emissions (which excludes methodology changes) are as follows:

- Electricity emissions (3.8% of overall decrease) - Emission decreased primarily due to an increase in use of relatively cleaner electricity generation sources in combination with a limited decrease in electricity consumption. The decrease of consumption was due to, in order of importance, the following: population decrease, building retrofits, a slightly warmer summer, and a slight decrease in employment.
- Natural gas emissions (3.0% of overall decrease) - Emissions decreased due to a reduction in natural gas consumption, which was due to, in order of importance, the following: a long-term decline in residential gas use (due to combination of more efficient use, housing turnover and long-term price trends), population decrease, building retrofits, a slightly warmer winter and a slight decrease in employment.
- Onroad emissions (0.7% of overall decrease) - Emissions decreased due to a reduction in vehicle-miles travelled (VMT) likely due to, in order of importance, the following: population decrease, an increase in rail transit use, and a slight decrease in employment.
- Landfill emissions (0.7% of overall decrease) - Emission decreased due to a reduction of waste disposal due to increased methane capture and reduced landfill methane generation. Landfill methane generation decreased due to a combination of decreased population and employment, increased waste diversion efforts and aging of existing landfill waste.

Chapter 6
Comparative Analysis of Emissions



Chapter 6
Comparative Analysis of Emissions

Introduction

Emissions results for the city of Chicago and the Chicago Region were compared to emissions from similar cities and counties, regional emissions, and average US emissions in regard to absolute emissions.

The comparative analysis yields the following conclusions, which are discussed in greater detail in the sections below:

- Per capita GHG emissions for the city of Chicago are lower than statewide and national per capita emissions, and represent a midpoint among other large cities included in this analysis.
- Per capita GHG emissions for the Chicago Region are lower than statewide and national per capita emissions, and are similar to other large regions included in this analysis.
- Per capita electricity use value for the city of Chicago is lower than national per capita and is lower than the midpoint of comparable large U.S. cities.
- Chicago's use of alternative transportation other than personal automobiles is greater than national levels and at approximately the midpoint of comparable large U.S. cities.
- Between 2005 and 2010, Chicago's overall emissions decreased at a faster rate than national emissions, while Chicago per capita emissions decreased at about half the rate of national per capita emissions because Chicago had a population decrease over this period compared to a national increase in population.

The methods used for inventories for other cities and regions are not always identical to those used to develop the 2010 Regional GHG Inventory, largely because no widely accepted uniform protocol for community inventory such that different protocols may have been used to develop the various inventories. [17] Comparison between different cities and regions to the city of Chicago and the Chicago Region should ideally account for differences in emissions estimations methodologies as well as other factors that may contribute to differences between the emissions associated with these areas. In addition, climate conditions, electricity generation fuel sources, and a myriad of other factors unrelated to consumption patterns will also influence differences between jurisdictions. Emissions estimation differences and numerous other factors are not addressed in this analysis.

Methods

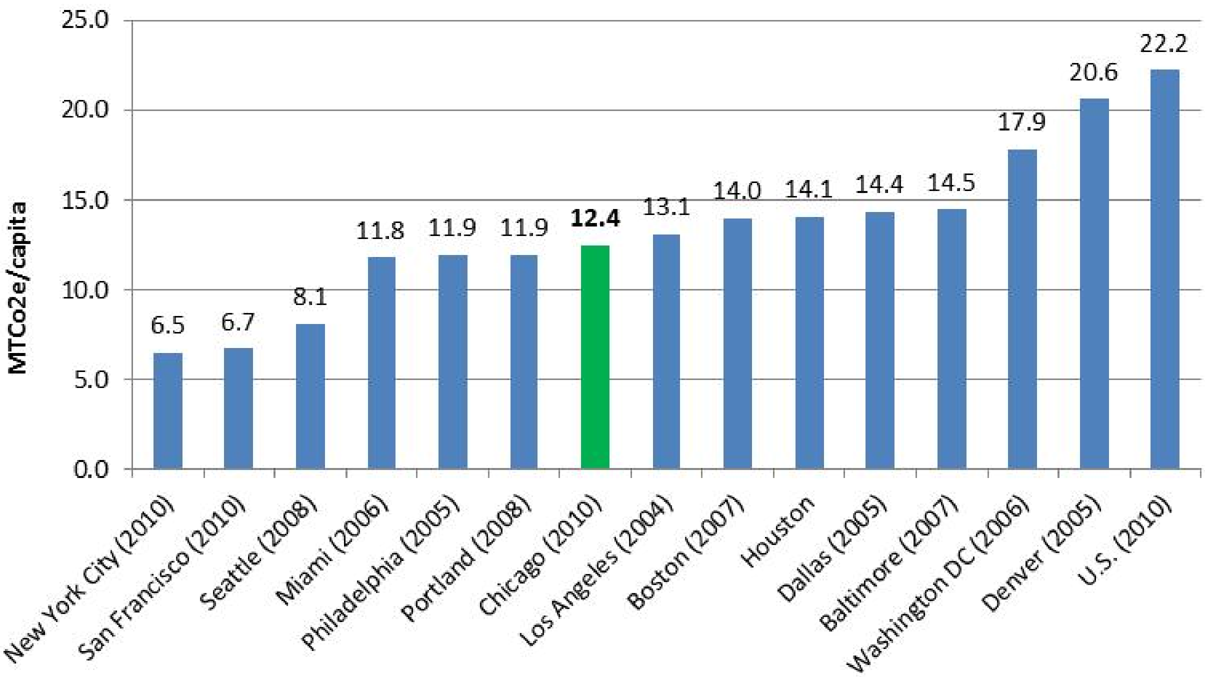
For the comparative analysis, the 2010 Regional GHG Inventory results were compared to similar results for other cities and regions.

[17] ICLEI is presently developing a community greenhouse gas inventory protocol with the involvement of many stakeholders and expects to release this protocol later in 2012.

GHG Emissions per Capita

GHG emissions per capita in Chicago in 2010 are approximately 12.4 $MTCO_2e$/person. As shown in Figure 6-1, Chicago's 2010 per capita emissions value is lower than that of several other large U.S. cities (of various inventory years), including: Los Angeles, Boston, Houston and Denver, slightly higher than Philadelphia, Miami and Portland, and higher than New York city, San Francisco, and Seattle.

Figure 6-1. City of Chicago GHG Emissions per Capita Compared to Other Cities



Source: Climate Action Plans and Greenhouse Gas Inventories for U.S. and Cities (see Reference List)

For the Chicago Region, total per capita emissions in 2010 are approximately 15.0 $MTCO_2e$/person, higher than the Southern California region[18] but lower than the Philadelphia metropolitan area, the State of Illinois, and the U.S. (Figure 6-2).

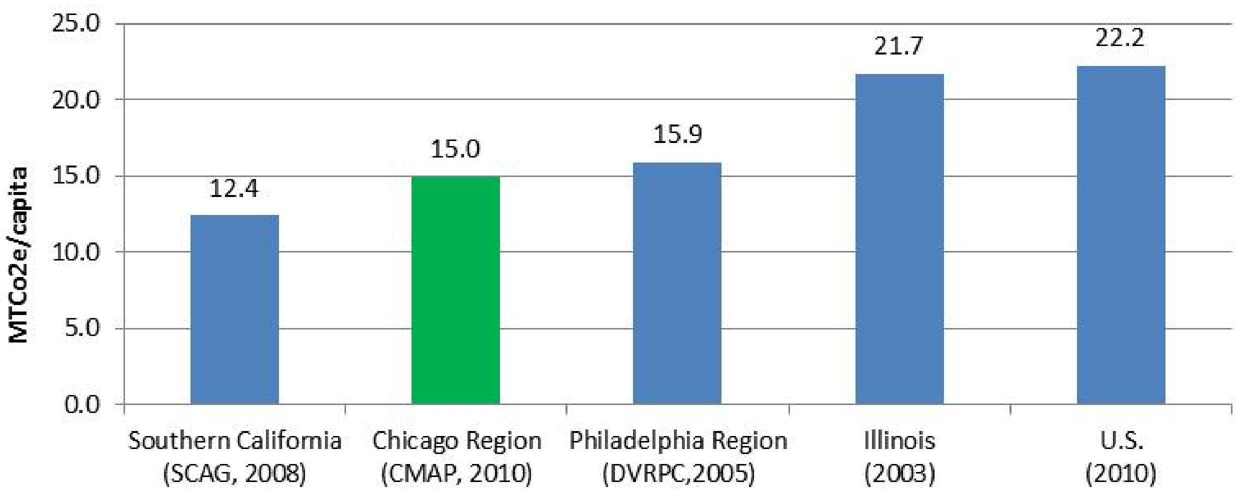
Differences in each jurisdiction's population, form, density, climate, geographical layout, housing characteristics, transportation system, and other aspects drive differences in per capita emissions and limited detailed comparison. In addition, the various inventories do not include the same emissions sectors or use the same methodologies in calculating emissions. For example, the New York City greenhouse gas inventory does not include off-road or consumer product use emissions, whereas the Chicago 2010 inventory does include these sectors.

[18] The Southern California region corresponds to the 6-county region under the jurisdiction of the cities and counties in the Southern California Association of Governments (SCAG), including Los Angeles, Imperial, Orange, Riverside, San Bernardino, and Ventura counties.

Electricity consumption and transportation activity were examined for comparison cities to identify some of the macro trends influencing the differences between different large U.S. cities. Based on the data reviewed below, the dominant difference between New York city and Chicago greenhouse gas emissions is likely due to relatively higher density (~27,000 persons/square mile in 2010 vs. ~12,000 persons/square mile in Chicago based on U.S Census data) and smaller housing unit size (resulting in lower building energy emissions) and extensive transit system in New York city (resulting in lower transportation emissions) compared to Chicago. The dominant difference between Los Angeles and Chicago is likely due to the combination of a milder climate (resulting in lower building energy emissions) and lower density (~8,000 persons/square mile) and less extensive transit system (resulting in higher transportation emissions) in Los Angeles compared to Chicago.

Given these differences, a useful comparable large city for benchmarking for the city of Chicago may be Philadelphia, as Philadelphia is a similarly large city (population of 1.5 million in 2010), is located at the center of a large metropolitan area (regional population of 6.1 million), has a similar city density (11, 000 persons/square mile). While Philadelphia has milder winter weather compared to Chicago, it is more similar in temperature to Chicago than other large southern or western cities that might be considered for comparison. Boston has similar densities to Chicago (~13,000 persons/square mile), but is a much smaller city (population of ~600,000 in 2010).

Figure 6-2. Chicago Region Total GHG Emissions per Capita Compared to Other Regions



Sources: This inventory for Chicago;Philadelphia - DVRPC, 2007; Southern California - CCS, 2010; Illinoise - World Resources Institute, 2007; U.S. - USEPA, 2012

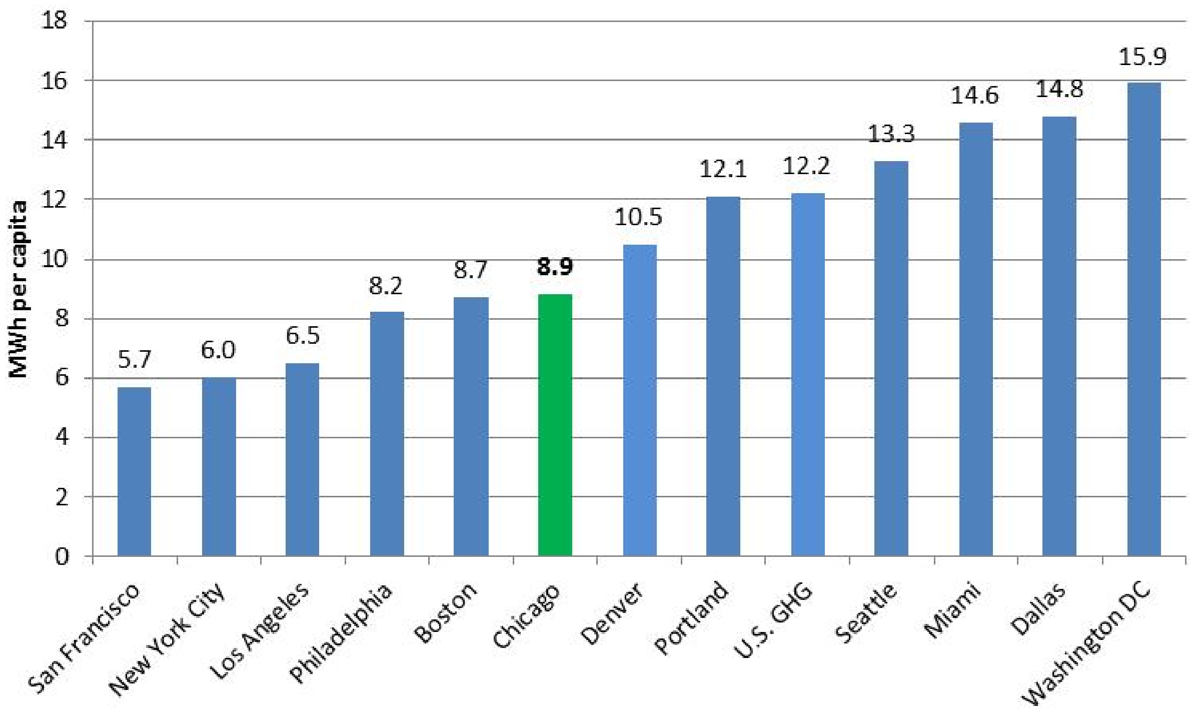
Electricity Consumption per Capita

Annual electricity consumption in the city of Chicago in 2010 was 8.9 MWh/person. This value is higher than San Francisco, New York city, and Los Angeles, slightly higher than Philadelphia and Boston, but lower that the U.S. average, Denver, Seattle, Dallas, and other cities.

Coastal California cities like San Francisco and Los Angeles will have lower relative electricity consumption compared to other cities in part due to moderate weather with lower cooling electricity demands than many Midwestern and northeastern cities. Dense, compact cities, like San

Francisco and New York City have a higher percentage of households in apartments and multi-family buildings with relatively smaller housing unit size which will also reduce electricity consumption.

Figure 6-3. City of Chicago Electricity Consumption per Capita Compared to Other Cities



Sources: This inventory for Chicago; other cities from City of New York, 2011

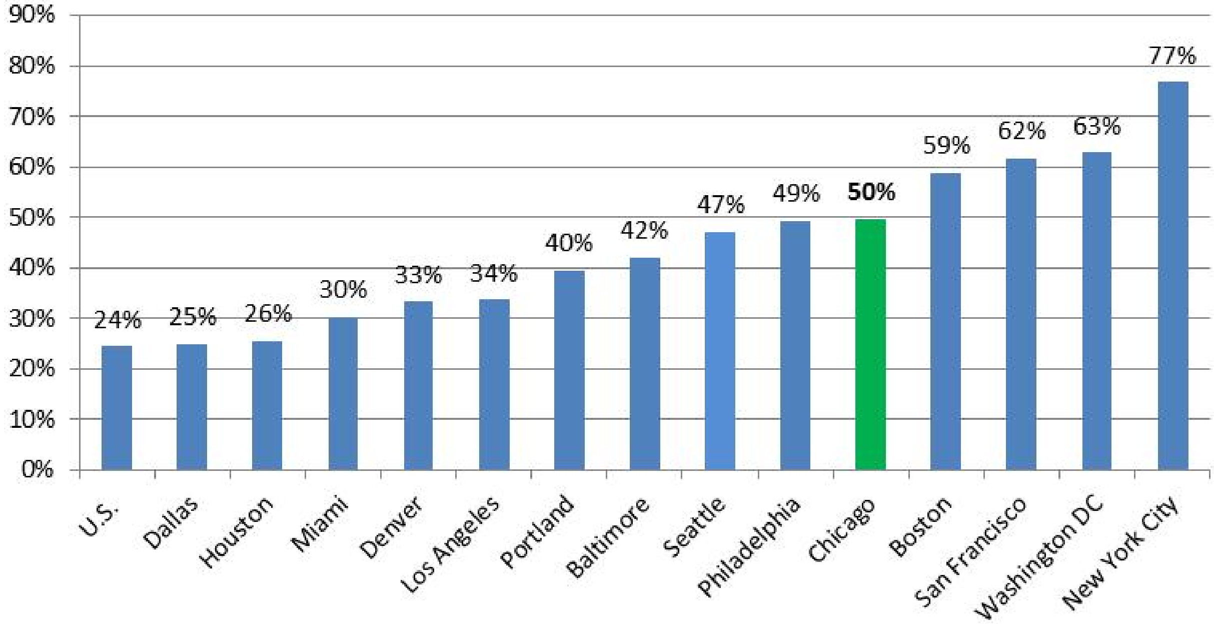
Transportation Activity

As shown below in Figures 6-4, 6-5, and 6-6, Chicago is in the middle range of large U.S. cities in terms of the characteristics of commuting transportation mode and use of alternatives to automobiles.

Among large U.S. cities, New York City has the highest numbers of commuters utilizing alternatives to personal vehicles, followed by Washington D.C., San Francisco, Boston, and Chicago. Chicago has a relatively high use of alternatives to personal vehicles, similar to Philadelphia and Seattle, higher than other large cities such as Los Angeles, Denver and Houston and far higher than the U.S. average. Chicago is also in the mid-range of households without automobiles with New York city having the higher number of households without automobiles and Houston the lowest. The share of commuters walking to work in Chicago is also in the mid-range, with Boston, New York city, San Francisco having the highest percentages and Miami, Los Angeles, Houston, and Dallas having the lowest percentages.

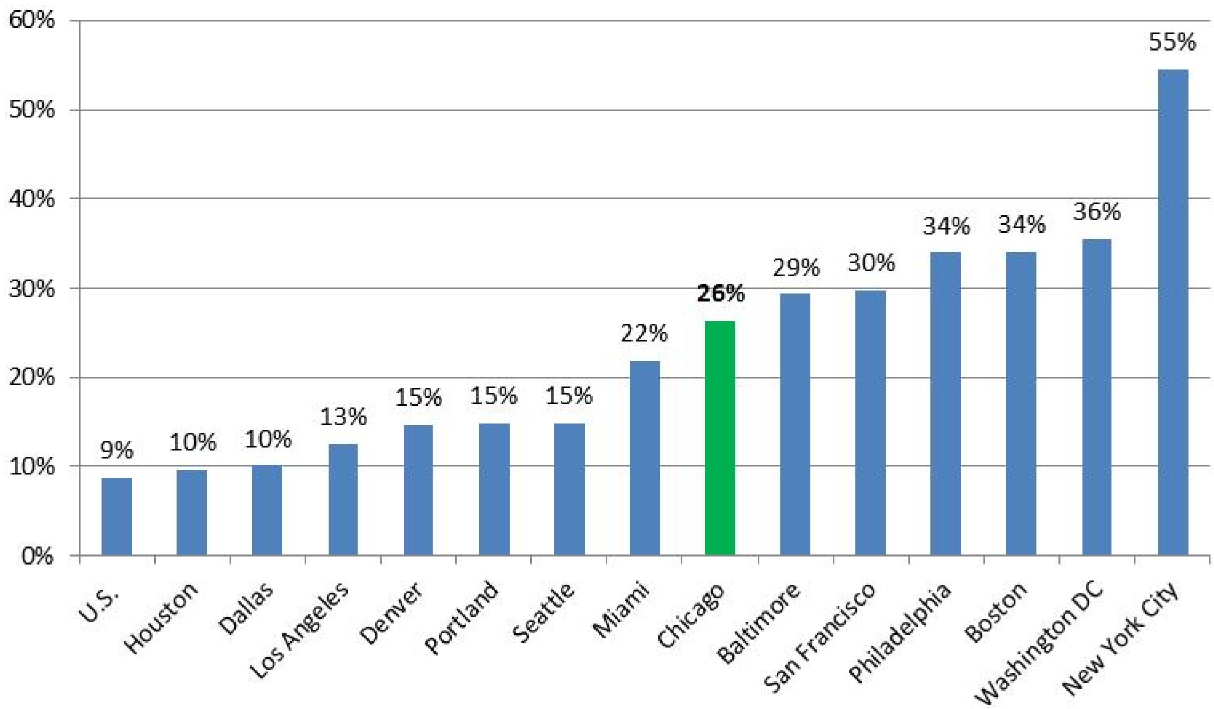
These trends of activity are the function of land use patterns, density, and the extent of the existing transportation systems in different cities and will drive differences in transportation greenhouse gas emissions as well.

Figure 6-4. Commuter Use of Non-Automobile Transportation by City



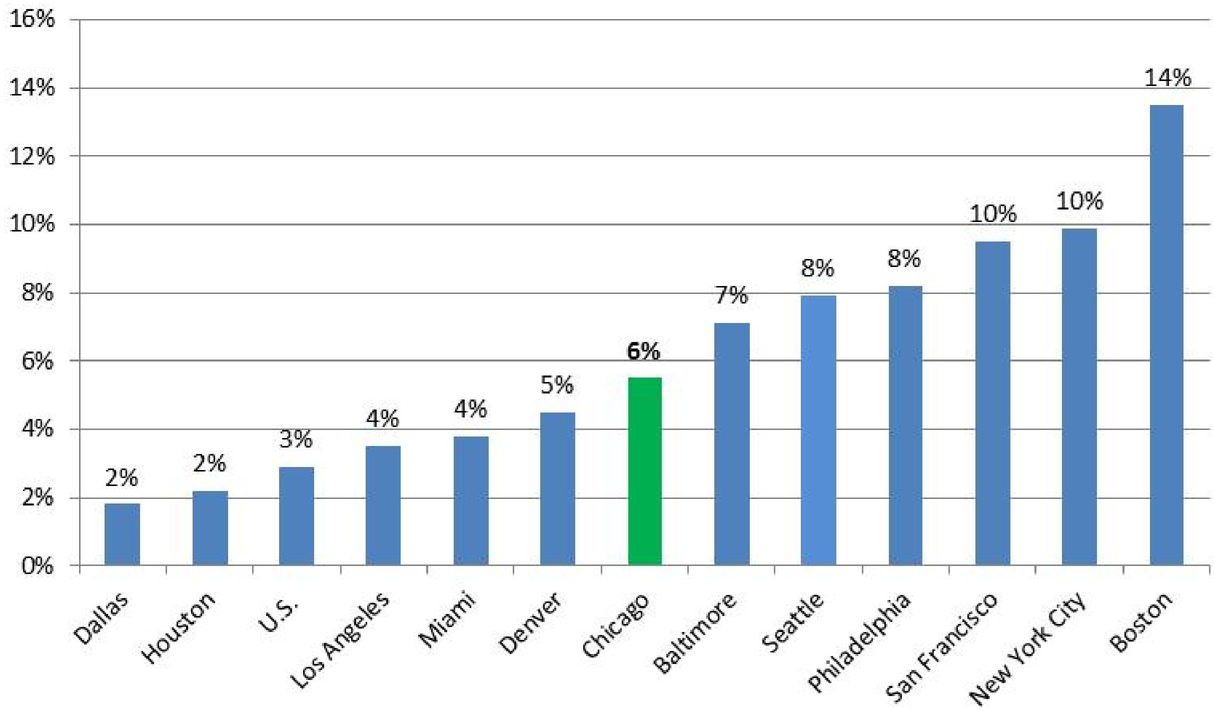
Source: American Community Survey, 2008 as cited in NYC, 2011

Figure 6-5. Percentage of Households without Automobiles by City



Source: American Community Survey, 2008 as cited in NYC, 2010

Figure 6-6. Percentage of Commuters Walking to Work by City



Source: American Community Survey, 2008 as cited in NYC, 2010

Comparison of Chicago and U.S. National Trends

U.S. national trends between 2005 and 2010 were reviewed in comparison to Chicago trends over the same period. The 2005 estimated emissions for Chicago were used to eliminate the effect of changes in inventory methodology between the 2005 CNT inventory and the 2010 ICF inventory.

As shown in Table 6-1, both Chicago and the nation saw a decrease in overall GHG emissions between 2005 and 2010 with a decrease in electricity emissions and onroad transportation emissions. In both Chicago and the nation, the carbon intensity of electricity emissions was lower in 2010 than in 2005 due in both cases to a relatively lower use of coal and relatively greater use of less carbon-intensive fuels such as natural gas. Chicago saw a decrease in non-electricity natural gas emissions in contrast to the nation as a whole, which experienced an increase in natural gas emissions. While Chicago's mass emissions decrease was nearly double the national rate, since Chicago's population decreased over the period while the U.S. population increased, the decline in GHG emissions per capita in Chicago was about half the national per capita emissions decrease.

Table 6-1: Comparison of Chicago and U.S. Trends, 2005 to 2010

Subject	U.S. Trend	Chicago Trend
GHG emissions	-4.8%	-8.3%
GHG emissions per capita	-8.8%	-3.9%
Electricity GHG emissions	-6.0%	-8.6%
Natural gas GHG emissions (other than electricity)	+5.0%	-10.5%
Onroad transportation GHG emissions	-7.5%	-3.9%
Landfill methane GHG emissions	-4.3%	-17.3%
Population	+4.4%	-4.6%
Note: Chicago trends were identified by comparison of 2005 estimated emissions and 2010 inventoried emissions to reduce the effect of methodological changes (see discussion at end of Chapter 5).		

Recommendations and Limitations

The comparative analysis has several limitations. First, one should be cautious in making comparisons of emissions of the city of Chicago and the Chicago Region to other areas, as these other emissions may have been calculated using different emissions estimation methods than those used to develop the 2010 Regional GHG Inventory. The scale and effect of this methodology difference is difficult to quantify, but can be accomplished for major sectors in future study where other greenhouse gas inventories provide thorough documentation of their data sources and methods.

Second, while a comparison of electricity consumption overall was completed based on available data noted above, a more detailed comparison of commercial energy use could not be completed due to the way in which utility energy data was provided for this inventory. If data were to be made available, a comparison could be made between commercial energy per capita values to that of other cities or the Commercial Energy Benchmark Survey (CBECS) values (U.S. Department of Energy 2003). However, commercial-only energy use for city of Chicago and the Chicago Region was unavailable because the utilities in the Chicago Region combined commercial and industrial electricity consumption into a single category. In contrast, the CBECS values are for commercial energy only. In the future, if this data could be provided by the energy utilities, a commercial energy use comparison can be included in this analysis.

Third, additional analysis of various other metrics and comparisons would provide additional insight into the relative magnitude of the city of Chicago and the Chicago Region's emissions. Metrics and comparisons could include, but are not limited to: fuel use, vehicle miles traveled, waste generation, and other emission-generating activities, compared to population, number of households, employment, and gross domestic product. Where these metrics are quantified in other city greenhouse gas inventories or in other sources of data, comparisons can be made similar to the comparisons above on electricity use and transportation activity. These additional comparisons were beyond the scope of this study.

Chapter 7
Forecasting Analysis

Chapter 7
Forecasting Analysis

Introduction

GHG emissions for each sector in the 2010 Regional GHG Inventory were forecast in 10-year increments from 2010 to 2020, 2030, 2040, and 2050 for the city of Chicago and each of the counties in the Chicago Region. The purpose of these forecasts is to show the current emissions trajectory of the city of Chicago and each county into the future. The Chicago forecasts can be used as a tool to assess the progress of the city toward its 2020 emissions goal of 24.2 $MMTCO_2e$ and its 2050 emissions goal of 6.5 $MMTCO_2e$, as specified in the CCAP (City of Chicago 2008), and as discussed in the Executive Summary of this Report.

This forecast may be considered an *update* to previous city of Chicago and Regional GHG emissions BAU forecasts from 2000 and 2005 emissions (Center for Neighborhood Technology 2010), since the base year for this forecast is 2010. As a result, this forecast reflects current consumption or demographic trends as well as recent actions by the City of Chicago and the counties in the Chicago Region to reduce emissions. The 2010 forecast also represents BAU conditions, since it establishes the future emissions trajectory of the city of Chicago and each county in the Chicago Region in the absence of new policy to reduce GHG emissions. Specifically, greenhouse gas mitigation measures from Chicago's CCAP or other federal, state, or local actions are not incorporated into the inventory forecasts, except to the extent that these measures were implemented prior to 2010 and are already incorporated into the inventory baseline.

The 2010 forecasts take into account individual rates of growth for the city and the counties to provide an estimate of future emissions for each region. Sector-specific growth rates were used to forecast emissions more accurately for each individual emissions sector, where data was available. Further, the forecasting methods for each emissions sector are discussed below, and in several cases have been refined or updated from those developed by CNT for the prior BAU forecast (Center for Neighborhood Technology 2010).

General Methods and Data

The majority of sectors were forecasted using socioeconomic and demographic projections data from the CMAP GOTO2040 plan "no plan" scenario, including population, housing, retail employment, and nonretail employment for the city and each county. Although some emissions-generating activities are not *exactly* correlated with these socioeconomic factors, they tend to be related with sufficient accuracy to provide a reasonable estimate of future emissions. Socioeconomic data and projections from the CMAP GOTO2040 plan "no plan" scenario was used for the forecasts, which represents the scenario where the GOTO2040 Plan is not implemented. This scenario also represents growth in the region without accounting for the CCAP or other climate action planning. In the sections below, "CMAP projection" or "CMAP data" refers to data from CMAP's "no-plan" scenario.

Where possible, emissions sectors were forecasted using projections in actual activity data directly related to emissions, such as future water withdrawals (for the water consumption sector) and future VMT (for the on-road transportation sector). These activity metrics generally provide more reliable forecasts than socioeconomic data, but are only available for a few sectors.

Summary of Forecasting Results

The Chicago Region's total emissions are forecasted to grow by 28% from 2010 to 2050, with an annual average growth rate of 0.6%. Total emissions growth in the Chicago Region is correlated with an increase in regional population, employment, and housing over this time period. The regional emissions sector expected to grow the most between 2010 and 2050 is building energy. Regional emissions from off-road transportation, solid waste, wastewater treatment, and water consumption are also predicted to increase, as these sectors are correlated with socioeconomic growth, which is projected to increase. In contrast, on-road transportation emissions are predicted to decrease, as vehicle fuel efficiency is anticipated to outpace VMT growth. Agricultural emissions are anticipated to decline as agricultural acreage decreases in the Chicago Region.

Table 7-1 and Figure 7-1 below present the emissions inventories and forecasts for the city and each county and by emissions sector. Table 7-2 presents population data for 2000, 2005, and 2010, along with population forecasts for 2040 from CMAP.

Table 7-1. Emissions and Forecasts for the City of Chicago and Chicago Region Counties (MMTCO$_2$e)

Year	City of Chicago	Cook County (balance)	Cook County (total)	DuPage County	Kane County	Kendall County	Lake County	McHenry County	Will County	7-County (Unallocated)	Regional Total
2000	34.7	0.0	73.9	14.7	5.8	1.0	10.2	3.7	8.1	0.0	118.6
2005	36.2	0.0	79.7	16.5	7.4	1.3	11.2	4.4	10.5	0.0	131.2
2010	33.5	39.2	72.7	15.4	8.1	1.5	11.5	4.9	11.9	0.2	126.3
2020	*34.2*	*40.2*	*74.4*	*16.1*	*9.4*	*1.9*	*12.0*	*5.6*	*14.6*	*0.3*	*134.2*
2030	*34.7*	*41.2*	*75.9*	*16.8*	*10.7*	*2.2*	*12.7*	*6.4*	*17.1*	*0.3*	*142.1*
2040	*35.6*	*42.6*	*78.2*	*17.7*	*12.2*	*2.6*	*13.6*	*7.3*	*20.1*	*0.3*	*151.9*
2050	*36.5*	*44.0*	*80.5*	*18.6*	*13.8*	*3.0*	*14.5*	*8.3*	*23.4*	*0.3*	*162.2*

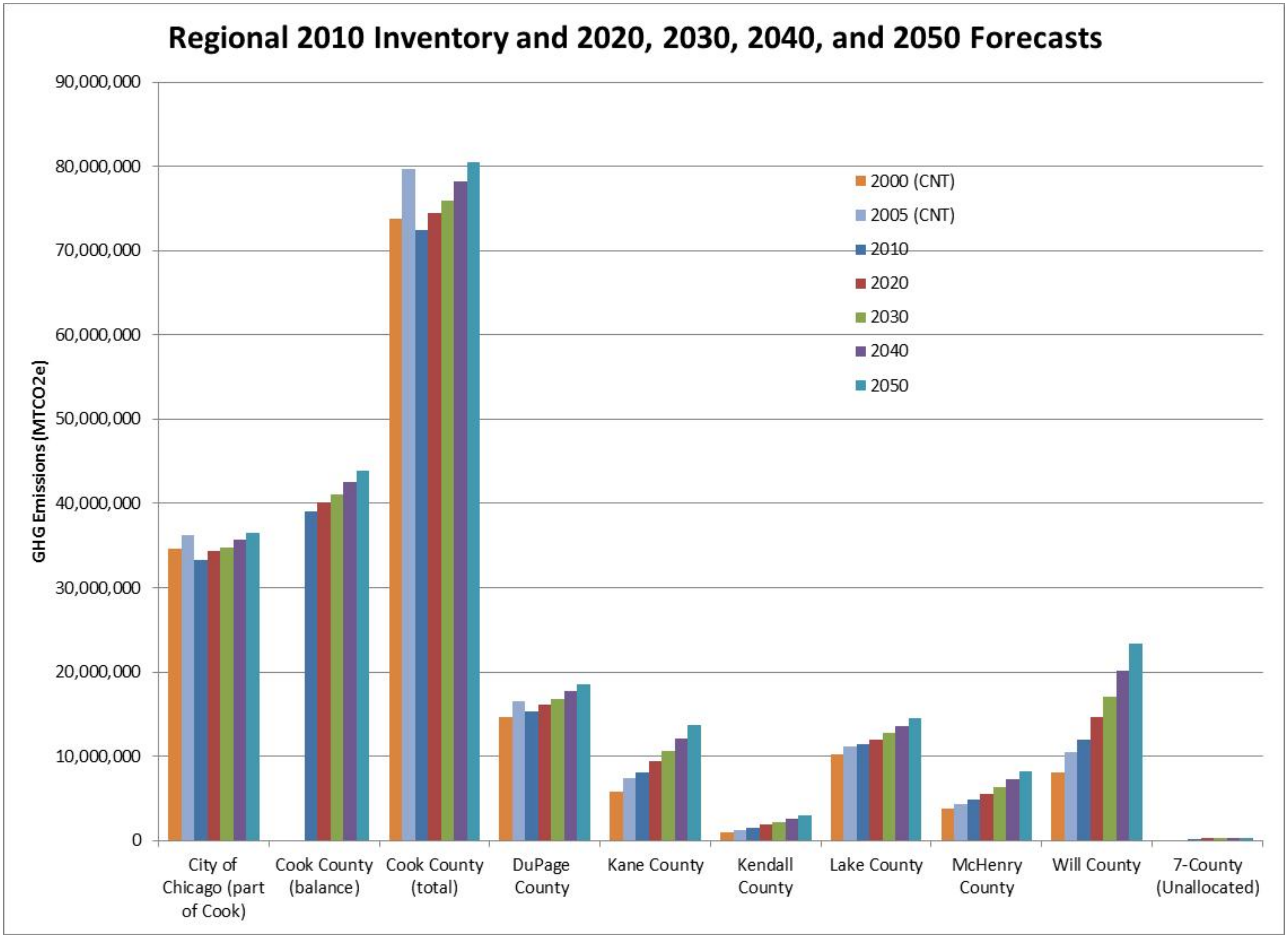
Note: 2000 and 2005 data from Center for Neighborhood Technology 2009 and 2010. 2010 from ICF (this report). 2020 to 2050 forecasted by ICF (this report). *Italicized* years represent "forecast" years.

Table 7-2. Population for the City of Chicago and Chicago Region Counties

County	U.S. Census 2000	U.S. Census 2005	U.S. Census 2010	CMAP Projected 2040
City of Chicago	2,896,016	2,824,584	2,695,598	3,247,621
Cook (w/Chicago)	5,376,741	5,268,513	5,194,675	6,001,375
DuPage	904,161	922,589	916,924	1,131,072
Kane	404,119	475,350	515,269	824,129
Kendall	54,544	79,054	114,736	201,398
Lake	644,356	691,815	703,462	975,409
McHenry	260,077	301,741	308,760	542,734
Will	502,266	631,397	677,560	1,243,728
7-County Region	8,146,264	8,370,459	8,431,386	10,919,845

Source: U.S. Census Bureau 2011; Chicago Metropolitan Agency for Planning 2011

Figure 7-1. City of Chicago and Chicago Region GHG Emissions Forecasts for 2020, 2030, 2040, and 2050



Major findings of the emissions forecasts are presented below:

- **Most Emissions Growth—Sector:** The sector which grows by the largest amount of emissions is building energy, adding 18.5 $MMTCO_2e$ from 2010 to 2050. This is because the building energy sector is the largest sector in the inventory, and future emissions are based on growth in population, housing, and employment.
- **Fastest Rate of Growth—Sector:** The sector with the fastest rate of growth is off-road transportation, which grows 59% from 2010 to 2050. This growth is embodied in the NONROAD model, and is likely based on fast rates of population growth and off-road vehicle activity projections.
- **Most Emissions Growth—City/County:** The county that grows by the largest amount of emissions is Will County; emissions in Will County increase by 11.5 $MMTCO_2e$ and 67.9% from 2010 to 2050. This is because Will's 2010 (and historical) emissions are relatively large, and the rate of population, housing, and employment growth is one of the highest of any county in the region. These two factors combined make Will grow the most in terms of total emissions (although Cook County emissions are larger, the rate growth in Cook County is lower than in Will).
- **Fastest Rate of Growth—City/County:** The county with the fastest rate of growth is Kendall County, which grows 70.8% from 2010 to 2050. This is because Kendall County's rate of population, housing, and employment growth is the highest of any County in the region.
- **Slowest Rate of Growth—City/County:** The city of Chicago has the slowest rate of growth (0.2%) when compared to the seven counties, which grows 8.4% from 2010 to 2050. This is because the city has the lowest rate of population and housing growth, and the third lowest rate of employment growth in the region.

Overall Data Limitations and Modeling Uncertainties

The following important data limitations, assumptions, and modeling uncertainties are common in most or all of the emission forecasts:

- For all sectors using CMAP data, projections were only available for the year 2040. These data were linearly interpolated to derive values for the years 2020 and 2030 and were linearly extrapolated to derive values for the year 2050.
- Emissions forecasted with socioeconomic data presume that emissions-generating activities (such as household energy use and solid waste generation) correlate with population, housing and employment. While this was the best method for forecasting emissions in many sectors, it does not provide a perfect picture of future emissions.
- Basic changes in the economy, such as housing and employment growth, were factored into the forecasts. More detailed changes (i.e., real estate) were not addressed, as they are difficult or not possible to forecast within the scope of this analysis.
- Modeling uncertainties are included in the forecasts, including those embodied in the CMAP models, the NONROAD model, and any uncertainties in other sources and reference reports used for the forecasts.

Forecasting Methods and Results by Sector

Forecasting methods associated with each emissions sector, including building energy, on-road transportation, off-road transportation, solid waste, water consumption, wastewater treatment, stationary sources/industrial processes and product use, and agriculture are presented below.

For each sector, the following topics are presented:

- Emission Forecasting Methodology
- Results of the Emissions Forecasts
- Data Limitations and Modeling Uncertainties

Table 7-3 below summarizes the general methods for the emissions forecasts for each inventory sector listed above. Emissions were forecasted separately for each community in the 2010 GHG Inventory (i.e., for the city and each county), as appropriate to each sector. Table 7-3 also presents a summary of the data sources used for the forecasts, along with the average annual regional growth rate and the main reason for growth in each sector.

Table 7-3. Summary of Forecasting Methods and Data Sources

Sector	Forecasting Methods	Data Sources	Average Annual Regional Growth (2010–2050) and Driver for Growth
Building Energy	Residential: Housing projections Commercial: Total employment projections Industrial: Non-retail employment projections	CMAP CMAP CMAP	0.79% Growth in housing, population, and employment for the city and all counties
On-Road Transportation	VMT projections from CMAP multiplied by emission factors forecasted for future years using national fuel economy growth rates from the Annual Energy Outlook report.	CMAP, Annual Energy Outlook (2011)	0.05% Growth in VMT for the city and all counties
Off-Road Transportation	Elevated Heavy Rail, "L" – CTA: CMAP projections of rail rapid transit service hours for 2010–2040 used to scale up 2010 passenger rail emissions and extrapolated to 2050 Intercity Passenger Rail—AMTRAK: CMAP projections of commuter rail service hours for 2010-2040 used to scale up 2010 passenger rail emissions and extrapolated to 2050	Elevated Heavy Rail, "L"—CTA: CMAP, RTA (for baseline 2010 emissions) Intercity Passenger Rail—AMTRAK: CMAP	1.46% Growth in use of public transit, freight miles, and off-road equipment use.

Sector	Forecasting Methods	Data Sources	Average Annual Regional Growth (2010–2050) and Driver for Growth
	Passenger Rail—Northern Indiana Commuter Transportation District (NICTD): Same as for Amtrak Freight Rail: CMAP projections for 2040 rail freight volumes to scale up 2010 emissions, interpolating estimates for 2020 and 2030 and extrapolating for 2050 Off-Road Equipment: NONROAD model projections for 2010, 2020, 2030, 2040, and 2050 Aviation: N/A	Passenger Rail—NICTD: CMAP Freight Rail: CMAP Freight Snapshot study Off-Road Equipment: USEPA, NONROAD Aviation: N/A	
Solid Waste	Population projections	CMAP	0.33% Growth in population for the city and all counties
Water Consumption	Future water withdrawal and demand projections	The Regional Water Demand Scenarios for Northeastern Illinois: 2005–2050 report	0.10% Growth in water withdrawals for the region.
Wastewater Treatment	Population projections	CMAP	0.63% Growth in population for the city and all counties
Stationary, Industrial, and Product Use	Stationary/Industrial Sources: Nonretail employment projections by sector Refrigerant Emissions: Household projections (residential) and total employment (commercial) Product Use: Same as Building Energy projections for SF_6; Regional population projections for N_2O.	Stationary/ Industrial Sources: CMAP Refrigerant Emissions: CMAP Product Use: CMAP, US Census	0.85% Growth in housing, population, and employment for the city and all counties.

Sector	Forecasting Methods	Data Sources	Average Annual Regional Growth (2010–2050) and Driver for Growth
Agriculture	Livestock & Fertilizer Emissions: Livestock population projections, agricultural land projections.	Livestock projections based on baseline USDA livestock growth rates, found in the Regional Water Demand Scenarios for Northeastern Illinois: 2005–2050 report; CMAP	-0.27% Decreasing agricultural land area in the Region
	Off-road Agricultural Equipment: NONROAD Model forecast	NONROAD Model	

Building Energy

Emission Forecasting Methodology

Building energy emissions were forecasted by projecting energy use (electricity and natural gas) in the residential, commercial, and industrial sectors. Residential energy use was forecasted using the growth in households provided by CMAP. Commercial energy was forecasted using the growth in total employment provided by CMAP. Industrial energy use was forecasted using the growth in non-retail employment provided by CMAP.

CMAP data, including household and employment projections, include values for 2010 and 2040. These data were linearly interpolated to derive estimates of households and employment for the years 2020 and 2030 and were linearly extrapolated to derive estimates of households and employment for the year 2050.

Although energy use may not directly correlate with population, housing, and employment in the future, this method allows separate energy forecasts for the city and each of the seven counties based on anticipated economic growth in each county. An alternative method involves using annual energy consumption projections from the 2011 Energy Outlook Report published by the U.S. Energy Information Administration (EIA). However, these projections do not have the level of detail necessary to project emissions separately for the city and each county, so they were not used in the emissions forecasts.

Emission Forecasting Results

Building energy emissions increase for the city and each county for all future years. This is because population, employment, and housing increase for the city and each county from 2010 to 2040. The average annual growth in building energy emissions for the Chicago Region is 0.8%, representing a 32% growth in emissions from 2010 to 2050. The annual rate of growth by jurisdiction varies, however, from 0.4% (City of Chicago and Cook County) to 1.9% (Kane and Will Counties).

As the city and counties grow, bringing new residents and jobs, overall building energy use is projected to rise.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the building energy emissions forecasts:

- It was assumed that energy-related emissions are directly proportional to population, housing, and employment
- The sources of electricity and energy efficiency rates are held constant
- Socioeconomic projections were only available for 2040; therefore, linear extrapolation was used to forecast socioeconomic values for the other forecasting years

On-Road Transportation

Emission Forecasting Methodology

On-road transportation emissions were forecasted using VMT projections for 2040 available from CMAP's travel demand model for the city and each county. These VMT projections represent the "no-plan" scenario CMAP. Because VMT projections for 2020, 2030, and 2050 were not available, a linear interpolation from 2010 to 2040 was used to estimate VMT for the interim years, and a linear extrapolation to 2050 was prepared to estimate VMT for 2050.

Emission factors for each future year were forecasted from the baseline 2010 MOVES emission factors by applying an annual growth rate in national fuel economy, available from the EIA's Annual Energy Outlook (AEO) for 2011. This report provides average annual fuel economy growth rates for gasoline and diesel vehicles; however, these growth rates are for the period 2009-2035. To forecast fuel economy and resulting emission factors for 2040 and 2050, the same annual growth was assumed. The AEO growth projections do not account for the latest CAFE (Corporate Average Fuel Economy) standards for light duty vehicle model years 2017–2025 recently approved by the Obama administration on July 29, 2011 (requiring 56 miles per gallon average fuel economy). The resulting forecasts are therefore unable to capture these new developments.

The forecasts also include an "alternative fuels credit," which represents conventional fuel savings (gasoline and diesel) from the use projected of alternative fuels in the future. This was calculated for the city and each county, and represents an approximate 22,000 $MTCO_2e$ savings for each future year.

Emission Forecasting Results

On-road transportation emissions decrease for the city, Cook County, DuPage County, and Lake County. Decreasing emissions occur because increases in fuel efficiency outpace the growth in VMT for these areas from 2010 to 2040. Emissions increase for Kane, Kendall, McHenry, and Will Counties. This occurs because the growth in VMT outpaces increases in fuel efficiency for these areas from 2010 to 2040.

The average annual growth in on-road transportation emissions for the Chicago Region is 0.05%, representing a 2% growth in emissions from 2010 to 2050. The annual rate of growth varies from 0.6% (City of Chicago) to 1.8% (Kendall County).

As the city and counties grow, bringing new residents and jobs, overall automobile use and VMT is projected to rise. However, the increasing fuel efficiency of the on-road vehicle fleet in the Chicago Region offsets this growth, and results in declining on-road emissions over time for some areas.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the on-road transportation emissions forecasts:

- VMT projections were only available for 2040; therefore, linear extrapolation was used to forecast VMT for the other forecasting years
- Changes in the use of alternative fuels were not included in the forecasts due to data availability limitations (alternative fuel use was held constant)
- Congestion was not included in the forecasts
- Fuel economy projections from the AEO were only available through 2035; linear extrapolation was used estimate fuel economy for the other forecasting years
- Modeling assumptions inherent in the CMAP transportation model are embodied in the 2040 VMT projections

Off-Road Transportation

Emission Forecasting Methodology

Passenger Rail

Future passenger rail emissions were calculated using data on “peak commuter service hours” from CMAP for 2010, 2020, 2030, and 2040. The change in service hour values from 2010 to future years was the basis for forecasting the change in emissions out to 2040 from the 2010 baseline emissions for passenger rail. Since the CMAP data does not include the year 2050, passenger rail emissions for that year were forecasted by extrapolating the 2040 emissions. Locomotive fuel efficiency is not likely to change significantly in the future, since locomotive engines are a mature technology. The fuel efficiency was therefore assumed constant in the future years.

Freight Rail

Emissions from freight rail were forecasted using CMAP’s projections of regional freight volumes for the year 2040, available from the Freight Snapshot study. Because freight volumes for 2020, 2030, and 2050 were not available, a linear interpolation from 2010 to 2040 was used to estimate freight volumes for the interim years, and a linear extrapolation to 2050 was prepared to estimate freight volumes for 2050. The CMAP freight snapshot predicts that rail activity will increase 62% from 2007 to 2040. This is equivalent to a 56% increase in rail activity from 2010 to 2040.

Off-Road Equipment

USEPA’s NONROAD model was used to forecast emissions for off-road transportation and equipment for the years 2020, 2030, 2040, and 2050. The NONROAD model allows the user to define any model year from 1970 to 2050 for the analysis, forecasting and backcasting data for each county based on actual growth data from 1990–2002.

Emission Forecasting Results

Off-road transportation emissions increase for the city and each county for all future years. This is because passenger hours, freight miles, and off-road equipment use increases for the city and each County from 2010 to 2040. The average annual growth in off-road transportation emissions for the region is 1.46%, representing a 59% growth in emissions from 2010 to 2050. The annual rate of growth varies from 1.3% (City of Chicago) to 1.6% (Cook and DuPage).

As the city and counties grow, bringing new residents and jobs, overall transit use, goods movement, and off-road equipment use is projected to rise.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the off road transportation emissions forecasts:

- Passenger Rail
  - It was assumed that emissions are directly proportional to service hours.
  - The CMAP data is simplistic in future years. Service hours are held constant from 2020 onwards. This likely represents a data limitation in their analysis that prevents CMAP from forecasting further into the future. The result is that passenger rail emissions for 2020, 2030, 2040, and 2050 are equal.
  - Service hours for 2050 were not available; therefore, linear extrapolation of service hours for available years was used to forecast emissions for 2050.
- Freight Rail
  - It was assumed that emissions are directly proportional to freight rail volume.
  - Freight rail volume projections were only available for 2040; therefore, linear extrapolation was used to forecast VMT for the other forecasting years.
- Off-road Equipment
  - The NONROAD model's emissions forecasts are less accurate for years further into the future; for example, the forecasts for 2020 are likely more accurate than the forecasts for 2050. This occurs because since the possibility for unforeseen changes in off-road activity and technology increases as the time gap increases.

Solid Waste

Emission Forecasting Methodology

Solid waste emissions were forecasted by projecting solid waste generation for the city and each of the counties based on growth in population provided by CMAP. Because population tends to correlate with solid waste generation, this method is sufficient for projecting solid waste emissions. Waste generation for the commercial and industrial sectors is not separately available, so separately forecasting non-residential solid waste is not possible. Some landfills currently being used by the Chicago Region may be scheduled to close before 2050. Landfill closing dates were factored into the analysis of future solid waste emissions.

CMAP population data include values for 2010 and 2040. These data were linearly interpolated to derive population estimates for the years 2020 and 2030 and were linearly extrapolated to derive estimates of population for the year 2050.

Emission Forecasting Results

Solid waste emissions decrease for the city and Cook County as a whole, and increase for the balance of Cook County and each other county for all future years. In the city of Chicago, more waste was deposited in the past relative to waste deposited in the future; because emissions are based on waste landfilled in the past, future emissions decrease for the city. For the counties, the larger population growth results in greater solid waste generation in the future relative to waste generated in the past, so emissions increase over time.

The average annual growth in solid waste emissions for the city of Chicago is -0.7%, representing a -26% growth in emissions from 2010 to 2050. The average annual growth in solid waste emissions for the Chicago Region is 0.3%, representing a 13% growth in emissions from 2010 to 2050. The annual rate of growth varies from -0.7% (City of Chicago) to 2.8% (Kendall County).

In general, as the city and counties grow, bringing new residents, overall solid waste generation and therefore emissions is projected to rise.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the solid waste emissions forecasts:

- It was assumed that solid waste generation is directly proportional to population
- Population projections were only available for 2040; therefore, linear extrapolation was used to forecast population for the other forecasting years

Wastewater Treatment

Emission Forecasting Methodology

Wastewater treatment emissions were forecasted by projecting wastewater generation using the growth in population provided by CMAP. Because population generally correlates with wastewater generation, this method is sufficient for projecting wastewater treatment emissions.

CMAP population data include values for 2010 and 2040. These data were linearly interpolated to derive population estimates for the years 2020 and 2030 and were linearly extrapolated to derive estimates of population for the year 2050.

Emission Forecasting Results

Wastewater treatment emissions decrease for the city and each county for all future years. This is because population, and therefore wastewater generation, increases for the city and each county from 2010 to 2040. The average annual growth in wastewater treatment emissions for the region is 0.6%, representing a 25% growth in emissions from 2010 to 2050. The annual rate of growth varies from 0.4% Cook County) to 1.9% (Kendall County).

As the city and counties grow, bringing new residents and jobs, overall wastewater generation and the amount of energy required to treat this wastewater is projected to rise.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the wastewater treatment emissions forecasts:

- It was assumed that wastewater generation is directly proportional to population
- The energy required to treat wastewater remains constant in all future years
- The treatment processes which emit fugitive GHG emissions remain constant in all future years
- Population projections were only available for 2040; therefore, linear extrapolation was used to forecast population for the other forecasting years

Water Consumption

Emission Forecasting Methodology

Water consumption emissions were forecasted for each county by projecting water demand and withdrawals. For the city of Chicago, however, water consumption was forecast using population forecasts from CMAP because future water flows were not available at the city level. Water demand and withdrawal projections for each county were obtained from the 2008 report, Regional Water Demand Scenarios for Northeastern Illinois: 2005–2050 (Southern Illinois University Carbondale 2008). This study presents future water-demand scenarios for geographical areas which encompass groundwater withdrawal points and surface water intakes in the 11-county regional planning area of Northeastern Illinois.

In this study, estimates of future water demand were prepared for three different scenarios: Scenario 1: Current Trends (CT) or Baseline; Scenario 2: Less Resource Intensive (LRI); and Scenario 3: More Resource Intensive (MRI). Scenario 1 was used for water projections, as this scenario best represents current relevant trends, such as economic, water conservation, and water pricing. This study contains water withdrawal projections in 5-year intervals starting in 2010. It also includes future water withdrawals by source (e.g., Ground-Water, River Water, and Lake Michigan Water) and sector (Public Supply, Power Generation, Industrial & Commercial, Agricultural & Irrigation, and Domestic Self-supplied). Water use was forecasted based on the total water projections for each of these categories and sources.

Emission Forecasting Results

Water consumption emissions increase for the city and each county except for Will County for all future years. Emissions increase for the city because population increases over time. For all Counties except for Will, water withdrawals are expected to increase each decade from 2010 to 2050. For Will County, water withdrawals are projected to decrease from 2010 to 2020 by 10% and then increase from 2020 to 2050 by 4% (for a total decrease of -0.1% from 2020 to 2050).

For most counties, water consumption increases because water demand is expected to rise from 2010 to 2050 as population increases. For Will County, water demand decreases from 2010 to 2020 as a result of retiring two power generation units, which consume large quantities of water.

The average annual growth in water consumption emissions for the region is 0.1%, representing a 4% growth in emissions from 2010 to 2050. The annual rate of growth varies from -0.1% (Will County) to 2.3% (Kendall County). As the city and counties grow, bringing new residents and jobs, overall water use is projected to rise.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the water consumption emissions forecasts:

- The energy required to convey, distribute, and treat water remains constant in all future years
- The *current trends* scenario best represents future water consumption in the region consistent with the purpose of the forecasts
- For the city of Chicago, it was assumed that water use is directly proportional to population.
- The water source mix was assumed to be the same as in 2010 for all years

Stationary, Industrial, and Product Use

Emission Forecasting Methodology

Stationary and industrial emissions were forecasted based on non-retail employment data from CMAP. Residential refrigerant emissions were forecasted based on the projected number of households for the city and each county from CMAP. Commercial refrigerant emissions were forecasted using total employment growth for the city and each county from CMAP. Population, employment, and housing projections were provided by CMAP. For product use, population projections from CMAP were used to forecast emissions.

CMAP data, including household, population, and employment projections, include values for 2010 and 2040. These data were linearly interpolated to derive estimates of households, population, and employment for the years 2020 and 2030 and were linearly extrapolated to derive estimates of households, population, and employment for the year 2050.

Emission Forecasting Results

Stationary, industrial, and product use emissions increase for the city and each county for all future years. This is because population, housing, and employment increase for the city and each county from 2010 to 2040. The average annual growth in industrial and stationary emissions for the region is 0.97%, representing a 39% growth in emissions from 2010 to 2050. The annual rate of growth varies from 0% to 1.21% (Will County). The average annual growth in refrigerant and product use emissions for the region is 0.7%, representing a 28% growth in emissions from 2010 to 2050. The annual rate of growth varies from 0.3% (McHenry) to 2.8% (Lake).

As the city and counties grow, bringing new residents and jobs, overall stationary, industrial and product use emissions is projected to rise.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the stationary, industrial and product use emissions forecasts:

- It was assumed that industrial and stationary emissions are directly proportional to nonretail employment (projections of industrial production were not readily available)
- It was assumed that refrigerant emissions are directly proportional to housing (residential) and employment (commercial)
- It was assumed that product use emissions (N_2O) are directly proportional to population
- Socioeconomic projections were only available for 2040; therefore, linear extrapolation was used to forecast socioeconomic values for the other forecasting years

Agriculture

Agriculture emissions, including enteric fermentation, manure management, and fertilizer use, were projected using livestock population projections as cited in Regional Water Demand Scenarios for Northeastern Illinois: 2005–2050, which bases projections on baseline USDA growth rates (Southern Illinois University Carbondale 2008). The total change in livestock population for the Northeastern region of Illinois was used to project emissions from enteric fermentation and manure management for each county in the Chicago Region. Emissions from fertilizer use were forecasted using the expected region-wide decrease in agricultural acres by 2040 (56%). Additional future years (2020, 2030, and 2050) were interpolated from existing data. For off-road agriculture vehicles, the NONROAD Model was used to calculate future year emissions.

Emission Forecasting Results

Agriculture emissions increase for Cook and Lake Counties, and decrease for all other counties (the city of Chicago has no agriculture emissions), for all future years. This is because rising enteric fermentation and manure management emissions from increasing livestock numbers outpace declining fertilizer-related emissions from decreasing agricultural land area in Cook and Lake Counties. For all other counties, declining fertilizer-related emissions from decreasing agricultural land area outpace rising enteric fermentation and manure management emissions from increasing livestock numbers.

The average annual growth in agriculture emissions for the region is -0.3%, representing a -11% growth in emissions from 2010 to 2050. The annual rate of growth varies from -1.9% (DuPage) to 0.6% (Cook). In general, as the amount of agricultural land in the region decreases over time, agricultural emissions are projected to decline in the future.

Data Limitations and Modeling Uncertainties

The following data limitations and modeling uncertainties are embodied in the agriculture emissions forecasts:

- Livestock projections for the entire region were used to forecast enteric fermentation and manure management emissions for the city and each county
- Agricultural land projections for the entire region were used to forecast fertilizer use emissions for the city and each county
- Livestock and agricultural land projections were only available for 2040; therefore, linear extrapolation was used to forecast these values for the other forecasting years.

Chapter 8

Carbon Stock and Sequestration

Chapter 8
Carbon Stock and Sequestration

Introduction

This section describes the results of carbon stock and sequestration analyses conducted by ICF for 2010 conditions in the Chicago Region.

Carbon stock is defined as the amount of carbon that is stored within vegetation and soil. It is presented in metric tons of carbon (MT C).

Carbon sequestration is the annual amount of carbon dioxide that is taken up by vegetation and soils per year. In this section, carbon sequestration is presented in metric tons of carbon dioxide per year ($MTCO_2$/year).

ICF prepared estimates for carbon stored and annually sequestered by different land covers in the Chicago Region in 2010, including the city of Chicago and seven counties (Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will). This section also provides a description of the methods and datasets used by ICF as part of these analyses. For this analysis, ICF utilized existing data, as available, and made efforts to ensure consistency between these datasets.

The sequestration analysis conducted for the Chicago Region shows that in 2010, carbon uptake by vegetation in the Chicago Region would offset approximately 1% of total GHG emissions by all sectors. Although carbon is stored in a variety of land cover types in the Chicago Region, based on this study, the annual uptake is dominated by trees. Carbon stock stored in vegetation and soil in the region represents approximately 140% of the total 2010 GHG emissions.

Methods and Data Sources

Carbon stock and sequestration were assessed for the following vegetation types.

- Forests (urban and natural)
- Grasslands
- Shrublands/scrublands
- Herbaceous wetlands
- Wooded wetlands
- Non-woody crops

These vegetation types were selected because they are the dominant general vegetation covers found in the study area there was available data on tree cover carbon stock and sequestration and/or vegetation cover acreages and stock and sequestration factors.

The following data sources were used to complete this analysis.

- Morton Arboretum (MA)—Tree census data for the Chicago Region (Morton Arboretum 2011)
- Chicago Wilderness (CW)—Carbon stock factors for grasslands, shrublands and scrublands, herbaceous wetlands and wooded wetlands (Chicago Wilderness 2010)
- National Agricultural Statistics Service (NASS)—spatial data of land cover types including several types of grasslands, forests, wetlands, and scrublands/shrublands as well as over 100 crop types (National Agricultural Statistics Service 2011)
- USEPA—annual carbon sequestration factors for grasslands and scrublands/shrublands as used in the U.S. National Greenhouse Gas Inventory (U.S. Environmental Protection Agency 2011c)
- U.S. Climate Change Science Program (USCCSP)—annual carbon sequestration factors for wetlands as reported in the First State of the Carbon Cycle Report (SOCCR) (U.S. Climate Change Science Program 2007)

Methods Used to Estimate Tree Carbon Stock and Sequestration

The Morton Arboretum has recently completed an assessment of trees in the Chicago Region. The assessment was based on collecting tree data in different CMAP land use categories, of which there are over 50 different designated categories. In order to have statistically significant data sets, the Morton Arboretum collapsed the CMAP land use-types into 4 categories: residential (urban and suburban), other (commercial, industrial, and transportation), agriculture, and open space (public and private, including recreational areas, parks, and undeveloped land). The Morton Arboretum assessment estimated the carbon stored in the living tree (i.e., tree "root to shoot") and does not capture soil carbon, understory[19], or other vegetation that may be present on the site (shrubs, etc.).

Methods used to Estimate Non-Tree Carbon Stock and Sequestration

As the Morton assessment captured tree carbon, a supplementary analysis was done for non-tree carbon stock and sequestration. To estimate the acres of land cover types other than trees, the CMAP county limits and the Chicago city limits were overlain with the land cover data set from the NASS database using GIS. The 254 NASS land cover types were collapsed into the seven generic land cover types (urban, forest, grassland, shrubland, herbaceous wetlands, woody wetlands, and non-woody crops). The NASS urban area was excluded to avoid double-counting as the Morton data set already included urban forests and there are limited carbon stock in non-tree vegetation in urbanized areas. The NASS forested areas were also excluded as tree carbon was already included in the Morton data set. The areas of each of the five remaining land cover types were then multiplied by generic stock and sequestration factors to yield carbon stock and annual carbon sequestration by land cover type for each study jurisdiction.

[19] Understory is defined as the area of a forest which grows at the lowest height level below the forest canopy, and can include juvenile trees.

Table 8-1. Default Factors for Carbon Stock and Annual Carbon Sequestration for Land Cover Types Used in This Analysis Other than Trees

Land Cover Type	Stock Factor (MT C/acre)	Source	Annual Sequestration Factor (MT C/acre/yr)	Source
Grasslands	35	Chicago Wilderness, 2010[a]	0.004	USEPA 2011c
Shrubland/Scrubland	50	Chicago Wilderness, 2010[b]	0.004	USEPA 2011c
Herbaceous Wetlands	25	Chicago Wilderness, 2010[c]	0.07	USCCSP 2007
Wooded Wetlands	45	Chicago Wilderness, 2010[d]	0.07	USCCSP 2007
Non-Woody Crops	32.1	USCCSP, 2007	0	USEPA 2011c

Note: When carbon sequestration is included in greenhouse gas inventories, it is often included as a negative number to reflect that it represents a reduction in atmospheric carbon dioxide. In this report, sequestration is reported as a positive value to indicate the amount of carbon uptake.

a. Considers soil organic carbon only, based on Gebhart et al. 1994 (measure of 90.8 tons/hectare [about 36 tons/acre] in Texas, Nebraska and Kansas); McLauchlan et al. 2006 (5800 to 7000 grams/square meter [about 23 to 28 tons/acre] in Minnesota, from Fig. 1A); and Matamala et al. 2008 (measure of 12.1 kilograms per square meter [about 48 tons/acre] in surface 0.16 milligrams per square meter soil mass in Illinois, Table 7).

b. No published value found by Chicago Wilderness for their study. The median of estimates for grasslands and forests was used.

c. Based on average range of organic carbon values for high-quality reference sites in the Prairie Pothole region (57 to 65 tons/hectare, or about 23 to 26 tons/acres) (Gleason et al. 2003).

d. No published value found by Chicago Wilderness for their study. The median of estimates for herbaceous wetlands and forests (65 MT C/Acre from Smith et al. 2007) was used.

Two stock factors were available for the annual sequestration factor for non-woody crops. According to USCCSP SOCCR, the biomass of non-woody crops is a transient and small carbon pool relative to forests. Thus the majority of associated carbon is stored in the soils. In estimating the carbon stored in crop soils, the USCCSP has generally assumed that agriculture and grazing lands in North America are neutral with respect to their soil carbon balance (U.S. Climate Change Science Program 2007). ICF has conservatively assumed no net gain in agricultural soil carbon (i.e., annual carbon sequestration factor = 0 MT C/acre/year). However, other research indicates that management practices including reduced till (limited plowing), no till (no plowing) and cover crop can greatly increase the carbon uptake of agricultural soils and that the potential for increased soil carbon nationwide is greatest in the upper mid-west (Pew Center on Global Climate Change 2006). According to a 2006 study prepared for the Pew Center for Climate Change, carbon soil accumulation in agricultural fields could be as high as 0.02 MT C/acre/year, while USCCSP has conservatively assume no net carbon soil accumulation in agricultural soils. For this study, ICF assumed no net carbon gain. A better understanding of agricultural soil carbon accumulation in the region, including, the current and future use of best management practices for enhanced soil carbon accumulation, is recommended.

Estimating Total Carbon Stock and Sequestration

The tree carbon totals (using the Morton Arboretum data) and the non-tree carbon totals (using the NASS data and stock/sequestration factors) were then added to yield a total value for carbon stock and annual carbon sequestration for each jurisdiction. It should be noted that the data collected on carbon stock and annual sequestration by trees in each of the sampled plots in the Morton Arboretum are of a higher resolution than the generic factors of carbon stock and annual sequestration used to assess non-tree land covers. Extensive field sampling was conducted as part of the Morton Arboretum Tree Census and the estimates of carbon stock and annual sequestration are based on thousands of actual tree measurements. A complete description of the methodology used by the Morton Arboretum to complete the tree census can be found in their report (to be published in early 2012) or in Chicago's Urban Forest Report (U.S. Forest Service 2010). However, while the plot –level data on trees is quite precise, in order to derive jurisdictional estimates, the Morton Arboretum scaled up from the plot data using amalgamated land use categories. In the scaling up of plot data, this methodology introduces some uncertainty into the jurisdictional totals as the randomized plots are not necessarily representative of the distribution and density of the forested areas (natural and urban) in each jurisdiction. The default carbon stock and carbon sequestration factors used to estimate the carbon stored for other land cover types represent typical or average conditions and are often based on national or regional, as opposed to local, data. However, the estimate of land cover acreages for non-tree land cover types used spatial data from NASS that is accurate on a broad scale.

Thus, the estimate of tree carbon stock and sequestration used highly specific plot data that is then roughly scaled to the jurisdictional level, whereas the estimate of non-tree carbon stock and sequestration used more general stock and sequestration factors, but reasonably precise land cover data.

Results

Forests have the highest carbon stock and carbon sequestration values of different vegetation cover types. Natural forests can contain as much as 65 MT C per acre (Chicago Wilderness 2010). Within developed areas, urban forests are much less dense and thus contain far less carbon per acre than natural forested areas. For example, using the Morton Arboretum data, the average amount of carbon stock per acre in residential areas vary from 5 to 14 metric tons of carbon per acre across the different jurisdictions in the CMAP area.

The acres of land cover type in the CMAP area are shown below in Table 8-2. The acres of the amalgamated land use types from the Morton Arboretum assessment are shown in below in Table 8-3.

The total carbon stored (MT C) and annual carbon sequestration by trees and other natural land-cover types are shown in Table 8-4 for each jurisdiction. Carbon stock is expressed in metric tons carbon stored (MT C) and annual carbon sequestration expressed in metric tons of carbon dioxide removed ($MTCO_2$/yr) each year. Total carbon stored on natural land cover types in 2010 is estimated to be just over 49 million MT C including carbon stored in trees (located on any land cover type) and other land-cover types (including grasslands, wetlands, shrub/scrub and non-woody agriculture). Orchard trees are captured as part of the Morton Arboretum's tree census as well as any natural or native trees located on or adjacent to crops or on the margins of grasslands. On an annual basis, these land cover types are removing approximately 1.6 million $MTCO_2$ per year from the atmosphere. Annual carbon sequestration by these land cover types would offset approximately 1.3% of total GHG emissions in 2010 (~125 million $MTCO_2$).

For the U.S. as a whole, carbon sequestration by forests and agricultural lands currently offsets 12% of U.S. GHG emissions from all sectors (U.S. Environmental Protection Agency 2005). Over 90% of this uptake occurs in the nation's forests. In urban Chicago and suburban Cook County, trees account for the majority of carbon stock (95% and 76%, respectively). In Will and Kane Counties, other land cover types account for the majority of carbon stock (85% and 84% respectively). Although in general, trees contain much greater carbon stock on a per acre basis relative to agricultural or grasslands, the high number of acres under cultivation or grasslands results in a significant amount of carbon stored in non-tree vegetation types in these two counties. For all counties, annual carbon sequestration is dominated by trees.

Recommendations and Limitations

Recommendations

There are a number of ways in which the analysis of carbon stock and sequestration could be improved in future years to help track changes in emissions over time and to track progress in maintaining and expanding carbon stock and carbon sequestration in the Chicago Region.

The Morton Arboretum approach appears to be most appropriate for urban forests. For natural forest areas, sampling of individual plots (like the Morton Arboretum approach) could be combined with land cover mapping of natural forest areas to derive more accurate estimates of natural forest carbon stock and sequestration than the rough scaling using land use types. For non-forested areas outside the urbanized areas, future estimates could be refined in the future with more locally specific data to derive more specific stock and sequestration factors combined with more refined vegetation mapping data.

Land Cover/Land Use Inventories

The current analysis utilized a land use type-based methodology for urban and suburban areas utilizing data from the Morton Arboretum assessment and a land-cover type-based methodology for other land covers using data from NASS. The Morton Arboretum methodology is a robust sampling/data driven process utilizing actual tree data that can be replicated periodically in the future and is appropriate for assessing the urban and suburban forest context. The Morton Arboretum assessment simplified the CMAP land use types into a small number of categories for the sake of efficiency. If resources were available, use of a greater number of land use categories would result in a more precise accounting of the variation of stock and sequestration across the urban and suburban context. In addition, the methodology used in the Morton Arboretum assessment may be most appropriate for use in the urban and suburban context, but other approaches may be more appropriate for natural land covers.

Table 8-2. Acres of Land Cover Type by Jurisdiction using National Agricultural Statistics Survey (NASS) Data

Land Cover Type	CMAP Area	Chicago	Rest of Cook County	DuPage County	Kane County	Kendall County	Lake County	McHenry County	Will County
Developed	1,235,019	140,708	372,077	173,801	111,841	28,444	163,179	86,470	158,499
Forest	282,988	2,240	54,204	19,079	26,276	12,320	58,787	53,835	56,248
Agriculture	693,879	43	9,247	5,222	142,231	140,324	22,231	161,864	212,716
Grasslands	321,607	1,035	22,227	12,577	50,201	23,145	33,852	79,350	99,219
Shrubland/ Scrubland	1,747	26	735	46	1	0	3	19	917
Wetlands	6,297	12	171	79	96	28	4,236	1,042	634
Water	63,409	2,770	8,558	3,000	4,763	2,024	18,802	8,338	15,154
Total	2,604,946	146,835	467,219	213,804	335,408	206,285	301,091	390,918	543,387

Source: National Agricultural Statistics Service 2011

Table 8-3. Acres by Amalgamated Land Use Categories Used in the Morton Arboretum Assessment

Land Use Category	CMAP Area	Chicago	Rest of Cook County	DuPage County	Kane County	Kendall County	Lake County	McHenry County	Will County
Residential	783,851	70,846	213,860	100,872	74,714	24,092	117,384	74,997	107,086
Other (Commercial, Industrial, Transportation)	363,113	55,931	111,082	52,662	30,796	4,908	38,563	18,153	51,018
Agriculture	855,810	--	17,629	4,868	171,269	158,220	37,301	205,389	261,134
Open (Recreational, Preserve, Undeveloped)	598,758	20,999	123,375	55,301	57,871	18,976	106,002	92,417	123,817
Total	2,601,533	147,776	465,947	213,704	334,651	206,195	299,250	390,956	543,055

Source: Morton Arboretum 2011. Morton data provided in tons and were converted to metric tons by ICF.

Table 8-4. Estimates of Carbon Stock and Annual Carbon Sequestration by Jurisdiction

	Trees		Other Natural Land Covers		Total	
Jurisdiction	Carbon Stock (MT C)	Annual Carbon Sequestration ($MTCO_2$/year)	Carbon Stock (MT C)	Annual Carbon Sequestration ($MTCO_2$/yr)	Carbon Stock (MT C)	Annual Carbon Sequestration ($MTCO_2$/yr)
City of Chicago	662,377	59,720	39,309	19	701,686	59,739
Cook County	3,612,907	391,968	1,117,389	680	4,730,296	392,648
DuPage County	1,802,318	171,050	612,752	375	2,415,070	171,425
Kane County	1,247,322	98,996	6,325,857	5809	7,573,179	104,805
Kendall County	461,227	60,032	5,315,579	5,365	5,776,806	65,397
Lake County	2,902,183	309,586	2,010,490	2,317	4,912,673	311,903
McHenry County	2,839,231	268,435	8,010,155	7,141	10,849,386	275,576
Will County	1,778,284	223,634	10,374,096	9,143	12,152,380	232,778
Total	15,305,849	1,583,422	33,805,628	30,848	49,111,477	1,614,270

Source: Calculations by ICF using methodology described above. Tree data derived from Morton Arboretum Assessment. Other natural land covers estimated using NASS land cover data and stock and sequestration factors noted above.

The methodology used for the Morton Arboretum assessment employed random plots within each county in the CMAP area and the city of Chicago. Most of the natural forest cover (approximately 70% based on NASS data) falls within the amalgamated "open" category used by Morton, but the open category includes a range of land cover types. Use of randomized plots in an area with diverse and non-evenly distributed natural land covers may not result in a representative assessment of tree carbon in such areas. ICF conducted a sensitivity analysis to assess this issue by estimating the carbon stock within forested areas in the amalgamated open category for each jurisdiction within the CMAP area by using the NASS data (National Agricultural Statistics Service 2011) and the stock factor used by Chicago Wilderness for forest areas of 65 MT C (Chicago Wilderness 2010). In comparison to the results in the Morton Arboretum assessment, the overall stock in forests would be approximately double (98% greater) by using the alternative methodology. The variation was not uniform by jurisdiction—in Chicago, the use of the NASS data and a stock factor resulted in a 22% lower carbon stock estimate than the Morton results, but in some of the outlying areas (including Kane, Lake, and Will Counties), the use of the alternative methodology resulted in carbon stock estimates approaching or exceeding three times that of the Morton assessment. Overall, if one were to use the alternative methodology for the amalgamated open land use category from the Morton assessment, the CMAP carbon stock estimate would increase by approximately 24%. Without further analysis and data on specific land covers in the study area, no conclusions can be made about the relative accuracy of these different methods. However, the sensitivity analysis suggests that in the future, the use of methods like those employed in the Morton assessment (which was originally designed for assessing urban forests, not natural forests), may be most appropriate for the urban and suburban context only, and that alternative methods utilizing land cover mapping may be more appropriate for natural land covers.

Outside of urban forests, stock and sequestration of natural land covers and croplands could be assessed using land cover mapping with greater disaggregation of land and crop cover types than that used by NASS. As a result, a more precise assessment of natural land cover and cropland stock and sequestration could be derived. However, NASS data, as freely available and as updated yearly, will still provide a useful snapshot of the non-urban forest land covers until a more precise land cover mapping data set is developed.

Stock/Sequestration Factors

Within the urban forest, a sampling/data driven approach, as used by Morton Arboretum, is recommended to derive stock/sequestration factors in the urban and suburban context. The assessment of urban forests could be expanded to include understory as the current assessment was limited to stock and sequestration in trees only. For natural land covers and croplands, specific stock and sequestration factors could be developed for a wider range of land cover and crop types, including assessment of on the ground implementation of soil carbon management by regional agriculture. Development of more locally specific factors would require research that may be best leveraged through private, academic, state, or federal research organizations or agricultural extension agencies best suited to complete such studies,

Future Stock/Sequestration Dynamics in Land Covers

Land covers are changing over time due to long-term climate change. As a result, carbon stock and sequestration dynamics will also change. As such, the use of past stock and sequestration factors may not accurately represent future stock and sequestration. Thus, in addition to the development and use of factors for a wider variety of land use types and land covers, future analyses should also consider the changing forest and soil dynamics with climate-induced changes in temperature, growing seasons, carbon dioxide levels, precipitation, and storm events.

Limitations and Uncertainty

The carbon stock and sequestration analysis is limited by the resolution of the data utilized by the Morton Arboretum and NASS to define land use and land cover types. As noted above, the NASS data in particular utilizes a simplified land cover typology that does not fully capture the range of land cover types. The Morton Arboretum assessment used a simplified set of land use types that do not fully capture the heterogeneity of different land uses across such a large area as the Chicago Region and thus scaling up of randomized plot data up to a jurisdictional level may not be fully representative of the distribution of actual land uses. The stock and sequestration factors used for land covers outside the urban forest are generic factors that will not reflect the variability of grasslands or cropland to sequester carbon and thus only provide a rough estimate of the existing stock and sequestration in these land covers. Finally, this analysis is a static picture in time and does not assess gains in carbon stock due to vegetative planting or soil management practices or loss in carbon stock due to land clearing and vegetation removal.

Chapter 9
References

Chapter 9

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Appendices

Appendix A
Supporting Information for the CO_2 Electricity Emissions Factor Update to 2010

This Appendix includes a brief summary of the methodology and results for the CO_2 emission factor update to 2010 conditions, performed by ICF as part of this study. The analysis focuses on the Reliability First Compliance (RFC) region and provides a plant level comparison for CO_2 emission factors in 2010 relative to 2007. The 2007 data used for comparison purpose is available through USEPA's Emissions & Generation Resource Integrated Database (GRID) database. Additionally, we have also provided an aggregated regional level comparison for the CO_2 emission factor analysis.

The scope of this analysis included: (1) extracting and consolidating plant level operation data for 2010 from publicly available sources such as the U.S. Energy Information Administration (EIA) and SNL Financial (SNL), (2) Utilizing the data obtained in Task#1 to compile generation and heat input (i.e., fuel consumption in million metric British thermal units [MMBtu]) by fuel type for each plant, (3) determining the CO_2 emissions for each plant by using the actual CO_2 emissions from the Continuous Emission Monitoring System (CEMS) database or estimating the CO_2 emissions by utilizing the heat input, fuel type information and ICF generic fuel type CO_2 emission rates; for plants where actual emissions data is not available, and (4) finally, evaluating the CO_2 equivalent emission rate for each plant and at the regional aggregate level. The scope of work also included, to an extent possible within the proposed budget, analyzing the approximate RFC's import/export for the 2010 period with the neighboring regions and adjusting the regional aggregate level emission factor, if RFC is net importer of electricity. However, we observed that RFC is a net exporter of electricity and hence, this adjustment to regional aggregate level emission factor is not warranted.

Methodology & Results

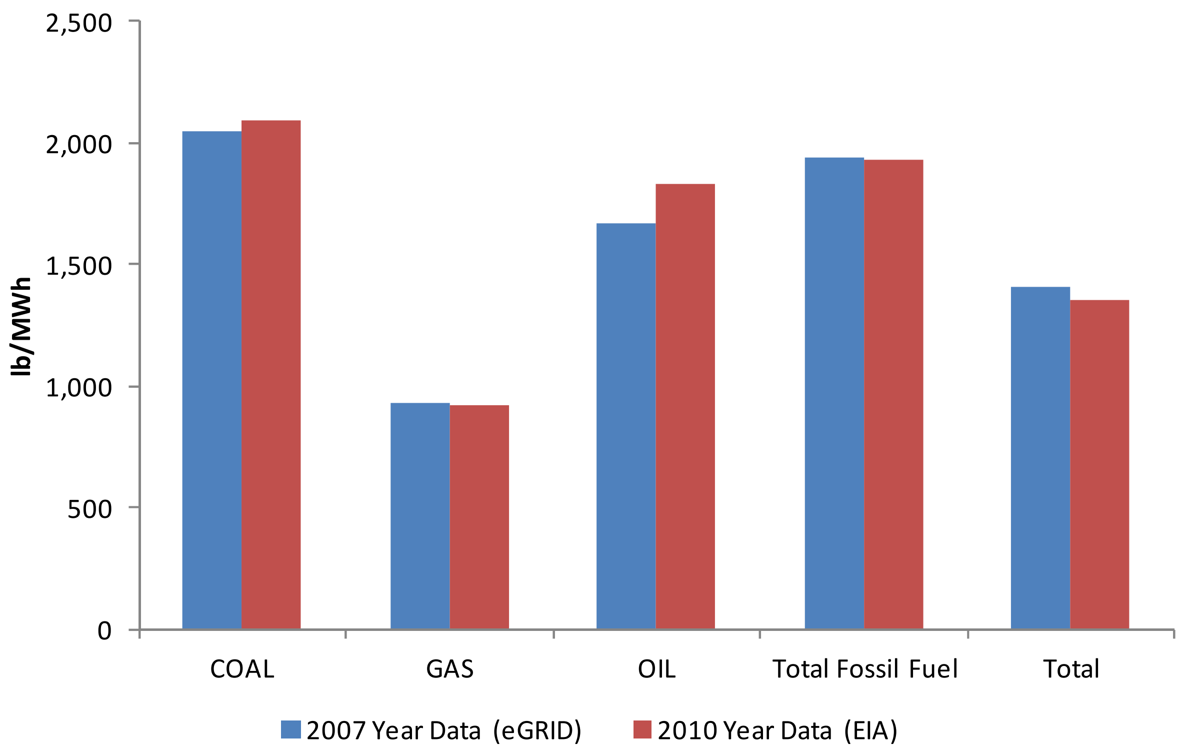
ICF started with the extraction and consolidation of plant operation data from EIA and SNL for RFC region in 2010. ICF utilized the EIA form 923 and SNL database to obtain a comprehensive list of plants in RFC and their corresponding (1) nameplate capacity (MW), (2) annual 2010 generation (gigawatt hour [GWh]), and (3) annual heat input (MMBtu) in 2010. For plants that had not been reported by 2010 EIA 923 and SNL, and which were operating in 2010, ICF assumed their annual generation (GWh) and annual heat input (MMBtu) to be equivalent to that in 2009. For these plants, ICF obtained operation data from 2009 EIA 923.

In the next step, ICF used data from the CEMS database to obtain actual plant CO_2 emissions in 2010. For plants for which the CO_2 emission information was not reported by CEMS, ICF estimated the emissions by using generic emission rates (in pounds/MMbtu) by fuel type and heat input (in MMBtu). Finally, ICF compared this data with the 2007 eGRID data to compile a plant-level summary of (1) generation (GWh), (2) heat input (MMBtu), (3) CO_2 emissions (tons), and (4) CO_2 emission rate (pounds/megawatt hour) for 2010 relative to 2007 plant performance. ICF also aggregated the 2007 eGRID data and ICF's compiled 2010 data to provide a regional level comparison of the CO_2 emission rates. The regional level results are summarized below.

ICF observed that the CO_2 emission rate for RFC has reduced from about 1,409 pounds/MMBtu in 2007 to 1,352 pounds/MMBtu in 2010; representing a decrease of about 4%. This can be primarily attributed to (1) increased non-fossil fuel generation (nuclear, hydro, wind & biomass) which increased from 28% of total generation in 2007 to 30% of total generation in 2010 or by approximately 10.2 terawatt hours, and (2) decrease in coal generation by about 66 terawatt hours relative to 2007 level. In absolute terms, ICF observes that the CO_2 emissions have reduced by about 7% in 2010 relative to 2007. Further, fossil fuel generation has reduced by about 6% over this period, while total RFC generation reduced by about 3%.

Figure A-1 below summarizes the change in CO_2 emission rates (pounds/megawatt hour) from 2007 to 2010, for different plant fuel types.

Figure A-1. RFC CO_2 Emission Rate (pounds/megawatt hour)



Appendix B

Linear Regression Analysis of Weather Impact on Building Energy Demand

This Appendix includes a brief summary of the methodology used to analyze the effect of weather on building electricity and natural gas consumption and associated greenhouse gas emissions.

ICF utilized 2010 monthly electricity and natural gas data from local utilities and 2010 weather data to complete a linear regression analysis to identify a relationship between weather and building energy consumption. Weather fluctuations are measured in "degree days". Cooling degree days (CDD) measure the number of days in which the temperature is above 65^{o} Fahrenheit (one day at 75^{o} would be ten heating degree days). Heating degree days (HDD) measure the number of days in which the temperature is below 65^{o} Fahrenheit (one day at 25^{o} would be 40 heating degree days). Weather data is from the Illinois State Climatologist (Illinois State Water Survey 2012).

As shown below in Figure B-1 and B-3, a positive correlation was identified between increases in cooling degree days and electricity consumption, reflecting the influence of increased air conditioning use in warmer weather. While there is a correlation, the strength of this correlation (r^2= 0.38 to 0.48) is not very strong. This is likely due to a substantial base demand for lighting, appliances, consumer electronics and other electricity uses, in addition to air conditioning, that are not related to weather changes.

As shown below in Figure B-2 and B-4, a positive correlation was also identified between increases in heating degree days and natural gas consumption, reflecting the influence of increased building heating in colder weather. The strength of this correlation (r^2 = 0.80 to 0.86) is stronger than the relationship between electricity and cooling degree days. This stronger correlation is likely due to a greater relative influence of heating in overall natural gas consumption.

With the established relationship between weather and consumption from the linear regression analysis, the expected electricity and natural gas consumption values were calculated for 2000, 2005, and 2010. These expected values were then compared to each other to isolate the effect of weather on energy consumption between the different years. The identified percentage electricity and natural gas consumption differences between the modeled years was then multiplied by electricity and natural gas greenhouse gas emissions for the base comparison years (2000 and 2005) in order to identify the contribution to changes in greenhouse gas emissions between the base comparison years and 2010. The results of this analysis are described in Chapter 5 of this Report.

Figure B-1. Correlation of Cooling Degree Days to Electricity Use, City of Chicago

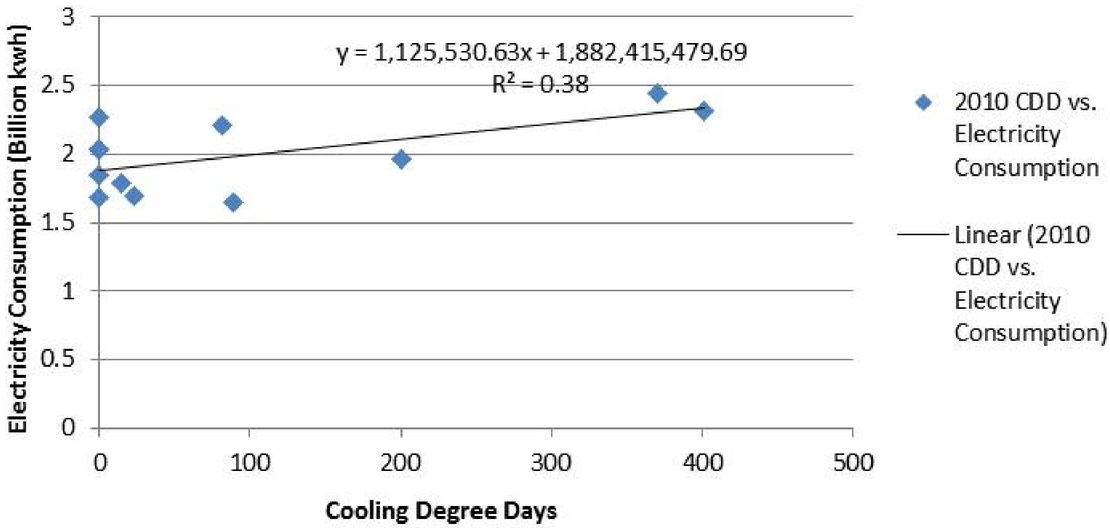


Figure B-2. Correlation of Heating Degree Days to Natural Gas Use, City of Chicago

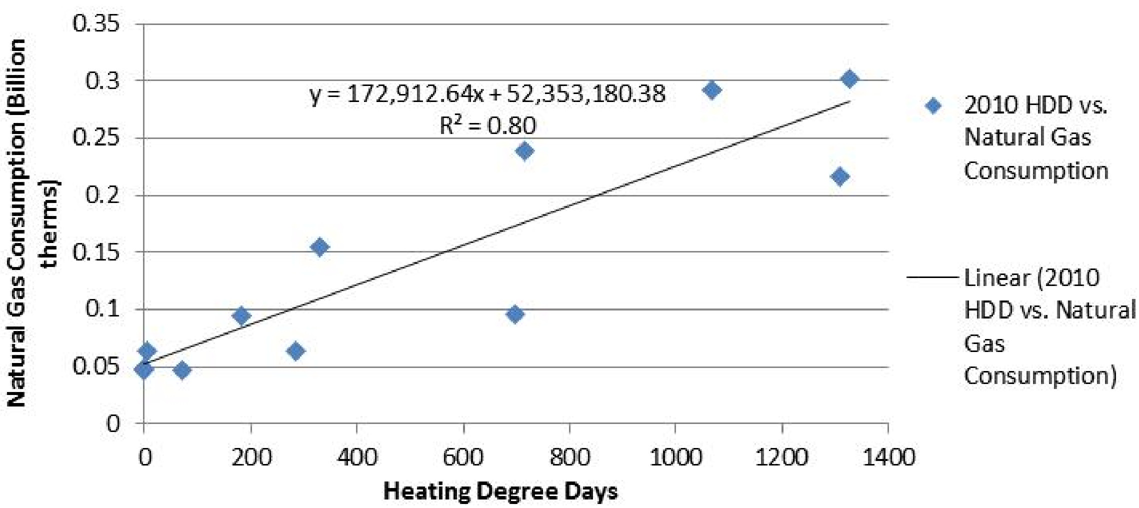


Figure B-3. Correlation of Cooling Degree Days to Electricity Use, Chicago Region

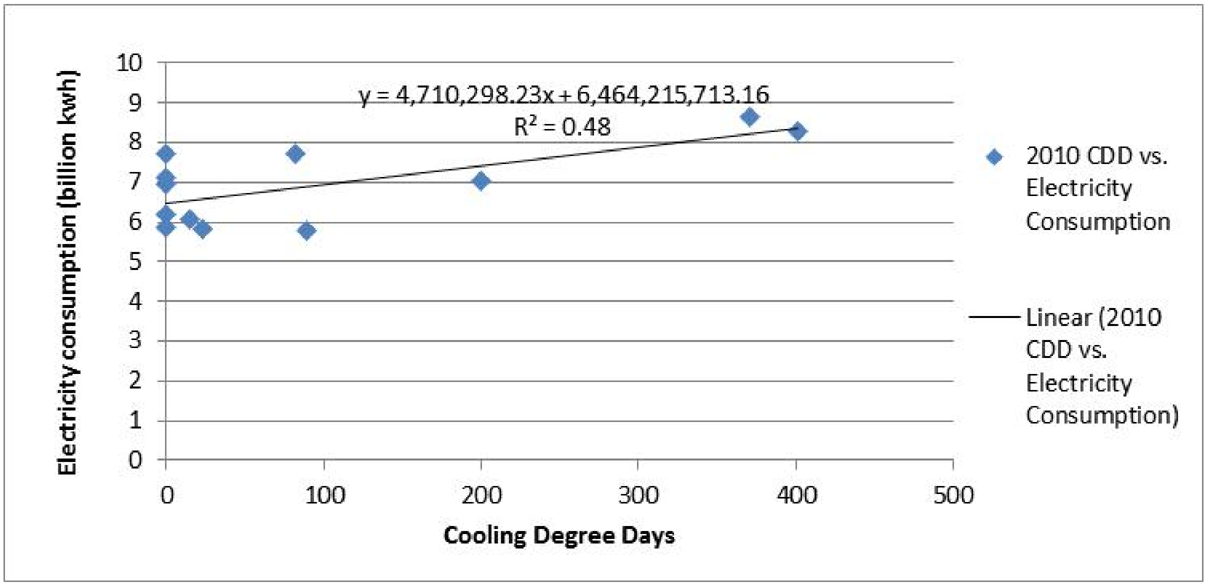
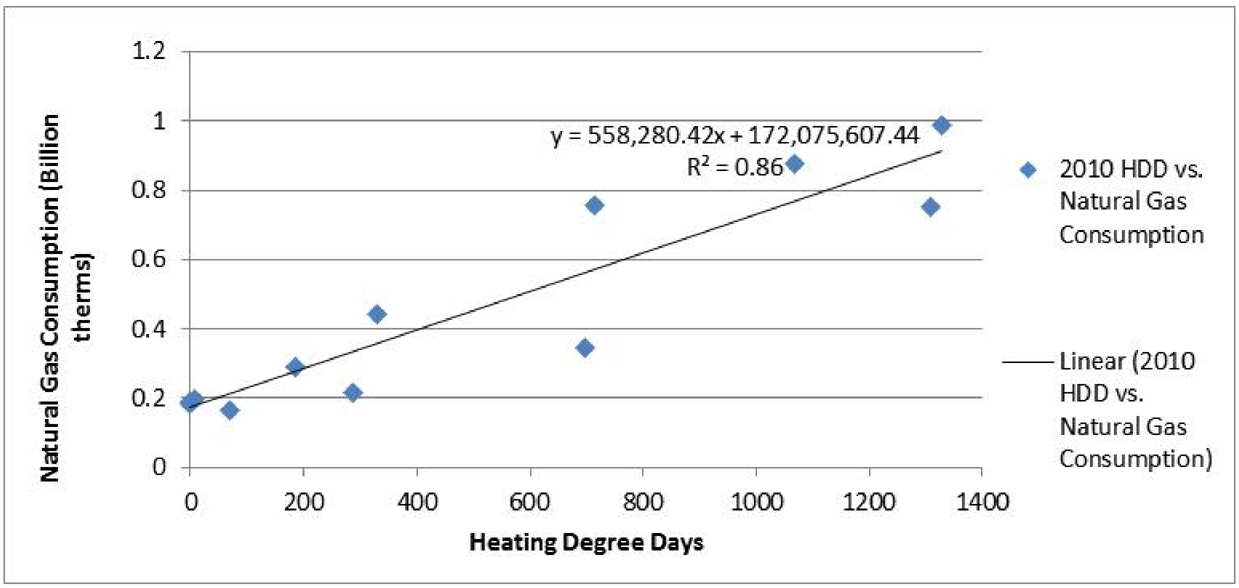


Figure B-4. Correlation of Heating Degree Days to Natural Gas Use, Chicago Region



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