Inventory of City of Madison Local Government Operations Greenhouse Gas Emissions

Inventory Year 2012

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5/10/13

ACKNOWLEDGEMENTS

The project team would like to thank the following individuals for their direction and contributions to this report.

- Bernard Lesieutre, Associate Faculty Associate, Nelson Institute of Environmental Studies, University of Wisconsin-Madison
- Jeanne Hoffman, Facilities and Sustainability Manager, City of Madison
- Elie Yewdall, Program Officer, ICLEI-Local Governments for Sustainability USA
- Brynn Bemis, Hydrogeologist, Engineering Division, City of Madison
- Wayne Block, Finance Manager, Madison Metro Transit
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- Robin Jahn, Transit Maintenance General Supervisor, Madison Metro Transit
- Kay Schindel, Engineer, Facilities and Sustainability Management, City of Madison

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FOREWORD

This marks the third time that the City of Madison has completed a carbon inventory of its local government operations. Beginning in 2007, the City partnered with students from the Nelson Institute of Environmental Studies' Energy Analysis and Policy (EAP) Certificate Program at the University of Wisconsin–Madison to collect, analyze, and report carbon emissions data. Another internal analysis was completed for the 2010 calendar year. For this 2012 report, the City once again partnered with EAP students to build upon previous years' work and provide a clearer analysis of Madison government facilities' carbon emission trends. The EAP students are enrolled in the Energy Analysis Seminar, the Capstone course in their graduate certificate program. According to the Nelson Institute's website:

> EAP is an optional graduate-level certificate or Ph.D. minor that gives students the knowledge and skills needed to become leaders in industry, government, consulting, and key energy fields. EAP's interdisciplinary curriculum considers technical, economic, political, and social factors that shape energy policy formulation and decision-making. It examines current topics in energy resources, energy market structures and practices, traditional public utilities, energy technology, energy and environmental linkages, energy and environmental policy, and energy services.

The Nelson Institute's mission is to "build partnerships to synergize and sustain excellence in the interdisciplinary research, teaching, and service that make the University of Wisconsin-Madison a world leader in addressing environmental challenges" (Nelson Institute 2012). To further this vision, the Nelson Institute facilitates and promotes interdisciplinary scholarship, fosters community partnerships, and inter-organizational collaboration. Its programs include undergraduate and graduate programs across several research centers, and a number of local, regional, national, and international partnerships.

The opinions and judgments presented in the report do not represent the views, official or unofficial, of the Nelson Institute or of the client for which the report was prepared.

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Executive Summary

In this 2012 inventory, the City of Madison seeks to quantify its local government operations greenhouse gas (GHG) emissions—the purpose of accounting for and reaching its sustainability goals. Previous reports have quantified emissions in 2007 and 2010. The City has a target of reducing its community-wide emissions by 80 percent by the year 2050; and government operations can be seen as a bellwether for trends in community emissions. The overarching goal is to prevent some of the negative effects of climate change by working on the local level.

For the purposes of this analysis and report, Madison is using the Local Government Operations Protocol (LGOP), developed by ICLEI—Local Governments for Sustainability and its partners, as well as the Clean Air Climate Protection (CACP) Software. These tools provide a framework for consistently analyzing Madison's GHG emissions over time, making forecasts, and setting goals. The LGOP lays out a five-milestone process that includes conducting a comprehensive GHG emissions baseline inventory and forecast, adopting an emissions reduction target, developing a formal local climate action plan, implementing plans, policies and measures, and monitoring progress, reporting results, and re-evaluating the plan.

The emissions inventory measures not only carbon emissions, but also emissions for other common GHGs such as methane and nitrous oxide. Most of the data is gathered through calculation-based methods using average emission coefficients published by the Environmental and Protection Agency. These emissions are divided into three scopes according to emissions control and responsibility to prevent double-counting. They are further categorized by sector, including buildings, transit, and waste.

In 2012, the City of Madison emitted approximately 95,000 tons of CO_2 equivalent emissions. Gasoline, electricity, and diesel were the top three sources of GHG emissions. "Buildings and facilities" was the top sector for CO_2 equivalent emissions, while water facilities, transit fleet, and solid waste facilities followed. Detailed calculations, including analyses by scope and sector, are included in this report.

Recommendations for future inventories include improving detail and consistency of reporting, hiring or allocating time for staff to complete inventories on a yearly basis, and investigating how specific measures are affecting GHG emissions. Energy usage should be consistently and accurately reported, with changes in facilities usage accounted for to make identifying trends easier. Finally, emissions data should be made available to the public via the Internet.

INTRODUCTION AND CLIMATE CHANGE BACKGROUND

Madison's sustainability goals consider a broad set of concerns, one of which is the continuing effect of carbon emissions on global climate patterns and its potential local effects. Reducing greenhouse gases is one method municipalities and local governments like Madison can take to mitigate the effects of climate change. Before any effort to intervene takes place, however, the City needs to (1) learn what carbon emissions its government facilities and activities produce, (2) establish trend lines from multiple years of emissions data, and (3) set reasonable goals for specific future action based on those trends. This report seeks to fulfill parts (1) and (2) of those efforts. Part (3) can be guided by the goals set forth in the Madison Sustainability Plan (2011), but is largely outside the scope of this report.

This first section of this report lays out some background of City of Madison, general information about climate change, and an introduction to the group that provided the protocol for the report ICLEI—Local Governments for Sustainability. The second section describes the methodology used for the analysis. Part three covers the results of the analysis, including emissions estimates for 2012 and a forecast of emissions. Finally, the conclusion lays out some recommendations for future study. A set of appendices with detailed methodology and results is attached.

Local Government Profile

Some brief statistics on the City of Madison used for this study include:

- Land Area: 76.79 square miles
- Population (2011): 236,901 (U.S. Census Bureau 2013)
- Number of Employees: 3676

Figure 1 below shows a population projection out to 2030 (City of Madison 2006).

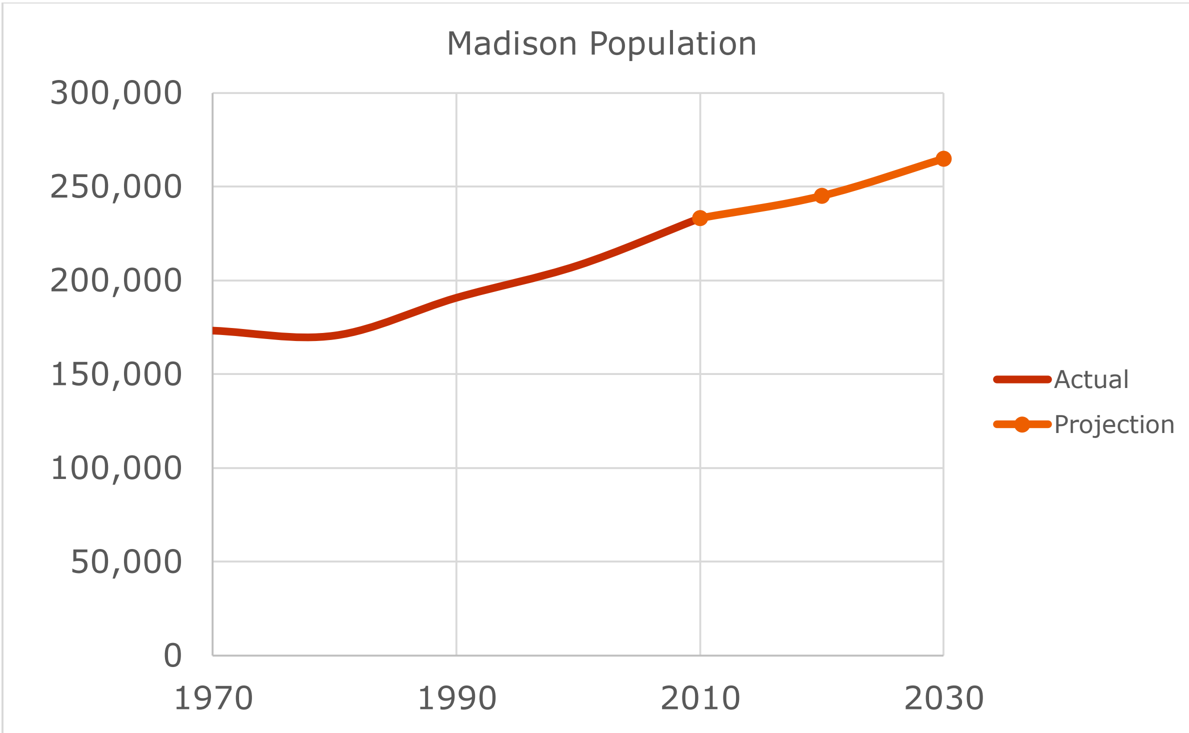


Figure 1. Population project to 2030 for City of Madison

Madison's adopted operating budget expenditures are listed below in Table 1, and represented as proportions in Figure 2 by function and department for 2012 (City of Madison 2012).

Table 1. Reported budget of City of Madison in 2012, in decreasing amount

Function or Department	Budget
Public Safety & Health	$107,866,381
Department of Public Works & Transportation	$55,570,405
Debt Service	$27,020,831
Administration	$18,606,338
Department of Planning and Development	$18,002,772
Library	$12,136,283
Miscellaneous	$12,005,653
General Government	$1,596,563
Public Facilities	$0

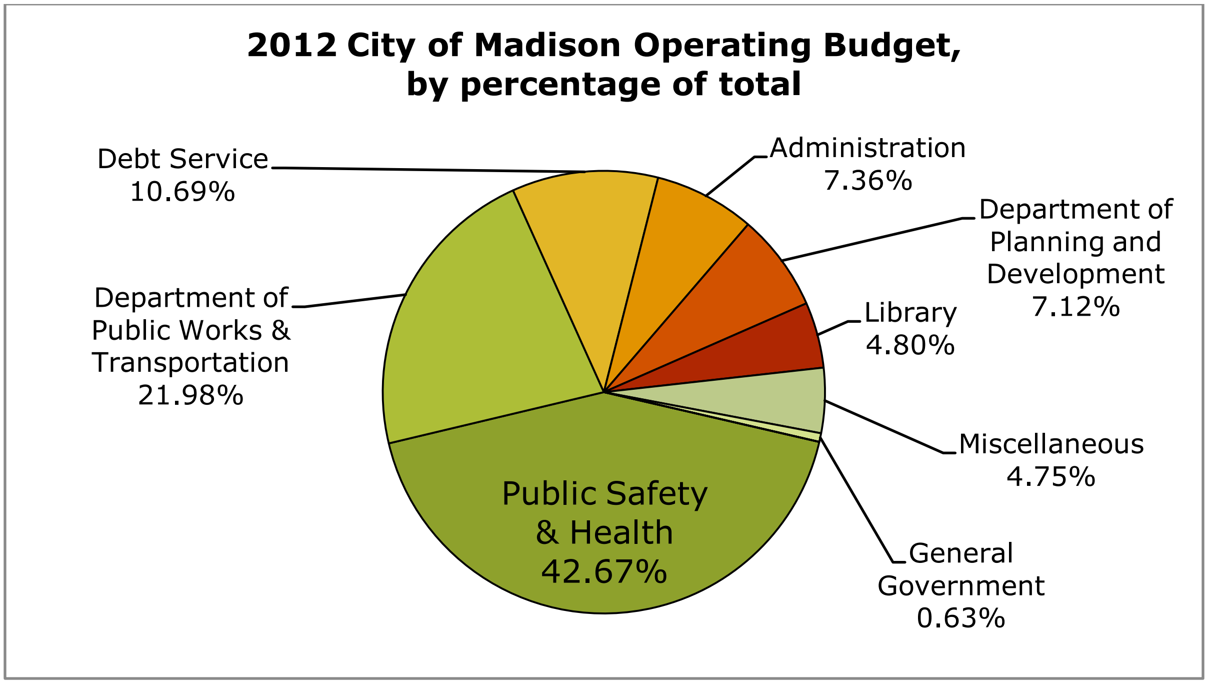


Figure 2. Operating budget expenditures for City of Madison, 2012

According to reported data, the departments or functions with top three operating budget are public safety and health, department of public works and transportation, and debt services. No operating budget is allotted for public facilities.

2012 Madison Climate Data

Madison's energy usage is heavily influenced by the heating and cooling of city-owned facilities. While the City can do a lot to influence the efficiency of its buildings, weather variation plays a significant role in energy use. The table below describes Madison's temperature, precipitation, and heating and cooling degree days in 2012. These should be considered when accounting for energy use during the inventory.

Table 2. Monthly climate data recorded in 2012 for City of Madison

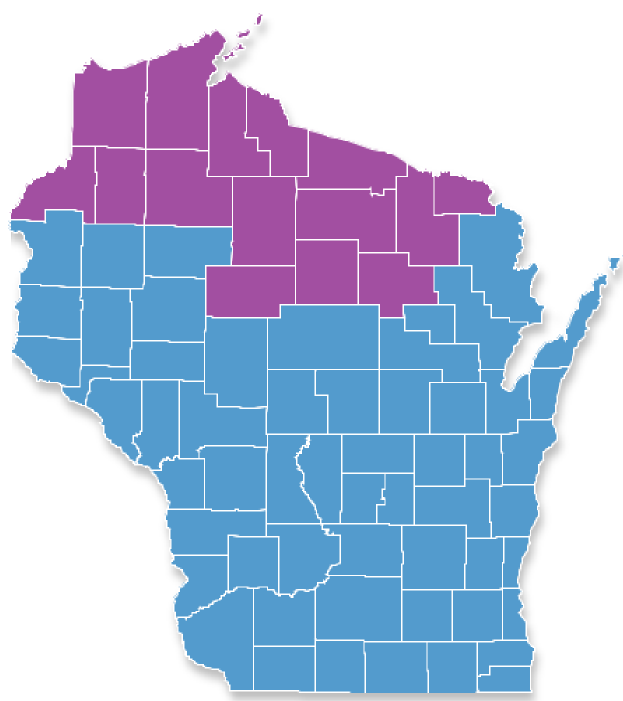
Data Recorded by Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Average Temperature (˚F)	25.5	29.6	50.1	47.9	63.4	71.6	79.4	70.7	60.6	48.6	38.1	29.9	51.3
Precipitation (inches)	1.4	1.03	2.61	2.85	3.19	0.31	4.00	1.58	1.33	4.56	0.90	2.60	26.4
Heating Usage (degrees heated X days heated)	1217	1021	479	509	121	22	0	17	195	503	800	1081	5965
Cooling Usage (degrees cooled X days cooled)	0	0	26	1	81	228	455	202	72	3	0	0	1068

Source: National Weather Service Climate (2013)

In addition, the county of Dane in which the City of Madison resides is in climate zone 6 (U.S. Department of Energy 2013). Buildings that are at standards for zone 6 or above will likely be more efficient than those that are not. The insulation requirements for zone 6 are shown below:

Table 3. Insulation requirements for City of Madison climate zone

Ceiling R-value	49
Wood Frame Wall R-value	20 or 13+5[h]
Mass Wall R-value	15/19
Floor R-value	30[g]
Basement Wall R-value	15/19
Slab R-value, Depth	10, 4 ft
Crawlspace Wall R-value	10/13
Fenestration U-Factor	0.35
Skylight U-Factor	0.60
Glazed fenestration SHGC	NR



Regional and Local Impacts

Published in 2011 by Wisconsin Initiative on Climate Change Impacts (WICCI), the report *Wisconsin's Changing Climate: Impacts and Adaptation* highlights that annual average temperature of Wisconsin will likely warm "by four to nine degrees Fahrenheit by the middle of the twenty-first century" (WICCI 2011, 22).[1] Under this projection, many regions in Wisconsin will likely see temperature and precipitation increases in the largest amount in the winter, followed by spring and fall. The combination of these changes is expected to cause primary impacts in forms of heavier events of rain or freezing rain (rather than snow) and bring secondary impacts, such as drainage and runoff flooding, to the region.

Specifically for the City of Madison, built environment of the local public may face challenges brought on by secondary impacts. Issues may include more frequent infrastructure damages from flooding; influx of waterborne diseases from inadequate stormwater treatment capacity or infiltration of sewage overflow; and rise in respiratory diseases, including asthma, due to worsening of air pollution from climatic conditions.

Evidence for Human-Caused Climate Change

There is overwhelming scientific consensus that the global climate is changing, and that human actions, primarily the burning of fossil fuels, are the main cause of those changes. The Intergovernmental Panel on Climate Change (IPCC) is the scientific body charged with bringing together the work of thousands of climate scientists. The IPCC's Fourth Assessment Report states that evidence pointing to the climate system's warming is unequivocal; and that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations" (Barker, 2007).

[1] Report cited additional climate modeling by University of Wisconsin-Madison climate scientists which indicated that such warming will likely be close to six to seven Fahrenheit.

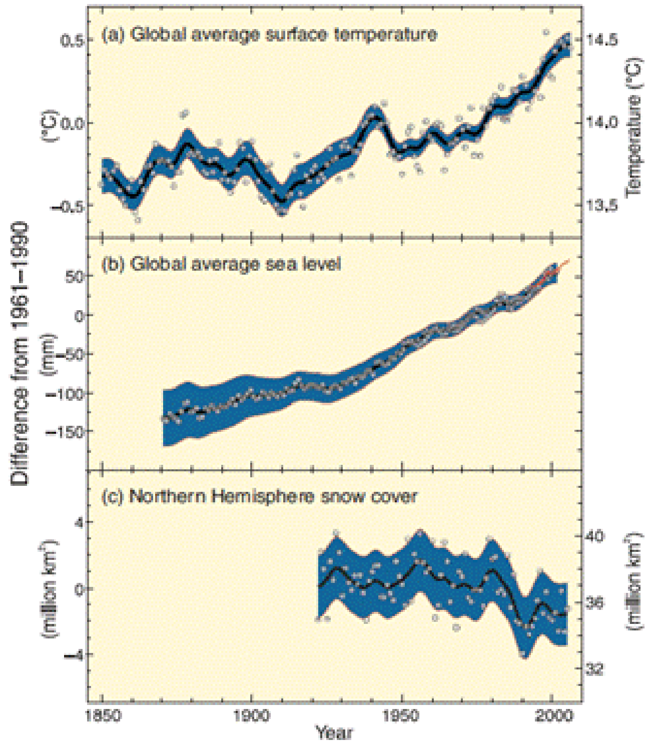


Figure 3. Observed changes in global temperature, sea level, and Northern Hemisphere snow cover

The year 2012 was the hottest on record for the continental United States, with two dozen cities breaking or tying their all-time high temperature records (Burt 2013). Globally, the 12 years from 2001-2012 are among the 14 hottest on record, and 1998 was the only year in the 20th century hotter than 2012 (NOAA, n.d.). The year 1976 was the last with a below average global annual temperature. The steady uptick in average temperatures is significant and expected to continue if action is not taken to greatly reduce greenhouse gas emissions.

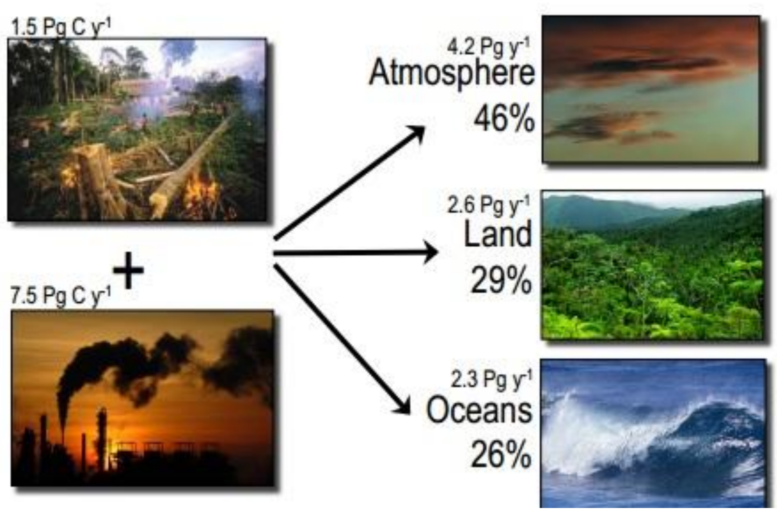


Figure 4. Distribution of carbon dioxide in the ecosystem

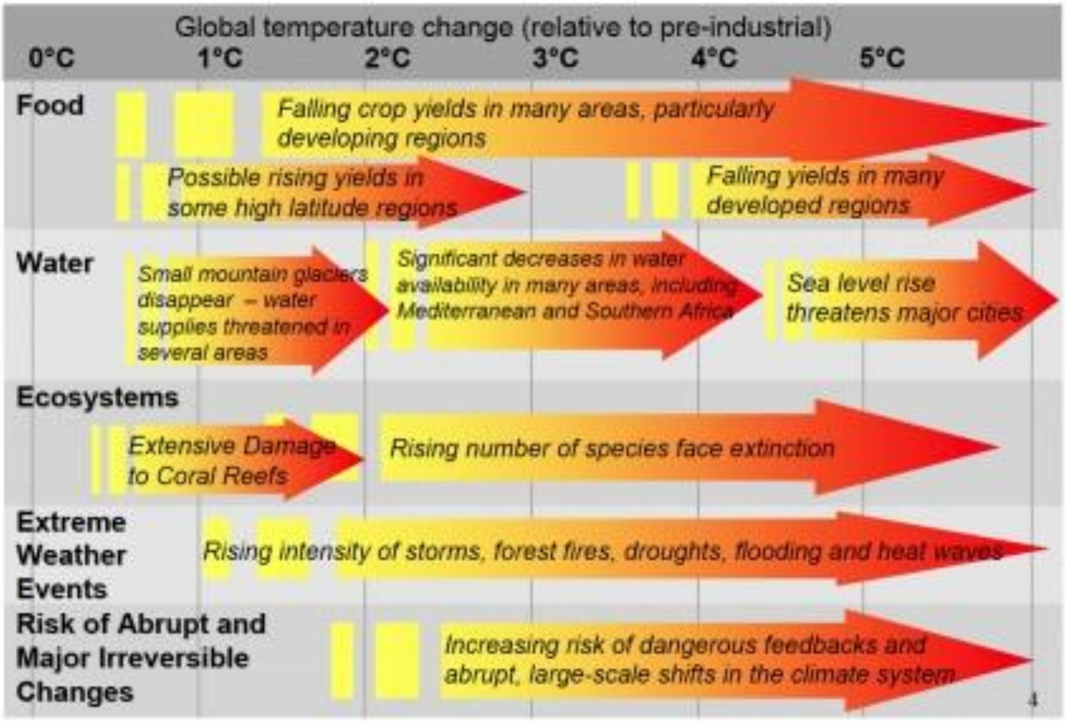


Figure 5. Global temperature change, relative to pre-industrial period
Source: Stern Review

The above Figure 5 and 6 show the proportion of carbon dioxide emitted into the atmosphere, land, and oceans and the effects of global climate change on the ecosystem. The current concentration of carbon dioxide in the atmosphere is 394 parts per million and the global climate temperature is 0.6 degrees Celsius above the pre-industrial period. If this concentration continues to increase, sea level is expected to rise by 0.6 meters which directly jeopardizes the lives of people near coastal areas. Global warming can also lead to forest fires, droughts, and heat waves. These major irreversible effects will occur if the global temperature rises beyond 2 degrees Celsius. In order to avoid these negative impacts, we need to take mitigation and adaptation measures to ensure environmental health and safety. Developing a carbon inventory is a mitigation effort taken at a local level associated with reducing greenhouse gas emissions. Keeping a record of emissions will not only help set targets to reduce them but will also help in making informed decisions for designing climate and energy programs in the future.

Thus, developing a greenhouse gas inventory is important to:

- Develop baseline energy/emissions data;
- Create emission reduction targets;

- Monitor emission reduction progress;
- Make informed decisions when designing climate/energy programs.

Sustainability and Climate Mitigation Activities in Madison

The City of Madison understands that the environment provides a foundation for the economy's and society's well-being (*The Madison Sustainability Plan : Fostering Environmental , Economic and Social Resilience Table of Contents*, n.d.). In order to ensure a sustainable path in the future, it is critical that the natural environment is an integral part of future growth while also balancing the needs of the economy and people. From a systems perspective, the natural systems include air, water, and natural habitats. Goals outlined in this section relates to the society's interaction and impacts with these systems.

The City of Madison wishes to preserve its natural environment to ensure its population continual access to a healthy lifestyle. Access to abundant, clean drinking water is expected in our communities. The Water Utility in Madison accomplishes this goal and is currently working on ways to improve non-health related issues of water quality. One way to do this is through effective stormwater management. While Madison has access to a large aquifer, it will be important to address conservation issues to ensure prolonged access. In addition to the urban environment of Madison, the City also strives to provide access to open space, such as bike and trail systems as well as green spaces, for its residents to enjoy and to reap health benefits associated with natural systems.

In order to work toward these priorities, the City of Madison has developed 10 major areas of focus. These are aimed to balance the society and economy with the environment by minimizing adverse health effects potentially passed onto future population as well as increasing the quality of life.

1. Natural Systems
2. Planning and Design
3. Transportation
4. Carbon and Energy
5. Economic Development
6. Economic and Workforce Development
7. Education
8. Affordable Housing
9. Health
10. Arts, Design, and Culture

Climate change presents one of the greatest challenges against the above focuses. Greenhouse gas (GHG) emissions come from a variety of sources and have an impact on the overall quality of life for the Madison region and beyond. Thus, significant sources of GHG, such as the top two sources of electrical power generation and motor vehicle use, need to be addressed.

Madison embraces sustainable approaches to fuel our economy and community, achieving an 80 percent carbon reduction by the year 2050, taking 2010 as the baseline year. Our City government and staff set examples of reduced energy use and emissions for businesses and individuals to emulate.

The goals to achieve this reduction in carbon emissions are as follows:

- Influence reductions in transportation-related carbon impacts;
- Systematically upgrade existing buildings, equipment, and infrastructure;
- Improve new buildings and developments;
- Engage the public in energy efficiency and climate change programs;
- Obtain 25 percent of electricity, heating, and transportation energy from clean energy sources by 2025;
- Report carbon footprint to the public (City of Madison, n.d.).

ICLEI—LOCAL GOVERNMENTS FOR SUSTAINABILITY

Madison's effort to inventory its carbon emission is largely made possible by its work with ICLEI–Local Governments for Sustainability. ICLEI is the world's leading association for cities and local governments dedicated to sustainable development. The organization promotes "local action for global sustainability and supports cities to become sustainable, resilient, resource-efficient, biodiverse, low-carbon; to build a smart infrastructure; and to develop an inclusive, green urban economy with the ultimate aim to achieve healthy and happy communities" (ICLEI, n.d.b). Founded in 1990 by a group of local governments who convened in New York at the World Congress of Local Governments for a Sustainable Future, ICLEI has grown to a membership of over 1,000 cities in 84 countries worldwide (ICLEI, n.d.a). The City Madison has been a member since 2006.

As a large and growing support network, "ICLEI provides technical consulting, training, and information services to build capacity, share knowledge, and support local government in the implementation of sustainable development at the local level" (ICLEI, n.d.a). Included in these services are the Local Government Operations Protocol (LGOP) documentation and the Clean Air and Climate Protection (CACP) software, which allows a city to conduct a GHG emissions inventory for both city operations and the community.

Greenhouse Gas Emissions Reduction Milestones

To meet this goal, ICLEI has set out five "milestones" to reduce emissions. These include:

1. Conducting a comprehensive GHG emissions baseline inventory and forecast for Government Operations and Community emissions;
2. Adopting an emissions reduction target;
3. Developing a formal local climate action plan;
4. Implementing the plans, policies, and measures;
5. Monitoring progress, reporting results, and re-evaluating the plan.

This report represents an ongoing effort by the City of Madison to sustain the first milestone, conducting an inventory and forecast. While the 2010 inventory reported community-wide emissions, the current analysis will cover only City of Madison government operations, so that the City can compare two previous data sets with more recent data and focus its energies on government operations. Another community-wide inventory is recommended for the next analysis.

THE LOCAL GOVERNMENT OPERATIONS PROTOCOL (LGOP)

The LGOP is the protocol used by the City of Madison to develop and report its emissions. Developed in 2008 by a consortium of environmental organizations including ICLEI, the Climate Registry, the California Air Resources Board, and the California Climate Action Registry, the LGOP is the most popular institutional accounting tool for calculating greenhouse gas emissions associated with government operations.

> The Protocol provides the principles, approach, methodology, and procedures needed to develop a local government operations GHG emissions inventory. It is designed to support the complete, transparent, and accurate reporting of a local government's GHG emissions. The Protocol guides participants through emissions calculation methodologies and reporting guidance applicable to all U.S. local governments (ICLEI 2010).

The purpose of the LGOP is to:

- Enable local governments to develop emissions inventories following internationally recognized GHG accounting and reporting principles defined with attention to the unique context of local government operations;
- Advance the consistent, comparable, and relevant quantification of emissions and appropriate, transparent, and policy-relevant reporting of emissions;
- Enable measurement towards climate goals;

- Promote understanding of the role of local government operations in combating climate change;
- Help to create harmonization between GHG inventories developed and reported to multiple programs (ICLEI 2010).

In addition, the LGOP enables local governments to track their emissions over time. Reductions in emissions measured through the protocol can be used to evaluate the effectiveness of actions and policies taken.

Inventory Methodology

LGOP clearly defines a method of tracking sources of emissions to produce an accurate calculation for GHG emissions. To quantify these emissions, local government activities are categorized by organizational boundaries, scopes and sectors, which are described in this section. In addition to providing the LGOP, ICLEI also developed analysis software for estimating emissions. A description of this software and detailed methodological considerations are included below.

Clean Air and Climate Protection (CACP) Software

Using the LGOP standards, ICLEI developed the Clean Air and Climate Protection (CACP) Software as a tool to assist local governments in collecting and assessing GHG emissions. The CACP software has a number of tabs that can be used for estimating either community or government emissions, as well as for analyzing the effects of measures taken to reduce those emissions. This study employed the Government Analysis tab in CACP to estimate GHG emissions for the City of Madison using LGOP defined standards. For this inventory, calculations were made using the CACP 2009 software, version 3.0.

Quantification Methods

Greenhouse gas emissions can be quantified in two ways:

- Measurement-based methodologies refer to the direct measurement of greenhouse gas emissions (from a monitoring system) emitted from a flue of a power plant, wastewater treatment plant, landfill, or industrial facility.
- Calculation-based methodologies calculate emissions using activity data and emission factors. To calculate emissions accordingly, the basic equation below is used: *Activity Data x Emission Factor = Emissions*.

Emissions sources in this inventory are quantified using calculation-based methodologies. Activity data refers to the relevant measurement of energy use or other greenhouse gas-generating processes such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. Please see Appendices A and B for a detailed listing of emissions factors and activity data used in composing this inventory.

Known emission factors are used to convert energy usage or other activity data into associated quantities of emissions. Emissions factors are usually expressed in terms of emissions per unit of activity data (e.g. lbs CO_2/kWh of electricity). These are taken from the EPA eGRID Summary Tables for 2009 using the subregion specifications recommended by ICLEI, and details are explained in Appendix A.

Organizational Boundaries

The LGOP depends on municipalities setting clear organizational boundaries. Local governments can choose to account for emission sources over which they have operational control or financial control. The City of Madison chooses to report its emissions based on operational control.

Base Year

The inventory process requires the selection of a base year with which to compare current emissions. Madison's government operations greenhouse gas emissions inventory utilizes 2007 as its base year, as this was the year the first inventory was completed. A subsequent inventory was done for 2010 and expanded to 2012 for this report.

Recognized GHG Emissions

LGOP recognizes the following six GHG emissions with their relative carbon dioxide equivalency, as determined by the IPCC. These are shown below in Table 4. (ICLEI 2010):

Table 4. Carbon dioxide equivalency for various greenhouse gases

Greenhouse Gas	CO_2 Equivalency
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydrofluorocarbons (HFCs)	12-11,700
Perfluorocarbons (PFCs)	6,500-9,200
Sulfur hexafluoride (SF_6)	23,900

The most important GHGs in terms of volume in the atmosphere are carbon dioxide, methane, and nitrous oxide. Although carbon dioxide is the least potent of these three greenhouse gas emissions, it is by the far the most abundant. The last three GHGs listed above (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) are associated with refrigerants and industrial processes. While the potency of these GHGs is very high, the total volume produced within energy systems is much lower than other GHGs.

Emissions Scopes

For the LGOP inventory, emissions are categorized by scope. Using the scopes framework helps prevent double-counting and defines how directly responsible the municipality is for the emissions. There are three scopes for LGOP emissions:

Scope 1: All direct emissions from a facility or piece of equipment operated by the local government. Examples include:

- Vehicle engine combustion
- On-site natural gas combustion
- Refrigerants leaked from refrigerators and air-conditioners

Scope 2: Indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, and cooling.

- Off-site electricity production
- Off-site heat or steam

Scope 3: All other indirect or embodied emissions not covered in Scope 2. Examples include contracted services, embodied emissions in good purchased by the local government, and emissions associated with disposal of government generated waste.

- Employee commute vehicle emissions
- Employee waste production
- Contracted services

Scope 1 and Scope 2 emissions are the most essential components of a government operations greenhouse gas analysis as they are the most easily affected by local operations directly-controlled by the City.

Sectors

Based on the LGOP scopes, the CACP software specifies twelve government sectors for analysis. The software is structured so that all inputs must be entered into separate sectors. Emissions can be defined by sector in order to use the results to better target emissions reductions policies.

The following sectors were reported, in order specified by CACP:

- Buildings and other Facilities – buildings operated by the city[2]
- Streetlights and traffic signals
- Vehicle fleet – garbage trucks, fire trucks, building inspection or water trucks, etc.
- Employee commute – City employees' personal vehicle transportation to work
- Transit fleet – city buses and assist vehicles
- Water delivery facilities – any building or facility operated by the water utility
- Solid waste facilities – landfill gas from five closed landfills
- Refrigerants – amount of refrigerants replaced in stationary or mobile sources
- Scope 3 waste - waste generated in city facilities and by city employees

The following sectors are not owned by the City and as such were not reported:

- Power generation facilities
- Port facilities
- Airport facilities
- Other industrial processes
- Dane County Landfill (except for Scope 3)

Limitations of the LGOP

By defining sources of emissions by scope and establishing organizational boundaries, the LGOP ensures that a regional greenhouse gas inventory conducted in the future by a neighboring local government will not overlap or double-count emissions from a neighboring municipal government with a pre-existing GHG baseline. As a result the CACP modeling software may not always produce comprehensive estimates of GHG emissions associated with a particular municipal area, particularly if significant emission sources belong to an adjoining municipality, county, or the State.

This is particularly relevant to Madison with regards to its purchase of Renewable Energy Credits through Madison Gas & Electric's (MGE) Green Power Tomorrow Program. While Madison offsets 22 percent of its electricity power consumption through MGE's program, the LGOP provides no accurate method of accounting for

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[2] The City of Madison is responsible for 39.69 percent of the City County Building operations.

these reduced emissions because they are dispersed throughout the electricity grid. Emissions factors are calculated on a regional basis as laid out by the EPA eGRID (EPA 2012), for accounting accuracy purposes. Thus, neighboring communities who elect not to purchase green power through MGE have the same energy portfolio as the City of Madison. While this could be viewed as a limitation of the LGOP, it is essential for properly viewing Madison in the context of ICLEI's worldwide GHG accounting efforts. Also important to note: electricity-related emissions are considered Scope 2 indirect emissions (see Emissions by Scope) and should be viewed separately from Scope 1 emissions over which the city has direct control.

GOVERNMENT OPERATIONS INVENTORY RESULTS

The City of Madison has provided energy usage reports under its operational boundaries for all sectors aforementioned. After data extraction and compilation from these reports, the data is inputted into the CACP software for calculation and sorting of emissions results.

This part of the report explains the LGOP emissions results for the year 2012 based on the calculation of the CACP software. Discussions of emissions results are categorized into sections of emissions by scope, emissions by source, cost analysis, and detailed sector analyses.

Emissions by Scope

As described previously, Scopes are used to keep track of emissions in order to avoid double-counting within and between entities. Scope 1 emissions come from fuel use in government facilities and vehicles; Scope 2 emissions come from electricity use, and Scope 3 are other indirect emissions. Table 5 lists City of Madison government operations emissions by scope.

Table 5. Government Operations Emissions by Scope

	CO_2e (tons)	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)
SCOPE 1	**43,120**	29,755	550	1,263,759
SCOPE 2	**45,622**	45,368	1,541	1,367
SCOPE 3	**6,273**	6,079	347	13,339
Total Emissions	**95,015**	81,202	2,438	1,278,465

Emissions by Source

Emissions by source accounts for a wide variety of sources, this includes gasoline from transportation, natural gas from power usage, or methane from deposition of wastes. According to LGOP information reported for the year 2012, CACP identified 11 sources of emissions. A summary of emissions by source results are displayed in Table 6, followed by further breakdown of emission sources by scope in Table 7 below.

Table 6. Summary of emissions by source, highest to lowest CO_2e

	CO_2e (tons)	CO_2 (tons)	N_2O(lbs)	CH_4 (lbs)
Gasoline	**65,846**	9,788	4,056	4,081
Electricity	**45,622**	45,368	11,541	1,367
Diesel	**21,636**	21,573	360	694
Methane	**13,251**	-	-	1,261,992
Natural Gas	**4,438**	4,427	17	835
Paper Products	**78**	-	-	7,382
Carbon Dioxide	**75**	75	-	-
Food Waste	**42**	-	-	4,006
Refrigerant (R-407C Blend)	**10**	-	-	-
Wood or Textiles	**9**	-	-	893
Plant Debris	**7**	-	-	686
Total	**151,014**	81,231	15,974	1,281,936

Table 7. Emissions by source, sorted by scope

		CO_2e (tons)	CO_2 (tons)	N_2O(lbs)	CH_4 (lbs)
SCOPE 1	**Carbon Dioxide**	**75**	75	-	-
	Diesel	**21,636**	21,573	360	694
	Gasoline	**3,709**	3,681	173	238
	Methane	**13,251**	-	-	1,261,992
	Natural Gas	**4,438**	4,427	17	835
	Refrigerant (R-407C Blend)	**10**	-	-	-
	Subtotal	**43,119**	29,756	550	1,263,759
SCOPE 2	**Electricity**	**45,622**	45,368	11,541	1,367
	Subtotal	**45,622**	45,368	11,541	1,367
SCOPE 3	**Gasoline**	**62,137**	6,079	347	372
	Food Waste	**42**	-	-	4,006

		CO_2e (tons)	CO_2 (tons)	N_2O(lbs)	CH_4 (lbs)
	Paper Products	**78**	-	-	7,382
	Plant Debris	**7**	-	-	686
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	Subtotal	**62,273**	6,079	347	13,339
TOTAL		**151,014**	81,203	12,438	1,278,465

As Table 6 shows, the top three LGOP emissions sources are gasoline, electricity, and diesel. Moreover, these results reveal that the level of emissions from gasoline (over 65,000 tons of CO_2e) is as high as the sum of the next two top emissions sources combined (electricity and diesel emitted over 45,000 and 21,000 tons of CO_2e, respectively). A further breakdown of emission source by scope in Table 7 reveals that the heaviest gasoline emissions contribution is from Scope 3, where employee commute is the only gasoline source.

While the City may exhibit more direct or indirect control over its electricity and diesel usages, it does not have control over its Scope 3 emissions level. This suggests that even though programs and resources targeted at reduction of electricity and diesel usage may yield success in reducing emissions by the City, employee commute still deserves significant attention in terms of emissions reduction because it is the single, most sizable source of emissions within LGOP boundaries.

Emissions by Sector, Detailed Analyses

Figure 6 below shows the total of Scope 1, Scope, 2 and Scope 3 emissions from different sectors of buildings and facilities, streetlights and traffic signals, water delivery facilities, vehicle fleet, transit fleet, employee commute, solid waste facilities, and Scope 3 wastes.

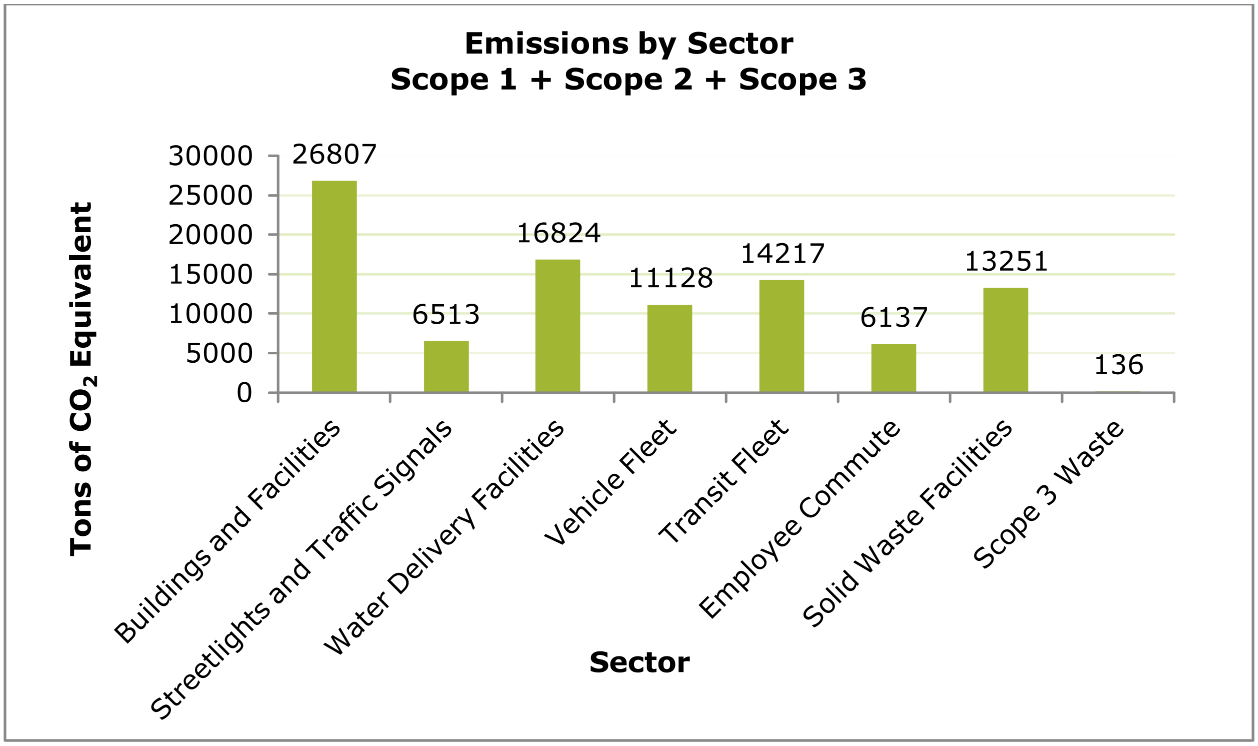

Figure 6. Emissions by sector, 2012

It is observed that tons CO_2 equivalent emitted is highest for buildings and facilities. This is due to high amount of electricity and natural gas consumed by City-County Building, Monona Terrace, and other government facilities. The next highest are water delivery facilities followed by transit fleet and solid waste facilities. However, the central library remained closed in 2012 and hence, its typically significant electricity consumption emissions have not been accounted for the year. Emissions from Scope 3 waste are very small as compared to emissions from other sectors.

Thus, in order to reduce emissions, the City of Madison should place emphasis on reducing emissions from buildings and facilities. Using compact fluorescent instead of incandescent lights and using sensors to turn on or turn off lights are efficient ways to reduce energy usage.

The calculations of each sector by Scopes 1, 2, and 3 are tabulated below:

Table 8. Emissions by sector under Scope 1 calculation, 2012

Sector	CO_2 eq (tons)	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	Energy (MMBtu)
Buildings and Facilities	**4,521**	4,500	17	835	75,710
Streetlights and Traffic Signals	**2**	2	-	-	39
Solid Waste Facilities	**13,251**	-	-	1,261,992	-

Sector	CO_2 eq (tons)	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	Energy (MMBtu)
Vehicle Fleet	**11,128**	11,054	425	823	137,941
Transit Fleet	**14,217**	14,199	109	109	174,255
Total	**43,120**	29,755	550	1,263,759	387,944

Buildings and Facilities

The primary source of emissions from buildings and facilities is Scope 2 electricity consumption, followed by Scope 1 natural gas consumption used mainly for heating. Buildings and facilities make up a significant portion of total emissions. Figure 7 shows available delineation of building emissions.

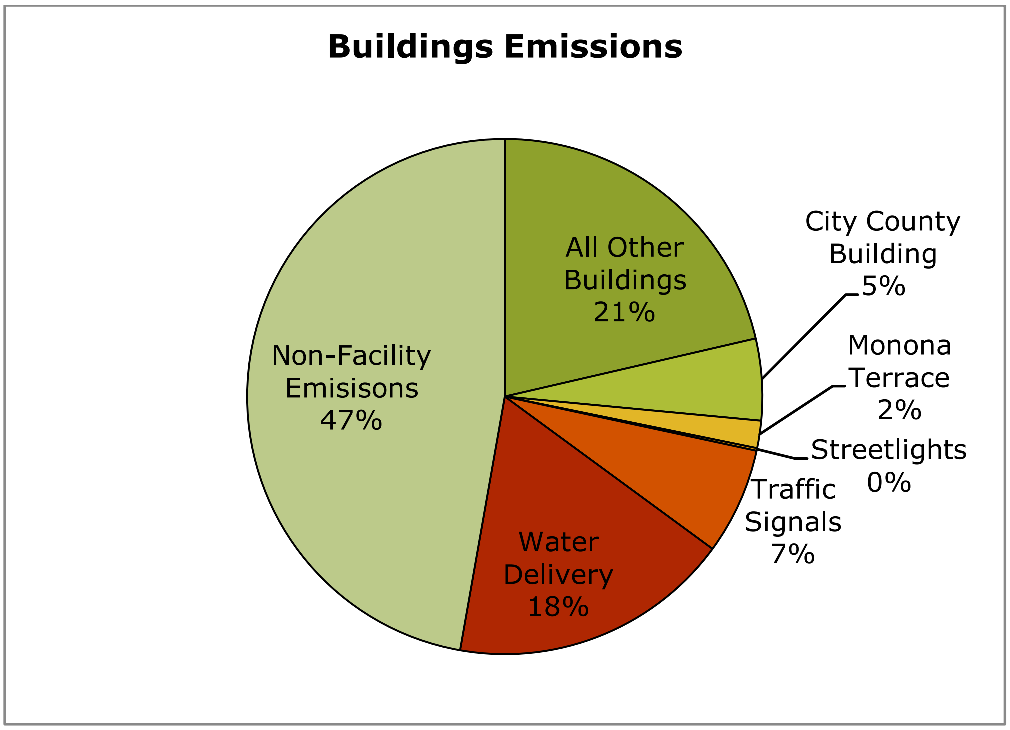

Figure 7. Building sector emissions

Transportation and Related

Transportation and related emissions include three sectors: transit fleet, vehicle fleet, and employee commute. Emissions from vehicle and transit fleets are the next largest, after facilities, from sectors in Scope 1 of government operation emissions.[3] Scope 3 transportation emissions are solely from employee commute. Figure 8 contains a summary of transportation and related emissions for all three surveyed years.

[3] Scope 2 emissions does not contain transportation sector.

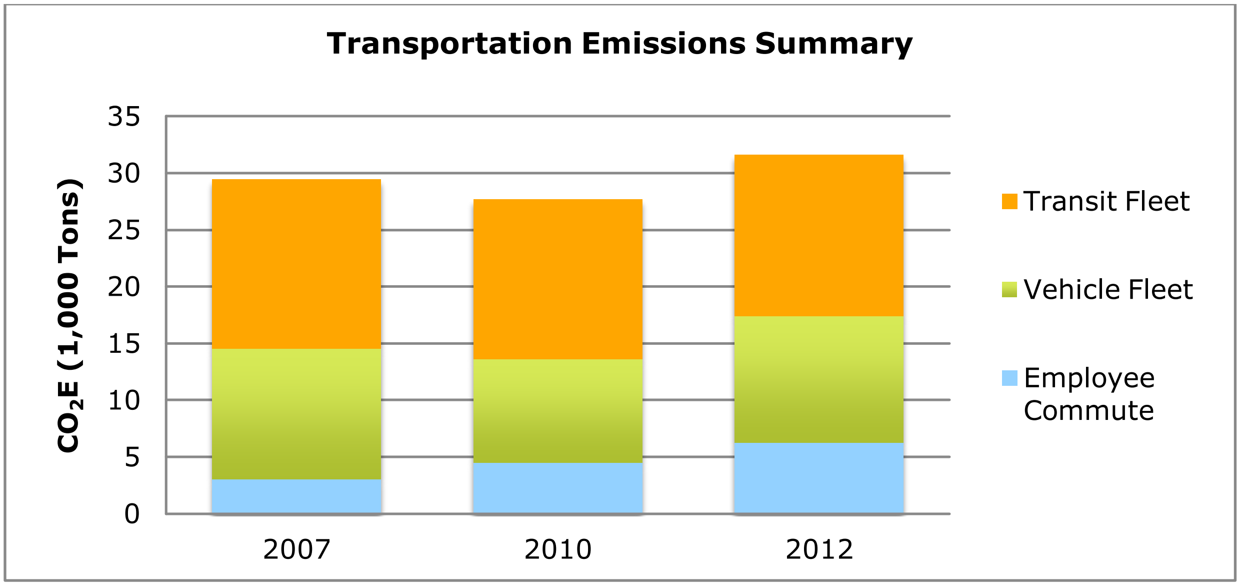

Figure 8. Emissions summary from transportation sectors, 2007-2012

Figure 8 shows overall CO_2 equivalent emissions from transportation sectors are quite stable from year to year since transportation emissions stayed within five percent of average emissions (29.5 thousand tons of CO_2 equivalent) of the past three survey years. Slight changes, however, can be seen within each sector; the following sections will discuss these changes in detail.

Transit Fleet

In 2012, the City operated a transit fleet of 353 vehicles, with total vehicle mileage reported at 6,113,911 miles. These include 252 main line, fixed-route revenue metro buses; 21 para-transit shuttle coaches; and 80 support vehicles ranging from a mix of cars, light trucks, and other specialized maintenance equipment to support metro line services. The transit fleet performed essential services including the provision of public metro services and the support and upkeep of these metro line services. Figure 9 shows fuel usages in the past three surveys, as well as annual costs spent on fuel purchase.

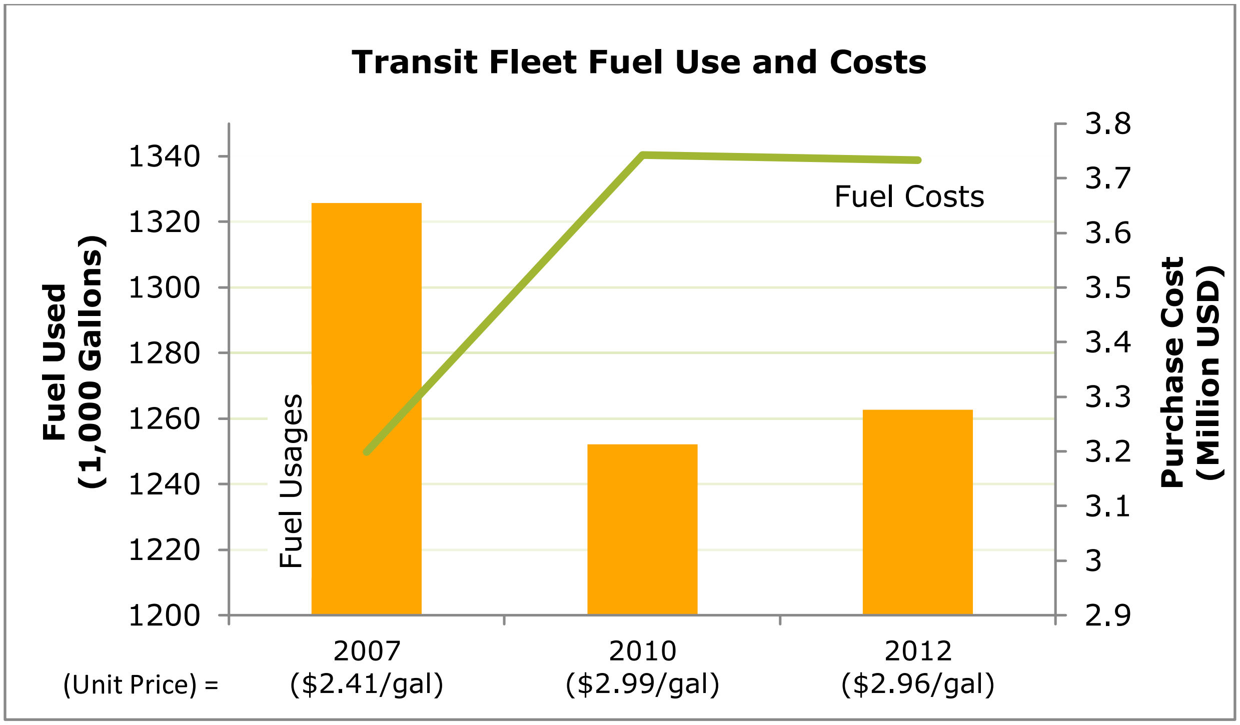

Figure 9. Fuel used and fuel costs for transit fleet, 2007-2012

Two main points arise from Figure 9: (1) transit fuel usages in 2010 and 2012 are comparatively lower than in 2007; and (2) total costs spent on transit fuel purchase in 2010 and 2012 are comparable but higher than in 2007, noting a possible relationship in the reduction of fuel usage with a sharper increase of fuel price.[4]

Investigation into the changes of fuel usage highlighted that two key transit fleet vehicle replacements occurred in 2007 and 2010 in which old buses were replaced by new hybrid models. In addition, increases in fuel costs, shown by annual unit fuel price, may have further discouraged fuel consumption and further justify increasing fuel economy of the fleet. And because metro line services can be modified from year to year (such as by addition of new routes) changes in fuel usage can be expected.

Vehicle Fleet

In 2012, the City of Madison operated a vehicle fleet with 1017 count of vehicles and non-vehicular engines, which contains a wide variety of service vehicles and construction equipment including police cars, fire trucks, construction tractors, etc. Total vehicle mileage reported in 2012 for the vehicle fleet was 4,653,111 miles. Figure 10 shows vehicle emissions by fuel usages and purchase costs from the past three survey years.

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[4] For transit fleet vehicles, main line and para-transit fuel purchases are made through bulk purchases negotiated by the City of Madison; therefore this fuel price is typically lower than consumer fuel prices.

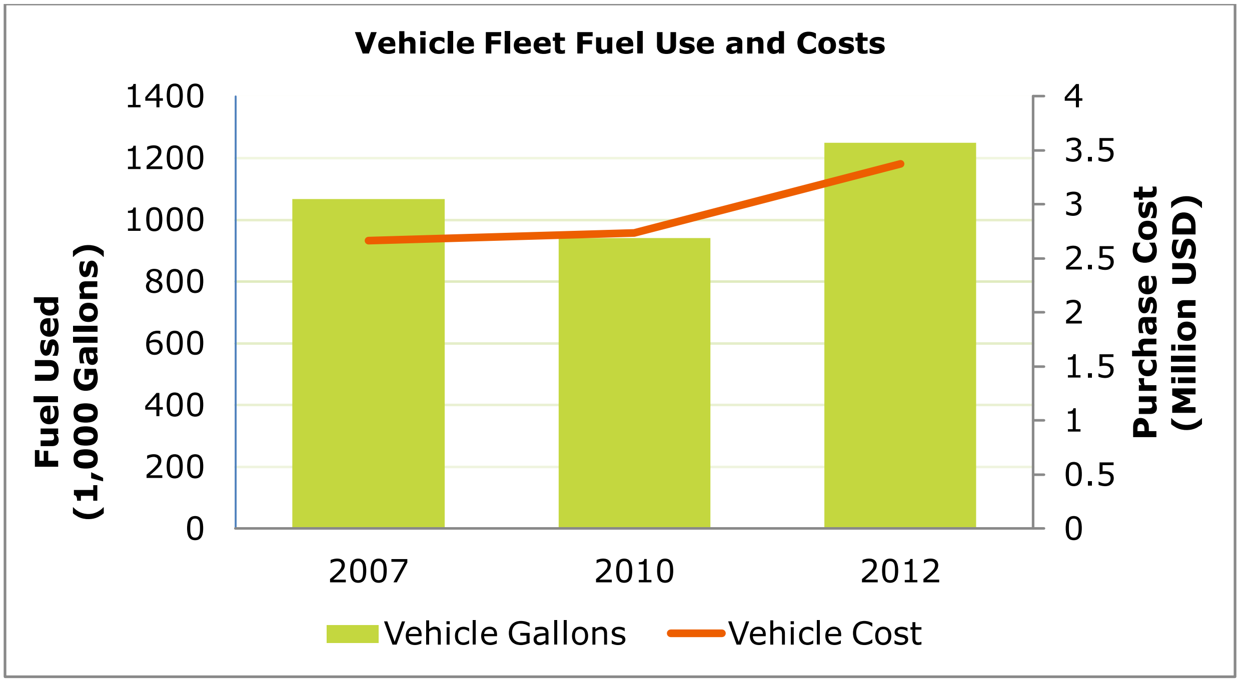


Figure 10. Fuel use and costs for vehicle fleet, 2007-2012

The costs of annul fuel purchase for vehicle fleets follow gas prices fluctuations. According to the City, gas mileage of vehicles used for vehicle fleet has not been changed. We can see that relatively similar fuel purchase costs in 2007 and 2010 resulted in less fuel purchased in 2007 than 2010. Gas prices in 2010 and 2012 are comparable, however, and the upward trend observed between these two years is likely a direct effect of increased fuel usage in 2012. In order to decrease expenditure on future fuel purchase, the City may consider alternatives that include reducing fuel usage of increasing the fuel mileage of the vehicle fleet.

Transportation: Employee Commute

Employee commute emissions are not under direct operational control of City of Madison, but the City may have a variety of tools available to influence them. Total employee commute emissions are 6079 metric tons CO2e, as shown in Table 9.

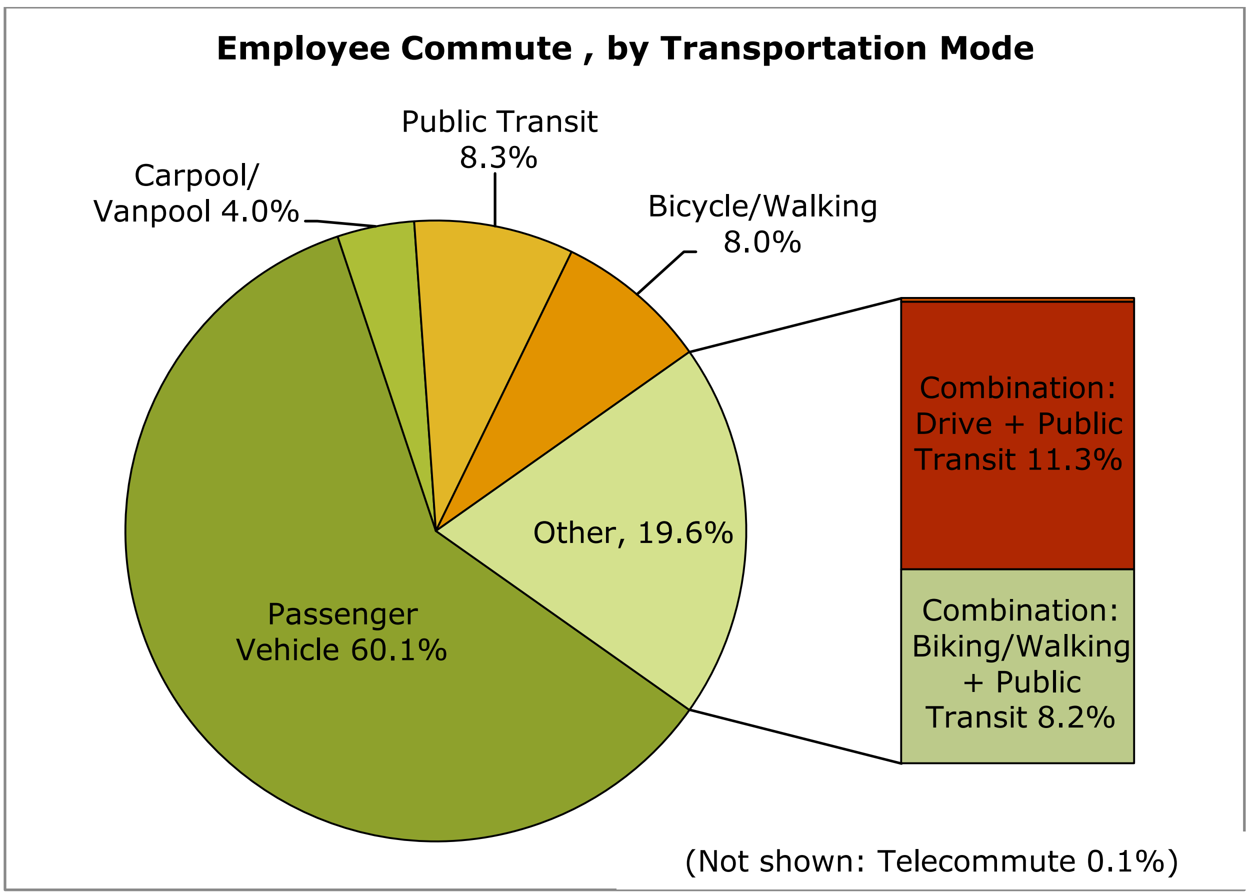
Table 9. 2012 City of Madison employee commute estimated emissions and characteristic

Employee Commute Vehicle Data – Reported unleaded gasoline only		
Indicators	Mobile Combustion	6,079 CO_2e
	Vehicle Miles Traveled	14.4 Million
	Number of Vehicles	2,900

A simple survey was issued to City of Madison employees in collecting the above data, as well as additional information regarding employees' choice of transportation mode and frequency of work commute. (Appendix D contains detailed explanation of this survey.) The final data estimates over 628,000 gallons were directly used by over 60 percent of all employee commute through vehicles ranging from heavy duty vehicles, sports utility vehicles, minivans, and passenger cars. An additional 11 percent of employees also combine passenger vehicle use with public transit for daily commute. The approximate fuel efficiency derived for overall passenger vehicles was an average of 23 miles per gallon in 2012.

The remaining portion of employees uses a variety of transportation mode. Options include biking or walking, carpool or vanpool, public transit, and telecommute. Figure 11 shows the current breakdown of employee trips to work by mode.

Figure 11. Employee commute trips by mode of transportation



City of Madison can influence employee commute emissions primarily by promoting alternative commute modes such as public transit and carpooling, and by offering options such as compressed workweeks and telecommuting that reduce the number of trips employees must make.

Solid Waste

The most prominent source of greenhouse gas emissions from solid waste facilities is fugitive methane released by the decomposition of organic waste over time in landfills. The scale of these emissions depends upon the size and type of the landfill and the presence of a landfill gas collection system. Madison has five closed landfills that are still emitting Scope 1 GHGs. No capture technology is currently being employed at these landfills. These landfills emitted 13,250 tons of CO_2e in 2012. Table 10 and Figure 12 show solid waste facility emissions estimated via a greenhouse gas reporting calculations worksheet and CACP included calculators. The Dane County Landfill is not included in this report, as it is not a city-owned facility.

Table 10. Estimate of carbon dioxide emissions by landfill

Landfill	CO_2 Equiv. Emissions
Demetral Landfill	1038
Greentree Landfill	4243
Mineral Point Landfill	1254
Olin Landfill	2039
Sycamore Landfill	4676
Totals:	**13250**

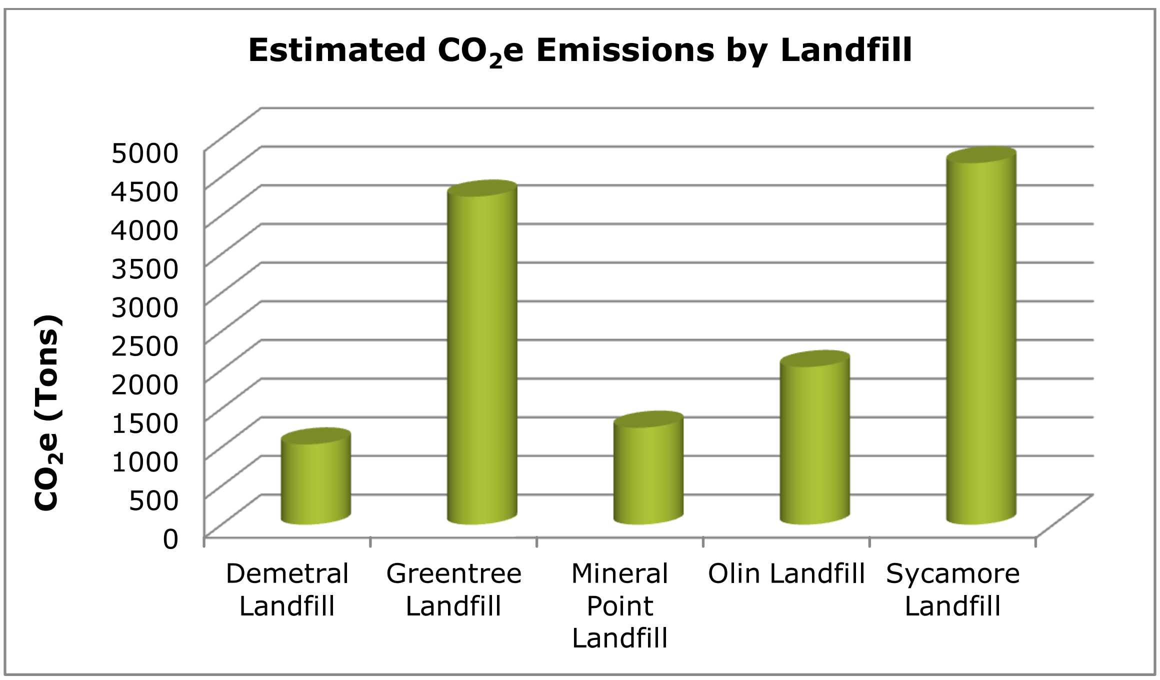


Figure 12. Graphical comparison of estimated landfill emissions

Scope 3 city employee generated waste was estimated at 1000 tons. A Madison waste study referenced in previous reports was used to input waste composition percentages. Each type of waste product produces a different mix of GHGs, which is calculated by the CACP software. Figure 13 shows a breakdown of waste composition analysis, and Figure 14 represents greenhouse gas emissions generated by such waste stream composition.

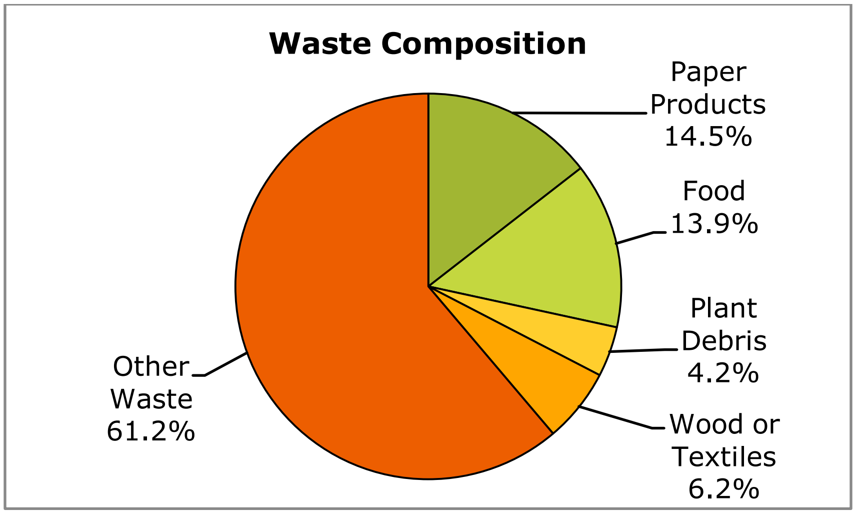


Figure 13. Waste composition

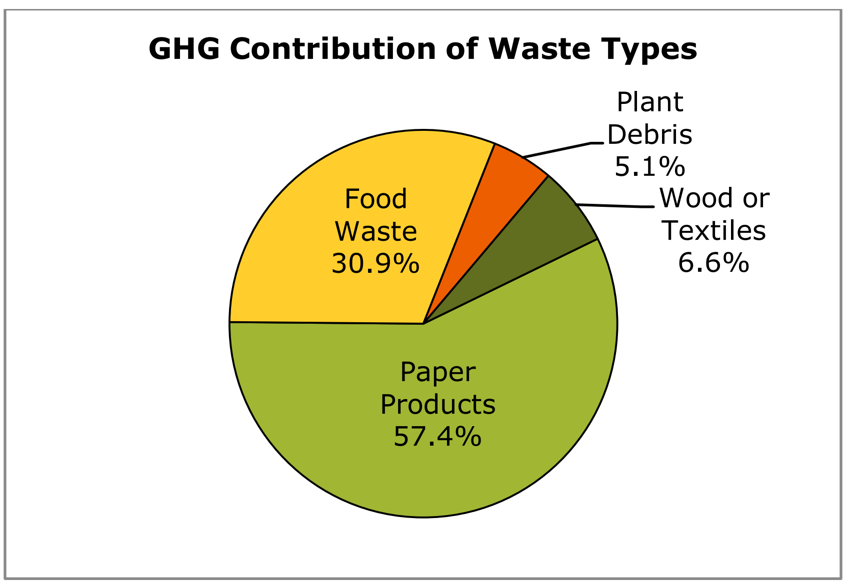


Figure 14. Greenhouse gas contribution of waste types

Important to consider is the relative contribution of different types of waste within the waste stream to GHG emissions. As Figure 13 and 14 above show, paper products contribute to nearly half of the emissions, despite being a relatively low portion of the overall waste stream. Reducing paper landfill waste could significantly decrease the overall contribution of waste to Madison's GHG emissions portfolio.

The total Scope 3 waste CO_2 equivalent emissions for 2012 were 136.20 tons. Information on the methodology for this calculation is included in Appendix E.

RECOMMENDATIONS

Future GHG Emissions Inventories

The four primary uses of a GHG inventory are (1) to track year-to-year changes in emissions; (2) to assess the efficacy of GHG reduction programs; (3) to compare emissions to other similar entities; and (4) to determine the emission sources that can most easily and efficiently be reduced. To these ends, the most important aspects of a GHG inventory are maximum levels of detail, and maximum consistency and accuracy in data reporting.

The City of Madison is currently transitioning to a new, more advanced energy and utility data management program. This will significantly improve the consistency of the data in future years, as well as allow for a more detailed breakdown of emissions, particularly in the sector of buildings and facilities. This step already fulfills one of the primary recommendations we would make: to improve detail and consistency of reporting in areas where the data is currently too general to make confident analyses.

We also recommend the City of Madison to find or acquire one long-term employee to become an expert at the CACP software. The software is an excellent and robust tool for assessing carbon emissions. However, it is fairly complex and the interface and tools require a significant amount of effort to become familiar and competent with. The current methodology of outsourcing means each new group is spending significant time re-learning the software, and thus less time on analysis. In addition, they do not have the knowledge and experience with previous inventories, so it is far more difficult to find and assess any possible data irregularities.

This leads into the next major recommendation: perform both government and community inventories every year. This would give more data points over a given time period, allowing for clearer and easier finding and tracking of trends, as well as more detailed assessment of the efficacy of specific GHG reduction measures. The expert analyst would also find it easier to keep previous years' data in mind, determine inconsistencies, and find areas where data, analysis, or emissions reductions could be best targeted and improved.

While these recommendations would take more resources, both the time saved from new groups re-learning the entire process every year and the consistent body of knowledge held by the person in charge of the inventory could potentially more than make up for the additional cost. While the budgetary and time constraints of having an employee dedicate part of their time to GHG inventories is not insignificant, resources could then directly go toward targeted analysis for emissions reductions only after high quality, consistent baseline information is established and standardized.

As well, this would allow the City of Madison to better utilize the Nelson Institute and other UW resources. Capstone projects could then be directed at deeper analytical problems ("deep dive studies") and more specific tasks and questions related to particularly relevant parts, instead of broad analyses for the GHG inventory. Ideally, perhaps even 1to 2 years of deep dive studies for the City's emissions reductions provided by Capstone students could be comparable to cost savings that may otherwise be used to purchase professional consultancy.

GHG Policy Development and Evaluation

While more robust recommendations related to policy development are outside the scope of this project, some basic observations can be shared. While Madison currently has set goals related to emissions, it has not tied its GHG emissions with its planning and reduction plans. Data-driven analysis and policy is the most efficient and effective way to target GHG emissions reduction programs. Having a person knowledgeable and experienced with the CACP software would allow more expertise to help suggest and direct policy related to emissions reductions.

As more entities participate in the GHG reporting program, better data will be available as well to compare emissions and emissions targets with other communities. Being aware of effective reduction measures can help guide policy.

General Accounting and Reporting

Ensuring the energy usage is consistently reported from year to year is the most important factor in effectively tracking emissions. If emission data is changing not because of changes in energy usage, but because of reporting methodology changes, the data is not particularly useful for identifying and managing emissions and assessing the efficacy of emissions reduction programs.

The second recommendation is tracking specific changes in energy usage to account for fluctuations in the data. Both of the Future Inventory recommendations, dedicating a person to manage the inventory and software and a yearly community-wide inventory, would increase the detail of the data. For instance, the central library in Madison is currently being remodeled; thus, its conventional energy usage is not represented in the data. Because this is not a permanent emissions reduction, it should be accounted for in the inventory so actual reductions can be effectively tracked. More detailed data could easily indicate the remodel had on overall energy use.

We also recommend making the data openly available and searchable to the public. An easy-to-use website would allow the public to see the progress the City is making on emissions, and perhaps even provide useful insight.

Buildings and Other Facilities

Individual tracking of building emissions and energy consumption would allow better assessment of which buildings would most benefit from conservation or improvement measures. It would also allow better tracking of the relative efficacy of measures taken on multiple buildings.

Finally, individual tracking would allow accommodation for unique circumstances that do not properly represent the long term emissions of the city. Specifically, when buildings are underutilized or temporarily shut down, such as currently the case of central library, individual tracking could allow for accounting of overall emissions values from the temporary reductions.

Streetlights and Traffic Signals

Tracking individual streetlights appears to be beyond the scope of the grid functionality, due to many streetlight systems being tied into traffic signal power. However, tracking differences between high efficiency light bulbs being currently installed compared to older light bulbs would allow for better assessment of the efficacy of the replacements.

However, because streetlights and traffic signals are a necessary part of city infrastructure, they have shown consistently declining energy use and emissions, and they are a relatively small portion of total emissions, efforts would most likely be put to better use in other sectors first. Our only major recommendation for streetlights is to continue current efficiency measures already in place.

Water Delivery Facilities

Due to the on-demand nature of water delivery, individual, more detailed accounting would only target conservation efforts at specific locales with high water usage. While potentially an effective mechanism, local targeting of water efficiency and conservation measures may not be significantly more effective than citywide water conservation actions.

Thus, current accounting of water delivery facilities is likely sufficient, and the only recommendation would be considering effective water conservation programs.

Transportation

For the city's transit and vehicle fleets, the team recommends the next survey to direct awareness to track changes in *total vehicle miles traveled (VMT)* for the transit and vehicle fleet. Overall, Madison has efficiently tracked comprehensive fuel use and fuel cost data for its transit and vehicle fleets, largely owing to the City's ability to implement recommendations from previous survey years by employees with high expertise. Because baselines information is readily accessible, the team was able to draw basic correlations between fuel usage and fuel cost for the past survey years. However, such discussion can be more comprehensive with investigation into the efficiency of transportation fuel use for City-operated vehicles. Ideally, City of Madison can use this information to determine cost-savings from investment into fuel efficiency, such as hybrid metro buses.

Secondly, the team recommends a more effective form of conducting employee commute evaluation. We believe data collection for this Scope 3 emissions estimate can become more standardized by:

- Utilization of same survey format and assumptions for every collection year;
- Perform finer data aggregating according to further categorizing of surveyed subjects, such as by
    - collecting primary and secondary mode of transportation;
    - averaging total number of employees employed throughout a given calendar year to prevent bias (i.e. upward bias if headcount was made at the beginning of year);
- Incentivize participation of survey through wider survey distribution routes, or consider more complex or randomized sampling;
- Employ more holistic data gathering, such as combining use of commute survey and declassified employee information (number of employees, full-/part-time employment status, zip codes, etc.).

Although Scope 3 emissions are not under direct control of the City, it constitutes the highest amount of emissions. Therefore, efforts in accounting for, and ultimately confronting, the City's greenhouse gas emissions may heavily depend on whether above recommendations or other improvements can be successfully implemented to correctly account for employee commute emissions.

Solid Waste

Scope 1 solid waste related emissions are estimated using EPA standards for solid waste decomposition and methane release. As such they are straightforward to estimate using available tools.

Scope 3 wastes, however, is somewhat difficult to estimate. No data is kept on employee and facility generated waste because the city does not collect trash from city facilities separately from the Madison community at large. Also, there are a number of private haulers that the city uses for other items that is not monitored or counted. This made estimating employee and facility waste very difficult. The methodology used is described in the appendix and led to a very generally and likely inaccurate estimate.

Suggestions for improving estimations of Scope 3 waste include:

- Perform a robust trash study to more adequately estimate total waste produced by the city and the composition of landfill waste. Perform this analysis for each facility in Madison;
- Monitor and measure waste taken by private haulers;
- Separate community and government waste streams and weigh each.

Because Scope 3 waste GHG emissions are relatively low in this analysis, the priority of these suggestions is perhaps lower than some other sectors included in the analysis.

CONCLUSION

This inventory marks the completion of Milestone One for government operations of the Five Milestones for Climate Mitigation. While Madison has outlined a community-wide target of reducing emissions by 80 percent by 2050, it should set a target for government operations and develop an action plan that identifies specific quantified strategies that can cumulatively meet that target. In addition, Madison should continue to track key energy use and emissions indicators on an ongoing basis. ICLEI recommends completing a re-inventory at least every five years to measure emissions reduction progress.

Emissions reduction strategies to consider for the climate action plan include energy efficiency, renewable energy, vehicle fuel efficiency, alternative transportation, vehicle trip reduction, and waste reduction among others. This inventory shows that Buildings and Facilities and Water Facilities will be particularly important to focus on. Through these efforts and others the City of Madison can achieve additional benefits beyond reducing emissions, including saving money and improving Madison's economic vitality and its quality of life.

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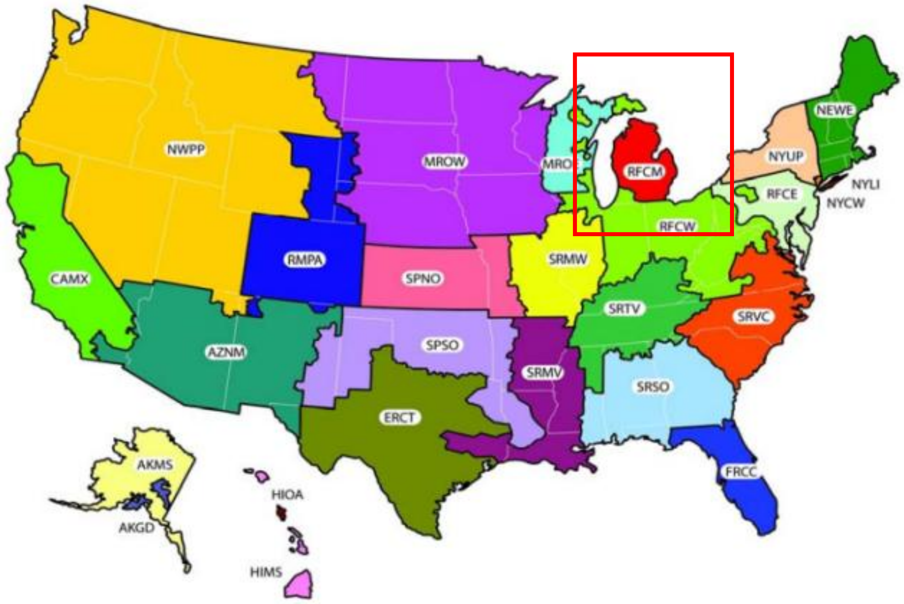
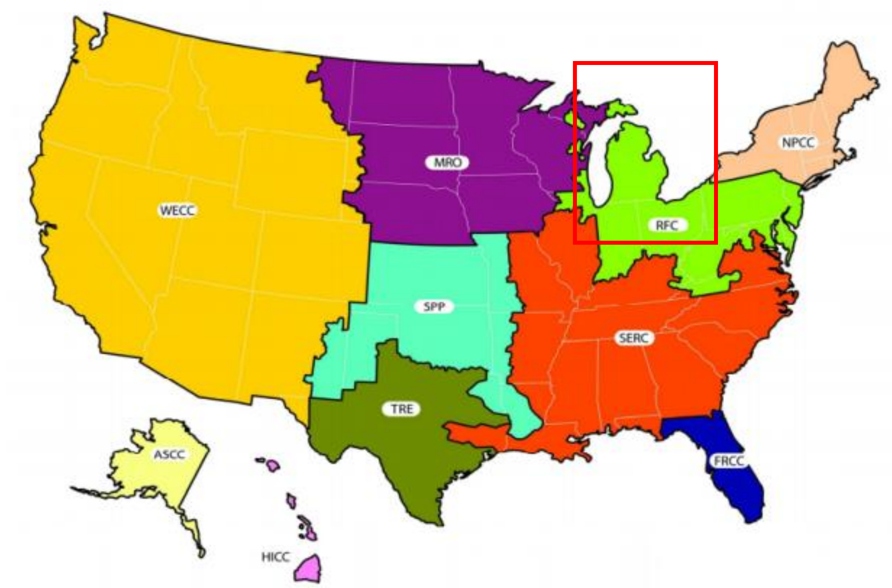
APPENDIX A: COEFFICIENTS

In order to determine emissions coefficients for data input setup, CACP directs users to consult eGRID. According to eGRID, Wisconsin is designated to be in the MROE and the MRO subregion, as seen in the following two figures (EPA 2012).





Using the combination of subregion destinations, eGRID's assigns emissions coefficients as follow in 2012:

Pollutant	CO_2	CH_4	N_20	NOx	SO_2
lb/MWh	1.591	0.024	0.027	2.205	4.303

Coefficients are inputted into CACP software according to eGRID's publication in 2012. When more current numbers have been published, we advise future updating of these emissions factors upon next survey year, which may fine-tune emissions results for 2012.

APPENDIX B: CACP OUTPUT

Greenhouse Gas Emissions in 2012 - *Scope 1 + Scope 2 + Scope 3*

	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	Equiv CO_2 (tons)	Bio CO_2 (tons)	Energy (MMBtu)	Cost ($)
Buildings and Facilities							
Madison, WI							
Buildings and Facilities							
Electricity	15,723	534	474	15,811	0	67,431	2,399,364
Natural Gas	4,406	17	831	4,417	0	75,381	431,570
Carbon Dioxide	75	0	0	75	0	0	0
R-407C Blend	0	0	0	10	0	0	0
Subtotal Buildings and Facilities	20,204	551	1,305	20,313	0	142,812	2,830,934

CO_2 is R22 Refrigerant CO_2 equivalent: 100 lbs R22 lost @ 1500lbs CO_2 per lb R22

	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	Equiv CO_2 (tons)	Bio CO_2 (tons)	Energy (MMBtu)	Cost ($)
CCB (Electricity + Gas)							
Electricity	2,103	71	63	2,115	0	9,021	250,303
Natural Gas	19	0	4	19	0	329	2,002
Subtotal CCB (Electricity + Gas)	2,123	72	67	2,134	0	9,349	252,305
CCB Steam							
Electricity	2,713	92	82	2,728	0	11,634	277,812
Subtotal CCB Steam	2,713	92	82	2,728	0	11,634	277,812
Monona Terrace							
Electricity	1,623	55	49	1,632	0	6,961	101,674
Subtotal Monona Terrace	1,623	55	49	1,632	0	6,961	101,674
Subtotal Buildings and Facilities	26,662	770	1,502	26,807	0	170,756	3,462,725
Streetlights & Traffic Signals							
Madison, WI							
Streetlights							
Electricity	153	5	5	153	0	654	92,457
Natural Gas	2	0	0	2	0	39	1,766
Subtotal Streetlights	155	5	5	156	0	693	94,223
Traffic Signals							
Electricity	6,323	215	191	6,358	0	27,116	1,110,537

	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	Equiv CO_2 (tons)	Bio CO_2 (tons)	Energy (MMBtu)	Cost ($)
Natural Gas	0	0	0	0	0	0	518
Subtotal Traffic Signals	6,323	215	191	6,358	0	27,116	1,111,055
Subtotal Streetlights & Traffic Signals	6,478	220	196	6,514	0	27,808	1,205,278
Water Delivery Facilities							
Madison, WI							
Water Pumping Facilities							
Electricity	16,731	568	504	16,824	0	71,750	2,315,334
Subtotal Water Pumping Facilities	16,731	568	504	16,824	0	71,750	2,315,334
Subtotal Water Delivery Facilities	16,731	568	504	16,824	0	71,750	2,315,334
Solid Waste Facilities							
Madison, WI							
Demetral Landfill							
Methane	0	0	98,899	1,038	0	0	0
Subtotal Demetral Landfill	0	0	98,899	1,038	0	0	0
Greentree Landfill							
Methane	0	0	404,063	4,243	0	0	0
Subtotal Greentree Landfill	0	0	404,063	4,243	0	0	0
Mineral Point Landfill							
Methane	0	0	119,468	1,254	0	0	0
Subtotal Mineral Point Landfill	0	0	119,468	1,254	0	0	
Olin Landfill							
Methane	0	0	194,227	2,039	0	0	0
Subtotal Olin Landfill	0	0	194,227	2,039	0	0	0
Sycamore Landfill							
Methane	0	0	445,334	4,676	0	0	0
Subtotal Sycamore Landfill	0	0	445,334	4,676	0	0	0
Subtotal Solid Waste Facilities	0	0	1,261,992	13,251	0	0	0

	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	Equiv CO_2 (tons)	Bio CO_2 (tons)	Energy (MMBtu)	Cost ($)
Vehicle Fleet							
Madison, WI							
Vehicles (computed by Eqp Engine Hr)							
OFF ROAD Diesel	5,170	263	587	5,217	0	63,425	1,516,919
OFF ROAD Gasoline	15	1	2	15	0	194	5,193
Subtotal Vehicles (computed by Eqp Engine Hr)	5,185	264	589	5,232	0	63,619	1,522,112
Vehicles (computed by mileage)							
Diesel	2,237	13	14	2,239	0	27,442	657,633
Gasoline	3,544	144	210	3,568	0	45,763	1,164,160
OFF ROAD Diesel	42	2	5	42	0	514	13,537
OFF ROAD Gasoline	47	2	5	47	0	603	18,073
Subtotal Vehicles (computed by mileage)	5,869	161	234	5,896	0	74,322	1,853,403
Subtotal Vehicle Fleet	11,054	425	823	11,128	0	137,941	3,375,515
Employee Commute							
Madison, WI							
Heavy Duty							
Gasoline	335	10	13	337	0	4,327	0
Subtotal Heavy Duty	335	10	13	337	0	4,327	0
Light Truck, SUV, Minivan							
Gasoline	2,802	175	164	2,830	0	36,179	0
Subtotal Light Truck, SUV, Minivan	2,802	175	164	2,830	0	36,179	0
Passenger Car							
Gasoline	2,943	163	196	2,970	0	38,004	0
Subtotal Passenger Car	2,943	163	196	2,970	0	38,004	0
Subtotal Employee Commute	6,079	347	372	6,137	0	78,510	0

	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	Equiv CO_2 (tons)	Bio CO_2 (tons)	Energy (MMBtu)	Cost ($)
Transit Fleet							
Madison, WI							
Main Line							
Diesel	13,692	80	85	13,705	0	167,979	3,590,488
Subtotal Main Line	13,692	80	85	13,705	0	167,979	3,590,488
Para-transit Coaches							
Diesel	405	2	3	406	0	4,971	106,231
Subtotal Para-transit Coaches	405	2	3	406	0	4,971	106,231
Support Vehicles							
Diesel	27	0	0	27	0	336	8,681
Gasoline	75	26	21	79	0	969	27,395
Subtotal Support Vehicles	102	26	22	107	0	1,305	36,076
Subtotal Transit Fleet	14,199	109	109	14,128	0	174,255	3,732, 795
Scope 3 Waste							
Madison, WI							
Employee Waste Disposal Method - Managed Landfill							
Paper Products	0	0	7,382	78	0		0
Food Waste	0	0	4,006	42	0		0
Plant Debris	0	0	686	7	0		0
Wood or Textiles	0	0	893	9	0		0
Subtotal Employee Waste	0	0	12,967	136	0		0
Subtotal Scope 3 Waste	0	0	12,967	136	0		0
Total	81,203	2,439	1,278,465	95,014	0	661,020	14,091,647

This report has been generated for Madison, WI using ICLEI's Clean Air and Climate Protection 2009 Software.

APPENDIX C: TRANSIT AND VEHICLE FLEETS

Three goals summarize the purpose of information compiled and extracted for transit and vehicle fleets:

(1) Vehicle fuel usage data, or total gallons used within surveyed year, should be compiled in forms in which direct data entry into CACP is ready;
(2) Additional data such as fuel costs and vehicle miles traveled are extracted and interpreted;
(3) Identify previous transit and vehicle data, either by archived CACP data or previous reports, and organize latest collected information in similar forms to allow comparison to previously surveyed years.

Transportation information for transit and vehicle fleets was gathered from City of Madison's Facility and Sustainability Manager Jeanne Hoffman, and further support of information was supplied by **Wayne Block** (WBlock@cityofmadison.com) and **Robin Jahn** (rjahn@cityofmadison.com), both from Madison Metro Transit.

Data for most vehicles consists of tracked miles and fuel costs, down to per vehicle detail. Below is a snapshot of transit fleet vehicle data for 2012, taken from tally of main line vehicle raw data.

Vehicle	Distance	------- Propulsion fuel ------- Fluid	Qty	Cost

Fixed route revenue vehicle

GILLIG HYBRID

Vehicle	Distance	Fluid	Qty	Cost
001	33,050	DIESEL	6094.1	175.10
002	36,217	DIESEL	7301.9	127.60
003	32,699	DIESEL	6794.5	88.90
004	30,674	DIESEL	6423.8	111.20
005	28,820	DIESEL	6093.0	26.10
006	50,402	DIESEL	9237.7	212.40
007	38,146	DIESEL	6757.8	317.50
008	37,617	DIESEL	6786.2	237.30
009	53,118	DIESEL	9622.7	195.00
010	52,995	DIESEL	9503.2	320.70
011	48,199	DIESEL	8730.4	175.10
012	56,056	DIESEL	10342.4	290.40
013	50,144	DIESEL	9306.1	141.40
014	49,488	DIESEL	9286.3	197.90
015	54,861	DIESEL	10013.4	255.60
016	57,260	DIESEL	10488.9	111.70
017	49,859	DIESEL	9200.6	269.00
018	42,982	DIESEL	8591.3	102.00
019	55,466	DIESEL	10046.0	247.60
Totals - GILLIG HYBRID	**858,053**		**160,620.3**	**3,602.50**

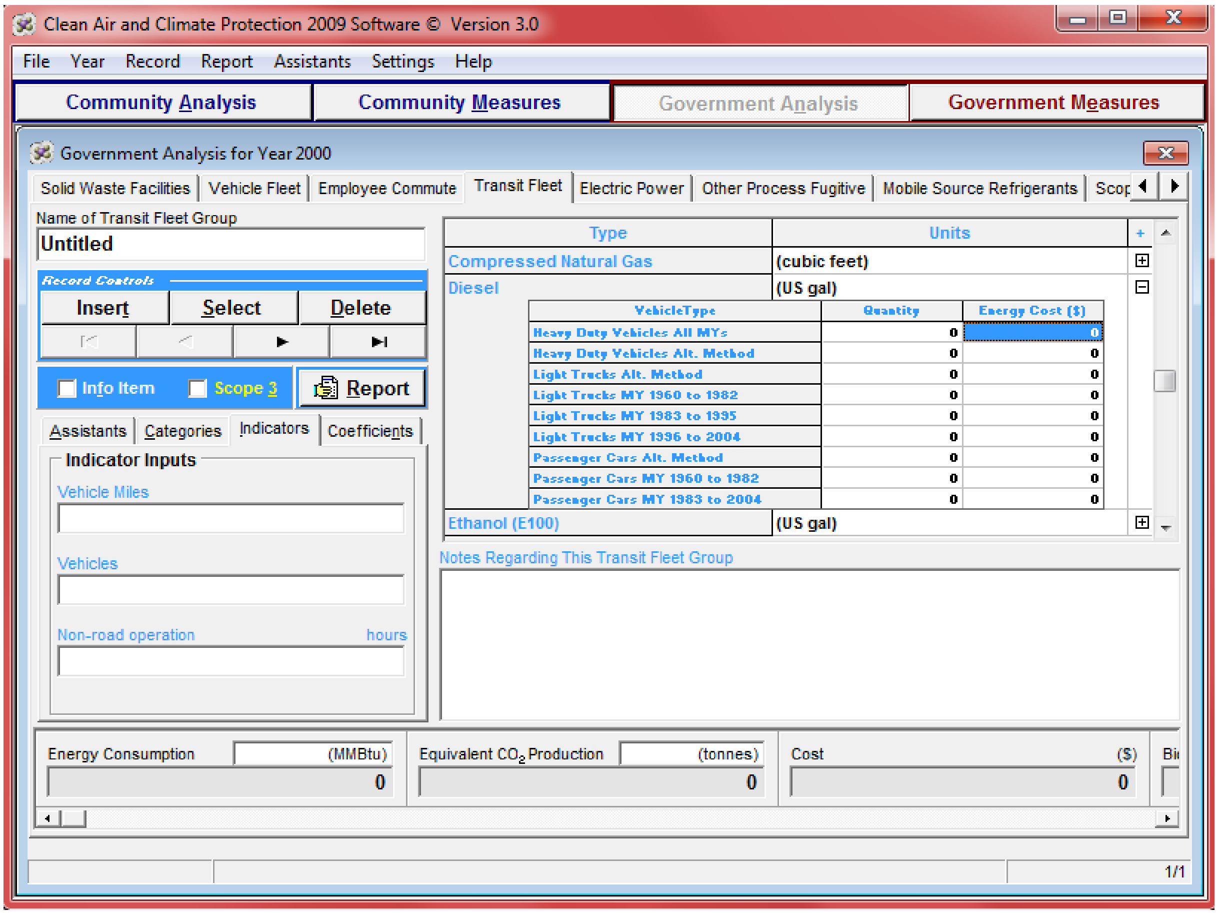
Non-vehicular equipment, such as construction tractors, contains only fuel use (and no vehicle mileage) information. See the snapshot below, taken from vehicle fleet equipment engines that used unleaded fuel, for an example of such data.

Madison Active Fleet	FUEL USAGE REPORT	p.2
W407 - FuelUsageDetailReport	BY H	
3/8/2013 10:06:58 AM	01/01/2012 to 12/31/2012	

This report shows meters driven and fuel gallons purchased for the specified meter and date range.
It also shows meters per gallon (MPG) and fuel cost per meter (CPM).
Costs shown include markup if the fuel markup is charged.
To view individual fuel transactions, click on the [+] by the asset number.

ASSET NUMBER	DESCRIPTION	BEG METER	END METER	USAGE	AVG MPG	AVG CPM	QTY	TOTAL COST
7911	1986 INGER RAND 175	690	701	11	0.298	$9.495	36.906	$104.445
7916	1993 INGER RAND P185WJD	580	600	20	0.803	$5.341	24.900	$106.821
8037	1997 CUSHMAN TRUCKSTER	3,344	3,403	59	5.076	$0.641	11.623	$37.826

Before data is ready for input into CACP, the user needs to organize these raw data by fuel type, and compile into further subcategories according to user-defined criteria and/or CACP pre-defined vehicle types. For example, transit fleet vehicles can be subcategorized by user-defined functional groups of main line, para-transit, and support vehicles; vehicle fleets can be broken down into pre-defined subcategories (see below) by fuel type and model year; or a combination of user-defined and pre-defined subcategories can be used, such as breaking down vehicle fleets by function (construction or shipping) as well as fuel type.



Because high level of detail is provided, direct data input by vehicle type and model year is feasible (alternative method is not necessary). The only caveat currently known is that fuel cost of transit fuel for main line and para-transit vehicles (excluding support vehicle) reported are not accurate, and this information is accounted by Madison Metro Transit's finance department instead. For the year 2012, the finance department manager Wayne Block was able to provide us with total fuel costs for main line and para-transit vehicles.

APPENDIX D: EMPLOYEE COMMUTE

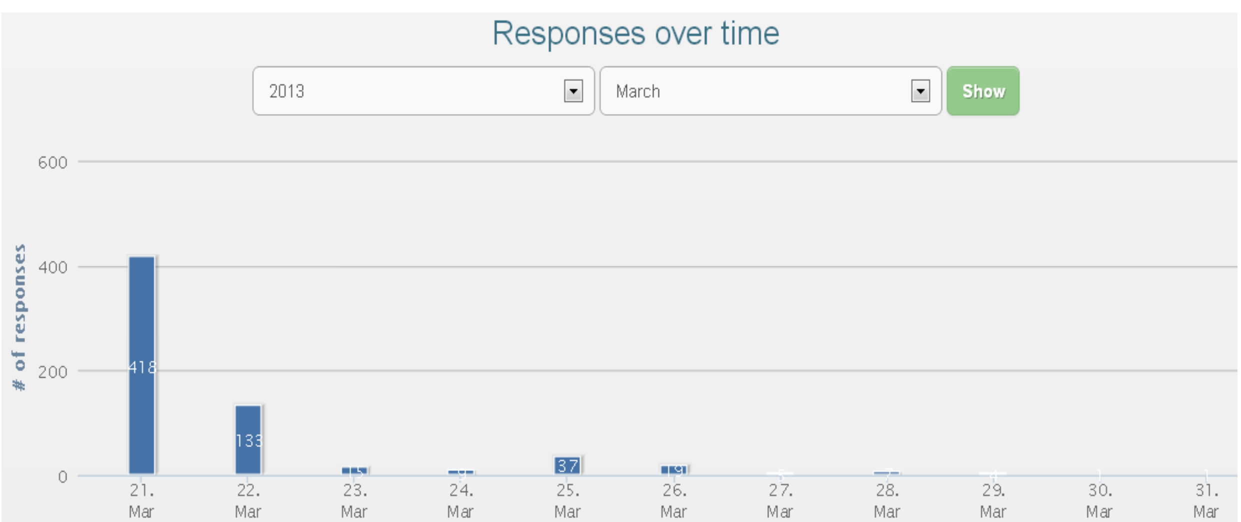
Data of employee commute emissions estimate were collected by a short, online survey distributed by City of Madison Facilities and Sustainability Manager. Lessons learned from the employee commute survey conducted in 2010 provided a few design guidelines for enhancing the effective of this survey. We implemented the following lists of characteristics for the 2012 customized online survey:

- Focused attempt on collecting mainly employees' commute distance to work, types of transportation mode used, types of fuel used, types of vehicle used, and gas mileage estimates of vehicles;
- Considered primary and secondary modes of transportation;
- Collected only one set of data from each unique IP address to eliminate the possibility of double-counting results;
- Allowed only multiple choices responses, no open-ended input by subjects;
- Limited the number of questions asked to 10 or less;
- Opened for a total of 10 days.

The above guidelines improved accuracy of results by increasing standardization of answers, keeping subjects engaged by limiting the number of questions, and accounting for emission opportunities from primary as well as secondary transportation modes (e.g. employees may choose public transportation as primary transportation mode, but drive to work some days of the week).

Survey Results in 2012

A total of 649 responses were received within 10 surveying days between March 21 to March 31, 2012, and about 65 percent responses were received within the first 24 hours. Final results were proportionally extrapolated from the raw 649 responses to estimate the aggregate for all 3600 employees in 2012.



Below contains the employee commute survey questions and raw response in their entirety. Additional notes, in red, are displayed as design comments and explanation of questioning logic used by the survey.

1) In 2012, what is the distance of your commute, ONE-WAY, to your City of Madison employment location? Please include total distance if necessary of, for example, dropping children to school or driving spouse to work. If you moved within the past year while as a City of Madison employee, please choose the distance you spent most of the year commuting.

Answer Choices	Number of Responses
0-5 miles	251 (38.7%)
6-10 miles	185 (28.5%)
11-15 miles	78 (12.0%)
15-20 miles	49 (7.6%)
21-25 miles	32 (4.9%)
26-30 miles	20 (3.1%)
31-35 miles	11 (1.7%)
36-40 miles	5 (0.8%)
41-45 miles	6 (0.9%)
46-50 miles	5 (0.8%)
51-75 miles	3 (0.5%)
76-100 miles	2 (0.3%)
Over 100 miles	2 (0.3%)

2) In 2012, how many days, on average, did you commute to your City of Madison employment location within a week?

Answer Choices	Number of Responses
0 day	2 (0.3%)
1 day	0 (0.0%)
2 days	26 (4.0%)
3 days	38 (5.9%)
4 days	70 (10.8%)
5 days	486 (74.9%)
6 days	26 (4.0%)
7 days	1 (0.2%)

3) In 2012, what was your primary mode of transportation for that commute?

Answer Choices	Number of Responses
Drive alone, directly from home to work	321 (49.5%)
Drive in combination of other chores, (such as dropping child off at school, bringing spouse to work, etc.)	69 (10.6%)
Carpool/Vanpool	26 (4.0%)
Public transit only	54 (8.3%)
Biking or walking only	52 (8.0%)
Combo: Drive + Transit	73 (11.2%)
Combo: Biking/walking + Transit	53 (8.2%)
Other/Telecommute	1 (0.2%)

4) If you did NOT primarily drive to work in 2012, how many days on average in a week did you drive as a secondary mode?

Answer Choices	Number of Responses
None. I either already drive to work or rely on my primary mode of transportation all the time.	528 (81.4%)
1 day	59 (9.1%)
2 days	34 (5.2%)
3 days	15 (2.3%)
4 days	5 (0.8%)
5 days	8 (1.2%)

5) What is the fuel type that best describes the vehicle you used most when driving to your City of Madison employment location in 2012?

Answer Choices	Number of Responses
Gasoline (including hybrid)	550 (84.7%) ... proceed to Question 6)
Diesel	8 (1.2%) ... proceed to Question 10)
Biodiesel	0 (0.0%) ... proceed to Question 10)
Fully Electric	1 (0.2%) ... proceed to Question 11)
None of the above (I always take public transit, bike, walk, or telecommute to work)	90 (13.9%) ... proceed to Question 12)

6) Which vehicle type best describes the vehicle you used most when driving to your City of Madison employment location in 2012?

Answer Choices	Number of Responses
Passenger Car	337 (61.5%) ... proceed to Question 7)
Light Truck, SUV or Minivan	192 (35.0%) ... proceed to Question 8)
Heavy Duty Truck or Vehicle	10 (1.8%) ... proceed to Question 9)
Motorcycle	9 (1.6%) ... proceed to Question 11)

7) Which model year best describes the vehicle you used most when driving to your City of Madison employment location in 2012? (Gasoline – Passenger Car) ... proceed to Question 11)

Answer Choices	Number of Responses
2005 or newer	201 (59.8%)
2004	24 (7.1%)
2003	22 (6.5%)
2002	15 (4.5%)
2001	19 (5.7%)
2000	16 (4.8%)
1999	8 (2.4%)
1998	11 (3.3%)
1997	6 (1.8%)
1996	5 (1.5%)
1995	5 (1.5%)
1994	0 (0.0%)
1993 or older	4 (1.2%)

8) Which model year best describes the vehicle you used most when driving to your City of Madison employment location in 2012? (Gasoline – Light Truck/SUV/Minivan) ... proceed to Question 11)

Answer Choices	Number of Responses
2005 or newer	110 (57.6%)
2004	14 (7.3%)
2003	11 (5.8%)
2002	10 (5.2%)
2001	9 (4.7%)
2000	10 (5.2%)
1999	8 (4.2%)
1998	11 (5.8%)
1997	4 (2.1%)
1996	1 (0.5%)
1995	1 (0.5%)
1994	0 (0.0%)
1987 to 1993	2 (1.0%)
1986 or older	0 (0.0%)

9) Which model year best describes the vehicle you used most when driving to your City of Madison employment location in 2012? (Gasoline – Heavy Duty) ... proceed to Question 11)

Answer Choices	Number of Responses
2005 or newer	7 (70.0%)
2004	0 (0.0%)
2003	1 (10.0%)
2002	0 (0.0%)
2001	1 (10.0%)
2000	1 (10.0%)
1999	0 (0.0%)
1998	0 (0.0%)
1997	0 (0.0%)
1996	0 (0.0%)
1990 to 1995	0 (0.0%)
1988 to 1989	0 (0.0%)
1987	0 (0.0%)
1986 or older	0 (0.0%)

10) Which vehicle type and model year best describes the vehicle you used most when driving to your City of Madison employment location in 2012? (Diesel / Biodiesel) ... proceed to Question 11)

Answer Choices	Number of Responses
Passenger Car, model year 2004 or newer	3 (42.9%)
Passenger Car, model year 1983 to 2004	1 (14.3%)
Passenger Car, model year 1982 or older	0 (0.0%)
Light Trucks/SUV/Minivan, model year 2004 or newer	1 (14.3%)
Light Trucks/SUV/Minivan, model year 1996 to 2004	1 (14.3%)
Light Trucks/SUV/Minivan, model year 1983 to 1995	0 (0.0%)
Light Trucks/SUV/Minivan, model year 1982 or older	0 (0.0%)
Heavy Duty Vehicle (any model year)	1 (14.3%)

11) What is the estimated average city and highway combined fuel efficiency of that vehicle, in Miles per Gallon (MPG)? Compile total miles driven by multiplying fuel efficiency with "vlookup" of each respondent's distance to commute, by fuel type and vehicle type. Then aggregate raw responses to all City of Madison employee (3600 employees for 2012)... proceed to Question 12).

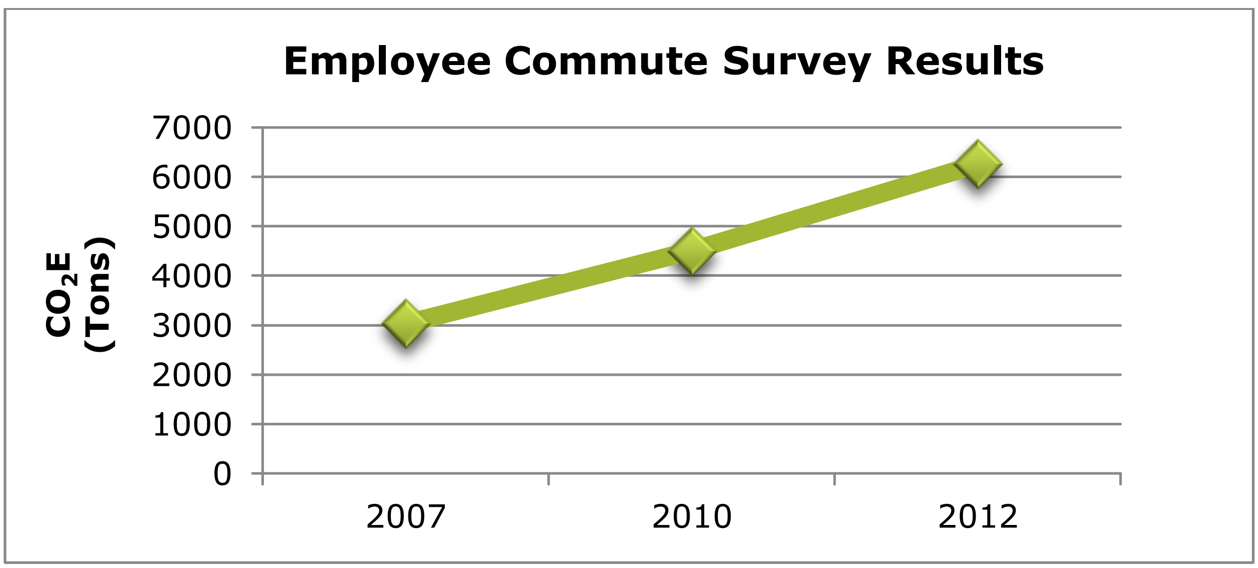
Answer Choices	Number of Responses
Less than 10 MPG	2 (0.4%)
11 to 15 MPG	41 (7.5%)
16 to 20 MPG	98 (17.8%)
21 to 23 MPG	94 (17.1%)
24 to 26 MPG	110 (20.0%)
27 to 30 MPG	82 (14.9%)
31 to 33 MPG	52 (9.5%)
34 to 36 MPG	29 (5.3%)
37 to 40 MPG	10 (1.8%)
40 to 45 MPG	18 (3.3%)
46 to 50 MPG	7 (1.3%)
50 or higher MPG	7 (1.3%)

12) Which of the following best describes your position at City of Madison in 2012? End of survey

Answer Choices	Number of Responses
Full-time, normal business hours (i.e. Monday to Friday around 8AM to 6PM)	394 (61.6%)
Full-time, non-normal business hours (i.e. shifts during nights, weekends or other flexible hours than above)	172 (26.9%)
Full-time, telecommuted primarily	0 (0.0%)
Part-time, normal business hours (i.e. Monday to Friday around 8AM to 6PM)	36 (5.6%)
Part-time, non-normal business hours (i.e. shifts during nights, weekends or other flexible hours than above)	38 (5.9%)
Part-time, telecommuted primarily	0 (0.0%)

Multi-Year Results Comparison

Comparison of emissions data for the past three survey years of City of Madison employee commute shows an upward trend, as seen in figure below.



From past reports, the numbers of City of Madison employee were reported to be around 4100 for the years 2007 and 2010. Recent data shows 2012 employee number to be around 3600. Although 2007 raw data was not accessible, we note similar response rates between the years 2010 and 2012 (707 and 649, respectively). Counter to the decrease in number of employees, an upward trend in employee commute emissions may be explained largely by flawed survey techniques. Inaccuracy of conducing employee commute survey also suggests that data baseline may have not yet been established.

Comparing raw data between 2010 and 2012, we find one main difference: past year data did not seem to include emissions from mixed-route commutes, such as those who choose to combine passenger vehicle driving and public transit during their normal commute. At the same time, current survey from 2012 may have over-estimated these mixed commute emissions by direct extrapolation. Specifically, out of the 649 who responded to the survey, almost 20 percent indicated they combine driving and other forms of transportation to work, and this was aggregate to estimate overall employees' commute; but the true percentage may be lower if all employees responded, hence introducing possibility of aggregation error.

Another potential injection of inaccuracy may be the fact that surveys subjects are 100 percent self-selected or self-reported. We cannot rule out perhaps that some employees, for example those who are proactive about sustainability or those living within the City, may feel more compelled than others, such as those indifferent to sustainable urban-living, in participating in this survey.

One helpful strategy to combat the last two inconsistencies above would be to employ better extrapolation techniques utilizing additional demographic details. One example would be to compare employment data to investigate how far employees have to commute to work, and compare this actual information to survey data received in order to gauge accuracy.

APPENDIX E: WASTE

Landfill Emissions

Landfill emissions calculated using EPA emissions estimates, based on quantity of waste disposed, age of facility, etc. Data from "GHG reporting calculations.xls" spreadsheet provided by Brynne Bemis:

Brynn Bemis, Hydrogeologist
City of Madison Engineering Division
Room 115 City/County Building
210 Martin Luther King Jr. Blvd.
Madison, WI 53703
(t) 608.267.1986
bbemis@cityofmadison.com

Data was inputed for 2007, 2010, and 2012 from the Mg/yr CO2-eq column (tonnes CO2)

Scope 3 Employee Waste

Employee Waste was calculated using a very general estimate. Calculation methodology is below:

E = # City Employees
P = # People Employed in Madison
T = Total City Waste
0.40 = Estimated percentage of non-residential waste (based on national EPA estimates)
[(E/P)*0.40*T]/E

This result was then averaged with an estimate of the amount of waste produced by the average CA city employee in 1999. It is likely that neither number is particularly accurate. City waste data does not include trash hauled by private haulers, and there is no way to know whether city waste production is typical of non-residential waste production in the city of Madison. The two figures were averaged to come up with a general number. They were both on the same order of magnitude and only estimated to one significant digit. This data was also entered in 2007 and 2010 data sets for consistency. Because the estimate was very general, no variance was assumed among the three years.

Waste Share numbers were based on a trash study noted in previous LGOP reports (see 2007 data and methodology notes). Numbers on total city waste production was available from the "Diversion.xls" spreadsheet provided by George Dreckmann.

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