Mankato and North Mankato Citywide Greenhouse Gas Inventories

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Table of Contents

Tables and Figures

Appendices

Appendix A: The Calculation of Vehicle Emission Rates
Appendix B: Spreadsheets for the Cities of Mankato and North Mankato (the following list of spreadsheet titles applies to the sheets for both cities)

A1. Summary of Greenhouse Gas Emissions
A2. Energy Consumption and Associated Greenhouse Gas Emissions
A3. Xcel Energy Electricity Data
A4. Benco Electric Cooperative Data
A5. CenterPoint Energy Data
A6. Greater Minnesota Gas Data
A7. Independent Generators
A8. Greenhouse Gas Emission Factors for Utilities
A9. Greenhouse Gas Emissions Associated with Transportation
A10. Vehicle Miles Traveled and Associated Greenhouse Gas Emissions
A11. Vehicle Emission Rate
A12. Airport-Related Emissions
A13. Greenhouse Gas Emissions Associated with Waste Management
A14. Waste Water Energy Use and Associated Greenhouse Gas Emissions
A15. City Comparisons, 2009

Main Findings / Executive Summary

Baseline: Findings for the Baseline Year 2008

1. **Total greenhouse gas (GHG) emissions:**
   - **Mankato:** 867,000 metric tons carbon dioxide equivalent (CO_2e); 23 metric tons CO_2e per capita (Table 1)
   - **North Mankato:** 182,000 metric tons CO_2e; 14 metric tons CO_2e per capita (Table 2)

2. **GHG emissions by source:**
   - **Mankato:** Electricity 41%; natural gas 30%; coal 14%; transportation 14%; waste 1% (Table 1, Figure 1)
   - **North Mankato:** Electricity 59%; natural gas 24%; transportation 16%; waste 1%; other fuels negligible (Table 2, Figure 2)

3. **GHG emissions by sector:**
   - **Mankato:** Residential 14%; commercial and industrial 71%; transportation 14%; waste 1% (Table 3, Figure 3)
   - **North Mankato:** Residential 32%; commercial and industrial 51%; transportation 16%; waste 1% (Table 4, Figure 4)

4. **Mankato's commercial and industrial sector:** Mankato's commercial and industrial sector accounted for a much greater share of Mankato's GHG emissions than North Mankato's because of a few large industrial emitters in Mankato.

Trends: Changes from 2008 to 2009

5. **Total GHG emissions:**
   - **Mankato:** 7% decrease (Table 1)
   - **North Mankato:** 5% decrease (Table 2)

6. **GHG emissions from electricity:**
   - **Mankato:** 8% decrease (Table 1)
   - **North Mankato:** 7% decrease (Table 2)

   The main reason for the decreases was a decrease in the electricity emission factors for Xcel and Benco. A cooler summer in 2009 and the economic downturn, which started in 2008, also contributed to the decreases.

7. **GHG emissions from natural gas:**
   - **Mankato:** 5% decrease (Table 1)
   - **North Mankato:** 7% decrease (Table 2)

   Likely reasons for the decreases were milder winter months in 2009 than in 2008 and the economic downturn, which started in 2008.

8. GHG emissions from transportation:

- **Mankato:** 1% decrease (Table 5)
- **North Mankato:** 2% increase (Table 6)

Changes in transportation emissions are due primarily to changes in vehicle miles traveled (VMT) (Figure 6).

Comparisons

9. City comparisons (Mankato, North Mankato, Burnsville): Per capita GHG emissions for each sector for all three cities are comparable except that Mankato's emissions from its commercial and industrial sector are much larger than for either of the other two cities. (Table 8)

10. Regional center comparisons (Greater Mankato/North Mankato, Rochester, Duluth): Per capita GHG emissions for each sector are comparable for the three regional centers included. (Table 9)

Recommendation

11. Future years: Conducting GHG emissions inventories for additional years (2010, 2011, 2012, and 2013) would help to track the trends.

1.0. Introduction

This report details the results of citywide greenhouse gas inventories conducted for Mankato and North Mankato for the years 2008 and 2009. Greenhouse gas inventories are important because anthropogenic greenhouse gases have been shown to be the major contributor to global warming and climate change. Climate change for Minnesota means among other things more hot days in the summer, more intense storms, and more extremes in weather including droughts and flooding, all of which will have severe consequences on economic well-being and quality of life in the greater Mankato area. Catastrophic climate change can be mitigated by developing and implementing plans to reduce greenhouse gas emissions. Plans can be made at many levels – nationally and internationally, statewide and citywide, as well as at the level of even smaller organizational units such as businesses, schools, government buildings, residences, etc. Measurement is an important part of any plan. As Osborne and Gaebler state in *Reinventing Government* (1992), "If you don't measure results, you can't tell success from failure. If you can't see success, you can't reward it. If you can't see failure, you can't correct it." Hence, the place to start a plan at any level to reduce GHG emissions is with a greenhouse gas inventory, or in other words, a carbon baseline assessment.

The cities of Mankato and North Mankato underwent an envisioning process called Envision 2020 (E2020) in 2005-2006. In this process, about 200 citizens from the local area, representing a number of different stakeholder groups, held meetings over a period of six months. The participants developed a vision for the greater Mankato/North Mankato area to work to achieve by 2020, and a series of specific goals, strategies, and action steps, which were organized into six focus areas, to move the area toward the vision. The E2020 Final Report, including the vision, goals, strategies and action steps, was presented to the community in September 2006. Greater Mankato Growth, an organization formed from the merger of the Greater Mankato Chamber of Commerce and Greater Mankato Economic Development, was given the charge of overseeing and facilitating the implementation of the goals.

One of the goals in the Economic Development focus area was to "work toward an emissions neutral / sustainable local economy by conserving energy, increasing energy efficiency, and developing renewable energy industries that are versatile and embrace new solutions." One of the groups formed to advance this goal was the Energy Conservation Task Force (ECTF). The ECTF decided to conduct a greenhouse gas inventory to establish a baseline against which progress in reducing GHG emissions could be measured. In 2012, the Cities of Mankato and North Mankato (the Cities) signed an agreement with the ECTF and the Minnesota Pollution Control Agency (MPCA). Under the terms of the agreement, representatives of the Cities obtained the data for the cities' inventories, which was then analyzed by a member of the ECTF (the author of this report) with the help of a consultant provided by the MPCA free of charge to the Cities under their Retiree Environmental Technical Assistance Program (RETAP). These inventories are the product of that agreement.

Greenhouse gas inventories are important to the cities of Mankato and North Mankato for the following reasons:

- They disclose the major sources of the cities' greenhouse gas emissions.
- They assist in promoting public understanding of the major sources of the cities' greenhouse gas emissions.
- They serve as a benchmark for measuring progress in reducing the cities' greenhouse gas emissions.
- They can suggest effective policies for reducing greenhouse gas emissions.
- They improve the Cities' competitiveness for federal and state funding opportunities that are targeted to cities that have taken steps to measure and reduce their carbon footprints.
- They can serve as a model for other Minnesota cities that wish to follow Mankato and North Mankato's examples of environmental leadership.

It should be noted that other sustainability initiatives have already been undertaken by Mankato and North Mankato. The City of Mankato in 2008 adopted a Strategic Plan for Sustainability and in 2010 became a participant in the Minnesota Green Step Cities Program. These inventories will help to achieve Mankato and North Mankato's future goals in these and other sustainability initiatives.

2.0. Scope of the GHG Inventories

Separate citywide greenhouse gas inventories were conducted for Mankato and for North Mankato using the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (Version 1.0, October 2012)* (hereafter referred to simply as the *Protocol*). A citywide greenhouse gas inventory is an accounting of all the greenhouse-gas-emitting activities that occur within the jurisdictional boundaries of a city in a year. The activities tracked for each city included the use of electricity; the use of fuel in residential, commercial, and industrial stationary combustion equipment; transportation, both vehicular and by air; processing of municipal solid waste; and treatment of wastewater.

3.0. Methodology

Electricity and natural gas data were obtained from Xcel, Benco, CenterPoint, and Greater Minnesota Gas by inquiries made by the representative of each city. Data on other fuels combusted within each city by stationary sources that required air permits were obtained from the Minnesota Pollution Control Agency (MPCA). Vehicle miles traveled (VMT) were obtained from the Minnesota Department of Transportation (MnDOT) website. Data on fuel use at the Mankato Regional Airport and electricity and natural gas use at the Wastewater Treatment Plant were obtained by inquiries made by the city representatives. Municipal solid waste (MSW) data were obtained from the individual waste haulers who operate in Mankato and North Mankato. Data from each activity were then analyzed and combined with the appropriate emission factors to calculate the greenhouse gas emissions for that activity.

4.0. Greenhouse Gases Tracked

These inventories account for the emissions of the three principal greenhouse gases required by the *Protocol*—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Quantities of greenhouse gases emitted are expressed in metric tons, or tonnes, where one tonne = one metric ton = 1,000 kilograms = 2,204.6 pounds. The heat-trapping contributions of these gases are expressed as CO_2 equivalent, or CO_2e. The greenhouse gases vary in their effectiveness at trapping heat in the atmosphere, for example, CH_4 and N_2O are much more effective than CO_2. The effectiveness of a greenhouse gas at trapping heat relative to CO_2 is called its global warming potential (GWP). The GWP of CO_2 is one; of CH_4, 21; and of N_2O, 310. To get the CO_2e in metric tons (mt) of GHG emissions from a source, the metric tons of each greenhouse gas multiplied by its GWP are summed. Thus: $mtCO_{2e} = mtCO_2 + 21 * mtCH_4 + 310 * mtN_2O$.

5.0. Greenhouse Gas Emissions

5.1. Greenhouse Gas Emissions by Source

Greenhouse gas emissions by source for Mankato and North Mankato for 2008 and 2009 are shown in Tables 1 and 2 and Figures 1 and 2. The sources are electricity, natural gas, other fuels, transportation, and waste. Electricity and natural gas are used in residential, commercial or industrial buildings, and 'other fuels' are combusted in commercial or industrial buildings, so these three sources are lumped together into a 'buildings' category.

Table 1: Mankato Greenhouse Gas Emissions by Source

GHG Sources	2008 (metric tons)	Percent of Total	2009 (metric tons)	Percent of Total	Percent Change
Buildings	738,332	85%	683,422	84%	-7%
Electricity	357,513	41%	329,775	41%	-8%
Natural gas	258,978	30%	247,025	30%	-5%
Other fuels (coal)	121,841	14%	106,621	13%	-12%
Transportation	117,358	14%	116,220	14%	-1%
Waste	11,222	1%	10,879	1%	-3%
CO2e Emissions Total	866,912	100%	810,520	100%	-7%
Population	38,295		38,908		2%
Per-capita emissions	23		21		-8%

Figure 1: Mankato Greenhouse Gas Emissions by Source, 2008

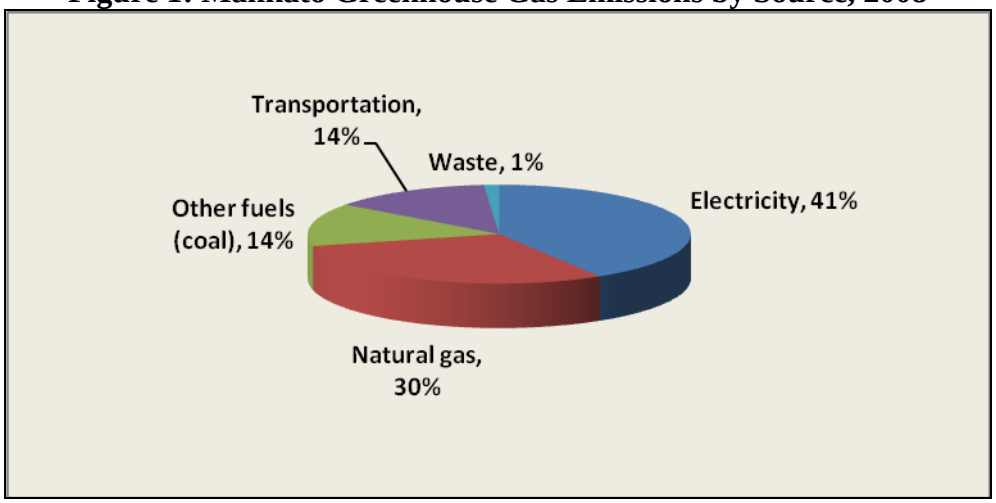
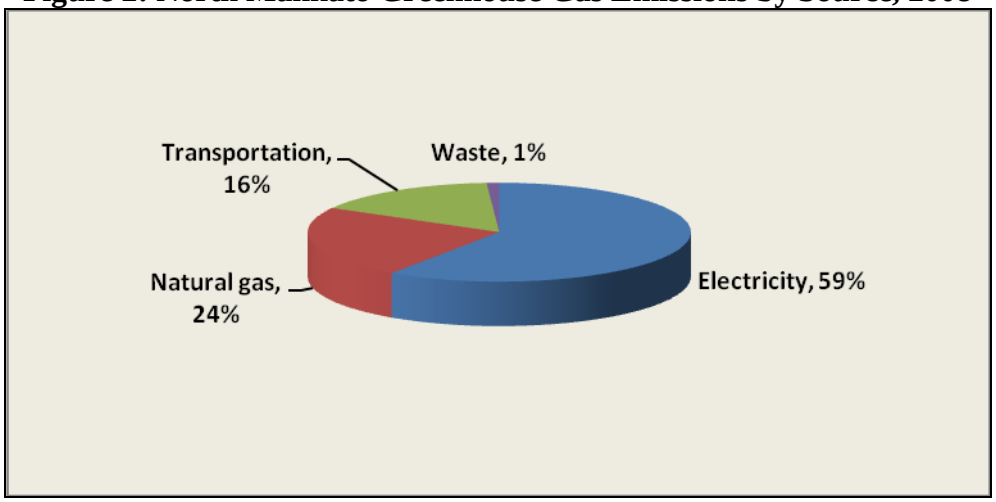


Table 2: North Mankato Greenhouse Gas Emissions by Source

GHG Sources	2008 (metric tons)	Percent of Total	2009 (metric tons)	Percent of Total	Percent Change
Buildings	151,002	83%	140,584	82%	-7%
Electricity	108,067	59%	100,524	59%	-7%
Natural gas	42,930	24%	40,058	23%	-7%
Other fuels	6	0%	2	0%	-73%
Transportation	28,805	16%	29,282	17%	2%
Waste	1,931	1%	1,948	1%	1%
CO2e Emissions Total	181,739	100%	171,814	100%	-5%
Population	13,154		13,295		1%
Per-capita emissions	14		13		-6%

Figure 2: North Mankato Greenhouse Gas Emissions by Source, 2008



5.2. Principal Findings from Tables 1 and 2

- Most GHG emissions for both Mankato and North Mankato were from buildings. For Mankato in 2008, buildings accounted for 85% of emissions; transportation, 14%; and waste, 1%. For North Mankato in 2008, the percentages were buildings, 83%; transportation, 16%; and waste, 1%. The 2009 percentages for each city were essentially the same as for 2008.

- Electricity is the largest source of GHG emissions in the buildings category.

- In 2008 in Mankato 41% of all emissions were from electricity, 30% from natural gas, and 14% from other fuels. Essentially all the emissions in the 'other fuels' category (>99%) came from a coal-fired boiler at an industrial facility. For North Mankato, the 2008 percentages were electricity, 59%; natural gas, 24%; and a very small contribution (<1%) from other fuels. The 2009 percentages for each city were essentially the same as for 2008.

- Total GHG emissions decreased for both Mankato and North Mankato between 2008 and 2009. For Mankato, the decrease was from 867,000 to 811,000 metric tons of CO_2e (from 23 to 21 metric tons CO_2e per capita), a change of -7%; North Mankato emissions decreased from 182,000 to 172,000 metric tons of CO_2e (from 14 to 13 metric tons CO_2e per capita), a change of -5%. Possible reasons for these decreases will be considered in later sections when sources (electricity, natural gas, other fuels, transportation, and waste) are considered individually.

- Generally, GHG emissions from each source decreased, with some exceptions:

    - Mankato: There were decreases in GHG emissions from 2008 to 2009 for all sources – electricity (-8%), natural gas (-5%), other fuels (-12%), transportation (-1%), and waste (-3%), and for buildings as a whole (-7%).

    - North Mankato: From 2008 to 2009 there were decreases in GHG emissions for electricity (-7%), natural gas (-7%), other fuels (-73%) and buildings as a whole (-7%) but small increases for transportation (+2%) and waste (+1%).

  Possible reasons for these decreases and increases will be considered in the later sections on individual sources.

5.3. Greenhouse Gas Emissions by Sector

GHG emissions by sector (residential, commercial and industrial, transportation, and waste) for Mankato and North Mankato for 2008 and 2009 are shown in Tables 3 and 4 and Figures 3 and 4.

Xcel, Benco, CenterPoint, and Greater Minnesota Gas classify their customers as either residential or commercial and industrial. Electricity and natural gas are split between these sectors using the utilities' classification. 'Other fuels' are all used in the commercial and industrial sector.

Table 3: Mankato Greenhouse Gas Emissions by Sector

Sector	2008 (metric tons)	Percent of Total	2009 (metric tons)	Percent of Total	Percent Change
Residential	122,221	14%	115,568	14%	-5%
Electricity	67,485	8%	64,904	8%	-4%
Natural gas	54,736	6%	50,664	6%	-7%
Commercial & Industrial	616,110	71%	567,853	70%	-8%
Electricity	290,028	33%	264,871	33%	-9%
Natural gas	204,241	24%	196,361	24%	-4%
Other fuels	121,841	14%	106,621	13%	-12%
Transportation	117,358	14%	116,220	14%	-1%
Waste	11,222	1%	10,879	1%	-3%
CO2e Emissions Total	866,912	100%	810,520	100%	-7%
Population	38,295		38,908		2%
Per-capita emissions	23		21		-8%

Figure 3. Mankato Greenhouse Gas Emissions by Sector, 2008

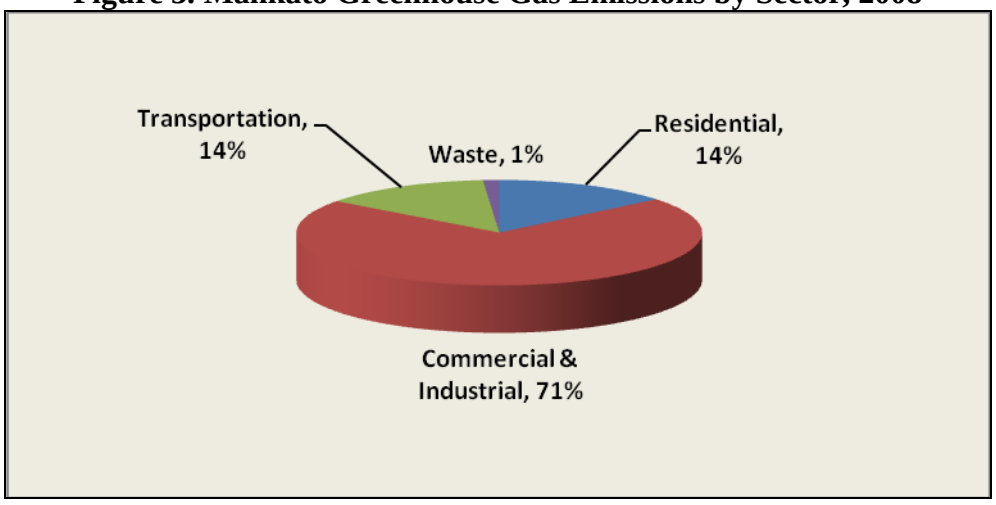
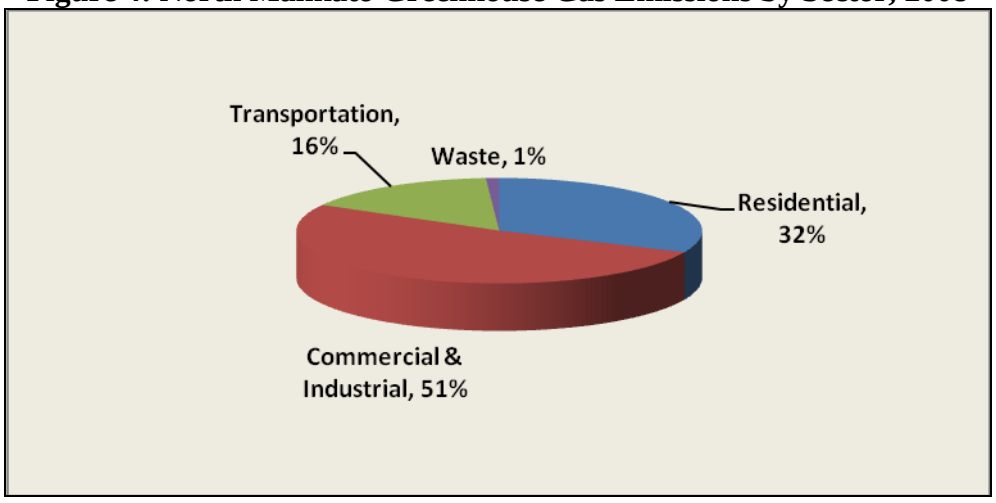


Table 4. North Mankato Greenhouse Gas Emissions by Sector

Sector	2008 (metric tons)	Percent of Total	2009 (metric tons)	Percent of Total	Percent Change
Residential	57,662	32%	56,570	33%	-2%
Electricity	34,715	19%	35,370	21%	2%
Natural gas	22,946	13%	21,200	12%	-8%
Commercial & Industrial	93,341	51%	84,014	49%	-10%
Electricity	73,351	40%	65,155	38%	-11%
Natural gas	19,984	11%	18,858	11%	-6%
Other fuels	6	0%	2	0%	-73%
Transportation	28,805	16%	29,282	17%	2%
Waste	1,931	1%	1,948	1%	1%
CO2e Emissions Total	181,739	100%	171,814	100%	-5%
Population	13,154		13,295		1%
Per-capita emissions	14		13		-6%

Figure 4: North Mankato Greenhouse Gas Emissions by Sector, 2008



5.4. Principal Findings from Tables 3 and 4

- Most GHG emissions for both Mankato and North Mankato were from the commercial and industrial sector.

- The biggest percentage of Mankato's emissions for 2008 comes from the commercial and industrial sector (71%), followed by residential (14%), transportation (14%), and waste (1%). For North Mankato for 2008, the percentages are commercial and industrial (51%), residential (32%), transportation (16%), and waste (1%). The percentages are essentially the same for 2009 for each city.

The reason that the Mankato commercial and industrial percentage is so much larger than that of North Mankato is that Mankato has a larger industrial base.

Essentially all (>99%) the emissions in the 'other fuels' category for Mankato is coal to heat a boiler at a large industrial facility, which in 2008 contributed 121,799 metric tons CO_2e of emissions. In addition, Mankato has eight CenterPoint customers in its largest industrial use category (>2,000 therms/day); North Mankato, none. In 2008, these eight customers consumed 54% of the natural gas supplied by CenterPoint to Mankato and contributed 139,307 metric tons CO_2e of emissions in 2008. Just these coal and natural gas emissions combined accounted for 30% of Mankato's total GHG emissions. If we subtract off these emissions, then the percentage of Mankato's GHG emissions from the commercial and industrial sector would be 59% (down from 71%); from the residential sector, 20%; transportation, 19%; and waste, 2%. These percentages are more in line with those of North Mankato.

6.0. Greenhouse Gas Emissions from Electricity

Tables 1 and 2 show a decrease in greenhouse gas emissions from electricity from 2008 to 2009, a change of -8% for Mankato and -7% for North Mankato. All else equal, a 2% increase for Mankato and 1% for North Mankato would be expected because of population increase.

There are three main reasons for the decrease:

- Xcel's emission factor for electricity decreased from 0.583 metric tons CO_2e / MWh in 2008 to 0.551 metric tons CO_2e / MWh in 2009, a change of -5%. Benco's emission factor for electricity, higher than Xcel's, also decreased, from 0.890 metric tons CO_2e / MWh in 2008 to 0.837 metric tons CO_2e / MWh in 2009, a change of -6%. The likely cause of these reductions is the switch by electric utilities to renewable energy sources mandated by the Next Generation Energy Act, which became law in Minnesota in 2007. For Xcel, the likely renewable energy source added during this time period was hydroelectricity purchased from Canada. Had the Xcel and Benco electricity emission factors not changed from 2008 to 2009, greenhouse gas emissions from electricity would have decreased by only 3% (not 8%) for Mankato, and only 1% (not 7%) for North Mankato. Thus, the biggest factor in reduction of GHG emissions from electricity for both Mankato and North Mankato was the decrease in the Xcel and Benco emission factors.

- The summer of 2009 was cooler than the summer of 2008 (there were 36% fewer cooling degree days), so there was less need for air conditioning, which accounts for a significant portion of electricity use in buildings. However, since we don't know how big a fraction of electricity in residential, commercial and industrial buildings is used for air conditioning, we can conclude only that the cooler summer in 2009 resulted in some decrease in electricity GHG gas emissions.

- The economic downturn that started in 2008 reduced residential, commercial and industrial spending. With less money to spend, both residential and commercial and industrial customers cut back on electricity use, reducing GHG emissions from electricity.

7.0. Greenhouse Gas Emissions from the Combustion of Natural Gas

Tables 1 and 2 show that the GHG emissions associated with the combustion of natural gas fell 5% between 2008 and 2009 for Mankato and by 7% for North Mankato. There are two likely reasons for the decrease:

- The colder months (January, February, March, November and December) in 2009 were milder than in 2008; Mankato and North Mankato had about 3% fewer heating degree days in 2009 than in 2008. In buildings space heating can account for 80% of natural gas consumption, hence some of the decrease in natural gas GHG emissions could be due to the milder winter months in 2009.

- The economic downturn undoubtedly contributed to a reduction in the consumption of natural gas, just as it did for the consumption of electricity.

8.0. Greenhouse Gas Emissions from Transportation

8.1. Summary

The transportation sector includes vehicular traffic and transportation by air. Greenhouse gas emissions from transportation for Mankato and North Mankato are shown in Tables 5 and 6, respectively. About 98% of transportation GHG emissions for both 2008 and 2009 for both cities are from vehicular traffic; the remaining 2% are each city's share of the emissions from air travel to and from the Mankato Regional Airport. The transportation emissions for Mankato decreased by 1.0% from 2008 to 2009, whereas for North Mankato there was a 1.7% increase. Changes in vehicle GHG emissions dominated the transportation changes: for Mankato vehicle emissions decreased by 1.1%; for North Mankato, they increased by 1.6%.

Table 5. Mankato Greenhouse Gas Emissions from Transportation

Transportation Mode	2008 (metric tons)	Percent of Total	2009 (metric tons)	Percent of Total	Percent Change
Vehicles	115,478	98%	114,238	98%	-1.1%
Mankato Regional Airport - Mankato share	1,880	2%	1,982	2%	5.4%
Total	117,358	100%	116,220	100%	-1.0%

Table 6. North Mankato Greenhouse Gas Emissions from Transportation

Transportation Mode	2008 (metric tons)	Percent of total	2009 (metric tons)	Percent of total	Percent Change
Vehicles	28,159	98%	28,605	98%	1.6%
Mankato Regional Airport - North Mankato share	646	2%	677	2%	4.9%
Total	28,805	100%	29,292	100%	1.7%

8.2. Vehicle Greenhouse Gas Emissions

Vehicle GHG emissions depend on two factors, vehicle miles traveled (VMT) and the vehicle emission rate (in metric tons of CO_2e / million VMT). Annual VMT for Minnesota cities and counties are determined by the Minnesota Department of Transportation and archived on their website at www.dot.state.mn.us/roadway/data. The determination of the vehicle emission rate of a city for a particular year is complicated because it depends on a number of factors (refer to the Appendix for additional details):

- The distribution of annual vehicle distance traveled (DAVDT), also called the fleet distribution. This is the percentage of the total VMT by each of the three vehicle types on the road – passenger cars, light trucks, and heavy-duty vehicles.
- The mix of gasoline and diesel used by each vehicle type.
- The mix of ethanol in gasoline and biodiesel in diesel in fuel sales in Minnesota because of Minnesota's biofuel mandates.
- The mix of arterial VMT and VMT on local streets for each city for a particular year.
- The emission factors for all the transportation fuels.

Vehicle emission rates calculated by this method vary from year to year and from city to city. For Mankato, the vehicle emission rates for 2008 and 2009 are (in units of metric tons CO_2e / million VMT) 427.9 and 428.8, respectively, an increase of 0.2%. For North Mankato, the vehicle emission rates are 424.9 and 425.6, respectively, also an increase of 0.2%.

As has been previously noted, between 2008 and 2009 vehicle emissions decreased by 1.1% for Mankato and increased by 1.6% for North Mankato. These changes in vehicle emissions are due primarily to changes in VMT (a decrease of 1.3% for Mankato, and an increase of 1.4% for North Mankato), since the changes in vehicle emission rates for the cities were much smaller in this time period.

According to the *Protocol*, the ethanol in gasoline and the biodiesel in diesel are biogenic, hence the CO_2 produced in the combustion of just the ethanol and the biodiesel in these blended fuels is not counted as a greenhouse gas. This means that the vehicle emission factors for gasoline with ethanol and for diesel with biodiesel are lower than if pure gasoline and pure diesel were combusted.

Had pure gasoline and pure biodiesel been combusted, the vehicle emission rates for Mankato would have been 468.1 metric tons CO_2e / million VMT in 2008 (9% larger) and 470.7 metric tons CO_2e / million VMT in 2009 (10% larger). Vehicle emission rates for North Mankato in 2008 and 2009 would also have been larger, and by the same percentages. Stated another way, the use of biofuels in gasoline and diesel in Mankato in 2008 and 2009 avoided emissions of 10,431 and 11,183 metric tons of CO_2e, respectively; for North Mankato, the emissions avoided were 2,667 and 2,817 metric tons of CO_2e respectively.

8.3. Long-term Trends

Long-term trends in the vehicle emission rates and the VMTs for Mankato and North Mankato are shown in Figures 5 and 6 for the period from 2001 to 2010. Figure 5 shows that North Mankato's vehicle emission rate is consistently about 4 metric tons CO_2e / million VMT smaller than Mankato's. This is because of North Mankato's greater percentage of local streets, with their smaller proportion of heavy commercial vehicles when compared to arterials. Figure 6 shows that the VMT in Mankato is consistently about four times greater than in North Mankato. Over this period, the vehicle emission rate decreased by 6% for both Mankato and North Mankato while the VMT increased by 25% for Mankato and by 37% for North Mankato, resulting in an increase in vehicle emissions by 17% for Mankato and by 28% for North Mankato.

Figure 5. Vehicle Emission Rates, 2001 – 2010

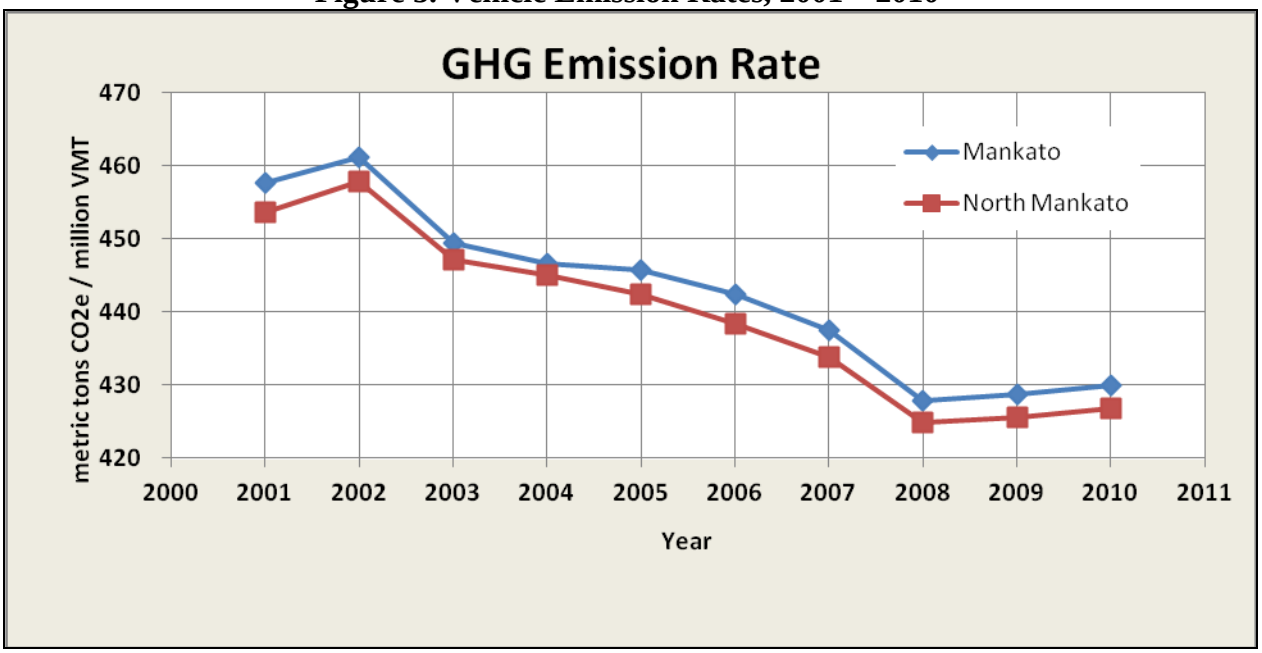
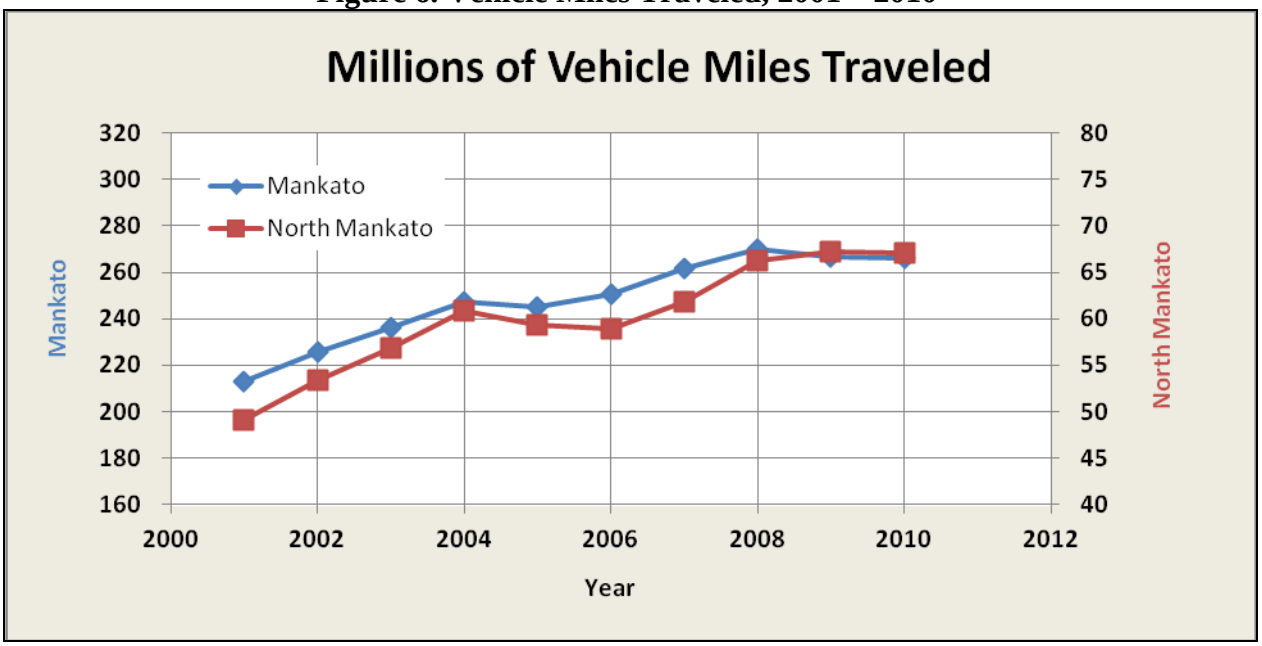


Figure 6. Vehicle Miles Traveled, 2001 – 2010



8.4. Greenhouse Gas Emissions from Freight Rail Traffic

Emissions from freight rail traffic within the cities' jurisdictional boundaries are not included in these inventories, as they are not required by the *Protocol*, and data on rail operations are notoriously difficult to obtain. In addition, rail emissions will most likely be small. Data from inventories for three other

medium-sized cities in Minnesota (Burnsville, Edina, and St. Louis Park) show emissions from rail operations to be less than 0.5% of transportation emissions, and Mankato's and North Mankato's rail emissions are most likely comparable.

9.0. Greenhouse Gas Emissions from Municipal Solid Waste

The processing of municipal solid waste (MSW) via incineration or by landfilling produces a very small percentage of total GHG emissions, about 1% for both Mankato and North Mankato. When MSW is incinerated, CO_2 is produced; when it is landfilled, CH_4 is produced. Some landfills reduce their GHG emissions by recovering and flaring the CH_4.

Municipal solid waste disposal for Mankato and North Mankato is handled by private waste haulers licensed by the Cities. All of the residential and some of the commercial MSW passes through the Minnesota Waste Processing Transfer Station in Mankato. Residential MSW is then sent to the Newport Resource Recovery Facility southeast of St. Paul where recyclables are separated out and the rest sent back for incineration at the Wilmarth Generating Station in Mankato. Commercial MSW is separated on site at the transfer station then incinerated at Wilmarth or landfilled at the Ponderosa Landfill in Blue Earth County. Although all the landfill gas at Ponderosa has been recovered and flared since 2010, there was no methane recovery for MSW disposed of at Ponderosa in 2008 or 2009.

10.0. Greenhouse Gas Emissions from the Treatment of Wastewater

Wastewater treatment produces an even smaller amount of GHG emissions than MSW processing. The City of Mankato Wastewater Treatment Plant (WWTP) serves both Mankato and North Mankato as well as a number of smaller communities. Emissions are produced from the electricity and natural gas used to operate the plant. In addition, the treatment process produces CH_4 and small amounts of N_2O. The CH_4 produced is either combusted for heat for plant operations or flared and almost none escapes to the atmosphere. The N_2O produced in a year is the source of less than 100 metric tons of CO_2e. Wastewater CH_4 and NO_2 emissions are thus very small and are not included in these inventories. The Mankato and North Mankato allocations of the electricity and natural gas GHG emissions from the treatment of wastewater have been included in Tables 1, 2, 3, and 4 and Figures 1, 2, 3, and 4. In Tables 3 and 4 and Figures 3 and 4, they are included in the commercial and industrial sector.

11.0. City Comparisons

A comparison of Mankato and North Mankato GHG emissions and GHG emissions per capita by sector for 2009 is shown in Table 7. We can see that per-capita emissions are roughly comparable except for the commercial and industrial sector. As has been noted before, this is because of the heavy industry present in Mankato but not North Mankato. If the emissions from the coal-burning facility and the eight largest industrial natural gas customers in Mankato were excluded, Mankato's commercial and industrial per-capita

emissions in 2009 would be 8.4 metric tons CO_2e, more in line with North Mankato's value of 6.3 metric tons CO_2e per capita.

Table 7. Comparison of Mankato and North Mankato Greenhouse Gas Emissions, 2009

Sector	Mankato		North Mankato	
	GHG Emissions (metric tons)	GHG Emissions per Capita	GHG Emissions (metric tons)	GHG Emissions per Capita
Residential	115,568	3.0	56,570	4.3
Commercial & Industrial	567,853	14.6	84,014	6.3
Transportation	116,220	3.0	29,282	2.2
Waste	10,879	0.3	1,948	0.1
CO2e Emissions Total	810,520	20.8	171,814	12.9
Population	38,908		13,295	

A comparison of Mankato and North Mankato GHG emissions per capita in 2009 with another Minnesota city for which data are available is shown in Table 8. The same methodology is used for all cities for this comparison: the vehicle emission rate is calculated by the method in the Appendix, and transportation includes only vehicular traffic and air transportation and not rail or river transportation. Residential emissions per capita are roughly the same for all cities, with Mankato having the smallest value at 3.0 metric tons CO_2e per capita. Transportation emissions per capita are largest for Burnsville, a suburban metropolitan city, with North Mankato having the smallest value at 2.2 metric tons CO_2e per capita. Mankato has the largest commercial and industrial emissions at 14.6; however, if Mankato's emissions from its coal-burning facility and its eight largest natural gas customers are excluded, its commercial and industrial emissions are 8.4, essentially the same as Burnsville at 8.6 (all numbers in metric tons CO_2e per capita).

Table 8. City Comparisons of 2009 Greenhouse Gas Emissions
(Metric Tons CO_2e per Capita)

Sector	Mankato	North Mankato	Burnsville
Residential	3.0	4.3	4.0
Commercial & Industrial	14.6	6.3	8.6
Transportation	3.0	2.2	4.3
Waste	0.3	0.1	0.1
CO2e Emissions Total	20.8	12.9	17.0
Population	38,908	13,295	61,047

Table 9 considers Mankato and North Mankato as a single regional center and compares its per-capita emissions with two other outstate regional centers, Rochester and Duluth. Residential emissions are smallest for Mankato and North Mankato combined at 3.3 and largest for Duluth at 5.6 (units are metric tons CO_2e per capita). In this comparison,

combined commercial and industrial per-capita emissions for Mankato and North Mankato are comparable to those of Rochester and Duluth; likewise, the per capita transportation emissions for all three regional centers are comparable.

Table 9. Regional Center Comparisons of 2009 GHG Emissions
(Metric Tons CO_2e per Capita)

Sector	Mankato / North Mankato	Rochester	Duluth
Residential	3.3	4.3	5.6
Commercial & Industrial	12.5	9.3	14.6
Transportation	2.8	3.0	3.5
Waste	0.2	0.3	0.2
CO2e Emissions Total	18.8	16.9	23.9
Population	52,203	104,578	85,530

12.0. Conclusions

Primary conclusions are as follows:

- Total GHG emissions for Mankato for the 2008 baseline year were 867,000 metric tons CO_2e (23 metric tons CO_2e per capita); for North Mankato, total GHG emissions were 182,000 metric tons CO_2e (14 metric tons CO_2e per capita).

- For the 2008 baseline year, for both Mankato and North Mankato, most GHG emissions by sector were from commercial and industrial, followed by residential, transportation, and waste. Most GHG emissions by source for Mankato were from electricity, followed by natural gas, coal, transportation, and waste; for North Mankato, most GHG emissions by source were from electricity, followed by natural gas, transportation, and waste (other fuels negligible).

- For both Mankato and North Mankato, total GHG emissions decreased from 2008 to 2009 (by 7% for Mankato, 5% for North Mankato). The most important factor in the decrease was the decrease in the electricity emission factor for both Xcel and Benco. Other factors in the decrease were the economic downturn and the weather. It is recommended that the Cities update the inventories for 2010, 2011, 2012 and 2013 to track the trends.

- Mankato's per-capita GHG emissions were much larger than North Mankato's because of Mankato's larger industrial base, in particular, because of a few large industrial emitters. Considering Mankato and North Mankato together as a single regional center, its per-capita emissions, total and by sector, were comparable to those of other regional centers in outstate Minnesota, in particular, Rochester and Duluth.

Appendix A
Calculation of Vehicle Emission Rates

This Appendix explains the method for calculating vehicle emission rates in these inventories. The calculation is found in the Mankato and North Mankato Data Files on the Vehicle Emission Rate A11 sheet.

To illustrate the method, consider the calculation on the sheet Vehicle Emission Rate A11 in the Mankato Data File to get the vehicle emission rate for Mankato in the baseline year 2008. The first step is to calculate the total gasoline VMT and diesel VMT. This is done by first calculating the VMT by each individual fuel type and vehicle type (gasoline passenger cars for example) and then adding the individual contributions together to get the total gasoline VMT and total diesel VMT. Inputs to the calculation are the Annual VMT, Mankato, the Distributions of Annual Vehicle Distance Traveled (DAVDTs), and the Distribution of Fuel Used by Vehicle Type (DFUVT). (Capitalization refers to the names of tables or entries in the Vehicle Emission Rate A11 sheet.) The calculation is complicated by the fact that MnDOT uses two DAVDTs, one for arterials and another for local streets.

Consider the calculation of VMT for gasoline passenger cars as an example. This calculation is broken into two parts, the VMT on arterials and the VMT on local streets. The VMT by just gasoline passenger cars on arterials is the total VMT on arterials (137,113,116 miles), multiplied by the DAVDT on arterials for passenger cars (65.9%), multiplied by the DFUVT of gasoline by passenger cars (99.5%), yielding 89,912,432 miles. Likewise, the VMT for just gasoline passenger cars on local streets is the total VMT on local streets (132,734,292 miles), multiplied by the DAVDT on local streets for passenger cars (67.9%), multiplied by the DFUVT of gasoline by passenger cars (99.5%), yielding 89,682,611 miles. Adding yields 179,595,707 miles, the total VMT by gasoline passenger cars on all roadways in Mankato in 2008. The other entries in the table VMT by Fuel and Vehicle Type are calculated in a similar way.

The second step is to calculate the Gallons of Fuel by Vehicle Type in the spreadsheet. This is done by dividing the VMT for a particular fuel type and vehicle type by the federal Energy Information Agency (EIA) Fuel Economy Assumption for that vehicle type. In our example of Mankato in 2008, the VMT for gasoline passenger cars is 179,595,043 miles. Divide that by the average fuel economy (average mileage) of passenger cars of 23.7 miles/gallon in 2008 to get 7,577,850 gallons of gasoline for passenger cars. The contributions from each vehicle type for each fuel type are then summed to get the Total Gasoline gallons and the Total Diesel gallons. Finally, each gallon of gasoline sold in Minnesota in 2008 and 2009 was 10% ethanol and each gallon of diesel sold was 5% biodiesel, because of the biofuels mandate. The biofuels portions are separated out and the gallons of all four fuels – gasoline, ethanol, diesel, and biodiesel – are listed in the table By Fuel Type.

The final step is to calculate the GHG emissions for each fuel type and vehicle type using the emission factors for each fuel. Ethanol and biodiesel are considered to be biogenic by the *Protocol*, so the CO_2 produced by their combustion is not counted as a greenhouse gas. The emission factor for unleaded gasoline is 8.78 kg CO_2 / gallon. The amount of gasoline used by passenger cars in 2008 was 7,577,850 gallons. Multiply 7,577,850 gallons by 90% to get the

gallons of unleaded gasoline without the ethanol, and then multiply by the emission factor to get 59,880 metric tons of CO_2. CO_2 emissions for each fuel type and vehicle type are then summed to get total CO_2 emissions in metric tons (Total CO_2 mt). Total CH_4 and N_2O emissions are found in a similar way except that the emission factors for these greenhouse gases are expressed in grams/mile rather than kilograms/gallon, so the emission factor must be multiplied by the total VMT for each fuel type and vehicle type rather than by the total gallons. Finally, the amount of each GHG is multiplied by its global warming potential (GWP) and all three contributions summed to get the total fossil fuel emissions in metric tons of CO_2e. The Total Fossil CO_2e in metric tons per million VMT is then the vehicle emission rate. For Mankato in 2008, the vehicle emission rate was 427.9 metric tons of CO_2e/million VMT.

Appendix B
Spreadsheets for the Cities of Mankato and North Mankato
(the following list of spreadsheet titles applies to the sheets for both cities)

A1. Summary of Greenhouse Gas Emissions
A2. Energy Consumption and Associated Greenhouse Gas Emissions
A3. Xcel Energy Data
A4. Benco Electric Cooperative Data
A5. CenterPoint Energy Data
A6. Greater Minnesota Gas Data
A7. Independent Generators
A8. Greenhouse Gas Emission Factors for Utilities
A9. Greenhouse Gas Emissions Associated with Transportation
A10. Vehicle Miles Traveled and Associated Greenhouse Gas Emissions
A11. Vehicle Emission Rate
A12. Airport-Related Emissions
A13. Greenhouse Gas Emissions Associated with Waste Management
A14. Waste Water Energy Use and Associated Greenhouse Gas Emissions
A15. City Comparisons, 2009