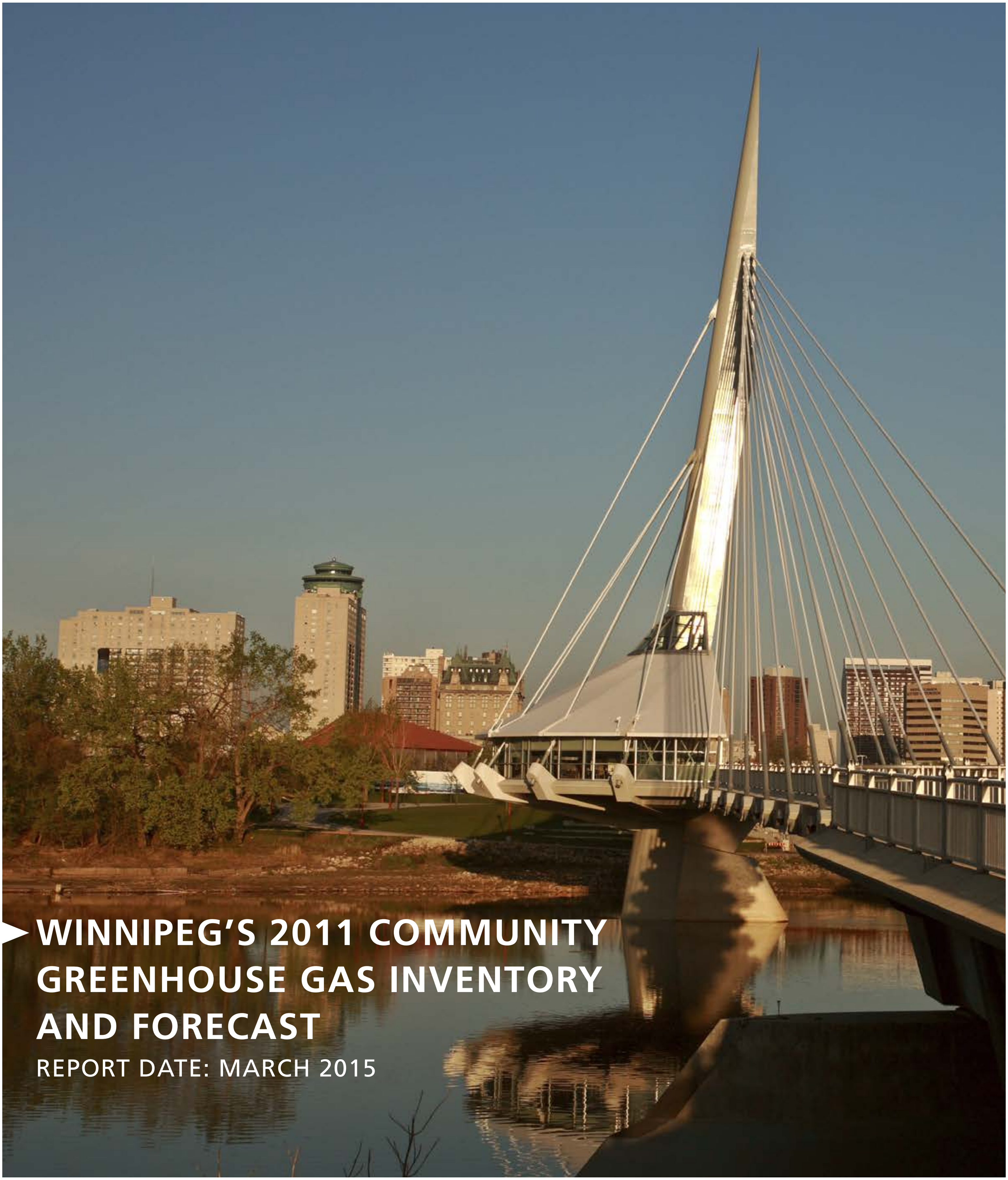

WINNIPEG'S 2011 COMMUNITY GREENHOUSE GAS INVENTORY AND FORECAST

REPORT DATE: MARCH 2015

Golder Associates

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ACKNOWLEDGEMENTS

This Plan was financed by the City of Winnipeg. Golder Associates was responsible for overall project management, analysis, strategic planning, and policy development with considerable contributions from the City's Project Steering Committee. The Plan benefitted from significant guidance and input from community stakeholders and City staff.

City Contributing Divisions

Core Project Team – Urban Planning Division

Planning, Property, and Development

Transportation Division

Public Works

Winnipeg Transit

Solid Waste, Water, & Wastewater Division

Water & Waste Division

Infrastructure Planning Division

Corporate Finance

Low Carbon Path Workshop Attendees

50 by 30

Manitoba Chapter, Canada Green Building Council

Manitoba Geothermal Alliance

Manitoba Home Builders Association

Manitoba Hydro

Manitoba Trucking Association

Province of Manitoba

Province of Manitoba

Richardson College for the Environment

Social Planning Council of Winnipeg

University of Manitoba

Urban Development Institute

Winnipeg Realtor's Association

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EXECUTIVE SUMMARY

The City of Winnipeg recognizes that climate change is a serious global environmental problem and thus endorsed *A Sustainable Winnipeg*, emphasizing a commitment to a 6% reduction in community emissions below 1998 levels. This commitment did not include a target year. Council has correspondingly committed to the development of a community Climate Action Plan including recommendations on how to achieve the 6% target. Although Council has established a target, *OurWinnipeg* does not provide specific guidance on how this target would be achieved.

In support of the carbon reduction strategy, the City of Winnipeg worked with Golder to provide an updated community energy and greenhouse gas inventory, and to forecast the energy and emission reductions that are likely to occur in Winnipeg as a while under three illustrative scenarios:

- **Business as Usual Scenario:** Depicts the likely emissions future should Winnipeg continue to grow as it has in the recent past, but in accordance with current market forecasts. Recent policy goals and targets associated with *OurWinnipeg* and related strategies are not considered.
- **OurWinnipeg Scenario:** Depicts the concerted implementation of measurable policies and actions adopted with *OurWinnipeg* that are likely to impact Winnipeg's energy use and greenhouse gas emissions. This scenario is guided by numerous recent strategies including *A Sustainable Winnipeg*, *Completed Communities*, the *Transportation Master Plan*, and the *Garbage and Recycling Master Plan*.
- **Low Carbon Path Scenario:** Depicts a series of outcomes leading to more significant reductions in community-wide energy consumption and greenhouse gases that are ambitious, yet achievable. This scenario presumes a desire to implement and lead world class reduction commitments that are ambitious, yet achievable.

All three scenarios incorporate the impact of adopted senior government regulations such as new vehicle efficiency standards and the Manitoba Energy Code for Buildings.

Golder undertook a review of the previously compiled 1994 and 1998 community wide energy and emissions inventory and produced a comprehensive inventory for 2011 using best practice accounting standards. Previous inventories were created with data and methods that are not compatible with modern reporting methods. Thus, comparisons between these inventories and the new comprehensive inventory for 2011 are difficult and may not necessarily reflect an accurate depiction of the changes in Winnipeg GHG emissions.

Under the Business as Usual Scenario, it was estimated that Winnipeg's GHG emissions would increase 2% by 2031 and 0.2% by 2050. This is primarily associated with increases in population competing with effects such as federal tailpipe emission standards, Manitoba Hydro demand-side management conservation programs, and increases in building energy efficiency due to newer technology.

Under the OurWinnipeg Scenario, more substantial reductions would occur, with GHG emissions declining 6% by 2031 and 11% by 2050. Although overall GHG emission reductions are not as prominent after 2031, projected increases in population translate to significant reductions in per capita emissions up to 2050. Above and beyond the reductions seen in the Business as Usual Scenario, GHG reductions are most significantly associated with increased diversion of organic waste, mitigation of landfill gas, expanded public transit and cycling lanes, and a shift toward multi-unit residential buildings.

Under the Low Carbon Path Scenario, emissions would decline 21% by 2031 and 35% by 2050. This is primarily due to aggressive City policies such as promotion of infill, multi-unit residential buildings, building-scale renewables, district energy systems, and electric vehicles. As population is forecasted to increase, overall decreases in GHG emissions represent sharp reductions in per capita emissions in this scenario.

Emission reduction opportunities beyond those currently pursued in the *OurWinnipeg* planning initiative were developed and analyzed as a part of the Low Carbon Path Scenario. Key opportunities include:

- Emphasis on development of highly walkable, transit-friendly, mixed-use complete communities;
- Pursuit of infill development as a primary growth strategy;
- Promotion of modest growth in building-scale renewable energy and district energy systems;
- Completion of the rapid transit network and improvement of transit service;
- Completion of active transportation network and promotion of alternative transportation options;
- Increased uptake of electric and low-emission vehicles, including partial electrification of the transit fleet;
- Enhancement of *Garbage and Recycling Master Plan* through increased composting and diversion;
- Expansion of landfill gas collection system for non-City landfills; and,
- Elimination of biosolid landfilling.

A summary of the impact of the emission reduction opportunities is shown below in Figure 1, with each emission reduction opportunity shown as having an incremental reduction in City emissions.

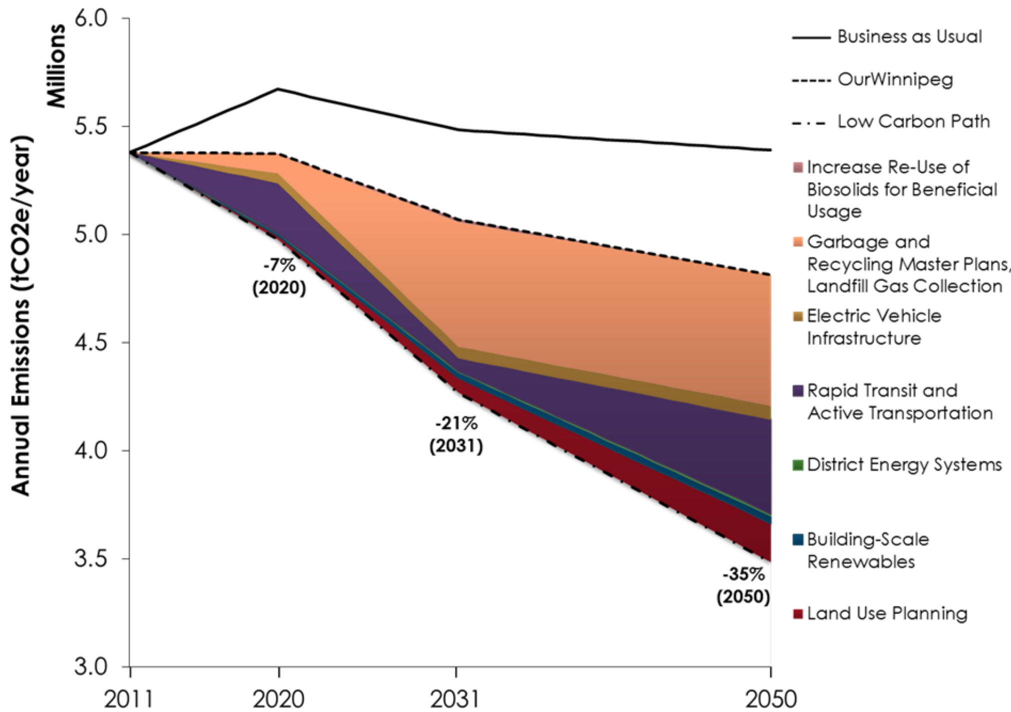


Figure 1: Summary of Emission Reduction Opportunities

1.0 INTRODUCTION

1.1 Terms of Reference

Golder Associates Ltd. (Golder) was contracted by the City of Winnipeg (the City) to develop a community greenhouse gas inventory and forecast for the City of Winnipeg. The City of Winnipeg Community Greenhouse Gas Inventory, Forecast and Emission Reduction Opportunity Assessment has been conducted in accordance to the scope of work outlined in RFP No 631-2012, subsequent addenda and detailed in the Golder Proposal dated October 17, 2012.

In support of the carbon reduction strategy, the City of Winnipeg worked with Golder to develop a community GHG inventory, emission forecasts and an emission reduction opportunity assessment.

1.2 Scope of Study

The City of Winnipeg recognizes that climate change is a serious global environmental problem resulting from the accumulation of greenhouse gases (GHG) in the atmosphere. Recognizing the importance of dealing with climate change, on November 25, 1998, the City of Winnipeg committed to the Federation of Canadian Municipalities (FCM) Partners for Climate Protection (PCP) program. The (PCP) program is a network of Canadian municipal governments, representing more than 80 per cent of the Canadian population, that have committed to reducing greenhouse gases (GHG) and to acting on climate change.

Winnipeg's commitment to reduce GHG emissions is emphasized in the City's sustainability strategy – *A Sustainable Winnipeg*. This sustainability strategy is part of the City's *OurWinnipeg* planning initiative. To achieve significant energy conservation and GHG reductions in the community, the development of a climate action plan with a vision, overarching and sector-specific goals, policies, and actions are proposed. The City's overarching goals include:

a) The intensification of energy and emissions policies and actions undertaken by the City within its sphere of influence as a local government;
b) Engagement with senior governments on realistic policies and measures within their sphere of influence; and,
c) Pursuit of Council's 6% reduction target in community-wide emissions from 1998 levels.

In support of the carbon reduction strategy, the City of Winnipeg worked with Golder to develop a community GHG inventory, emission forecasts and an emission reduction opportunity assessment. The objectives of the strategy are to:

a) Develop a robust measurement of Winnipeg's community greenhouse gas emissions inventory and key performance indicators.
b) Perform careful and scientifically defensible analyses and forecasts of the energy and emissions impact that consider:
    1) Relevant proposed or adopted local and senior government policy and actions;

2) Future changes in community land use, transportation, waste and wastewater management corresponding to the direction established by the City's development plan, *OurWinnipeg*, and supporting strategies;
3) Additional opportunities pertaining to the carbon reduction experience in other cities; and,
4) Additional opportunities developed through consultation with Council, City staff, stakeholders, and the broader community.

c) Model a low carbon path and fine-tune strategies to achieve a balance of emission reductions with efficient efforts across each sector.
d) Create a public-facing technical report summarizing all findings.

The geographic scope of the study is limited to energy consumed and greenhouse gases generated within the City of Winnipeg city limits, with the exception of City of Winnipeg waste landfilled outside of the city limits.

The following report summarizes the findings of the study.

1.3 Report Structure

The Plan is organized into seven sections:

Section 1: Introduction describes the scope of the study and outlines the report structure.

Section 2: Background provides a profile of the City energy and emissions and examines local regional climate and energy context for the Plan.

Section 3: Methodology presents the overall study methodology and data sources used in the preparation of this study.

Section 4: Energy and GHG Inventory describes the community GHG forecast for the City of Winnipeg for the 2011 calendar year by source.

Section 5: Energy and GHG Forecasts provides community GHG forecasts for the 2020, 2031 and 2050 calendar years corresponding with three development scenarios.

Section 6: Analysis of GHG Emission Reduction Opportunities evaluates a selection of GHG reduction policy actions for their overall impact on community GHG emissions.

Section 7: Recommended Further Actions details suggested steps that the City of Winnipeg could consider toward developing their current carbon reduction strategy.

Section 8: Report Limitations details the stated limitations of the use of this report, inventory and forecast.

Section 9: Works Cited provides a list of documents where information and data is referenced from in this report.

Section 10: Closure provides a sign-off of the report by the Golder project team.

2.0 BACKGROUND

2.1 Community Profile

Winnipeg, the largest city in Manitoba, serves as the capital of the province. Winnipeg experiences a continental climate with hot summers and cold winters. A multiethnic modern municipality and regional centre, the community has diverse economy based on manufacturing, service, government, and trade.

With a 2011 city population of over 690,000, Winnipeg is currently experiencing rapid population growth. After a flat growth period in the 80s and 90s, the City experienced a rapid population growth driven by immigration and migration from the rest of Canada. This growth is forecasted to continue at 9,000 to 10,000 new residents per year over the next 20 years, shown in Figure 2.

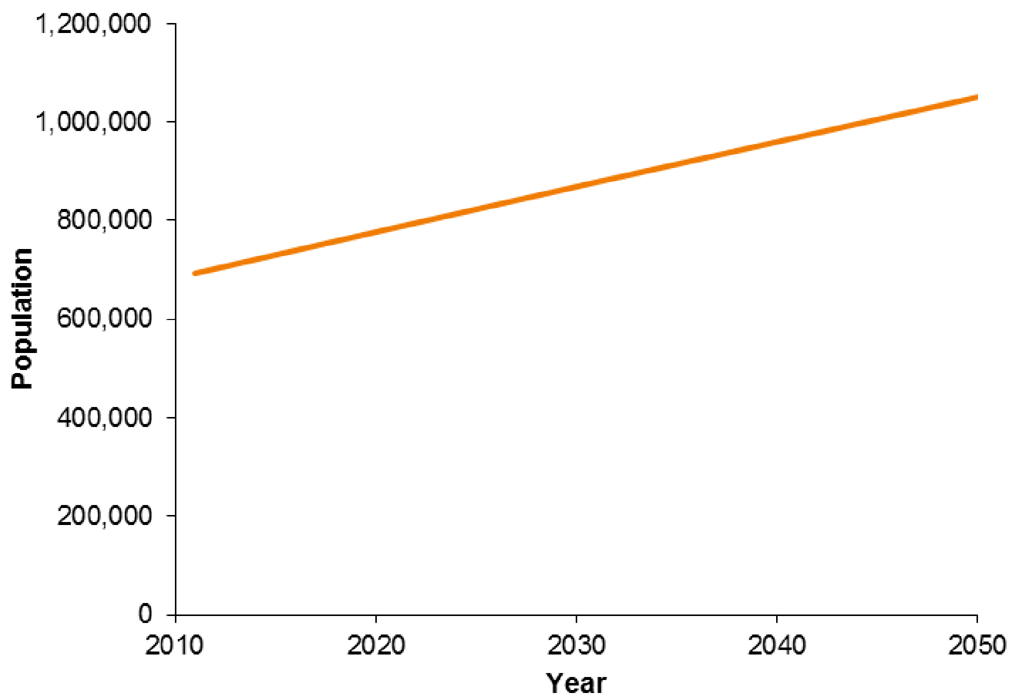


Figure 2: Forecasted Population Growth [1]

The City of Winnipeg at a Glance

- Population (2011): 691,800
- Projected Population (2031): 876,700
- Jobs in Winnipeg (2011): 392,640
- Projected Jobs (2031): 489,600
- Per Capita GHG Emissions in Winnipeg (2011): 7.59 tonnes CO_2e/person/year

Winnipeg obtains both electricity and natural gas from Manitoba Hydro – the provincial energy utility. Electricity rates in Manitoba, Winnipeg included, are some of the lowest in the country and natural gas prices are on par with the rest of the country. Manitoba generates electricity almost exclusively from hydroelectric, with small amounts of thermal power used for peaking and backup loads. As a result, Winnipeg has very low greenhouse gas emissions associated with electricity consumption.

Winnipeg serves a regional transportation hub with a broad transportation system that includes a large network of surface streets, rail service and an international airport. The road transportation system consists of a large ring road – the Perimeter Highway –

that connects to the Trans-Canada highway as well as other provincial highways. Within the city, several major arterial roads provide high-volume vehicle roadways that service the city. Adjacent to the airport and within city limits, the City operates CentrePort Canada, an inland port for trucking routes, rail carriers and air cargo.

Public Transit in Winnipeg is operated by Winnipeg Transit. Winnipeg Transit is a bus-based system, and in recent years has begun to implement measures to optimize operation, including transit priority signals, diamond lanes for transit, and BRT (bus rapid transit). Winnipeg Transit has a fleet of approximately 580 buses on 95 routes within the city. Winnipeg Transit's first segment of BRT, Phase 1 of the Southwest Transitway, opened in 2012. 13 routes make use of the corridor. A second phase of this line is in the process of being planned to extend service to the University of Manitoba, and 5 additional legs of rapid transit are ultimately anticipated.

The City of Winnipeg operates one active landfill for disposal of solid waste: the Brady Road Resource Management Facility, also known as the Brady Road Landfill. The landfill accepts waste from residential, industrial/commercial, construction/demolition, and city operation sources. Recycling and composting can also be done at the landfill for items such as yard waste, scrap metal, bicycles, batteries, and used tires. The Brady Road Resource Management Facility operates a landfill gas collection system. Additional private landfills are operated in proximity to the City of Winnipeg and receive commercial, industrial, construction and demolition waste from Winnipeg.

Potable water for Winnipeg comes from Shoal Lake and is stored at the Deacon Reservoir. Before being delivered to the end users, potable water goes through a treatment process. Wastewater is collected in sewer systems and septic tanks and the majority of it is treated in the North End Water Pollution Control Centre, with the remainder treated by the West End Water Pollution Control Centre and the South End Water Pollution Control Centre.

The following sub-sections provide additional detail with respect to community factors influencing greenhouse gas emissions in key areas.

2.2 Buildings

With a significant percentage of overall residential building stock dedicated to single family housing, the City of Winnipeg is one of the lowest density cities in Canada, outside of Alberta. Greenfield development continues to represent a majority of overall community growth; while the downtown core of Winnipeg is the major centre of employment in the City, but has limited residential buildings within the core itself. However, the core of Winnipeg is experiencing a re-vitalization with increased focus on infill development and promotion of residential growth closer to the city core.

The use of electricity and natural gas by residential buildings constitutes the largest share of energy and greenhouse gas (GHG) emissions in the buildings sector. In commercial and residential buildings, electricity is used for heating/hot water, lighting and appliances, and natural gas for space heating and heating hot water. The key factors affecting energy use in residential and commercial buildings are:

- Building type and size;
- Building energy efficiency, influencing energy consumption; and,
- Energy sources – e.g., hydro-electricity, natural gas, solar thermal.

Climate plays a major factor in building energy use. Winnipeg experiences hot summers and cold winters, leading to a high air conditioning load in the summer and high heating load in the winter. Buildings in Winnipeg also experience significant solar exposure as the weather is often sunny. Thus, the addition of solar water heaters may be an increasingly viable method of reducing energy consumption.

Housing type can influence residential building energy use. Typically, attached and multi-unit residential buildings tend to consume less energy per unit floor area than detached buildings due to shared walls and fewer exposed surfaces. Although this is not always the case because of factors such as differences in construction standards, empirical data suggests that, on average, energy use per person is significantly lower (up to 48%) for apartment towers compared to single-family residences. On a municipal basis, this means that higher density development reduces building energy consumption and GHG emissions when compared to single family homes.

Table 1 below presents the overall breakdown of single family and multi-unit residential buildings in 2011.

Table 1: City of Winnipeg Housing Mix (2011) [2]

Residential Building Type	Household Count	Percentage
Single Family	184,740	63%
Multi-Unit Residential Buildings	106,575	37%

Another important factor in energy use in buildings is the age of the building. Based on Canadian EnerGuide assessments, on average the older the home, the higher the energy consumption (based on a per-area basis). Given limited growth in City population since 1990, the average building age in Winnipeg is older than in similar prairie cities that have had more consistent growth patterns. Recently, the province of Manitoba has adopted the 2010 National Model Construction Codes which have provisions for increased energy efficiency for new construction. Over time, the implementation of the new building code will gradually reduce building per capita energy and GHG intensities.

While the energy efficiency of individual devices and appliances continues to improve, the adoption of new and emerging technologies such as smart phones, tablets, PVRs and personal computers lead to increased electricity consumption per capita. As personal consumer electronics continue to grow in availability and popularity, these trends will likely continue.

Winnipeg obtains both electricity and natural gas from Manitoba Hydro – the provincial utility. Manitoba generates electricity almost exclusively from hydroelectric, with small amounts of thermal and wind power. Future expansion of Manitoba Hydro hydroelectric assets would suggest that low-carbon hydroelectricity will continue to represent that vast majority of electricity provided to the City of Winnipeg. Winnipeg does import some fossil energy from the regional network, which has a significant impact on electricity emissions in years of drought.

Within the City of Winnipeg, a limited number of buildings use geothermal building-scale renewables to displace natural gas use. Building-scale renewables have fewer GHG emissions than natural gas use for heating. Building-scale renewables for electricity generation would not have the same benefit due to the low electricity cost and GHG emissions in Winnipeg.

District energy systems are one of the most efficient forms for heating commercial and multi-unit residential buildings. Conversion from fuel to heat is done at one centralized site instead as opposed to in each building or home. In addition, district energy system often can capture waste heat, increasing the overall efficiency. Because one large system is used to serve the needs of many customers, fuel type is very flexible in district energy systems, with systems having the ability to use conventional fuels such as natural gas, or renewables. Currently, the City has very few district energy systems in operation, limited to several residential complexes and a few other applications, including the Manitoba Hydro building downtown and the University of Manitoba district waste heat recovery system.

2.3 Transportation

Personal vehicle travel is the predominant mode of transportation in the City of Winnipeg, representing 81% of total weekday trips. Primary factors influencing the relatively high mode share associated with personal vehicle travel include the relatively low-density across much of the City, and the distances between people’s homes and their daily destinations (i.e., work, school, shopping, and areas of recreation). Within this context, cold winter temperatures only further discourage active and alternative modes of transportation.

Compact, mixed-use development that is focused around direct transit routes creates urban form that increases liveability of neighbourhoods and accessibility to daily destinations and amenities, while decreasing resource use and greenhouse gas emissions associated with transportation. To help the City move towards this type of urban form, Winnipeg has created neighbourhood and community plans; however, Winnipeg's current densities, land use mix, and transportation network limit low carbon transportation alternatives.

A mixed land use provides nearby options for working, shopping, school, and recreation that, as a result, decrease auto dependency. Winnipeg's City Centre and key redevelopment areas are becoming increasingly walkable with a diversity of key destinations. However, these destinations are not necessarily easily accessible by transit, walking, and cycle by a significant portion of residents, especially those living at the City peripheries.

2.4 Waste

Community waste generation rates in Winnipeg are similar to other Canadian municipalities with a mix or inorganic and organic waste. The City operates city-wide collection service with traditional waste collection and a blue-box recycling program for non-organics. Organics recycling is planned as a part of the City of Winnipeg *Garbage and Recycling Master Plan*, but is currently limited to a yard waste collection program and voluntary composting facilities operating throughout the community. Residential and some commercial/institutional waste is currently sent to and disposed at the Brady Resource Recovery Centre. Additional commercial, industrial and construction waste is collected by private landfills operated within or near the City of Winnipeg boundaries. While waste generation is similar to other Canadian cities, diversion rates have been comparatively poor in Winnipeg. This has been improving with the adoption of the *Garbage and Recycling Master Plan*.

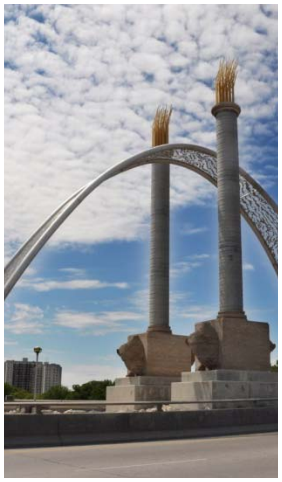
For accounting purposes under the ICLEI protocol, all landfill emissions related to the decomposition of waste generated in the City of Winnipeg are assumed to be attributable to the community, regardless of whether the landfill is located within the community boundaries. Greenhouse gas emissions from the solid waste sector are calculated using a "methane commitment" approach, where Scope 3, indirect emissions, that occur outside the geographic boundaries of the City are included in the City's inventory. The methane commitment method attributes all future emissions to the year in which the waste was produced. The main advantage of using the methane commitment method is that it provides results that are comparable to the estimated emissions avoided by reduce, reuse, and recycle programs. For example, reducing the amount of waste produced avoids all emissions that would have been released over the lifetime of the waste's decomposition.

Since landfill GHG emissions are due primarily to organic waste, the amount of organic waste sent to the landfill is the primary factor in landfill emissions. Traditional landfill gas is formed from the decomposition of organic wastes which is then released uncontrolled to the atmosphere. In 2013, the City of Winnipeg constructed and began operation of a landfill gas system at the Brady Resource Recovery Centre that captures a large percentage of the landfill's methane emissions and converts them through combustion to the less impactful carbon dioxide, reducing the life-cycle GHG intensity of the landfill by up to 80%.

2.5 Water and Waste Water

GHG emissions from waste treatment primarily result from the production of biogas from sludge digestion and waste water decomposition. The City currently operates three waste water treatment plants: the North End Water Pollution Control Centre; the South End Water Pollution Control Centre, and West End Sewage Pollution Control Centre.

Currently, the waste water plants produce biosolids which are either composted or landfilled. The City is currently working to increase the percentage of biosolids either composted or sold for beneficial usage as fertilizer or soil conditioner. Biosolids were 100% landfilled in 2011; however, a composting trial is scheduled to begin in 2015. The biogas produced is collected and stored for use as heating or alternatively, combusted to carbon dioxide when no heating load is present.



3.0 METHODOLOGY

For this study, the inventory and forecasts were developed through active engagement between the City and key stakeholders, rigorous analysis, and innovative policy and planning. Briefly, the approach involved the following steps:

Data Collection

A first step of the process was data collection and analysis. Data was requested from a variety of sources, including the City of Winnipeg, Manitoba Hydro, Manitoba Public Insurance and the James Armstrong Richardson Airport. Data sources used in the inventory are discussed in more detail in Section 4.3. Note that the James Armstrong Richardson Airport was not able to provide any GHG data.

GHG Inventory Development

The next step was the development of a GHG Inventory representing the current activities in the City, using 2011 data. This inventory was created following the ICLEI protocol for accounting and reporting greenhouse gas emissions for communities [3]. The GHG Inventory provided a baseline understanding of current emissions performance within the City.

Business as Usual and OurWinnipeg Scenario Development

A Business as Usual forecast was created to show the likely emissions future in the absence of municipal intervention through the policy commitments and action statements associated with *OurWinnipeg* and its supporting strategies. An OurWinnipeg forecast was developed based on the expected maximum potential of the City's *OurWinnipeg* planning blueprint. The OurWinnipeg forecast represents the likely emissions future based on the City's current plans for growth and management. Forecasts were created for 2020, 2031, and 2050. Both scenarios used identical population forecasts, based on the Conference Board of Canada report on the Winnipeg CMA [1]. As the Conference Board of Canada only had values up to 2035, forecasts were extrapolated to 2050.

Low Carbon Path Scenario Development

To identify key areas of opportunity for new emission reductions and their expected impact, a Low Carbon Path was considered. The Low Carbon Path will likely require community, local and senior government leadership, including the adoption of new commitments extending beyond the present scope of *OurWinnipeg* and its supporting strategies.

On May 30th, 2014, the City met with key stakeholders to identify high level strategies and priorities to inform a potential Low Carbon Path for the City. Participants suggested and ranked a number of community-based actions and initiatives which could be enacted to realize emission reductions in Winnipeg. Low carbon emission reduction opportunities were then analyzed for economic, technical, and political feasibility. Using the refined list of ideas for a low carbon strategy, a Low Carbon Path forecast was developed for the City to determine the potential reductions in GHGs. Forecast were created for 2020, 2031, and 2050. Population forecasts used were identical to the Business as Usual and OurWinnipeg Scenarios. **Appendix D** contains a summary of the ideas generated in the Low Carbon Path Workshop breakout sessions.

Looking Forward

Recommendations for the creation of a Climate Action Plan were put together to assist the City in their task of guiding Winnipeg toward a green and sustainable future.

4.0 ENERGY AND GHG INVENTORY

4.1 General Approach

The protocol includes guidance on scoping, and lists the five ICLEI basic emission-generating activities that must be included in all GHG emission reports.

The inventory was created following the 2012 "U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions", developed by ICLEI – Local Governments for Sustainability USA [3]. The standard was designed to guide local governments in the accounting and reporting of greenhouse gas (GHG) emissions associated with communities.

The protocol includes guidance on scoping, and lists the five ICLEI basic emission-generating activities that must be included in all GHG emission reports:

- Use of Electricity by the Community
- Use of Fuel in Residential and Commercial Stationary Combustion Equipment
- On-Road Passenger and Freight Motor Vehicle Travel
- Use of Energy in Potable Water and Wastewater Treatment and Distribution
- Generation of Solid Waste by the Community

For more details on the methodology used, please refer to **Appendix A**.

4.2 Scope of Study

A summary of the community sectors included within the City of Winnipeg Energy and GHG Inventory is presented in Table 2, along with corresponding ICLEI activities.

Table 2: Community Sectors and ICLEI Activities

Community Sector	ICLEI Activities Included
Building Electricity and Natural Gas	Use of Electricity by the Community, Use of Fuel in Residential and Commercial Stationary Combustion Equipment
Vehicles	On-Road Passenger and Freight Motor Vehicle Travel
Transit	On-Road Passenger and Freight Motor Vehicle Travel
Waste Disposal	Generation of Solid Waste by the Community
Water and Waste Water	Use of Energy in Potable Water and Wastewater Treatment and Distribution

The following items were not included within the scope of the Energy and GHG Inventory:

- Fugitive emissions from refrigerant / coolant use
- Indirect emissions from transboundary on-road inter-city or international transportation trips that originate and/or complete their journey within the City
- Railway emissions
- Water-borne navigation emissions
- Aviation emissions
- Off-road transportation emissions
- Industrial process emissions
- Agriculture, forestry, and land use emissions
- Transboundary emissions due to exchange / consumption of goods and services

These items were not included because they are either insignificant (and thus considered de minimis), their activities are not occurring with the City of Winnipeg, or accurate data was not readily available at the time of study. For more details on the scope, please refer to **Appendix A**.

4.3 Data Sources

Key data sources for the Energy and GHG Inventory are shown below in Table 3.

Table 3: Energy and GHG Inventory Data Sources

Item	Data Provided	Data Source
Building Electricity Consumption	kWh of electricity consumption by building type over 2011 fiscal year (April 1, 2011 to March 31, 2012)	Manitoba Hydro
Building Natural Gas Consumption	m^3 of natural gas consumption by building type over 2011 fiscal year (April 1, 2011 to March 31, 2012)	Manitoba Hydro
Transit Vehicle Fuel Consumption	L of B2 diesel fuel for all transit vehicles	Winnipeg Transit
Vehicle Kilometers Travelled	vkmt by vehicle and fuel type for residential and commercial vehicles	Calculated using Golder transportation model
City of Winnipeg Registered Vehicle Count	number of vehicles by vehicle and fuel type for residential and commercial vehicles	Manitoba Public Insurance

Item	Data Provided	Data Source
Waste Generated and Disposed in Landfills	tonnes of waste generated and disposed in landfills for residential, industrial/commercial, construction/demolition, and City operations	City of Winnipeg *Garbage and Recycling Master Plan*
Landfill Gas System Information	% coverage, % efficiency	City of Winnipeg *Garbage and Recycling Master Plan*
Breakdown of Landfilled Waste	% breakdown of landfilled waste by type for residential, industrial/commercial, construction/demolition, and City operations	City of Winnipeg *Garbage and Recycling Master Plan*
Wastewater Characteristics	m^3 of biogas produced, tonnes of biosolids produced, wastewater quality, wastewater volume	City of Winnipeg

For more details on the data sources used, please refer to **Appendix A**.

4.4 Building Electricity and Natural Gas

Building electricity consists of the GHG emissions incurred through the use of electricity in residential, commercial, and industrial buildings within the City of Winnipeg. Emissions from the consumption of electricity appear at the source – where the electricity is generated – as opposed to where the electricity is being used. As Winnipeg obtains the majority of electricity from hydroelectric generating stations, GHG from the consumption of electricity are much lower on a per kilowatt-hour basis than other Canadian cities. However, Winnipeg's clean low-emission electricity is vulnerable to factors such as unpredictable drought, which may dramatically increase electricity emissions in future years.

Building natural gas is comprised of the GHG emissions due to the combustion of natural gas in residential, commercial, and industrial buildings, as well as stationary combustion within the City of Winnipeg. Natural gas is used within the city for space heating and hot water heaters and, thus, is very dependent on annual variations in weather. Due to Winnipeg's continental climate which experiences cold winters, natural gas use is quite high compared to other, more temperate Canadian cities. Therefore, natural gas usage for space heating represents a significant contributor to GHG emissions in Winnipeg.

The winter of 2011 was an unseasonably warm as thus experienced a notably lower than average natural gas consumption. A discussion of how the 2011 natural gas consumption was adjusted in future forecast scenarios is discussed in Section 5.3

4.5 Transit

Currently, public transportation in Winnipeg is facilitated by a network of buses which serve the transit needs of residents. Buses in the City are fueled by B2 diesel; a common blend of biodiesel comprised of 98% petrodiesel and 2% biodiesel. For the 2011 inventory, electric buses were not yet in use within the City, but as of 2015, Winnipeg Transit is testing four new battery-powered electric buses in a four-year trial program.

4.6 Vehicles

GHG emissions from residential and commercial vehicles depend on the vehicle and the distance travelled. A list of registered vehicles was provided by Manitoba Public Insurance. Based on the vehicles age, make, model, fuel consumed, and/or description, the registered vehicles were matched with a fuel consumption rate and associated greenhouse gas emission factors, taken from the 2012 Climate Registry [4] and the US Department of Energy; Energy and Efficiency and Renewable Energy [5].

Vehicles were categorized as being Passenger Vehicles, Light Truck, or Heavy Truck, depending on the make and model. Additionally, vehicles were separated into gas, diesel, and CNG fueled vehicles. Average distance travelled per vehicle was calculated with a Golder model. The Golder model set up 465 traffic zones in Winnipeg, and calculated the number of trips by mode between, within, and from each traffic zone to surrounding areas. Standard weekly and daily patterns were applied to the model, calibrated with data from other prairie cities and indicators from the Transportation Association of Canada.

Calculated emissions may not be based on factors such as driver behaviour and road conditions. While these factors do have an impact on vehicle emissions, the model only deals with average fuel consumption rates.

4.7 Waste Disposal

All non-recycled, non-composted solid waste in the City of Winnipeg was considered to be landfilled at either the City-operated Brady Resource Recovery Centre or at nearby private landfills. While private landfills may not necessarily be within the City boundaries, emissions associated with Winnipeg-generated community waste is attributable to the City in the community GHG inventory. Landfill emissions are unique among sources of emissions in that the emissions are generated over long periods of time from the activity that caused them. For the purposes of the inventory, life cycle emissions were taken as occurring within the year of disposal, as per the methane commitment method of accounting landfill GHG emissions [3]. This calculation method is quicker and simpler than using the first order of decay model, which requires knowledge of historic waste disposal information, while still providing accurate results.

Emissions from waste generation were separated into the following sub-categories:

- Residential;
- Industrial and commercial;
- Construction and demolition; and
- City operations.

Note that wastewater biosolids were not included within this section as they are covered under the following section, Water and Waste Water. Also note that composting was not considered as contributing to City of Winnipeg GHG emissions because composting was assumed to be carbon neutral.

A landfill gas cap and collection system was first commissioned in 2013 to capture methane emissions, which are presently flared, and convert methane emissions into carbon dioxide, which is far less GHG-intensive. It is anticipated that the landfill gas collection system will continue to be expanded in tandem with new areas of the landfill. The amount of methane conversion is based upon the landfill gas coverage, date of installation, and efficiency the system.

4.8 Water and Waste Water

Waste water includes both the treatment and disposal of waste water in the City of Winnipeg. GHG emissions from waste water depend on the type of process used and amount of waste water generated. Emissions from biogas combustion, waste water processing, biosolids landfilling, and biosolids composting were included within this section. Waste water processing electricity consumption was not included within this section because it was covered under Building Electricity.

4.9 GHG Emissions Summary

Overall GHG Emissions are shown below in Table 4 and Figure 3.

Table 4: Summary of GHG Emissions

Activity	Annual Emission Rate (tonne CO_2e/year)				GHG Intensity (tonne CO_2e per capita)	Percent of Total
	CO_2	CH_4	N_2O	Total GHGs		
Building Electricity	18,284	0	0	18,284	0.03	0.3%
Building Natural Gas	1,790,048	1,073	9,906	1,801,027	2.60	33.5%
Transit	43,044	57	395	43,495	0.06	0.8%
Vehicles-Residential	1,689,442	2,434	33,241	1,725,116	2.49	32.1%
Vehicles-Commercial	938,779	338	6,525	945,642	1.37	17.6%
Waste Disposal	—	798,801	—	798,801	1.15	14.9%
Water and Waste Water	4,922	33,620	8,117	46,659	0.07	0.9%
Total	**4,484,518**	**836,322**	**58,184**	**5,379,024**	**7.78**	**100%**

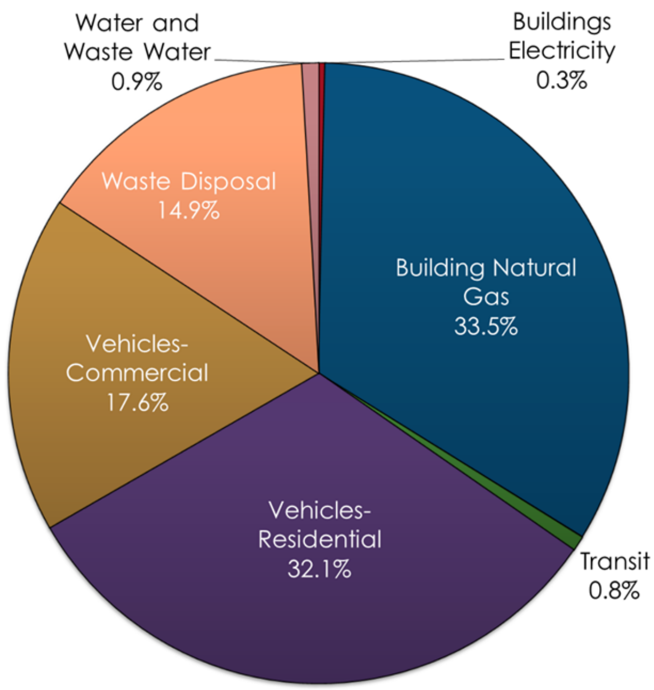


Figure 3: Summary of GHG Emissions

Building Natural Gas and Vehicles show the highest emissions, accounting for 83.1% of total emissions when combined. Waste disposal follows closely behind with14.9% of total GHG emissions. The remaining categories comprise of less than a percentage each. Note that airport emissions are not included due to data availability from the Winnipeg Airport Authority. The inventory tool has a place to enter in airport emissions if they are obtained at a later date.

4.10 Comparison with Other Municipalities

Winnipeg GHG emissions per capita were compared to several other large Canadian municipalities. Data sources used in obtaining data are shown in Table 5.

Table 5: Data Sources for Other Municipalities

City	Data Source
Calgary	"Calgary Climate Change Action Plan Target 50: The City of Calgary Corporate and Community Outlook on Climate and Air Quality Protection", City of Calgary Environmental Management. 2006
Edmonton	"Edmonton's Energy Transition: Discussion Paper", Pembina Institute & HB Lanarc. 2012
Toronto	"Greenhouse Gases and Air Pollutants in the City of Toronto: Toward a Harmonized Strategy for Reducing Emissions", ICF International. 2007
Ottawa	"Framing Our Future: An Energy & Emissions Plan for Canada's Capital Region", HB Lanarc. 2012
North Vancouver	"Community Energy and Emissions Plan: City of North Vancouver", HB Lanarc. 2010
Vancouver	"City of Vancouver: Greenest City – 2020 Action Plan", City of Vancouver. 2012

The comparison of GHG emissions per capita is shown in Figure 4 and Figure 5.

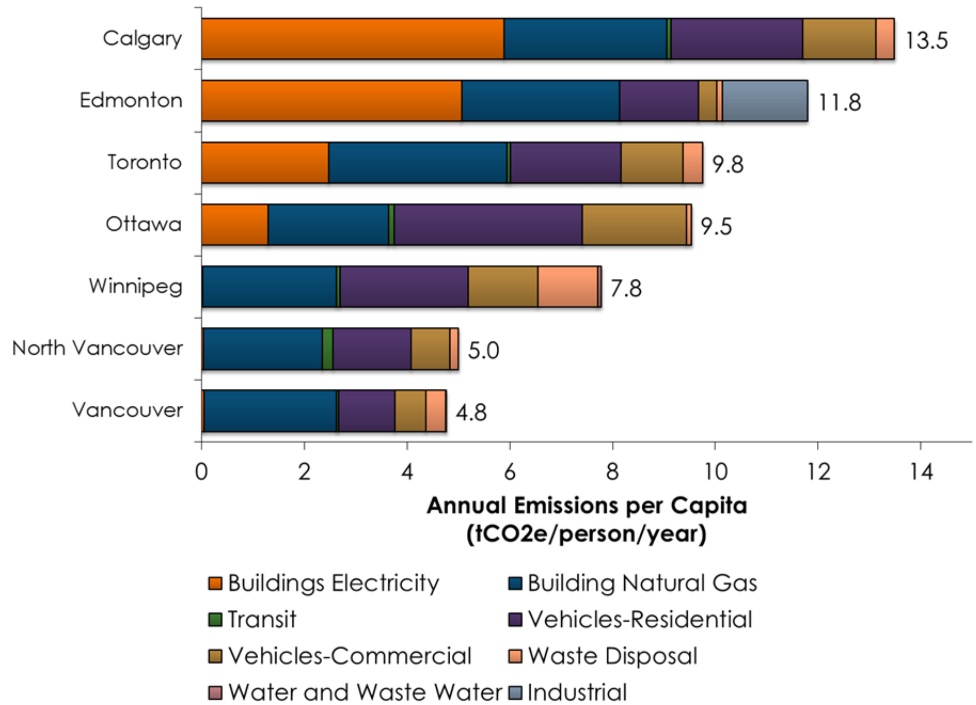


Figure 4: Comparison of GHG Emissions per Capita by City

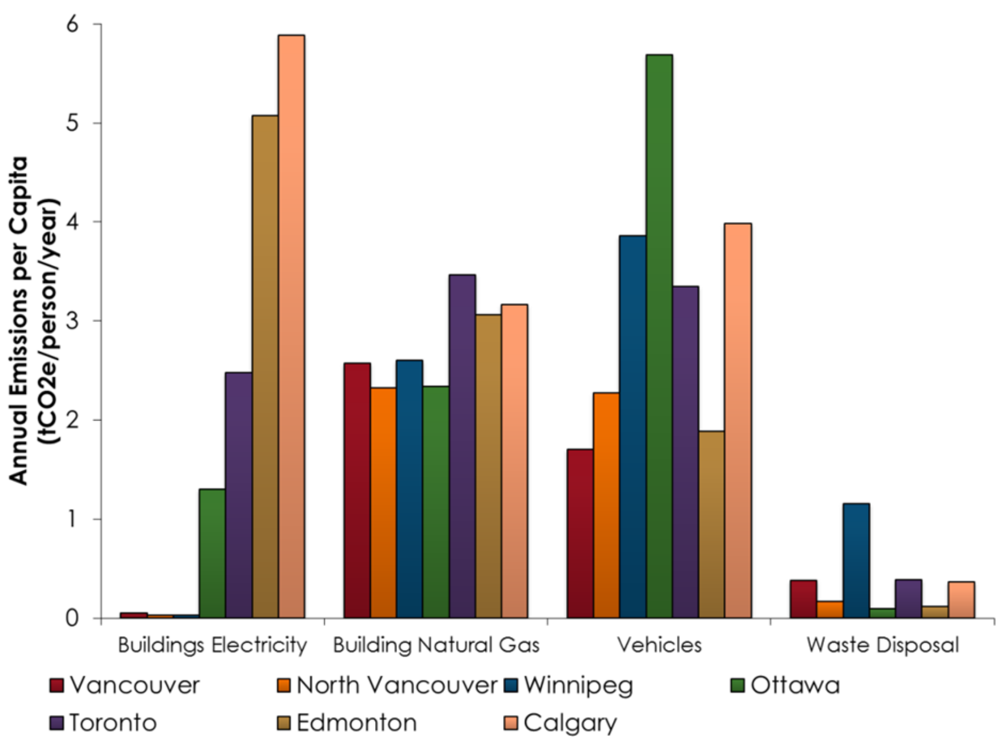


Figure 5: Comparison of GHG Emissions per Capita by Key Sectors

Major Canadian municipalities showed a range of 4.8 to 13.5 tonnes of CO_2 equivalent per person per year, with Winnipeg coming in at the lower end at 7.8 tonnes of CO_2 equivalent per person per year. Cities such as Winnipeg, Vancouver and North Vancouver show low levels of greenhouse gas emissions primarily due to the use of hydroelectricity as a major source of electricity. Note that direct emissions from industry were not included in many municipalities due to lack of data. However, most cities, including Winnipeg, do not have a large amount of industrial emissions occurring within the city limits. Most emissions for industry are covered under natural gas and electricity use. Also note that Edmonton shows large industrial emissions due to the refineries in the city.

4.11 Comparison with Previous Inventories

Previously, the City of Winnipeg had GHG inventories created for 1994 and 1998. The inventories were prepared using software developed by Torrie Smith Associates for the Cities for Climate Protection Campaign of The International Council for Local Environmental Initiatives.

The documentation in regards to the inventory scope and calculation methodologies used was not included in the report documentation and other data provided, thus, a comprehensive comparison between these inventories and the 2011 inventory presented in this report is challenging.

A summary of the previous inventories is shown below in Table 6.

Table 6: Previous Inventories Results

Activity	Annual Emission Rate (tonne CO_2e/year)	
	1994	**1998**
Residential	1,491,602	1,176,928
Commercial	209,171	188,323
Industrial	2,121,086	2,102,396
Transportation	1,575,472	1,650,494
Waste	217,088	139,183
Total	**5,614,419**	**5,257,324**

As the breakdown of emission categories does not match the 2011 inventory categories, re-organization of the emissions into broader categories was necessary to allow for comparison. However, because the inventory methodology, data sources, and geographical boundaries potentially differ between inventories, this comparison does not necessarily reflect an accurate depiction of the changes in Winnipeg GHG emissions.

Table 7: Comparison of Previous Inventories to 2011 Inventory, By Source

Activity	Annual Emission Rate (tonne CO_2e/year)		
	1994	**1998**	**2011**
Building Electricity	83,565	89,872	18,284
Building Natural Gas	3,738,295	3,377,776	1,801,027
Vehicles and Transit	1,575,472	1,650,494	2,714,253
Waste, Water, & Wastewater	217,088	139,183	845,460
Total	**5,614,419**	**5,257,324**	**5,379,024**

The comparison of inventories shows a 2.3% increase in GHG emissions between 1998 and 2011. However, as there are a number of differences between the inventories, this does not necessarily mean that the City did not meet their 6% reduction target. Previous inventories are not clear on what was included, meaning that a number of items which have been included in the 2011 inventory may be absent from the previous inventories.

Differences and other findings noted when comparing the 1994/1998 inventories and the 2011 inventory are summarized below:

- The GHG emission factor for Scope 2 electricity consumed in the City was significantly higher in the 1994/1998 inventories. It appears the factor represents a blend of hydroelectricity and fossil fuel emission factors reflective of electricity import from the United States. For the 2011 calendar year, the emission factor assigned by Environmental Canada's Nation Inventory Report (NIR) and used in the City of Winnipeg 2011 community inventory is approximately 3.4 g/kWh. As comparison, the emission factors provided by Environmental Canada's National Inventory Report for 1990 and 2000 were 26 g/kWh and 31 g/kWh, respectively. The emission factor used in the City of Winnipeg 1998 community inventory was 13.6 g/kWh.

- The 1994/1998 inventory omitted emissions from wastewater and sewer sludge. The 2011 inventory included emissions from wastewater and sewer sludge.
- It is unclear whether commercial transportation was included in the 1994/1998 inventories based on the documentation provided. Commercial transportation was developed separately from residential transportation in the 2011 inventory.
- The per capita GHG emissions prepared in the 1994/1998 inventories was roughly on par with the per capita GHG emissions developed in the 2011 inventory, however, the 1994/1998 inventories estimated significantly higher natural gas usage, while estimating significantly lower transportation emissions. As presented in 4.10, the per capita GHG emissions profile of the 2011 inventory is fairly consistent with other Canadian municipalities. Comparing the City's emissions profile developed in 1994/1998 inventories with other similar Canada cities highlights the discrepancies in community transportation and natural gas emissions.
- A significant difference exists in the breakdown of natural gas and electricity emissions between industrial, residential and commercial from the 1994/1998 inventories to the 2011 inventory. In the 1994/1998 inventories, industrial natural gas use is significantly greater than commercial natural gas usage. The 2011 inventory suggests that commercial natural gas use is significantly greater than industrial natural gas usage. It is possible that the designation of commercial customers versus industrial customers may have changed, as their additive consumption total is similar.

- In discussion with Manitoba Hydro, it is also understood that Centra Gas' natural gas and Winnipeg Hydro's electricity consumption data recordkeeping prior to their acquisition by Manitoba Hydro was less developed at the community-level, thus the quality of building energy data used prior 2002 may potentially be suspect.

Table 8: Comparison of Natural Gas and Electricity Emissions from Previous Inventories to 2011 Inventory, By Sector (Total Consumption)

Activity	Natural Gas and Electricity Annual Emission Rate (tonne CO_2e/year)		
	1994	1998	2011
Residential	1,491,602	1,176,928	682,215
Commercial	209,171	188,323	928,001
Industrial	2,121,086	2,102,396	196,584
Total	**3,821,859**	**3,467,647**	**1,806,799**

Table 9: Comparison of Natural Gas and Electricity Emissions from Previous Inventories to 2011 Inventory, By Sector (Percentage)

Activity	Percentage of Overall Natural Gas and Electricity Emissions,		
	1994	1998	2011
Residential	39%	34%	38%
Commercial	5%	5%	51%
Industrial	56%	61%	11%

5.0 ENERGY AND GHG FORECASTS

5.1 General Approach

As a part of examining possible emission futures for the City of Winnipeg, energy and GHG forecasts were prepared for 2020, 2031, and 2050. Estimates were made in conjunction with the City for key parameters and policies which were then translated to Inventory inputs. After inputs had been updated, results from the forecasted years were compared to the original inventory to observe changes in emissions over time. Three scenarios were considered: Business as Usual, OurWinnipeg, and Low Carbon Path. Differences between the scenarios were limited to what was possible for the City to reasonably influence. For example, factors such as population growth, provincial policies, and changes in technology were kept the same in all scenarios. However, areas which may be influenced by City policies, such as transit infrastructure, housing densities, and waste diversion rates, did vary between scenarios. The forecasting and scenarios are described in more detail in the following sections.

As weather can potentially have a large unpredictable impact on GHG emissions, all forecasts have been normalized for climate extremes. This includes weather events such as drought, which would reduce the amount of hydro-electricity generated within Manitoba and thus raise electricity emissions due to reliance on imported electricity. Any anticipated effects from climate change have not been factored into the analysis.

A number of indicators are outlined for each scenario and sector, which can be viewed by sector for each scenario. To view all indicators for all scenarios side-by-side, see **Appendix E**.

5.2 Community Trends

Between all scenarios, overall community trends in population and jobs were taken as being the same. Forecasted population for 2020 and 2031 were taken from a report on the long term forecasts for Winnipeg CMA by the Conference Board of Canada. To estimate population in 2050, an extrapolation of the population trend from 2011 to 2035 was used. Job forecasts were also taken from the Conference Board of Canada report on Winnipeg CMA, using a factor of 0.96 – the historical ratio of jobs in the City to jobs in the CMA [1].

A summary of the input values is shown below in Table 10.

Table 10: Community Trend Input Values

Inputs	2011	2020	2031	2050	Reference
Population	691,800	776,100	876,700	1,050,000	Conference Board of Canada [1]
Jobs	392,640	441,600	489,600	508,800	Conference Board of Canada [1]

5.3 Climate Impacts

An unseasonably warm or cold winter can have a significant impact on natural gas consumption reflecting a lesser or greater need for space heating. In 2011, Winnipeg experienced a warmer than usual winter. Accordingly, Manitoba Hydro reported that natural gas consumption for their 2011/2012 fiscal year was approximately 9% lower than their 2010/2011 fiscal year (11% lower than the six-year average).

Heating degree days (HDDs) is a measurement designed to reflect the energy consumption needed to heat a building. In the 2011/2012 fiscal year, the number of heating degree days for Winnipeg was 4,066 whereas the average number of HDDs in experience in the past six fiscal years was 4,851. The lower amount of HDDs experienced in 2011/2012 compared to the average confirms that the 2011 Winnipeg winter was unseasonably warm.

Table 11: Historical Natural Gas Consumption in the City of Winnipeg

Fiscal Year[1]	Annual Natural Gas Consumption (m^3)	Natural Gas Deviation from Six-Year Average	Heating Degree Days	Heating Degree Days Deviation from Six-Year Average
2012/13	1,051,260,142	-2%	5,075	5%
2011/12	953,878,222	-11%	4,066	-16%
2010/11	1,046,672,257	-2%	4,862	0%
2009/10	1,068,026,780	0%	4,694	-3%
2008/09	1,155,335,524	8%	5,302	9%
2007/08	1,144,300,344	7%	5,109	5%
Average	**1,069,912,211**	**-**	**4,851**	**-**

[1]The Manitoba Hydro fiscal year begins April 1st and Ends March 31st.

Accordingly a heating degree day (HDD) analysis was conducted on the data to evaluate the relationship between the outdoor temperature and the natural gas consumption, shown in Figure 6.

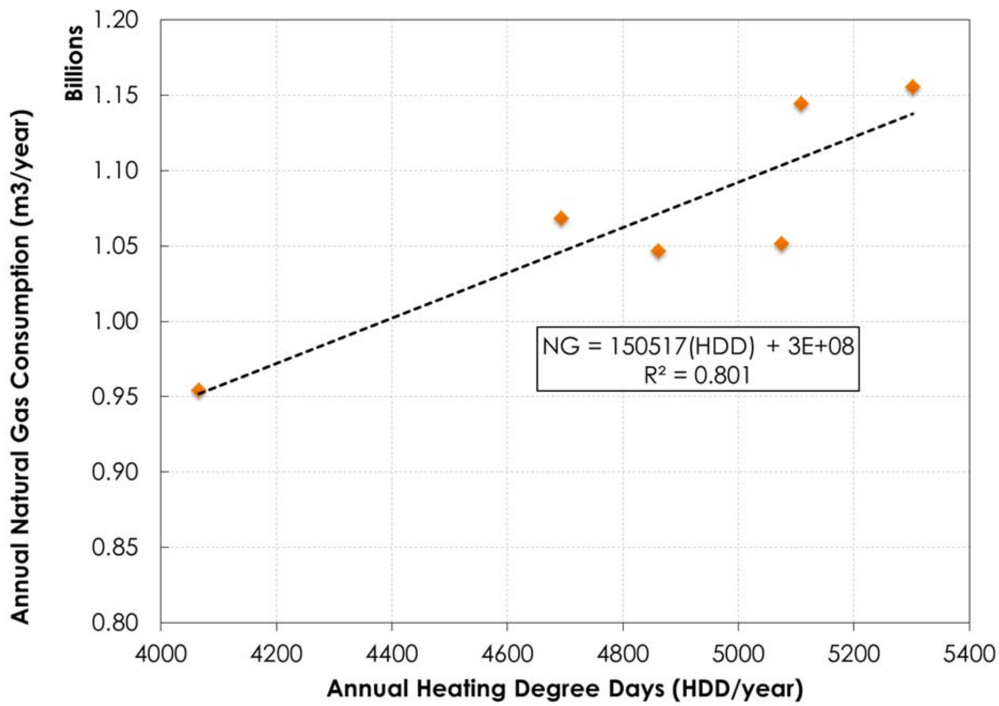


Figure 6: City of Winnipeg HDD vs. Natural Gas Consumption (2007/2008 to 2012/2013 Fiscal Years)

The relationship shown in Figure 6 was used to develop a baseline for natural gas consumption for the City of Winnipeg in 2011, normalized for weather. Accordingly, we would expect that baseline natural gas consumption to increase 12%, to approximately 1,069,912,211 m^3 per year. This climate-adjusted baseline natural gas estimate is used in all scenarios in lieu of the actual 2011 natural gas assumption for forecasting purposes.

5.4 Land Use Implications

Land use policies and plans not only strongly impact emissions related to building use and transportation, but also impact transit, waste and wastewater. Thus, land use and development policies within the City have an indirect, rather than direct, impact on overall community GHG emissions.

Throughout Winnipeg's growth, development has often resulted in continuously outward development of low-density communities supporting predominantly single-family housing development. While new development of low-density communities on the fringe of large municipalities is relatively common, older communities at the municipal core become opportunities for transformative and infill development (Figure 7).

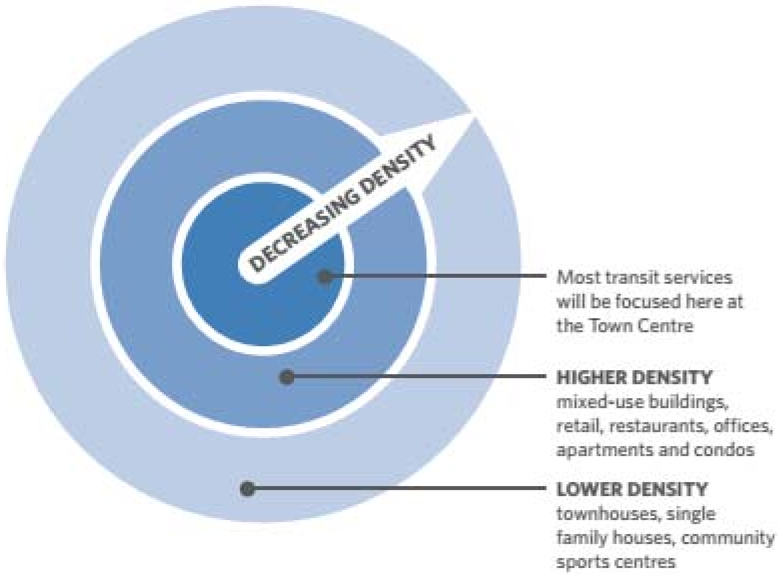


Figure 7: Typical Municipal Density Progression, Complete Communities [6]

Sustainable land use is a label which reflects a City planning philosophy that envisions livability, environmental protection, accessibility, mobility and affordable housing production as key tenets to community growth. Table 12 contrasts traditional land-use strategies with sustainable strategies that promote a lower-carbon footprint for the urban growth.

Table 12: Contrasting Traditional and Low Carbon Land Use Strategies

Land Use & Development Policy	Traditional	Low Carbon	Impacts to GHG Drivers
Growth strategy	Outward growth focusing on developing new low-density neighborhoods at community periphery. Growth of community transportation infrastructure focussing on supporting personal vehicle travel over public and alternative transportation options.	Mixed development, balancing the growth of new neighborhoods with revitalizing existing neighborhoods through infilling, densification and development of transit corridors / centres	Decrease in building energy consumption intensity Reduction in number of vehicle trips Reduction in length of vehicle trips
Residential building	Development focused on single family buildings	Development mix of single family and multi-unit residential buildings	Decrease in building energy consumption intensity
Commercial buildings	Development of commercial buildings separate from residential areas which may include big box development, large shopping centres and strip malls	Integrate commercial buildings within or in close proximity to residential neighborhoods with a focus on providing necessary retail within an easily commutable transit, biking or walking distance from residents	Reduction in number of vehicle trips Reduction in length of vehicle trips
Energy supply	Electricity supply supplied by public power grid Individual space heating for each unit / building	Electricity supplied by public smart grid and building-scale generation Promotion of shared or district energy heating systems for space heating	Decrease in building energy consumption intensity Increase in renewable energy supply
Transportation	Network and facility design focused on providing convenient and efficient access and travel by personal vehicle	Network and facility design that provides convenient and effective Transit and active transportation-travel options.	Reduction in number of vehicle trips Reduction in length of vehicle trips

For the Business as Usual and OurWinnipeg scenarios, the impacts from current and planned land use policies have been directly translated into GHG key performance indicators (e.g., growth by building type, infill, number of trips) primarily through transportation and land-use planning data that was already developed by the City of Winnipeg. Additional transportation modeling was conducted through Golder's Community Energy and Emissions Modeling (CEEMAP) tool.

The Business as Usual Scenario was created to show the likely emissions future if no further City actions were implemented.

5.5 Business as Usual Scenario

5.5.1 Description

The Business as Usual Scenario was created to show the likely emissions future in the absence of municipal intervention through the policy commitments and action statements associated with *OurWinnipeg* and its supporting strategies. In general, the City continues along current trends, with many key indicators remaining the same at 2011 baseline levels.

Inputs for the Business as Usual Scenario were primarily taken from the 2011 Energy and GHG Inventory, allowing for scaling up with the forecasted increases in population. An overview of the assumptions used in the development of the Business as Usual Scenario can be found in the following sections.

5.5.2 Assumptions

The following sub-sections present an overview of the assumptions and key indicators used in the development of the Business as Usual Scenario. For a more detailed explanation on the calculation methodology used, please refer to **Appendix B**.

5.5.2.1 Land Use

For the Business as Usual scenario, it is assumed that land use policies will be consistent with a continuation of recent development patterns, policies, and priorities currently undertaken by the City of Winnipeg.

The key characteristics of the Business as Usual Scenario are as follows:

- Development of new neighbourhoods at the City periphery dominating residential unit growth;
- Largest share of new units being suburban low-density single family;
- Limited mix of land uses with low densities;
- Limited residential development in the downtown and mixed use areas;
- Infilling continuing to represent a very small contribution to overall neighborhood development;
- No additional development of transit infrastructure will occur with the exception of the completion of the Southwest transit way; and,
- No significant increase in biking or active transportation infrastructure beyond what is currently in place.

A summary of the key indicator values is shown below in Table 13.

Table 13: Business as Usual Scenario – Building and Land Use Key Indicators

Inputs	2011	2020	2031	2050	Reference
Single-Family Homes	63%	63%	63%	63%	Conference Board of Canada
Multi-Unit Residential Building Homes	37%	37%	37%	37%	Conference Board of Canada
Infill Percentage of New Residential Construction	N/A	2%	5%	8%	Developed with CEEMAP

5.5.2.2 Building Electricity and Natural Gas

Building electricity and natural gas use are influenced by a number of factors that are independent of the scenarios considered. In the absence of other influences, consumption scales with population and, therefore, increases in the City's population have a large effect on electricity and natural gas use. Provincial demand-side management programs under Manitoba Hydro have targets for reductions in both electricity and natural gas use throughout the province. Additionally, changes in building technology would have an impact on reducing the energy consumption of all new homes. The demand for electricity is expected to increase in residential buildings due to an increase in the number of consumer electronics. All of these factors are outside of the control of the City, and are independent of the scenarios considered.

For the Business as Usual Scenario, building stock makeup (i.e., single family homes vs. multi-unit residential buildings) was assumed to remain at 2011 levels. Thus, there would be no efficiency gains from a shift from single family homes to multi-unit residential buildings. Growth in building-scale renewables, mostly geothermal heating systems, would also stay at the same proportions as 2011 in this scenario. Finally, there would no new buildings connected to district energy systems to offset heating loads.

A summary of the key indicator values is shown below in Table 14.

Table 14: Business as Usual Scenario – Building Electricity and Natural Gas Key Indicators

Inputs	2011	2020	2031	2050	Reference
Building Electricity Intensity Reduction due to Demand Side Management	0%	4%	5%	10%	Manitoba Hydro
Building Natural Gas Intensity Reduction due to Demand Side Management	0%	2%	3%	6%	Manitoba Hydro
New Building Energy Intensity Reduction due to Building Stock Changes	0%	0%	0%	0%	Assumed
New Building Energy Intensity Reduction due to Technology Changes	0%	9%	20%	39%	Assumed
Additional Electricity Use	0%	5%	10%	21%	Manitoba Hydro
Residential Building Scale Renewables	1.5%	1.5%	1.5%	1.5%	Manitoba Geothermal Energy Alliance
Commercial/Industrial Building Scale Renewables	1.5%	1.5%	1.5%	1.5%	Manitoba Geothermal Energy Alliance
Residential Buildings Connected to District Energy Systems	0%	0%	0%	0%	Assumed
Commercial Buildings Connected to District Energy Systems	< 1%	< 1%	< 1%	< 1%	Assumed
Residential Electricity Use (kWh/year)	1,690,588,866	1,897,087,432	2,175,793,596	2,498,264,543	Calculated
Commercial Electricity Use (kWh/year)	3,046,484,478	3,276,408,397	3,499,055,017	3,293,713,564	Calculated
Industrial Electricity Use (kWh/year)	837,309,539	900,502,866	961,696,068	905,259,096	Calculated
Residential Natural Gas Use (m^3/year)	488,426,808	595,966,809	648,519,154	687,570,870	Calculated
Commercial Natural Gas (m^3/year)	361,222,578	441,801,677	473,031,695	453,652,964	Calculated
Industrial Natural Gas (m^3/year)	104,025,761	127,231,127	136,224,824	130,644,089	Calculated
Single-Family Homes	63%	63%	63%	63%	Conference Board of Canada
Multi-Unit Residential Building Homes	37%	37%	37%	37%	Conference Board of Canada

5.5.2.3 Transit

The Business as Usual Scenario includes no major changes to the City of Winnipeg public transportation fleet. Transit vehicles continue to use B2 biodiesel fuel, although due to changes in technology, fuel consumption per kilometer does improve. The number of transit vehicles and transit routes operated by the City does not change in this scenario. Additional travel is assumed to be undertaken by personal vehicles.

A summary of key indicator values is shown below in Table 15.

Table 15: Business as Usual Scenario – Transit Key Indicators

Inputs	2011	2020	2031	2050	Reference
Kilometers of Transit Travel (km/year)	24,300,000	24,300,000	24,300,000	24,300,000	Assumed
Transit Fuel Type (% of kilometers travelled)	100% B2 Biodiesel	100% B2 Biodiesel	100% B2 Biodiesel	100% B2 Biodiesel	Assumed
Diesel Fuel Use (L/year)	16,163,620	15,173,364	13,184,596	10,025,073	Calculated
Electricity Use (MWh/year)	0	0	0	0	Calculated

5.5.2.4 Vehicles

Between all scenarios, GHG emissions per kilometer travelled are also expected to decrease as the result of new technology and new government policies, such as federal government tailpipe emission standards. As vehicular usage represents a large percentage of overall community emissions, the extent of fuel economy improvements represents one of the most significant areas of uncertainty in the overall community GHG emissions forecast. Fuel economy improvements assumed in the forecast are based on the continued adoption of government regulations mandating vehicular fuel efficiency standards, technology roll-out for low-emission vehicles and economic considerations, such as sustained increase in oil prices.

A projection of emissions per kilometer travelled for new vehicles was obtained from a UNEP study on Canadian Automotive Fuel Economy Policy [7]. To determine the GHG emissions from the combined fleet on the road, the average vehicle on the road in Winnipeg was assumed to be 10 years old. This assumption was based on the current vehicle makeup from the registration data provided by the Manitoba Public Insurance.

In the Business as Usual Scenario, public transit did not increase service to match the increased population. Additionally, no expansion to the cycling network was assumed. With continued greenfield development and limited public transit and active transit availability, the weekday travel shifts slightly toward vehicles. As a result of these factors and the increased population, the total kilometers travelled increases for all vehicles. There is no shift toward electric vehicles here as this scenario does not include any significant outlaying of charging stations within the City.

A summary of key indicator values is shown below in Table 16.

Table 16: Business as Usual Scenario – Vehicle Key Indicators

Inputs	2011	2020	2031	2050	Reference
Cycle Network (km)	274	274	274	274	Assumed
Total Residential Vehicle Kilometers Travelled (vkmt/year)	5,175,656,607	5,526,529,233	6,256,030,891	8,241,968,092	Calculated
Total Commercial Vehicle Kilometers Travelled (vkmt/year)	932,055,814	1,105,305,847	1,251,209,851	1,648,393,618	Calculated
Electric Vehicle Use	0%	0%	0%	0%	Assumed
Weekday Trips by Mode Auto Driver Auto Passenger Public Transit Walk/Cycle	 64% 18% 10% 8%	 64% 18% 10% 8%	 65% 19% 9% 7%	 66% 20% 8% 6%	Assumed
Average Residential Fleet Emissions (gCO_2e/km)	370	278	196	133	Calculated
Average Commercial Fleet Emissions (gCO_2e/km)	1015	761	538	365	Calculated

5.5.2.5 Waste Disposal

In all scenarios, the average waste generated remains the same. This means that across the scenarios, the waste increases proportionally as the City grows.

In the Business as Usual Scenario, there are no changes to the diversion rates for waste. Additionally, no supplementary policies are introduced which could affect the amount or makeup of waste. Finally, as the landfill gas collection system is not expanded any further, the landfill gas collection efficiency remains constant.

A summary of key indicator values is shown below in Table 17.

Table 17: Business as Usual Scenario – Waste Disposal Key Indicators

Inputs	2011	2020	2031	2050	Reference
Residential Waste (tonne/year)	278,896	312,881	353,438	423,303	Calculated
Commercial/Industrial Waste (tonne/year)	348,000	391,394	433,936	450,954	Calculated
Construction/Demolition Waste (tonne/year)	124,000	139,462	154,621	160,685	Calculated
Residential Diversion Rate	15%	15%	15%	15%	Assumed
Commercial/Industrial Diversion Rate	20%	20%	20%	20%	Assumed
Construction/Demolition Diversion Rate	20%	20%	20%	20%	Assumed
Landfill Gas Collection Coverage (City Landfills)	100%	100%	100%	100%	Assumed
Landfill Gas Collection Efficiency (City Landfills)	55%	55%	55%	55%	Assumed
Landfilled Waste Per Capita (tonne/person/year)	1.09	1.09	1.07	0.99	Calculated

5.5.2.6 Water and Waste Water

For all scenarios, total mass of biosolids associated with waste water increases with population. In the Business as Usual Scenario, the treatment methods do not change at all. Additionally, no biosolids are sold for beneficial use or composted, suggesting that 100% of biosolids generated are landfilled.

A summary of key indicator values is shown below in Table 18.

Table 18: Business as Usual Scenario – Water and Waste Water Key Indicators

Inputs	2011	2020	2031	2050	Reference
Mass of Biosolids Disposed (tonne/year)	13,982	15,700	17,700	21,200	Calculated
Biosolids Sold for Beneficial Use	0%	0%	0%	0%	Assumed
Biosolids Composted	0%	0%	0%	0%	Assumed

5.5.3 Results

The results from the Business as Usual Scenario can be seen below in Table 19 and Figure 8.

Table 19: Business as Usual Scenario Results

Activity	Annual Emission Rate (tonne CO_2e/year)			
	2011	**2020**	**2031**	**2050**
Airport	N/A	N/A	N/A	N/A
Buildings Electricity	18,284	19,923	21,768	21,967
Building Natural Gas	1,801,027	2,200,116	2,375,323	2,401,926
Transit	43,495	40,831	35,479	26,977
Vehicles-Residential	1,725,116	1,534,331	1,227,376	1,098,322
Vehicles-Commercial	945,642	841,061	672,696	601,892
Waste Disposal	798,801	982,933	1,093,004	1,173,095
Water and Waste Water	46,659	51,876	56,945	65,807
Total	**5,379,024**	**5,671,070**	**5,482,591**	**5,389,987**
Per Capita Emissions	**7.78**	**7.31**	**6.25**	**5.13**

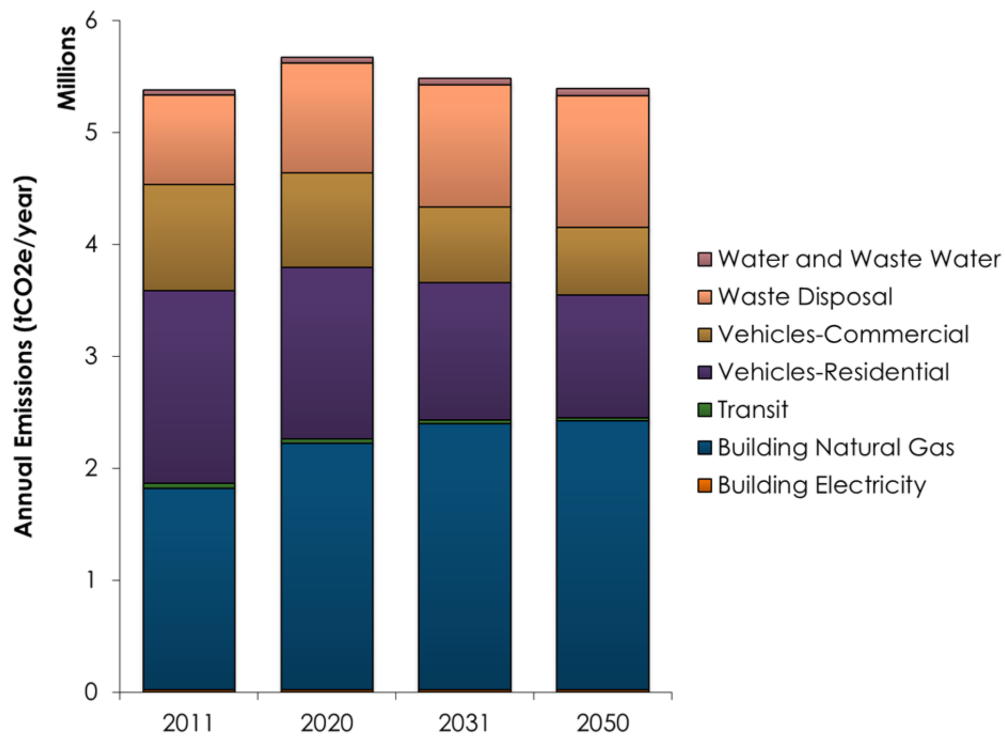


Figure 8: Business as Usual Scenario Results

In this scenario, there are no large changes to the overall GHG emissions for the City. This is due to the competing effects of increased population and better technology. Looking at individual sectors, the largest increases in GHG emissions are in Waste Disposal and Water and Waste Water. Because no additional policies have been implemented in this scenario to make these processes more efficient, emissions scale up with population. Building Electricity and Natural Gas show similar trends, although the increase in consumption due to the increase in population is tempered by efficiency gains due to technology improvements and provincial demand-side management programs. Residential, Commercial, and Transit vehicles all show decreases in emissions due to natural fleet replacement with better, more fuel-efficient vehicles.

Overall, the Business as Usual Scenario shows a 2% increase in emissions by 2031. As population is forecasted to increase by 27% in this time, this indicates a reduction in per capita emissions. In 2011, per capita emissions were 7.78 tonnes of CO_2e per person, which reduces 20% to 6.25 tonnes of CO_2e per person in 2031. Looking farther ahead to 2050, we can see overall emissions increasing by 0.2% while the population increases by 52%. Per capita emissions are forecasted at 5.13 tonnes of CO_2e per person in 2050, representing a decrease of 34% from 2011. See Table 20 for a summary of the changes to emission by year and sector.

Table 20: Business as Usual Scenario Emission Changes

Activity	**Change in Annual Emission Rate**			
	2011	**2020**	**2031**	**2050**
Airport	N/A	N/A	N/A	N/A
Buildings Electricity	0%	9%	19%	20%
Building Natural Gas	0%	22%	32%	33%
Transit	0%	-6%	-18%	-38%
Vehicles-Residential	0%	-11%	-29%	-36%
Vehicles-Commercial	0%	-11%	-29%	-36%
Waste Disposal	0%	23%	37%	47%
Water and Waste Water	0%	11%	22%	41%
Total	**0%**	**5%**	**2%**	**0%**
Per Capita Emissions	**0%**	**-6%**	**-20%**	**-34%**

The OurWinnipeg Scenario represents the current plans of the City of Winnipeg, outlined in the 2011 report, "OurWinnipeg: It's Our City, It's Our Plan, It's Our Time" and the OurWinnipeg companion documentation.

5.6 OurWinnipeg Scenario

5.6.1 Description

The OurWinnipeg Scenario represents the current plans of the City of Winnipeg, outlined in the 2011 report, "*OurWinnipeg: It's Our City, It's Our Plan, It's Our Time*" and the *OurWinnipeg* companion documentation:

- *Complete Communities Direction Strategy* (July 20, 2011)
- *Sustainable Transportation* (July 20, 2011)
- *Sustainable Water & Waste* (July 20, 2011)
- *A Sustainable Winnipeg* (July 20, 2011)

In July 2011, City Council approved *OurWinnipeg*, a development plan that will guide the physical, social, environmental, and economic development of the City of Winnipeg for the next few decades. In addition, other key approved plans paved the way for the OurWinnipeg scenario, including the *Transportation Master Plan* and *Garbage and Recycling Master Plan*. Golder developed individual forecast parameters for the 2020 and 2031 forecast years based on the assumptions of those studies and data directly provided by City of Winnipeg staff.

The OurWinnipeg GHG forecast scenario is not strictly considered a business as usual case because it does assume changes to management practices. However, the scenario represents a reasonable forecast of future emissions based on the currently known assumptions in regards to building growth, waste and wastewater management, and transportation developments. Population growth in OurWinnipeg follows the same forecasts as all other scenarios.

The *OurWinnipeg* development plans set GHG targets until the 2031 calendar year. Because the scope of this study is to project greenhouse gas emissions to 2050, the study window exceeds the planning windows ending in 2031. Thus, for the 2050 forecast, Golder extrapolated the emissions forecast based on the available data from the 2011, 2020 and 2031 forecast years. No additional insight was assumed in regards to growth or management strategies for the 2050 forecast year.

The inputs for the OurWinnipeg scenario were largely based on Council adopted strategies, targets, and previous studies supporting these planning efforts. For example, the transportation model outputs developed for the *Transportation Master Plan* were used as inputs to this scenario, as were the solid waste estimates developed for the *Garbage and Recycling Master Plan*. After populating the inputs and before modelling the results, the consulting team sought confirmation from the City that the scenario was being appropriately modelled.

5.6.2 Assumptions

The following sub-sections present an overview of the assumptions and key indicators used in the development of the OurWinnipeg Scenario. For a more detailed explanation on the calculation methodology used, please refer to **Appendix B**.

5.6.2.1 Land Use

The planning document, *OurWinnipeg: It's Our City, It's Our Plan, It's Our Time,* was adopted in 2011 as a 25-year planning vision for City development. The OurWinnipeg forecast assumes an optimistic and full implementation of the policies and development strategies outlined in the *OurWinnipeg* planning document. The land-use strategy was outlined in the companion document *Complete Communities: Winnipeg's Guide to Land Use and Development*. The report outlines areas of stability within the City and areas slated for new development or redevelopment.

To support the development of this scenario, the City provided TransCAD and land use forecasting (PLUM) data which supported development of transportation, building and land-use key performance indicators for the 2031 forecast scenario. The current plans include a modest shift of new building stock makeup from single family homes to multi-unit residential buildings. As multi-unit residential buildings are more energy efficient than single family homes, this shift would represent a decrease in energy use per person, both electricity and natural gas.

The key characteristics of the *OurWinnipeg* land use plan are as follows:

- Move towards are more balanced growth between greenfield and infill development with future dwelling demand reflecting historical forecast trends;
- Increase share of duplexes, secondary suites, row houses, and multi-unit residential buildings to overall new building stock;
- Direct most infill to transformative areas, including transit-oriented regional and neighbourhood centres and corridors, major redevelopment sites, and the downtown to provide compact, mixed-use, high-quality development;
- Repurpose obsolete and underutilized industrial lands for mixed use, complete communities;
- Develop higher density regional mixed used centres over time, primarily co-located with existing neighborhood centres / major shopping developments (e.g., Polo Park, St. Vital Centre, Kenaston & McGillivary);
- Promote high density residential developments and pedestrian-oriented transportation in the downtown;

- Develop three additional rapid transportation corridors, beyond the Southwest transit way before 2031:
  - Southwest: Downtown to University of Manitoba;
  - West: Downtown to Polo Park, Red River College and the Airport; and,
  - East: Downtown to Kildonan Place.
- Additional rapid transportation corridors to be developed after 2031 based on community growth.
- Develop additional transit quality corridors throughout the City; and,
- Increase active transportation infrastructure throughout the City, particularly in new communities.

The proposed land-use and transit corridor plans a presented in Figure 9 and Figure 10, respectively

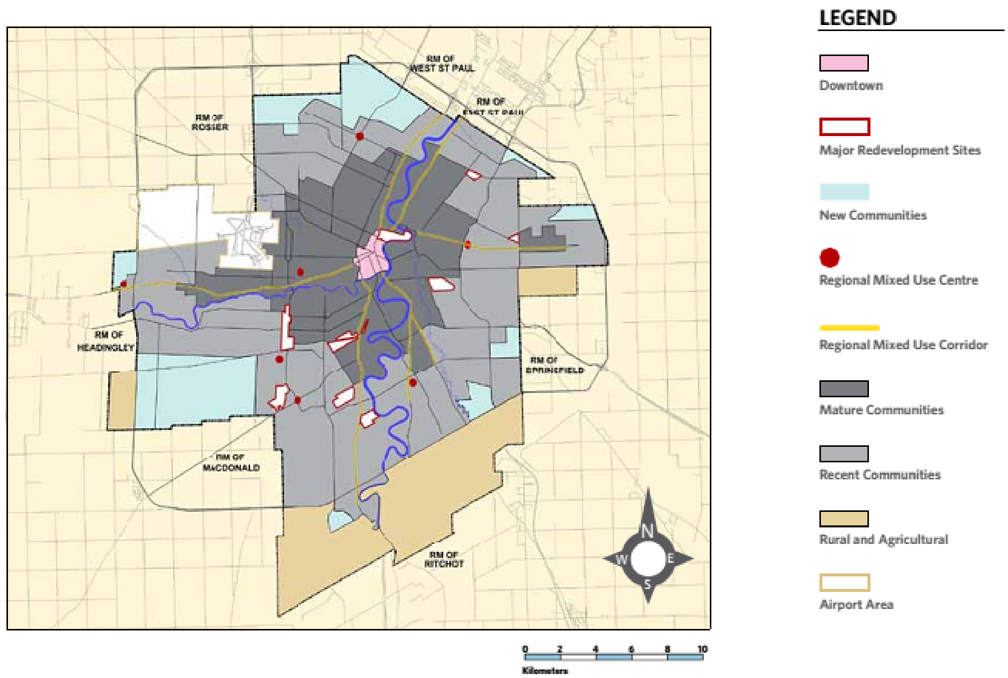


Figure 9: OurWinnipeg Land Use Plan [6]

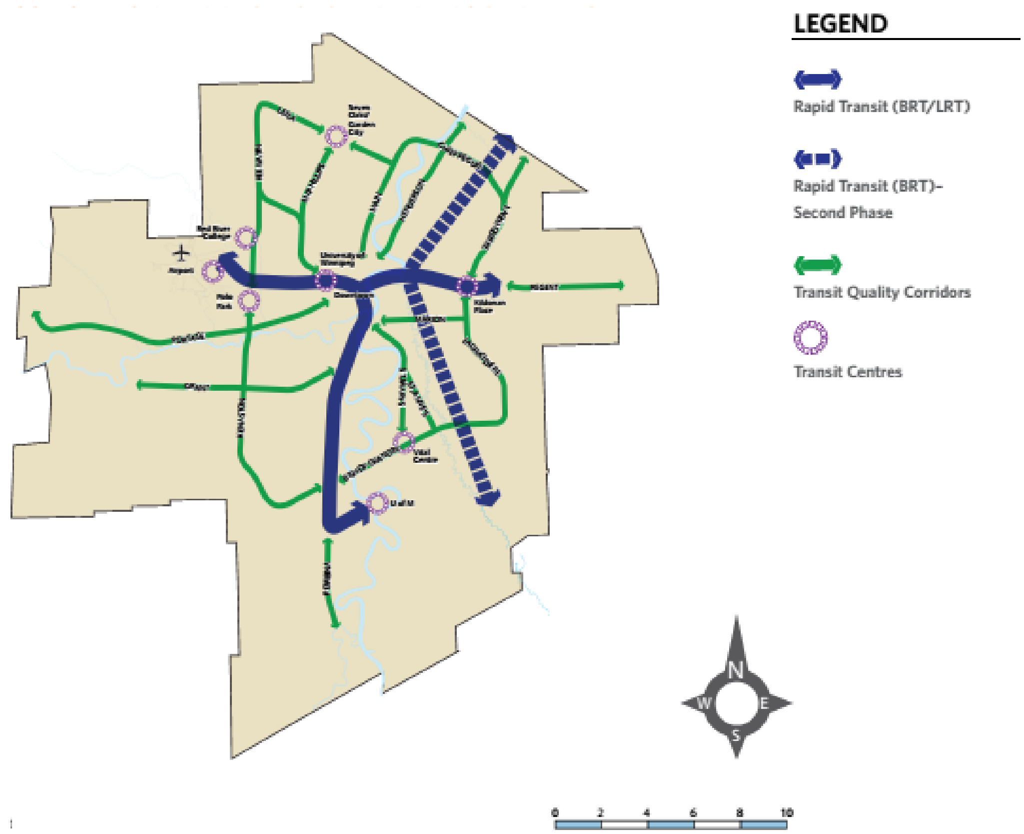


Figure 10: OurWinnipeg Transit System Plan [8]

A summary of the key indicator values is shown below in Table 21.

Table 21: OurWinnipeg Scenario –Land Use Key Indicators

Inputs	2011	2020	2031	2050	Reference
Single-Family Homes	63%	62%	61%	59%	Conference Board of Canada
Multi-Unit Residential Building Homes	37%	38%	39%	41%	Conference Board of Canada
Infill Percentage of New Residential Construction	N/A	7%	16%	25%	Developed with CEEMAP

5.6.2.2 Building Electricity and Natural Gas

Building electricity and natural gas use are influenced by a number of factors that are independent of the scenarios considered. Increases to City population has a large effect on electricity and natural gas use due to consumption scaling with population in the absence of other influences. Provincial demand-side management programs under Manitoba Hydro have targets for reductions in both electricity and natural gas use throughout the province. Additionally, changes in building technology would have an impact on reducing the energy consumption of all new homes. It is also expected that the demand for electricity would increase in residential buildings due to an increase in consumer electronics. All of these factors are outside of the control of the City, and are independent of the scenarios considered.

Building-scale renewables, mostly geothermal heating systems, would continue to grow at historic rates in this scenario as this scenario includes no City plans for policies, targets, or goals concerning these technologies. Finally, there would be a limited promotion of district energy systems, leading to a small number of buildings connected to district energy systems to offset heating loads.

A summary of the key indicator values is shown below in Table 22.

Table 22: OurWinnipeg Scenario – Building Electricity and Natural Gas Key Indicators

Inputs	2011	2020	2031	2050	Reference
Building Electricity Intensity Reduction due to Demand Side Management	0%	4%	5%	10%	Manitoba Hydro
Building Natural Gas Intensity Reduction due to Demand Side Management	0%	2%	3%	6%	Manitoba Hydro
New Building Energy Intensity Reduction due to Building Stock Changes	0%	4%	8%	16%	Calculated
New Building Energy Intensity Reduction due to Technology Changes	0%	9%	20%	39%	Assumed
Additional Electricity Use	0%	5%	10%	21%	Manitoba Hydro
Residential Building Scale Renewables	1.5%	2%	4%	8%	Manitoba Geothermal Energy Alliance
Commercial/Industrial Building Scale Renewables	1.5%	3%	6%	15%	Manitoba Geothermal Energy Alliance
Residential Buildings Connected to District Energy Systems	0%	1%	2%	4%	Assumed
Commercial Buildings Connected to District Energy Systems	< 1%	1%	3%	6%	Assumed
Residential Electricity Use (kWh/year)	1,690,588,866	1,890,028,752	2,143,841,778	2,397,080,071	Calculated
Commercial Electricity Use (kWh/year)	3,046,484,478	3,276,408,397	3,499,055,017	3,293,713,564	Calculated
Industrial Electricity Use (kWh/year)	837,309,539	900,502,866	961,696,068	905,259,096	Calculated
Residential Natural Gas Use (m^3/year)	488,426,808	592,503,952	633,883,431	647,309,955	Calculated
Commercial Natural Gas (m^3/year)	361,222,578	439,550,725	466,306,958	435,777,875	Calculated
Industrial Natural Gas (m^3/year)	104,025,761	126,754,010	134,692,295	126,234,851	Calculated

5.6.2.3 Transit

The OurWinnipeg Scenario assumes that the City would continue to use B2 diesel in buses, with fuel efficiency of buses improving due to changes in technology. Additionally, there would be some phase-in of diesel-electric hybrid buses. The City would expand their transit network to accommodate the increased population at a rate of 8 new vehicles per year.

A summary of key indicator values is shown below in Table 23.

Table 23: OurWinnipeg Scenario – Transit Key Indicators

Inputs	2011	2020	2031	2050	Reference
Kilometers of Transit Travel (km/year)	24,282,940	27,297,374	30,981,682	37,345,487	Assumed
Transit Fuel Type (% of kilometers travelled)	100% B2 Biodiesel	100% B2 Biodiesel	90% B2 Biodiesel 10% Electric	85% B2 Biodiesel 15% Electric	Assumed
Diesel Fuel Use (L/year)	16,163,620	17,056,954	15,139,554	13,105,190	Calculated
Electricity Use (MWh/year)	0	0	10,844	19,606	Calculated

5.6.2.4 Vehicles

Between all scenarios, GHG emissions per kilometer travelled are also expected to decrease as the result of new technology and new government policies, such as federal government tailpipe emission standards. As vehicular usage represents a large percentage of overall community emissions, the extent of fuel economy improvements represents one of the most significant areas of uncertainty in the overall community GHG emissions forecast. Fuel economy improvements assumed in the forecast are based on the continued adoption of government regulations mandating vehicular fuel efficiency standards, technology roll-out for low-emission vehicles and economic considerations, such as sustained increase in oil prices.

A projection of emissions per kilometer travelled for new vehicles was obtained from a UNEP study on Canadian Automotive Fuel Economy Policy [7]. To determine the GHG emissions from the combined fleet on the road, the average vehicle on the road in Winnipeg was assumed to be 10 years old. This assumption was based on the current vehicle makeup from the registration data provided by the Manitoba Public Insurance.

In the OurWinnipeg Scenario, the public transit infrastructure expands to meet the increased population and capture additional corridors. In parallel with improvements in transit, the City has planned expansion of cycling lanes by 20km per year to 2031. Electric vehicles have also been assumed to gradually penetrate the market.

A summary of key indicator values is shown below in Table 24.

Table 24: OurWinnipeg Scenario – Vehicle Key Indicators

Inputs	2011	2020	2031	2050	Reference
Cycle Network (km)	274	454	674	674	Assumed
Total Residential Vehicle Kilometers Travelled (vkmt/year)	5,175,656,607	5,483,855,690	6,161,200,794	8,057,049,404	Calculated
Total Commercial Vehicle Kilometers Travelled (vkmt/year)	932,055,814	1,096,771,138	1,232,240,159	1,611,409,881	Calculated
Electric Vehicle Use	0%	1%	2%	5%	Assumed
Weekday Trips by Mode Auto Driver Auto Passenger Public Transit Walk/Cycle	 64% 18% 10% 8%	 64% 18% 10% 8%	 63% 18% 10% 9%	 62% 17% 11% 10%	Assumed
Average Residential Fleet Emissions (gCO_2e/km)	370	276	193	129	Calculated
Average Commercial Fleet Emissions (gCO_2e/km)	1015	759	538	360	Calculated

5.6.2.5 Waste Disposal

In all scenarios, the average waste generated remains the same. This means that across the scenarios, the waste increases proportionally as the City grows.

In the OurWinnipeg Scenario, the City implements the 2011 *Garbage and Recycling Master Plan* [9] and *Comprehensive Integrated Waste Management Plan* [10], which includes increases in residential waste sent for beneficial use (i.e., recycling or composting). Aside from the *Garbage and Recycling Master Plan*, this scenario also has improvements to landfill gas collection efficiency through continuous expansion of the landfill gas collection system to incorporate all new waste and higher methane capture efficiency. Additionally, this scenario includes a reduction in yard waste sent to landfills due to initiatives by the City, leading to an overall decrease in residential waste and a slight change in the residential waste makeup. The scenario assumes the rollout of a residential source separated organics program to meet the 50% residential diversion rate target.

A summary of key indicator values is shown below in Table 25.

Table 25: OurWinnipeg Scenario – Waste Disposal Key Indicators

Inputs	2011	2020	2031	2050	Reference
Residential Waste (tonne/year)	278,896	234,477	199,588	239,042	Calculated
Commercial/Industrial Waste (tonne/year)	348,000	337,577	108,484	112,738	Calculated
Construction/Demolition Waste (tonne/year)	124,000	130,746	38,655	40,171	Calculated
Residential Diversion Rate	15%	35%	50%	50%	Assumed
Commercial/Industrial Diversion Rate	20%	20%	20%	20%	Assumed
Construction/Demolition Diversion Rate	20%	20%	20%	20%	Assumed
Landfill Gas Collection Coverage (City Landfills)	100%	100%	100%	100%	Assumed
Landfill Gas Collection Efficiency (City Landfills)	55%	75%	75%	75%	Assumed
Landfilled Waste Per Capita (tonne/person/year)	1.09	0.99	0.90	0.81	Calculated

5.6.2.6 Water and Waste Water

For all scenarios, total mass of biosolids associated with waste water increases with population. In the OurWinnipeg Scenario, the treatment methods do not change at all. However, this scenario does show promotion of biosolids sent for beneficial use and composting due to City initiatives.

A summary of key indicator values is shown below in Table 26.

Table 26: OurWinnipeg Scenario – Water and Waste Water Key Indicators

Inputs	2011	2020	2031	2050	Reference
Mass of Biosolids Disposed (tonne/year)	13,982	15,700	17,700	21,200	Calculated
Biosolids Sold for Beneficial Use	0%	20%	40%	60%	Assumed
Biosolids Composted	0%	20%	30%	40%	Assumed

5.6.3 Results

The results from the OurWinnipeg Scenario can be seen below in Table 27 and Figure 11.

Table 27: OurWinnipeg Scenario Results

Activity	Annual Emission Rate (tonne CO_2e/year)			
	2011	**2020**	**2031**	**2050**
Airport	N/A	N/A	N/A	N/A
Buildings Electricity	18,284	19,900	21,663	21,635
Building Natural Gas	1,801,027	2,188,425	2,332,091	2,283,812
Transit	43,495	45,899	40,776	35,330
Vehicles-Residential	1,725,116	1,511,810	1,191,832	1,036,053
Vehicles-Commercial	945,642	832,395	659,158	580,901
Waste Disposal	798,801	738,425	796,266	839,371
Water and Waste Water	46,659	36,785	27,171	14,863
Total	**5,379,024**	**5,373,639**	**5,068,956**	**4,811,966**
Per Capita Emissions	**7.78**	**6.92**	**5.78**	**4.58**

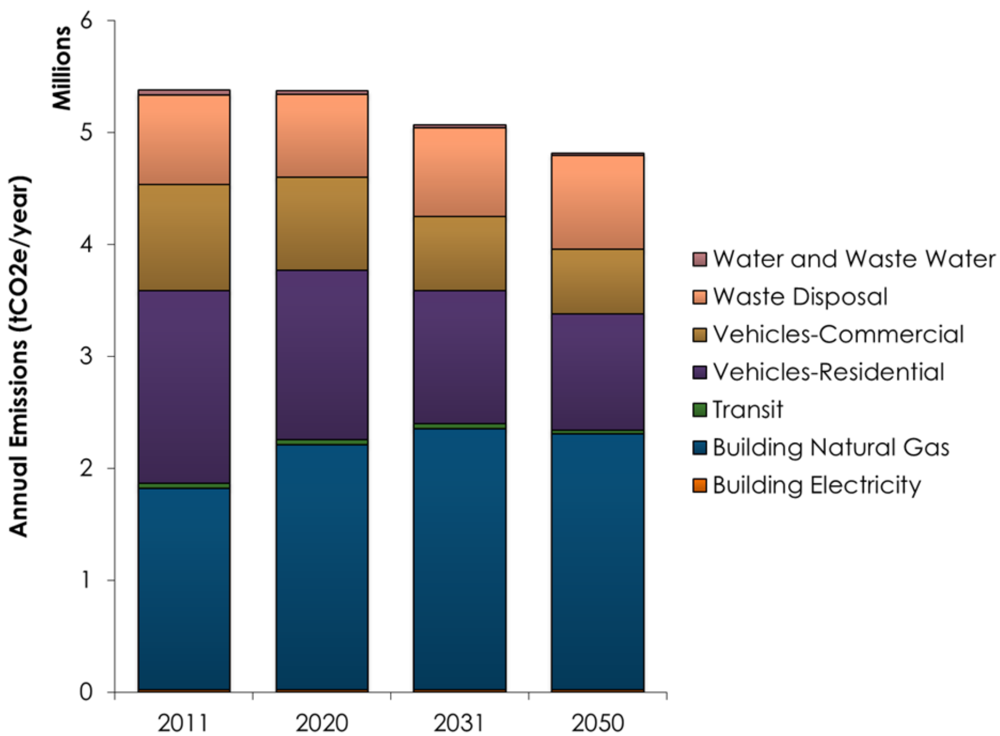


Figure 11: OurWinnipeg Scenario Results

In this scenario, overall emissions decrease significantly for the City. This is due to the effects of new technology and City policies reducing emission rates while population increases. Increases in emissions are seen in Building Natural Gas and Building Electricity, which are purely due to increases in population. Increases in energy efficiency and the use of building-scale renewables dampen this effect; population increases by 52% by 2050 whereas emissions from natural gas and electricity only increase by 18% and 27% each, respectively. Waste Disposal also shows a slight increase in emissions due to population increases.

Other sectors all show decreases due to higher efficiency, more stringent standards, new technology, and the use of recycling and compost as an alternative to landfill. Vehicles both for residential and commercial use illustrate this clearly as even though total kilometers travelled increases by over 70%, the gains in efficiency and use of electric cars cause the net emissions to decrease by 40%.

Overall, the OurWinnipeg Scenario shows a 6% reduction in GHG emissions by 2031. Because population is forecasted to increase by 27% in this time, this indicates a reduction in per capita emissions. In 2011, per capita emissions were 7.78 tonnes of CO_2e per person, which reduces 26% to 5.78 tonnes of CO_2e per person in 2031. Looking farther ahead to 2050, we can see overall emissions reducing by 24% while the population increases by 52%. Per capita emissions are forecasted at 4.58 tonnes of CO_2e per person in 2050, representing a decrease of 41% from 2011. See Table 28 for a summary of the changes to emission by year and sector.

Table 28: OurWinnipeg Scenario Emission Changes

Activity	Change in Annual Emission Rate			
	2011	**2020**	**2031**	**2050**
Airport	N/A	N/A	N/A	N/A
Buildings Electricity	0%	9%	18%	18%
Building Natural Gas	0%	22%	29%	27%
Transit	0%	6%	-6%	-19%
Vehicles-Residential	0%	-12%	-31%	-40%
Vehicles-Commercial	0%	-12%	-30%	-39%
Waste Disposal	0%	-8%	0%	5%
Water and Waste Water	0%	-21%	-42%	-68%
Total	**0%**	**0%**	**-6%**	**-11%**
Per Capita Emissions	**0%**	**-11%**	**-26%**	**-41%**

The Low Carbon Path outlines a series of policies and actions that will result in significant GHG emission reductions.

5.7 Low Carbon Path Scenario

5.7.1 Description

The Low Carbon Path is made up of an overall vision in addition to sector-specific goals, policies, and actions. The Low Carbon Path outlines a series of policies and actions that will result in significant GHG emission reductions over the current *OurWinnipeg* planning scenario. To ensure that policies and actions result in an emissions path that is both achievable and ambitious, Golder facilitated a workshop with the City and key stakeholders to develop the parameters of the Low Carbon Path.

5.7.2 Assumptions

The following sub-sections present an overview of the assumptions and key indicators used in the development of the Low Carbon Path Scenario. For a more detailed explanation on the calculation methodology used, please refer to **Appendix B**.

5.7.2.1 Land Use

The land use strategy for the Low Carbon Path Scenario assumes an evolutionary shift over the OurWinnipeg scenario with a focus infill growth, transit-oriented communities and densification.

The key characteristics of the Low Carbon Path land use plan are as follows:

- Significant and measurable emphasis is placed on achieving development patterns and urban form in new neighbourhoods that are highly walkable, transit-friendly, mixed-use, and complete communities;
- Infilling and redevelopment ramping up modestly over time to become the primary mechanism for building growth beyond 2031;
- Substantial increase in proportion of new duplexes, secondary suites, row houses, and multi-unit residential buildings;
- Prioritization of centre and corridor intensification as focal points, characterized by a mix of uses, higher densities, pedestrian and transit-oriented development, and a high level of accessibility through multiple modes of transportation;
- Prioritization of high density residential developments and pedestrian-oriented transportation in the downtown;
- Transit-oriented, pedestrian-oriented and active transportation development being commonplace in all new communities;
- Implementation of district energy systems for new development, where practical;

- Development of five additional rapid transportation corridors, beyond the Southwest Transit Way, before 2031:
  - Southwest: Downtown to University of Manitoba;
  - West: Downtown to Polo Park, Red River College and the Airport;
  - East: Downtown to Kildonan Place;
  - Southeast: St. Boniface to St. Vital; and
  - Northeast: St. Boniface to River East.
- Development of additional rapid transportation corridors after 2031 based on community growth.
- Development of additional transit quality corridors throughout the City; and,
- Significant increase in active transportation infrastructure throughout the City with a focus on developing dedicated corridors for commuting.

As the Low Carbon Forecast scenario is not based on any current city plans, the building and transportation impacts from land-use policies were modeled based on the Golder Community Energy and Emissions Mapping and Planning (CEEMAP) tool. The CEEMAP tool uses a combination of geographic information system (GIS) spatial analysis and information contained in databases to model the effect of various land use, urban form and transportation changes.

A summary of the key indicator values is shown below in Table 29.

Table 29: Low Carbon Path Scenario – Building and Land Use Key Indicators

Inputs	2011	2020	2031	2050	Reference
Single-Family Homes	63%	61%	58%	53%	Developed with CEEMAP
Multi-Unit Residential Building Homes	37%	39%	42%	47%	Developed with CEEMAP
Infill Percentage of New Residential Construction	N/A	23%	50%	70%	Developed with CEEMAP

5.7.2.2 Building Electricity and Natural Gas

Building electricity and natural gas use are influenced by a number of factors that are independent of the scenarios considered. Increases to City population has a large effect on electricity and natural gas use as the consumption scales with population in the absence of other influences. Provincial demand-side management programs under Manitoba Hydro have targets for reductions in both electricity and natural gas use throughout the province. Additionally, changes in building technology have an impact on reducing the energy consumption of all new homes. Also the demand for electricity is expected to increase in residential buildings due to an increase in consumer electronics. All of these factors are outside of the control of the City, and are independent of the scenarios considered.

In the scenario, the City is assumed to heavily promote a shift of building stock makeup from single family homes to multi-unit residential buildings. Because multi-unit residential buildings are more energy efficient than single family homes, this would represent a decrease in energy use per person, both electricity and natural gas. The City would also promote building-scale renewables and energy efficient technologies through new policy tools and incentives, which might include promotion of Passivehaus, LEED, or EnergyStar building design. Building-scale renewables would continue to be primarily limited to geothermal heating systems with some solar water heating. Additionally, within the Low Carbon Path Scenario, the City would aim to increase district energy systems by promoting limited adoption in targeted areas such as downtown, and requiring district energy system readiness in new developments.

A summary of the key indicator values is shown below in Table 30.

Table 30: Low Carbon Path Scenario – Building Electricity and Natural Gas Key Indicators

Inputs	2011	2020	2031	2050	Reference
Building Electricity Intensity Reduction due to Demand Side Management	0%	4%	5%	10%	Manitoba Hydro
Building Natural Gas Intensity Reduction due to Demand Side Management	0%	2%	3%	6%	Manitoba Hydro
New Building Energy Intensity Reduction due to Building Stock Changes	0%	8%	17%	33%	Calculated
New Building Energy Intensity Reduction due to Technology Changes	0%	14%	30%	59%	Assumed
Additional Electricity Use	0%	5%	10%	21%	Manitoba Hydro
Residential Building Scale Renewables	1.5%	4%	8%	14%	Manitoba Geothermal Energy Alliance
Commercial/Industrial Building Scale Renewables	1.5%	6%	12%	22%	Manitoba Geothermal Energy Alliance
Residential Buildings Connected to District Energy Systems	0%	2%	4%	8%	Assumed
Commercial Buildings Connected to District Energy Systems	< 1%	3%	6%	12%	Assumed
Residential Electricity Use (kWh/year)	1,690,588,866	1,873,133,493	2,066,458,470	2,144,637,253	Calculated
Commercial Electricity Use (kWh/year)	3,046,484,478	3,259,313,820	3,423,823,982	3,117,963,439	Calculated
Industrial Electricity Use (kWh/year)	837,309,539	895,804,516	941,019,231	856,955,139	Calculated
Residential Natural Gas Use (m^3/year)	488,426,808	583,814,306	604,010,541	570,215,446	Calculated
Commercial Natural Gas (m^3/year)	361,222,578	433,410,227	448,167,147	403,452,094	Calculated
Industrial Natural Gas (m^3/year)	104,025,761	125,152,448	129,843,331	117,562,603	Calculated

5.7.2.3 Transit

The Low Carbon Path Scenario assumes that the City would continue to use B2 diesel in buses, with fuel efficiency of buses improving due to changes in technology. Additionally, there would be a larger phase-in of diesel-electric hybrid or fully electric buses. The City would rapidly expand their transit network and increase land use intensification around transit corridors to accommodate the increased population and to promote a more transit-friendly city. This transit network expansion would result in a significant increase in transit usage in the city. The City is also expected to introduce electric light rail transit in this scenario, the first being completed before 2031.

A summary of key indicator values is shown below in Table 31.

Table 31: Low Carbon Path Scenario – Transit Key Indicators

Inputs	2011	2020	2031	2050	Reference
Kilometers of Transit Travel (km/year)	24,282,940	31,351,034	41,205,637	61,377,308	Assumed
Transit Fuel Type (% of kilometers travelled)	100% B2 Biodiesel	85% B2 Biodiesel 15% Electric	60% B2 Biodiesel 40% Electric	25% B2 Biodiesel 75% Electric	Assumed
Diesel Fuel Use (L/year)	16,163,620	16,651,425	13,423,738	6,334,817	Calculated
Electricity Use (MWh/year)	0	16,459	57,688	161,115	Calculated

5.7.2.4 Vehicles

Between all scenarios, GHG emissions per kilometer travelled are also expected to decrease as the result of new technology and new government policies, such as federal government tailpipe emission standards. As vehicular usage represents a large percentage of overall community emissions, the extent of fuel economy improvements represents one of the most significant areas of uncertainty in the overall community GHG emissions forecast. Fuel economy improvements assumed in the forecast are based on the continued adoption of government regulations mandating vehicular fuel efficiency standards, technology roll-out for low-emission vehicles and economic considerations, such as sustained increase in oil prices.

A projection of emissions per kilometer travelled for new vehicles was obtained from a UNEP study on Canadian Automotive Fuel Economy Policy [7]. To determine the GHG emissions from the combined fleet on the road, the average vehicle on the road in Winnipeg was assumed to be 10 years old. This assumption was based on the current vehicle makeup from the registration data provided by the Manitoba Public Insurance.

In the Low Carbon Path Scenario, the public transit infrastructure expands rapidly, reducing the number of passenger vehicles on the road. In parallel with improvements in transit, this scenario includes an aggressive expansion of year-round connected networks of bike trails and active transportation infrastructure. Additionally, the City will promote segregated bike lanes and off-road bike paths. Electric vehicles will have increased adoption due to substantial growth of private and public electric vehicle infrastructure. The City fleet would also be partially retrofitted to electric vehicles.

A summary of key indicator values is shown below in Table 32.

Table 32: Low Carbon Path Scenario – Vehicle Key Indicators

Inputs	2011	2020	2031	2050	Reference
Cycle Network (km)	274	600	800	800	Assumed
Total Residential Vehicle Kilometers Travelled (vkmt/year)	5,175,656,607	4,943,881,915	5,976,259,971	5,889,224,738	Calculated
Total Commercial Vehicle Kilometers Travelled (vkmt/year)	932,055,814	988,776,383	1,195,251,994	1,177,844,948	Calculated
Electric Vehicle Use	0%	4%	8%	16%	Assumed
Weekday Trips by Mode Auto Driver Auto Passenger Public Transit Walk/Cycle	 64% 18% 10% 8%	 61% 18% 11% 9%	 58% 18% 13% 10%	 54% 18% 15% 11%	Assumed
Average Residential Fleet Emissions (gCO_2e/km)	370	269	185	121	Calculated
Average Commercial Fleet Emissions (gCO_2e/km)	1015	752	532	359	Calculated

5.7.2.5 *Waste Disposal*

In all scenarios, the average waste generated remains the same. This means that across the scenarios, the waste increases proportionally as the City grows.

In the OurWinnipeg Scenario, the City goes beyond the 2011 *Garbage and Recycling Master Plan* to further increases the amount of residential, commercial/industrial and construction/demolition waste sent for beneficial use (i.e., recycling or composting). This scenario also has improvements to landfill gas collection efficiency above and beyond the OurWinnipeg Scenario through greater expansion of the landfill gas collection system to incorporate all new waste and higher methane capture efficiency. Additionally, the Low Carbon Path includes a reduction in yard waste sent to landfills due to initiatives by the City, leading to an overall decrease in residential waste and a slight change in the residential waste makeup. The scenario assumes the rollout of a residential source separated organics program to meet the residential diversion rate targets.

A summary of key indicator values is shown below in Table 33.

Table 33: Low Carbon Path Scenario – Waste Disposal Key Indicators

Inputs	2011	2020	2031	2050	Reference
Residential Waste (tonne/year)	278,896	209,225	99,794	119,521	Calculated
Commercial/Industrial Waste (tonne/year)	348,000	337,577	108,484	112,738	Calculated
Construction/Demolition Waste (tonne/year)	124,000	130,746	38,655	40,171	Calculated
Residential Diversion Rate	15%	42%	75%	75%	Assumed
Commercial/Industrial Diversion Rate	20%	31%	80%	80%	Assumed
Construction/Demolition Diversion Rate	20%	25%	80%	80%	Assumed
Landfill Gas Collection Coverage (City Landfills)	100%	100%	100%	100%	Assumed
Landfill Gas Collection Efficiency (City Landfills)	55%	75%	75%	75%	Assumed
Landfilled Waste Per Capita (tonne/person/year)	1.09	0.87	0.28	0.26	Calculated

5.7.2.6 Water and Waste Water

For all scenarios, total mass of biosolids associated with waste water increases with population. In the Low Carbon Path Scenario, the treatment methods do not change at all. However, this scenario does show a near-elimination of biosolids sent to landfill through beneficial use and composting due to City initiatives.

A summary of key indicator values is shown below in Table 34.

Table 34: OurWinnipeg Scenario – Water and Waste Water Key Indicators

Inputs	2011	2020	2031	2050	Reference
Mass of Biosolids Disposed (tonne/year)	13,982	15,700	17,700	21,200	Calculated
Biosolids Sold for Beneficial Use	0%	35%	70%	80%	Assumed
Biosolids Composted	0%	20%	30%	20%	Assumed

5.7.3 Results

The results from the OurWinnipeg Scenario can be seen below in Table 35 and Figure 12.

Table 35: Low Carbon Path Scenario Results

Activity	Annual Emission Rate (tonne CO_2e/year)			
	2011	2020	2031	2050
Airport	N/A	N/A	N/A	N/A
Buildings Electricity	18,284	19,773	21,095	20,269
Building Natural Gas	1,801,027	2,157,394	2,232,262	2,060,799
Transit	43,495	44,863	36,314	17,581
Vehicles-Residential	1,725,116	1,328,977	1,106,737	711,609
Vehicles-Commercial	945,642	743,520	636,026	423,165
Waste Disposal	798,801	650,971	219,989	234,502
Water and Waste Water	46,659	31,126	14,411	14,863
Total	**5,379,024**	**4,976,624**	**4,266,834**	**3,482,788**
Per Capita Emissions	**7.78**	**6.41**	**4.87**	**3.32**

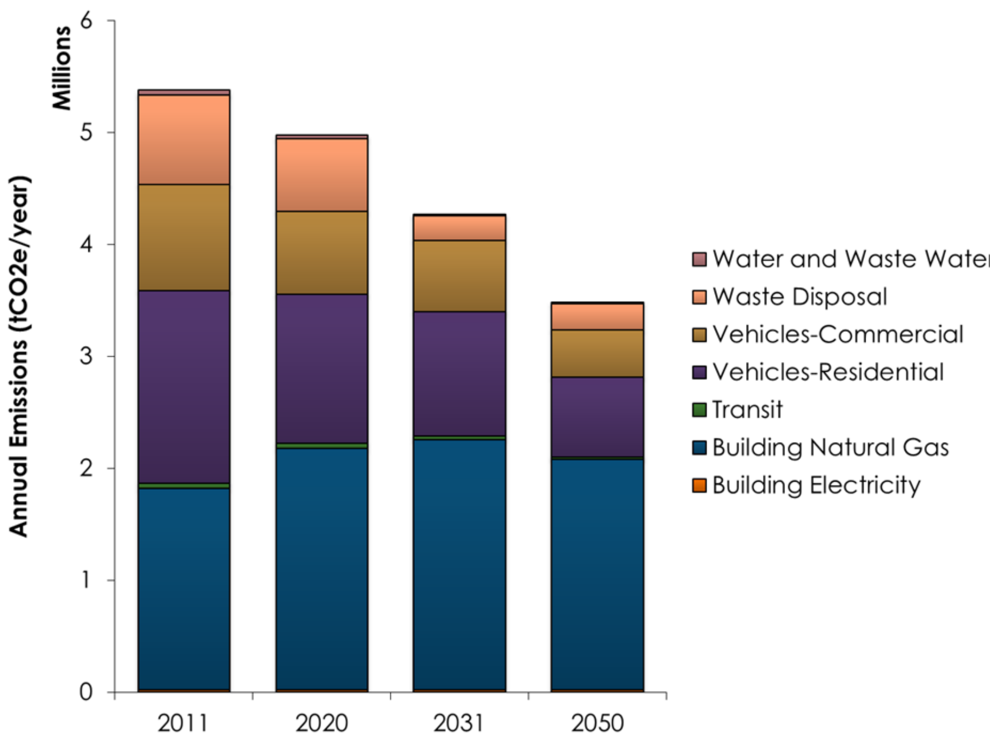


Figure 12: Low Carbon Path Scenario Results

In this scenario, overall emissions decrease very significantly for the City. This is due to the effects of new technology and aggressive City policies reducing emission rates while population increases. Increases in emissions are only seen marginally in Building Natural Gas and Building Electricity, which are purely due to increases in population. Promotion of multi-unit residential buildings, increases in energy efficiency, and the use of building-scale renewables considerably dampen this effect; population increases 52% by 2050 whereas emissions from natural gas and electricity only increase by 11% and 14% each, respectively.

Other sectors all show significant decreases due to City policies, higher efficiency, more stringent standards, new technology, and the use of recycling and composting as an alternative to landfill.

Overall, the Low Carbon Path Scenario shows a 21% reduction in GHG emissions by 2031. As population is forecasted to increase by 27% in this time, this indicates a drastic reduction in per capita emissions. In 2011, per capita emissions were 7.78 tonnes of CO_2e per person, which reduces 37% to 4.87 tonnes of CO_2e per person in 2031. Looking farther ahead to 2050, we can see overall emissions reducing by 35% while the population increases by 52%. Per capita emissions are forecasted at 3.32 tonnes of CO_2e per person in 2050, representing a decrease of 57% from 2011. See Table 36 for a summary of the changes to emission by year and sector.

Table 36: Low Carbon Path Scenario Emission Changes

Activity	**Change in Annual Emission Rate**			
	2011	**2020**	**2031**	**2050**
Airport	N/A	N/A	N/A	N/A
Buildings Electricity	0%	8%	15%	11%
Building Natural Gas	0%	20%	24%	14%
Transit	0%	3%	-17%	-60%
Vehicles-Residential	0%	-23%	-36%	-59%
Vehicles-Commercial	0%	-21%	-33%	-55%
Waste Disposal	0%	-19%	-72%	-71%
Water and Waste Water	0%	-33%	-69%	-68%
Total	**0%**	**-7%**	**-21%**	**-35%**
Per Capita Emissions	**0%**	**-18%**	**-37%**	**-57%**

5.8 Summary of Forecast GHG Emissions

A comparison of the scenarios for 2031 can be seen below in Table 37 and Figure 13.

Table 37: Comparison of Scenario Results

Activity	Annual Emission Rate (tonne CO_2e/year)			
	Baseline (2011)	**Business as Usual (2031)**	**OurWinnipeg (2031)**	**Low Carbon Path (2031)**
Airport	N/A	N/A	N/A	N/A
Buildings Electricity	18,284	21,768	21,663	21,095
Building Natural Gas	1,801,027	2,375,323	2,332,091	2,232,262
Transit	43,495	35,479	40,776	36,314
Vehicles-Residential	1,725,116	1,227,376	1,191,832	1,106,737
Vehicles-Commercial	945,642	672,696	659,158	636,026
Waste Disposal	798,801	1,093,004	796,266	219,989
Water and Waste Water	46,659	56,945	27,171	14,411
Total	**5,379,024**	**5,482,591**	**5,068,956**	**4,266,834**
Per Capita Emissions	**7.78**	**6.25**	**5.78**	**4.87**

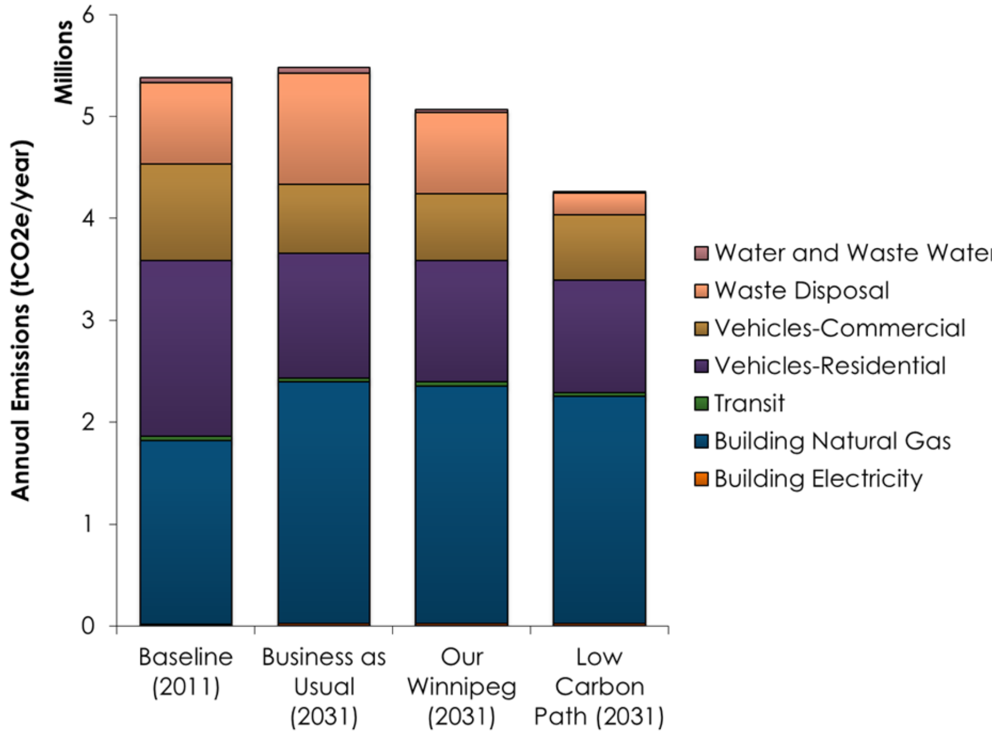


Figure 13: Comparison of 2031 Scenario Results

The Business as Usual Scenario shows a slight increase in emissions by 2031 where the OurWinnipeg Scenario has a moderate reduction and the Low Carbon Path Scenario shows a significant reduction in GHG emissions. Recall that the primary difference between the scenarios was actions taken by the City.

By examining the sectors individually, we observe the importance of City policies on Waste Disposal and Water and Waste Water. The Business as Usual Scenario shows a significant increase in these categories whereas the OurWinnipeg Scenario shows a slight decrease and the Low Carbon Path Scenario shows a significant decrease in emissions. This emphasizes the influence of the City's policies such as diversion rates, yard recycling, land fill gas collection efficiency, and biosolid composting and sales for beneficial use.

Conversely, we find that emissions from building electricity and natural gas, transit, and vehicles do not seem to be impacted significantly by City policies. However, noting that these sectors show much slower response to GHG reduction policies because they involve replacement on time-scales of 10 or more years is important. This means that even though drastic results are not yet shown in the forecasts for 2031, emission-focused policies will set the City on the path toward long-term sustainability.

This this path towards long-term sustainability can be seen in Figure 14, below, which illustrates the changes in GHG emissions over time for all Scenarios.

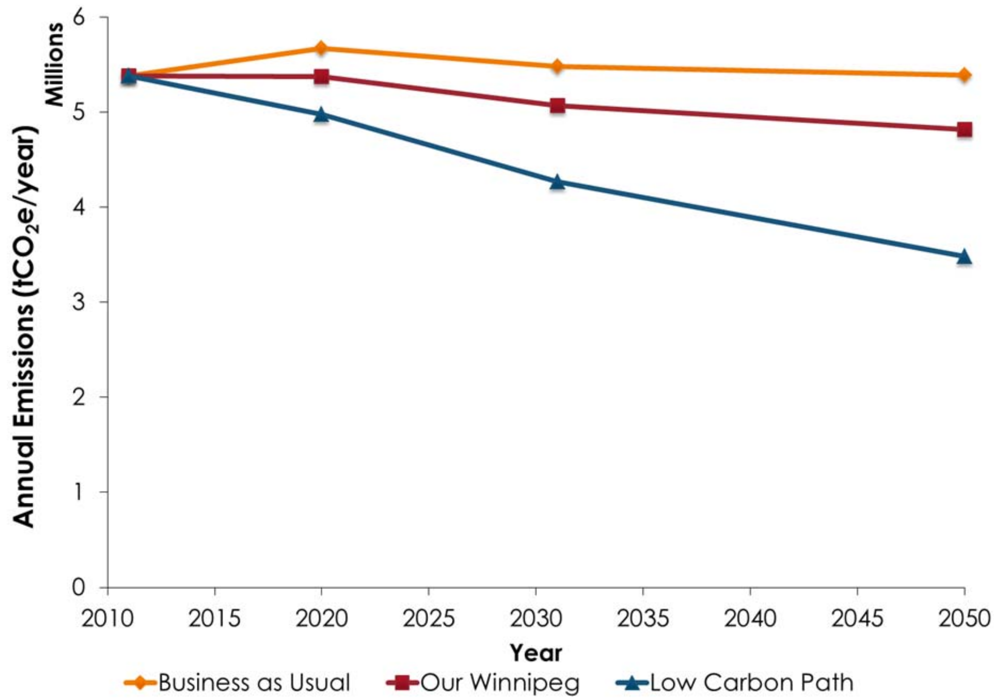


Figure 14: Comparison of All Scenarios Results

From these trends, we can clearly see that even though the aggressive emission-focused policies of the Low Carbon Path Scenario did not make a very large impact in 2031, they do offer a trend in the right direction. By 2050, the Low Carbon Path Scenario shows a reduction in emissions of 35% for the City whereas the OurWinnipeg Scenario only shows 11%. For comparison, the Business as Usual Scenario has almost no change, with an increase of only 0.2% overall.

Examining the categories individually again, we look to Figure 15 for a breakdown of the 2050 emissions for all scenarios.

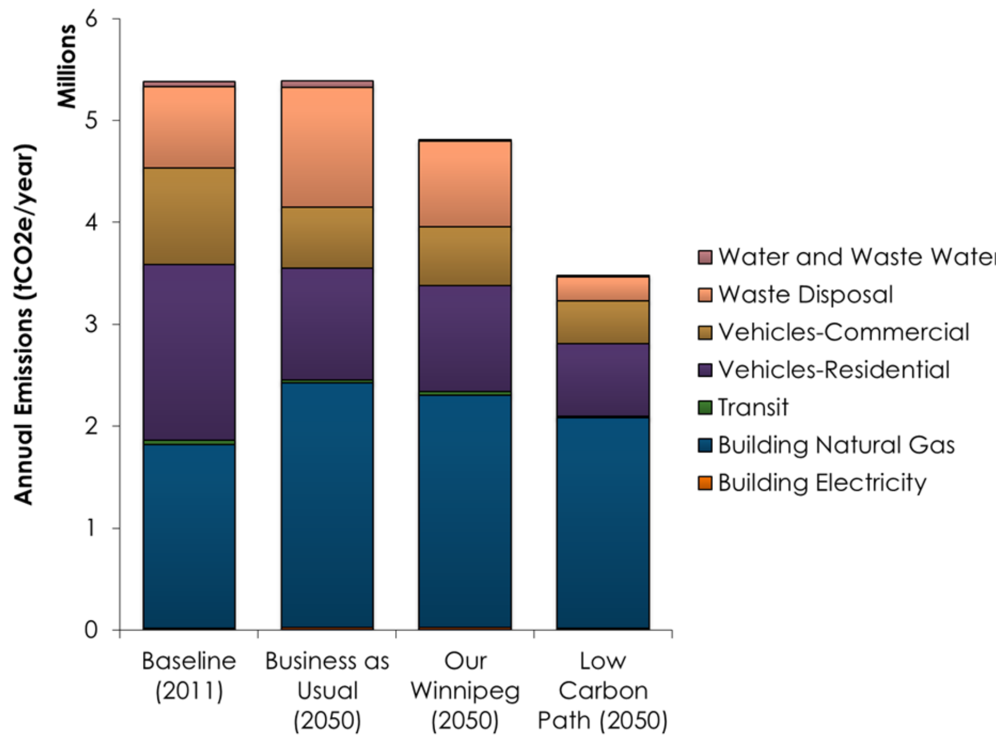
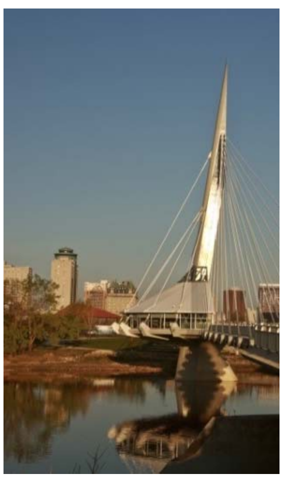


Figure 15: Comparison of 2050 Scenario Results

As in the 2031 comparison, the drastic differences in emissions associated with Waste Disposal and Water and Waste Water are apparent. However, here we can see that emissions from Building Natural Gas and Electricity are clearly different between scenarios. This is primarily due to the differences in building stock. The OurWinnipeg Scenario has a moderate shift from single family homes to multi-unit residential buildings, which leads to the slight improvement in emissions over the Business as Usual Scenario. The Low Carbon Path shows even further improvements in building emissions because it involves a much greater promotion of multi-unit residential buildings.

Looking at all transportation emissions, we can see the effects of the City policies of an expanded public transportation network and promotion of electric vehicles for the general public, City vehicles, and transit vehicles. Because of these factors, the total kilometers driven for residential and commercial vehicles decrease in the OurWinnipeg and Low Carbon Path Scenarios, leading to the reduced emissions. Furthermore, although the OurWinnipeg and Low Carbon Path Scenarios would have more kilometers traveled for transit vehicles, overall emissions go down due to the shift toward electric hybrid and full electric buses.

While the forecast shows a reduction in carbon emissions, many of the emissions reductions are associated with technological and senior government level policies that are not directly within the purview of the City of Winnipeg.



6.0 ANALYSIS OF EMISSION REDUCTION OPPORTUNITIES

Emission reduction opportunities are currently being pursued by the City of Winnipeg as a part of their *OurWinnipeg* planning initiative. While the forecast shows a reduction in carbon emissions, many of the emissions reductions are associated with technological and senior government level policies that are not directly within the purview of the City of Winnipeg.

The Low Carbon Path forecast scenario was developed to demonstrate what additional potential carbon reduction strategies could be pursued beyond the policies set out as a part of the *OurWinnipeg* planning initiative. The policy assumptions of the Low Carbon Path are considered to be a moderate, evolutionary and practical improvement over the current plans.

The emission reduction opportunities have been divided into the following areas for analysis:

- Land Use and Buildings;
- Transportation; and
- Waste, Wastewater and Water Management.

To reduce GHG emissions to this level and noticeably change the energy mix in Winnipeg, the City would likely need to undertake the activities outlined below.

Note that the cost, timing, or sequencing of these recommendations has not been evaluated or proposed as part of this discussion paper. Further analysis by the City on the resource requirements for these recommendations, opportunities for implementation, readiness of the marketplace, and timing considerations is recommended. This analysis will allow the City to prioritize these recommendations and create a more detailed implementation plan as part of the City of Winnipeg carbon reduction strategy.

6.1 Land Use and Buildings

Table 38: Land Use and Buildings Emission Reduction Opportunity Assessment

Opportunity Description	Comparison of Key Performance Indicators between OurWinnipeg and Low Carbon Path Forecast	Estimated GHG Impact
Land Use Planning Beyond *OurWinnipeg* *OurWinnipeg* and the *Complete Communities Direction Strategy* promotes a transitional growth strategy that balances economic development and livable communities. Further low carbon consideration would prioritize infill, intensification, and transit oriented development in Transformative Areas (including the downtown, mixed use centres and corridors, major re-development sites, and rapid transit corridors) over low-density and greenfield development at the City's periphery. In Recent and Mature Communities, the focus is on the conservation of ageing building stock, increasing housing choice, while maintaining the existing character of mature neighbourhoods. Infilling in these areas focuses on densification by decreasing lot size and promoting the development of mixed developments and multi-units residential buildings as the norm. Where *OurWinnipeg* planning initiative outlines new neighbourhoods where the emphasis is on developing highly walkable, transit-friendly, mixed-use, and complete communities, in the Low Carbon Path scenario, this planning design becomes the norm. The result is that the majority of new communities are designed for livability and to minimize their carbon-impact. New communities placed on transit quality corridors.	**Percentage of New Buildings which are Greenfield Developments in 2031 Calendar Year:** *OurWinnipeg:* 84% *Low Carbon Path*: 50% **Percentage of New Buildings which are Infill Developments in 2031 Calendar year:** *OurWinnipeg:* 14% *Low Carbon Path*: 50% **Percentage of New Residential Household Development from 2011 to 2031:** *OurWinnipeg:* Single Family Homes: 53% Multi-Unit Residential Buildings: 47% *Low Carbon Path:* Single Family Homes: 40% Multi-Unit Residential Buildings: 60%	Reduction in Overall Emissions 2031: 1.3% 2050: 3.8% Reduction in Sector Emissions 2031: 2.8% 2050: 7.8%
Pursue Infill Development As Primary Growth Strategy Infill development is typically more challenging to pursue than greenfield development, as it is subject to unique barriers, risks, and uncertainties. The Low Carbon Path depicts a substantial acceleration in the proportion of new dwelling units that are built in Transformative Areas served by existing municipal infrastructure and assumes that barriers to infill can be overcome through municipal leadership and in partnership with City builders.		

Opportunity Description	Comparison of Key Performance Indicators between OurWinnipeg and Low Carbon Path Forecast	Estimated GHG Impact
Promote Modest Growth of Building-Scale Renewable Energy Building scale renewables have had limited implementation primarily due to the current low cost of electricity (5 to 7¢ per kWh) and natural gas (17¢ per m^3). While the low price of electricity makes investment in building-scale renewable electricity generation impracticable from an economic perspective, alternative space and hot water heating technologies have become an attractive way to reduce natural gas usage over time. The Low Carbon Path assumes that non-electricity generating building-scale renewables, such as geoexchange or solar hot water system, will be promoted by means of a tax incentive or subsidy, but will not be required on new development opportunities. Development of building scale renewables will be promoted with a small subsidy or tax incentive. Other strategies such as promotion of 'solar-ready' new developments will also be implemented in the Low Carbon Path.	**Percentage of All Buildings that Operate Building-Scale Renewables in 2031:** *OurWinnipeg:* 4% Residential 6% Commercial and Industrial *Low Carbon Path:* 8% Residential 12% Commercial and Industrial	Reduction in Overall Emissions 2031: 0.6% 2050: 0.7% Reduction in Sector Emissions 2031: 1.2% 2050: 1.5%
Increase Uptake of District Energy Systems in New in New Residential, Commercial and Industrial Development District energy system are an effective means to provide economic heating and even electrical power to large developments. Currently, there is limited implementation of geoexchange district energy such as the Forks Market, IKEA and McPhillips Common geoexchange systems. In the *OurWinnipeg* planning initiative it is assumed that geoexchange district energy systems will continue to grow for some of the new developments. In the Low Carbon Path it is assumed that municipal tax incentives have been implemented to promote the further implementation of district energy systems.	**Percentage of Buildings Connected to District Energy Systems in 2031** *OurWinnipeg:* 2% Residential 3% Commercial and Industrial *Low Carbon Path:* 4% Residential 126 Commercial and Industrial	Reduction in Overall Emissions 2031: 0.1% 2050: 0.2% Reduction in Sector Emissions 2031: 0.2% 2050: 0.4%

6.2 Transportation

Table 39: Transportation Emission Reduction Opportunity Assessment

Opportunity Description	Comparison of Key Performance Indicators between OurWinnipeg and Low Carbon Path Forecast	Estimated GHG Impact
Complete the Rapid Transit Network and Improvement of Transit Service The OurWinnipeg forecast assumes a build-out of rapid transit in accordance with Winnipeg's *Transportation Master Plan*, including the completion of the Southwest, East, North, and West corridors by 2031, and continued implementation of improvements to designated Transit Quality Corridors. The Low Carbon Forecast assumes a full build-out of the rapid transit system proposed in the *Transportation Master Plan* by 2031, including the Southeast and Northeast corridors. Additionally, all transit routes are assumed to have achieved at least 30-minute service headways at all times. The Low Carbon Forecast further assigns a majority of new infill development along rapid transit corridors, transit quality corridors, and mixed use centres and corridors identified in the *Transportation Master Plan* and the *Complete Communities Direction Strategy*. This accelerated infill is assumed to be achieved through supportive policy, planning tools, and incentives complementary to increasing the efficiency of the transit network. New suburban communities as identified in the Complete Communities direction strategy are targeted for enhanced service and access to this network of corridors.	**Commuter Mode Share in 2031:** *OurWinnipeg:* 63% Auto-Driver 18% Auto-Passenger 10% Public Transit 8% Walking/Cycling *Low Carbon Path:* 58% Auto-Driver 18% Auto-Passenger 13% Public Transit 10% Walking/Cycling **Total Annual Vehicle Kilometers Traveled in 2031:** *OurWinnipeg:* Residential: 6,161,200,000 km / year Commercial: 1,232,200,000 km / year *Low Carbon Path:* Residential: 5,976,300,000 km / year Commercial: 1,195,300,000 km / year	Reduction in Overall Emissions 2031: 1.2% 2050: 9.1% Reduction in Sector Emissions 2031: 3.1% 2050: 26.4%
Complete the Active Transportation Network and Promotion of Alternative Transportation Options Winnipeg's *Transportation Master Plan* includes a proposed long term active transportation network expansion to 674km from 274km in 2011. The OurWinnipeg forecast assumes this proposed network will be complete by 2031.	Active Transportation Network *OurWinnipeg:* 674 km *Low Carbon Path:* 800 km	

Opportunity Description	Comparison of Key Performance Indicators between OurWinnipeg and Low Carbon Path Forecast	Estimated GHG Impact
The Low Carbon Path assumes that the active transportation network completion is accelerated and grows as the City expands to facilitate convenient and direct trips to daily destinations and amenities by foot or by bike. The Low Carbon Path also assumes additional incentives and policies are implemented to manage transportation demand within the community. This may include high-occupancy vehicle lanes along major corridors and car pool programs which are estimated to allow the share of vehicle passenger travel to keep up with the growth in City population.		
Increase Uptake of Electric and Low-Emission Vehicles In 2014, the first public electric vehicle charging station was installed in Winnipeg. As electric vehicle technology improves, the infrastructure needed to support the technology will also need to be developed. While Winnipeg has abundant block heater outlets, most outlets are cycled, which make the impractical for electric vehicle usage. The Manitoba provincial government has begun the implementation of its Electric Vehicle road map; however, the planned roll is limited and will not support anything beyond a minor adoption of electrical vehicle in the near future. Whereas the OurWinnipeg forecast assumes modest in electric vehicles, the Low Carbon Path forecast presumes more aggressive growth in electric vehicles by 2031. Local regulatory and policy tools and incentives are assumed to support this growth through the provision of 'electric-vehicle ready' homes and the strategic installation of public rapid charging infrastructure in new development. Additionally, the forecast assumes that new provincial incentives for charging infrastructure and electric vehicle deployment may be required. Up to 50% of the City's own municipal non-transit passenger vehicles are assigned to be electric in accordance with an expansion of the City's *Green Fleet Plan*.	**Electric Vehicle Share as Percentage of Overall Vehicle Kilometers Traveled in 2031:** *OurWinnipeg:* 2% *Low Carbon Path:* 8%	Reduction in Overall Emissions 2031: 0.6% 2050: 0.7% Reduction in Sector Emissions 2031: 1.5% 2050: 2.0%

Opportunity Description	Comparison of Key Performance Indicators between OurWinnipeg and Low Carbon Path Forecast	Estimated GHG Impact
Electrification of Transit Fleet As a part of Winnipeg Transit long-term planning, 10% of their transit fleet is estimated to be replaced by battery-electric vehicles by 2031. In the Low Carbon Path, replacement is assumed to have been expanded through both the one-for-one replacement of diesel and biodiesel buses with battery-electric vehicles, but also the limited implementation of electric trolley buses.	**Percentage of Winnipeg Transit Diesel and Electric Buses Fleet in 2031** *OurWinnipeg:* Diesel and Biodiesel: 90% Electric: 10% *Low Carbon Path:* Diesel and Biodiesel: 60% Electric: 40%	Reduction in Overall Emissions 2031: 0.5% 2050: 0.6% Reduction in Sector Emissions 2031: 1.4% 2050: 2.0%

6.3 Waste, Water and Wastewater

Table 40: Waste, Water and Wastewater Emission Reduction Opportunity Assessment

Opportunity Description	Comparison of Key Performance Indicators between OurWinnipeg and Low Carbon Path Forecast	Estimated GHG Impact
Enhance the *Garbage and Recycling Master Plan* The Sustainable Water and Waste component of the *OurWinnipeg* planning initiative outlines various new policies and programs that will be implemented by 2031 to reduce the amount of waste entering the landfill including yard waste composting and development of an organics strategy. The Low Carbon Path forecast assumes that additional educational programs and waste policies are implemented to further increase the diversion rate of existing recycling programs. A City-wide organics diversion program is assumed to have been implemented.	**Waste Diversion Percentages in 2031:** *OurWinnipeg:* Residential: 50% Commercial/Industrial: 20% Construction/Demolition: 20% *Low Carbon Path:* Residential: 75% Commercial/Industrial: 80% Construction/Demolition: 80% **Landfill Gas Collection Coverage for Non-City Landfills in 2031** *OurWinnipeg:* 0% *Low Carbon Path:* 25% **Landfill Gas Collection Efficiency for City Landfills in 2031** *OurWinnipeg:* 75% *Low Carbon Path:* 75%	Reduction in Overall Emissions 2031: 11.4% 2050: 12.6% Reduction in Sector Emissions 2031: 72.4% 2050: 72.1%
Expand Landfill Gas Collection System for Non-City of Winnipeg Landfills The OurWinnipeg forecast presumes that the Brady Resource Recovery Centre's landfill gas collection system will be expanded over time and its methane collection efficiency will improve to 75%. A large proportion of commercial, industrial, institutional, and construction and demolition waste is landfilled outside of the City. The Low Carbon Path assumes that measures will be in place to capture at least 25% of the methane generating potential of this waste by 2031.		
Eliminate the Landfilling of Biosolids The City of Winnipeg is currently looking at ways to commercialize the biosolids generated as a part of their wastewater treatment system. In 2031, the City plans to market some of its biosolids for resale and compost the remaining amount. In the Low Carbon Forecast scenario, the City is	**Percent of City Wastewater Biosolids Diverted for Commercial Usage in 2031** *OurWinnipeg:* 40% *Low Carbon Path:* 70%	Reduction in Overall Emissions 2031: 0.3% 2050: 0.0%

Opportunity Description	Comparison of Key Performance Indicators between OurWinnipeg and Low Carbon Path Forecast	Estimated GHG Impact
assumed to be able to market the majority of its biosolids for use in the agriculture or landscaping industries, offsetting the amount of fertilizer that is required.		Reduction in Sector Emissions 2031: 47.0% 2050: 0.0%

6.4 Summary of Emission Reduction Opportunities

A summary of the impact of the *OurWinnipeg* emission reduction opportunities is shown in Figure 16. Each emission reduction opportunity is shown as having an incremental reduction in City emissions from the Business as Usual Scenario.

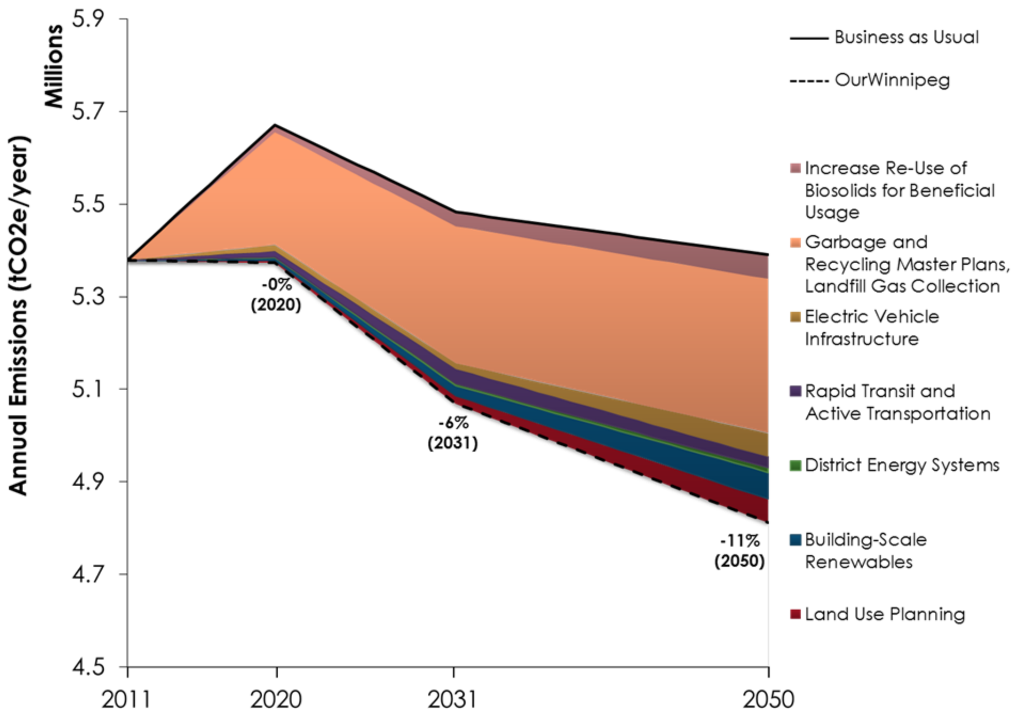


Figure 16: Summary of OurWinnipeg Emission Reduction Opportunities

A summary of the impact of the Low Carbon Path emission reduction opportunities is shown below in Figure 17. The emissions reduction beyond the OurWinnipeg Scenario is shown for each reduction opportunity. The Low Carbon Path forecast assumes all of the emission reduction opportunities have been implemented.

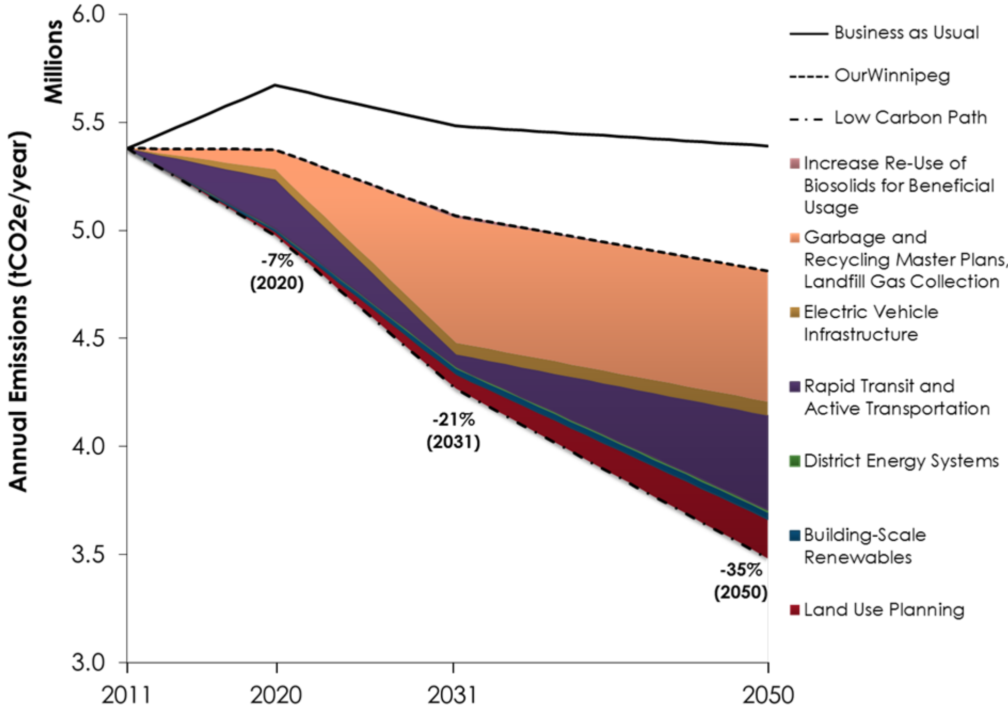


Figure 17: Summary of Low Carbon Path Emission Reduction Opportunities

The largest impact to overall emissions is seen through rapid transit and active transportation improvements. Additionally, land use planning also represents the potential for significant emission reductions within the City. These opportunities do not yet show a drastic improvement by 2031; however, they set the City on the right path for a low emissions future. Looking forward to the 2050 forecast, we can see that these emission reduction opportunities show the largest GHG reductions for the City.

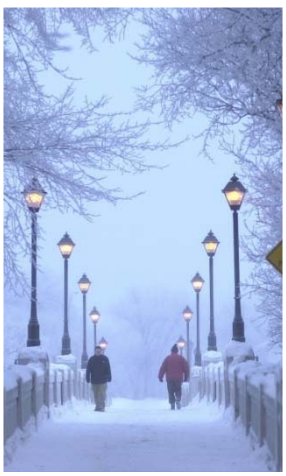
Future City of Winnipeg community GHG inventories should include emissions associated non-building energy consumption at the airport (mobile equipment and aircraft) within the scope of the community inventory in accordance with the ICLEI protocol.

7.0 RECOMMENDED FURTHER ACTIONS

Update Inventory to Include James Armstrong Richardson International Airport

The 2011 City of Winnipeg community GHG inventory excluded emissions assigned to the Winnipeg James Armstrong Richardson International Airport. Originally, the airport emissions were to be included within the scope of the study, however, the Winnipeg Airport Authority (WAA) GHG consumption data was under the process of being prepared, but not publically available at the time of the study.

Future City of Winnipeg community GHG inventories should include emissions associated non-building energy consumption at the airport (mobile equipment and aircraft) within the scope of the community inventory in accordance with the ICLEI protocol. As the airport is currently preparing their own GHG inventory report, the inclusion of airport emissions should be a relatively simple exercise. The key would be to ensure that the emissions from building electricity and natural gas consumption included in the WAA GHG report be excluded, as it is already included from the MB Hydro energy consumption dataset.



Track Key Performance Indicators

As a part of the preparation of the community inventory, several key performance indicators (KPIs) were identified as driving community GHG performance. Some of the KPIs were readily available based information supplied by data providers. Other indicators may need to be developed and tracked based on a broader City engagement with external organization.

Particularly, additional data monitoring and collection is recommended with respect to the building energy consumption and the data set provided by Manitoba Hydro and collected by the City of Winnipeg. The indicators include, but are not limited to:

- Residential, commercial and institutional electricity and natural gas intensity as a function of energy consumption per unit building area;
- Inventory of existing building stock including building type and age; and
- Energy consumption disaggregated by postal code.

Other major planning indicators include:

- Transit headway;
- Density on transit corridors;
- Transportation mode share;
- Waste generation per capita; and
- Infill (i.e., comparison of new building starts in greenfield vs. existing development areas).

A complete summary of all GHG KPIs recommended to be tracked a part of an overall community action plan is included in **Appendix C**. The goal of collecting these additional KPIs will be to provide to set the data collection methodologies and collect the data necessary to set targets and goals as a part of a broader Community Energy Plan.

Develop Advisory Group

To move ahead with climate action planning in the City of Winnipeg, it is recommended that the City develop an Advisory Group that will set GHG planning goals and targets in consultation and with approval of the City of Winnipeg Council. A core group of 10-14 individuals is recommended to form the executive of the group with a broader consultation group including many of the same members who participated in the Low Carbon Path stakeholder engagement component of the inventory project. The core executive is recommended to consist of:

- City of Winnipeg Council Sponsor
- City of Winnipeg Climate Change Coordinator
- City of Winnipeg Transportation Planner
- City of Winnipeg Waste Planner
- City of Winnipeg Land Use Planner
- Manitoba Hydro Power Smart
- Winnipeg Airport Authority
- 4-6 leaders from non-governmental community organizations, which may include, but is not limited to:
  - Community environmental and social advocacy groups;
  - Winnipeg Chamber of Commerce;

- First Nations groups
- Local academia experts focussing on climate change, alternative energy and/or energy efficiency.

The core executive of the Advisory Group would meet regularly and would lead the design, implementation and monitoring of the Climate Action Plan. Input and feedback should be solicited from the broader action group for targeting setting, policy development and to review and comment on key deliverables.

Engage the Public

To solicit feedback outside the Advisory Group during the preparation and implementation of the Climate Action Plan, the development of a public engagement strategy is recommended. Feedback could be solicited through a series of public workshops, mail outs, social media and online resources. The City's communication department is recommended to play an active role is communicating the role of the Climate Action Plan to ensure representative feedback is received by the community.

Develop a Climate Action Plan

The key tool that outlines how the City of Winnipeg will set their climate goals and implement their reduction strategy should be the implementation of a detailed Climate Action Plan. The goal of the plan is to serve as a blueprint for how to community will achieve its energy and GHG reduction targets. Several protocols and guides have been developed that outlines the scope and methodology that should be used in the preparation of the plan, including, but not limited to:

- Federation of Canadian Municipalities Partners, Climate Change Milestone 3 protocol [11];
- Quality Urban Energy Systems of Tomorrow (QUEST), Advancing Integrated Community Energy Planning in Ontario: A Primer [12];
- The Community Energy Association's (CEA's) and the Province of British Columbia, Community Energy & Emissions Planning: A Guide for B.C. Local Governments [13]; and
- Natural Resources Canada, Community Energy Planning Guide [14].

Each protocol approaches community energy planning from a slightly different perspective. However, irrespective of the protocol, many of the tenets are similar and generally consist of:

- Outlining measurable, quantifiable and actionable goals for community energy and GHG reductions broken down by sector (waste, transportation, buildings, etc.) based on the KPIs developed and tracked;
- Setting milestones for key actions;
- Identifying available funding sources and needs to implement the plan;
- Outlining how the community will be consulted on the implementation of the plan;
- Assigning roles and responsibilities for the implementation of the plan; and,
- Discussing how the targets, goals and KPIs will be tracked throughout the implementation of the plan.

Various funding sources are available for the development of Climate Action Plans.

Implement Climate Action Plan

Once the Climate Action Plan has been prepared, the approval and support of council, municipal staff and the community are essential to the plan's success. The roles and proposed commitment under the Climate Action Plan for key groups are as follows:

City Council	■ **Provide leadership** in advocating for the Climate Action Plan ■ **Secure budget** for the implementation of the Climate Action Plan ■ **Legislate polices, projects and regulations** in support of the Climate Action Plan ■ **Review annual** report on progress and be accountable for achieving results
Advisory Group	■ **Provide technical support** for the practical implementation of Climate Action Plan project, plans and policies ■ **Outline the vision** for the implementation of the Climate Action Plan ■ **Act as the Liaison** between council, City staff and community stakeholders ■ **Manage and oversee the implementation** of the Climate Action Plan
City Staff	■ **Provide technical support** for the practical implementation of Climate Action Plan project, plans and policies ■ **Align department procedures** with the Climate Action Plan actions and new policies and regulation ■ **Execute projects, policies and plans** for individual Climate Action Plan initiatives ■ **Develop policies and regulations** based on the goals of the Climate Action Plan for council approval
Community Stakeholders	■ **Provide input and feedback** on Climate Action Plan policies and regulations ■ **Champion initiatives** to reduce energy and carbon within their organization and partners

Once the implementation of the Climate Action Plan is underway, monitoring the implementation progress is important to analyze progress and learn from successes and failures.

Implementing the Climate Action Plan in the plan timeline is essential. The Advisory Group should meet frequently to review the implementation of the plan and to amend the plan, targets and schedule as necessary. Communication of progress to Council and the public is essential.

Numerous resources are available, which discuss strategies from taking community planning from ideas to actions. Once such resource is *From Great Ideas to Great Communities*: *A Guide for Implementing Integrated Community Sustainability Plans in Nova Scotia* [15], which provides excellent guidance on how to move beyond community planning to implementing to programs, policies and actions necessary to meet energy and GHG targets.

Monitor Progress and Report Results

Once the implementation of the Climate Action Plan is underway, monitoring the implementation progress is important to analyze progress and learn from successes and failures. Specifically, monitoring should assess whether:

- Projects, plans and policies are producing the anticipated results;
- Amendments to the plan are required; and
- Community energy and GHG emissions targets will be met.

Monitoring the implementation of the action plans should be led by the Advisory Group, but may require additional external technical support, should internal resources not be available. Monitoring consists of various control measures, but generally should include:

- Updating the community GHG inventory annually;
- Updating the key performance indicators annually;
- Updating the Climate Action Plan annually; and,
- Preparing a public facing annual summary report which outlines:
  - Projects, plans and policies implemented during the year;
  - An updated community GHG inventory;
  - A list of implementation challenges and opportunities encountered;
  - A description of stakeholder engagement activities;
  - A list of amendments to the Climate Action Plan; and,
  - A revised Climate Action Plan schedule.

Climate action planning should be considered an evolving process in order to adapt to changing environmental, economic and political realities.

8.0 REPORT LIMITATIONS

This report was prepared for the exclusive use of the City of Winnipeg. Golder or its employees will not be responsible for any use of the information contained in this report or any reliance on or decisions made based on it by an unauthorized third party. The report is based solely on the information available provided by the City of Winnipeg, Manitoba Hydro and Manitoba Public Insurance during the pre-inventory documentation request. No site visits or field data collection was conducted as a part of this inventory. If additional information is discovered in the future, Golder should be requested to re-evaluate the conclusions presented in this report and to provide amendments as required.

In evaluating the project, Golder has relied in good faith on information provided by individuals as noted in this report. We assume that the information provided is factual and accurate. We accept no responsibility for any deficiency, misstatements, or inaccuracies contained in this report as a result of omissions, misinterpretation, or fraudulent acts of the persons interviewed or contacted. No other warranties are expressed or implied.

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10.0 CLOSURE

We trust the information contained in this report is sufficient for your present needs. Should you have any additional questions regarding the project, please do not hesitate to contact the undersigned.

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APPENDIX A

GHG Inventory Calculation Methodology

1.0 GENERAL APPROACH

The inventory was created following the 2012 "U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions", developed by ICLEI – Local Governments for Sustainability USA. The standard was designed to guide local governments in the accounting and reporting of greenhouse gas (GHG) emissions associated with communities.

The protocol includes guidance on scoping, and lists the five basic emission-generating activities that must be included in all GHG emission reports:

- Use of Electricity by the Community
- Use of Fuel in Residential and Commercial Stationary Combustion Equipment
- On-Road Passenger and Freight Motor Vehicle Travel
- Use of Energy in Potable Water and Wastewater Treatment and Distribution
- Generation of Solid Waste by the Community

Emission calculations are described within the protocol by community sector. For each GHG source, the protocol presents accounting methodologies, some with multiple methodologies of varying accuracy to be selected based on the level of data quality. Most calculations are based on activity data, emission factors, and conversion of resultant emissions to CO_2 equivalent through the use of global warming potentials.

The protocol also provides recommendations for the reporting of a community GHG report. These include an emissions report summary table, quantified estimates of emissions associated with the five basic emission-generating activities, and data for each emission source or activity such as activity data, emission factors, accounting methodology, and emissions. Community context data should also be included within any GHG report; total population and households at a minimum. The protocol also recommends inclusion of additional information such as notes on data sources, confidence in data accuracy, and any additional context data [1].

2.0 SCOPE OF STUDY

The scope of the GHG Inventory is shown below in Table 1.

Table 1: Scope of Study

GHG Emissions Source	Accounting Approach	Included*
Stationary Units		
Residential Buildings		
Direct Emissions (Scope 1)	In-Boundary Fuel Combustion (Natural Gas)	Yes
Energy Indirect Emissions (Scope 2)	In-Boundary Energy Consumption (Electricity)	Yes
Commercial / Institutional Facilities		

GHG Emissions Source	Accounting Approach	Included*
Direct Emissions (Scope 1)	In-Boundary Fuel Combustion (Natural Gas)	Yes
Energy Indirect Emissions (Scope 2)	In-Boundary Energy Consumption (Electricity)	Yes
Industrial Energy Use		
Direct Emissions (Scope 1)	In-Boundary Fuel Combustion (Natural Gas)	Yes
Energy Indirect Emissions (Scope 2)	In-Boundary Energy Consumption (Electricity)	Yes
Energy Generation		
Direct Emissions (Scope 1)	In-Boundary Fuel Combustion	No, IE
Energy Indirect Emissions (Scope 2)	In-Boundary Energy Consumption	No, IE
Fugitive Emissions		
Direct Emissions (Scope 1)	In-Boundary Refrigerant / Coolant Emissions	No, NE
Mobile Units		
On-Road Transportation		
Direct Emissions (Scope 1)	In-Boundary Fuel Combustion	Yes
Energy Indirect Emissions (Scope2)	In-Boundary Energy Consumption	Yes
Indirect Emissions from Transboundary On-Road Inter-City or International Transportation Trips that Originate and/or Complete their Journey Within the Community (Scope3)		No, NE
Railways		
Direct Emissions (Scope 1)	Proportional Fuel Combustion	No, NE
Energy Indirect Emissions (Scope2)	Proportional Energy Consumption	No, NE
Indirect Emissions from Transboundary Inter-City or International Railway Trips that Originate and/or Complete their Journey Within the Community (Scope3)		No, NE
Fugitive Emissions		
Direct Emissions (Scope 1)	Direct Emissions (Scope 1)	No, NE
Water-Borne Navigation		

GHG Emissions Source	Accounting Approach	Included*
Direct Emissions (Scope 1)	Proportional Fuel Combustion	No, NE
Energy Indirect Emissions (Scope2)	Proportional Energy Consumption	No, NE
Indirect Emissions from Inter-City or International Water-Borne Navigation Trips that Originate their Journey Within the Community (Scope3)		No, NE
Aviation		
Direct Emissions (Scope 1)	Proportional Fuel Combustion	No, NE
Energy Indirect Emissions (Scope 2)	Proportional Energy Consumption	No, NE
Indirect Emissions from Inter-City or International Aviation that Originate and/or Complete their Journey Within the Community (Scope 3)		No, NE
Off-Road		
Direct Emissions (Scope 1)	In-boundary Fuel Combustion	No, NE
Waste		
Solid Waste Disposal		
Option-1: First Order Decay (FOD) Method - Direct (Scope1-Current Year) and Indirect (Scope3-Previous Years) Emissions from Landfills Located Within the Community Boundary (excluding emissions due to incoming waste from other communities)	In-boundary Waste Generated and Proportional Waste Treated	No, IE
Option-2: Methane Commitment (MC) Method - Direct (Current Year) and Indirect (Scope3-Future Year) Emissions from Landfills Located Within the Community Boundary (excluding emissions due to incoming waste from other communities)	In-boundary Waste Generated and Proportional Waste Treated	Yes
Indirect Emissions (Scope3) from Community Wastes Deposited in Landfills Located Outside the Community Boundary	Proportional Waste Treated	Yes
Biological Treatment of Waste		

GHG Emissions Source	Accounting Approach	Included*
Direct (Scope1) Emissions from Biological Treatment of Waste in the Community Boundary (excluding emissions due to incoming waste from other communities)	In-boundary Waste Generated and Proportional Waste Treated	Yes
Indirect Emissions (Scope3) from Biological Treatment of Wastes Outside the Community Boundary	Proportional Waste Treated	No, NO
Incineration and Open Burning		
Direct (Scope 1) Emissions from Incineration and Open Burning of Waste in the Community Boundary (excluding emissions due to incoming waste from other communities)	In-boundary Waste Generated and Proportional Waste Treated	No, NO
Indirect Emissions (Scope 3) from Incineration and Open burning of Wastes Outside the Community Boundary	Proportional Waste Treated	No, NO
Wastewater Treatment and Discharge		
Direct (Scope 1) Emissions from WWT and discharge in the Community Boundary (excluding emissions due to incoming waste from other communities)	In-boundary Waste Generated and Proportional Waste Treated	Yes
Indirect Emissions (Scope 3) from WWT and discharge Outside the Community Boundary	Proportional Waste Treated	No, NO
Industrial Processes and Product Use (IPPU)		
Direct Emissions from Industrial Processes	In-boundary Production	No, NE
Agriculture, Forestry, and Land Use (AFOLU)		
Direct Emissions from AFOLU	In-boundary Areas	No, NE
Other Indirect Emissions		
All other Scope 3 Emissions from all sources		No, NE
All transboundary Scope 3 emissions due to exchange/consumption of goods and services		No, NE

*IE=Included Elsewhere, NE=Not Estimated, NO=Not Occurring

3.0 COMMUNITY SECTORS

The GHG Inventory is made up of the following sectors.

3.1 Building Electricity

This section is comprised of the GHG emissions from electricity consumption of buildings within the City of Winnipeg. Electricity use has been split up into a number of categories for residential, commercial, and industrial buildings.

Building categories, number of buildings, and total electricity consumed were provided by Manitoba Hydro. Using the total electricity consumed and the electricity generation GHG intensities for Manitoba, provided in the National Inventory Report 1990-2011 Part 3 [2], the GHG emission rate was calculated as follows:

$$ER_{CO2e} = \frac{1\ tonne}{10^6\ g} \times \sum_{i}^{n} E_i \times (EF_{CH4} + EF_{N2O} + EF_{CO2})$$

Where: ER_{CO2e} is the annual City of Winnipeg building electricity GHG emission rate (tonne CO_2e),

E_i is the building category total electricity consumed (kWh),

EF_{CH4} is the methane electricity generation intensity (g CO_2e/kWh),

EF_{N2O} is the nitrous oxide electricity generation intensity (g CO_2e/kWh), and

EF_{CO2} is the carbon dioxide electricity generation intensity (g CO_2e/kWh).

3.2 Building Natural Gas

This section is comprised of the GHG emissions due to natural gas combustion from buildings within the City of Winnipeg. Natural gas use has been split up into a number of categories for residential, commercial, and industrial buildings.

Building categories, number of buildings and total natural gas consumed were provided by Manitoba Hydro. The GHG emission rates were calculated based on the methodology outlined in ICLEI (2012) Appendix C [1]. A sample calculation is provided below.

$$ER_{CO2e} = \frac{1\ tonne}{10^3\ kg} \times \sum_{i}^{n} G_i \times \frac{10.35\ kWh}{1\ m^3} \times \frac{3412\ Btu}{1\ kWh} \times \frac{1\ MMBtu}{10^6\ Btu} \times (GWP_{CH4} \times EF_{c\,CH4} + GWP_{N2O} \times EF_{c\,N2O} + EF_{CO2})$$

Where: ER_{CO2e} is the annual City of Winnipeg building natural gas consumption emissions (tonne CO_2e),

G_i is the building category natural gas consumption (m^3/year),

GWP_{CH4} is the global warming potential for methane,

$EF_{c,CH4}$ is the methane emission factor for building category industrial, commercial or residential (kg CH_4/MMBtu),

GWP_{N2O} is the global warming potential for nitrous oxide,

$EF_{c,N2O}$ is the nitrous oxide emission factor for building category industrial, commercial or residential (kg N_2O/MMBtu), and

EF_{CO2} is the carbon dioxide emission factor (kg CO_2/MMBtu).

3.3 Transit

Public transit vehicles were calculated separately from residential and commercial vehicles using total fuel consumed provided by the City of Winnipeg. Vehicles in this category are all fueled with B2 diesel. Emission factors were obtained from the National Inventory Report 1990-2011 Part 2 [2].

It was assumed that all vehicles would be bus-like (heavy duty vehicle) and would also have moderate air emission controls. Emissions were calculated as detailed below:

$$ER_{CO2e} = \frac{1\ tonne}{10^6\ g} \times \sum_i^n Fuel\ Consumed \times \left(EF_{CH4} \times GWP_{CH_4} + EF_{N2O} \times GWP_{N_2O} + EF_{CO2}\right)$$

Where: ER_{CO2e} is the annual City of Winnipeg public transit vehicle emissions (tonne CO_2e),

Fuel Consumed is the annual volume of fuel consumed by transit vehicles (L),

EF_{CH4} is the emission factor for methane (g/L fuel),

GWP_{CH4} is the global warming potential for CH_4 (tonne CO_2e/tonne CH_4),

EF_{N2O} is the emission factor for N_2O (g/L fuel),

GWP_{N2O} is the global warming potential for N_2O (tonne CO_2e/tonne N_2O), and

EF_{CO2} is the emission factor for CO_2 (g/L fuel).

3.4 Vehicles

This section consists of GHG emissions for residential and commercial vehicles. Vehicular emissions were calculated based on data supplied by The Climate Registry, the US Department of Energy, and the City of Winnipeg.

Vehicle fuel efficiency was obtained from the 2012 Climate Registry Default Emission Factors, Table 13.2 [3]. Greenhouse gas emission factors for the vehicles, based on manufactured year, were obtained in the Climate Registry, Tables 13.4 and 13.5. Vehicle descriptions (manufacturer, year, vehicle class) were obtained from the US Department of Energy; Energy and Efficiency and Renewable Energy [4].

A list of registered vehicles was provided Manitoba Public Insurance. Based on the vehicles age, make, model, fuel consumed, and/or description the registered vehicles were matched with a fuel consumption rate (mile/gallon, km/L) and associated greenhouse gas emission factors (GHG emission/mile travelled, g/km). Vehicles that were assigned commercial or industrial within the list of registered vehicles were excluded from the analysis. With regards to the fuel consumption it was assumed, based on recommendations in The Climate Registry [3], all vehicles travel 45% on highway (freeway) ad 55% on city roads.

Vehicles were defined in 10 different categories based on the fuel type and engine type. The emission factors of these 10 vehicle categories were derived from calculating the average value of the emission factors assigned based on the method described above for the 2011 datasets.

Next, annual vehicle kilometers were estimated using TransCAD, a GIS transportation software tool. Average annual vehicle kilometers were then multiplied by the individual vehicle emission factors to determine the annual GHG emissions, as shown in the following equation.

$$ER_{CO2e} = \frac{1\ tonne}{10^6\ g} \times \sum_i^n VKT_i \times \left(GWP_{CH4} \times EF_{i,CH4} + GWP_{N2O} \times EF_{i,N2O} + EF_{i,CO2}\right)$$

Where: ER_{CO2e} is the annual City of Winnipeg vehicular GHG emission rate (tonne CO_2e),

VKT_i is the individual annual vehicle km travelled (km/year),

GWP_{CH4} is the global warming potential for methane,

$EF_{i,CH4}$ is the methane emission factor vehicle category i (g/km),

GWP_{N2O} is the global warming potential for nitrous oxide,

$EF_{i,N2O}$ is the nitrous oxide emission factor for vehicle category i (g/km), and

$EF_{i,CO2}$ is the carbon dioxide emission factor for vehicle category i (g/km).

3.5 Waste Disposal

Solid waste disposal for Winnipeg were considered to be entirely landfill. Landfill emissions are unique among sources of emissions in that the emissions are generated over long periods of time from the activity that caused them. Within the City of Winnipeg, waste generation falls into the following categories:

- Residential;
- Industrial and commercial;
- Construction and demolition; and
- City operations, excluding wastewater biosolids.

Some landfill gas is collected through a collection system (LFG).

The landfilling or composting of city biosolids was covered in the waste water GHG calculations. Process based GHG emissions (electricity consumption, etc.) associated with waste disposal were included in different emission activity groups.

Emissions from waste disposal were calculated using the total tonnage of all landfilled waste, taken from the City of Winnipeg Comprehensive Integrated Waste Management Plan [5]. Waste was divided into categories and emission factors were applied based on the type of waste. In this way, lifetime emissions from landfilled waste were taken all during the inventory year, with no calculation of emissions from already existing waste. Landfill gas collection systems were also considered in these calculations.

Note that no emissions were assigned for composting. While conventions for greenhouse gas accounting, such as those presented by the US EPA, indicate negative GHG emissions or a "carbon sink" for composting of organic materials, on the extent to which composting materials break down and potentially sequester carbon is not fully defined. Thus, for the purposes of this inventory, no composting emissions have been considered.

Emission rates were calculated using the following formula:

$$ER_{CH4} = GWP_{CH4} \times (1 - CE) \times (1 - OX) \times \sum_{i}^{n} M_i \times EF_i$$

Where: ER_{CH4} is the community generated waste emissions from waste disposal (tonne CO2e/year),

GWP_{CH4} is the CH_4 global warming potential,

M_i is the mass of each fraction of waste component i (wet short ton),

Ef_i is the emission factor for material i (tonne CH_4/wet short ton),

CE is the LFG collection efficiency, and

OX is the oxidation rate.

3.6 Water and Waste Water

Waste water includes both the treatment and disposal of waste water in the City of Winnipeg. Emissions from biogas combustion, waste water processing, landfilling, and composting were all included within this section. Waste water electricity consumption was not included, as it was covered under the electricity section.

The emission calculation for water and waste water was divided into bio-gas combustion, process-based N_2O emissions, and outflow GHG emissions.

3.6.1 Bio-gas Combustion

Bio-gas combustion emissions were based on method WW.1.a within Appendix F for calculating GHG emission from bio-gas combustion from anaerobic digesters [1]. Emission rates were calculated using the following formula:

$$ER_{CH4} = GWP_{CH4} \times \left(Digester\ Gas\ \times 0.61 \times\ BTU_{CH4}\ \times\ \frac{1\ MMBTU}{10^6\ BTU}\ \times\ EF_{CH4} \times \frac{365.25\ days}{1\ year}\ \times\ \frac{1\ tonne}{1000\ kg}\right)$$

Where: ER_{CH4} is the annual methane emitted by devices designed to combust digester gas (tonne CO_2e/year),

Digester gas is the standard cubic feet of digester gas produced per day (std ft^3/day),

GWP_{CH4} is the CH_4 global warming potential,

0.61 is the fraction of CH_4 in the gas (provided by the City of Winnipeg),

BTU_{CH4} is the Default BTU content of methane (BTU/ft^3), and

EF_{CH4} if the methane emission factor (kg CH_4/MMBTU).

The emission calculations due to nitrous oxide combustions were similar to methane except EF_{CH4} was replaced by the emission factor for nitrous oxide (EF_{N2O}) and the GWP_{CH4} was replaced by the global warming potential for nitrous oxide (GWP_{N2O}).

3.6.2 Process Based Nitrous Oxide Emissions

Waste water treatment plants also emit nitrous oxide during process operation. As over the next five years the city of Winnipeg will have systems with and without denitrification, two methods were used to determine nitrous oxide emission rates; methods WW.7 and WW.8, Appendix F [1].

Emission rates were calculated using the following formula:

$$ER_{N2O} = GWP_{N2O} \times \left(P\ \times\ F_{ind-com} \times EF\ \times \frac{1\ tonne}{10^6\ g}\right)$$

Where: ER_{N2O} is the total annual nitrous oxide emissions by WWTP processes (tonne CO_2e),

P is the population serviced by the waste water treatment facility,

$F_{ind-com}$ is the factor for nitrogen loading due to industrial and commercial processes, and

EF is the emission factor for WWP (g N_2O/person/year).

3.6.3 Process Based Carbon Dioxide Emissions

Carbon dioxide is emitted during processing as methanol is used in the nitrification/denitrificaiton process, detailed in calculation method WW.9, Appendix F [1].

Emission rates were calculated using the following formula:

$$ER_{CO2} = Methanol_{Load} \times F \times \frac{44.01 \frac{g}{mol} CO_2}{32.04 \frac{g}{mol} CH_3OH} \times 365.25 \frac{days}{year}$$

Where: ER_{CO2} is the total annual carbon dioxide emitted (tonne CO_2e),

$Methanol_{Load}$ is the amount of neat chemical used per day (tonne CH_3OH/day), and

F is the sludge disposal factor.

3.6.4 Outflow GHG Emissions

Nitrous oxide is also emitted from WWTP effluent outflow. As the nitrogen content of the WWTP outflow is routinely monitored, the sample calculation detailed in method WW.12 was used [1].

Emission rates were calculated using the following formula:

$$ER_{N2O} = N_{Load} \times EF_{effluent} \times \frac{44.01 \frac{g}{mol} N_2O}{28.01 \frac{g}{mol} N_2} \times 365.25 \frac{days}{year} \times \frac{1\ tonne}{1000\ kg} \times GWP_{N2O}$$

Where: ER_{N2O} is the annual nitrous oxide emitted from the effluent outfall (tonne CO_2e/year),

N_{load} is the average total nitrogen content per day (kg N/day), and

$EF_{effluent}$ is the emission factor (kg N_2O-N/kg sewage-N discharged).

3.6.5 Landfill Emissions

Methane is emitted from decomposition of biosolids in the landfill. The following sample calculation was used to estimate the methane emissions [6].

$$ER_{CH4} = S_L \times VS \times C_o \times \frac{16.04 \frac{g}{mol} CH_4}{12.01 \frac{g}{mol} C} \times CH4_{LFG} \times DOC_r \times D \times MCF_{landfill} \times 0.9 \times GWP_{CH4}$$

Where: ER_{CH4} is the annual methane emitted by decomposition of biosolids in the landfill (tonne CO_2e/year),

S_L is the mass of biosolids landfill disposed (tonne/year),

VS is the percent volatile solids (%),

C_o is the organic carbon content in the VS (%),

$CH4_{LFG}$ is the methane content in landfill gas (%),

DOC_r is the decomposable organic fraction of raw wastewater solids,

D is the percent decomposition rate (%),

$MCF_{landfill}$ is the methane correction for anaerobic managed landfills, and

0.9 is the model uncertainty factor [7].

3.6.6 Composting Emissions

Carbon dioxide is emitted from decomposition of biosolids in compost. The following sample calculation was used to estimate the carbon dioxide emissions [6].

$$ER_{CO2} = S_c \times C_o \times \frac{44.01\frac{g}{mol}CO_2}{12.01\frac{g}{mol}\ C} \times DOC_r \times D$$

Where: ER_{CO2} is the annual CO_2 emitted from the compost biosolid decomposition (tonne CO_2e/year), and

S_c is the mass of biosolids composted (tonne/year),

C_o is the organic carbon content in the VS (%),

DOC_r is the decomposable organic fraction of raw wastewater solids, and

D is the percent decomposition rate (%).

APPENDIX B

Forecast Methodology

Golder based forecasts primarily on key indicators supplied by the City of Winnipeg and Manitoba Hydro relating to building electricity, building natural gas, transit, waste disposal, and water and waste water. For sectors where the availability of key indicators was limited, Golder utilized the Community Energy and Emissions Modeling and Planning tool, CEEMAP (see Figure 1). Golder used the CEEMAP tool to drive key indicators for the OurWinnipeg and Low Carbon Path forecasts, particularly in relation to land use and transportation.

CEEMAP is based on several dynamic, interactive modules that use key policy inputs to estimate greenhouse gas emissions for each sector over which local governments have significant influence. CEEMAP uses the following categories of indicators:

- Socio Economic Data, e.g., residential and employment population.
- Land Use & Community Design, e.g., location and density of commercial and residential buildings.
- Transportation Technology & Patterns, e.g., number and type of automobiles, transit routes and frequency.
- Building Type & Performance, e.g., single detached or multi family home type, building energy rating, retrofit rate.
- Heat & Electricity Supply, e.g., electricity from grid or other, specific district energy technology, building-scale.
- Solid Waste Management, e.g., waste composition and mass, management practice.

To start the process, a baseline model is populated using values for the year for which the best data is available. In this case, key indicators from 2011 were used.

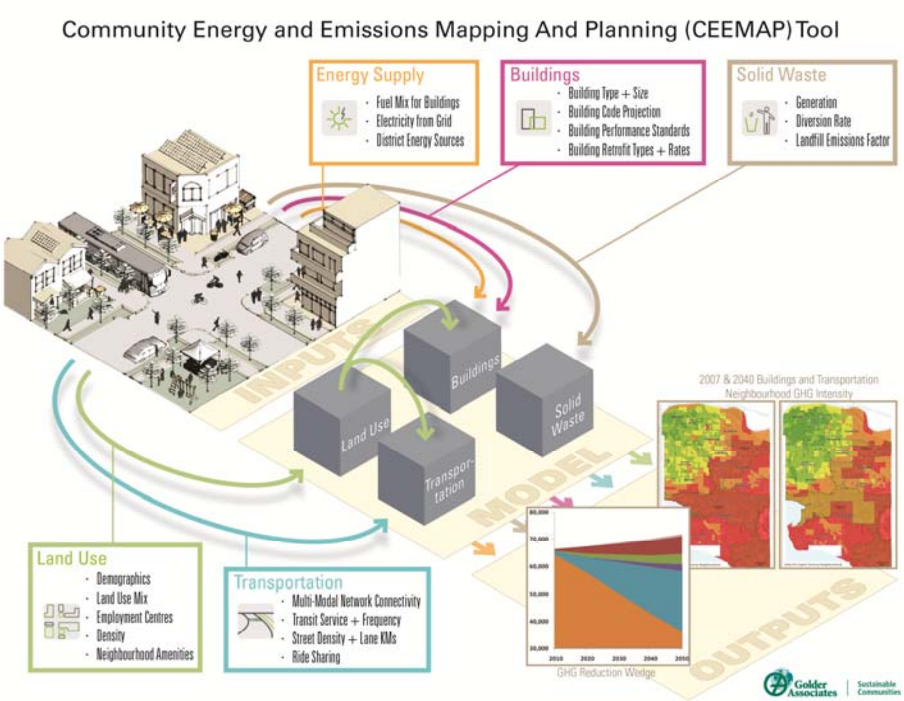

Figure 1: CEEMAP Diagram

Values for indicators were projected into the future based on the type and intensity of strategies that the City could implement. CEEMAP then used empirically-derived knowledge of the relationships between indicators to calculate sector emission changes at future milestone years. As well as changes to greenhouse gas emissions, CEEMAP generated other outputs such as vehicle kilometers travelled by neighbourhood and across the community.

The following sections detail the approach taken in constructing the Business as Usual, OurWinnipeg, and Low Carbon Path Scenarios, by sector.

1.0 BUILDING ELECTRICITY AND NATURAL GAS

Building electricity and natural gas was assumed to grow differently for residential, commercial, and industrial sectors. Residential electricity and natural gas was assumed to grow in proportion to population growth. Commercial and industrial electricity and natural gas was assumed to grow in proportion to job growth. All growth-related factors are independent of scenario.

Provincial demand-side management programs undertaken by Manitoba Hydro have outlined forecasts for the reductions in electricity and natural gas up until 2031. These programs are primarily targeted at existing buildings, as there exists a far greater potential to reduce energy use. For the 2050 forecasts, values were extrapolated from the Manitoba Hydro targets. As the demand-side management programs are provincial, the savings were applied to all scenarios.

Multi-unit residential buildings (MURBs) are generally more energy efficient in nature than single family homes. By promoting a shift toward MURBs, gains in both electricity and natural gas efficiency are possible for new buildings. The Business as Usual Scenario assumes that residential building stock does not change from 2011, thus there are no efficiency benefits. The OurWinnipeg Scenario follows the Conference Board of Canada forecasts for the City of Winnipeg which see a gradual movement toward MURBs due to City policies. The Low Carbon Path Scenario assumes a much greater effort on the part of the City to promote MURBs, and thus has a higher gain in new residential building energy efficiency.

Newer buildings are more energy efficient than older buildings due to changes in technology. Thus it has been assumed that new buildings of all types (residential, commercial, and industrial) see gains in both electricity and natural gas efficiency. This is also influenced by policies such as the Manitoba (National) Building Code and 2007 Green Building Policy. The Business as Usual and OurWinnipeg Scenarios assume no City intervention and see modest increases in new building energy efficiency. The Low Carbon Path has the City promoting new technology and more stringent energy standards, thus gaining a bit more in efficiency.

As demand for consumer electronics has steadily increased, it is expected that residential households will use more electricity on a per capita basis to support these products. Manitoba Hydro has made some forecasts assuming a modest growth rate in electricity use. Based on these, the forecasting model uses a 0.5% increase in residential electricity use per person per year. This factor is independent of all scenarios.

Building-scale renewables, primarily geothermal heat with some limited solar water heating, represent an opportunity to reduce natural gas consumption in buildings. The forecasting model used assumed that buildings with building-scale renewables installed would be able to save 25% of their natural gas. For the Business as Usual Scenario, no growth in building-scale renewables was used. For the OurWinnipeg Scenario, it was assumed that trends in the uptake of building-scale renewables would continue at the same rates. For the Low Carbon Path Scenario, a more aggressive targeting of building-scale renewables was assumed, leading to a higher growth rate.

District energy systems also represent an opportunity to reduce the heating load in residential and commercial buildings. Due to the complexity of industrial processes, industrial buildings were excluded from district energy systems. Buildings connected to district energy systems were assumed to be able to save 10% of their natural gas due to efficiencies in having a larger centralized system. The Business as Usual Scenario assumed no district energy systems. The OurWinnipeg Scenario assumed a very modest growth in buildings connected to district energy systems where the Low Carbon Path Scenario had a slightly higher growth rate.

Calculation for building electricity use and natural gas is shown below:

$$E_{res,yearX} = E_{res,2011}\left[(1-i_{DSM}) + \left(\frac{P_{yearX}-P_{2011}}{P_{2011}}\right)(1-i_{BS})(1-i_{T})\right](1+i_{add})$$

Where: $E_{res,yearX}$ = residential electricity use in year X, calculated

$E_{res,2011}$ = residential electricity use in 2011, from Manitoba Hydro

P_{yearX} = population in year X, from the Conference Board of Canada (2012)

P_{2011} = population in 2011, from the Conference Board of Canada (2012)

i_{DSM} = reduction in electricity intensity due to demand-side management for existing buildings, from the Manitoba Hydro Power Smart Plan (2013)

i_{BS} = reduction in electricity intensity due to changes in building stock for new buildings, calculated based on trends in building stock from Conference Board of Canada (2012)

i_{T} = reduction in electricity intensity due to newer technology for new buildings, assumed, based on the Manitoba Building Code (2011)

i_{add} = increase in electricity intensity due to increased electricity use per person, from the Manitoba Hydro Electric Load Forecast (2013)

$$E_{com,yearX} = E_{com,2011}\left[(1-i_{DSM}) + \left(\frac{J_{yearX}-J_{2011}}{J_{2011}}\right)(1-i_{T})\right]$$

Where: $E_{com,yearX}$ = commercial electricity use in year X, calculated

$E_{com,2011}$ = commercial electricity use in 2011, from Manitoba Hydro

J_{yearX} = jobs in year X, from the Conference Board of Canada (2012)

J_{2011} = jobs in 2011, from the Conference Board of Canada (2012)

i_{DSM} = reduction in electricity intensity due to demand-side management for existing buildings, from the Manitoba Hydro Power Smart Plan (2013)

i_T = reduction in electricity intensity due to newer technology for new buildings, assumed, based on the Manitoba Building Code (2011)

$$E_{ind,yearX} = E_{ind,2011}\left[(1 - i_{DSM}) + \left(\frac{J_{yearX} - J_{2011}}{J_{2011}}\right)(1 - i_T)\right]$$

Where: $E_{ind,yearX}$ = industrial electricity use in year X, calculated

$E_{ind,2011}$ = industrial electricity use in 2011, from Manitoba Hydro

J_{yearX} = jobs in year X, from the Conference Board of Canada (2012)

J_{2011} = jobs in 2011, from the Conference Board of Canada (2012)

i_{DSM} = reduction in electricity intensity due to demand-side management for existing buildings, from the Manitoba Hydro Power Smart Plan (2013)

i_T = reduction in electricity intensity due to newer technology for new buildings, assumed, based on the Manitoba Building Code (2011)

$$NG_{res,yearX} = NG_{res,2011}\left[(1 - i_{DSM}) + \left(\frac{P_{yearX} - P_{2011}}{P_{2011}}\right)(1 - i_{BS})(1 - i_T)\right] \times \left[1 - \left(x_{ren,yearX} - x_{ren,2011}\right)(0.25)\right] \times \left[1 - (d_{yearX})(0.1)\right]$$

Where: $NG_{res,yearX}$ = natural gas use in year X, calculated

$NG_{res,2011}$ = natural gas use in 2011, from Manitoba Hydro

P_{yearX} = population in year X, from the Conference Board of Canada (2012)

P_{2011} = population in 2011, from the Conference Board of Canada (2012)

i_{DSM} = reduction in natural gas intensity due to demand-side management for existing buildings, from the Manitoba Hydro Power Smart Plan (2013)

i_{BS} = reduction in natural gas intensity due to changes in building stock for new buildings, calculated based on trends in building stock from Conference Board of Canada (2012)

i_T = reduction in natural gas intensity due to newer technology for new buildings, assumed, based on the Manitoba Building Code (2011)

$x_{ren,yearX}$ = fraction of residential buildings with building-scale renewables in year X, based on trends from Manitoba Geothermal Energy Alliance

$x_{ren,2011}$ = fraction of residential buildings with building-scale renewables in 2011, from Manitoba Geothermal Energy Alliance

d_{yearX} = fraction of residential buildings connected to district energy systems in year X, assumed

$$NG_{com,yearX} = NG_{com,2011}\left[(1 - i_{DSM}) + \left(\frac{J_{yearX} - J_{2011}}{J_{2011}}\right)(1 - i_T)\right] \times \left[1 - \left(x_{ren,yearX} - x_{ren,2011}\right)(0.25)\right] \times \left[1 - (d_{yearX})(0.1)\right]$$

Where: $NG_{com,yearX}$ = commercial natural gas use in year X, calculated

$NG_{com,2011}$ = commercial natural gas use in 2011, from Manitoba Hydro

J_{yearX} = jobs in year X, from the Conference Board of Canada (2012)

J_{2011} = jobs in 2011, from the Conference Board of Canada (2012)

i_{DSM} = reduction in natural gas intensity due to demand-side management for existing buildings, from the Manitoba Hydro Power Smart Plan (2013)

i_T = reduction in natural gas intensity due to newer technology for new buildings, assumed, based on the Manitoba Building Code (2011)

$x_{ren,yearX}$ = fraction of commercial buildings with building-scale renewables in year X, based on trends from Manitoba Geothermal Energy Alliance

$x_{ren,2011}$ = fraction of commercial buildings with building-scale renewables in 2011, from Manitoba Geothermal Energy Alliance

d_{yearX} = fraction of commercial buildings connected to district energy systems in year X, assumed

$$NG_{ind,yearX} = NG_{ind,2011}\left[(1 - i_{DSM}) + \left(\frac{J_{yearX} - J_{2011}}{J_{2011}}\right)(1 - i_T)\right] \times \left[1 - \left(x_{ren,yearX} - x_{ren,2011}\right)(0.25)\right]$$

Where: $NG_{ind,yearX}$ = industrial natural gas use in year X, calculated

$NG_{ind,2011}$ = industrial natural gas use in 2011, from Manitoba Hydro

J_{yearX} = jobs in year X, from the Conference Board of Canada (2012)

J_{2011} = jobs in 2011, from the Conference Board of Canada (2012)

i_{DSM} = reduction in natural gas intensity due to demand-side management for existing buildings, from the Manitoba Hydro Power Smart Plan (2013)

i_T = reduction in natural gas intensity due to newer technology for new buildings, assumed, based on the Manitoba Building Code (2011)

$x_{ren,yearX}$ = fraction of industrial buildings with building-scale renewables in year X, based on trends from Manitoba Geothermal Energy Alliance

$x_{ren,2011}$ = fraction of industrial buildings with building-scale renewables in 2011, from Manitoba Geothermal Energy Alliance

2.0 TRANSIT

The first parameter affecting the GHG emissions from transit is the total distance travelled by all transit vehicles. The Business as Usual Scenario assumes no increase in the transit fleet or service, which means that the total distance travelled is unchanged from 2011. Note that this does have implications for the residential vehicle GHG emissions, as discussed in the following section. The OurWinnipeg Scenario assumes gradual increase in the size of the transit fleet of 8 vehicles per year, with the average annual distance travelled by vehicle remaining constant. The Low Carbon Path Scenario also assumes an increase in the transit fleet of 8 vehicles per year, but also assumes the average annual distance travelled is increasing, representing a large push by the City to make Winnipeg a more transit-friendly city.

The other factor affecting the GHG emissions from transit is the type of vehicle used. For all scenarios, improvements in technology and more stringent tailpipe standards would lead to an increase in fuel efficiency of newer vehicles, taken as being 0.7% per year. In the Business as Usual Scenario, the entire transit fleet continues to be made up of buses using B2 diesel fuel. In the OurWinnipeg Scenario, transit vehicles shift toward some diesel-electric hybrid buses. In addition, the City would gradually introduce electric light rail transit, the first being completed in 2031. Electric light rail transit has been assumed to consume 3.5 kWh per kilometer travelled based on a technical study done in Calgary. The Low Carbon Path Scenario follows a similar trend to the OurWinnipeg Scenario, with the exception of having a greater shift to diesel-electric buses and electric light rail.

Calculations are shown below:

$$Diesel\ Fuel\ Efficiency_{year\ X} = Diesel\ Fuel\ Efficiency_{year\ 2011}(1-0.007)^{X-2011}$$

Where: $Diesel\ Fuel\ Efficiency_{year\ X}$ = fuel efficiency of B2 diesel buses in L/km in year X, calculated

$Diesel\ Fuel\ Efficiency_{year\ 2011}$ = fuel efficiency of B2 diesel buses in L/km in 2011, calculated at 0.6656L/km

X = year of forecast

$$Number\ of\ Vehicles_{year\ X} = Number\ of\ Vehicles_{2011} + (X-2011)\times(i_{vehicle})$$

Where: $Number\ of\ Vehicles_{year\ X}$ = number of transit vehicles on the road in year X, calculated

$Number\ of\ Vehicles_{2011}$ = number of transit vehicles on the road in 2011, from the City of Winnipeg

X = year of forecast

$i_{vehicle}$= increase in transit vehicles per year, 0 for Business as Usual Scenario, 8 for OurWinnipeg and Low Carbon Path Scenarios, from the City of Winnipeg

$$Kilometers\ Travelled_{year\ X} = \frac{Kilometers\ Travelled_{2011}}{Number\ of\ Vehicles_{2011}} \times Number\ of\ Vehicles_{year\ X} \times i_{kmt}$$

Where: $Kilometers\ Travelled_{year\ X}$ = total kilometers travelled by transit vehicles in year X, calculated

$Kilometers\ Travelled_{2011}$ = total kilometers travelled by transit vehicles in 2011, from the City of Winnipeg

$Number\ of\ Vehicles_{2011}$ = number of transit vehicles on the road in 2011, from the City of Winnipeg

$Number\ of\ Vehicles_{year\ X}$ = number of transit vehicles on the road in year X, calculated

i_{kmt}= increase in kilometers travelled per vehicle, 0 for Business as Usual Scenario and OurWinnipeg Scenarios, assumed for Low Carbon Path Scenario

$$Diesel\ Fuel\ Use_{year\ X} = Kilometers\ Travelled_{year\ X} \times Diesel\ Vehicle\ Share \times Diesel\ Fuel\ Efficiency_{year\ X}$$

Where: $Diesel\ Fuel\ Use_{year\ X}$ = the amount of diesel consumed in year X for transit, calculated

$Kilometers\ Travelled_{year\ X}$ = total kilometers travelled by transit vehicles in year X, calculated

$Diesel\ Vehicle\ Share$ = the proportion of diesel in the transit fleet, from the City of Winnipeg

$Diesel\ Fuel\ Efficiency_{year\ X}$ = fuel efficiency of B2 diesel buses in L/km in year X, calculated

$$Electricity\ Use_{year\ n} = Kilometers\ Travelled_{year\ n} \times Electric\ Light\ Rail\ Transit\ Share \times 3.5\frac{kWh}{km}$$

Where: $Electricity\ Fuel\ Use_{year\ X}$ = the amount of electricity consumed in year X for transit, calculated

$Kilometers\ Travelled_{year\ X}$ = total kilometers travelled by transit vehicles in year X, calculated

$Electric\ Light\ Rail\ Transit\ Share$= the proportion of the electric light rail in the transit fleet, from the City of Winnipeg

3.0 VEHICLES

Vehicle kilometers travelled were modelled using Golder’s transportation model. As part of this, items such as transit, cycling lanes, and policies were taken into consideration in order to form the input to the model. The Winnipeg Transportation Master Plan (2011) was the major guiding document for the transportation inputs.

GHG emissions per kilometer travelled are also expected to decrease as the result of new technology and new government policies, such as federal government tailpipe emission standards. A projection of emissions per kilometer travelled for new vehicles was obtained from a UNEP study on Canadian Automotive Fuel Economy Policy. To determine the GHG emissions from the combined fleet on the road, it was assumed that the average vehicle on the road in Winnipeg would be 10 years old. This was based on the current vehicle makeup from the registration data provided by the City.

For the Business as Usual Scenario, no electric vehicles were assumed. For the OurWinnipeg Scenario, limited adoption of electric vehicles was assumed to gradually penetrate the market. The Low Carbon Path Scenario has electric vehicles with increased adoption due to substantial growth of private and public electric vehicle infrastructure. The City fleet would also be partially retrofitted to electric vehicles in this scenario.

4.0 WASTE DISPOSAL

It was assumed that residential waste generated would increase with population such that waste generated per person per year would remain the same. Similarly, the commercial / industrial and construction / demolition waste was assumed to increase with the number of jobs such that waste generated per job per year would remain constant. This was taken as being the same for all scenarios.

Diversion rates for all waste play a major factor in the GHG emissions of landfilled waste. As diversion rates increase, the amount of landfilled waste goes down. For the Business as Usual Scenario, it was assumed that no new initiatives would be introduced, leading the diversion rates to not change from 2011. The OurWinnipeg Scenario has the implementation of the 2011 Comprehensive Integrate Waste Management Plan, which includes expansion of services to all sectors to increase diversion rates. The Low Carbon Path assumed more aggressive City policies targeting residential diversion rates, with other diversion rates the same as the OurWinnipeg Scenario. Also note that both the OurWinnipeg and Low Carbon Scenarios included a yard waste composting facility, reducing the amount of yard waste ending up in landfills.

Landfill gas capture rate determines that amount of methane gas emitted to the atmosphere. The Business as Usual Scenario has no change to landfill gas capture efficiency. The OurWinnipeg and Low Carbon Path Scenarios show a moderate increase in landfill gas capture efficiency, due to the implementation of the 2011 Comprehensive Integrate Waste Management Plan.

Calculations for waste generated and waste sent to landfills are shown below:

$$Res\ Waste\ Generated_{year\ X} = \frac{Res\ Waste\ Generated_{2011}}{Population_{2011}} \times Population_{year\ X}$$

Where: $Res\ Waste\ Generated_{year\ X}$ = residential waste generated in year X, calculated

$Res\ Waste\ Generated_{2011}$ = residential waste generated in 2011, from City of Winnipeg

$Population_{2011}$ = population in 2011, from the Conference Board of Canada (2012)

$Population_{year\ X}$ = population in year X, from the Conference Board of Canada (2012)

$$Res\ Waste\ in\ Landfills_{year\ X} = Res\ Waste\ Generated_{year\ X} \times (1 - Res\ Diversion\ Rate_{year\ X})$$

Where: $Res\ Waste\ in\ Landfills_{year\ X}$ = residential waste sent to landfills in year X, calculated

$Res\ Waste\ Generated_{year\ X}$ = residential waste generated in year X, calculated

$Res\ Diversion\ Rate_{year\ X}$ = residential diversion rate in year X, from City of Winnipeg

$$Com/Ind\ Waste\ Generated_{year\ X} = \frac{Com/Ind\ Waste\ Generated_{2011}}{Jobs_{2011}} \times Jobs_{year\ X}$$

Where: $Com/Ind\ Waste\ Generated_{year\ X}$ = commercial/industrial waste generated in year X, calculated

$Com/Ind\ Waste\ Generated_{2011}$ = commercial/industrial waste generated in 2011, from City of Winnipeg

$Jobs_{2011}$ = jobs in 2011, from the Conference Board of Canada (2012)

$Jobs_{year\ X}$ = jobs in year X, from the Conference Board of Canada (2012)

$$Com/Ind\ Waste\ in\ Landfills_{year\ X} = Com/Ind\ Waste\ Generated_{year\ X} \times (1 - Com/Ind\ Diversion\ Rate_{year\ X})$$

Where: $Com/Ind\ Waste\ in\ Landfills_{year\ X}$ = commercial/industrial waste sent to landfills in year X, calculated

$Com/Ind\ Waste\ Generated_{year\ X}$ = commercial/industrial waste generated in year X, calculated

$Com/Ind\ Diversion\ Rate_{year\ X}$ = commercial/industrial diversion rate in year X, from City of Winnipeg

$$Con/Dem\ Waste\ Generated_{year\ X} = \frac{Con/Dem\ Waste\ Generated_{2011}}{Jobs_{2011}} \times Jobs_{year\ X}$$

Where: $Con/Dem\ Waste\ Generated_{year\ X}$ = construction/demolition waste generated in year X, calculated

$Con/Dem\ Waste\ Generated_{2011}$ = construction/demolition waste generated in 2011, from City of Winnipeg

$Jobs_{2011}$ = jobs in 2011, from the Conference Board of Canada (2012)

$Jobs_{year\ X}$ = jobs in year X, from the Conference Board of Canada (2012)

$$Con/Dem\ Waste\ in\ Landfills_{year\ X} = Con/Dem\ Waste\ Generated_{year\ X} \times (1 - Con/Dem\ Diversion\ Rate_{year\ X})$$

Where: $Con/Dem\ Waste\ in\ Landfills_{year\ X}$ = construction/demolition waste sent to landfills in year X, calculated

$Con/Dem\ Waste\ Generated_{year\ X}$ = construction/demolition waste generated in year X, calculated

$Con/Dem\ Diversion\ Rate_{year\ X}$ = construction/demolition diversion rate in year X, from City of Winnipeg

5.0 WATER AND WASTE WATER

No changes to water and waste water treatment were assumed in any of the scenarios. The only changes to water and waste water were the handling of biosolids. In the Business as Usual Scenario, all biosolids continue to be sent to landfills. In the OurWinnipeg Scenario, the City promotes biosolids sold for beneficial use and sent to compost. The Low Carbon Path Scenario has a similar approach as the OurWinnipeg Scenario, with the difference being additional biosolids being sold for beneficial use. All scenarios showed biosolid production increasing with population.

APPENDIX C

Key Indicators to Track

The following sections detail the key indicators to track by sector as well as the base year values in 2011.

1.0 COMMUNITY TRENDS

The following table lists key indicators in community trends to track.

Table 1: Community Trend Key Indicators

Indicator	Indicator Description	Base Year (2011)
Population	Population living within the City of Winnipeg limits	691,800
Jobs	Number of jobs within the City of Winnipeg limits	392,640
Single Family Homes	Percentage of residential households that live single family homes	63%
Multi-Unit Residential Building Homes	Percentage of residential households that live in multi-unit residential buildings	37%

2.0 BUILDING ELECTRICITY AND NATURAL GAS

The following table lists key indicators in building electricity and natural gas to track.

Table 2: Building Electricity and Natural Gas Key Indicators

Indicator	Indicator Description	Base Year (2011)
Building Electricity Intensity Reduction due to Demand Side Management	Reduction in electricity use per building due to Manitoba Hydro sponsored demand-side management programs	0%
Building Natural Gas Intensity Reduction due to Demand Side Management	Reduction in natural gas use per building due to Manitoba Hydro sponsored demand-side management programs	0%
New Building Energy Intensity Reduction due to Building Stock Changes	Reduction in electricity and natural gas use per residential household due to changes in building stock (i.e., from single family homes to multi-unit residential buildings)	0%
New Building Energy Intensity Reduction due to Technology Changes	Reduction in electricity and natural gas use per building due to changes in building technology.	0%
Additional Electricity Use	Increase in residential electricity use per person due to more consumer electronics	0%
Residential Building Scale Renewables	Percentage of residential buildings connected to building-scale renewable systems	1.5%
Commercial/Industrial Building Scale Renewables	Percentage of commercial and industrial buildings connected to building-scale renewable systems	1.5%
Residential Buildings Connected to District Energy Systems	Percentage of residential buildings connected to district energy systems	0%
Commercial Buildings Connected to District Energy Systems	Percentage of commercial buildings connected to district energy systems	0%
Residential Electricity Use	Total annual consumption of electricity from residential	1,690,588,866

Indicator	Indicator Description	Base Year (2011)
(kWh/year)	buildings	
Commercial Electricity Use (kWh/year)	Total annual consumption of electricity from commercial buildings	3,046,484,478
Industrial Electricity Use (kWh/year)	Total annual consumption of electricity from industrial buildings	837,309,539
Residential Natural Gas Use (m^3/year)	Total annual consumption of natural gas from residential buildings	488,426,808
Commercial Natural Gas (m^3/year)	Total annual consumption of natural gas from commercial buildings	361,222,578
Industrial Natural Gas (m^3/year)	Total annual consumption of natural gas from industrial buildings	104,025,761

Other potential indicators to track include residential, commercial, and industrial building electricity and natural gas intensity on a kWh/m^2 and GJ/m^2 basis, respectively.

3.0 TRANSIT

The following table lists key indicators in transit to track.

Table 3: Transit Key Indicators

Indicator	Indicator Description	Base Year (2011)
Kilometers of Transit Travel (km/year)	Total annual kilometers of transit travel for all transit vehicles	24,300,000
Bus Fuel Type	Breakdown of fuel use for buses	100% Diesel
Diesel Fuel Use (L/year)	Total annual diesel fuel use for transit vehicles	16,163,620
Electricity Use (MWh/year)	Total annual electricity use for transit vehicles	0
Residents Close to Transit	Percentage of residents within a 5 minute walk of a transit service route	95%
Maximum Route Headway (minutes)	Maximum route headway for City transit vehicles	60

Other potential indicators to track include transit ridership per capita.

4.0 VEHICLES

The following table lists key indicators in vehicles to track.

Table 4: Vehicle Key Indicators

Indicator	Indicator Description	Base Year (2011)

Indicator	Indicator Description	Base Year (2011)
Cycle Network (km)	Total length of all City cycle paths	274
Total Residential Vehicle Kilometers Travelled (vkmt/year)	Total annual distance travelled by all residential vehicles	5,175,656,607
Total Commercial Vehicle Kilometers Travelled (vkmt/year)	Total annual distance travelled by all commercial vehicles	932,055,814
Electric Vehicle Use	Percentage of vehicles that are full electric vehicles	0%
Modal Share	Breakdown of residential vehicle trips by mode	Auto-Driver: 64% Auto-Passenger: 19% Public Transit: 9% Walk/Cycle: 7%
Vehicle Emissions	Reduction in vehicle emissions per kilometer travelled relative to base year	0%
Average Residential Fleet Emissions (gCO_2e/km)	Average greenhouse gas emissions from the residential fleet	370
Average Commercial Fleet Emissions (gCO_2e/km)	Average greenhouse gas emissions from the commerical fleet	1015

5.0 WASTE DISPOSAL

The following table lists key indicators in waste disposal to track.

Table 5: Vehicle Key Indicators

Indicator	Indicator Description	Base Year (2011)
Residential Waste (tonne/year)	Total annual residential waste sent to landfills	278,896
Commercial/Industrial Waste (tonne/year)	Total annual commercial and industrial waste sent to landfills	348,000
Construction/Demolition Waste (tonne/year)	Total annual construction and demolition waste sent to landfills	124,000
Residential Diversion Rate	Amount of residential waste diverted from landfills	15%
Commercial/Industrial Diversion Rate	Amount of commercial and industrial waste diverted from landfills	20%
Construction/Demolition Diversion Rate	Amount of construction and demolition waste diverted from landfills	20%
Landfill Gas Collection Coverage (City Landfills)	Percentage of City Landfill Area with Landfill Gas Collection	100%
Landfill Gas Collection Efficiency (City Landfills)	Efficiency of Landfill Gas Collection for City Landfills	55%

Other potential indicators to track include waste generated per capita.

6.0 WATER AND WASTE WATER

The following table lists key indicators in water and waste water to track.

Table 6: Vehicle Key Indicators

Indicator	Indicator Description	Base Year (2011)
Mass of Biosolids Disposed (tonne/year)	Total annual biosolids disposed from water and waste water	13,982
Biosolids Sold for Beneficial Use	Percentage of biosolids sold for beneficial use	0%
Biosolids Composted	Percentage of biosolids composted	0%

APPENDIX D

Low Carbon Path Workshop Outcomes, May 30, 2014

Winnipeg Low Carbon Path Workshop

This document captures the suggestions that were made by the participants in a workshop hosted by the City of Winnipeg and Golder Associates at the Winnipeg Millennium Library on May 30, 2014.

Golder began by giving a presentation on the process, assumptions, methods, and results of the project so far.

The participants were then arranged into groups of four or five people at four tables. Each table had a facilitator who recorded the participants' ideas on sheets of flipchart paper. During that table discussion session, 32 sheets of ideas were captured.

At the end of the table discussion session, each participant was asked to mark one vote with an "*" for one idea from each of the four topic areas.

There was then a "regroup" session where the ideas that had received a "*" were read out and comments invited.

Before participants left the workshop, they were given sticker "dots" and asked to place them next to whichever ideas they felt should be given priority. Land Use received 31 dots, Transportation 23, Solid waste 18, and Buildings received 5

These are the topic areas that were considered during this workshop:

LAND USE

Land use priorities

These are all of the ideas that received table votes (*) or voting dots in the area of Land Use:

- (5 dots) Permeable for AT - Neighbourhood plans include cut-throughs
- * (plus 4 dots) Corporate Energy Management Plan - pools, adm, comm. centre - lead by example
- ** (plus 3 dots) Require District System readiness
- ** (plus 3 dots) Increasing uptake of District Energy in new / existing communities
- * (plus 3 dots) Energy modeling programs - monitoring
- * (plus 3 dots) Multifamily / Apartment - more greenspace within and near multifamily developments (Verve Tache) - intergenerational
- **** (plus 2 dots) Increasing fine grained mix of uses including population, jobs (challenged by existing policy / practice)
- * (plus 2 dots) Mixed Use
- (2 dots) Transit oriented development
- **** (plus 1 dot) Force ourselves to implement our plan / improve plan; More specifics, Targets, Results driven, Mechanism for regular review
- * (plus 1 dot) Increased density
- (1 dot) Repurpose / Redevelop old industrial
- (1 dot) Develop in targeted areas (incentives)
- * Decentralize community services (e.g. Library, Community Centre, Schools) - neighbourhood based
- * Maximize solar capture, green roof
- * Everything within 400 m
- * Decrease land consumption for surface parking
- * Require trip generation / energy use / carbon emissions analysis - lead to evaluation with new vs redevelopment

Table selections for Land Use

The following are the Land Use ideas that were shared during the “regroup” session.

These ideas were identified to be a priority by at least one participant during the table session. Ideas that were identified by multiple groups were amalgamated:

- Decentralize common services
- More multifamily / Mixed use

- Locate all services within 400 meters
- Improve plan
- Less surface parking
- New and infill have District energy

Other ideas for Land Use

These are all of the ideas exactly as recorded on the flip chart sheets during the table discussions of Land Use:

- Financial incentives / mechanisms (e.g. Local improvement charges)
- LED street lights
- Brownfield incentives to increase infill
- Balance of single vs. Multi-family
- TDM[1] built into new developments
- More focus on density / dev along corridors - create a network and link with Transit
- Green job development to create efficiencies (i.e. Quality jobs)
- **** (plus 2 dots) Increasing fine grained mix of uses including population, jobs (challenged by existing policy / practice)
- Commitment to efficiency in new building developments
- Promotion of telecommuting (affected by zoning)
- Increase in infill development
- ** (plus 3 dots) Increasing uptake of District Energy in new / existing communities
- * (plus 3 dots) Energy modeling programs - monitoring
- Building operator training
- Building labeling of energy rating
- * Maximize solar capture, green roof
- Incentive programs? - There is risk associated with the end of incentives, Use to fill a market gap
- Require solar / electric vehicle / other energy efficiency readiness
- ** (plus 3 dots) Require District System readiness
- LEED / Advanced energy requirements (partial?)
- (1 dot) Green building policy updated; more clarity before implementation

[1] Transportation Demand Management

- * (plus 4 dots) Corporate Energy Management Plan - pools, adm, comm. centre - lead by example
- Building code - enhance provisions
- Incentive to exceed code
- High energy efficiency standard
- Property tax inc
- Utilities tax inc
- Biomass District energy
- Examine renewable energy during building design
- Geothermal and Biomass District energy in 50% of new developments
- * Decentralize community services (e.g. Library, Community Centre, Schools) - neighbourhood based
- Make public buildings multipurpose - schools in evening, community centres, churches
- Regional strategy - transportation authority
- Plan to accommodate multi-modal transportation
- Annex communities / RM[2] lands to enable efficient land use planning
- Allow tiny houses - smaller lots
- (2 dots) Transit oriented development
- Allow Car share to reduce parking requirements
- Walkable placement of everything (shopping...)
- * (plus 3 dots) Multifamily / Apartment - more greenspace within and near multifamily developments (Verve Tache) - intergenerational
- (1 dot) Repurpose / Redevelop old industrial
- * (plus 2 dots) Mixed Use
- Educate public about value of mixed use
- * (plus 1 dot) Increased density
- (5 dots) Permeable for AT - Neighbourhood plans include cut-throughs
- (1 dot) Develop in targeted areas (incentives)
- Dis-incent development in areas that are not part of plan
- Cost recovery of development
- Conserve existing natural greenspace and create new
- Greater inner city development, less sprawl

[2] Rural Municipality

- Greenspace vs. Infill - Use un-used or industrial land before greenspace
- Use rail land for infill
- Tax incentives for infill
- Tax dis-incentive for sprawl
- By 2031 75% PERC(?) density
- Convert policy to practice
- Rooftop agriculture
- Reduce single family homes
- “Fence” limit - No new growth beyond current footprint - determine where fence should be
- * Everything within 400 m
- Policy that survives admin change
- New area development
  - Higher density
  - Mixed use
  - Transit orientation
  - Closer proximity to destination
  - Better land use planning / integration with transportation planning
- **** (plus 1 dot) Force ourselves to implement our plan / improve plan
  - More specifics
  - Targets
  - Results driven
  - Mechanism for regular review
- * Decrease land consumption for surface parking
  - More efficient use of space
  - Build up more
- Reduction of heat islands (map them)
- Land development(?) needs to go hand-in-hand with provision of services
- * Require trip generation / energy use / carbon emissions analysis - lead to evaluation with new vs redevelopment
- Consider more District energy (Vancouver requires it) - Require District Energy business case

TRANSPORTATION

Transportation priorities

These are all of the ideas that received table votes (*) or voting dots in the area of Transportation:

- ** (plus 5 dots) Integration of Land Use and Transportation planning
- ** (plus 3 dots) Transit - improve service; frequency, wi-fi, multi-modal
- ** (plus 3 dots) Addressing multi-modal needs more comprehensively
- * (plus 3 dots) No additional road capacity (VKT is not going up)
- *** (plus 2 dots) Regional Transit development (demand responsive)
- * (plus 2 dots) Downtown bike share 2020, City-wide bike share 2031
- *** (plus 1 dot) Making Transit / walking / cycling more convenient for most trips (caution against making car use too convenient)
- ** (plus 1 dot) Aggressive deployment of rapid charge electric buses
- (1 dot) Pay as you drive insurance by 2020; all, personal only
- (1 dot) Revenue neutral carbon tax (relevant to all topics)
- (1 dot) Mode share targets
- * Regional AT development
- * Full / Aggressive implementation of AT strategies / Transit strategies
- * Retrofit City vehicles with alternative energy / low emissions / electric
- * Rapid Transit
- * More Quality Corridors (than are currently on Transportation Master Plan)
- * Recharging station network
- * Distance based insurance
- * Plan cycle facilities such that they are excellent in summer and therefore adequate in winter (snow storage and clearing)
- * More river transportation

Transportation table selections

The following are the Transportation ideas that were shared during the "regroup" session.

These ideas were identified to be a priority by at least one participant during the table session. Ideas that were identified by multiple groups were amalgamated:

- Retrofit or replace City fleet vehicles
- Regional Transit development
- Regional Active Transportation strategy

- Aggressive deployment of rapid charge electric buses
- Address multi-modal transportation comprehensively
- Make Transit / walking more convenient for most trips
- Integrate land use and transportation planning
- Create a city-wide bike share system
- Recharging station network
- Distance-based insurance
- Plan cycling facilities that are so good in summer that they are adequate in winter (e.g. leave space for cleared snow)
- More river transportation
- Improve quality of Transit (e.g. Wi-Fi, frequency, multi-modal)
- More Transit Quality Corridors - Go beyond the routes defined in the Transportation Master Plan

Other ideas for transportation

These are all of the ideas exactly as recorded on the flip chart sheets during the table discussions of Transportation:

- * Plan cycle facilities such that they are excellent in summer and therefore adequate in winter (snow storage and clearing)
- Separated cycling facilities
- * More river transportation
- More walking / cycling bridges
- Reduce parking minimum requirements (for building permits)
- ** (plus 3 dots) Transit - improve service; frequency, wi-fi, multi-modal
- * Rapid Transit
- * More Quality Corridors (than are currently on Transportation Master Plan)
- Become a Transit City (instead of a Car City)
- School travel planning (encourage kids)
- Car sharing on post secondary campuses
- Bike share within offices (instead of fleets)
- Regional subscription service for car pooling
- Preferences (e.g. Parking) for “green” cars
- * Recharging station network
- Sidewalk clearing in winter

- * Distance based insurance
- Connectivity improvement within AT[3] network - especially major intersections (e.g. Osborne underpass)
- TDM requirements for large facilities and employers (e.g. California, Washington)
- Buy local
- Better Transit / cycling int.
- More park and ride
- Set car-share mode target
- Improve Transit network for more convenient travel
- Commercial vehicle diamond lanes (trucks, taxi, Canada Post, etc)
- Goods delivery scheduling
- Physically separated bike facilities
- * (plus 3 dots) No additional road capacity (VKT is not going up)
- ** (plus 5 dots) Integration of Land Use and Transportation planning
- When developing - What's required to get there
- Modeling shortcoming - congestion
- (1 dot) Pay as you drive insurance by 2020; all, personal only
- * Downtown bike share 2020, (2 dots) City-wide bike share 2031
- Targeted street standard for more efficient goods movement
- Unbundling of parking requirement (incentive to not own a car)
- Charging stations
- More plugs for long-term parking
- Increased use of waterways (winter and summer)
- *** (plus 1 dot) Making Transit / walking / cycling more convenient for most trips (caution against making car use too convenient)
- Education - bike / Transit, not just Driver's Ed
- Accommodate LSEV[4] - licensing and infrastructure
- (1 dot) Revenue neutral carbon tax (relevant to all topics)
- Prioritizing snow and road cleaning
- ** (plus 3 dots) Addressing multi-modal needs more comprehensively
- (1 dot) Mode share targets

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[3] Active Transportation

[4] Low Speed Electric Vehicle

- Lawnmower exchange programs (to push / electric)
- Speed limit / Intelligent transportation systems
- Reduce ROW[5] width - Alternate time of day lanes
- Signal synchronization
- Minimum standards on car share for certain developments (origin and destination)
- Institutional shuttle services / pool vehicles
- ** (plus 1 dot) Aggressive deployment of rapid charge electric buses
- Electrification of RT[6] system
- End of life transport improvements
- Community / Campus bike share
- Increase biofuel standards
- Reduce overall VKT
- *** (plus 2 dots) Regional Transit development (demand responsive)
- * Regional AT development
- Vehicle use restrictions?
- Vehicle Corydons's / Tolls?
- Distance-based insurance
- Gas tax increases?
- * Full / Aggressive implementation of AT strategies / Transit strategies
- Target growth in electric charging stations
- Target growth in priority parking
- Target growth in car-share deployment
- Bike lane expansion
- Not enough Transit buses during high gas prices
- Compare Active Transportation to cities such as Amsterdam for limit
- Set up transportation authority - charge vehicles in city to fund
- Suburban Transit access - build new routes
- Build Transit interchange to allow better access to Rapid Transit - Shuttles, expand inter-city, free bus
- Target cars in downtown; tax, limit

[5] Right of Way

[6] Rapid Transit

- Target Active Transportation - 50% target for AT
- Compare other cities with good transit to set goal
- Limit parking downtown; reduce spaces, cost / tax
- Electric vehicle; all City vehicles, with City Centre to start
- Rapid Transit to airport
- * Retrofit City vehicles with alternative energy / low emissions / electric

BUILDINGS

Buildings priorities

These are all of the ideas that received table votes (*) or voting dots in the area of Buildings:

- *** (plus 3 dots) Energy labelling on new buildings and transfer of ownership
- ** (plus 2 dots) Mandated energy audits when selling buildings (consumer disclosure)
- *** Renewable ready (solar, geothermal); District energy in right of way
- * Renovation code
- * Adaptable / durable / resilient buildings
- * Geothermal as a utility
- * Energy audits and incentives for middle market
- * Incentives for retrofits (more PAYS)
- * CHP[7] / District energy in re-development sites
- * Focus on identifying the barriers to building energy efficiency (factors that impact the market) and develop a strategy to eliminate

Buildings table selections

The following are the Buildings ideas that were shared during the “regroup” session.

These ideas were identified to be a priority by at least one participant during the table session. Ideas that were identified by multiple groups were amalgamated:

- Create an Energy Management plan for corporate City buildings
- Perform energy modelling on more buildings
- Maximize solar capture
- District energy system readiness / redevelopment
- Identify market barriers for high-performance buildings
- Mandate energy audit when selling a building (e.g. as is done in UK)
- Incentives for middle market
- Geothermal as a utility
- Incentives for retrofit
- Energy labelling for new buildings
- Adaptable, durable building design

[7] Combined Heat and Power

Other ideas for buildings

These are all of the ideas exactly as recorded on the flip chart sheets during the table discussions of Buildings:

- * Geothermal as a utility
- * Energy audits and incentives for middle market
- Building performance monitoring and management services
- Performance metrics; more visible / standardized, for sale, during use -
- Winter city design (not California)
- Building performance feedback (meters, Apps)
- Co-location of heat-producers with heat users
- Passive solar design; solar walls, seasonal water use
- Green roofs; food, "grass"
- Public green spaces
- * Incentives for retrofits (more PAYS)
- Bike facilities within buildings; storage, access (stairs), multiple commercial tenants with access to shared facility
- Passivhaus
- Building energy improvement costs shared - include geothermal
- Increase education / efficiency promotion
- Large institutional / Building fuel switching (e.g. Biomass)
- * CHP[8] / District energy in re-development sites
- Tax credits incentives for efficiency
- What communities all stack (?)
- Retrofit existing buildings; begin with City buildings, aggressive targeting
- Technical feasibility of geothermal in Winnipeg
- Add heat utility
- Available capital funds for energy efficiency
- Internal carbon tax
- Municipal gas / carbon tax
- U of M, U of W, HSC big carbon
- Winnipeg as leader in "green" building

[8] Combined Heat and Power

- Decouple Manitoba Hydro Power Smart; allow consultant assessments
- Electric vehicle-ready housing
- *** (plus 3 dots) Energy labelling on new buildings and transfer of ownership
- Commercial energy disclosure; challenge sub-metering
- *** Renewable ready (solar, geothermal); District energy in right of way
- * Renovation code
- * Adaptable / durable / resilient buildings
- Green building incentives / standard
- MLS listing - energy rating
- Remove barriers to building energy efficiency - lack of availability of smaller, more energy efficient homes, lots -
- * Focus on identifying the barriers to building energy efficiency (factors that impact the market) and develop a strategy to eliminate
- ** (plus 2 dots) Mandated energy audits when selling buildings (consumer disclosure)

SOLID WASTE

Solid Waste priorities

These are all of the ideas that received table votes (*) or voting dots in the area of Solid Waste:

- **** (plus 7 dots) Provincial regulations enforcing material bans (organics, drywall, lumber, etc)
- **** (plus 6 dots) Biomass / Waste streams as heat / power source (waste-to-energy)
- * (plus 4 dots) Life Cycle Analysis carbon analysis for diversion
- ** (plus 1 dot) Water sensitive urban design (regulations)
- *** Curbside organics (commercial, industrial, residential)
- ** Industrial composting (grocery, hospitals, restaurants)
- ** Biomass energy strategy 2020
- ** Greywater use
- * Increase household composting (e.g. Workshops)
- * Construction waste recovery and reuse
- * Expand methane capture

Solid Waste table selections

The following are the Solid Waste ideas that were shared during the "regroup" session.

These ideas were identified to be a priority by at least one participant during the table session. Ideas that were identified by multiple groups were amalgamated:

- Material ban from landfill
- Life Cycle Analysis for diversion -
- Water sensitive urban design -
- Biomass strategy
- Curbside organics
- Methane capture for industrial / commercial
- Industrial composting -
- Household composting
- Construction waste recovery / reuse -

Other ideas for Solid Waste

These are all of the ideas exactly as recorded on the flip chart sheets during the table discussions of Solid Waste:

- * Increase household composting (e.g. Workshops)
- ** Industrial composting (grocery, hospitals, restaurants)
- Consistent diversion system (i.e. Clear identification of what is acceptable on each bin)
- * Construction waste recovery and reuse
- Tipping fees are too low
- *** Curbside organics (commercial, industrial, residential)
- * Expand methane capture
- Methane beneficial reuse
- **** (plus 6 dots) Biomass / Waste streams as heat / power source (waste-to-energy)
- Naturalization of green spaces
- ** (plus 1 dot) Water sensitive urban design (regulations)
- Xerscaping
- Wetland treatment
- Usage of urban waste wood for energy
- ** Biomass energy strategy 2020
- * (plus 4 dots) LCA carbon analysis for diversion
- More efficient diversion
- Improve load efficiency in collection
- Compost organics at home - not City collection
- Recycle half / Incinerate half
- Water pricing
- **** (plus 7 dots) Provincial regulations enforcing material bans (organics, drywall, lumber, etc)
- Curbside composting
- Commercial composting
- Expand use of landfill gas (plan for elimination)
- Ban plastic bags (scope?)
- Target reductions in packaging
- Expansion of product stewardship for end-of-life of specific products
- ** Greywater use

APPENDIX E

Forecast Scenario Indicators

The following sections detail the key indicators for the base year (2011) and each scenario (2031).

1.0 COMMUNITY TRENDS

The following table lists key indicators in community trends.

Table 1: Community Trend Key Indicators

Indicator	Base Year (2011)	Business as Usual (2031)	OurWinnipeg (2031)	Low Carbon Path (2031)
Population	691,800	876,700	876,700	876,700
Jobs	392,640	489,600	489,600	489,600
Single Family Homes	63%	63%	61%	58%
Multi-Unit Residential Building Homes	37%	37%	39%	42%

2.0 BUILDING ELECTRICITY AND NATURAL GAS

The following table lists key indicators in building electricity and natural gas.

Table 2: Building Electricity and Natural Gas Key Indicators

Indicator	Base Year (2011)	Business as Usual (2031)	OurWinnipeg (2031)	Low Carbon Path (2031)
Building Electricity Intensity Reduction due to Demand Side Management	0%	5%	5%	5%
Building Natural Gas Intensity Reduction due to Demand Side Management	0%	3%	3%	3%
New Building Energy Intensity Reduction due to Building Stock Changes	0%	0%	8%	17%
New Building Energy Intensity Reduction due to Technology Changes	0%	20%	20%	30%
Additional Electricity Use	0%	10%	10%	10%
Residential Building Scale Renewables	1.5%	1.5%	4%	8%
Commercial/Industrial Building Scale Renewables	1.5%	1.5%	6%	12%
Residential Buildings Connected to District Energy Systems	0%	0%	2%	4%
Commercial Buildings Connected to District Energy Systems	< 1%	< 1%	3%	6%
Residential Electricity Use (kWh/year)	1,690,588,866	2,175,793,596	2,143,841,778	2,066,458,470
Commercial Electricity Use (kWh/year)	3,046,484,478	3,499,055,017	3,499,055,017	3,423,823,982
Industrial Electricity Use (kWh/year)	837,309,539	961,696,068	961,696,068	941,019,231

Indicator	Base Year (2011)	Business as Usual (2031)	OurWinnipeg (2031)	Low Carbon Path (2031)
Residential Natural Gas Use (m^3/year)	488,426,808	648,519,154	633,883,431	604,010,541
Commercial Natural Gas (m^3/year)	361,222,578	473,031,695	466,306,958	448,167,147
Industrial Natural Gas (m^3/year)	104,025,761	136,224,824	134,692,295	129,843,331

3.0 TRANSIT

The following table lists key indicators in transit.

Table 3: Transit Key Indicators

Indicator	Base Year (2011)	Business as Usual (2031)	OurWinnipeg (2031)	Low Carbon Path (2031)
Kilometers of Transit Travel (km/year)	24,300,000	24,300,000	30,981,682	41,205,637
Bus Fuel Type	100% B2 Biodiesel	100% B2 Biodiesel	90% B2 Biodiesel 10% Electric	60% B2 Biodiesel 40% Electric
Diesel Fuel Use (L/year)	16,163,620	13,184,596	15,139,554	13,423,738
Electricity Use (MWh/year)	0	0	10,844	57,688

4.0 VEHICLES

The following table lists key indicators in vehicles.

Table 4: Vehicle Key Indicators

Indicator	Base Year (2011)	Business as Usual (2031)	OurWinnipeg (2031)	Low Carbon Path (2031)
Cycle Network (km)	274	274	674	800
Total Residential Vehicle Kilometers Travelled (vkmt/year)	5,175,656,607	6,256,030,891	6,161,200,794	5,976,259,971
Total Commercial Vehicle Kilometers Travelled (vkmt/year)	932,055,814	1,251,209,851	1,232,240,159	1,195,251,994
Electric Vehicle Use	0%	0%	2%	8%
Weekday Trips by Mode Auto Driver Auto Passenger Public Transit Walk/Cycle	 64% 19% 9% 7%	 65% 19% 9% 7%	 63% 18% 10% 9%	 58% 18% 13% 10%
Average Residential Fleet Emissions (gCO_2e/km)	370	196	193	185
Average Commercial Fleet Emissions (gCO_2e/km)	1015	538	538	532

5.0 WASTE DISPOSAL

The following table lists key indicators in waste disposal.

Table 5: Vehicle Key Indicators

Indicator	Base Year (2011)	Business as Usual (2031)	OurWinnipeg (2031)	Low Carbon Path (2031)
Residential Waste (tonne/year)	278,896	353,438	199,588	99,794
Commercial/Industrial Waste (tonne/year)	348,000	433,936	433,936	108,484
Construction/Demolition Waste (tonne/year)	124,000	154,621	154,621	38,655
Residential Diversion Rate	15%	15%	50%	75%
Commercial/Industrial Diversion Rate	20%	20%	20%	80%
Construction/Demolition Diversion Rate	20%	20%	20%	80%
Landfill Gas Collection Coverage (City Landfills)	100%	100%	100%	100%
Landfill Gas Collection Efficiency (City Landfills)	55%	55%	75%	75%
Landfilled Waste Per Capita (tonne/person/year)	1.09	1.07	0.90	0.28

6.0 WATER AND WASTE WATER

The following table lists key indicators in water and waste water.

Table 6: Vehicle Key Indicators

Indicator	Base Year (2011)	Business as Usual (2031)	OurWinnipeg (2031)	Low Carbon Path (2031)
Mass of Biosolids Disposed (tonne/year)	13,982	17,700	17,700	17,700
Biosolids Sold for Beneficial Use	0%	0%	40%	70%
Biosolids Composted	0%	0%	30%	30%

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