Options for Reducing GHG Emissions in Calgary

– Research Report

February 2011

This report was compiled by the Pembina Institute based on the research presented in the appendix and feedback from stakeholders.

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List of acronyms

AESO Alberta Electric System Operator

CCS Carbon capture and storage

CHP Combined heat and power

CTP Calgary Transportation Plan

GHG Greenhouse gas

GSHP Ground source heat pumps

HVAC Heating, ventilation and air conditioning

MDP Municipal Development Plan

RFS Renewable fuel standard

Executive summary

The City of Calgary, with support from Alberta Environment and the Federation of Canadian Municipalities' Green Municipal Fund, has commissioned this study to provide input to the development of a Community Greenhouse Gas (GHG) Reduction Plan and other related initiatives.

The development of a Community GHG Reduction Plan for Calgary is motivated by the 2009-2011 Council Priority 2.2, which directs Administration to:

> *"Develop a multi-stakeholder plan and implementation strategy to reduce community-wide GHG emissions in support of imagineCALGARY's long-term community goals."*

Another motivator is the Calgary Climate Change Accord,[1] in which The City committed to creating a plan to reduce GHG emissions[2] and promote low-carbon living for the community. The targets outlined in the Calgary Climate Change Accord for reducing corporate GHG emissions are:

- 20% below 2005 levels by 2020
- 80% below 2005 levels by 2050

The Accord also commits The City to pursuing parallel GHG reduction strategies for the community.

The development of a Community GHG Reduction Plan also directly benefits the city in several other ways including improved air quality, economic development, and alignment with municipal, provincial and federal policy. Many of the approaches also have cost savings associated with them (e.g., through energy efficiency and conservation, public transit, walking or cycling, reduced infrastructure costs, idling reduction, or passive solar energy.)

Of course, if programs and policies are not designed or implemented well, efforts to reduce GHG emissions could also have certain disadvantages. Programs and policies that provide flexibility, competitiveness within the region and cost effectiveness were encouraged by some stakeholders.

The purpose of this study is to identify and assess potential options for reducing GHG emissions in Calgary in order to help identify areas for The City and other stakeholders to best focus and prioritize their resources individually and collaboratively.

The research began by identifying all of the opportunities for reducing urban GHG emissions that have been quantitatively shown to have a notable impact on city-wide emission levels. These opportunities can be grouped into eight different categories. While these categories provide an indication of the opportunities with the greatest potential, it is also necessary to integrate thinking and actions across the categories to maximize potential and avoid working at cross-purposes.

1. Provincial electricity grid
   - Including large-scale wind farms, natural gas cogeneration, coal with carbon capture and storage (CCS), and nuclear power
   - See Appendices A.4 through A.8 and A.13 for more information
2. Energy efficiency
   - Including buildings, vehicles, and electrical and industrial equipment
   - See Appendices A.2, A.3 and A.11 for more information
3. Solar heating and electricity
   - Including passive space heating, active water and air heating, and photovoltaics
   - See Appendix A.8 for more information
4. Transportation mode shifting
   - Including land use and transportation planning and pricing
   - See Appendix A.10 for more information
5. Combined heat and power generation (in-city)
   - See Appendix A.5 for more information
6. Behaviour changes (other than transportation mode shifting)
   - Including driver training, feedback systems and other assistive technologies
   - See Appendices A.1 and A.12 for more information
7. Other fuel switching
   - Includes biofuels, natural gas vehicles, electric vehicles and ground source heat pumps
   - See Appendices A.9 and A.11 for more information
8. Landfill gas capture
   - See Appendix A.13 for more information

1 World Energy Cities Partnership, "Calgary Climate Change Accord," 2009, http://www.energycities.org/accord.asp

2 The City of Calgary's corporate GHG emissions were estimated to be approximately 3% of city-wide GHG emissions prior to the implementation of The City's GHG emissions reduction activities.

Executive Summary

An assessment was completed to determine the potential of each of the options to reduce GHG emissions in Calgary. Figure 1 demonstrates that most, if not all, of the options are required in order to meet the emissions reduction targets established by The City.

In order to achieve these emissions reduction potentials, the research indicates that a combination of regulations, price signals, incentives and education are needed in each of the areas. In many cases, regulations or permanent price signals, such as a price on carbon, are the ultimate policy end-goal required to meet the community targets, whereas education and incentives were identified to be useful tools to get to the end-goals.

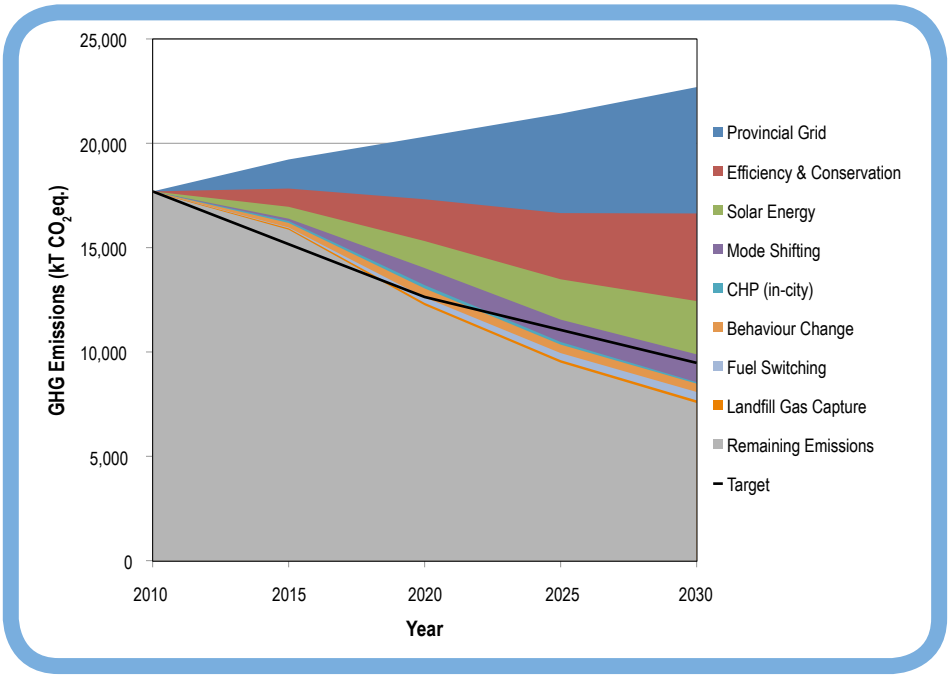

Figure 1: Estimated emissions reduction potential for Calgary

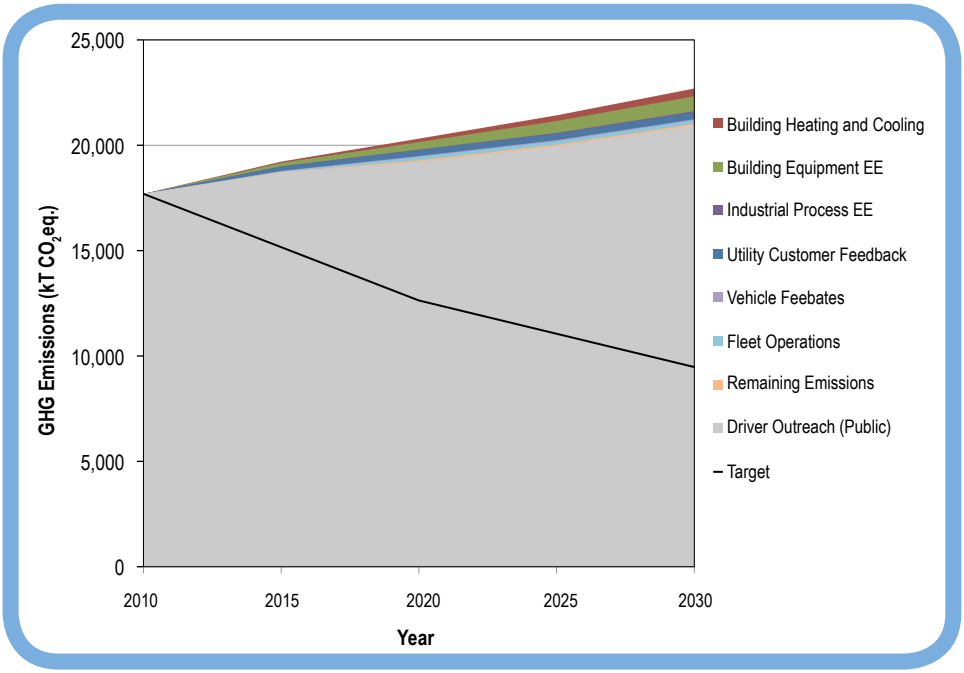

Figure 2: Estimated emissions reduction potential for energy efficiency and behaviour change using only incentives and education

If incentives and education are the only tools used to drive GHG emissions reduction in Calgary, The City's GHG targets are not expected to be met. Figure 2 shows the level of emissions reductions that were estimated for energy efficiency and behaviour change using only incentives and education.

The assessment also identifies emissions reduction options that reduce overall costs (i.e., energy efficiency, transit, walking, cycling, idling reduction and passive solar energy), or are currently cost competitive (i.e., large-scale wind power and natural gas cogeneration). In other cases, there are a wide range of estimates regarding cost effectiveness (i.e., solar air and water heating, behaviour change programs, natural gas vehicles), while some are currently more expensive than conventional technologies (i.e., coal with CCS, nuclear power, photovoltaics and biofuels).

Finally, the report concludes by summarizing the actions that were identified in the research as likely to be necessary in order to meet The City's emissions reduction targets. These actions represent the end-goals required to be reached, whereas the Community GHG Reduction Plan itself will identify all of the steps required to reach these end-goals such as engagement of stakeholders, increasing the market penetration of supportive products and services (including information services), and building political support for price signals and regulations.

1. Provincial, federal, or municipal*[3] government
    a. Incent or require low carbon power generation in the province.
    b. Incent and then regulate improved efficiencies of energy using products including:
        i. building envelopes*
        ii. heating, ventilation and air conditioning (HVAC) systems*
        iii. lighting, appliances and electronics
        iv. water heating and fixtures*
        v. industrial equipment
        vi. light-duty and heavy-duty vehicles
        vii. freight efficiency technologies (including road and rail)
    c. Develop programs and innovative financing mechanisms for replacing existing products.*
    d. Incent and then require energy labelling of buildings* and other energy-using products not currently labeled.
    e. Incent and then require solar heating and PV on buildings, as well as passive solar heating design.*
    f. Institute pay-as-you-drive insurance, road pricing* and / or fuel pricing.
    g. Pilot and expand fleet efficiency and consumer feedback programs.*
    h. Support and possibly require the expanded use of biofuels, natural gas vehicles, electric vehicles* and ground source heat pumps* (dependent on their forecasted ability to reduce emissions).
    i. Incent or require emission reductions from large facilities.
2. Municipal or provincial government
    a. Align land use and transportation planning and funding with the Municipal Development Plan and Calgary Transportation Plan.[4]
    b. Shift away from the provision of a minimum number or free parking spaces for new developments with access to transportation alternatives.
    c. Support the development of large-scale combined heat and power within the city.
    d. Support land use planning that maximizes passive solar heating for small buildings through appropriate lot orientation and consideration of features that create shading.
    e. Increase the amount of landfill gas captured.
3. Private sector and individuals (with respect to electricity and heat generation, energy efficiency and conservation, transportation mode shifting, land development, fuel switching and waste reduction)
    a. Develop, offer and purchase new products and services (including information services).
    b. Replace existing products.
    c. Label energy using products.
    d. Change behaviour that affects energy consumption.
    e. Support changes to the design of products, buildings, neighbourhoods and energy infrastructure.

This research report provides many different options for reducing GHG emissions in Calgary, but does not attempt to put these together into a strategy or plan. The purpose of this report is to provide a base of information from which further discussions can occur in order to develop a formal plan for reducing GHG emissions in Calgary. The next step in the community GHG planning process is just that: to develop a draft Community GHG Reduction Plan for The City of Calgary. A public consultation with the draft plan will occur prior to its submission to City Council

3 The municipal government does not have the ability to directly influence all of the areas included under #1 in the list. Areas of greater opportunity for the municipal government are identified with an asterisk (*).

4 These plans include creating a more compact city, reducing the outward growth of the city, intensifying vacant and underused lands, supporting density with transit, walkable destinations, and cycling infrastructure. More compact development is also needed to support other opportunities such as district energy and reducing building energy demand.

Introduction

The City of Calgary has established a set of Council Priorities for 2009 to 2011. Council Priority 2.2 is to:

> *"Develop a multi-stakeholder plan and implementation strategy to reduce community-wide GHG emissions in support of imagineCALGARY's long-term community goals."*

Another motivator is the Calgary Climate Change Accord[5] under which The City committed to creating a plan to reduce GHG emissions and promote low-carbon living for the community. The targets outlined in the Calgary Climate Change Accord for reducing corporate GHG emissions[6] are:

- 20% below 2005 levels by 2020
- 80% below 2005 levels by 2050

The Accord also commits The City to pursuing parallel GHG reduction strategies for the community.

The final community targets will be approved by City Council as part of the community plan. One stakeholder organization has suggested that the targets should be tied to population growth.

This research report provides input on the development of the multi-stakeholder GHG reduction plan and implementation strategy, as well as the development of future related strategies.

Co-benefits of reducing GHG emissions

In addition to reducing GHG emissions, the strategies reviewed impact the lives of Calgarians in many other economic, environmental and social ways. Some of the strategies can save people money (e.g., through energy efficiency, public transit, walking or cycling, and reduced infrastructure costs), while others can cost more money (e.g., carbon capture and storage, nuclear power, photovoltaics and biofuels). Nearly all of the strategies reduce air pollution, and other environmental impacts at the same time they reduce GHG emissions, although some reduce environmental impact more than others. Additionally, some of the strategies impact community design, which can thus impact people's lifestyle.

Of course, these costs and benefits need to be considered within the context of climate change, which also has significant costs associated with it.

The reduction of GHG emissions in Calgary also supports The City in meeting objectives outlined within Council Priorities, imagineCALGARY, the Municipal Development Plan and the Calgary Transportation Plan. It also contributes to Calgary's global reputation.

All of these factors are important to take into account when reviewing potential strategies to reduce GHG emissions in Calgary. This research report, therefore, is focused on how to achieve the greatest triple-bottom-line return on investment, while reducing our impact on climate change.

5 World Energy Cities Partnership, "Calgary Climate Change Accord," 2009, http://www.energycities.org/accord.asp

6 The City of Calgary's corporate GHG emissions were estimated to be approximately 3% of city-wide GHG emissions prior to the implementation of The City's GHG emissions reduction activities.

Background

Sources of GHG emissions

GHG emissions within Calgary city boundaries come primarily from the burning of fossil fuels: natural gas, gasoline and diesel (as shown in Figure 3). Electricity use within Calgary is also a significant cause of GHG emissions as power plants outside the city burn coal or natural gas to generate power for use in Calgary. Finally, Calgary's landfills produce methane, a greenhouse gas, which also must be considered as part of Calgary's overall emissions profile.

It is estimated that approximately 70% of the gasoline use is for personal transportation and the rest for commercial purposes. Most of the diesel fuel, on the other hand, is estimated to be used in heavy-duty vehicles including trucks and buses.

In the residential sector, space heating uses about three-quarters of the natural gas, with most of the rest of the natural gas being used for heating water. Appliances, electronics and lighting make up the electricity demand.

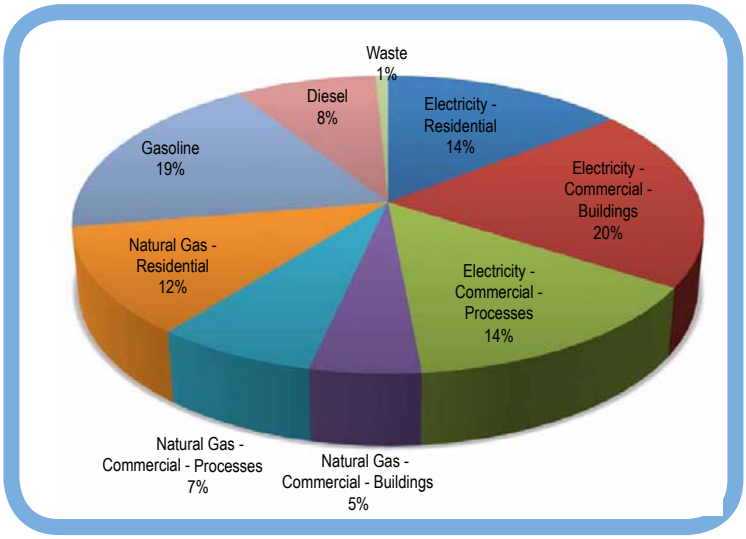

Figure 4: Sources of GHG emissions in Calgary (2008) – estimate of disaggregated commercial sector

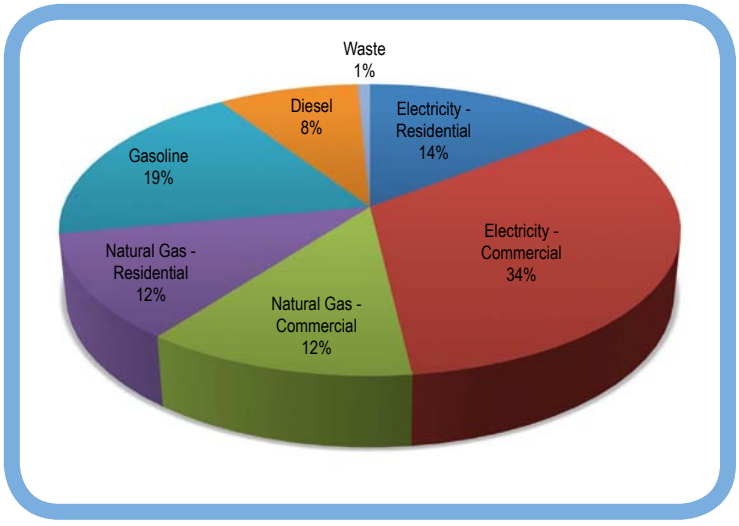

Figure 3: Sources of GHG emissions in Calgary (2008)

For the commercial sector, there is limited data available to differentiate between the energy used for commercial buildings and the energy used in industrial processes. Based on rough estimates, 57% of the commercial sector electricity is estimated to be used for typical building demands such as pumps, motors, fans, lighting, computers and other electronics; whereas the remaining 43% is estimated to be used in industrial processes such as equipment used in manufacturing. Conversely, natural gas is estimated to be split 40% for space and water heating, while 60% is estimated to be used in industrial processes. Based on employment data[7], it appears as though the largest manufacturing sectors within Calgary are for machinery, fabricated metal, food, computers and electronics, furniture, wood products, plastic and rubber, printing and related services, and non-metallic minerals. Figure 4 shows the city-wide emissions with the commercial sector disaggregated into building-related emissions and emissions related to industrial processes.

7 Calgary Economic Development, *Calgary: Manufacturing Force, Manufacturing Sector Profile*, 2009, http://www.calgaryeconomicdevelopment.com/files/Sector%20profiles/CED_MFTG_SP.pdf

Cost of energy

Energy used in Calgary also has a significant cost: over $3.4 billion per year is spent on electricity, natural gas, gasoline and diesel. A breakdown of costs by energy source is presented in Figure 5.

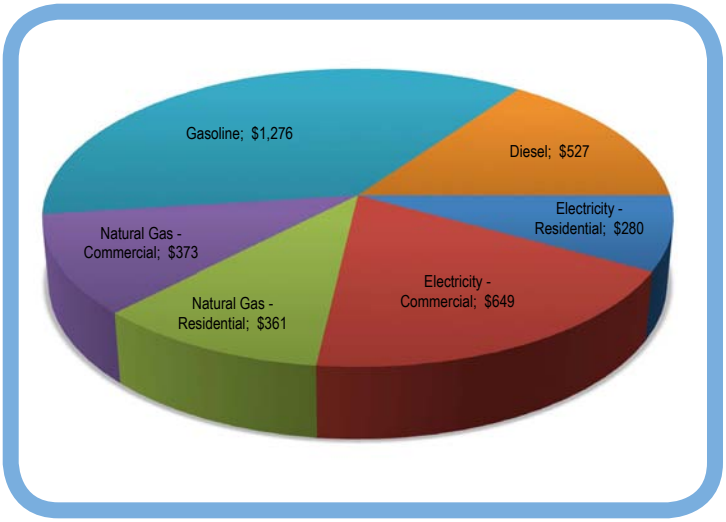

Figure 5: Energy expenditures in Calgary (2008)[8]

Historical GHG emissions

The City of Calgary has compiled data from 1990 to 2008 on energy use in the city. Figure 6 shows that GHG emissions continue to increase as population (and overall energy demand) increases. It should be noted that GHG emission growth can be decoupled from population growth. The strategies to achieve this are the focus of this research report.

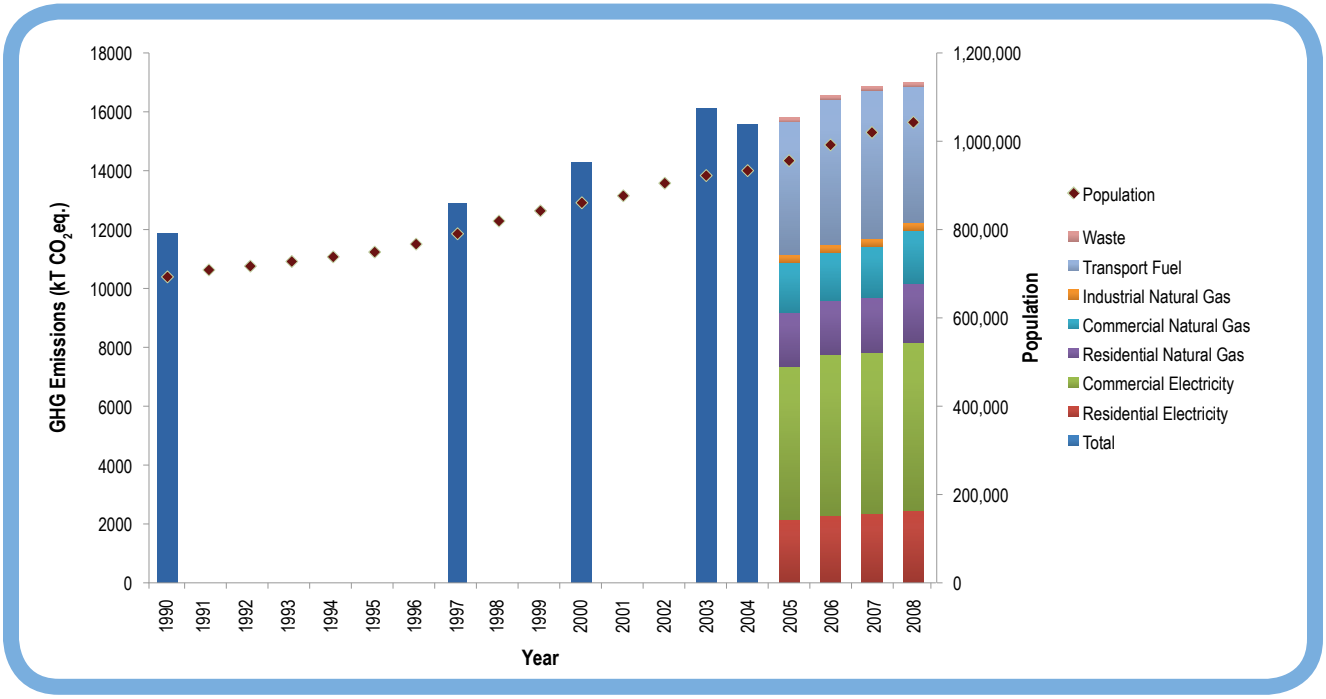

Figure 6: Historical GHG emissions in Calgary (for the years data is available)

8 Includes variable charges only for electricity and natural gas. Assumes retail prices of $0.10/kWh of electricity, $9/GJ of natural gas and $1.00 / litre of gasoline and diesel based on 2008 rates [http://ucahelps.alberta.ca/historic-rates-2008.aspx].

Trends in climate and energy policy

Increasingly, governments around the world are establishing policies to reduce greenhouse gas emissions and transition towards new energy technologies. In many cases, the motivation for advancing new energy technologies has as much to do with managing costs and resources, energy security, economic development or air quality as it does with tackling climate change. Reducing GHG emissions is therefore sometimes a value-added byproduct.

Economic policy

According to analysis by HSBC Bank, many countries are placing low-carbon investments at the heart of their economic stimulus plans. China allocated 37.8% of its stimulus to green measures; South Korea, 80.5%; and the European Union, 58.7%.[9]

National security policy

Many countries, including the U.S., China and the European Union, are advancing alternative energy technologies to increase the security of their energy supplies. The U.K. is also increasingly considering climate change as a national security issue due to the possibility that climate change may cause resource shortages, mass migrations of people, and conflict. "You cannot have food, water, or energy security without climate security," Foreign Secretary William Hague recently told the Council on Foreign Relations.[10]

Health policy

Many jurisdictions are realizing the public health benefits of cleaner energy production. Ontario, for example, is significantly reducing air pollution while taking the single biggest emissions reduction action in Canada by phasing out coal power by 2014. Much of this capacity will be replaced by a rapidly growing renewable energy sector and energy conservation. Some coal-fired power plants in the United States are repowering with biomass in order to meet emissions standards for air pollution.[11]

9 Nick Robbins et al, *A Climate For Recovery: The Colour of Stimulus Goes Green* (London, UK: HSBC Bank Plc., 2009), 2, http://globaldashboard.org/wp-content/uploads/2009/HSBC_Green_New_Deal.pdf.

10 William Hague, "An effective response to climate change 'underpins our security and prosperity,'" Address to the Council on Foreign Relations, Nov. 27, 2010, http://www.fco.gov.uk/en/news/latest-news/?view=Speech&id=22924054

11 See, for example, U.S. EPA, "Ohio Edison agrees to repower power plant with renewable biomass fuel," news release, August 12, 2009, http://yosemite.epa.gov/opa/admpress.nsf/0/7EEF89C1A5D3B60985257610047A74D.

Lloyd's of London and Chatham House perspective

A recent report from Lloyd's of London and Chatham House highlighted, "[e]nergy security and climate change concerns are unleashing a wave of policy initiatives and investments around the world that will fundamentally alter the way that we manage and use energy. Companies which are able to plan for and take advantage of this new energy reality will increase both their resilience and competitiveness. Failure to do so could lead to expensive and potentially catastrophic consequences."[17]

International comparisons

In a study by the United Nations Environment Programme, Calgary had the fifth-highest per capita GHG emissions out of the 50 cities studied — due primarily to a high reliance on coal-fired power.[12]

When considering overall ecological footprint, it is estimated that if everyone lived as people do in Calgary, over four planets worth of resources would be required. Energy use accounts for approximately 56% of Calgary's overall ecological footprint.[13]

Internationally, there is broad consensus among all major emitting nations that global temperature rise should not exceed 2˚C relative to pre-industrial levels.[14] Countries around the world continue to set targets and GHG reduction plans, including the G8 countries who support the target of reducing their collective emissions 80% by 2050 (relative to 1990 or a more recent year).[15] The Government of Canada has set a target to reduce emissions by 17% below 2005 levels by 2020 and 60% to 70% by 2050. Canada's 2020 target is tied to that of the United States, while other developed countries have shown their willingness to achieve more ambitious targets. The Government of Alberta also has a Climate Change Strategy which has led to the direct engagement of municipalities on climate change, and the establishment of a Municipal Climate Change Action Centre in the province. The City of Calgary, meanwhile, has signed the Calgary Climate Change Accord effectively committing The City to pursuing strategies to reduce community emissions.

Some countries and regions have also indicated that they would like their trading partners to undertake similar GHG emissions reductions. Recent climate proposals in the United States have included programs for border adjustments and other trade measures to encourage others to take action.[16] This has prompted the Canadian government to set a similar GHG reduction target as the United States. Provinces and states such as B.C., Ontario, Quebec and California are also implementing policies that favour low carbon energy sources, whether they are generated locally or imported.

Internationally, countries are moving towards alternative energy sources and technologies, and they are looking for others to do the same. Trends appear to indicate that regulatory, trade and financial signals for reducing GHG emissions will increase over time, increasing the value of reducing GHG emissions within Calgary.

12 United Nations Environment Programme, *Representative GHG Baselines for Cities and their Respective Countries*, 2010. http://siteresources.worldbank.org/INTUWM/Resources/GHG_Index_May_18.pdf

13 City of Calgary, *Calgary's Ecological Footprint Baseline Summary 2008*, 2009, http://www.calgary.ca/docgallery/bu/environmental_management/ecological_footprint/2008_foot_baseline_report_summary.pdf

14 Declaration of the Leaders of the Major Economies Forum on Energy and Climate (2009), http://www.g8italia2009.it/static/G8_Allegato/MEF_DeclarationI.pdf.

15 Responsible Leadership for a Sustainable Future, declaration of the 2009 G8 Leaders' Summit (July 2009) 65, http://www.g8italia2009.it/static/G8_Allegato/G8_Declaration_08_07_09_final,0.pdf.

16 Danielle Droitsch and Clare Demerse, *The American Power Act: An Analysis of the May 2010 Discussion Draft* (The Pembina Institute, 2010) http://www.pembina.org/pub/2036.

17 Antony Froggatt and Glada Lahn, *Lloyd's 360˚ Risk Insight: Sustainability Energy Security: Strategic risks and opportunities for business* (London, UK: Chatham House / Lloyd's, 2010), 4. Available online at http://www.chathamhouse.org.uk/publications/papers/view/-/id/891/.

The City of Calgary corporate GHG emissions reduction activities

The City of Calgary has had a corporate GHG reduction plan since 2000. In 2006 the plan was updated with the Calgary Climate Change Action Plan Target Minus 50 policy. This policy required The City to reduce corporate emissions by 20% below 1990 levels by 2020 and 50% below 1990 levels by 2050. Since 2000, The City has already met the 2020 target, reducing GHG emissions by more than 34% below 1990 levels.

This has been accomplished primarily through long term purchase agreements for wind power that has allowed their electricity provider, ENMAX, to build new wind farms. The City currently uses about 75% green energy for City operations, and on January 1, 2012, this will be increased to 100%.

In December 2009, The City also signed the Calgary Climate Change Accord,[18] in which the signatories:

- urged world leaders to establish targets for GHG reduction in an ambitious global agreement,
- committed to reducing GHG emissions from their corporate activities to a minimum of 20% by 2020 and 80% by 2050 using 2005 as a baseline,
- committed to creating a plan for reducing GHG emissions from all community sources,
- committed to working collaboratively to develop capacity and share experiences including during an annual forum, and
- committed to pursuing partnerships with industry, government, NGOs, media and local community groups with a view to establishing innovative low-carbon urban sustainability projects in their communities.

The City has also undertaken to:

- improve the energy efficiency of its buildings, vehicles, street lights and traffic lights
- reduce vehicle idling
- purchase biofuels
- capture methane from landfills
- implement water conservation measures

Established activities and scope of the study

Many activities are already being undertaken in Calgary to reduce GHG emissions. A selection of these are included in the background research contained in Appendix A for each sector. One of the organizations that is most active is The City of Calgary itself. For example, The City established a policy and targets to reduce GHG emissions from its own corporate buildings, fleet, water services, and streetlights.[19] The initiative to establish a Community GHG Reduction Plan, and consequently this research report, is therefore focused on all of the GHG emissions in Calgary except for those from The City of Calgary Corporation, which are the subject of a separate plan and policies.

Note that The City of Calgary's corporate GHG emissions were estimated to be approximately 3% of city-wide GHG emissions prior to the implementation of The City's GHG emissions reduction activities.

18 World Energy Cities Partnership, "Calgary Climate Change Accord," 2009, http://www.energycities.org/accord.asp

19 City of Calgary, *Calgary Climate Change Action Plan: Target Minus 50*, 2006. http://www.calgary.ca/docgallery/bu/environmental_management/climate_change_program/target_50_climate_change_action_plan.pdf

Funding partners

The process to develop a Community GHG Reduction Plan and this supporting research paper were funded through:

- The Federation of Canadian Municipalities Green Municipal Fund
- Alberta Environment
- The City of Calgary

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Government of Alberta
Environment

THE CITY OF CALGARY

Planning process

This research report is only one component of a larger process to establish a Community GHG Reduction Plan for The City of Calgary. Figure 7 shows how this research report is intended to support the development of a Community GHG Reduction Plan. The plan will ultimately be presented to City Council for discussion and approval.

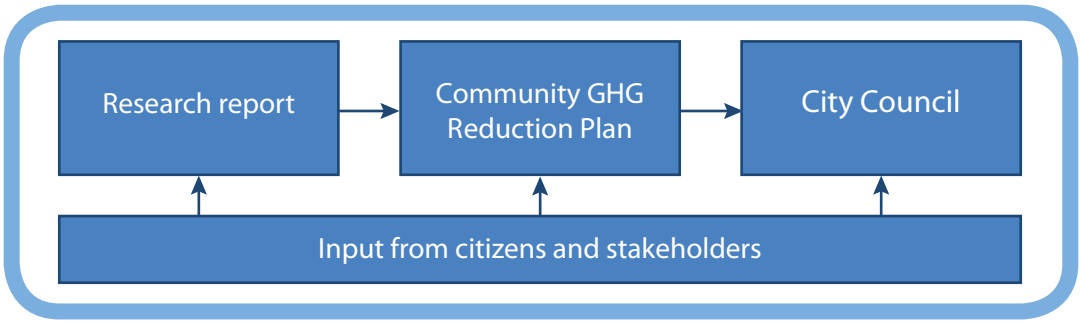

Figure 7: Planning process for the Community GHG Reduction Plan

Report purpose, methodology and outline

The purpose of this report is to present the results of research modelling and initial stakeholder engagement as a starting point for discussions about best options for reducing GHG emissions in Calgary.

Initial input for the report was collected during The City of Calgary's Low Carbon Future Roundtables and Summit where citizens from across the city were invited to provide their input on ways to reduce GHG emissions.

This was followed up by identifying local, provincial, national and international examples of emissions reduction projects and initiatives, as well as studies that have estimated the emissions reduction potential of existing technologies and approaches. These examples and studies were then assessed for their applicability to Calgary, as well as their triple-bottom-line impact.[20]

A quantitative model was then built, which divided the energy use in Calgary into its end uses such as lighting, furnaces and vehicles. The emissions reduction opportunities in the report were then modelled both individually and as part of various scenarios by adjusting the variables within the model. The model then estimated the total GHG emissions for the years 2011 to 2050 for the various opportunities. The modelling results are presented in the Emissions reduction potential section of the report.

A draft report was prepared and circulated to a stakeholder group, made up of the following organizations, for comments. These organizations also provided input at the start of the research process during two stakeholder meetings.

- City of Calgary
- Alberta Environment
- Calgary Economic Development
- ENMAX Corporation
- Urban Development Institute
- Canadian Home Builders' Association – Calgary Region
- Building Owners and Managers Association
- Alberta Motor Transport Association
- Calgary Chamber of Commerce
- Federation of Calgary Communities
- Momentum
- Climate Change Central
- Sustainable Calgary
- University of Calgary
- Calgary Regional Partnership

It was not possible to conduct a full public consultation on this research report, but a public consultation will take place for the actual Community GHG Reduction Plan.

Based on the feedback received from reviewers, and follow-up discussions, the research report was revised to include the additional information provided by the stakeholder group.

The intention of this report is to provide not one perspective on how GHG emissions could be reduced in Calgary, but rather multiple perspectives. It is hoped that the compilation of these various perspectives, as well as discussions that take place, will provide a well-rounded foundation for designing emissions reduction initiatives to be undertaken by not only The City of Calgary, but other organizations both inside and outside Calgary.

Report outline

Following the Introduction, a summary of the different sectors and emissions reduction opportunities are presented.

Due to the large number of ways to reduce emissions, the original list of measures was filtered to remove opportunities with relatively low expected impact on city-wide emissions. It should be noted that these opportunities that were filtered out may be worth further consideration in the future as circumstances change (e.g., as technologies advance), or as precursors to larger initiatives as 'low hanging fruit' to create momentum.

Next, the results of a more detailed comparative analysis are presented. This begins with the introduction of a reference scenario where GHG emissions are projected into the future assuming that per capita emissions remain the same as 2008 (the latest year for which data is available).

The reference scenario is then compared to scenarios where action is taken to reduce the per capita emissions in Calgary. Each action is presented according to its potential if it is implemented by itself, as well as alongside a set of compatible actions to show what is achievable when multiple strategies are pursued.

Observations of the results are then presented as part of the Discussion section. Finally, key findings are summarized in the Conclusion section.

20 A summary of the analysis can be found in Appendix A.

Emissions reduction opportunities

The majority of GHG emissions in a city come from buildings, industry, transportation and waste. The major categories of emissions reduction opportunities are shown in Figure 8.

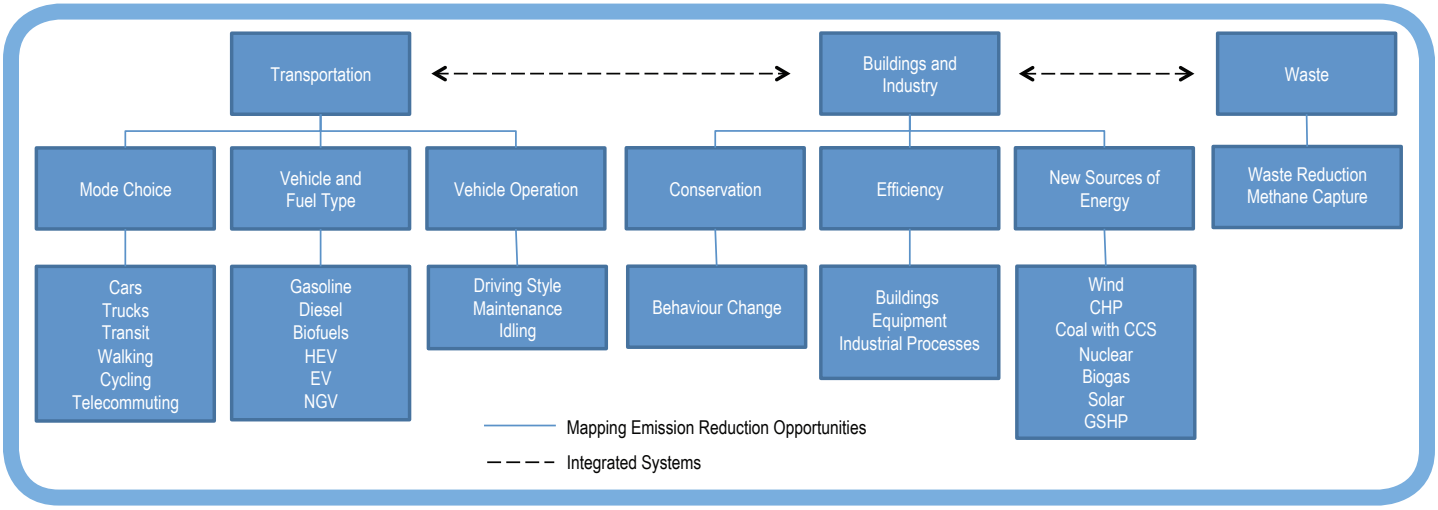

Figure 8: Map of emissions reduction opportunities[21]

Buildings and industry

GHG emissions from commercial and industrial facilities make up 46% of the GHG emissions in Calgary, while residential buildings are responsible for 26%.

The methods of reducing GHG emissions fall into three general categories:

1. Conservation – reduce the amount of energy we use
2. Efficiency – do more with less energy
3. New sources of energy – develop and use energy from sources that have a low carbon footprint

Note that this report does not deal with the production of building materials, except where it occurs within city boundaries. Construction emissions are generally accounted for as either industrial emissions or as a portion of diesel emissions within the transportation sector.

Conservation

Conservation measures for buildings include:

- turning off lights and other energy using equipment
- turning down the thermostat in the winter or up in the summer
- building smaller or fewer buildings

Each of these measures can reduce GHG emissions significantly, but having people do them on a city-wide level can be difficult. The research did identify, however, several actions that could be taken to achieve notable emissions reductions through conservation:

- feedback systems for residential utility customers
- increased residential densities

A triple-bottom-line evaluation of these options is detailed in Appendix A.1.

Other activities to encourage energy conservation were also identified, such as education and outreach programs, but there is little data demonstrating their impact in isolation. These were, however, identified to be important components of other strategies described in Appendix A.1.

21 Note that Figure 8 does not include considerations such as land use design, market forces and the regulatory environment, which have a significant impact on each of the emissions reduction opportunities. These are, however, discussed within the analysis portion of the report.

Efficiency

The efficiency of buildings and industry in the city can be broken into two general categories:

1. the efficiency of space heating and cooling
2. the efficiency of running equipment that are not involved in space heating and cooling (e.g., lights, appliances, electronics, industrial processes)

For space heating and cooling, increased efficiency is generally obtained through:

- improvements to the building envelope (stops heat loss or gain)
- improvements to the heating and cooling systems (includes furnaces, boilers, fans, pumps and their control systems)

Note that a reduction in heating and cooling demand through smaller buildings or different practices or equipment in the building is addressed in the Conservation section.

A triple-bottom-line evaluation of the options for improving the efficiency of space heating and cooling is detailed in Appendix A.2.

For other equipment, increased efficiency is achieved through:

- purchasing and installing more efficient products (e.g., Energy Star products)
- designing the system of equipment to be more efficient (e.g., optimizing the number of lights in a space, or installing electronic control systems to automatically turn off equipment when it's not needed)

A triple-bottom-line evaluation of the options for improving the efficiency of non-space-heating and cooling equipment is detailed in Appendix A.3.

There are many different approaches to achieving greater building efficiencies including regulations, incentives and information. These approaches are further described and explored in Appendices A.2 and A.3.

New sources of energy

The type of fuel used for heating or electricity production makes a significant difference in overall GHG emissions.

For electricity production, there are a significant number of options for reducing GHG emissions from current levels. The following options are currently available and have the highest potential for large-scale adoption:

- wind farms
- natural gas combined heat and power plants
- coal power plants with carbon capture and storage
- nuclear power plants
- biogas power plants using methane from landfills
- solar photovoltaics

For heat supply, there are also a number of options for reducing GHG emissions from current levels:

- natural gas combined heat and power plants
- district heating systems
- solar water and space heating
- ground source heat pumps

A triple-bottom-line evaluation of these options is detailed in Appendices A.4 through A.9 and A.13.

Many different approaches can be used to encourage the development of new electricity and heating sources, including regulations, incentives and information. These approaches are further described and explored in Appendices A.4 through A.9 and A.13.

Other electricity and heat sources such as geothermal power plants, packaged nuclear power plants or biomass heat or power are not as close to large-scale deployment in Alberta as the other electricity and heating sources listed, and were not investigated in detail. With regard to power generation using wood (from Alberta forests in particular), research in this area is currently limited.

Transportation

GHG emissions from gasoline use make up 19% of the GHG emissions in Calgary, while diesel fuel contributes 8% of the emissions. For Calgary, an estimated 71% of gasoline is used in passenger vehicles and 29% for freight (light- and medium-duty trucks), while diesel fuel is most commonly used in trucks for commercial purposes.

The methods of reducing GHG emissions in the transportation sector fall into three general categories:

1. mode choice
2. vehicle and fuel type
3. vehicle operation

Mode choice

The level of GHG emissions from transportation varies considerably based on the type or mode of transportation used. While freight transportation in a city typically uses trucks, the modes for other transportation can include:

- cars and trucks
- transit
- cycling
- walking

There is also an option to reduce the amount of vehicle use through:

- shorter trips (e.g., living closer to work and amenities, route planning)
- fewer trips (e.g., telecommuting, combining trips, carpooling)

A triple-bottom-line evaluation of these options is detailed in Appendix A.10.

There are many different approaches to encouraging these different modes of transportation including land use planning, transit oriented development, infrastructure development, pricing and information. These approaches are also further described and explored in Appendix A.10.

Vehicle and fuel type

If a vehicle is the transportation mode of choice, then the type of vehicle and its fuel are important factors to its overall GHG emissions. Likely vehicle and fuel types include:

- standard gasoline and diesel vehicles (with or without blending with biofuels)
- hybrid electric vehicles
- electric vehicles
- natural gas vehicles

Besides different fuel types and drivetrain configurations, vehicle efficiency also affects GHG emissions.

It should also be noted that these options for reducing GHG emissions apply across applications — from personal vehicles to on-road freight vehicles to rail and off-road construction vehicles — to varying degrees (e.g., natural gas and electric vehicles are more commonly available in on-road applications while electric vehicles are typically light duty).

A triple-bottom-line evaluation of these options is detailed in Appendix A.11.

There are many different approaches to encouraging the purchase of efficient vehicles or different vehicles and fuel types. These include regulations, incentives, infrastructure development and information. These approaches are further described and explored in Appendix A.11.

Vehicle operation

Once a transportation mode, vehicle and fuel type are chosen, there is also an opportunity to reduce GHG emissions through the way the vehicle is operated. This includes reducing fuel consumption through:

- driving style (e.g., reducing accelerations, braking and overall speed)
- maintenance
- reducing idling while parked

A triple-bottom-line evaluation of these options is detailed in Appendix A.12.

There are many different approaches to encouraging more efficient vehicle operation, including driver outreach programs, fleet driver training and feedback programs, and idling reduction equipment for cargo trucks and rail locomotives such as auxiliary power units and plug-ins. These approaches are further described and explored in Appendix A.12.

Approaches that involved driver training for individuals were not considered in the detailed analysis as this was not found to have significant emissions reduction potential.

Waste

GHG emissions from waste make up approximately 0.8% of the GHG emissions in Calgary. These emissions are estimated based on the characteristics of the three active landfills within the city boundaries.

The methods of reducing GHG emissions from landfills fall into three general categories:

1. waste reduction
2. methane capture
3. waste-to-energy

A triple-bottom-line evaluation of these options is detailed in Appendix A.13.

Emissions reduction potential

As part of the analysis, the emissions reduction potential for each of the options was evaluated to determine its potential contribution towards the GHG emission targets. The results for each option are presented individually, and then as part of various packages to demonstrate potential strategies for reaching the emission targets.

Each of the options and option packages are presented relative to a reference case to show how they differ from a business-as-usual future.

Reference case

In order to demonstrate the potential for different actions to reduce GHG emissions in the city, a reference case was developed. The reference case, or business–as-usual, presents a future where GHG emissions continue to increase at a similar rate as population — a trend that has continued for at least the last 20 years. Over this time, an increase in energy efficiency has been counteracted by an increasing demand for energy services such as bigger buildings, larger cars, increased driving and more energy-using devices per person.

The reference case, shown in Figure 9, assumes emissions from residential and commercial buildings and facilities as well as vehicles continue to increase over the next 40 years.

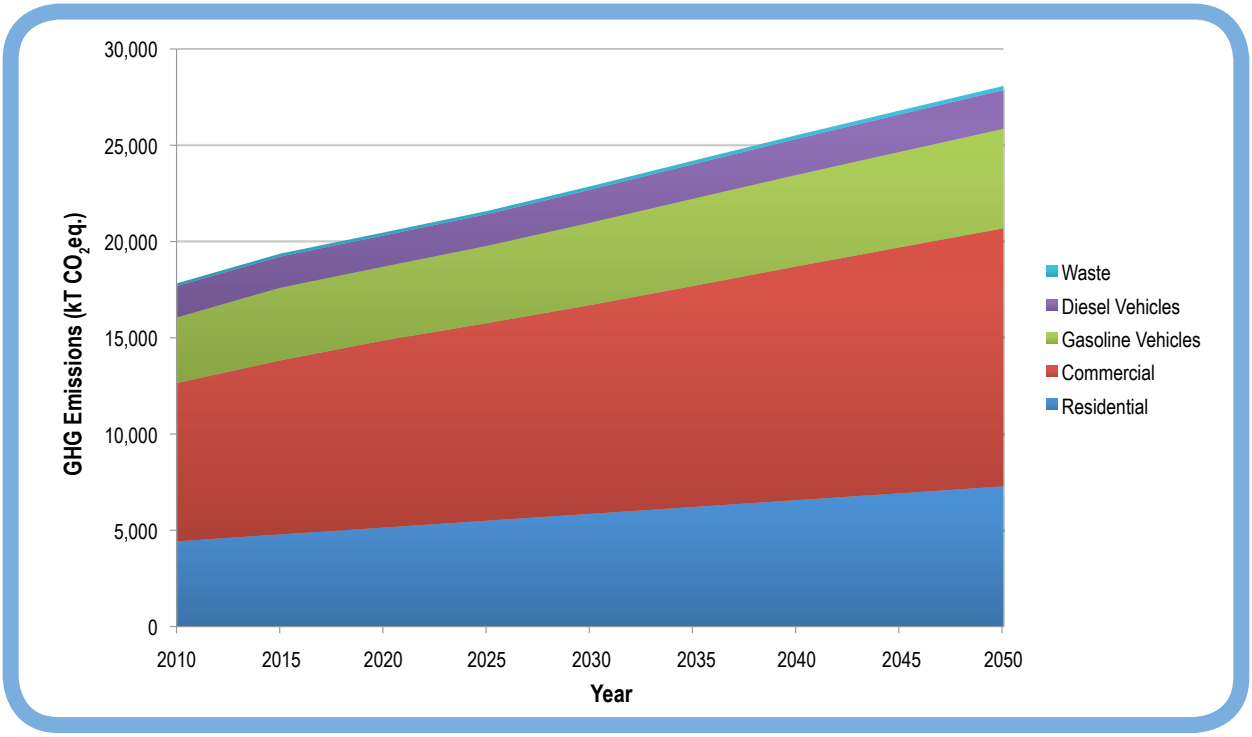

Figure 9: Assumed business-as-usual GHG emissions growth

Emissions reduction targets

As described in the Background section, The City of Calgary and other governments have established targets for reducing GHG emissions as shown in Figure 10. These targets demonstrate the significant downward trend that is desired for GHG emissions.

The City of Calgary targets outlined in the Calgary Climate Change Accord for reducing corporate GHG emissions are:

- 20% below 2005 levels by 2020
- 80% below 2005 levels by 2050

The Accord also commits The City to pursuing parallel GHG reduction strategies for the community.

The imagineCALGARY Long Term Urban Sustainability Plan[22] also includes the following targets for city-wide GHG emissions:

- 6% below 1990 levels by 2012
- 50% below 1990 levels by 2036

These targets will be used as additional reference points for comparing possible strategies for reducing emissions.

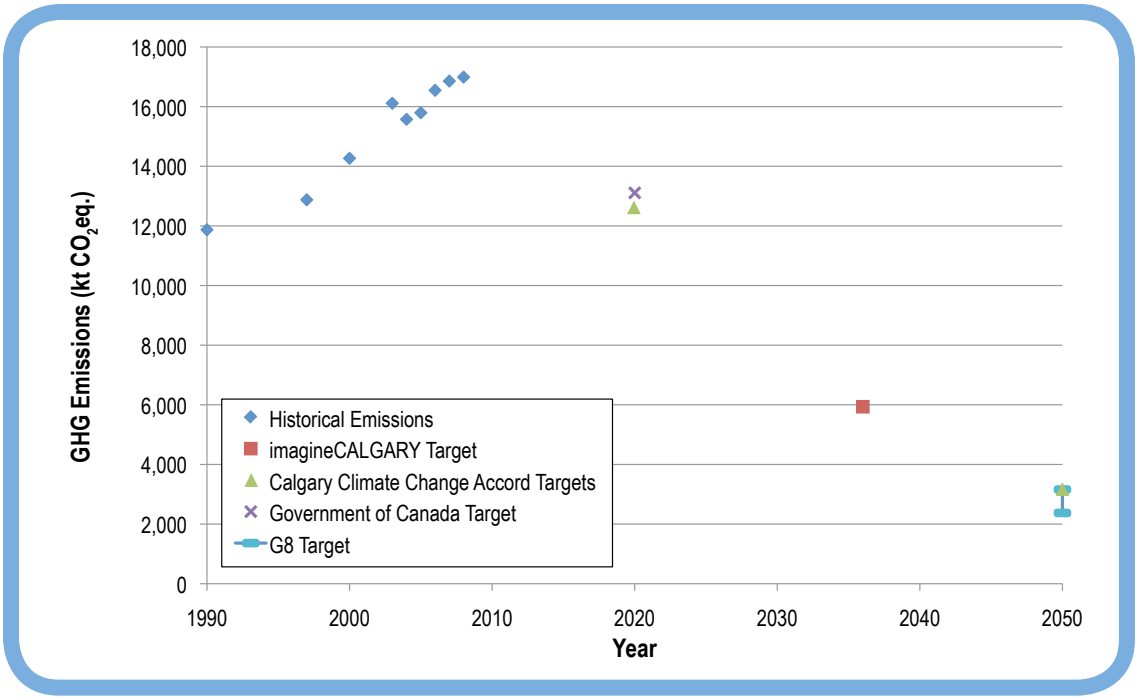

Figure 10: Comparing various GHG emissions reduction targets to Calgary historical emissions

22 imagineCALGARY, *imagineCALGARY Plan for Long Range Urban Sustainability*, 2006, http://www.imaginecalgary.ca/imagineCALGARY_long_range_plan.pdf.

Results

This section summarizes the results of the emission modelling completed and identifies several categories of notable emissions reduction potential. While these categories provide an indication of the opportunities with the greatest potential, it is also necessary to integrate thinking and actions across the categories to maximize potential and avoid working at cross-purposes.

Electricity grid

The single biggest opportunity for reducing emissions in Calgary is through changes to the provincial electricity grid. Currently, the grid is more than 70%[23] coal powered, which is significantly more carbon-intensive than other electricity sources. If greater amounts of lower-emission electricity generation are developed in the province, such as wind power, natural gas power plants, fossil fuel power plants with carbon capture and storage and nuclear power plants, this would have a significant impact on reducing Calgary's carbon footprint.

For example, in 2007 the Alberta Electric System Operator (AESO) developed several scenarios of possible future expansion of the electricity grid in the province.[24] When applying an average of these scenarios to Calgary, city-wide GHG emissions are reduced by 15% compared with a 2020 business-as-usual scenario of no changes to the electricity grid, as shown in Figure 11. Of course, since business-as-usual emissions grow from 2010 levels, much more than a 15% reduction from business-as-usual is needed to reach the GHG emissions reduction target.

However, if an even more aggressive approach to reducing GHG emissions in the provincial electricity grid is taken, greater emissions reductions for Calgary could be achieved.

For example, if conventional coal-fired electricity plants were replaced by a combination of wind power and natural gas cogeneration over the next 20 years, a 23% reduction in GHG emissions from business-as-usual could be achieved by 2020. The estimated emissions reduction for this scenario is presented in Figure 12. See Appendices A.4 through A.8 and A.13 for more information on electricity generation options for Calgary.

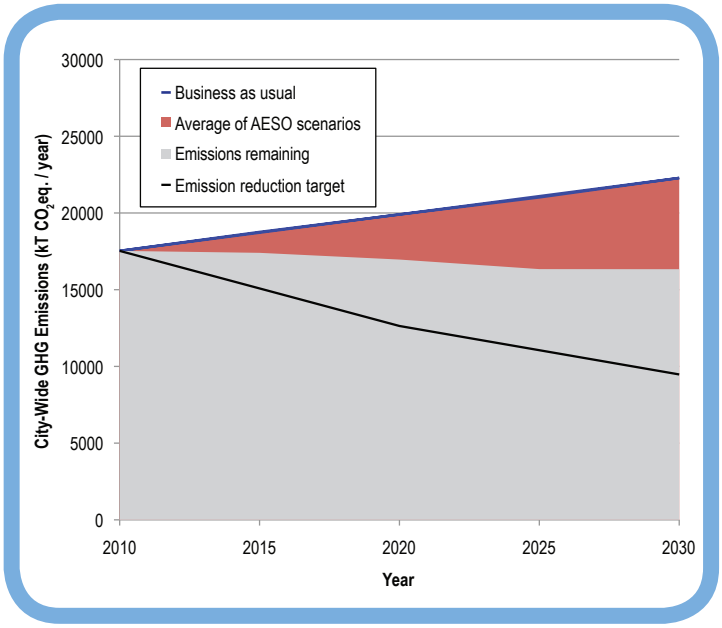

Figure 11: Estimated GHG emissions reduction for average of AESO future scenarios

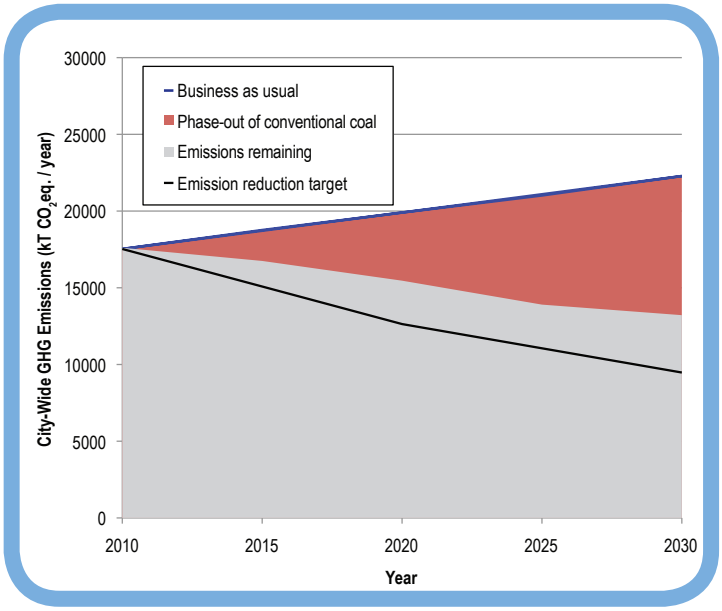

Figure 12: Estimated GHG emissions reduction if conventional coal power is replaced with wind and natural gas

23 Jeff Bell and Tim Weis, *Greening the Grid: Powering Alberta's Future with Renewable Energy* (Pembina Institute, 2009).

24 Draft Generation Scenarios, Alberta Electric System Operator, Long-Term Transmission System Planning AESO Stakeholder Consultation, November 16, 2007, www.aeso.ca/downloads/Nov_16_Long_Term_Transmission_Stakeholder_Presentation- _for_posting.pdf.

Ground source heat pumps

Technologies such as ground source heat pumps (GSHP), which use electricity to transfer heat out of the ground for use in buildings, could be used to reduce GHG emissions, but only if changes to the Alberta grid take place. For example, if GSHPs are used on 10% of the buildings in the city (approximately one-third of all new buildings), they could reduce emissions in Calgary by 0.3% in 2020 compared with business-as-usual in the case where an average of the AESO scenarios is used. However, if the electricity grid remains the same, using GSHPs would actually increase GHG emissions by 0.3% in 2020 compared with business-as-usual. See Appendix A.9 for more information on ground source heat pumps.

Building and industrial energy efficiency

A second key area of potential emissions reductions is improving the energy efficiency of residential, commercial and industrial buildings and processes in Calgary.

Through aggressive programs and policies to upgrade both new and existing buildings, and the equipment in those buildings (not including equipment used for industrial purposes), GHG emissions could be reduced in Calgary by 7.2% compared with business-as-usual in 2020, as shown in Figure 13.

If a less aggressive approach is taken (e.g., limited to information and incentive programs), the emissions reduction in 2020 is estimated to be 2.5% compared with business-as-usual. As shown in the results summary, this level of emissions reduction is likely not sufficient to meet the community targets.

The energy efficiency measures that most contribute to energy efficiency reductions in buildings (for both scenarios) include:

- efficient equipment and lighting[25] and low-flow water fixtures
- construction of high-efficiency buildings
- efficiency upgrades to existing buildings

In addition to building-specific energy efficiency, there are also opportunities for reducing GHG emissions through improving the energy efficiency of industrial processes. Estimates of the achievable energy efficiency potential in the industrial sector are variable, so a range of a 1% to 15% efficiency improvement over 20 years was used. This translates into a city-wide emissions reduction of up to 2% compared with business-as-usual by 2020, which is shown in Figure 14. See Appendices A.2 and A.3 for more information on energy efficiency.

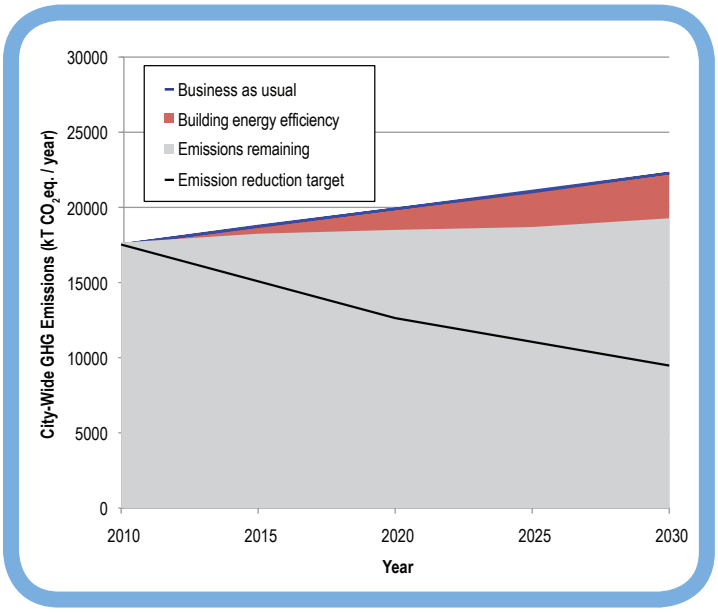

Figure 13: Estimated GHG emissions reduction from improved building energy efficiency

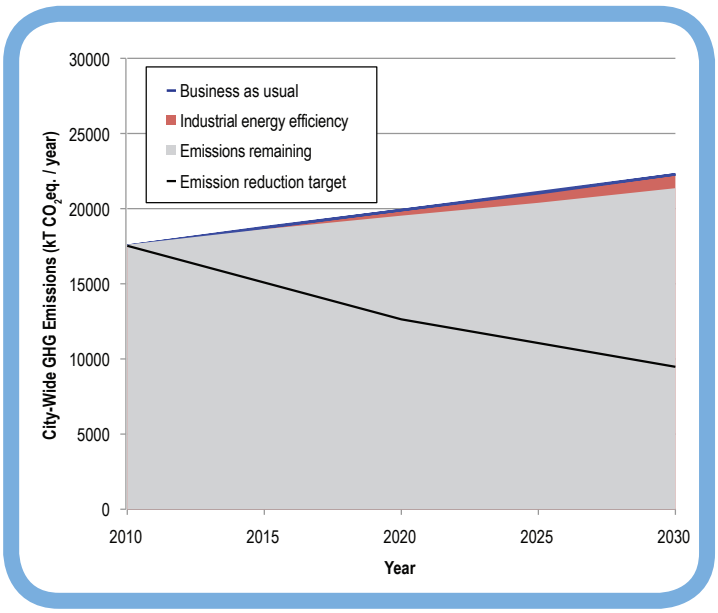

Figure 14: Estimated GHG emissions reduction from improving industrial energy efficiency by 15%

25 More than half of the emissions reduction opportunity for buildings is associated with electrical equipment and lighting.

Customer feedback systems

Demonstrations of feedback systems for residential electricity customers were found to have reduced electricity consumption by a notable amount. For modelling purposes, it was assumed that customer feedback systems, such as providing information on utility bills or having an in-home or online display of electricity consumption, could reduce residential electricity consumption by up to 10%. This translates into as much as 5% emissions reduction in the residential sector and over 1% reduction in city-wide emissions compared with a business-as-usual estimate in 2020. See Appendix A.1 for more information on customer feedback systems.

In-city cogeneration

Constructing cogeneration or combined heat and power (CHP) plants in Calgary is another way to displace higher GHG electricity from the grid, and facilitate the use of high-efficiency district heating or energy sharing. This opportunity was investigated separately from electricity produced on the provincial grid outside of the city as it relates to stakeholders within Calgary in a different way.

If 330 MW of CHP with district energy (equivalent to two of ENMAX's proposed Bonnybrook (CHP) Energy Centres) were brought online in Calgary by 2030, city-wide GHG emissions in Calgary would decrease by nearly 2% compared with business-as-usual in 2020. See Appendix A.5 for more information on in-city cogeneration.

Solar heating

The Energy Mapping Study completed for The City of Calgary estimated quite a high potential for heating both domestic hot water and buildings themselves using solar collectors on the roofs of buildings. The study estimated the total potential of solar thermal collectors in Calgary given the roof space and types of buildings. The total amount of energy generated assumes that both residential and non-residential buildings use solar thermal collectors. The maximum potential for solar thermal collectors in Calgary was assumed to be achieved by 2036. Assuming fairly consistent growth towards 2036 starting in 2012, the application of solar thermal collectors is estimated to reduce city-wide emissions by 4% in 2020 compared with business-as-usual.

The opportunity for using the heat from the sun to pre-heat air before it is drawn into a commercial or industrial building is estimated to be about one-fifth of the solar hot water potential. If fully implemented in the same manner as the solar thermal collectors scenario above, the city-wide emissions reduction is estimated to be less than 1% in 2020 compared with business-as-usual.

Buildings can also gain heat passively through the sun that shines on the building exterior and through windows. Passive solar heating can be increased by facing windows southward, appropriate shading and placement of heat absorbing materials inside the building. A 0.3% reduction in GHG emissions compared with business-as-usual in 2020 was estimated if all new residential buildings after 2014 are built to use passive solar heating to reduce their natural gas demand by 20%. See Appendix A.8 for more information on solar heating.

Photovoltaics

The Calgary Energy Mapping Study estimates approximately 1500 GWh/year of solar power could be generated in Calgary by 2036. This would reduce city-wide GHG emissions in Calgary by approximately 2% in 2020 compared with business-as-usual emissions. See Appendix A.8 for more information on photovoltaics.

Land use and transportation planning

Plan It Calgary — the recent City process to develop a new Municipal Development Plan (MDP) and Calgary Transportation Plan (CTP) — utilized three hypothetical scenarios for visualizing potential development in Calgary over the next 50 years or more. These scenarios were never proposed for the MDP and CTP themselves and significant concerns about them were expressed by industry. However, since modelling data were available for these scenarios, they were used in this study to estimate future GHG emission reductions using a wide range of approaches to land use and transportation planning. Modelling data for the newly approved MDP and CTP are not yet available and so GHG emissions reductions expected from these plans were not modelled.

A 'Dispersed' scenario was used during Plan It to estimate the potential growth of the city if current development practices (prior to the adoption of the new MDP and CTP) were continued. This scenario is considered to be part of the business-as-usual growth in GHG emissions presented in Figure 9. Of course, with the adoption of a new MDP and CTP, this Dispersed Scenario is not being pursued, but it is still used as a reference point in this GHG study to demonstrate the impact on emissions if the goals of the new MDP and CTP are not achieved.[26]

The 'Compact' scenario within the Plan It process involved limiting new development to the existing built-up area of the city. This scenario was estimated to reduce overall vehicle travel by approximately 25% compared with the business-as-usual scenario by 2050, and also included a shift away from single-family houses. Figure 15 demonstrates the impact of this scenario on city-wide emissions. The city-wide emissions reductions are about 6% in 2050 and 1% in 2020 compared with business-as-usual, as shown in Figure 15.

The scenario in between the Compact scenario and the Dispersed scenario is the 'Hybrid' scenario. Modelling the Hybrid scenario shows a 16% reduction in vehicle travel by 2050 compared with business-as-usual, or a 3% and 0.6% reduction in city-wide GHG emissions by 2050 and 2020 respectively. This scenario most closely aligns with the approved Municipal Development Plan and Calgary Transportation Plan documents and provides some insight into what GHG emissions reductions might be if the plans are fully realized.

It was not possible to assess other scenarios, such as the impact from the development of the west leg of the city's light rail transit, given the resources available.

The land use and transportation planning characteristics included in the Hybrid and Compact scenarios, as well as the approved MDP, include communities that are compact, walkable, transit-oriented and mixed use. See Appendices A.1 and A.10 for more information on land use and transportation planning.

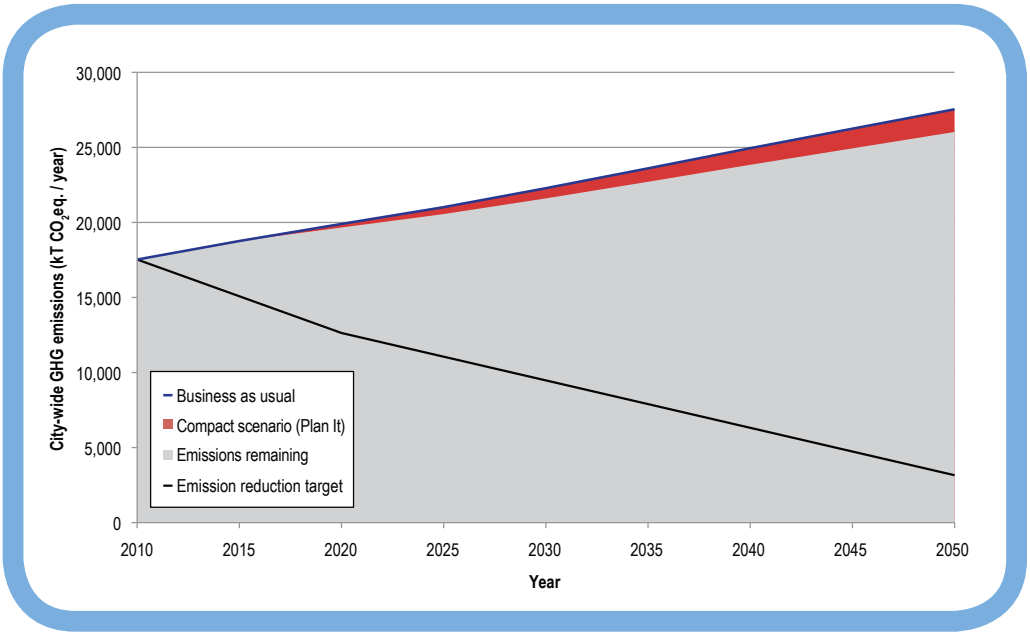

Figure 15: Estimated GHG emissions reduction potential for the Plan-It Compact growth scenario

26 As an example, a 10-year review of The City's 1995 Go Plan demonstrated that not all of the plan's objectives had been achieved.

Pay-as-you-drive insurance

Pay-as-you-drive insurance, where insurance premiums are based on distance travelled as opposed to a fixed amount, is estimated to reduce vehicle travel by 8% to 10%. At this level, the city-wide emissions reduction is approximately 2%. See Appendix A.10 for more information on pay-as-you-drive insurance.

Road and fuel pricing

Vehicle travel can also be reduced through other pricing policies such as road pricing (e.g., toll roads) and fuel pricing (e.g., fuel surcharges). The impact of road and fuel pricing on reducing vehicle travel is estimated to be between 1% and 15%. This translates to a reduction in city-wide GHG emissions between 0.2% and 3%. See Appendix A.10 for more information on road and fuel pricing.

Fuel economy standards

Currently, the federal government has proposed fuel economy standards for light-duty vehicles to 2016 that would improve the average efficiency of vehicles sold in Canada. If these standards are continually increased at the same rate proposed between 2010 and 2016, city-wide GHG emissions are estimated to decrease by 1% compared with business-as-usual in 2020.

If similar improvements occur with heavy-duty vehicles, the city-wide emissions reductions would be 0.9% in 2020. See Appendix A.11 for more information on fuel economy standards.

Feebates

A feebate program provides rebates for energy-efficient products while also attaching a fee to less-efficient ones. Introducing a feebate for light-duty vehicles on top of the proposed federal fuel economy standard is expected to reduce city-wide GHG emissions by an additional 0.2% compared to business-as-usual in 2020. See Appendix A.11 for more information on feebates.

Biofuels

The current provincial renewable fuel standard (RFS) requires 5% ethanol in all gasoline in the province. This is estimated to reduce city-wide GHG emissions by up to 0.4% compared with business-as-usual in 2020. If the RFS were expanded to 5% biodiesel and 10% ethanol, a city-wide emissions reduction of up to 1% is estimated. This emissions reduction could be even higher if biofuels with lower life cycle GHG emissions are used, such as biodiesel from waste sources and ethanol from straw or other cellulosic material. See Appendix A.11 for more information on biofuels.

Electric vehicles

Potential growth in electric vehicle use is uncertain at this point. If electric vehicles can account for 1% to 5% of total light-duty vehicle travel in Calgary by 2020, the city-wide emissions reduction is estimated to be between 0.1% and 0.4% respectively compared with business-as-usual. See Appendix A.11 for more information on electric vehicles.

Natural gas vehicles

Natural gas vehicles currently cost more than gasoline vehicles, but have lower fuel costs. They are therefore more economically attractive for use as commercial vehicles, which are generally driven further than personal vehicles. Assuming 10% of commercial light-duty and medium-duty commercial vehicles in Calgary are natural gas by 2020, city-wide emissions would be reduced by 0.2%. See Appendix A.11 for more information on natural gas vehicles.

Rail yards

Due to the fact that locomotives make up just a small part of the GHG emissions in Calgary, the estimated city-wide emissions reduction was insignificant; however, individual GHG emissions saving opportunities are still significant. Research suggests that GHG emissions from these units could be reduced by up to 70% with payback in less than two years through hybrid electric drivetrains, automated start/stop controls, auxiliary power units, diesel heaters and electrical plug-ins. The reduction in air pollution associated for each upgraded locomotive was also found to be significant.See Appendix A.12 for more information on rail yards.

Fleet training and freight technologies

Demonstration projects for fleet programs have shown a 10% to 20% reduction in fuel consumption through training and monitoring programs aimed at changing driver behavior (e.g., driving style, idling, vehicle maintenance). If a 10% savings could be achieved for all freight road transportation that originates from Calgary, city-wide emissions would be reduced by approximately 0.8% in 2020.

Driver training could be supplemented through technologies such as on-board computers to provide feedback on driving style, plug-ins at loading docks and plug-in refrigeration units, auxiliary power units, and logistics management to reduce unnecessary trips.

See Appendix A.12 for more information on fleet training and freight technologies.

Landfill gas

Opportunities to reduce GHG emissions from landfills was investigated because landfills are included in the community GHG inventory. The City's policy to increase waste diversion from the current level of 25% to 80% by 2020 was modelled in this case. The growth in landfill gas emissions was, therefore, assumed to be reduced by 73% in 2020 compared with business-as-usual. This translates into a reduction in city-wide emissions of 0.03% in 2020 and 0.1% in 2030. GHG emissions from the waste already in place also changes over time (an initial increase before a decrease in methane generation), but these changes are considered small compared with the reductions from a 73% increase in waste diversion.

There is also an opportunity to capture up to 70% of the methane being emitted from landfills in Calgary. Currently, only approximately 14% of emissions are captured. If The City increases this amount to 70%, city-wide GHG emissions would be reduced by approximately 0.6%.

See Appendix A.13 for more information on waste reduction.

Results summary

Most of the results presented above are summarized in Table 1. Some of the smaller emissions reduction opportunities have not been presented to simplify the table. An additional column has also been presented for a scenario where the provincial grid has a lower carbon intensity as this affects the emissions reduction potential of many of the options, while also providing greater overall GHG emissions reductions.

When the results are plotted, it is clear that most of the options listed are required to meet the emissions reduction targets. Figures 16 and 17 show the maximum potential for each of the options in both provincial grid scenarios.

Of course, if the maximum emissions reduction potential is not achieved in each of the categories, the city-wide emissions reductions will not be as great.

Table 1: Summary of emissions reduction options

Option	Reduction in 2020 compared to business-as-usual		Notes
	Assumes current grid	Assumes grid becomes average AESO scenario	
Changes to provincial grid	0%	15%	23% reduction if coal w/o CCS phased out.
Ground source heat pumps	-0.3%	0.3%	Assumes 10% of buildings use GSHP by 2020.
Efficient equipment and lighting	1.7% to 4.0%	1.2% to 2.8%	Low estimate reached through incentives; high estimate reached through regulations.
Efficient building heating and cooling	0.8% to 3.1%		Assumes new building code. High estimate through mandatory renovations at time of sale.
Efficient industrial processes	0.2% to 2.3%	0.1% to 1.8%	High estimate maximizes all economic opportunities.
Consumer feedback systems	0% to 1.4%	0% to 0.9%	0% to 10% reduction in residential electricity consumption.
Combined heat and power (in-city)	1.9%	0.8%	330 MW of installed capacity.
Solar hot water heating	3.8%		Maximum potential for Calgary.
Solar air heating	0.8%		Maximum potential for Calgary.
Passive solar heating	0.3%		Assumes 20% heating savings in new residential buildings starting in 2014.
Photovoltaics	2.4%	1.5%	Maximum potential for Calgary.
Land use and transportation planning	0.6% to 1.2%		Ranges from Plan It Hybrid scenario to Compact scenario; does not include info from the new MDP.
Pay-as-you-drive insurance	1.9%		Assumes 10% reduction in passenger vehicle travel.
Road and fuel pricing	0.2% to 2.8%		Assumes 1% to 15% reduction in passenger vehicle travel.
Fuel economy standards	1.3%		Proposed federal regulations plus continual improvement to 2020.
Fuel economy standards	0.9%		Similar improvements for heavy duty vehicles.
Vehicle feebates	0.2%		
Biofuels	0.4% to 1.0%		Range from current RFS to expanded RFS.
Electric vehicles	0.1% to 0.4%	0.1% to 0.5%	Assumes 1% to 5% EVs by 2020.
Natural gas vehicles	0.2%		Assumes 10% of commercial light-duty and medium-duty vehicles by 2020.
Fleet operational efficiency	0.8%		Assumes 10% fuel savings.
Driver outreach (public)	0.2% to 0.4%		Assumes 1% to 2% reduction in fuel use.
Landfill gas capture	0.6%		Assumes 70% of landfill gas is captured.

Emissions reduction potential

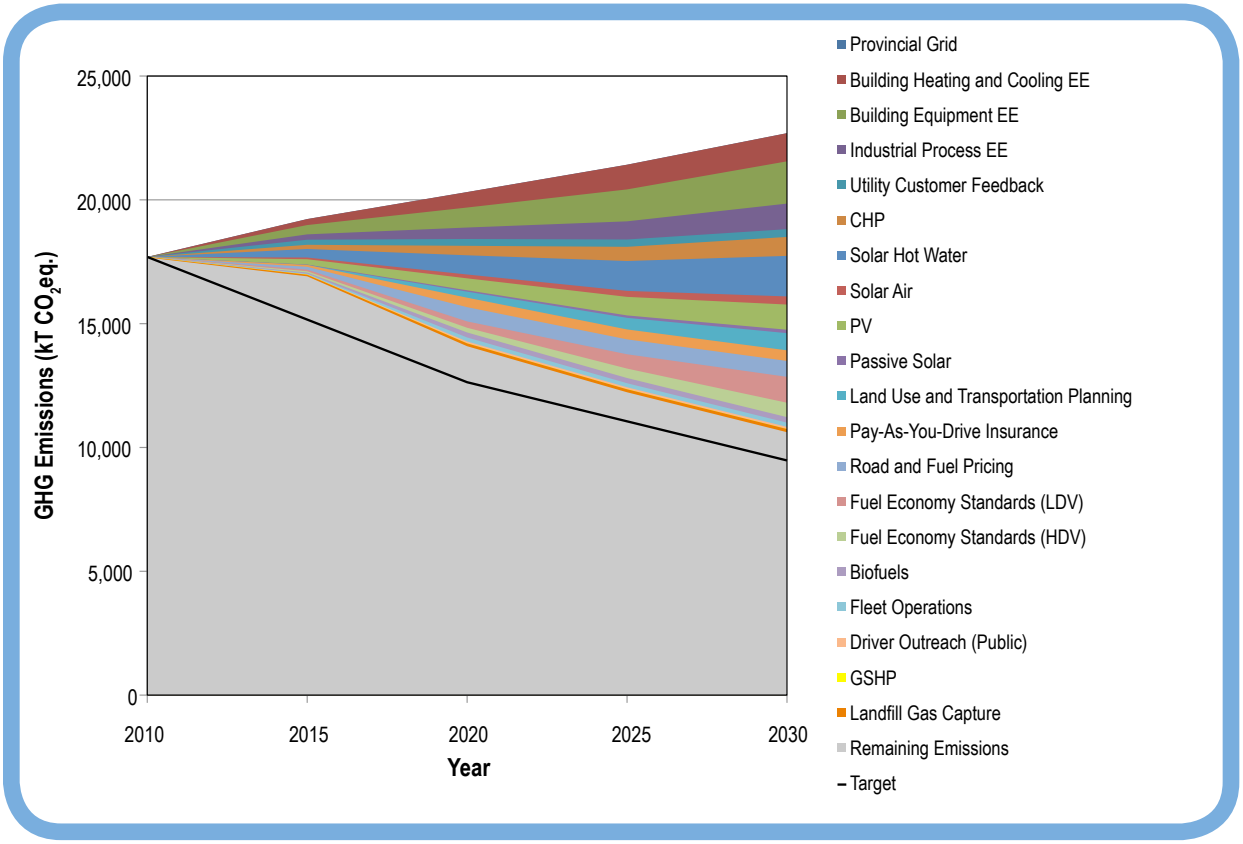

Figure 16: Maximum emissions reduction potential for all options (no change to provincial grid)

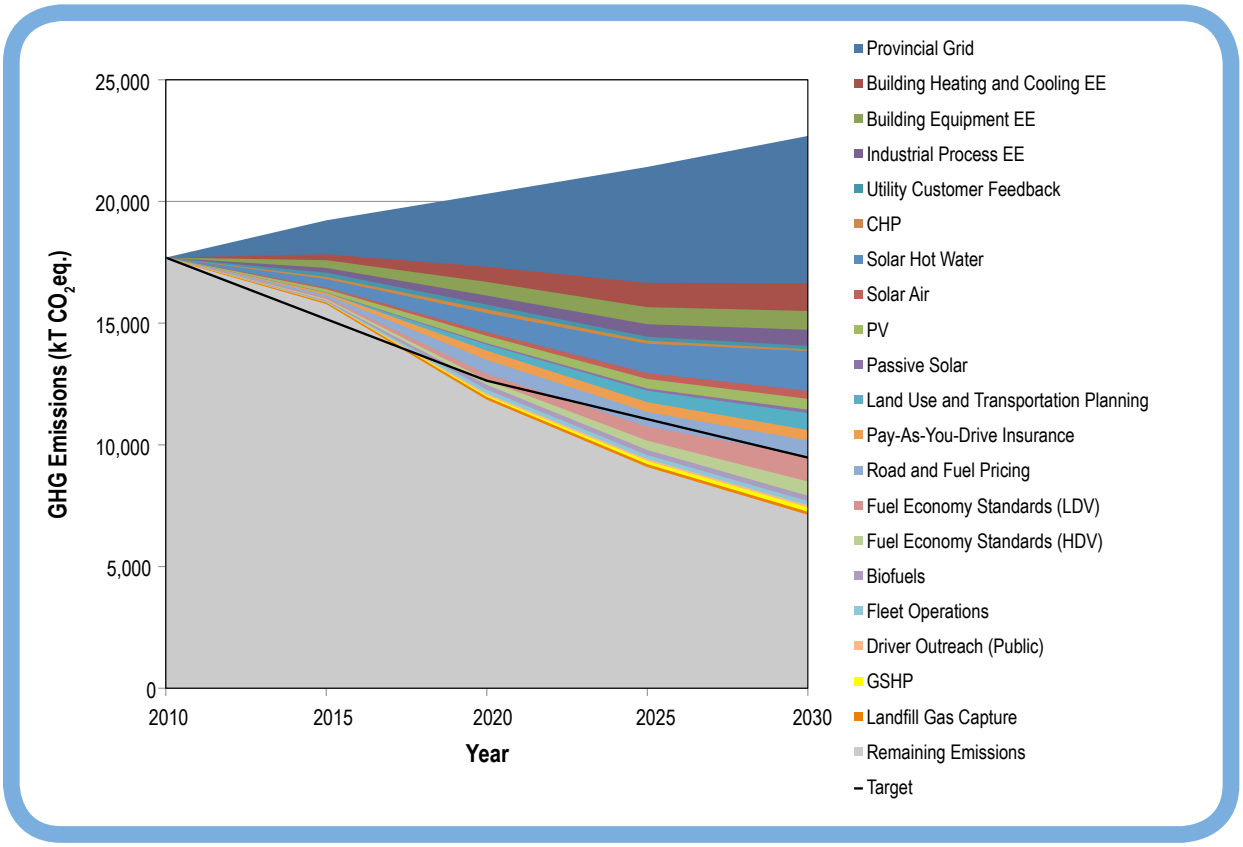

Figure 17: Maximum emissions reduction potential for all options (assumes average of AESO future scenarios for grid)

Discussion

The opportunities for GHG emissions reductions in Calgary are discussed in this section. As part of the discussion, the group or groups that have the greatest ability to influence each of these opportunities are identified. While these groups provide an indication of the opportunities with the greatest potential, it is also necessary to integrate thinking and actions across the groups to maximize potential and avoid working at cross-purposes.

The timing of the potential actions associated with each opportunity area have not been included in the discussion at this point, but will be further discussed as part of the overall planning process following the completion of this research report.

The section is organized starting with the opportunities with the largest GHG emissions reduction potential.

Provincial grid

It is clear that the future make-up of the provincial electricity grid will have significant influence on Calgary's ability to meet its emissions reduction targets. Currently, electricity accounts for almost half of the GHG emissions in the city.

There are also a number of different technologies that can be used to reduce GHG emissions from the provincial grid. Wind power and natural gas-fired power plants are already cost-competitive in the province, and have the ability to reduce GHG emissions at a relatively low cost per tonne. They also have a much lower impact on provincial air quality than the current grid make-up, which is dominated by coal-fired power plants. Additional capacity in these power sources would need to be added to the grid to achieve these emissions reductions.

The provincial electricity grid is primarily the responsibility of the provincial government. Currently, the market structure allows energy generators to connect to the grid without consideration of the technology used.

There are, however, emission regulations in place provincially that require incrementally increasing emissions reductions from large emitters, including large fossil-fuel-fired power plants. This regulation has had some impact on the costs of power plants, but has not stopped the development of new coal-fired power in the province.

The federal government has also proposed regulations that require coal power plants to reduce their emissions significantly. These regulations are expected to have the most impact after 2025.

Given this market structure, there is some motivation for moving towards a lower-carbon electricity grid, but no guarantees that it will happen. Both provincial and federal governments have the ability to greatly accelerate this transition through the use of public policy. In fact, this is the only approach that has been demonstrated in other jurisdictions to have significantly lowered the GHG intensity of electricity grids.

Energy efficiency

There are a number of opportunities to reduce GHG emissions through improving the efficiency of energy-consuming products including buildings, vehicles, and electrical and industrial equipment. Together, the potential of energy efficiency to reduce GHG emissions is estimated to be between 2.3% and 10% in 2020, or almost one-quarter of the required reduction.

Energy efficiency offers a unique opportunity as it saves more money than it costs. All of the energy efficiency measures modelled in these scenarios are considered to be economically viable at this time (i.e., they have a positive return on investment), but are not currently being implemented for other reasons. These barriers[27] include product and service availability, lack of energy literacy and awareness, capital financing, transaction costs, perceived risks and rewards, split or disconnected incentives, and institutional or regulatory barriers. Programs and policies to address these barriers would likely need to be initiated at national, provincial or local levels depending on the product or service. Emissions reductions can be achieved through a variety of approaches including regulations and incentives, but also through innovative financing programs and providing energy-related information.

It should be noted that the high estimate of energy efficiency potential required the following approaches to be taken[28]:

- subsidies targeted to energy efficiency measures
- marginal cost pricing for electricity
- a carbon liability
- an aggressive schedule of legislatively-backed advanced minimum energy performance targets for both equipment and buildings
- an aggressive schedule of subsidies to accelerate the market penetration of on-site renewable energy technologies
- changes in the shares of projected housing types (low-rise versus mid- to high-rise) to mimic the potential effects of aggressive urban land use policy instruments to affect intensities, densities, shares of building types and advance community energy systems

27 Energy Efficiency Working Group, *Energy Sustainability Sector Table, Energy Efficiency in Canada: Status and Potential*, 2008, http://www.sst.gc.ca/ED717E3F-17AF-48CB-AE8D-7AC3A6FFC178/Foundation_Paper.pdf.

28 Marbek Resource Consultants and MK Jaccard and Associates, "Appendix C: Achievable Scenarios," in *Demand Side Management Potential in Canada: Energy Efficiency Study*, http://www.electricity.ca/media/pdfs/policy_statements/EE-DSM_Appendix%20c%20achievable%20potential%20scenarios.pdf.

Solar heat and power

The Canadian Urban Institute has estimated that there is a significant potential for solar heating and power in Calgary. If this potential were to be fully maximized, the emissions reduction would be 6.4% to 7.2% compared with business-as-usual in 2020 with over half coming from solar thermal collectors on the roofs of residential and non-residential buildings.

The economics of solar thermal collectors and using solar energy to pre-heat air going into a commercial building is highly dependent on the price of natural gas. At $15 per gigajoule of heat from a solar collector, solar hot water heating is currently relatively expensive, but it could become more cost-competitive as natural gas prices change or the cost of collectors come down. For pre-heating air entering a building, there is a wide range of cost estimates, so the economics are expected to largely depend on the application.

Increasing the solar heating of a building using south-facing windows, on the other hand, can be done at essentially no cost as basic designs impact only building orientation, the placement of windows and thermal mass inside the building, and shading.

Electricity generation from solar power is currently the most expensive way to displace conventional energy with solar energy, although costs are expected to continue to drop.

The advancement of solar heating in Calgary depends on the decisions of building owners , the economics of solar heating and systems, market forces, land use and building design, and City approvals. Full deployment of active solar heating and PV systems is likely only achievable through aggressive government incentives and possibly regulations to achieve economies of scale in the region.

Transportation mode shifting

Personal vehicles are responsible for about 19% of GHG emissions in Calgary. A number of approaches were identified for reducing the amount of personal vehicle travel including land use and transportation planning, pay-as-you-drive insurance, and road or fuel pricing. Each approach was found to have a varying degree of impact.

Creating more compact communities through land use and transportation planning reduces transportation emissions in the city over the long term as people need to drive less and have greater access to alternative transportation. In addition, this type of development was found to be less expensive for the municipal government as well as citizens due to the decreased amount of infrastructure required to service a smaller area. Implementation of more compact communities will require a market shift from current practices. The possibility of people shifting to surrounding municipalities should also be considered. The municipal government undertakes land use and transportation planning in the city, and approves development applications proposed by landowners.

For pay-as-you-drive programs, one estimate concluded that two-thirds of consumers would pay less than they are currently paying for automotive insurance, while the other third would pay more. Insurance is regulated provincially, while insurance products are provided by insurance companies.

Road pricing is a mechanism that can be put in place by both the municipal and provincial governments, depending on who owns and operates the road. Fuel pricing policies can be set at both the provincial and federal level. To reduce GHG emissions, these policies would be used to increase the cost of driving, but the revenues could be used to reduce costs in other areas. For example, they could be used to subsidize transit, thus providing a net financial benefit for some but a net cost for others compared to current pricing policies.

Combined heat and power (in-city)

The construction of one or two large-scale combined heat and power plants within the city (such as the proposed 165 MW Bonnybrook Energy Centre) could have a significant impact on Calgary's GHG emissions. Two of these centres would reduce emissions in Calgary by an estimated 0.8% to 1.9%.

The costs of these systems are considered to be competitive with other forms of new electricity generation, particularly if there are financial incentives to develop low-carbon generation, but finding a suitable customer for the heat remains one of the biggest barriers to broader implementation. The development of CHP in Calgary is dependent on municipal and provincial decision making, as well as private sector activity.

Behaviour changes

While it was generally difficult to identify large-scale behavioural changes that have occurred to reduce emissions, besides the transportation mode shifting described above, there are some programs that have demonstrated notable behaviour change for a smaller group. Driver training and freight technology programs, as well as feedback systems for residential utility customers, were two such programs that could each reduce city-wide emissions by up to 2.5% if they could be successfully implemented on a city-wide scale.

These programs would have a net cost savings if successful. Implementation of the programs would likely require government support throughout the life of the program, while the fleet programs would also require significant involvement with fleet operators.

Other fuel switching

Other fuel switching includes using biofuels, natural gas and electricity for vehicles, as well as using electricity to heat buildings through the use of heat pumps. (Wind power, natural gas for electricity, nuclear power and solar energy are already described in other categories above.) Each of these was found to have the potential for notable impacts on GHG emissions in Calgary under certain conditions.

The federal and provincial governments have already regulated biofuels content in gasoline, but the emissions reductions are estimated to have a relatively high cost per tonne of GHG reduction. There is also some uncertainty regarding the emissions reductions given the impact that biofuel production may have globally on the conversion of land.

Light-duty natural gas vehicles have been in use for decades, but have never achieved significant market penetration. With higher capital costs but lower fuel costs, natural gas vehicles have a higher return on investment in high-use applications, such as commercial fleets.

Emissions reductions from both electric vehicles and heat pumps depend on the make-up of the provincial electricity grid. Both of these technologies are still emerging in Alberta and could benefit from government incentives. Requiring 220 V plugs in garages is something that has also been done at a municipal level.

Landfill gas capture

The City currently captures and burns approximately 14% of the methane created at landfills in Calgary. The City could invest in additional infrastructure to increase this to as much as 70%. The cost-effectiveness of this measure would depend on whether the gas is used to generate heat and electricity, or whether it is simply flared. Cost-effectiveness also depends on whether The City's landfills are subject to provincial or federal regulations limiting methane emissions.

Carbon offsets and credits

In order to achieve the reduction targets set beyond 2020, evaluating new opportunities might be necessary. Carbon offset credits may be one option. Despite technological innovations, achieving reductions will cost more per tonne of CO_2 as the cheapest reduction options are implemented. One way of achieving the community target in a cost-effective manner might be for citizens and businesses to offset emissions through purchasing credits. Another option may be to strategically sell some achieved emission reductions as carbon offsets to generate revenue.

Although it's not possible to sell offset credits while also counting them against an inventory, using the revenue to fund specific projects can allow financial resources to be used to build emission reduction projects when costs are low. Thus, the ability to buy offset credits provides flexibility in the timing of emission reduction projects. This could result in lower overall costs of achieving targets.

The use of offset credits in community GHG reduction needs further research as it poses real risks and opportunities. Today, more than 9.4 million tonnes of CO_2 has been verified through offset projects in the Province of Alberta.[29] However, emission reductions in offset projects need to pass strict additionality and other tests in order to be legitimate. There can also be significant transaction costs.

The role of The City of Calgary or other organization could be as a convener, collaborating with the private sector to identify projects, access carbon market opportunities and determine the net effect of the projects on the community emission profile.

The capacity for cities to have knowledge in this area is being supported through the Federation of Canadian Municipalities (FCM), who assist municipalities with carbon offset strategies for their own operations. To accommodate the resources required to develop carbon offset projects or access markets for real credits FCM has created the Green Municipal Corporation (GMC) to assist municipalities in the process of validation, verification and registration, which will reduce transaction costs. The GMC also limits the financial risks for both project developers and buying municipalities by aggregating all the credits of offsetting projects and acting as a buffer for price fluctuations and project delays.[30]

To meet the challenge of global climate change and achieve reduction targets, traditional and innovative strategies will be needed and the use of offsets poses interesting possibilities.

29 Climate Change Central website

30 The use of offsets for city emissions will be fully explored in The City of Calgary's corporate climate change plan process in 2011.

Financial cost summary

Through the research, it was identified that some options for reducing emissions are more cost-effective than others. Despite the fact that all of the options identified are likely needed to reach The City's emissions reduction targets, there is value in identifying the current cost-effectiveness of the various options. This provides some indication of what approaches are most appropriate at different times. For example, an option that is currently cost-competitive with conventional energy systems may benefit from a different approach to implementation than is used for options that currently have a high cost premium.

A broader triple-bottom-line analysis will be completed for items included in the final community GHG reduction plan.

Table 2 summarizes the relative costs of the various options for reducing GHG emissions.

Table 2: Cost summary of emissions reduction options

Cost competitiveness	Option	Comments
Reduces overall costs	Energy efficiency	A significant number of energy efficiency opportunities have a positive return on investment. This includes all of the efficiency opportunities presented in the results section.
	Transit, walking and cycling	Overall costs, as well as reduced infrastructure requirements for compact development were found to be less than using personal vehicles.
	Idle reduction technologies	Very short payback periods demonstrated for idle reduction technologies.
	Passive solar energy	Some no cost options available for passive solar heating and lighting.
Cost competitive	Large scale wind power and natural gas cogeneration	There are power projects currently being developed in the province given the current economic framework. These options could be accelerated with additional incentives.
	Ground source heat pumps	GSHPs have higher capital costs, but lower operating costs than conventional heating appliances.
Range of estimates	Solar air and water heating	Sources differed on the cost of solar air and water heating. This is expected to be due to the range of economics possible depending on the application.
	Behaviour change	The economics of programs to change behaviour depend on the level of behaviour change created.
	Natural gas vehicles	The economics of natural gas vehicles depend on relative fuel prices, the amount of use and the relative cost of the vehicles.
	Landfill gas capture	The economics of landfill gas capture depends on whether electricity is generated as well as the extent of GHG emission regulations.
Currently more expensive	Coal with CCS	Research currently shows higher costs than conventional energy sources in current market structure (ie. given the current price on carbon).
	Nuclear power	
	Photovoltaics	The costs of solar PV in particular are expected to continue to decrease at a relatively high rate.
	Biofuels	

Required action

In order to meet The City of Calgary's GHG emissions reduction target, the research indicates that regulations and price signals are required in all sectors. Education and incentives were also identified as potentially useful tools to enable the adoption of regulations and price signals, but can not be an end in themselves if the community targets are to be met. Below is a summary of the actions that are suggested to be required to meet the community GHG targets.

These actions represent the end-goals required to be reached, whereas the Community GHG Reduction Plan itself will identify all of the steps required to reach these end-goals such as engagement of stakeholders, increasing the market penetration of supportive products and services (including information services), and building political support for price signals and regulations.

1. Provincial, federal, or municipal*[31] government

a. Incent or require low carbon power generation in the province.

b. Incent and then regulate improved efficiencies of energy using products including:

   i. building envelopes*

   ii. heating, ventilation and air conditioning (HVAC) systems*

   iii. lighting, appliances and electronics

   iv. water heating and fixtures*

   v. industrial equipment

   vi. light-duty and heavy-duty vehicles

   vii. freight efficiency technologies (including road and rail)

c. Develop programs and innovative financing mechanisms for replacing existing products.*

d. Incent and then require energy labelling of buildings* and other energy-using products not currently labeled.

e. Incent and then require solar heating and PV on buildings, as well as passive solar heating design.*

f. Institute pay-as-you-drive insurance, road pricing* and / or fuel pricing.

g. Pilot and expand fleet efficiency and consumer feedback programs.*

h. Support and possibly require the expanded use of biofuels, natural gas vehicles, electric vehicles* and ground source heat pumps* (dependent on their forecasted ability to reduce emissions).

2. Municipal or provincial government

a. Align land use and transportation planning and funding with the Municipal Development Plan and Calgary Transportation Plan.[32]

b. Shift away from the provision of a minimum number or free parking spaces for new developments with access to transportation alternatives.

c. Support the development of large-scale CHP within the city.

d. Support land use planning that maximizes passive solar heating for small buildings through appropriate lot orientation and consideration of features that create shading.

3. Private sector and individuals (with respect to electricity and heat generation, energy efficiency and conservation, transportation mode shifting, land development, and fuel switching)

a. Develop, offer and purchase new products and services (including information services).

b. Replace existing products.

c. Label energy using products.

d. Change behaviour that affects energy consumption.

e. Support changes to the design of products, buildings, neighbourhoods and energy infrastructure.

31 The municipal government does not have the ability to directly influence all of the areas included under #1 in the list. Areas of greater opportunity for the municipal government are identified with an asterisk (*).

32 These plans include creating a more compact city, reducing the outward growth of the city, intensifying vacant and underused lands, supporting density with transit, walkable destinations, and cycling infrastructure. More compact development is also needed to support other opportunities such as district energy and reducing building energy demand.

Conclusions

The work completed to identify options for reducing GHG emissions in Calgary has identified a number of key emissions reduction opportunities with respect to:

- the provincial electricity grid;
- energy efficiency;
- solar heat and power;
- vehicle mode shifting;
- in-city combined heat and power generation;
- a focused number of behavioural changes;
- possibly some switching to fuels such as biofuels, natural gas and electricity for vehicles, and geothermal heating and cooling; and
- integration between these areas.

An estimate of the potential to use these measures to meet The City's GHG emission target shows that all of the measures will be required. Of course, it is possible that some of the measures will reduce emissions even more than estimated, or that new opportunities will arise, but at this time, it appears as though a high level of effort is required in most of the areas identified.

The actions that are required to meet the estimated emissions reduction vary depending on the sub-sector. The research was clear, however, that if the maximum potential emissions reduction is to be made, government regulations and price signals are required. Education and incentives can be used to prepare markets for the transition and to successfully implement these mechanisms.

Government regulation is not as effective in encouraging the replacement of energy-using products with long lifespans, such as buildings. In this case, innovative financing mechanisms and programming targeted at building owners could be used. Energy price signals and providing energy-related information for buildings can also make significant contributions. These approaches can also be used for other products to accelerate turnover and also make it easier for new regulations to be adopted.