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City of Saskatoon CO_2 Reduction Initiatives Report

June 2018

Executive Summary

In August 2017, the Standing Policy Committee on Finance ("SPC on Finance") approved, as part of the annual Internal Audit Plan, a project to review risks associated with Greenhouse Gas emission targets both on a corporate and community level. The City of Saskatoon's (the City's) Risk Register contains two risks relevant to the strategic goal of Environmental Leadership and, more specifically, to climate change:

1. EL-2: The City's community education and awareness initiatives regarding carbon footprint may not be affecting change in people's attitudes and behaviors.

2. EL-3: The City may fail to identify and pursue corporate CO2 reduction initiatives.

In November 2015, the City committed to the Global Covenant of Mayors, which requires the City to address both Climate Change Mitigation and Climate Change Adaptation. On May 11, 2017, the Saskatoon Environmental Advisory Committee (SEAC) reviewed and approved updated greenhouse gas emission reduction targets. On June 12, 2017, City Council considered and adopted the following:

1. The greenhouse gas emissions reduction target for the City of Saskatoon (Corporate) shall be adjusted to utilize 2014 as the base year, specifically, a reduction of 40% below 2014 levels by 2023, and a reduction of 80% below 2014 levels by 2050; and

2. The recommended reduction targets for the community proposed by the Saskatoon Environmental Advisory Committee be adopted.

This report includes analysis on the reasonability of the targets; the achievability of the targets based on current resourcing; identified funding and supported mitigation programs, policies, and plans; and commentary on resources required to further the City's mitigation efforts. For clarity, this report does not offer an "audit opinion" on actual emissions of the City following specific assurance standards, but rather our approach leveraged each sub-project to build an overall assessment of the strategy and resources needed and their connection back to the identified risks from the City's risk register. As indicated in the following quotation, municipalities have unique opportunities to engage in mitigation activities, such as infrastructure investments, land use plans, various technologies, and the built environment, which directly link to mitigation efforts:

> *"Thousands of cities are undertaking climate action plans, but their aggregate impact on urban emissions is uncertain. Local governments and institutions possess unique opportunities to engage in urban mitigation activities and local mitigation efforts have expanded rapidly. However, there has been little systematic assessment regarding the overall extent to which cities are implementing mitigation policies and emission reduction targets are being achieved, or emissions reduced."*[1]

Through the course of this internal audit project, PwC observed that the staff at the City have collaborative working relationships, and many individuals have sought creative solutions to resourcing and funding. We observed a general agreement between different team leaders to share resources and develop creative solutions to funding that addresses resource shortfalls. Please refer to Tables 10 (page 24) and 12 (page 26) for examples of current mitigation programs and measures that the City has put in place. We thank the participants interviewed during this project for their time and the Environmental and Corporate Initiatives Division for facilitating and providing resources and information.

[1] Seto K.C., S. Dhakal, A. Bigio, H. Blanco, G.C. Delgado, D. Dewar, L. Huang, A. Inaba, A. Kansal, S. Lwasa, J.E. McMahon, D.B. Müller, J. Murakami, H. Nagendra, and A. Ramaswami, 2014: Human Settlements, Infrastructure and Spatial Planning. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Overall themes

We have listed below the overall project observations, which are the combined observations from the three sub-projects. The eight overall project observations can be distilled into two key themes:

1. Strategy: The process of setting climate goals and the risks identified in the City's Risk Register are disconnected. The risks identified are not aligned with the commitment of reduction targets and do not support a plan of action or policy designed to achieve the overall aim of deep decarbonization.
2. System approach: The City lacks a management system approach of "plan, do, check, act" to setting greenhouse gas targets, identifying risks associated with these targets, and implementing actions required to achieve deep decarbonization.

Summarized project observations

Observation	*Sub-project*	*Details*
1	Sub-project 1 Sub-project 2 Sub-project 3	The City has set targets that align with the commitments of other peer cities; however, the achievement of these targets is doubtful given the composition of the Greenhouse Gas (GHG) inventory and the current programs in place. We suggest either changing the targets and/or increasing the emphasis on GHG mitigation measures.
2	Sub-project 2 Sub-project 3	The City requires some fundamental tools to support strategic decision making. As a minimum, a tailored Marginal Abatement Cost Curve (MAC curve) for the City and a more robust GHG data management system would be beneficial.
3	Sub-project 2	To achieve significant emission reductions, the City needs to focus on items such as street light replacements and building insulation for both the corporate and community inventories. Applying the strategy of "choosing the least GHG emitting technology when faced with two equal cost but competing technologies" will not produce significant emission reductions.
4	Sub-project 1 Sub-project 2 Sub-project 3	The City's current strategy for GHG emission reductions will not generate the emission reductions to achieve its targets. A realistic strategy with reasonable targets, focused on the areas of greatest emission reduction potential and employing appropriate levers, should be designed, reviewed and updated frequently. Given the profile of both the corporate and community emissions inventory, the greatest areas of emission reduction are in electricity (reduction of consumption, replacement of grid with renewable, electrification of vehicles, or changes in grid intensity) and increased efficiency in the use of natural gas. An important aspect of reduced consumption and electrification of vehicles will be the modification and densification of transport infrastructure.
5	Sub-project 2	If implemented, a carbon levy of $50/t CO2e in 2022 will cost the City $2 million in direct payments and $4.5 million in indirect payments, annually. GHG mitigation measures that focus on the reduction of fuel and electricity consumption will ameliorate some of these costs.
6	Sub-project 3	There is inconsistent messaging regarding the importance of GHG emission reductions within the City (e.g., encouragement of the purchase and sale of City electricity generation or the encouragement of low-density land development conflicts with GHG emission reductions). Developing a consistent framework for incentivizing and evaluating projects and actions will be necessary to reduce this conflict. Efforts to identify and pursue carbon reduction initiatives are not currently fully embedded in work plans and budgets.

Observation	*Sub-project*	*Details*
7	Sub-project 1 Sub-project 2 Sub-project 3	The current resourcing focusses on mitigating risk EL-2 (community education and awareness). The projects associated with community mitigation are voluntary actions and largely based in education and awareness efforts. Current resourcing does not address EL-3 (identify and pursue corporate emission reductions). If the City wishes to achieve their GHG emission reduction targets, both community and corporate, significantly more effort and resources are required.
8	Sub-project 1 Sub-project 2 Sub-project 3	There is minimal resourcing allocated to understanding the corporate inventory and implementing systematic continuous improvement measures to make meaningful reductions.

Getting to 2022

A broad body of research relating to deep decarbonization is available to municipalities, and significant efforts are being made to support municipalities on their journey to achieving 80% reduction by 2050 ("80 by 50"). Tools, collaboration, models and lessons are being shared; however, these must be adapted for each municipality's specific context. Many municipal climate action plans focus on interim goals, shorter time horizons, and incremental targets.

Municipal systems are extremely complex and must take into consideration energy supply, buildings, transportation, land use, water, food systems and waste. Achieving deep decarbonization may require multiple strategies over time. Changes must be sequenced and sustained over years through election cycles, new technologies and energy market volatility. The magnitude of these commitments cannot be under-estimated. The approach will evolve and will be analytical and political in nature.

> *"The difficulty, of course, is that there remain a great many uncertainties about what a successful path to 80 by 50 looks like and many factors that have to be managed are not in most cities' control. Committing to 80 by 50 is an act of leadership and a commitment to manage toward a goal that probably may not be achieved with a fixed plan, but instead will require iterative experimentation, measurement and course correction."*[2]

At present there is no single "how-to" formula for achieving deep decarbonization[3]. We recommend the City take an approach of sequential next steps to be achieved by 2022:

1. Develop MAC curves specific to the City's circumstances to enhance sound decision-making.
2. Develop City-specific emission reduction goals based on a more sophisticated understanding of the inventory and aligned with the environmental management system.
3. Develop an emission reduction strategy to achieve City-specific reduction goals, and a timeline that includes milestones and interim goals along the way.
4. Develop an environmental management system that includes high-level goals, objectives and targets, including those related to deep decarbonization.
5. Implement a data management system to ensure quality data control over the GHG inventory and to effectively measure performance.

[2] Carbon Neutral Cities Alliance, Framework for Long-Term Deep Carbon Reduction Planning. Developed for the Carbon Neutral Cities Alliance by the Innovation Network for Communities, page 44.

[3] Carbon Neutral Cities Alliance, Framework for Long-Term Deep Carbon Reduction Planning. Developed for the Carbon Neutral Cities Alliance by the Innovation Network for Communities.

Contents

1. Overview

1.1. Strategic risk

The City's Risk Based Management Program sets a positive and proactive risk management culture for the Administration through the adoption of a systematic, practical and ongoing process for understanding and managing risk. The City's Strategic Risk Register contains two risks relevant to the Strategic Goal of Environmental Leadership and, more specifically, to climate change.

> EL-2 states "The City's community education and awareness initiatives regarding carbon footprint may not be affecting change in people's attitudes and behaviors". Key impacts are that citizens are not aware of and do not take appropriate action against climatic change such as property damage, economic loss, and personal injury. Both preventative actions (i.e., reduction in greenhouse gas emissions to avoid a rise in average global temperatures) and predictive actions (i.e., flood protection), are considered.
>
> EL-3 states "The City may fail to identify and pursue corporate CO_2 reduction initiatives". Key impacts include increased carbon taxes or costs of energy, property damage, economic loss, personal injury due to the effects of climate change, and the loss of credibility as an environmental leader. A clear vision, near and long-term goals and strategies to achieve reductions in CO_2 emissions, clear linkages to project design and selection, and a supporting data and environmental management system are considered.

This Internal Audit project assesses whether the City's current environmental strategy is appropriate can be properly implemented, and whether there are adequate resources to implement the strategy. The implications of the federal government's proposal for a carbon levy have been included in this assessment.

1.2. Authority

The City is governed by The Cities Act. This legislation outlines the primary functions and services that municipalities are requested or enabled to provide, which provides the City with the ability to create regulation, policy and bylaws. Section (2) of the Cities Act recognizes local governments to:

(a) Provide the legal structure and framework within which cities must govern themselves and make decisions that they consider appropriate and in the best interest of their residents;
(b) Provide cities with the power, duties and functions necessary to fulfil their purposes;
(c) Provide cities with the flexibility to respond to the existing and future needs of their residents in creative and innovative ways; and
(d) Ensure that, in achieving these objectives, cities are accountable to the people who elect them and are responsible for encouraging and enabling public participation in the governance process.

Climate change is one of the biggest intangible issues facing the City. The Cities Act provides the City with the authority to develop plans, programs, and actions to mitigate risks associated with climate change.

1.3. Background

Municipal GHG targets and inventories are divided into Corporate and Community categories:

- Corporate GHG inventories represent the GHG emissions that occur from the provision of municipal services and tend to be emissions that a municipality has direct control over either through technologies, purchasing requirements, or operational patterns.
- Community GHG inventories represent the GHG emissions within municipal boundaries from the activities within the municipal boundaries. A municipality tends to have influence over these emissions through programs, availability of services, and campaigns.

Corporate inventories are typically less than 10% of the total municipal inventory. Corporate inventories are more accurate than Community inventories because the information and assumptions made in deriving the inventory are more precise. Targets set for Corporate inventories are generally more aggressive than Community inventories because of the direct control, rather than influence, that a municipality has in implementing mitigation measures.

Saskatoon memberships and commitments

As a member of the Federation of Canadian Municipalities (FCM), the City signed the Compact of Mayors, which is a global coalition of city leaders that addresses climate change by pledging to cut greenhouse gas emissions and prepare for the future impacts of climate change. In 2016, the Compact of Mayors united with the EU Covenant of Mayors for Climate and Energy. The Global Covenant provides guidance for a phased approach, enabling communities to commit, develop an inventory, create targets and metrics, and finally establish an action plan. This work is complementary to the Partners for Climate Protection initiated by the Federation of Canadian Municipalities.

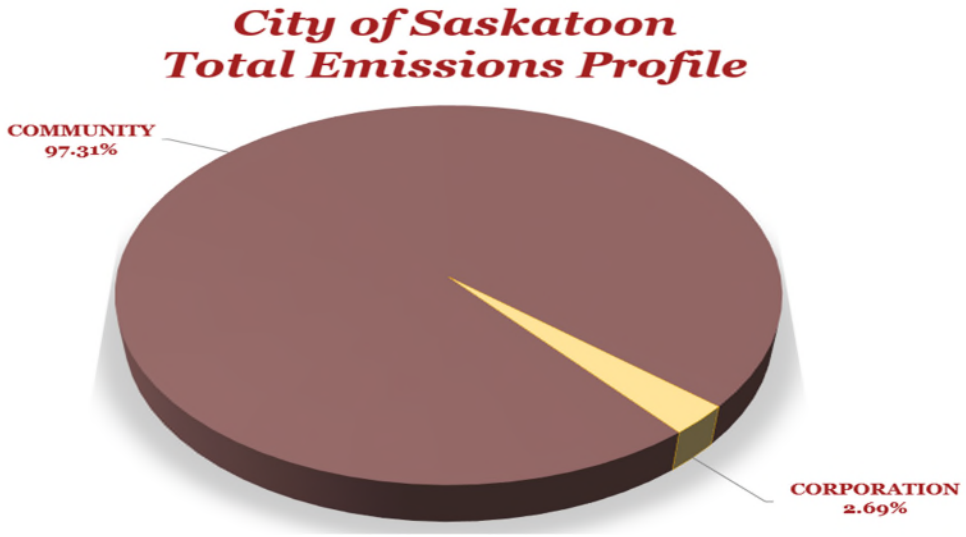

Figure 1: City of Saskatoon GHG emissions

On June 12, 2017, City Council considered and adopted:

1. That the greenhouse gas emissions reduction target for the City of Saskatoon (Corporate) be adjusted to utilize 2014 as the base year; specifically, a reduction of 40% below 2014 levels by 2023; and a reduction of 80% below 2014 levels by 2050[4]; and
2. That the recommendation for reduction targets for the community proposed by the Saskatoon Environmental Advisory Committee be adopted. The Saskatoon Environmental Advisory Committee (SEAC), at its May 11, 2017 meeting, passed a motion to recommend community-wide GHG targets of:

    a. 15% emissions reductions below 2014 levels by 2023; and
    b. 80% emissions reductions below 2014 levels by 2050.

Table 1: Saskatoon's GHG emission reduction targets[5]

Inventory	Base Year	2023	2050
Corporate	2014	40	80
Community	2014	15	80

[4] An 80% reduction by 2050 (or 80 by 50) is considered deep decarbonization. According to the Carbon Neutral Cities Alliance *deep decarbonization planning is starting to emerge as a sophisticated, data-driven, adaptive, performance management approach increasingly integrated with other city planning processes.*

[5] 2014 Saskatoon Greenhouse Gas Emissions Inventory

1.4. Scope and approach

1.4.1. Scope

The project scope was to determine if the City has set appropriate goals and whether there are adequate measures and resources in place to meet those goals. This project was divided into three sub-projects:

1. Mitigation goal setting and benchmarking, which examined the goals set relative to other similar municipalities and reviewed the GHG inventory to determine whether the goals are realistic.
2. Mitigation risk identification and measures assessment, which examined the current actions undertaken by the City to determine whether these actions would result in a trajectory that would meet the goals.
3. Data management analysis, which examined the integrity of the underlying data that comprises the GHG inventories to determine the degree of reliance that can be made on the information when making decisions.

Throughout each of these sub-projects, we examined the resources allocated to determine whether the City had sufficient resources to achieve its goals. Our commentary on resources is limited to resourcing required to achieve immediate next steps, as opposed to the full resourcing required to achieve deep decarbonization by 2050, as these final full resourcing needs are intimately tied to the City's chosen climate change strategy, which has yet to be fully developed.

1.4.2. Approach

Our general approach consisted of conducting a literature review, understanding the current situation, and analyzing the information. Examples of the steps we have taken are shown in the following table:

Table 2: General Approach

Phase	Examples of Actions
Literature review	• Research of other Canadian, North American and international emissions inventories, both corporate and community • Good practice research
Gain an understanding	• Interviews with staff to understand the current state of targets • Review of budgeting and funding sources associated with initiatives • Identifying key considerations
Analysis	• Benchmarking targets against comparison cities • Sensitivity analysis of proposed programs • Evaluation of impact of various climate change strategies • Application of system change architecture

2. Mitigation goal setting and benchmarking

2.1. Objectives

The objectives of this sub-project are to:

1. Identify comparable cities and determine their climate change goals.
2. Provide an assessment of what comparable cities expect to achieve in terms of climate change mitigation goals.
3. Provide an assessment of whether the City's climate change mitigation goals are reasonable given the distribution of the current GHG inventory, available techniques/technologies, and reasonable costs.
4. Provide an assessment of resources required to meet the City's mitigation goals.

2.2. Assessment of comparable cities

The assessment of comparable cities involved the identification and selection of the comparable cities and determining their targets, which provided a relative assessment of the emission reduction expectations compared to the City's peers. The City of Saskatoon is unique and thus a completely comparable city cannot be found; however, the selected municipalities have comparable elements and the following section describes how they are comparable and what their emission reduction targets are.

2.2.1. Elements of comparison

Our approach to assessing the City against comparable cities was to first identify comparable cities based on the types of pressures or drivers for GHG emissions that each city experiences. These pressures include latitude as a surrogate indicator for climate and temperature; population density (number of people/area) as a surrogate indicator for transportation and amount of roads; industrial base; regulatory environment; and electricity grid composition. These drivers affect municipal GHG emissions and influence the mitigation activities that can be undertaken. We identified twelve comparable cities through an extensive literature review and with input from City staff. Cities identified and researched included Canadian, North American, and international municipalities. For the basis of this comparison, PwC narrowed this selection to three:

1. Calgary, Alberta;
2. Edmonton, Alberta; and
3. London, Ontario.

Table 3: Elements of Comparison

City	GHG emissions (kt CO_2e/yr)	Pop (000's)	Pop density[6] (#/km^2)	Lat	Avg temp (°C)	Grid intensity (t CO2e /MWh)	Industries	Regulations
Saskatoon	**3,876**	**246**	**1080**	**52.1°**	**3.3**	**0.63**	**Potash, Oil, Agriculture**	**Prairie Resilience[7]** **Federal Backstop[8]**
Calgary	18,207	1,204	1420	51.0°	4.1	0.79	Oil & Gas	CCIR* Carbon levy
Edmonton	16,576	878	1280	53.5°	3.6	0.79	Oil & Gas, Petrochemical	CCIR* Carbon levy
London	3,070	375	890	42.0°	7.9	0.041	Medical Research, Insurance, Manufacturing	Cap and trade program

*Carbon Competitiveness and Incentive Regulation

Despite being five times Saskatoon's size, Calgary and Edmonton are the most comparable in terms of latitude, average temperature, grid intensities, industries, and regulations. London was the most comparable city of similar population to Saskatoon; however, note that the densities, latitude and grid intensity are significantly different.

2.3. Emission reduction target analysis

Each City has established their own mid-term and long-term emission reduction targets. Base year dates (reference GHG inventories) vary due to when cities felt comfortable with the completeness and accuracy of their inventory and political pressures. Mid-term targets tend to occur in 2020 and range from 10-50% emission reductions for corporate inventories and 15-35% emission reductions for community inventories. Long-term targets are consistent and are 80% reductions by 2050. Most municipalities cannot achieve current long-term targets with existing technologies and have assumed that the future will bring new and evolving technologies that will assist in meeting their goals.

Corporate targets

The City's corporate targets are shown in the following tables compared to comparable cities: Calgary, Edmonton, and London

[6] Population density is related to the efficient use of land and other resources. Research shows that an increase of density reduces dependencies on private motor vehicles, thereby reducing emissions. Dense urban settlements enable lifestyles that reduce per capita GHG emissions, and a concentration of services reduce the need to travel large distances.

[7] Prairie Resilience: A Made in Saskatchewan Climate Change Strategy was announced in 2017 and focuses on the principles of readiness and resilience. Regulations to support this strategy are being developed, until they are finalized the Federal Backstop will be put into place.

[8] The federal government of Canada has introduced legislation and regulations to implement a carbon pollution pricing system, to be applied in jurisdictions that do not have carbon pricing systems that align with the benchmark. The federal carbon pollution backstop has two elements: a carbon levy applied to fossil fuels, and an output-based pricing system for industrial facilities that emit over a certain threshold.

Table 4: Comparable cities corporate emission reduction targets

City	Base year date	Mid date	Target (% reduction)	End date	Target (% reduction)
Saskatoon	**2014**	**2023**	**40**	**2050**	**80**
Calgary	2005	2020	20	2050	80
Edmonton	2008	2020	50	2050	80
London	2014	2020	10	2050	80

The below figure presents the information in graphical format, allowing for a better method of comparison. The vertical axis represents the percent of the base year inventory and the horizontal axis represents time. In 2014, 100% of Saskatoon's corporate inventory is displayed because this is the base year. In 2050, 20% of all cities inventory is displayed because this is an 80% reduction from their base year. Cities that set their base year earlier have longer lead times to achieve the emission reductions and less emission reductions to realize because earlier inventories are smaller. Cities that set aggressive mid-term targets are generally in a better position to achieve the 80 by 50 targets, as the last emissions reductions will be the hardest and most expensive to achieve.

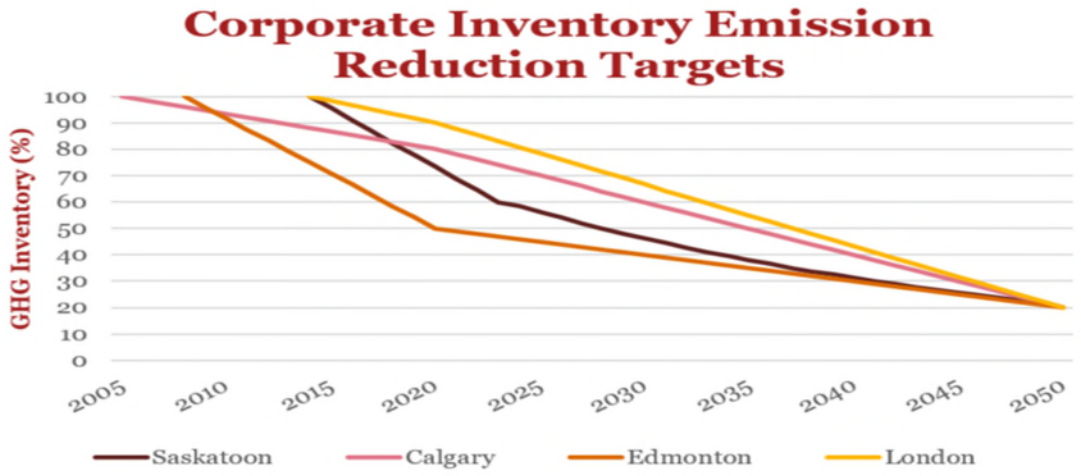

Figure 2: Comparable cities corporate emission reduction targets

The City of Calgary's 2011 GHG Reduction plan has a 2020 and 2050 target; the 2020 target will not be met. The City of Calgary is presenting a new Climate Resilience Plan to City Council in 2018 that will outline strategies and actions that the City of Calgary can take to improve energy management and reduce greenhouse gas emissions. The plan will also include a Low Carbon Plan to reduce emissions and improve energy management in Calgary to support Calgary's long-term targets of 20% below 2005 levels by 2020. The City of Edmonton is still nearly 2% higher than its 2005 baselines and therefore well above the 2035 target of 35% reduction below 2005 levels. The 2016 per capita emissions for both Calgary and Edmonton are comparable. The research on comparable cities show that London, Ontario is on track to meet their emission reduction targets. In 2016, the City of London was 15% below 1990 levels and 18% below 2007 levels. Ontario's phase out of coal-fired power plants in 2014 has significantly aided in supporting municipalities in achieving their targets.

Corporate target analysis

Compared with other cities, Saskatoon's final target of 80 by 50 is aligned. The City has established the base year later than other cities, which reduces the available time to achieve the 80 by 50 target. The City has a similar target system as Edmonton, with relatively aggressive targets early on when emission reductions should be easier to achieve and a lessening of the emission reductions as the 2050 target approaches, which should level efforts over time.

Community targets

The community targets for Saskatoon and comparable municipalities are shown in the following table:

Table 5: Comparable cities community emission reduction targets

City	Base year date	Mid date	Target (% reduction)	End date	Target (% reduction)
Saskatoon	**2014**	**2023**	**15**	**2050**	**80**
Calgary	2005	2020	20	2050	80
Edmonton[9]	2008	2035	35	-	-
Lethbridge	2014	2020	15	2050	80

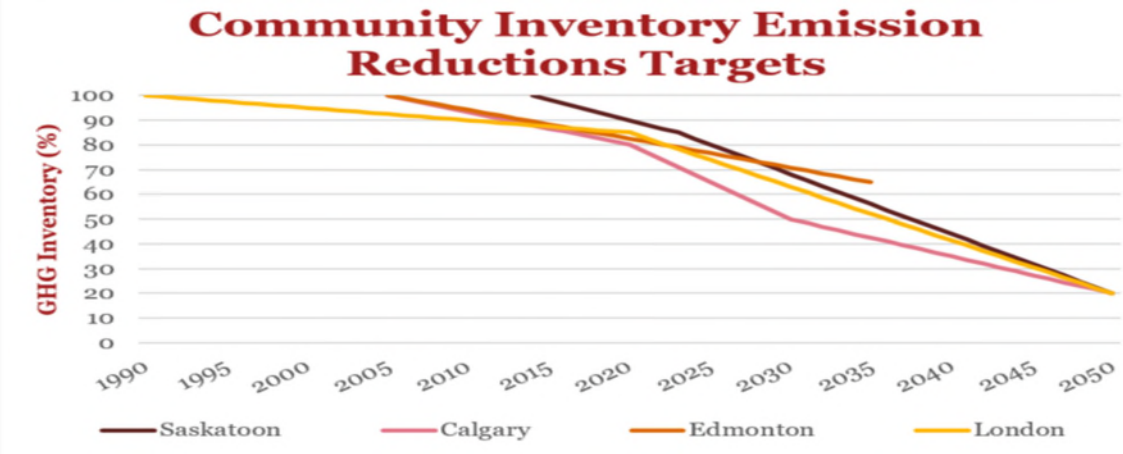

Figure 3: Comparable cities community emission reduction targets

Community analysis

Compared with other cities, Saskatoon's final target of 80 by 50 is aligned. The base year for community emission reduction targets varies widely; however, Saskatoon has the latest base year. This places the City at a disadvantage compared to other cities as there is less time to achieve emission reductions. This is particularly problematic for behavior modification and program intensive mitigation measures because time is required to permeate the community with the new methods of operation. The target curve is convex rather than concave, which implies that more emission reductions are expected closer to 2050. This is likely an unrealistic strategy, as emission reductions become more challenging to find and implement as the "low hanging fruit" of emission reductions have already been deployed. If the City continues with this approach, more resources will be required at the end of the time frame than at the beginning.

Observation 2.1: The targets set by the City, for both its Corporate and Community GHG emissions, are reasonable when compared to other similar cities; however, the City has set their base year later than these cities and has less time to achieve these emission reductions.

Observation 2.2: Target setting should be concave in pattern to reflect the difficulty in achieving emission reductions as energy use becomes more efficient and emission reductions costlier.

We also note that many other cities have implemented environmental management systems to support their greenhouse gas reduction efforts, including Edmonton and Calgary. An environmental management system ("EMS") is a structured framework designed to manage an organization's environmental performance and minimize its environmental impact. A certified EMS may provide assurance to the public and other stakeholders that the municipality is doing everything in its power effectively manage its environmental responsibilities.

[9] Edmonton City Council set a 35% reduction target by 2035, and an energy efficiency target of 25% below 2009 levels by 2035.

2.4. Assessment of reasonableness of targets

We assessed the reasonableness of the City's targets using two methods: assessing the sensitivity of the GHG inventory to certain strategies (sensitivity analysis) and examining the effect of these strategies in practice using similar circumstances (wedge analysis).

Sensitivity analysis

A sensitivity analysis examines the effect on the GHG inventory by applying an emission reduction technique as 100% of the solution. It reveals how the inventory may be influenced and allows for a ranking of approaches. It does not provide a GHG emission reduction strategy.

There are three techniques for reducing GHG emissions:

- Fuel switching;
- Increasing efficiencies; and
- Carbon (geological and biological) sequestration[10].

Given the infrastructure required for geological sequestration, we believe this technique not to be a viable alternative for the City. Biological sequestration is possible but will be limited given the ecoregion of Saskatoon and the land area required. Fuel switching and increasing efficiencies are the most viable techniques.

Wedge analysis

Stabilization wedge diagrams are a method of illustrating the impact of various climate change strategies. Each wedge represents a technology and the emissions reductions that result if adopted over time. We have taken the above three focus areas and estimated the emission reductions that could be achieved given standard practices and adoption rates. We have used the New York City's Greener, Greater Buildings Plan[11] to determine approximate emission reductions that can be expected from building retrofits (both heat and electricity) given a regulatory incentive (local law 87) but a reasonable return on investment.

It is worth noting the following:

- The return on investment analysis will be different between Saskatoon and New York City given differences in average wages and costs of materials.
- New York City enacted a law, complete with benchmarking, audits, and enforcement mechanisms, to ensure the program was adhered to. The City of Saskatoon currently has no similar regulatory mechanism.
- This program applied to all New York City buildings (with some exceptions), including those owned and maintained by New York City. Saskatoon may be able to achieve higher rates of adoption with its own buildings despite a lack of a regulatory mechanism, but only if the political mandate is established.

2.4.1. Corporate inventory

The City has committed to a corporate emission reduction target of 40% by 2023 from 2014 base year level(s) and 80% by 2050. Total greenhouse gas emissions for the City are 106.5 kt CO2e (2014). This commitment equates to an emission reduction of 43 kt CO2e in five years and an 85.2 kt CO2e in 32 years.

The City of Saskatoon corporate GHG inventory consists primarily of emissions from electricity consumption (66%), and natural gas from heating (21%). The City has limited influence over the emissions that result from electricity

[10] A natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form.

[11] The Greener, Greater Buildings Plan (GGBP) is the most comprehensive set of energy efficiency laws in the U.S., targeting New York City's largest existing buildings which constitute half its built square footage and 45 percent of citywide energy use. For these buildings, the policies require an annual benchmarking of energy and water use with public disclosure; an audit and retro-commissioning every ten years; for non-residential spaces, upgrades for lighting to meet the energy code, and the installation of electrical meters or sub-meters for large tenant spaces. http://www.nyc.gov/html/gbee/downloads/pdf/greener_greater_buildings_plan.pdf

generation, but it does have control over how much electricity is consumed and it does have control over how natural gas is used.

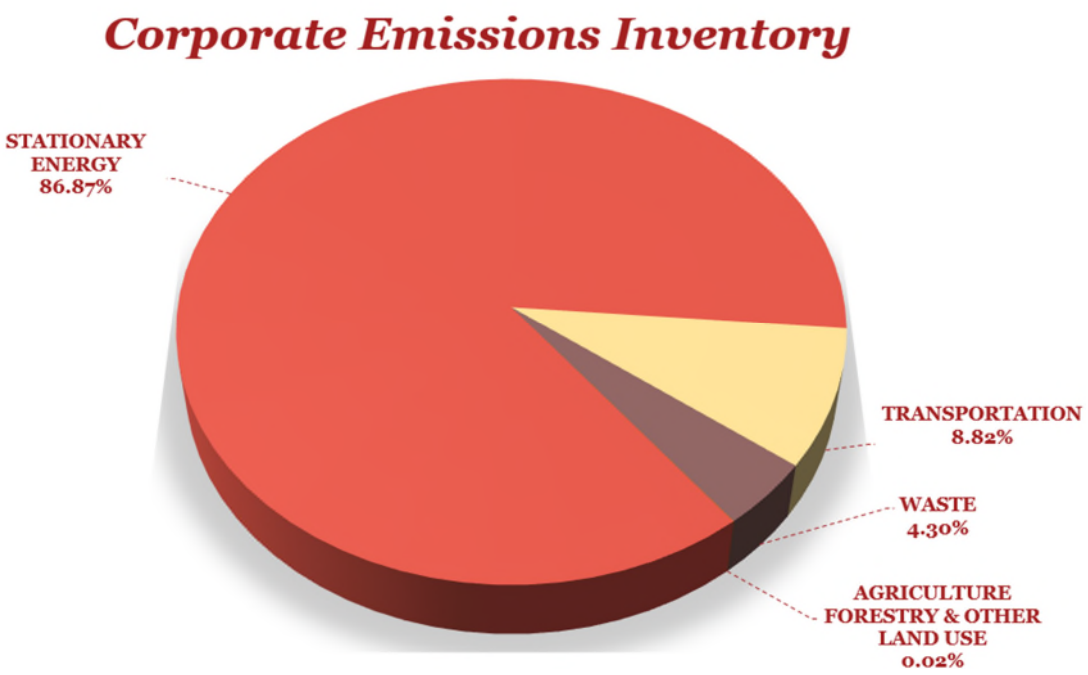

Figure 4: Saskatoon's corporate GHG inventory[12]

Corporate - sensitivity analysis

We examined five extreme scenarios to determine the bounds of what emission reductions are feasible given the City's GHG inventory. These scenarios are:

1. Fuel switching
    a. Switching natural gas for renewable energy (geothermal, solar panel, etc.)
    b. Switching grid-based electricity for renewable energy (photovoltaic solar cells)
2. Increased energy efficiency
    a. Reduction of natural gas consumption
    b. Reduction of electricity consumption
3. Grid intensity improvements

Table 6: Corporate emission reduction strategies and necessary configurations

Strategy	Strategy conditions	Configuration needed to meet 40% by 2023 target	Configuration needed to meet 80% by 2050 target
Fuel switching	No change in grid intensity. Renewable fuels used for natural gas.	Unachievable	Unachievable
	No change in grid intensity or natural gas consumption or efficiency of use. Renewable fuels used for electricity.	Solar installation of 5 MW	Solar installation of 100 MW

[12] 2014 Saskatoon Greenhouse Gas Emissions Inventory

Strategy	Strategy conditions	Configuration needed to meet 40% by 2023 target	Configuration needed to meet 80% by 2050 target
Increased energy efficiency	No change in grid intensity or electricity consumption or efficiency of use. Natural gas consumption reduced through efficiency measures.	Unachievable	Unachievable
	No change in grid intensity or natural gas consumption or efficiency of use. Electricity consumption reduced through efficiency measures.	Electricity consumption would need to reduce by one third	Unachievable
Grid intensity improvements	Changes to grid intensity. No change in natural gas consumption or efficiency of use.	Grid intensity would need to decrease by 50% (0.336 t CO2e/MWh)	Unachievable
Combined strategies		Achievable	Achievable with technological development

Fuel switching

Fuel switching is one method of eliminating GHG emissions. The most viable source of fuel switching for natural gas and electricity are solar panels and cells, and geothermal[13]. Other alternatives that significantly reduce GHG emissions are the use of biofuels (e.g., wood pellets, landfill gas) and wind. If the City were to eliminate GHG emissions associated with the consumption of natural gas, it would not meet its target. In fact, if the electricity grid and consumption were to remain unchanged and the City could eliminate all other GHG emission sources (40 kt CO2e), it would still be unable to meet its target (42 kt CO2e).

Increasing energy efficiency

Increasing efficiencies is helpful but will not eliminate GHG emission reductions as there is a finite amount that efficiencies can be improved and, in general, the more the improvement, the costlier the measure. Improvements in efficiencies can originate in the generation of energy or in the use of energy. Current boiler technology is operating at 99% efficiency compared to older installations at 75-80% efficiency. Current building construction methodologies (e.g., NexGen R2000) and retrofits can reduce heating losses by 50% (to 25%). CanmetENERGY has a target of having sustainable netZero communities operational by 2030. In the short term (e.g., five years), it is reasonable to expect that a 50% reduction in heating losses could be obtained through retrofits on older buildings. New construction would represent additions to the inventory since it is unlikely the netZero building construction could be economically feasible in the next five years but could be feasible in ten years. Water and wastewater treatment facilities incur GHG emissions through the use of pumps and recent studies have shown that pump selection and demand are key attributes in reducing GHG emissions. Savings in the range of 10-25% have been reported by various US jurisdictions[14].

Grid intensity improvements

Another strategy would be to rely on the grid intensity to change, thus producing the emission reduction required. This strategy has successfully been used by the City of London (Ontario). The carbon intensity of the provincial electricity grid is a key component in the emissions profile of the City. The City of Edmonton has modelled that in order to reduce their emissions from electricity, the carbon intensity of the grid would need to be reduced significantly. Power generation would have to be from natural gas, combined heat and power or renewable energy.

[13] US DOE - Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017

[14] US EPA - Energy Efficiency in Water and Wastewater Facilities 2013

The best solution for the City will lie between these extremes, but the following can be drawn from the analysis:

1. A multi-prong approach is necessary to achieve the 80 by 50 target as each single solution approach yields either unachievable emission reductions or unrealistic installation scenarios.
2. The GHG corporate inventory is most sensitive to electricity consumption and grid intensity.
3. The installation of 5 MW of solar energy is a significant undertaking and will take 3-5 years to implement. The main challenge with solar installations will be the requisite 20 acres[15] for the panels and infrastructure. The same challenge applies for a 100 MW installation, which will require 400 acres.
4. Using renewables to replace the entire natural gas heating is, at this point, very difficult from a technological and financial perspective.
5. An increase in the efficiency of natural gas use will not achieve the targeted emission reductions by itself.

Given these observations, the City should consider focusing on areas for their corporate emission reductions in:

1. Reductions in electricity and water consumption;
2. Installation of renewable energy for both electricity and heating; and
3. Increase efficiency of natural gas use either in the use or generation of heat or electricity.

Corporate - wedge analysis

We have created three wedges representing three types of initiatives:

- Wedge 1: Electricity consumption is reduced at a rate of 0.3%/annum, which is a rate predicted by New York City's Greener, Greater Buildings Plan[16].
- Wedge 2: Renewable electricity is introduced at a rate of 0.25 MW/annum, which uses about one acre per year of building tops for solar.
- Wedge 3: Natural gas consumption efficiency improves 0.3%/annum.

Given these adoption assumptions, the stabilization wedge diagram is shown in Figure 5 immediately below. The City's current GHG inventory is 106.5 kt CO2e and the target for 2023 is 63.5 kt CO2e (the top and bottom of the vertical scale). Each wedge represents an initiative.

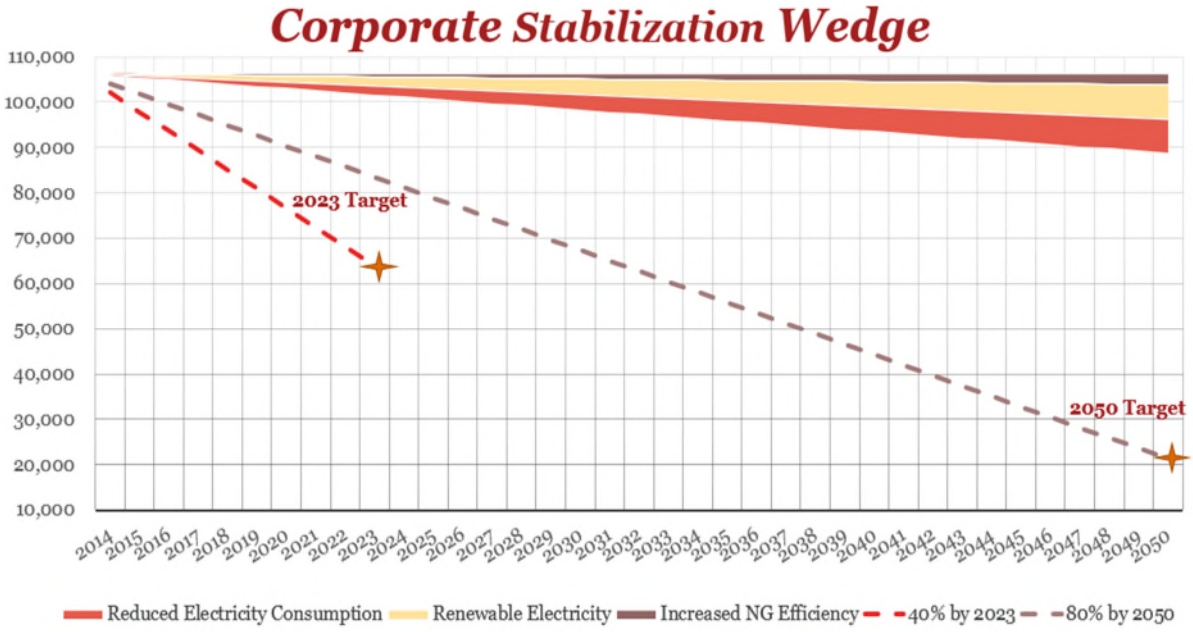

Figure 5: Corporate stabilization wedge

[15] 1 MW needs about 4 acres for land for the panels and associated infrastructure assuming conventional solar PV power plants – those that are based on crystalline silicon and do not use trackers. Source: Suncyclopedia, http://www.suncyclopedia.com/en/area-required-for-solar-pv-power-plants/, 2017

[16] Note that Saskatoon does not have the regulatory system that the NY City's Greener, Greater Buildings plan and is likely to be less effective.

Given the adoption rates experienced by the City of New York under a formalized scheme that requires the choice of less GHG impact when the economics are equal, and with enforcement mechanisms, the combined initiatives of reduced electricity and natural gas consumption and introduction of renewable energy won't allow the City to meet its corporate emission reduction targets. Significant planning will be required to develop a detailed strategy for transforming the carbon performance of the Corporate GHG Inventory.

> *"A few cities have commissioned studies that describe long-term road maps, scenarios (not plans) for arriving at the 80 by 50 target. And as more and more cities plan, implement and learn, the challenging strategic, technical, and political landscape through which they will have to navigate to 2050 goals is becoming more visible. What is clear, though, is that transformative strategies, not just more of the same, will be needed to reach the goal"*[17]

Observation 2.3: Given the areas of greatest reduction in the City's Corporate GHG Inventory and using typical adoption and emission reduction expectations from off-the-shelf technologies in these areas, it will be very difficult for the City to meet its short-term GHG emission reduction target of 40% by 2023 and its longer-term target of 80% by 2050.

Observation 2.4: Given the profile of the corporate inventory, the greatest area of emission reductions lies in electricity: either in the reduction of consumption, replacement of grid with renewable electricity, or changes in grid intensity.

2.4.2. Community inventory

The City has committed to a Community emission target of 15% by 2023 and an 80% reduction by 2050 from 2014. The total emissions are 3,863 kt CO2e and a 15% emission reduction is approximately 580 kt CO2e and an 80% emission reduction is approximately 3,090 kt CO2e. The community inventory main sources consist of electricity (33%), natural gas (26%), and gasoline (25%) consumption. We assumed the two most feasible mechanisms for emission reductions are fuel switching or increased energy efficiency and developed the following scenarios to determine whether the targets established are reasonable.

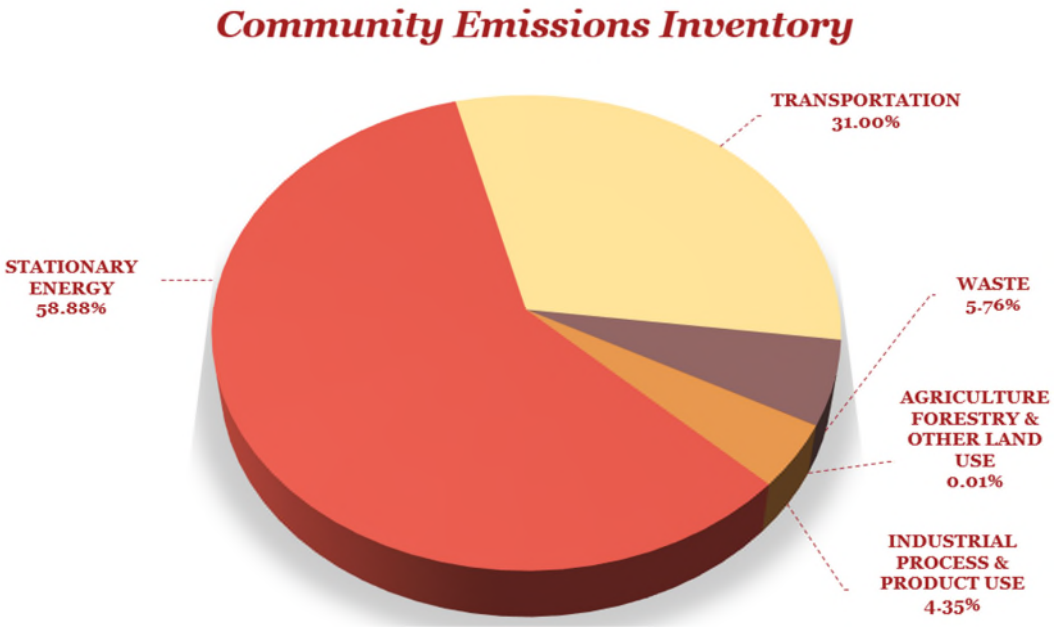

Figure 6: Saskatoon's community GHG inventory[18]

[17] Carbon Neutral Cities Alliance, Framework for Long-Term Deep Carbon Reduction Planning. Developed for the Carbon Neutral Cities Alliance by the Innovation Network for Communities. pg 3

[18] 2014 Saskatoon Greenhouse Gas Emissions Inventory

Community - sensitivity analysis

We examined seven extreme scenarios to determine the bounds of what emission reductions are feasible given the City's GHG inventory. These scenarios are:

1. Fuel switching
   a. Switching natural gas to renewable energy (geothermal, solar panel, etc.)
   b. Switching grid-based electricity to renewable (photovoltaic solar cells)
   c. Switching gasoline to electricity (electric vehicles)
2. Increased energy efficiency
   a. Reduction of electricity consumption
   b. Reduction of natural gas consumption
   c. Reduction of gasoline consumption (transit, city densification, walk/bike pathways)
3. Grid intensity improvements

Similar types of mechanisms used in the corporate inventory to explore the limits of emission reductions will be used in the community analysis with the addition of fuel switching and reduction of gasoline consumption.

The switch from gasoline to electricity will reduce emissions from gasoline combustion by about 40% using Saskatchewan's grid intensity of 0.63 kg CO2e/kWh, which will change as the grid intensity changes. Methods for reducing gasoline consumption are to increase transit density and reduce transit either by eliminating the need for transit (e.g., home-based business) or reducing transit times (e.g., urban densification). Some researchers have suggested that a doubling of the density decreases emissions by 20-40%[19]; however, others have claimed that the emission reductions aren't as significant once you control for GDP. We estimated that a doubling of urban densification results in a 10% emission reduction; however, we also have estimated that 5% of the population won't need to use transit because of home-based offices that result from urban densification and have left the effect of urban densification at 15% emission reduction per doubling of density. Note that Saskatoon's urban density of 1080 people/km2 is significantly less than average established residential areas that range from 2,855-11,850 people/km2 (depending on the income bracket). The City of Calgary has a densification goal of 30% of growth in existing neighborhoods by 2039 and 50% by 2069.

Table 7: Community emission reduction strategies and necessary configurations

Strategy	Strategy conditions	Configuration needed to meet 15% by 2023 target	Configuration needed to meet 80% by 2050 target
Fuel switching	Renewable fuels used for natural gas. No change in grid intensity or to gasoline consumption.	60% of the natural gas would need to be replaced with renewable fuel sources	Unachievable
	Renewable fuels used for electricity. No change in grid intensity, natural gas consumption or efficiency of use, or gasoline consumption.	Solar installation of 700 MW	Solar installation of 3600 MW
	Grid used for gasoline (electric vehicles). No change in grid intensity or natural gas consumption or efficiency of use.	Unachievable	Unachievable

[19] Dodman, David, 2009, Urban Density and Climate Change – global averaged number

Strategy	Strategy conditions	Configuration needed to meet 15% by 2023 target	Configuration needed to meet 80% by 2050 target
Increased energy efficiency	Natural gas consumption reduced through efficiency measures. No change in grid intensity, electricity consumption or efficiency of use, or gasoline consumption.	Unachievable	Unachievable
	No change in grid intensity or natural gas consumption or efficiency of use. Electricity consumption reduced through efficiency measures.	45% reduction in electricity consumption	Unachievable
	Increased urban densification.	Population density would need to double	Population density would need to increase by ten-fold
Grid intensity improvements	Changes to grid intensity. No change in natural gas consumption or efficiency.	Grid intensity would need to decrease by 45% (0.35 t CO2e/MWh)	Unachievable
Combined strategies		Achievable	Achievable with technological development

The best solution for the City will lie between these extremes but the following can be drawn from the analysis:

1. A multi-prong approach is necessary to achieve the 80 by 50 target, as each single solution approach yields either unachievable emission reductions or unrealistic installation scenarios.
2. The GHG community inventory is most sensitive to electricity consumption and grid intensity but secondary significant sources are natural gas and gasoline consumption.
3. These scenarios do not reveal the multiplicative beneficial effect of the combination of grid intensity changes and strategies that reduce electricity consumption or replace fossil fuel consumptions with grid electricity.
4. The installation of 700-3600 MW of solar energy is a significant undertaking and becomes more challenging in the community environment. Decentralized energy production is difficult to incent in the population due to significant upfront capital costs, lack of knowledge by owners and builders, and difficulties in the approval process.
5. Using renewables to replace the entire natural gas heating is, at this point, very difficult from a technological and financial perspective.
6. An increase in the efficiency of natural gas use will not achieve the targeted emission reductions by itself.
7. Urban densification can assist in lowering GHG emissions; however, we believe that a ten-fold increase in urban density will be unfeasible from a cultural perspective. This strategy also tends to apply to new developments or areas under revitalization and has limited deployment.

Given these observations, the City's focus areas for emission reductions should be:

1. Reductions in electricity consumption;
2. Installation of renewable energy for both electricity and heating;
3. Increase efficiency of NG use either in the use or generation of heat or electricity; and
4. Electrification of fossil fuel-based vehicles[20].

[20] Current sales rate of electric vehicles in Canada is approximately 2%; however, it is experiencing a growth rate of 64%. (FleetCarma, 2018, www.fleetcarma.com/electric-vehicle-sales-canada-2017)

Community - wedge analysis

As with the corporate inventory, we have developed stabilization wedges for the community inventory based on the suggested focus areas on the previous page as follows:

- Wedge 1: Electricity consumption is reduced at a rate of 0.3%/annum.
- Wedge 2: Renewable electricity is introduced at a rate of 0.25 MW/annum, which uses about one acre per year of building tops for solar.
- Wedge 3: Natural gas consumption efficiency improves 0.3%/annum.
- Wedge 4: Vehicle electrification occurs at 1.5%/annum, which is half the current purchase rate of electric vehicles in the US[21].

Given these adoption assumptions, the stabilization wedge diagram is shown in Figure 7 immediately below. The City's current Community GHG inventory is 386.27 kt CO2e and the target for 2023 is 328.4 kt CO2e (the top and bottom of the vertical scale). Each wedge represents an initiative.

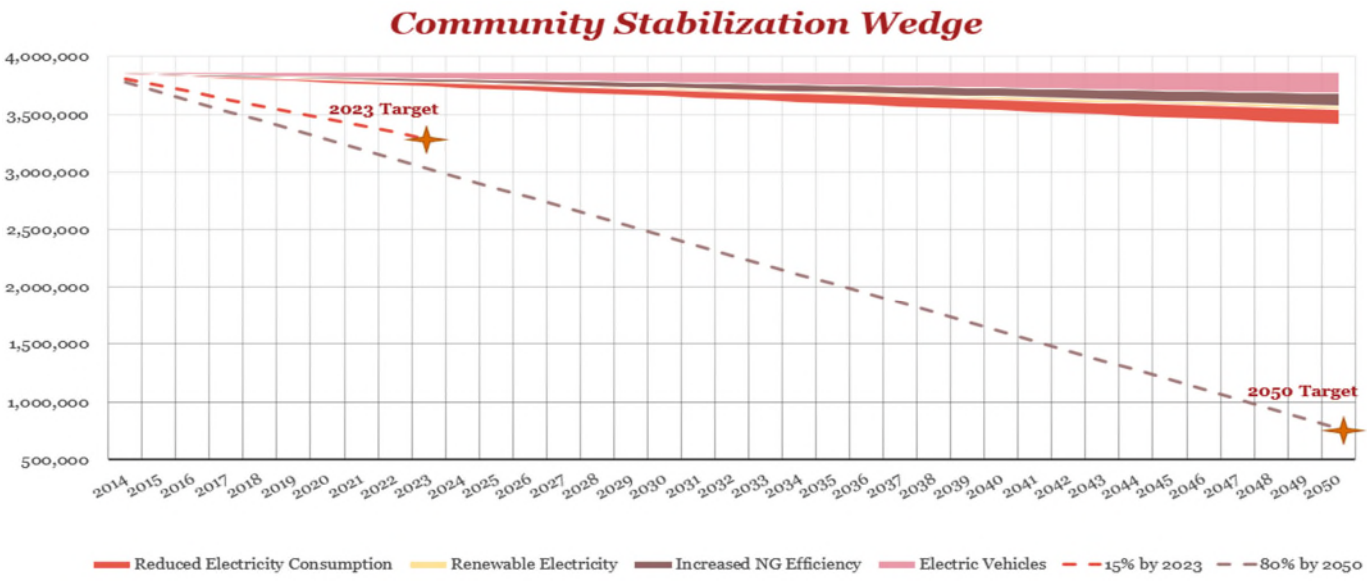

Figure 7: Community stabilization wedge

The combined initiatives of reduced electricity and natural gas consumption, and introduction of renewable energy and electric vehicles will not allow the City to meet its community emission reduction targets.

> *"It is important to note that while a number of cities have committed to reduce carbon emissions within their boundaries by at least 80% or more by 2050… No city has detailed strategies and plans for getting all the way to the 80 by 50 target yet, and there are large gaps in what cities know about exactly what will need to be done to reach the ambitious 2050 targets. There is wide recognition among the cities that doing so will require a fundamental, transformational redesign of core systems and the development of new technologies.[22]"*

Observation 2.5: Given the areas of greatest reduction in the City's Community GHG Inventory and using typical adoption and emission reduction expectations from off-the-shelf technologies in these areas, it will be very difficult for the City to meet its short-term GHG emission reduction target of 15% by 2023 and its longer-term target of 80% by 2050. The City will need to actively search for new technologies to assist in achieving its goals.

Observation 2.6: Given the profile of the community inventory, the greatest areas of emission reductions are in: electricity (either in the reduction of consumption, replacement of grid with renewable electricity, or changes in grid intensity); increased efficiency in the use of natural gas; and electrification of vehicles.

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[21] McKinsey and Company, 2017, Electrifying insights: How automakers can drive electrified vehicle sales and profitability

[22] Carbon Neutral Cities Alliance, Framework for Long-Term Deep Carbon Reduction Planning. Developed for the Carbon Neutral Cities Alliance by the Innovation Network for Communities. pg 2

3. Mitigation risk identification and measures assessment

3.1. Objectives

The objectives of this sub-project are to:

1. Provide an assessment whether the City has identified the most appropriate mitigation measures to manage.
2. Provide an assessment of the effect of a carbon levy on fossil fuel consumption on the City.
3. Provide an assessment whether the mitigation measures the City is taking to address the climate change risks are appropriate and are adequately resourced.

3.1.1. Assessment of mitigation measures[23]

In assessing whether the City has identified the most appropriate mitigation measures, we identified the typical mitigation measures used by cities to manage their emissions and the marginal costs associated with these actions. This provided a ranked list of measures based on their financial viability. We compared this list with the current and proposed mitigation measures the City has planned and classified these measures by type of lever.

PwC sourced the definition of levers from the Carbon Neutral Cities Alliance Framework for Long-Term Deep Carbon Reduction Planning. A lever is a general approach to changing underlying drivers in a system in ways that can dramatically shift the system's performance. The system change architecture provides municipalities with a progression of approaches to changing underlying drivers in a system. The starting point is voluntary action, recognizing that voluntary action is unlikely to yield substantial reductions in emissions. Mandates are generally the last resort, and when cities impose mandates they usually phase them in over time. The types of levers are shown in the table below.

Table 8: Types of mitigation levers

Lever	Definition
Voluntary action	Providing information, challenges, learning opportunities, technical assistance, examples, and other support can motivate people to try new behaviors.
Price signals	Changing the economic impacts - the cost of consumption and other behaviors and the return on investments- through subsidies and incentives can motivate new behaviors and investment.
Government investments	Investing government funds, short and long term, can create conditions that stimulate others to behave in new ways, and also significantly change the government's own carbon footprint.
Mandates	Requiring behavior and enforcing the requirements can result in widespread compliance.

[23] Carbon Neutral Cities Alliance, Framework for Long-Term Deep Carbon Reduction Planning. Developed for the Carbon Neutral Cities Alliance by the Innovation Network for Communities

Typical mitigation measures

Emission reductions are created when there is a substitution for a current activity in the GHG inventory. For example, electric vehicles substitute for gasoline vehicles, or better insulated houses are substituted for standard or older style residential housing. We compiled a list of mitigation measures from literature and from leading cities (including Kelowna, BC; Denver, CO; and Freiburg, Germany) to determine what types of mitigation activities could be expected at the City. We compared this list with the City's current or planned activities. We identified the activities that were most feasible and determined the marginal cost (i.e., the difference between the cost of the mitigation versus current activity) and the emission reductions associated with the mitigation measure to develop rudimentary marginal abatement cost curves ("MACC" or "MAC curves").

The below table is a list of common mitigation measures categorized by GHG inventory line-item and approach. The City is currently employing, for the most part, standard technologies, programs, and/or products.

Table 9: Typical mitigation measures

Category			**Standard technology/ program/ product**	**Substitute technology/ program/ product**
Buildings	Efficiency	Heat generation	Boiler	Combined heat and power/ co-generation
		Heat consumption	Building code required insulation and construction practices	Shallow, moderate, and deep retrofits
		Electricity consumption	High pressure sodium	Light emitting diode (LED)
			Standard mix of incandescent, CFL, halogen, and LED lighting	Shallow, moderate, and deep retrofits
			Low education and awareness program	Education and awareness program
Transportation	Efficiency		Gasoline vehicle	Electric vehicle
			Gasoline vehicle	Hybrid vehicle
			Diesel vehicle	Hybrid vehicle
			Diesel bus	Electric bus
Urban densification	Efficiency	City design	Current density	Double density
Waste	Efficiency	Waste disposal	Landfill with < 10% composting	Landfill with landfill gas collection to flare
			Landfill with < 10% composting	Composting
	Efficiency/ fuel switching	Waste disposal	Landfill with < 10% composting	Landfill with landfill gas collection to electricity*

* The City is employing this substitute technology.

Category			Standard technology/ program/ product	Substitute technology/ program/ product
Wastewater	Efficiency/ fuel switching	Wastewater treatment	Standard wastewater treatment	Bio-digester to electricity
Buildings	Fuel switching	Electricity generation	Grid electricity	Solar electricity
			Grid electricity	Ground source heat pump
Transportation	Fuel switching		Gasoline	Bio-ethanol
			Diesel	Bio-diesel

Marginal abatement cost is the cost of reducing environmental negatives such as GHG emissions. Marginal cost is an economic concept that measures the cost of an additional unit. The marginal abatement cost ("MAC"), in general, measures the cost of reducing one more unit of GHG emissions. A MAC curve is a succinct and straightforward tool for presenting carbon emissions abatement options relative to a baseline (typically a business-as-usual pathway). A MAC curve permits an easy to read visualization of various mitigation options or measures organized by a single, understandable metric: economic cost of emissions abatement.

MAC curves are useful for framing carbon emissions abatement options, providing a tidy and accessible tool that orders measures on a simple economic metric ($/tCO2). This allows measures from various sectors (e.g. transportation and power) to be compared on equivalent terms, serving as an initial lens of where abatement opportunities are potentially the largest and most cost effective. Therefore, MAC curves can be powerful for robust initial framing and identification of options to further evaluate. In this sense, MAC curves provide a great conversation starter from which deeper discussion and analysis can evolve with consideration of additional important dimensions and suitable policy options for unlocking the potential in each block.

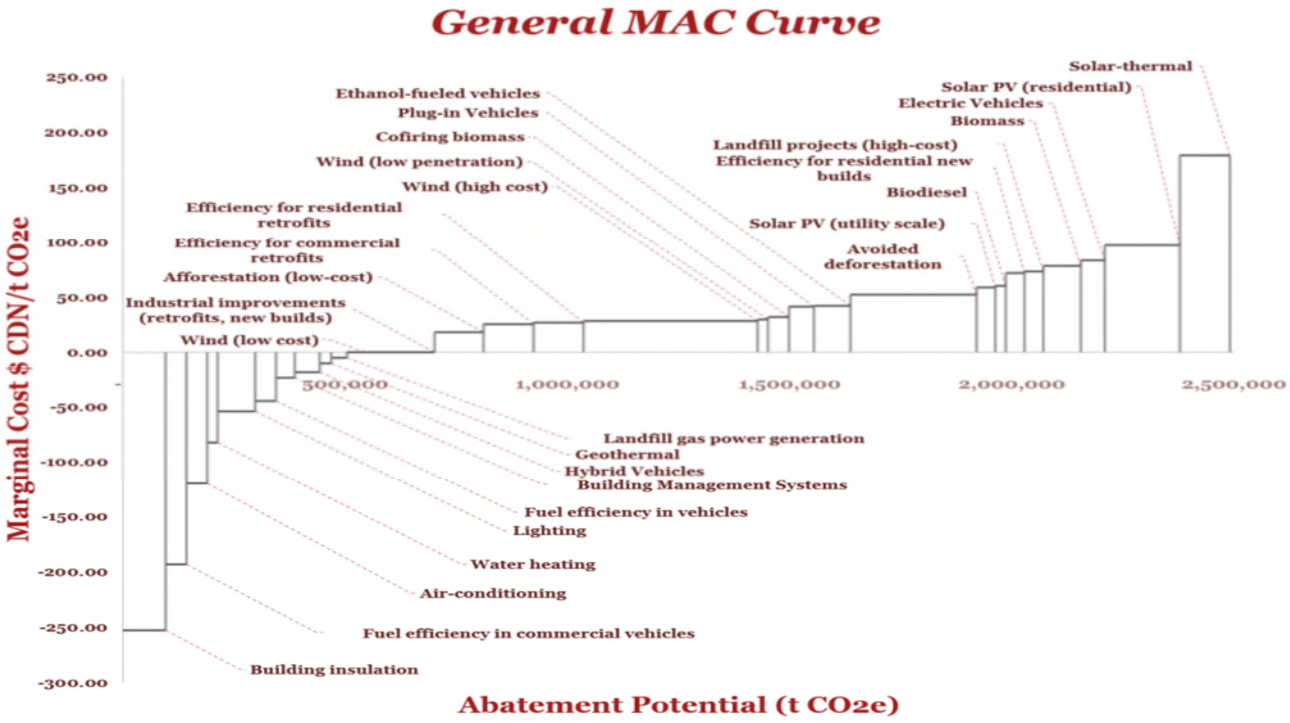

Figure 8: General MAC Curve

MAC curves are broken into discrete 'blocks'. Each block represents an individual or set of similar carbon abatement measures. For each block (or measure), the width indicates the amount of potential carbon emissions abatement (tCO_2) while the height estimates the marginal cost of the carbon emissions abatement ($/$tCO_2$). Typically, the blocks are ordered such that the lowest cost options, which may represent net cost savings (negative $/$tCO_2$), are shown first on the left with subsequent higher cost options proceeding to the right. MAC curves alone are not sufficient to base policy decisions on. Limitations of MAC curves include:

- Do not capture non-market barriers to implementation, including indirect or non-transaction costs;
- Contain limited treatment of uncertainties in the underlying analysis and assumptions (e.g. technology economics, learning rates, choice of discount rates, time of retirement for working capital goods);
- Have difficulty capturing interactions between different measures that may limit the total abatement potential; and
- Do not address dimensions other than direct costs, including strategic, operational, or political factors.

We obtained and compiled MAC curves from a variety of sources. Please note that these MAC curves are only meant to provide a general direction for decision making because the assumptions made in their development are not sufficiently precise or tailored to base business cases for the City. This general MAC curve demonstrates the top four net cost savings associated with the initiatives such as:

1. Building insulation;
2. Fuel efficiency in commercial vehicles;
3. Air conditioning; and
4. Water heating.

The top four net incremental costs are associated with the following options:

1. Solar-thermal;
2. Solar photovoltaic (residential);
3. Electric vehicles; and
4. Biomass.

Corporate analysis

The initiatives that fall below the horizontal line of the MAC curve provide potential net cost savings for the City. Building insulation, lighting, building management systems, and landfill gas projects may reduce the City's spending over time. Other types of projects may also save money when the price of carbon increases to its predicted $50/t CO_2e in 2022. The City has the projects shown in the following table funded and in progress.

Table 10: Current corporate mitigation programs/measures

Lever	Programs and projects	Definition
Government investment	Solar power	The Saskatoon solar power demonstration site is a collaboration between Saskatoon Light & Power, the Saskatchewan Environmental Society Solar Co-operative, and Saskatchewan Polytechnic. The site is located at the landfill gas power generation facility at the landfill.
Government investment	Energy performance contracting	The City is making green improvements in approximately 20 civic facilities. Energy Performance Contracting is a unique form of procurement, whereby an energy services company performs energy and water audits, retrofits civic buildings, and guarantees savings. The loan for the capital costs is repaid from avoided utility expenditures, which are measured, verified and guaranteed.
Government investment	Landfill gas collection & power generation system	The system, which began operation in 2014, is operated by the City of Saskatoon. By collecting methane gas from the landfill, the City has reduced greenhouse gas emissions by over 45,000 tonnes per year, produced enough energy to power 1,300 homes each year, and improved air quality and reduced odours at the landfill. The system currently generates approx. $1.3 million in expense reduction. Expansion opportunities are currently being explored.

Lever	Programs and projects	Definition
Government investments	Combined heat and power	The City installed natural gas combined heat and power (CHP) units at two swimming pools in 2014 to provide supplemental heating of pool water, space heating, and domestic hot water. A 265 kWe (400 kW thermal) natural gas burning unit was installed at the Shaw Centre and a 155 kWe (220 kW thermal) natural gas burning unit was installed at Lakewood Civic Centre. The electrical generation reduces the electricity purchased by the City from SaskPower and the waste heat from the reciprocating engines is delivered to the facilities heating loops. Electricity generation, heat generation, and natural gas consumption are all monitored and reported. Lessons learned from the demonstration projects have been shared with a Saskatchewan CHP working group, the Building Saskatchewan Green Conference, and multiple industry representatives and building owners. Site tours and more information on the project are provided upon request as part of this technology demonstration project. The City has also operated two CHP units at its landfill gas collection & power generation facility since 2014.

The City has focused on solar power, building energy efficiency, landfill gas collection, and CHP. Given the MAC curve, we would encourage more investment into LED lighting replacement, use of fuel-efficient vehicles, and deeper building energy efficiency measures. Deeper building efficiency measures can apply to new builds, through supplementing the national building standard, as well as active retro-fitting. In implementing these measures, the City is employing government investment as a lever which is a moderately strong lever.

The following table lists proposed Corporate mitigation measures and their status.

Table 11: Proposed Corporate programs and projects

Program/project name	Lever	Funding identified	Administration time/effort allocated
LED Street Lights	Government investment	No	Listed in work plans, not identified as project, not identified as a 2018 deliverable.
Electric Vehicles	Government investment	No	Listed in work plans, not identified as project, not identified as a 2018 deliverable.
Deep Energy Retrofit	Government investment	No	Listed in work plans, not identified as project, not identified as a 2018 deliverable.
Biofuel Blending	Government investment	No	Listed in work plans, not identified as project, not identified as a 2018 deliverable.

Observation 3.1: Although Tables 10 and 11 list current and proposed mitigation efforts, the City has not yet taken a fully strategic approach to identifying greenhouse gas mitigation projects in relation to the Corporate inventory. Efforts to identify and pursue carbon reduction efforts are not fully embedded into work plans and budgets and there is little resourcing allocated to understanding the Corporate inventory, and to implementing systematic continuous improvement measures to make meaningful reductions.

Community analysis

There are a variety of measures at the Community level that will likely save money and reduce GHG emissions: building insulation, LED lighting replacements, geothermal, efficient air-conditioning and water heating. The list of financially feasible mitigation measures expands to full retrofits and plug-in vehicles when the price of carbon is $50/t CO2e. Other measures, such as photovoltaic solar, appear to come at an incremental cost but may have long-term strategic value.

The City has the following community mitigation measures currently in progress:

Table 12: Community mitigation programs/measures

Lever	Programs and projects	Definition
Voluntary action	Environmental cash grant	The City annually allocates $20,000 to local non-profit organizations to implement initiatives that relate to the protection of the environment; conservation of natural resources; protection of water resources; and/or environmental communications, education or research.
Voluntary action	Student action for a sustainable future	The program engages teachers and students in learning, action, and inquiry in areas of energy, waste, water, food, biodiversity, and transportation. Projects lead to measurable greenhouse gas reductions, as well as other sustainability benefits in students' classrooms, schools, households, and the community.
Voluntary action	Advanced metering infrastructure	Smart meters are electronic meters that measure and record actual power and water usage by time intervals throughout the day. That data will be used to quickly and easily communicate with customers about their energy and water use, encourage conservation, and detect leaks and other high-usage variances. Most of the meters have now been installed and options to deliver an online customer platform are being explored.
Voluntary action	**Saskatoon light and power educational programming**	**The in-home display program allows customers to borrow an electricity monitor for a one-month period to learn when and how much electricity they use. They also offer 20- 30 school tours annually that align with the Saskatchewan science curriculum. Students learn how electricity systems can be safe, smart, and sustainable.**

As demonstrated above, the four programs primarily associated with community reductions are voluntary actions, which is the weakest lever for impacting change.

Observation 3.2: The current projects and levers are appropriate for mitigating risk EL-2. The projects identified and funded for Community mitigation are voluntary actions and largely based in education and awareness efforts, which is the weakest lever for impacting change. Commitment to deep community decarbonization requires a strategy that evolves over time. The starting point is voluntary action, however the City will have to motivate the community to change behavior by mandating performance requirements and increased stringency in energy performance if it is going to make strides towards its deep decarbonization goals. A particularly important and effective lever would be the mandating of building standards that exceed the national building standard in terms of energy performance.

3.1.2. Assessment of effect of carbon levy/tax

The Government of Canada has established a carbon pricing backstop. This backstop places a carbon price in all jurisdictions by 2018[24]. For jurisdictions with explicit price-based systems, the price starts at $10 per t CO2e in 2018

[24] Note that the Federal Government also plans to introduce regulations on methane emissions from landfills, but this is a separate piece of legislation than the carbon levy.

and increases $10/annum to $50/t CO2e in 2022. Provinces can deploy either a carbon tax/carbon levy with a performance-based emissions system or a cap and trade system. Each jurisdiction can use resulting revenues according to their needs, including to address impacts on vulnerable populations and sectors and to support climate change and clean growth goals. Considering the Federal carbon pricing backstop, the Saskatchewan government has announced that an Output-Based Allocation (OBA) will be designed and implemented that shows equivalency. The provincial government is developing legislation and supporting regulations that will be released later in 2018

During this uncertain time, we have assessed the financial impact to the City as if the Federal carbon pricing backstop is implemented as a carbon tax at the point of consumption. The current carbon pricing for common fossil-based fuels is shown in the below table.

Table 13: Federal carbon pricing backstop

Fuel		2018 ($10/tonne)	2019 ($20/tonne)	2020 ($30/tonne)	2021 ($40/tonne)	2022 ($50/tonne)
Gasoline	¢/L	2.33	4.65	6.98	9.3	11.63
Diesel/light fuel oil	¢/L	2.74	5.48	8.21	10.95	13.69
Natural gas	¢/m3	1.96	3.91	5.87	7.83	9.79
Propane	¢/L	1.55	3.10	4.54	6.19	7.74
Waste fuel (e.g. landfill gas)	#/t	19.97	39.95	59.95	79.89	99.87

Given the current Corporate fossil fuel consumption, accounting for population growth[25] and inflation (1.5%), we estimate, at this carbon price, the City will pay an additional $5.74 million in carbon taxes between 2018 and 2022 if no mitigation measures were implemented. If mitigation measures are implemented to meet the City's target of a 15% reduction by 2023 from 2014, the City will pay an additional $5.25 million in carbon taxes between 2018 and 2022. These values are related only to Corporate consumption and exclude the cost of fuel. We do not anticipate a relief in the carbon tax after 2022. The City may have an opportunity to recover this cost either directly or through the federal or provincial governments.

Table 14: Estimated cost of the Federal carbon pricing backstop

Fuel	2018	2019	2020	2021	2022
Incremental cost ($CAD 2018) w/o mitigation measures	$348,340	$720,855	$1,121,171	$1,547,813	$2,002,512
Incremental cost ($CAD 2018) including mitigation measures that meet target	$348,340	$697,106	$1,048,820	$1,402,119	$1,757,009

Most electricity generators enter into power purchase agreements that allow them to flow through the costs associated with legislative and regulatory requirements. We anticipate that the costs of electricity will rise because of the Federal carbon pricing backstop. Using coarse assumptions about heat rates and grid intensity, we estimate that the additional cost of the Federal carbon pricing backstop to be between 0.5-2.1 ¢/kWh. Estimating the consumption of electricity based on population growth and no mitigation measures, and assuming all the costs associated with a carbon tax on fossil fuel electricity generation are passed to the consumer, the City will indirectly pay an additional

[25] City of Saskatoon and Saskatoon Census Metropolitan Area Population Projections 2015 to 2035

$12 million in carbon taxes by 2022. Assuming mitigation measures are implemented that meet the 15% reduction target, the indirect cost of electricity would be $11.5 million in carbon taxes by 2022. These values exclude the cost of the electricity. We do not anticipate a relief in the carbon tax after 2022.

Table 15: Estimated cost of increased electricity prices from carbon levy

		2018	2019	2020	2021	2022
Electricity consumption w/o mitigation measures	kWh	131,355,482	144,475,374	162,253,827	185,834,148	216,980,771
Electricity consumption w/mitigation measures that meet target	kWh	131,355,482	148,975,132	166,594,782	184,214,432	201,834,082
Grid intensity	t CO2e/MWh	0.58	0.55	0.52	0.49	0.46
Forecasted increase in electricity due to carbon levy	(¢/kWh)	0.5	1.0	1.4	1.8	2.1
Incremental cost without mitigation measures	($CAD 2018)	651,964	1,379,537	2,229,630	3,255,749	4,526,795
Incremental cost including mitigation measures that meet target	($CAD 2018)	651,964	1,379,537	2,229,630	3,120,589	4,121,490

There will be an opportunity to optimize the cost of payments to the carbon levy through the choice of GHG emission reduction technologies and programs. Over the short term, the estimated cost of increased electricity prices is approximately the same in both cases; it is in the further future where mitigation makes a significant difference in the cost of electricity.

Observation 3.3: If implemented, a carbon levy of $50/t CO2e in 2022 will cost the City $2 million in direct payments and $4.5 million in indirect payments annually. GHG mitigation measures that focus on the reduction of fuel and electricity consumption will ameliorate some of the costs.

4. Assessment of resources

We assessed whether the City has adequate resources to manage the necessary actions and programs currently in place as well as proposed future actions and programs. The assessment was conducted based on work plans and budgets associated with the resourcing and staffing of the climate change mitigation business plan. The assessment did not consider project staffing from other departments where projects may have a residual benefit to the emission reduction targets. Our commentary on resources is limited to resourcing required to achieve immediate next steps regarding the development of further strategies and tools, as opposed to the full resourcing required to achieve the City's current targets of 15% emission reduction by 2023 and 80% reduction by 2050 from 2014. The development of further climate change strategies and tools at the City, combined with this first stage of incremental resourcing, will then put the City in a better position to evaluate the full resource needs required to fully achieve its stated mitigation goals. Given the complexity of emission reduction planning the, City must first develop the technical capacity for analyzing, modelling designing and planning for emission reduction activities.

> *"Long term systems transformation requires political leadership and "out of the box" thinking about providing services, investing in infrastructure, and engaging stakeholders"*[26]

Table 16: Estimated and actual resources allocated to climate change mitigation

Role		Current	Recommended					
		Q3 2018	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Q3 2019	Q4 2019
Climate Change Strategy Development and Program Design								
MACC Development and Research				1	1	1		
Policy Development and Implementation		1.35	1.5				1	0.25
Advocacy and Awareness								
Management System and Design				1	1	1	1	0.25
Data Management and Reporting		1	1	1.5	1.5	1.5	1.5	0.5
Corporate Program Implementation								1
Renewable/Low Carbon Electricity Generation	*Solar*		1	1	1	1	1	1
	Combined heat and power	0.25	1.25	1.25	1.25	1.25	1.25	1.25
	Ground source heat pumps							
Energy Efficiency	*Building retrofits*							
	Energy performance	0.125	1	1	1	1	1	1
	LED street lights		1	1	1	1	1	1
	Hybrid/Electric vehicle							
	Urban densification/ Urban planning							
	Building code supplement							
Fuel Switching	*Biofuels*							
	Electrification programs							
Waste and Water Management	*Consumption reduction*							
	Landfill gas collection		1	1	1	1	1	1
	Composting							
Community Program Implementation								1
Renewable/Low Carbon Electricity Generation	*Solar home program*							
Energy Efficiency	*Grants*							
	Education and awareness	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Advanced metering	0.2	0.5	0.5	0.5	0.5	0.5	0.5
	Transit and bike paths							
	Building retrofits							
	New building code requirements							
Fuel Switching	*Grants*	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Education and awareness							
	EV Plugin stations							
Waste and Water Management	*Consumption reduction*							
TOTAL		**3.5**	**8.8**	**9.8**	**9.8**	**9.8**	**9.8**	**9.3**

The analysis immediately above was based on a review of work plans and job descriptions in Environmental and Corporate Initiatives and included interviews with staff. While we have totaled initiatives listed to an "Actual FTE" it

[26] Framework for Long Term Deep Carbon-Reduction Planning

should be noted that these FTE numbers represent cumulative efforts of many people working in a percentage base of annual efforts to support these initiatives. There may not be a dedicated full-time resource allocated to these line items. In many instances, efforts were shared across teams and individuals and having various individuals who allocate 20% of their time to an initiative, as opposed to having dedicated resources, diminishes the ability to advance projects and programs in a timely manner. This assessment of resources considers requirements in the next 12 months; a longer-term assessment to 2050 would require a more detailed road map of programs and projects.

Observation 4.1: If the City wishes to achieve their GHG emission reduction targets, which requires more efforts than the current programs/techniques, they will be significantly under-resourced. The FTE gap identified is related to actions and programs currently in place and proposed in the internal work plans.

The City requires sound information to base their decisions on and an infrastructure to implement the decisions. The lack of a City specific MAC curve significantly hinders the ability to assess goals, design a strategy, and prioritize programs. Combined with a sound GHG data management system, we believe that this should be the first focus area. The following resources would assist in closing this first gap and addressing this first focus area:

1. 1 FTE for 12 months to conduct research and develop the MAC curve, provide background information, consult with internal stakeholders, and develop a strategy for the corporate and community GHG inventory, including target re-assessment. This position could be sub-contracted but would still require internal resources as information sources and consultation. Longer term, once the strategy is developed, 0.25 FTE would be required to maintain and update the information.
2. 0.5 FTE to project manage and champion the development of a GHG data management system including robust processes and controls. Longer term, this role would be responsible for the ongoing reporting of the GHG inventory and the resource requirement would drop to 0.25 FTE.
3. 1 FTE to be a database technician, understanding the technical requirements of the database required for the inventory. This role may be scaled back to 0.25 FTE after the database is developed and implemented.

After the climate change strategy has been determined, the resources required will be clearer and we anticipate that the City will likely require the following resources:

1. 1 FTE to project manage and champion the development of a robust environmental management system. This role would be required to work collaboratively with multiple business units, senior leadership and Council. Longer term this role would be responsible for the ongoing implementation and maintenance of the environmental management system and may be scaled back to 0.25 FTE.
2. 1 FTE to project manage and champion all Corporate related emissions reduction projects. This role would rely on data supplied from the GHG inventory and would create project charters and ensure that all projects efficiently and effectively achieved measurable reductions for the Corporate emissions inventory. This role would be responsible for reporting on the success of Corporate emissions reduction projects.
3. 1 FTE to project manage and champion all Community related emission reduction projects. This role would rely on data supplied from the GHG inventory and would create project charters and ensure that all projects efficiently and effectively achieved measurable reductions for the Community inventory. This role would be responsible for reporting on the success of Community emissions reduction projects.

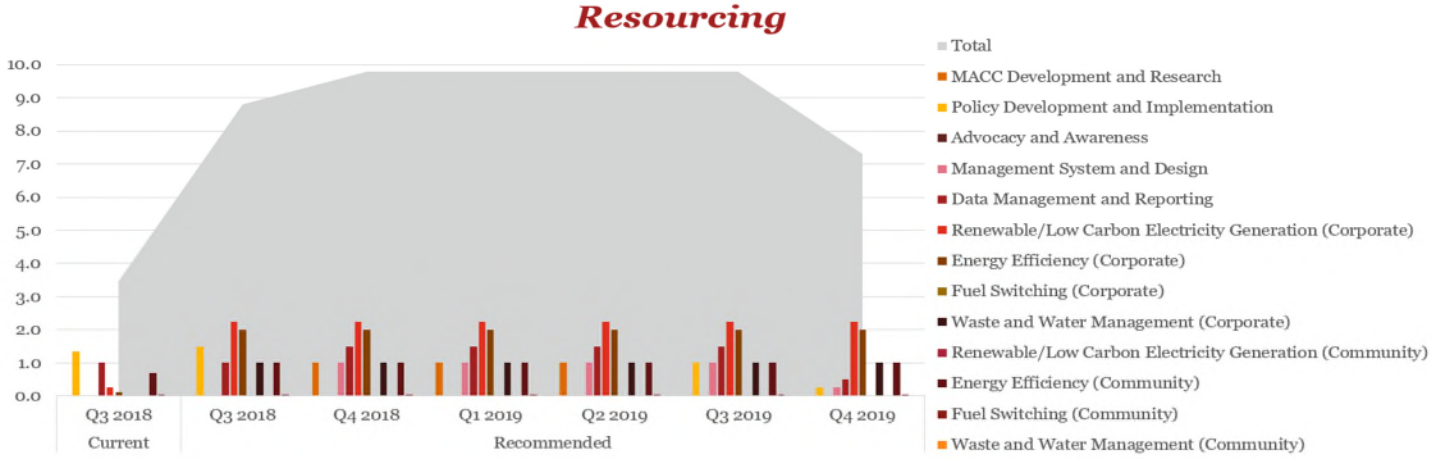

Figure 9: Resourcing

The resourcing of dedicated full-time staff recognizes the long-term commitment required to achieve deep decarbonization. This does not include support, such as specialized contractors, for the implementation of projects. Development of a comprehensive strategy for the City and the community, including MAC curves, is required first to determine the best-fit projects and investments.

Our analysis of comparable cities and other related research demonstrated that few, if any cities have clearly identified a well-defined plan for achieving deep decarbonization. However, it should be noted that cities such as Calgary and Edmonton have dedicated staff related to climate change mitigation and emission reduction efforts. Edmonton has a dedicated team of 16 individuals, with 6 in corporate roles and 10 staff embedded in departments. In addition, Edmonton established an Energy Transition Committee of Council in May of 2016, which provides both political and senior administrative support to emission reduction efforts.

5. Data management analysis

5.1 Objectives

The objectives of this sub-project are to:

1. Provide an assessment of the efficiency and effectiveness of the data management system that underlies the City's GHG inventory, including an assessment of the controls put in place to manage the GHG information.
2. An assessment of the resources required to collect, report, and manage the City's GHG inventory on an ongoing and go-forward basis.

5.1.1 Assessment of data management system

In assessing the data management system used to manage and report the City's Corporate and Community inventories, we developed data flow maps and control matrices based on available information at the City, which have been provided to the Administration. Note that our procedure for this sub-project included an assessment of controls and review of the flow of data but did not extend to providing assurance on or auditing the integrity of the emissions inventory itself.

We noted the following based on our review of available information:

- A rudimentary data management system underlies the City's GHG inventory;
- Much of the data requested is from sources outside of the City and is then transferred into spreadsheets;
- The "source" of data is often an unknown data storage system;
- Controls used to maintain data management system integrity are undocumented, informal, and limited; and
- When calculations are applied, they are checked by project engineers.

We noted that the City's GHG inventory has been verified. Verification can occur without a check on the data management system and its associated controls if the verifier decides to employ a detailed approach, which examines only the data and does not rely on controls. This approach tends to be time consuming as the effort is greater than relying on controls. Verification is not a control in the City's data management system.

Observation 5.1: The GHG inventory is not currently fully utilized as a tool for supporting decisions. Deep decarbonization planning requires sophisticated, data-driven, and adaptive performance management[27]. Many cities have designed robust data measurement and reporting systems as a crucial first step to supporting their strategies. Infrastructure, including software solutions, will be required to measure, track and report on progress of reducing carbon emissions. Having a strong, credible and transparent system for tracking carbon emissions and reporting on the actions of the City is an essential building block.

5.1.2 Assessment of resources required

The City has allocated very limited resources to the collection, reporting and management of the City's GHG inventory. The integrity of underlying data is critical to making sound decisions. We believe that having one resource is appropriate if the City maintains its current method of collecting and analyzing its GHG inventory; however, we would highly recommend developing a more robust system that is more automated and extends the entire length of the data management system to ensure the integrity of reporting. This will cause a short-term demand in designing and implementing the system but will have the long-term benefit of reduced workloads and greater certainty of the GHG inventory values. In addition, it would be prudent for the City to have their data processes and data independently verified on an annual basis. Reasonable assurance over processes and data demonstrates the integrity

[27] Carbon Neutral Cities Alliance, Framework for Long-Term Deep Carbon Reduction Planning. Developed for the Carbon Neutral Cities Alliance by the Innovation Network for Communities pg. vi

of the GHG inventory, which should be the foundation of programming and investment decisions. Having a program that effectively measures and reports emissions is inherently linked to commitments made to reduction targets.

The activities of collecting and reporting are very different than that of managing an inventory. Collection and reporting is often an exercise of looking back and reporting on historic data. The City will require sophisticated systems to analyze and map their emissions system. This will entail technical infrastructure and professional skills and expertise to understand the economics, technologies and policy landscape to implement and embed carbon reduction strategies into broader city plans.

Observation 5.2: At this time, there are limited resources allocated to the collection and reporting of the GHG inventory. The corporate reporting function has minimal visibility into how the data is captured and stored at its source. Controls used to ensure that the GHG data is complete, accurate and valid are informal and undocumented. Section 4 (pages 29 to 31) includes comments on resources and efforts related to data management.

6. Overall themes, observations and next steps

The intent of this review was to assess the strategy and resources dedicated to mitigating the risks EL-2 and EL-3 and assess whether the City's current environmental strategy is appropriately implemented and has adequate resources to implement the strategy. Our observations within the sub-projects are intended to provide a connected assessment. The overall project observations can be distilled into 2 key themes:

1. Strategy: The process of setting climate goals and the risks identified in the City's Risk Register are disconnected. The risks identified do not support a plan of action or policy designed to achieve the overall aim of deep decarbonization.
2. System approach: The City lacks a management system approach of "plan, do, check, act" to setting greenhouse gas targets, identifying risks associated with these targets, and implementing actions required to achieve deep decarbonization.

6.1. Summarized project observations

Observation	*Sub-project*	*Details*
1	Sub-project 1 Sub-project 2 Sub-project 3	The City has set targets that align with the commitments of other peer cities; however, the achievement of these targets is doubtful given the composition of the Greenhouse Gas (GHG) inventory and the current programs in place. We suggest either changing the targets and/or increasing the emphasis on GHG mitigation measures.
2	Sub-project 2 Sub-project 3	The City requires some fundamental tools to support strategic decision making. As a minimum, a tailored Marginal Abatement Cost Curve (MAC curve) for the City and a more robust GHG data management system would be beneficial.
3	Sub-project 2	To achieve significant emission reductions, the City needs to focus on items such as street light replacements and building insulation for both the corporate and community inventories. Applying the strategy of "choosing the least GHG emitting technology when faced with two equal cost but competing technologies" won't produce significant emission reductions.
4	Sub-project 1 Sub-project 2 Sub-project 3	The City's current strategy for GHG emission reductions will not generate the emission reductions to achieve its targets. A realistic strategy with reasonable targets, focused on the areas of greatest emission reduction potential and employing appropriate levers, should be designed, reviewed and updated frequently. Given the profile of both the corporate and community emissions inventory, the greatest areas of emission reduction are in electricity (reduction of consumption, replacement of grid with renewable, electrification of vehicles, or changes in grid intensity), and increased efficiency in the use of natural gas. An important aspect of reduced consumption and electrification of vehicles will be the modification and densification of transport infrastructure.
5	Sub-project 2	If implemented, a carbon levy of $50/t CO2e in 2022 will cost the City $2 million in direct payments and $4.5 million in indirect payments, annually. GHG mitigation measures that focus on the reduction of fuel and electricity consumption will ameliorate some of these costs.
6	Sub-project 3	There is inconsistent messaging regarding the importance of GHG emission reductions within the City (e.g., encouragement of the purchase

		and sale of City electricity generation or the encouragement of low-density land development conflicts with GHG emission reductions). Developing a consistent framework for incentivizing and evaluating projects and actions will be necessary to reduce this conflict. Efforts to identify and pursue carbon reduction initiatives are not currently fully embedded in work plans and budgets.
7	Sub-project 1 Sub-project 2 Sub-project 3	The current resourcing focusses on mitigating risk EL-2 (community education and awareness). The projects associated with community mitigation are voluntary actions and largely based in education and awareness efforts. Current resourcing does not address EL-3 (identify and pursue corporate emission reductions). If the City wishes to achieve their GHG emission reduction targets, both community and corporate, significantly more effort and resources are required.
8	Sub-project 1 Sub-project 2 Sub-project 3	There is minimal resourcing allocated to understanding the corporate inventory and implementing systematic continuous improvement measures to make meaningful reductions.

6.2. Next steps

Getting to 2022

It is important to note that there is a broad body of research related to deep decarbonization, and significant efforts are being made to support municipalities on their journey to 80 by 50. Tools, collaboration, models and lessons are being shared, however, these must be adapted for each municipality's specific context. Many municipal climate action plans focus on interim goals, shorter time horizons, and incremental targets. Municipal systems are extremely complex, and as a result achieving deep decarbonization may require multiple strategies over time, as changes have to be sequenced and sustained over years, through election cycles, new technologies and energy market volatility. The magnitude of these commitments cannot be minimized. The approach required will evolve. At present there is no single "how-to" formula for achieving deep decarbonization[28]. Based on our understanding, we recommend the City take an approach of sequential next steps to be achieved by 2022:

1. Develop MAC curves specific to the City's circumstances to enhance sound decision-making.
2. Develop City-specific emission reduction goals based on a more sophisticated understanding of the inventory and aligned with the environmental management system.
3. Develop an emission reduction strategy to achieve City-specific reduction goals, and a timeline that includes milestones and interim goals along the way.
4. Develop an environmental management system that includes high-level goals, objectives and targets, including those related to deep decarbonization.
5. Implement a data management system to ensure quality data control over the GHG inventory and to effectively measure performance.

[28] Carbon Neutral Cities Alliance, Framework for Long-Term Deep Carbon Reduction Planning. Developed for the Carbon Neutral Cities Alliance by the Innovation Network for Communities

Appendix A: Comparative city descriptions

Calgary, Alberta
Joined the Compact of Mayors in 2016. Calgary is a southern Alberta municipality and home to much of Canada's upstream oil and gas industry. Crossing through the city is the Bow River. Calgary is close to the Rocky Mountains. Calgary was chosen as a comparable city for the purposes of this exercise due to its similarities in weather, latitude and longitude. The electricity grid in Alberta is similar in design to Saskatchewan.

Edmonton, Alberta
Joined Compact of Mayors 2016. Edmonton is the capital of the province of Alberta and home to the University of Alberta. As of 2016, it had a population of 932,546. Edmonton was chosen as a comparable city for the purposes of this exercise due to similarities in the age of some of the infrastructure, similarities in climate and the economic drivers of both oil and gas, and agriculture. Edmonton has been actively engaging in climate changes issues since 2007 when it registered its climate change concern through support of the Alberta Urban Municipalities Resolution for Support for Municipal Climate Change Initiatives.

London, Ontario
Joined the Compact of Mayors in 2015. London does a report on energy consumption by commodity. Their plan is called the Corporate Energy Conservation and Demand Management Plan, approved by council in July 2014. They have separate reports for community and corporate emissions. Community Energy Action Plan (CEAP) is a 4-year strategy that encompasses 40 City-led actions; as at June 2017 over half of the actions have been completed. Total GHG were almost 15% lower than they were in 1990, putting London in a good position to achieve their 2020 goal. London City Centre was re-certified to ISO 14001 in 2016- it is the only commercial office tower in Canada to receive this certification.

Other cities were included in our research including Kelowna, New York, Denver, and Freiburg (Germany).

City	GHG emissions (t CO_2e/a)	Population (2014)	Area (km^2)	Latitude	Average temperature (°C)	Grid intensity (t/MWh)	Industries	Regulatory Environment
Saskatoon	**3,876,000**	**246,000**	**228**	**52.1°**	**3.3**	**0.63**	**Potash, Oil, Agriculture**	**Prairie Resilience** **Federal Backstop**
Calgary	18,207,232	1,203,915	1420	51.0°	4.1	0.79	Oil & Gas	CCIR* Carbon levy
Edmonton	16,576,702	878,000	1280	53.5°	3.6	0.79	Oil & Gas, Petrochemical	CCIR* Carbon levy
London	3,070,000	375,000	890	42.0°	7.9	0.041	Medical Research, Insurance, Manufacturing	Cap and trade program

*Carbon Competitiveness and Incentive Regulation

Appendix B: Recommendations for the Administration

Based on our understanding and expanding on the high-level next steps included in the report, we recommend that the Administration take into consideration an approach of sequential next steps to achieve by 2022 as outlined by the recommendations that follow.

1) We recommend that the Administration develop MAC curves specific to the City's circumstances to enhance sound strategic decision-making. This is a minimum fundamental tool as MAC curves are a succinct and straightforward tool for presenting carbon emissions abatement options relative to a baseline and permit an easy to read visualization of various mitigation options or measures organized by a single, understandable metric: economic cost of emissions abatement. MAC curves provide a great conversation starter from which deeper discussion and analysis can evolve with consideration of additional important dimensions and suitable policy options for unlocking potential in each block of a MAC curve (with each block representing an individual, or set of, similar carbon abatement measures).

2) We recommend that the Administration develop City-specific emission reduction goals based on a more sophisticated understanding of the inventory and aligned with the environmental management system.

    a) We suggest either changing the targets and/or increasing the emphasis on GHG mitigation measures, as the achievement of the current targets is doubtful given the inflexibility of the GHG inventory and the current programs in place.

    b) Applying the strategy of "choosing the least GHG emitting technology when faced with two equal but competing technologies" will not produce significant emission reductions. In order to achieve these significant emission reductions, as an example, the City would need to focus on items such as street light replacements and building insulation for both the corporate and community inventories.

3) We recommend that the Administration develop a realistic emission reduction strategy with reasonable targets, focused on the areas of greatest emission reduction potential, and employing appropriate levers to achieve City specific reduction goals.

    a) The strategy needs to be reviewed and updated frequently and include a timeline that includes milestones and interim goals along the way.

    b) Given the profile of both the corporate and community emissions inventory, the greatest areas of emission reduction are electricity (either in the reduction of consumption, in replacement of grid or changes in grid intensity), increased efficiency in the use of natural gas and the electrification of vehicles.

    c) GHG mitigation measures that focus on the reduction of fuel and electricity consumption will ameliorate some of the costs of a carbon levy.

    d) Included in the emission reduction strategy should be a consistent framework for incentivizing and evaluating projects as there is currently inconsistent messaging regarding the importance of GHG emission reductions within the City (e.g. encouragement of the purchase and sale of City electricity generation and the encouragement of low-density land development conflict with GHG emission reductions).

4) We recommend that the Administration develop an environmental management system (EMS) that includes high-level goals, objectives and targets, including those related to deep decarbonization. An EMS is a structured framework designed to manage an organization's environmental performance and minimize its environmental impact. A certified EMS may provide assurance to the public and other stakeholders that the City is doing everything in its power to manage its environmental responsibilities effectively. We note that other municipalities have implemented EMS to support their GHG reduction efforts, including Edmonton and Calgary.

5) We recommend that the Administration implement a system to ensure quality data control over the GHG inventory to effectively measure performance. The importance of this is underscored by the fact that the current data management system underlying the City's GHG inventory is rudimentary, and a significant amount of the data relied upon is currently required to be received from sources outside of the City and then transferred into spreadsheets. The controls used to maintain the current data management system's integrity are currently manual and informal. A more robust, automated system that extends the entire length of the data management cycle will ensure the integrity of reporting.

6) Ultimately, for the City to achieve the GHG emission reduction targets that it establishes, more effort will be required than the current programs and techniques allow for and levels of resourcing will be an obstacle. Efforts to identify and pursue carbon reduction initiatives are not currently embedded in work plans and budgets to the extent necessary. There is currently minimal resourcing allocated to better understanding the corporate inventory and implementing systematic continuous improvement measures to make meaningful reductions.

   Currently, we estimate there is a gap of at least 5 to 6 FTE's based on the actions and programs currently in place and proposed in the internal work plans. We recommend that the Administration build out a resourcing plan that incorporates the following:

   a) In the near term (i.e. within a year) up to 2 additional FTE's to individually 1) project manage and champion the development of a robust EMS and 2) project manage and champion the development of a sophisticated data system including processes and controls.

   b) Once the data system, including processes and controls, is fully developed, an additional FTE (database technician) to be responsible for ongoing management of the GHG inventory and the underlying system.

   c) In the longer term, up to 2 additional FTE's to take leadership and be project managers and/or champions for the corporate emissions strategy and the community emissions strategy. These roles would rely on data supplied from the GHG inventory and would create project charters and ensure that all projects efficiently and effectively achieved measurable reductions for the corporate and community emissions inventories. These personnel would be responsible for reporting on the success of corporate and community emissions reduction projects.

Appendix C: Detailed observations

Sub-project	Observation
1 (Mitigation goal setting & benchmarking – Section 2 pages 9-20)	2.1 The targets set by the City, for both its corporate and community GHG emissions, are reasonable when compared to other similar cities; however, the City has set their base year later than these cities and has less time to achieve these emission reductions.
	2.2 Observation 2.2: Target setting should be concave in pattern to reflect the difficulty in achieving emission reductions as energy use becomes more efficient and emission reductions costlier.
	2.3 Given the areas of greatest reduction in the City's Corporate GHG Inventory and using typical adoption and emission reduction expectations from off-the-shelf technologies in these areas, it will be very difficult for the City to meet its short-term GHG emission reduction target of 40% by 2023 and its longer-term target of 80% by 2050.
	2.4 Given the profile of the corporate inventory, the greatest area of emission reductions lies in electricity: either in the reduction of consumption, replacement of grid with renewable electricity, or changes in grid intensity.
	2.5 Given the areas of greatest reduction in the City's Community GHG Inventory and using typical adoption and emission reduction expectations from off-the-shelf technologies in these areas, it will be very difficult for the City to meet its short-term GHG emission reduction target of 15% by 2023 and its longer-term target of 80% by 2050.
	2.6 Given the profile of the community inventory, the greatest areas of emission reductions are in: electricity (either in the reduction of consumption, replacement of grid with renewable electricity, or changes in grid intensity); increased efficiency in the use of natural gas; and electrification of vehicles.
2 (Mitigation risk identification and measures assessment AND Assessment of resources – Section 3 pages 21-28 AND Section 4 pages 29-31)	3.1 The City hasn't taken a strategic approach to identifying greenhouse gas mitigation projects in relation to the Corporate Inventory. Efforts to identify and pursue carbon reduction efforts aren't embedded in the work plans and budgets, there is little resourcing allocated to understanding the corporate inventory and implementing systematic continuous improvement measures to make meaningful reductions.
	3.2 The current projects and levers are appropriate for mitigating risk EL-2. The projects identified and funded for Community mitigation are voluntary actions and largely based in education and awareness efforts, which is the weakest lever for impacting change. Commitment to deep community decarbonization requires a strategy that evolves over time. The starting point is voluntary action; however, the City will have to motivate the community to change behavior by mandating performance requirements and increased stringency in energy performance if it is going to make strides towards its deep decarbonization goals. A particularly important and effective lever would be the mandating of building standards that exceed the national building standard in terms of energy performance.
	3.3 If implemented, a carbon levy of $50/t CO2e in 2022 will cost the City $2 million in direct payments and $4.5 million in indirect payments annually. GHG mitigation measures that focus on the reduction of fuel and electricity consumption will ameliorate some of the costs.
	4.1 If the City wishes to achieve their GHG emission reduction targets, which requires more efforts than the current programs/techniques, they will be significantly under-resourced. The FTE gap identified is related to actions and programs currently in place and proposed in the internal work plans.

Sub-project	Observation
3 (Data management analysis – Section 5 pages 32-33)	5.1 The GHG inventory is not currently fully utilized as a tool for supporting decisions. Deep decarbonization planning requires sophisticated, data-driven, and adaptive performance management. Many cities have designed robust data measurement and reporting systems as a crucial first step to supporting their strategies. Infrastructure, including software solutions, will be required to measure, track and report on progress of reducing carbon emissions. Having a strong, credible and transparent system for tracking carbon emissions and reporting on the actions of the City is an essential building block.
	5.2 At this time, there are limited resources allocated to the collection and reporting of the GHG inventory. The corporate reporting function has minimal visibility into how the data is captured and stored at its source. Controls used to ensure that the GHG data is complete, accurate and valid are informal and undocumented.

Appendix D: References

- OECD Economic Surveys Canada, June 2016
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- The Maple Leaf in the OECD, Canada's Environmental Performance, David Suzuki Foundation
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- International Local Government Emissions Analysis Protocol (IEAP), ICLEI October 2009
- PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol

Appendix E: Glossary

Biomass	Organic matter such as trees and wood products.
Deep Decarbonization	Climate action planning that includes deep reductions in carbon emissions. Generally understood to be 80% reduction of municipal emissions by 2050.
Grid Intensity	The amount of carbon dioxide equivalent emitted (kg CO_2e) per unit of electricity generated (kWh).
Plan, Do, Check, Act	Main elements of a management system approach.