1 Executive summary

A ROADMAP TO ACHIEVE THE OBJECTIVE OF NET ZERO ENERGY AND EMISSIONS

The Municipal Energy Plan will improve energy efficiency, and reduce energy consumption and greenhouse gas emissions in established and new community areas.

The City of Markham's Municipal Energy Plan is a comprehensive long-term city-wide energy plan that will improve energy efficiency, and reduce energy consumption and greenhouse gas emissions in established and new community areas. The MEP provides a roadmap to achieve the objective of net zero energy and emissions[1] by 2050 as outlined in the Energy & Climate priority in the Greenprint, Markham's Community Sustainability Plan. In order to identify the roadmap, the MEP explores a range of questions, including the following:

- How is energy used in the City?
- What are the factors which influence patterns of energy use?
- What are the greenhouse gas emissions associated with the use of energy?
- What are the financial implications of energy use?
- What are the opportunities for saving energy?
- What are the opportunities for reducing GHG emissions?

1 The MEP considers the impact on energy and emissions of pursuing net zero waste and water (included in Markham's Greenprint net zero objective), but does not include a strategy to achieve net zero waste and water, which is a separate effort.

The long term vision to reach net zero by 2050 is guided by

three main principles:

1. Decrease overall local energy consumption in all sectors;
2. Switch to low carbon renewable sources of energy; and,
3. Increase local energy generation from renewable sources.

These principles guided both the selection of actions and the manner in which actions were evaluated. The first priority is to reduce energy consumption, through reductions in energy demand and improvements in the efficiency of the energy system on both the supply and demand sides. The second priority is to switch from fossil-fuel-based energy sources to renewable energy. The third priority is to generate as much renewable energy as possible locally to maximize the local economic benefit and to ensure a resilient energy system. Remaining GHG emissions are then offset either by exporting renewable energy or storing GHG emissions in carbon sinks, preferably within the City boundary.

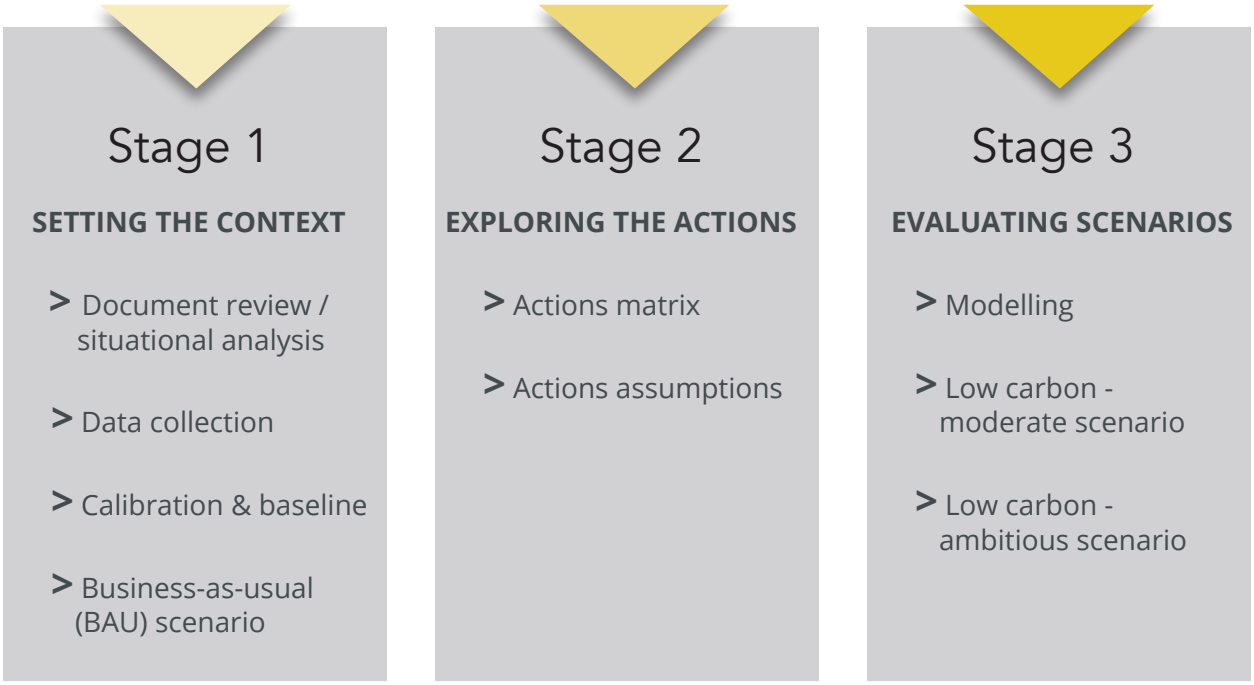

Figure 1. Process diagram

THE PROCESS OF DEVELOPING THE MEP

Stage 1: Setting the context

A **document review/situational analysis** was undertaken to understand the current context for energy and emissions in Markham. This process included a review of municipal, regional, provincial and federal policy on municipal energy and emissions; projected growth and demographic trends in various sectors; and, review of all plans, policies, programs, targets, actions, and initiatives currently planned, approved, funded and/or underway at all levels of government.

A process of **data collection resulted** in the development of a **baseline energy and emissions inventory** for the City for the year 2011.

Informed by the review/situational analysis and the baseline inventory, a **business-as-usual (BAU) scenario** was developed for the period from 2012 to 2050 to illustrate energy use and greenhouse gas emissions for the City of Markham, if no additional policies, actions or strategies are implemented.

Stage 2: Exploring the actions

The next stage involved the development of an **actions matrix**, a catalogue of actions based on research of best practices of municipal actions to reduce energy consumption and greenhouse gas emissions. The matrix was reviewed with City staff and refined, resulting in a list of actions relevant to the context of Markham. The identification of actions was informed by the results of the BAU, which provided insight on the major drivers of emissions in the City.

Modelling assumptions and parameters were developed for each action. These assumptions were derived from a detailed review of academic literature, and the application or modelling of the action in other cities. Initially, assumptions for one low carbon scenario were developed – the moderate scenario, which achieved an 80% reduction in emissions. After analysis of the initial results, a more ambitious low carbon scenario was developed in order to more closely approach the objective of net zero.

Stage 3: Evaluating scenarios

Stage 3 involved the **modelling and testing of the actions** to develop an integrated scenario. Two low carbon scenarios were developed and modelled for the period of 2016[2] to 2050. The types of actions do not differ between the two low carbon scenarios; the only differences are in the assumptions associated with the rate of application or the level of ambition for certain actions in order to approach the net zero energy emissions target.

The ambitious low carbon scenario results nearly achieves this target by 2050, with just 0.16 $MtCO_2e$ remaining. Additional strategies such as offsets or purchases of green energy are therefore required to fully achieve the net zero objective.

2 The model is calibrated with a 2011 baseline year; the BAU scenario was developed for the period 2012–2050, using observed data to calibrate to the year 2015. The low carbon scenarios, which explore the impact on future unobserved years, start in 2016.

ENGAGEMENT

A Stakeholder Working Group (SWG) was established in 2014 by the City of Markham to provide recommendations and feedback towards the development of Markham's Municipal Energy Plan through:

- Identifying energy opportunities and solutions to increase local energy production and conservation.
- Identifying synergies between industry stakeholders to implement MEP recommendations and actions.
- Providing input on MEP development and engage residents and the community.

The SWG were engaged through stages 1–3 noted above, providing input, feedback, and recommendations to inform the BAU and low carbon scenarios.

MODELLING

A detailed energy, emissions and finance model called CityInSight was used to evaluate scenarios for the City of Markham. The modelling process involved:

1. The development of a baseline for the year 2011, which is calibrated against observed data from the utilities and other sources;

2. The creation of the BAU scenario;

3. The modelling of actions to reduce GHG emissions;

4. The creation of 'moderate' and 'ambitious' low carbon scenarios (LC-mod, and LC-amb, respectively) which integrate the actions; and

5. The identification of targets.

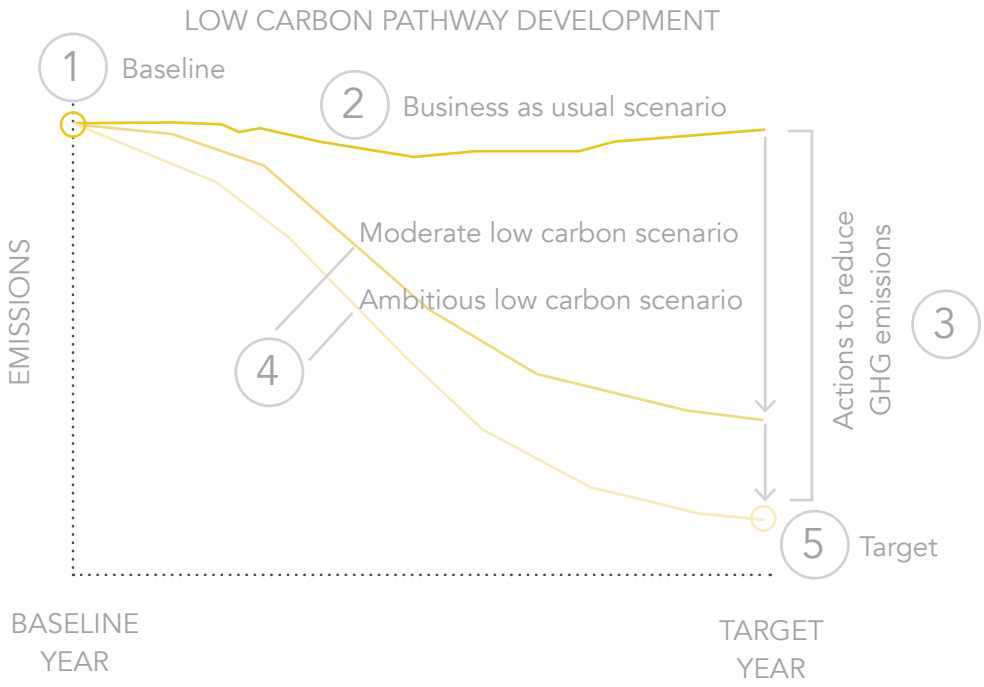

Figure 2. Steps used to model future scenarios for the City of Markham.

Energy and emissions in the baseline year

Total modelled energy consumption for the City of Markham for the baseline year 2011 amounts to approximately 29.69 Peta Joules. Buildings account for two thirds of energy use; with the remainder being consumed in the transportation sector. Natural gas is the most significant fuel type, accounting for 47% of total energy, followed by gasoline at 29%. Total GHG emissions for the City of Markham for the baseline year 2011 were 1.779 megatonnes of carbon dioxide equivalent (CO_2e). The buildings sector stands out as a dominant contributor to overall emissions, accounting for 49% of total emissions, followed by transportation at 37%.

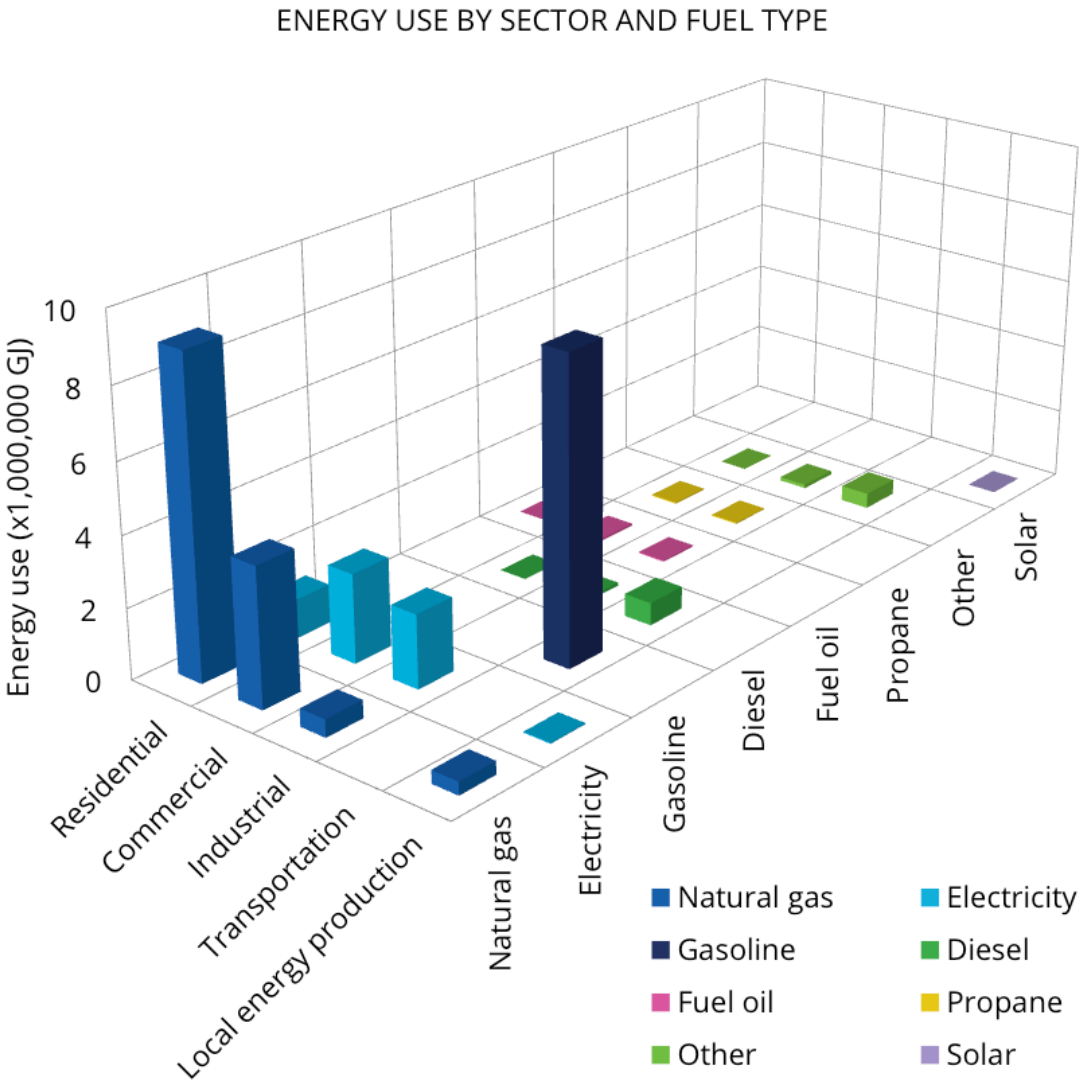

Figure 3. Total energy use by sector and fuel type.

Business as usual

While the population continues to grow, the BAU projections indicate that emissions have a slightly decreasing trajectory, from 1.78 $MtCO_2e$ in 2011, to 1.75 $MtCO_2e$ in 2050. The primary drivers for this reduction are reduced GHG emissions from electricity, improved vehicle fuel efficiency standards, a decrease in heating degree days due to a warming climate, ongoing retrofits of buildings and increasing numbers of electric vehicles.

Twenty-two actions were identified in the buildings, energy and transport sectors, including enhanced energy performance in new construction, retrofits of existing buildings, additional renewable energy both on buildings and on a larger scale, electrification of vehicles and enhanced mode shifting to walking, cycling and transit. The actions are described in Table 1.

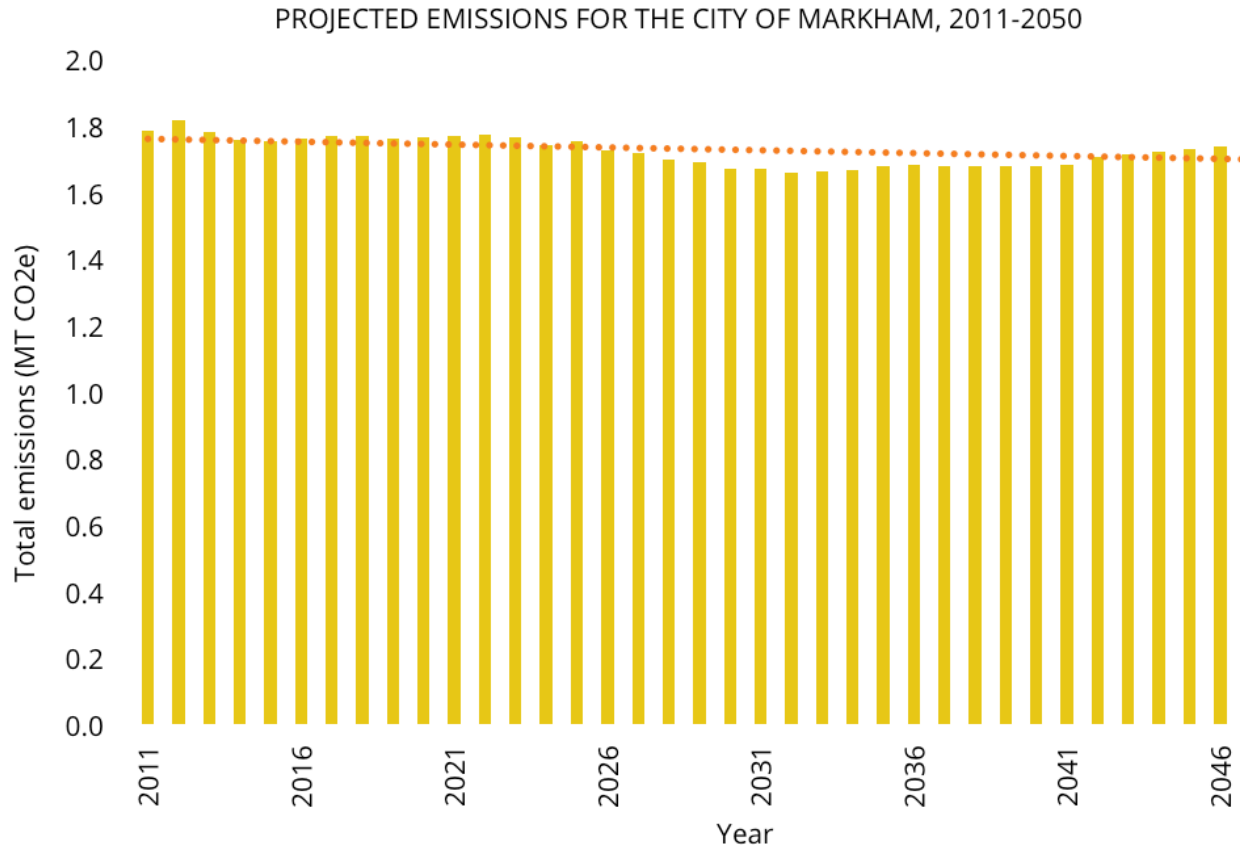

Figure 4. Projected BAU GHG emissions for Markham, 2011–2050.

THE LOW CARBON SCENARIOS

Two low carbon scenarios were developed. The first scenario, LC-mod, represents a major effort to reduce GHG emissions but was not sufficient to achieve the net zero energy emissions target. LC-amb is an ambitious version of LC-mod, with the same set of actions but more aggressive targets in order to achieve an outcome closer to the objective of net zero energy emissions by 2050. Table 1 provides a summary of the actions. For detailed assumptions related to the actions in the scenarios see Appendix 1.

The emissions descent pathways of the two low carbon scenarios over time are illustrated relative to the BAU scenario in Figure 5.

Table 1. Actions modelled in the low carbon scenarios.

BUILDINGS		LC-MOD	LC-AMB
NEW BUILDINGS - BUILDING CODES & STANDARDS			
1	Residential - New residential housing development targets net zero, including solar PV	✓	✓
2	Multi-residential (incl. condominiums), & ICI (institutional, commercial and industrial) - Passivehouse standard applied to multi-unit residential, commercial and institutional buildings	✓	✓
3	Renewable energy installation requirements or incentives on multi-res, commercial and institutional buildings	✓	✓
EXISTING BUILDINGS - RETROFITTING			
4	Retrofit homes prior to 1980	✓	✓
5	Retrofit homes after 1980	✓	✓
6	Retrofits in ICI sector	✓	✓
7	Retrofits of multi-residential	✓	✓
8	Re-commissioning of buildings	✓	✓
9	Renovation threshold requirement to meet codes and standard	✓	✓

RENEWABLE ENERGY GENERATION (ON-SITE, BUILDING SCALE)			
10	Installation of heat pumps: air and ground source residential	✓	✓
11	Installation of heat pumps: air and ground source commercial	✓	✓
12	Solar PV - Net metering all existing buildings	✓	✓
13	Solar heating/hot water	✓	✓
ENERGY GENERATION			
LOW OR ZERO CARBON ENERGY GENERATION (COMMUNITY SCALE)			
14	Solar PV - ground mount	✓	✓
15	Switch district energy to renewable natural gas		✓
16	Energy storage	✓	✓
17	Renewable natural gas		✓
TRANSPORT			
TRANSIT			
18	Electrify transit system	✓	✓
ACTIVE			
19	Increase/improve cycling & walking infrastructure	✓	✓
20	Car free zones	✓	✓
PRIVATE/PERSONAL USE			
21	Electrify personal vehicles	✓	✓
22	Electrify commercial vehicles	✓	✓

✓ LC-mod assumption

✓ LC-amb assumption (higher level of ambition than LC-mod)

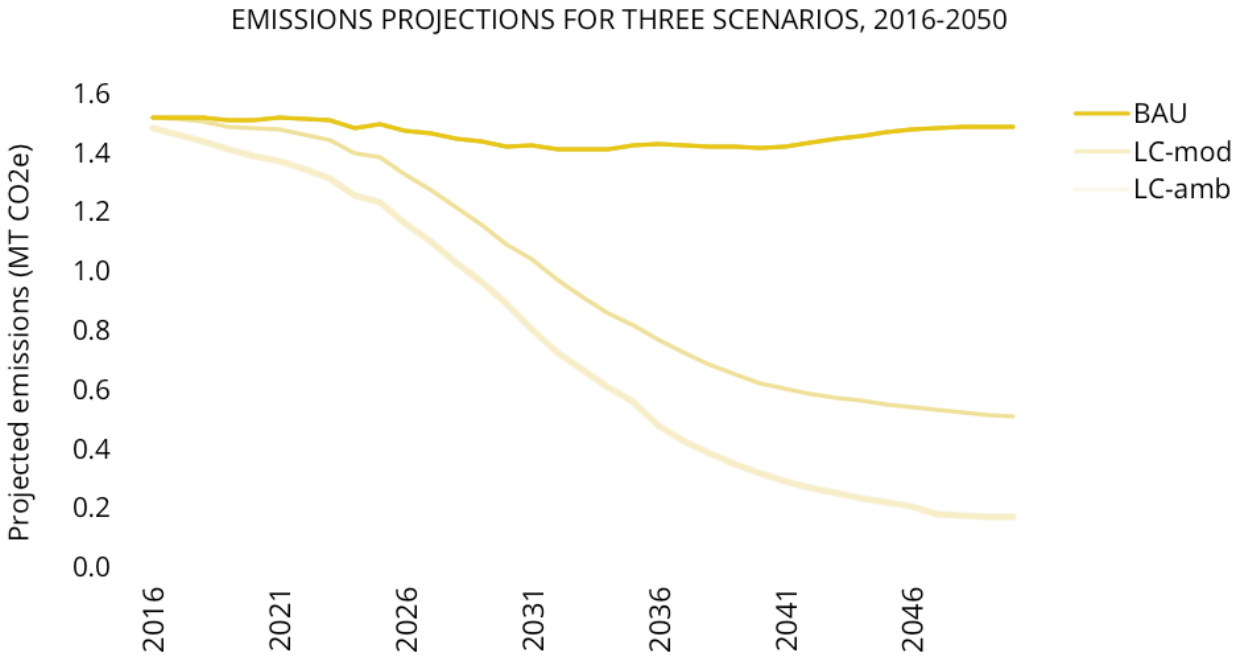

Figure 5. BAU, LC-mod and LC-amb projections, 2016–2050.

Table 2. Summary results of the scenarios.[3]

SCENARIO	2050 ($ktCO_2e$)	% CHANGE OVER 2011	2050 (tCO_2e/ CAPITA)	% CHANGE OVER 2011
BAU	1,478	-5%	2.55	-49%
LC-MOD	501	-68%	0.87	-83%
LC-AMB	162	-90%	0.28	-94%

3 Because of the focus of the net zero definition on GHG emissions from energy sources, GHG emissions from waste have been removed from these calculations.

THE FINANCIAL IMPACTS

A low carbon City is also a lower cost City.

Total expenditures were evaluated in each of the three scenarios, which include capital investments, operating expenditures and revenues in buildings, transportation and energy. A result of negative expenditures indicates that the low carbon scenario results in financial savings, whereas a positive number indicates an increase in expenditures over the BAU scenario.

The BAU scenario projects that a total of $120 billion will be spent on buildings, transportation and energy in the City of Markham between 2017 and 2050, including capital and operating expenditures. The LC-amb and LC-mod scenarios project savings of approximately $7 billion and $8 billion respectively over that same time period. This reduction represents the net of increased and decreased expenditures for households, businesses, the municipality and the energy sector, summed up year over year for the period.

By the year 2050, household energy costs for transportation and homes will decline by 60% on a per capita basis as a result of significant efficiency gains. Vehicle costs (excluding energy but including capital and maintenance) are another major source of savings; per capita vehicle costs will decline by two thirds by 2050 over 2016, as a result of a shared, electric vehicle fleet, which requires fewer vehicles and reduced maintenance.

The capital investments associated with the low carbon scenarios are more intensive in the early years, resulting in initial increases in expenditures of approximately $700 million between 2017 and 2027. This increase ranges from 1% to 5% per year over the background rate of expenditures on buildings, transportation and energy for the first ten years. By 2028, total expenditures are lower in both low carbon scenarios than in the BAU scenario, as illustrated in Figure 7. LC-mod's reduction is greater than that of LC-amb because of the more ambitious investment in heat pumps in LC-amb, required to achieve deeper GHG reductions.

The combination of the actions in the LC-amb result in a **DECREASE IN TOTAL EXPENDITURES** (capital and operating) in the buildings, transportation and energy sectors over the business-as-usual (BAU) scenario, of **$7 BILLION** between 2017 and 2050 in 2017 (constant) dollars.

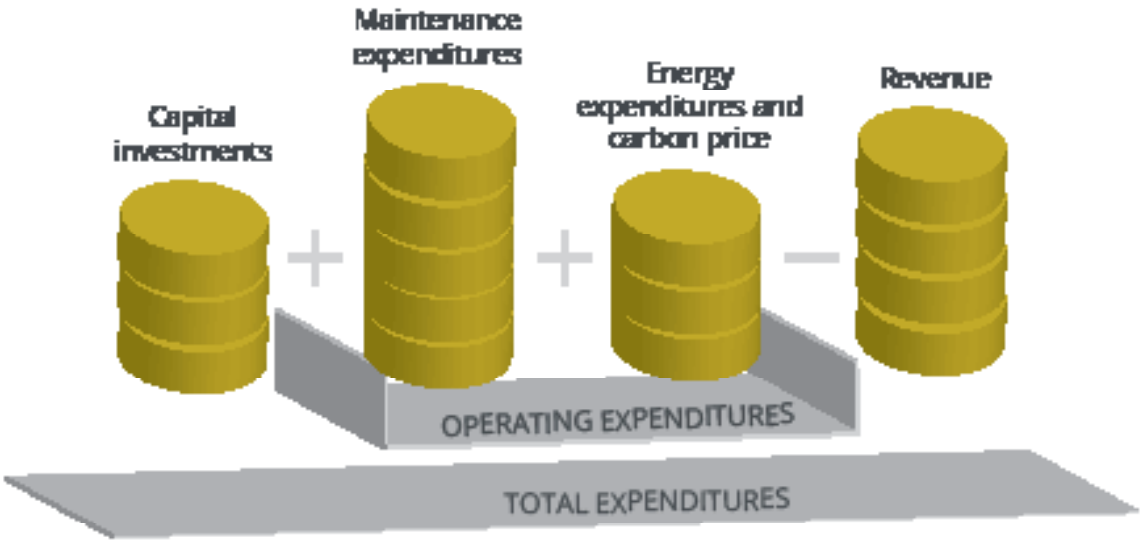

Figure 6. Framework used to evaluate the financial impacts of the scenarios.

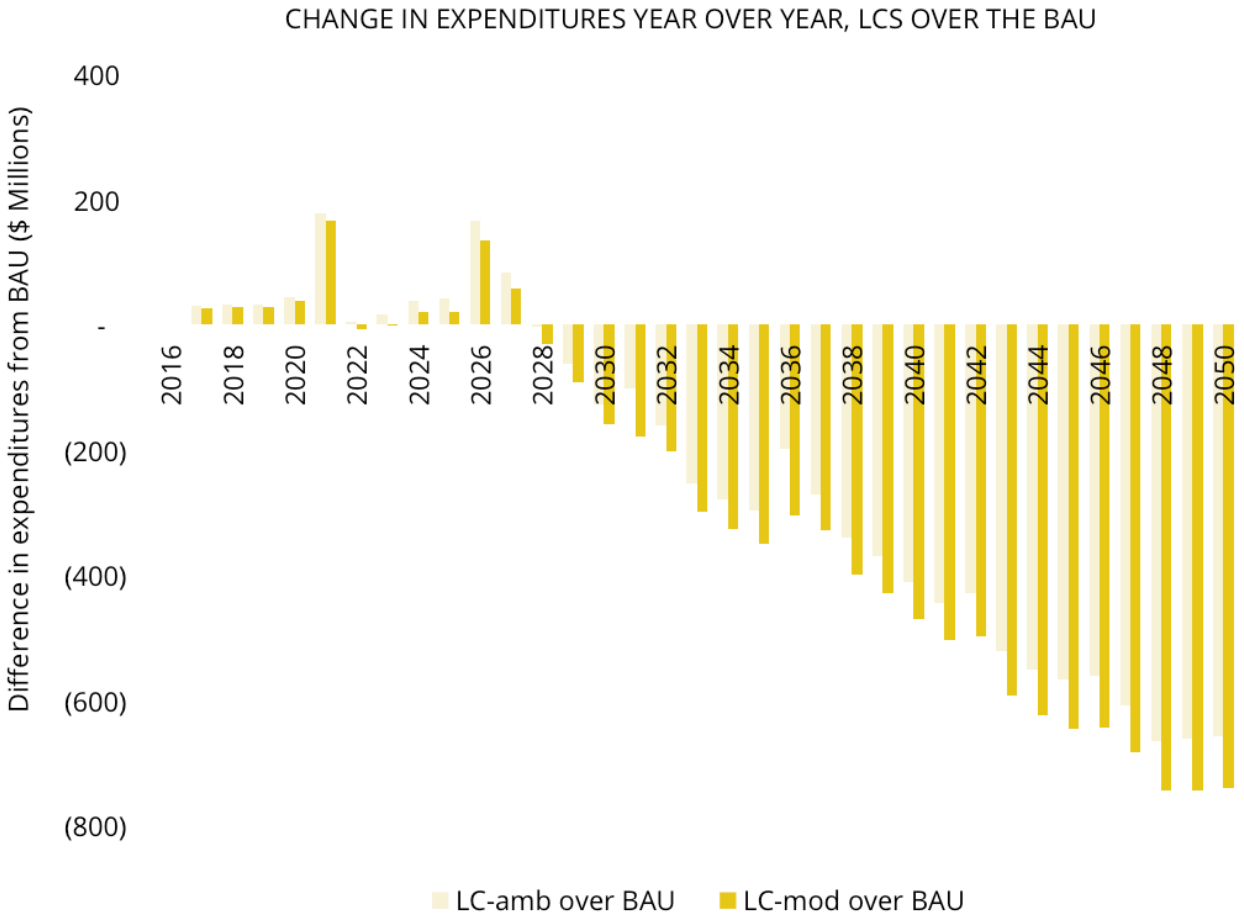

Figure 7. Expenditures in the LC amb and LC mod over the BAU.

The capital investments in LC-amb result in the creation of an additional 35,000 person-years of employment between 2018 and 2050, primarily in the building sector. Employment will decline in the automotive sector as fewer vehicles will be required, but this decline is projected to be offset by increased requirement for jobs in retrofits and decentralized renewable energy.

There are multiple business and investment opportunities for projects with a positive net present value (NPV) for the municipality, households and businesses. All but seven of the actions in the low carbon scenarios are projected to result in financial savings. Opportunities include residential and commercial building retrofits, residential and commercial solar PV, energy storage, shared, autonomous vehicles and financing programs. Businesses and residents are projected to benefit from reduced exposure to fluctuating energy prices in general and oil prices specifically.

Additional co-benefits associated with the low carbon scenario, such as reduced air pollution, reduced congestion and improved health outcomes have not been quantified, but will result in increases in social and economic welfare. Further, the benefits of increased resilience as a result of the investments in the energy system have not been quantified, nor has the benefit of avoided damage from climate change impacts. These aspects, even without quantification, further enhance the business case for the net zero target.

While the LC-amb scenario achieves significant emissions reductions, it does not fully achieve the net zero energy emissions target. In order to fully achieve the target, an additional expenditure on green electricity and renewable natural gas is required. Using a carbon offset strategy, the cost would be approximately $3 million in 2050; alternatively, purchasing green electricity would cost approximately $85 million in 2050. It is also possible that by 2050 advancements in technologies may facilitate the achievement of the target with carbon offsets or purchases of green energy.

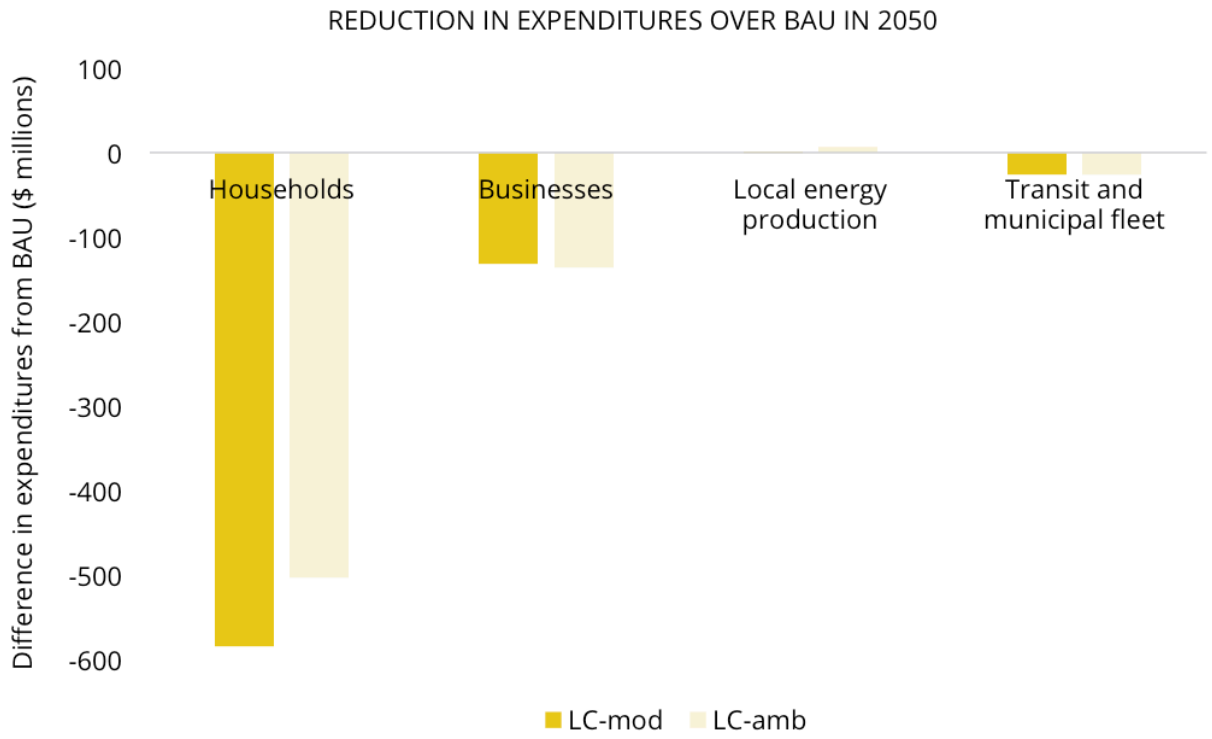

Figure 8. Total expenditures are lower in both scenarios for all sectors by 2050.

IMPLEMENTING THE ACTIONS

Each of the actions is supported by programs, capacity and a financing strategy, and in many cases, the same strategy can address multiple actions. A number of the programs build on existing efforts already underway by the City of Markham or strategies that have been implemented in other jurisdictions in Ontario. The recommend programs detailed on page 17 to page 21 are designed to launch the City of Markham on to the low carbon pathway lending to its achievement of the net zero energy emissions target.

THE PROGRAMS

Markham Green Standard

The Markham Green Standard (MGS) is a parallel effort to Toronto's Green Standard (TGS), which is currently being updated to require advanced building energy performance when approving zoning bylaw amendments, site plans and draft plans of subdivisions.[4] As part of this update, the City of Toronto has developed a specific pathway to net zero emissions buildings. The City of Markham can synchronize with that program both for energy performance and for other sustainability considerations.

The new version of the TGS uses a performance-based approach which incrementally increases over time, providing certainty to developers and the building industry. Additionally, the incremental costs for the standards were assessed for different building types and the incremental cost was 6% or less for each building type. The TGS includes three types of intensity targets – a total energy demand, a thermal energy demand, and GHG intensity – which apply to Part 3: Buildings. Part 3 buildings exceed 600 m2 in building area or exceed three storeys in building height.

It is recommended that Markham also establish targets for net zero energy for single family dwellings, which TGS does not cover. The City is currently working on a Net Zero Energy and Emissions pilot project which will help to inform the direction of the residential component of the MGS.

Markham High Performance Building Initiative

The Initiative will support building retrofits in the residential, commercial and industrial sectors as well as building recommissioning. Specific programs will be developed for each sector using the local improvement charge mechanism.

4 For details on the updated TGS, see The City of Toronto Zero Emissions Building Framework: https://www1.toronto.ca/City%20Of%20Toronto/City%20Planning/Developing%20Toronto/Files/pdf/TGS/Zero%20Emissions%20Buildings%20Framework%20Report.pdf

Markham Energy Co-operative

The City of Markham has expertise in solar photovoltaic (PV) and district energy. Building on this expertise, an arm's length energy cooperative can be launched with the mandate of achieving the renewable energy goals in the MEP. Designed as a multi-stakeholder cooperative, members can include the City, utilities, businesses and individuals.

Markham Electric Vehicle Strategy

The Electric Vehicle Strategy will be a multi-departmental coordinated effort by the City to support the increased uptake of electric vehicles. Strategies will include preferential parking rules, an enhanced network of appropriate charging stations, requirements for charging stations in buildings, and other supports.

Low Carbon City Planning

Many of the enabling conditions for low carbon strategies result from city planning. Wherever possible, the City should enhance its efforts to support land-use patterns focussed on complete, compact community design to enable district energy, walking and cycling, and frequent transit. The City has developed a terms of reference for community energy planning which aims to achieve these objectives at the scale of secondary plans.

Local improvement charge

The City of Markham can use Local Improvement Charges (LICs), further detailed in Appendix 7. LICs are a financing mechanism authorized by O.Reg. 322/12 under the Municipal Act, 2001 for building retrofits, and assuming that a future legal opinion identifies LICs are also applicable, for the cost increment of new construction of high performance houses and buildings over code. Additional funding can be raised through green bonds or climate bonds.

Table 3. Implementation mechanisms.

ACTION	PROGRAMS	CAPACITY	FINANCE	ENGAGEMENT
NEW CONSTRUCTION				
Residential - New residential housing development targets net zero, including solar PV	Markham Green Standard	City of Markham Planning	Local improvement charge (potential) +other incentives	Net zero engagement strategy
Multi-residential (incl. condominiums) & commercial and institutional - Passivehouse standard applied to multi-unit residential and commercial buildings				
Renewable energy installation requirements or incentives on multi-res, institutional, commercial and industrial buildings				
EXISTING BUILDINGS				
Retrofit homes prior to 1980	Markham High Performance Buildings Initiative	City of Markham, utilities	Local improvement charge	Net zero engagement strategy
Retrofit homes after 1980				
Retrofits in ICI sector				
Retrofits of multi-residential				
Re-commissioning of buildings			Utility partnerships	
Renovation threshold requirement to meet codes and standard	Markham Green Standard	City of Markham Planning	Local improvement charge	

ACTION	PROGRAMS	CAPACITY	FINANCE	ENGAGEMENT
RENEWABLE ENERGY GENERATION, BUILDING SCALE				
Installation of heat pumps: air and ground source residential	Markham High Performance Buildings Initiative	City of Markham, utilities, private sector	Local improvement charge	Net zero engagement strategy
Installation of heat pumps: air and ground source commercial				
Solar PV - net metering all existing buildings	Markham Energy Co-operative			
Solar heating/hot water				
LOW OR ZERO CARBON ENERGY GENERATION				
Solar PV - ground mount	Markham Energy Co-operative	Private sector	Green/ climate bonds	Net zero engagement strategy
Switch district energy to renewable natural gas	Markham District Energy Corporation	Markham District Energy Corporation		
Energy storage		Markham District Energy Corporation, private sector		
Renewable natural gas	Markham Energy Co-operative	Private sector	To be identified	

ACTION	PROGRAMS	CAPACITY	FINANCE	ENGAGEMENT
TRANSPORT				
Electrify transit system	Markham Electric Vehicle Strategy	City of Markham	Infrastructure funding	Net zero engagement strategy
Increase/improve cycling & walking infrastructure	City of Markham			
Car free zones				
Electrify personal vehicles	Markham Electric Vehicle Strategy	City of Markham, businesses	Non-financial	
Electrify commercial vehicles				

A COMMUNICATIONS PLAN

The MEP is an ambitious plan that requires the City to significantly enhance its efforts in new and existing spheres of activity. Community engagement will be a critical element in ensuring support and participation in these activities. An engagement effort has been designed to support the implementation of the MEP, including events, programs, pilot projects, online strategies and other aspects.

EVALUATING

Many of the policies and interventions in the MEP represent enhancement efforts in existing program areas. Tracking the effectiveness of these actions helps to manage the risk and uncertainty associated with these efforts, as well as external forces such as evolving senior government policy, and new technologies which can disrupt the energy system. Key motivations for monitoring and evaluation include the following:

- Identify unanticipated outcomes
- Adjust programs and policies based on their effectiveness
- Manage and adapt to the uncertainty of climate change
- Manage and adapt to emerging technologies

Specific activities which have been identified to support the implication of the MEP include an annual work plan and review, an annual indicator report, an update of the GHG inventory every two years and an update of the MEP every five years.

Table 4. Monitoring and evaluation activities.

ACTIVITY	PURPOSE	DESCRIPTION	FREQUENCY
1. ANNUAL WORK PLAN AND REVIEW	Review work to-date and set annual priority actions	Annual report with prioritized actions	Annual
2. ANNUAL INDICATOR REPORT	Track effectiveness of actions	Annual report on set of indicators with an analysis of the results.	Annual
3. INVENTORY	Update GHG emissions profile	Re-calculate the GHG emissions inventory	Every 2 years
4. UPDATE THE MEP	Update the MEP to reflect changing conditions	Work through each stage of the community energy and emissions planning process	Every 5 years

The MEP represents a detailed analysis of a pathway to achieve the net zero energy emissions target for the City of Markham. This pathway represents a transformation in the way in which energy is generated and used in the City, but the analysis demonstrates viable and realistic options. The pathway requires significant investment, particularly in the short term, but over the long-run results in financial benefits for households, businesses and the municipality. The actions and programs described require an enhanced effort by the City and new partnerships, building on efforts already underway.