Orillia's Climate Future

Our Community Climate Action Plan

SSG

Orillia's Climate Future

ORILLIA

Contents

Glossary of Terms

BAU: Business-as-Usual Scenario

BEV: Battery Electric Vehicle

CAFE: Corporate Average Fuel Economy

CBSC: Community Based Steering Committee

CEEP: Community Energy and Emissions Plan

DE: District Energy

EPA: Environmental Protection Agency

ESG: Environmental, Social, and Governance

EV: Electric Vehicle

FCM: Federation of Canadian Municipalities

GHG: Greenhouse Gas

GJ: Gigajoule

HV: Heavy-Duty Vehicle

ICI: Institutional, Commercial, and Industrial

IESO: Independent Electricity System Operator

IPCC: Intergovernmental Panel on Climate Change

J: Joule

kWh: Kilowatt hour

ktCO2e: Kilotonnes Carbon Dioxide Equivalent

LIC: Local Improvement Charges

MTSA: Major Transit Station Area

MW: Megawatt

NEB: National Energy Board

NZ: Net-Zero Emissions

O&M: Operations and Maintenance

OPG: Orillia Power Generation

OPO: Ontario Planning Outlook

PACE: Property Assessed Clean Energy

PJ: Petajoule

PV: Photovoltaics

RNG: Renewable Natural Gas

SCC: Social Cost of Carbon

tCO2e: Tonnes Carbon Dioxide Equivalent

TGS: Toronto Green Standard

TJ: Terajoule

UNFCCC: UN Framework Convention on Climate Change

WWTP: Wastewater Treatment Plant

ZEV: Zero Emission Vehicle

Acknowledgements

Land Acknowledgement

The City of Orillia would like to respectfully acknowledge that we are situated on the traditional territory of the Anishinaabe peoples, specifically the Chippewas of Rama First Nation, a member of the Chippewa Tri-Council, which includes the Chippewas of Beausoleil First Nation and the Chippewas of Georgina Island First Nation. These lands are covered by the Williams Treaties and the Upper Canada Treaties and were signed by our governments on behalf of the Anishinabek and Canadian peoples. We are thankful for the opportunity to honour and recognize the long and enduring presence of Indigenous Peoples - First Nations, Metis and Inuit - on this land. Their teachings and stewardship, culture and way of life have shaped our City's unique identity.

As we strive to foster a welcoming, caring, inclusive, and accessible community for all citizens, the City of Orillia is committed to helping our community understand, honour, and take action toward real Truth and Reconciliation through education and acknowledgement and moving forward with respect, harmony, and dignity for our Indigenous peoples of the past, present, and future.

Community Engagement Acknowledgement

The Community Based Steering Committee (CBSC) was formed with membership from a cross-section of residents, organizations, academic institutions and businesses in Orillia. Their participation, guidance, and feedback is gratefully acknowledged and is central to the creation of *Orillia's Climate Future*.

ORGANIZATION	MEMBER NAME
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Community Development Corporation	Carol Benedetti
Couchiching Conservancy	Mark Bisset
Duncor Enterprises Inc.	Rick Newlove
Enbridge Gas	Mary Sye, Municipal Energy Advisor
Environmental Advisory Committee	Tim Adamson Lee Hanson Rick Ruegg
Hydro One	Gillian Lind

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Lakehead University	Ellen Field, Assistant Professor Ledah McKellar, Sustainability Coordinator
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Project Team Acknowledgement

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Executive Summary

Executive Summary

"Orillia's Climate Future signals our community's commitment to deep and effective climate action. While the journey ahead is long, we have the drive and persistence to make it our reality."

Andrew Schell, General Manager of Environment and Infrastructure Services, City of Orillia

Climate change is the greatest long-term global challenge that human society faces. Greenhouse gas emissions (GHGs) from human activity are warming the planet, and the resulting changes in temperature and weather patterns are negatively impacting human health, infrastructure, livelihoods, and ecosystems.

The Paris Agreement, adopted by 197 countries in December 2019, aims to limit global warming to safe levels—that is, well below a 2°C increase, and preferably to a 1.5°C increase—above pre-industrial levels.[1] However, the world is not on track to meet this agreement. Despite a temporary decline in global emissions in 2020 due to the COVID-19 pandemic, the world is heading toward 3°C or more of warming.[2]

The City of Orillia is joining cities around the world in setting a target of net-zero emissions. Net-zero emissions is achieved when decarbonization of the economy reduces GHG emissions to as close to zero as possible, and remaining human-driven emissions are balanced by carbon sequestration using natural or technological means.

Two plans, the Corporate and Community Climate Change Action Plans, form *Orillia's Climate Future*. These plans identify a path to reduce community emissions by one-third (over 2018 levels) by 2030 and approach net-zero emissions by 2050.

For the City of Orillia, net-zero will be achieved by rapidly decarbonizing, thereby reducing GHG emissions from how people move around, how residents operate buildings, how goods are produced and manufactured, and how people consume and dispose of waste.

A Business-as-Usual (BAU) Scenario was developed for Orillia to project energy use and GHG emissions in the community between now and 2050, should the community continue on its current course of action. Orillia's BAU tells the story of a missed opportunity—for the climate, for economic development and innovation, and for community benefit. Because of the efficiency measures that are already planned, energy use and emissions only go up slightly despite the city's projected growth. While this future could obviously be worse, following the BAU trajectory

[1] United Nations Framework Convention on Climate Change. (2015) The Paris Agreement. Retrieved from: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[2] United Nations Climate Change (2021). New UNEP Synthesis Provides Blueprint to Urgentaly Solve Planetary Emergencies and Secure Humanity's Future. https://unfccc.int/news/new-unep-synthesis-provides-blueprint-to-urgently-solve-planetary-emergencies-and-secure-humanity-s

does not address Orillia's contribution to climate change, and forgoes all of the benefits associated with a decarbonized city.

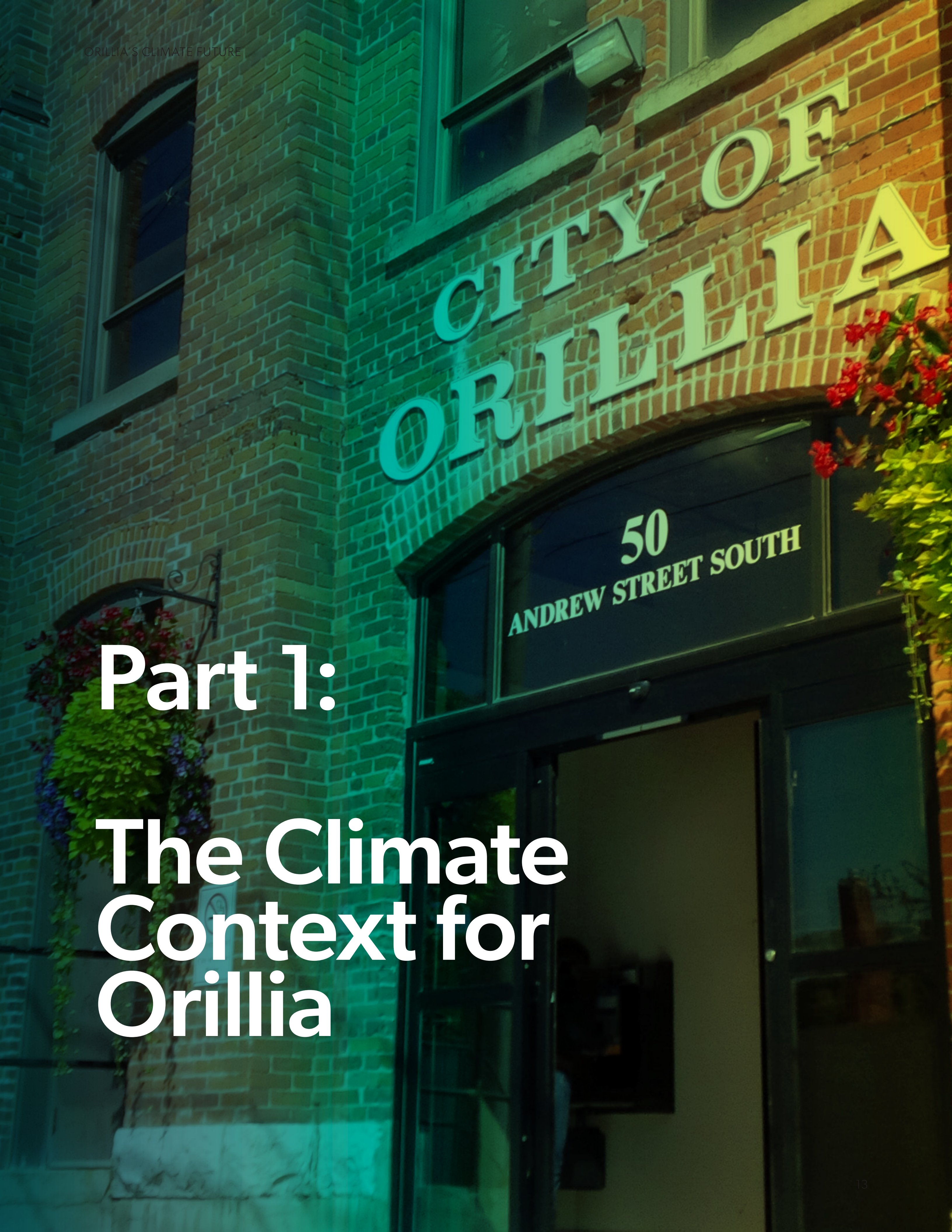
The Low-Carbon Pathway (LCP), which outlines actions that upgrade Orillia's energy systems, transportation, and buildings, is an opportunity to save emissions and energy, both of which have financial and non-market value. By 2030, every tonne of emissions saved avoids $170 in carbon taxes and every GJ of energy saved is valued between $15 and $60 (depending on the price of electricity, natural gas, and gasoline). Each tonne of GHG emissions avoided is one tonne less in the atmosphere that can cause extreme weather events and untold damage. Every GJ saved is energy that does not need to be produced or generated, saving land for biodiversity, agriculture, or parks.

Orillia's decarbonization actions are grouped into three Big Moves:

- **Big Move 1: Renewable Energy**
- Renewable energy replaces fossil fuel and non-renewable energy sources from the grid. Increased solar energy generating capacity gives the city more control over how it meets its energy needs.
- **Big Move 2: Transportation**
- Increased uptake of electric vehicles reduce emissions from driving, while investments in public transit and active transportation get more people in buses and on bikes.
- **Big Move 3: Buildings**
- Retrofitted existing buildings and high-efficiency new builds make for more comfortable homes that are cheaper to run and better for the climate.

The shift to a low-carbon future will take effort and dedication. But the rewards of the Low-Carbon Pathway go beyond decarbonization and lessening Orillia's contribution to climate change. More efficient homes and transportation decrease household energy costs, which are felt most keenly by low-income households. The City saves money that would otherwise be earmarked for carbon taxes. And new, good paying jobs are created as skilled people are needed to retrofit buildings, operate the improved transit system, and install and maintain the city's energy infrastructure.

Taking climate action will lead to a better life for the community of today and of tomorrow.



Part 1:

The Climate Context for Orillia

Part 1: The Climate Context for Orillia

This action plan shows that there is no one magic silver technology bullet to manage our GHG emissions; the solution, as shown, relies on a lot of smaller individual actions; some which we can take as individuals and some as a community. Climate change is a 21st century problem, and we have been trying to solve it with 19th century organizational setup; this CCAP shows that actions and crosscutting communications will be key to getting the results in a timely manner at the lowest cost. These plans are not going to be free, but as has been widely shown elsewhere, the cost of not doing anything will be far higher. These actions will help Orillia evolve into the sustainable community of the 21st century for the benefit of all of us. We can also translate these actions into our own areas of living.

Tim Adamson, member of the CBSC

1.1 A Global Threat; A Local Opportunity

Climate change is the greatest long-term global challenge that human society faces. Greenhouse gas emissions (GHGs) from human activity are warming the planet, and the resulting changes in temperature and weather patterns are negatively impacting human health, infrastructure, livelihoods, and ecosystems. As the planet warms, these impacts become more intense and more destructive in every region of the world, with disproportionate impacts on vulnerable people.[3]

Countries have agreed to a global, collective response. In December 2015, the Paris Agreement was adopted by 197 countries. The Paris Agreement aims to limit global warming to safe levels—that is,well below a 2°C increase, and preferably to a 1.5°C increase—above pre-industrial levels.[4] The Paris Agreement is a framework to help each country do its part.

However, the world is not on track to meet this agreement. Despite a temporary decline in global emissions in 2020 due to the COVID-19 pandemic, the world is heading toward 3°C or more of warming.[5] This degree of warming threatens human health, economic well-being, and the survival of the natural systems that humans and eight million other plant and animal species depend upon.[6]

We are increasingly at risk. Every year of delay adds to the cumulative amount of GHGs that will exist in the atmosphere. Every tonne of GHGs emitted comes with associated social and

[3] Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., ... & Ibrahim, Z. Z. (2022). Climate change 2022: impacts, adaptation and vulnerability.

[4] United Nations Framework Convention on Climate Change. (2015) The Paris Agreement. Retrieved from: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[5] United Nations Climate Change (2021). New UNEP Synthesis Provides Blueprint to Urgentaly Solve Planetary Emergencies and Secure Humanity's Future. https://unfccc.int/news/new-unep-synthesis-provides-blueprint-to-urgently-solve-planetary-emergencies-and-secure-humanity-s

[6] Ibid.

economic costs. Hesitation only increases the challenge of decarbonising and decreases the likelihood of a smooth transition (Figure 1).

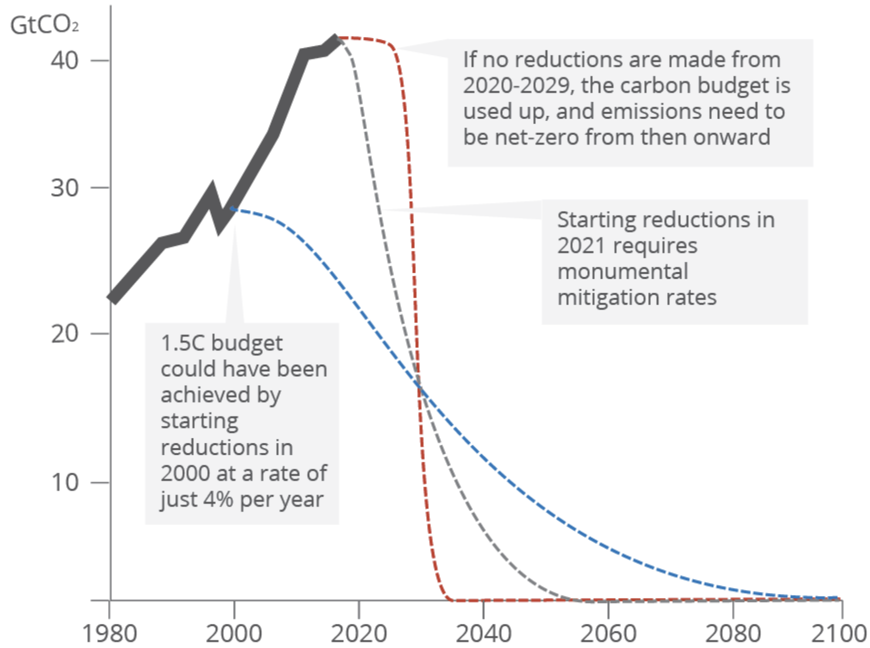


Figure 1. The risk of delay and the imperative to act . [7]

The Tragedy of the Horizon

"Climate change is the Tragedy of the Horizon," according to Mark Carney, former Head of the Bank of Canada and former Governor of the Bank of England. "The catastrophic impacts of climate change will be felt beyond the traditional horizons — beyond the business cycle, the political cycle, and the horizon of financial institutions like central banks. Climate risks are a direct function of cumulative emissions, so earlier action will significantly decrease the cost of future adjustments. As such, it is in society's best interest to restrict climate change to avoid global warming above 1.5°C."[8]

But there is a path forward. In May 2021, the International Energy Agency (IEA) released a milestone report titled Net Zero by 2050.[9] Globally, the IEA found that the path to net-zero is narrow. It requires massive deployment of all available clean energy technologies, including renewables, electric vehicles (EVs), and energy efficiency building retrofits between now and 2030. IEA's key findings echo those of the analysis in this report. The net-zero pathway will bring

[7] IPCC. (2018). Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. https://www.ipcc.ch/sr15/chapter/spm/

[8] Carney, M. (2015). Breaking the Tragedy of the Horizon – climate change and financial stability. bankofengland.co.uk/-/media/boe/files/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability.pdf?la=en&hash=7C67E785651862457D99511147C7424FF5EA0C1A

[9] IEA (2021). Net-zero by 2050. Retrieved from: https://www.iea.org/reports/net-zero-by-2050

jobs and growth, and they will stem from the necessary leaps in clean energy innovation and the rapid shift away from fossil fuels. Electricity will become the core of the energy system, and new low-emissions industries will flourish. Similar to the IEA, Orillia's Climate Action Plan describes a pathway to transform the energy system.

A low-carbon Orillia is a better city. Homes that are properly insulated and use heat pumps for heating and cooling are more comfortable and more affordable to run. Swapping gas- and diesel-powered vehicles for electric vehicles reduces air pollution, which results in less asthma in children and less COPD and other chronic diseases in the elderly. Additionally, increased walking, biking, and transit improves fitness, increases social interactions, and results in a more vibrant community.

The shift to a low-carbon future will take effort and dedication. But the rewards go beyond lessening Orillia's contribution to the climate crisis. Taking climate action will lead to a better life for the community of today and of tomorrow.

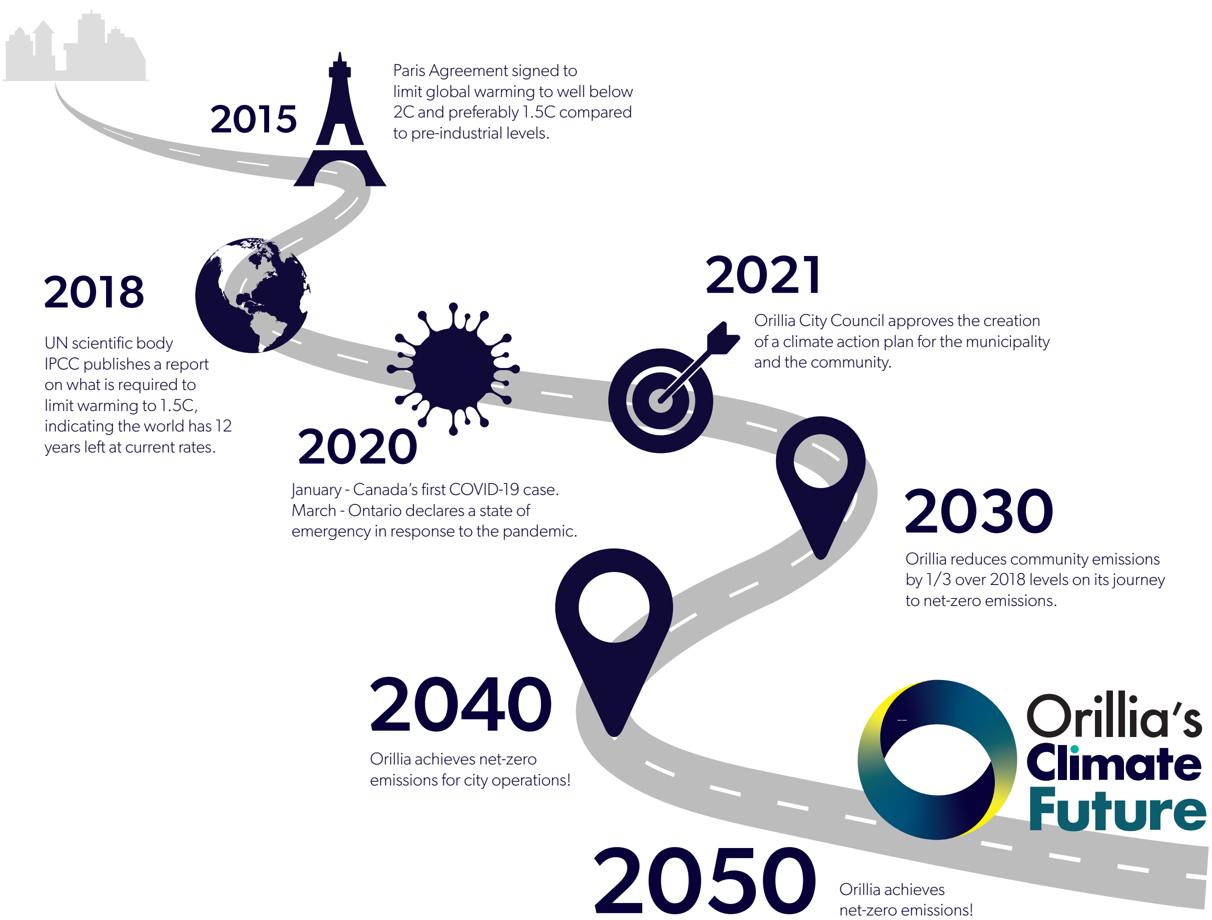


Figure 2. Timeline of climate action in Orillia.

1.2 How This Plan Came Together

"With this plan, the City is putting the building blocks in place to confirm Orillia as a net-zero community by 2050. 'Orillia's Climate Future' is a comprehensive sustainability initiative and its successful implementation will do much to ensure the quality of life in our community for all residents, present and future."

Susanne Laperle, member of the CBSC, Sustainable Orillia

Orillia's Climate Future identifies a path to reduce community emissions by one-third (over 2018 levels) by 2030 and approach net-zero emissions by 2050. The actions identified provide a foundation on which the City can build to achieve even greater emissions reductions in the future. This snowball effect helps maintain momentum as the City builds on its own successes.

This plan was developed through two complementary streams. Technical analysis calculated Orillia's energy and emissions makeup and projected how the City could shape the future. The engagement stream, led by the Orillia's Climate Future project team (composed of SSG and City of Orillia staff), sought out voices from the community to learn what residents would need from a climate plan. Four workshops were held with the Community-Based Steering Committee (CBSC) to introduce the technical aspects of the plan and gather their intelligence.

Additionally, the process integrated the expertise of representatives from the Environment and Infrastructure Services Department. Staff representatives were able to seek out and capture additional intelligence across all City Departments.Meetings were held with an internal technical committee of staff with representation from all major departments in the City of Orillia, and a presentation was made to the Mayor and Members of Council.

Table 1. Summary of engagement phases with outcomes.

ENGAGEMENT	DETAILS	OUTCOMES
1: The Process	Introduce the Internal Technical Committee (ITC) to the process that will form the CAP and the CCAP. Introduce the Community-Based Steering Committee (CBSC) to the process that will form the CAP and the CCAP.	ITC provided data and feedback on data gaps. CBSC drafted vision statements and co-designed the Town Hall.

ENGAGEMENT	DETAILS	OUTCOMES
2: Community and Corporate Targets	• The science-based target is introduced to both committees.	• The ITC and Staff Project Team provided input to shape the corporate climate target. • The CBSC recommended a carbon budget for the corporate plan, which was included. • The CBSC agreed with moving toward a science-based community target.
3: Roadmap to Net-Zero	• Review work completed by staff and SSG to create a pathway to net-zero by 2050. • Gain feedback on the pathway and what challenges or opportunities may be available.	• The CBSC, the technical staff committee, and Members of Council were able to review and provide feedback on the low-carbon assumptions. • Overall direction for the targets and how to shape the actions was also informed by the results of the city-wide survey and focus groups.

What is a Climate Emergency?

In January 2020, 11,000 scientists signed a report titled World Scientists Warning of a Climate Emergency.[10] The scientists indicated that climate change is more severe than anticipated, and that it threatens natural ecosystems and the fate of humanity. As of March 2021, 1,904 jurisdictions in 34 countries, including 15 national governments and the EU Parliament, had declared climate emergencies.[11] An emergency requires immediate action; it is a moment when one phones 911 to request urgent help. By declaring a climate emergency, governments at all levels are signalling that the situation is dire and urgent.

[10] Ripple, W., Wolf, C., Newsome, T., Barnard, P., Moomaw, W., & Grandcolas, P. (2019). World scientists' warning of a climate emergency. BioScience.

[11] Climate Emergency Declaration. Climate emergency declarations in 1,904 jurisdictions and local governments cover 826 million citizens. March 14, 2021. Retrieved from: https://climateemergencydeclaration.org/climate-emergency-declarations-cover-15-million-citizens/

1.3 Leading By Example: Modernizing the City's Buildings and Fleet

In 2021, the City of Orillia began a new climate action planning process to provide concrete climate policy and action recommendations as well as a target for GHG emissions reductions.

This planning process has resulted in comprehensive Corporate and Community Climate Change Action Plans, now known as Orillia's Climate Future. Together, these plans will enable the City to achieve the Partners for Climate Protection (PCP) Program[12] milestones 1 through 3 to reduce corporate and community-wide emissions.

The Corporate Plan establishes the City as a leader in climate action. By actively addressing the energy and emissions associated with its own buildings and vehicles, the City demonstrates its willingness to invest in tackling its share of the community GHGs.

The Corporate Climate Action Plan identifies a pathway to net-zero GHG emissions for City operations by 2040 that also meets the following targets:

1. Buildings

1.1 Existing buildings:

- By 2030, the City will reduce heating consumption by 50%, and by 2040, the City will reduce non-heating energy use by 20–50% through retrofit and renovation.

1.2 Recreational buildings:

- By 2030, the City will reduce energy consumption in arenas and swimming pools by 20–50%, and by 2040, the City will reduce GHG emissions in arenas and swimming pools by 100%.

1.3 Building heat consumption:

- By 2040, the City will meet all heating demands in corporate buildings using 100% clean electricity.

1.4 New buildings:

- After 2023, all new buildings will meet Passive House or equivalent according to the building type, and meet net-zero GHG standards.

2. Vehicle Fleet

2.1 Light-duty vehicles:

- After 2023, the City will purchase electric light-duty vehicles where available/possible, with the goal of solely purchasing electric vehicles by 2030.

2.2 Medium- and heavy-duty vehicles:

- The City will delay procurement of medium-duty pick-up trucks, where possible, until a new fleet of electric pick-ups are available in 2025.
- By 2025, the City will convert 100% of utility and maintenance ATVs to electric.
- By 2030, the City will convert 50% of heavy-duty vehicles (e.g. snow removal, dump truck) to electric or hydrogen-powered.

[12] To learn more about the Partners for Climate Protection Program, please see: https://www.pcp-ppc.ca/

- By 2040, the City will only procure zero-emissions vehicles (electric or hydrogen).

3. Clean Electricity

- By 2040, the City will develop the capacity to generate 6–8 MW of renewable energy or engage in another strategy to purchase renewable energy and/or its benefits.

Key Implication: Orillia's Corporate Carbon Budget

The Corporate CAP embeds the consideration of GHG emissions, capital and operating budgets, infrastructure planning, and fleet management.

In order to align financial and GHG management, Orillia will apply a carbon budget. Like a financial budget, the carbon budget aims to limit the emissions the City "spends." The carbon budget is designed to be applied in four-year intervals to line up with the City's financial budgeting process. The carbon budget assigns a cap of GHGs the City can emit in each four-year period. The suggested carbon budget, which is to begin in 2023, is provided below:

Table 2. Orillia's corporate carbon budget.

4-YEAR PERIOD	BUDGET (TCO2E)
2023-2026	7,084
2027-2030	5,465
2031-2034	3,643
2035-2038	1,700
2039-2042	121

Key Implication: City Budget

The transition to net-zero corporate emissions will require investments over and above what is currently allocated to the maintenance of current buildings and fleet. However, if retrofits are planned to coincide with building maintenance and upgrades already scheduled, then those costs can be reduced. For example, if a building façade needs to be updated in 2032 for structural or integrity reasons, then installing insulation at the same time would be less expensive than installing insulation at a separate time. Combining these efforts also limits the disruption to municipal staff and to the public. The CAP also identifies investments in renewable energy to ensure the availability of clean electricity by 2040.

The following table provides estimates of the investments needed to make Orillia's corporate operations net-zero by 2040. The bulk of the retrofits take place between 2031 and 2035, in order to allow the City to develop a program for the retrofits and maximise use of existing equipment. Expediting these retrofits would accelerate the reduction of GHG emissions and save on energy costs.

Table 3. Estimated total investment cost (2023–2040).

	2023–2025	2026–2030	2031–2035	2036–2040	TOTAL
Investments (in millions, $2018)					
Buildings	4.6	7.9	15.2	0.2	27.9
Fleet	3.7	3.4	2.7	2.5	12.3
Renewable Energy	4.5	6.1	1	1	12.6
Total Investment	12.8	17.4	18.9	3.7	52.8
Energy Cost Savings (in millions, $2018)					
Buildings	0.07	0.4	1.4	1.9	3.8
Fleet	0.25	1.2	1.8	2.1	3.6
Renewable Energy	0.6	3.1	4.6	5.1	13.5
Total Fuel Cost Savings	0.92	4.7	7.8	9.1	20.9

The estimates of energy consumption, GHG emissions, and selected financial flows (i.e. fuel costs, vehicle operations and maintenance (O&M) costs, carbon costs, capital investments) will inform and guide the City's efforts to reduce its corporate emissions and can support subsequent decision-making processes for specific buildings and vehicles.

The full Corporate Climate Action Plan can be found in Appendix D of the accompanying document.

1.4 The Risk of Inaction: A Missed Opportunity

A Business-as-Usual (BAU) Scenario was developed for Orillia to project energy use and GHG emissions in the community between now and 2050, should the community continue on its current course of action. The BAU assumes no additional GHG–reducing or low-carbon policies, actions, or strategies are implemented by 2050 beyond those that are currently approved and funded or underway.

Orillia's BAU tells the story of a missed opportunity—for the climate, for economic development and innovation, and for community benefit. It illustrates a relatively stable trajectory of GHG emissions in the community, increasing from approximately 320 ktCO2e in 2018 to almost 400 ktCO2e by 2050. Throughout the scenario, the transportation sector accounts for nearly half of community emissions, while emissions related to the operation of buildings make up most of the other half. Waste, agriculture, and fugitive emissions from the transportation and distribution of natural gas contribute marginally to overall community emissions.

Similarly, energy use increases slightly from under 6,100,000 GJ in 2016 to nearly 6,700,000 GJ in 2050. Throughout the scenario, the transportation sector is responsible for over 40% of community energy use while the buildings sector (residential, commercial, and industrial) makes up nearly 60%.

The Low-Carbon Pathway is an opportunity to save emissions and energy, both of which have financial and non-market value. By 2030, every tonne of emissions saved avoids $170 in carbon taxes. Moreover, experts estimate that each metric tonne of carbon emitted leads to $51 in social and economic costs globally.[13] Every GJ of energy saved is valued between $15 and $60 (depending on the price of electricity, natural gas, and gasoline).

Each tonne of GHG emissions avoided is one tonne less in the atmosphere that can cause extreme weather events and untold damage. Every GJ saved is energy that does not need to be produced or generated, saving land for biodiversity, agriculture, or parks.

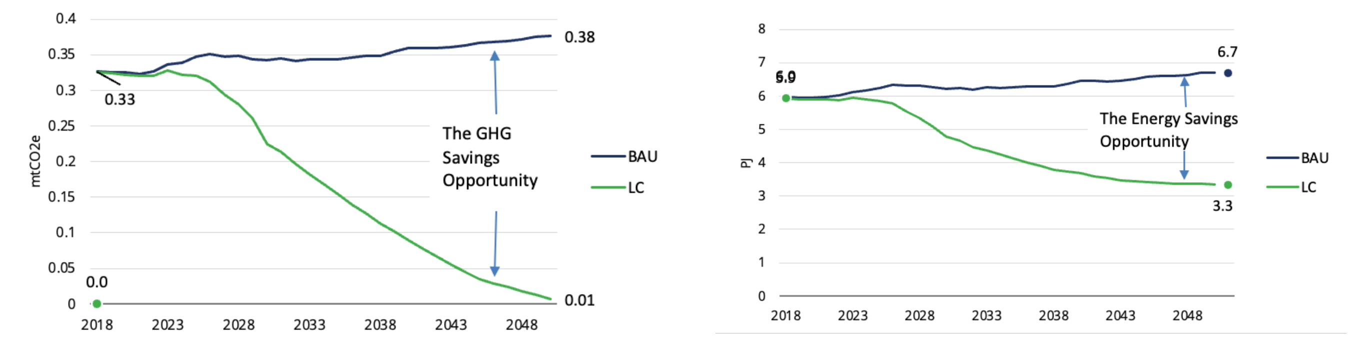


Figure 3. The opportunity of the Low-Carbon Pathway.

Orillia's Climate Future will help steer the community's policies and investments in a way that minimizes the economic risk and stimulates the transition to a green economy. Many of the investments that are identified will result in innovation, industry development, and job creation.

Lock-in and Latency

Many municipal planning decisions made today will still have environmental impacts 100 years from now. In the case of infrastructure investments and land-use plans, the environmental consequences continue for centuries. This leads to "lock-in" and a situation where past decisions limit the options and increase the costs for future decisions. In the context of community energy and emissions planning, this makes the longest-term decisions among the most urgent. It is also difficult to shift direction and build momentum, a concept known as latency. It takes time to scale up actions. For example, if the City develops a retrofit program, it needs to design the program, hire staff, negotiate financing, prepare legal agreements, secure contractors, develop a marketing and engagement approach, etc. It takes time for people to learn about the program, apply, be accepted, and arrange for implementation. Both latency and lock-in are reflected in the technical analysis; retrofit programs are scaled up incrementally, for example.

[13] Chemnick, J. (2021) Cost of Carbon Pollution Pegged at $51 a Ton. Scientific American. Retrieved from: https://www.scientificamerican.com/article/cost-of-carbon-pollution-pegged-at-51-a-ton/

1.5 Aiming for Zero

The City of Orillia is joining many other cities in setting a target of net-zero emissions. Net-zero emissions is achieved when decarbonization of the economy reduces GHG emissions as close to zero as possible, and any remaining human-driven emissions are balanced out by an equivalent amount of carbon removals. Carbon removals or sequestration can be achieved by restoring natural lands and soils or through direct air capture and storage technology.

For the City of Orillia, net-zero will be achieved by rapidly decarbonizing, thereby reducing GHG emissions from how people move around, how residents operate buildings, how goods are produced and manufactured,[14] and how people consume and dispose of waste.

Avoiding Delay: The Risk of the "Net" in the Net-Zero Target

In an influential article, three climate scientists described how net-zero targets were developed because climate models could no longer identify safe pathways with GHG reductions alone; the only viable pathways also require removal of emissions from the atmosphere.[15] They argue that these pathways are more theoretical than real as large scale carbon dioxide removal (CDR) technologies do not yet exist. As a result, a net-zero pathway can mislead by conveying opportunities for reductions where they may not exist. For this reason, the scenarios analysed for the City of Orillia focus solely on efficiency gains and emissions reductions, highlighting any remaining emissions as a gap that may need to be addressed using CDR or other strategies as they emerge.

Table 4 presents a checklist that provides an overview of the scope of Orillia's net-zero strategy evaluated in this analysis.[16]

Table 4. What does a net-zero target mean for Orillia?

QUESTIONS	RESPONSE BASED ON THIS ANALYSIS
Scope	
What global temperature goal does this plan contribute to (to stabilize global temperature or see it peak and decline)?	1.5°C
What is the target date for net-zero?	2050
Which GHGs are considered?	CO2, CH4, NO2

[14] While consumption-based emissions are not addressed in this analysis, the City of Orillia is seeking to influence these emissions through additional projects.

[15] Dyke, J., Watson, R., and Knorr, W. (2021). Climate scientists: Concept of net-zero is a dangerous trap. Retrieved from: https://theconversation.com/climate-scientists-concept-of-net-zero-is-a-dangerous-trap-157368

[16] Rogelj, J., Geden, O., Cowie, A., & Reisinger, A. (2021). Net-zero emissions targets are vague: Three ways to fix.

QUESTIONS	RESPONSE BASED ON THIS ANALYSIS
How are GHGs calculated (GWP100 or another metric)?	GWP100, GWP20
What is the extent of the emissions (over which territories, time frames, or activities)?	City of Orillia's geographic boundary, with some exceptions
What are the relative contributions of reductions, removals, and offsets?	To be determined
How will risks be managed around removals and offsets?	To be determined
Fairness/Equity	
What principles are being applied?	The City of Orillia aims to align with Science-Based Climate Targets: A Guide for Cities.
Would the global climate goal be achieved if everyone did this?	Yes
What are the consequences for others if these principles are applied universally?	Globally, cities with the highest levels of poverty would be allowed to increase their emissions to raise their populations out of poverty, while cities with lower levels of poverty would reduce their emissions.
How will your target affect others' capacity to achieve net-zero and their pursuit of other Sustainable Development Goals?	By minimizing the demand for scarce low-carbon resources such as renewable natural gas (RNG) and hydrogen, the pathway creates opportunities for less flexible sectors and jurisdictions to use these resources. The pathway will also help reduce costs for low-carbon strategies, which will have regional and international implications.
Roadmap	
What milestones and policies will support achievement?	This report details milestones against which to measure progress, but it does not identify specific policies.
What monitoring and review system will be used to assess progress and revise the target?	An annual climate lens and carbon budget is proposed.

QUESTIONS	RESPONSE BASED ON THIS ANALYSIS
Will net-zero be maintained or is it a step towards net-negative?	This analysis provides a pathway to net-zero that creates the possibility for going net-negative. However, net-negative strategies have not been evaluated as part of this plan.
Limitations/Opportunities for Additional Investigation	
Impacts on peak electricity demand	The impacts on peak demand and the electricity capacity required to support the demand was outside the scope of this analysis. Marginal emissions factors for electricity that result from using natural gas for peaks were also not assessed in the analysis.
Consideration of embodied carbon	The impact of equipment and materials production for the City of Orillia was not evaluated. The choice of materials can have a significant impact on the GHG profile of building retrofits. Additionally, the benefit of a walking trip is much greater when the embodied carbon in infrastructure and vehicles is considered.

Part 2:

Orillia's Low-Carbon Climate Future

Part 2: Orillia's Low-Carbon Climate Future

2.1 The Future Orillia Residents Want

At Orillia Soldiers' Memorial Hospital, we are driven by our shared purpose that we are a community that is committed to improving health and wellness. Orillia's Climate Future action plan is a significant step in support of this purpose. With focus on sustainable transportation and complete communities, the action plan aims to prioritize planning concepts that promote the health and well-being of our community.

Tom Roberts, VP Corporate Services & CFO, Orillia Soldiers' Memorial Hospital

Orillia residents voiced their opinions on Orillia's Climate Future through several engagement events. Each event—from the town hall (with keynote speaker and CBC Radio One host Bob McDonald) to community steering committee meetings, a city-wide survey, and focus groups with youth and equity-seeking groups—was designed to obtain their aspirations and concerns at each step of the climate action planning process. Residents were also asked for feedback on the assumptions used in the modelling process to produce the targets and actions found in Orillia's Climate Future.

There was widespread support for a science-based approach to align with the Paris Agreement—86% of respondents selected either strongly agree or agree in the city-wide survey.[17]

Residents were also asked to create vision statements to help guide the plan's implementation. Members of the CBSC drafted statements in the following six categories: community (overall visions for the community's future), economy, energy, green and blue spaces (natural areas), transportation, and waste. The vision statements were then included in the survey for broader feedback. These statements serve as a "North star" for the community as it embarks on a path to create a successful, vibrant, and equitable low-carbon future.

COMMUNITY VISION STATEMENTS[18]

1. We acknowledge climate justice as central to decision-making, and we strive to do our fair share to eliminate GHG emissions. Orillia's climate action will enact principles of equity, accessibility, diversity, and inclusion.
2. We will be a community that fosters community resilience to the impacts of climate change through mitigation and adaptation strategies.
3. We will be a community that meets the needs of current residents without compromising

[17] 245 residents took part in the survey. Of the respondents, 7.7% either disagreed or strongly disagreed, while 4.5% were neutral, and 1.6% needed additional information.

[18] 80.5% of respondents either strongly support or support the proposed community vision statements.

the ability of future residents to meet their needs.

ECONOMY[19]

1. The City of Orillia and the community will strive to achieve a sustainable circular economy that will protect the environment, drive future economic growth, and encourage green investment immediately.

ENERGY[20]

1. The City of Orillia and the community will reduce their energy use and strive to achieve 100% renewable energy and energy conservation before 2050.
2. The City will strive to fuel switch 100% of its heating sources ahead of 2050, choosing electric sources or non-emitting sources including green hydrogen.

NATURAL AREAS (GREEN AND BLUE SPACES)[21]

1. The City will increase its tree cover by 5% per year over the next 20 years. The natural landscapes will become a place of learning for all of Orillia's citizens.
2. The City will preserve, protect, and enhance a variety of connected green and blue spaces that are equitably distributed and accessible to all people.

TRANSPORTATION[22]

1. By 2050, the community will have a transportation system consisting of primarily zero-emission vehicles.
2. By 2050 Orillia and the community will have a transportation system featuring 50% or higher non-vehicle modes, which will contribute to zero emissions, a healthier population, and lower healthcare costs.
3. Orillia will focus the majority of development on building complete communities, prioritizing infill, and growing up rather than out after 2025.

WASTE[23]

1. The City of Orillia will achieve zero waste by 2050 through community-driven leadership, the development of a circular economy, regenerative agriculture practices, and education actions. The City will assist community members, businesses, and organizations who may struggle to reach these goals.

The list of engagement activities undertaken for this plan can be found in Appendix B of the accompanying document.

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[19] 84.% of survey respondents either strongly support or support the proposed economic vision statement.

[20] 75.9% of respondents either strongly support or support the proposed energy vision statements.

[21] 86.7% of respondents either strongly support or support the proposed natural areas vision statements.

[22] 71.8% of respondents either strongly support or support the proposed transportation vision statements.

[23] 77.2% of respondents either strongly support or support the proposed vision statement.

As the President of Sustainable Orillia and a resident, I recognize the role of the Climate Change Action Plan as a key determinant of sustainability for our Community. Also, both organizationally and personally, I have found participation on the Community Based Steering Committee informative and positive in terms of ensuring as broad a cross section of our community as possible, given the COVID restrictions we have faced, will have their views represented. I also think this process was a great way to inform and educate the community representatives.

Stan Mathewson , member of the CBSC, Sustainable Orillia

2.2 How Do We Decarbonize a City?

At a high level, the pathway and actions to decarbonize a city are well established and have been evaluated in cities across Canada. However, the specific mix of actions and rate of technology adoption varies from city to city, according to factors such as the existing building stock, the rate of growth, the character of the city's built environment, energy costs, the mix of local industry, etc.

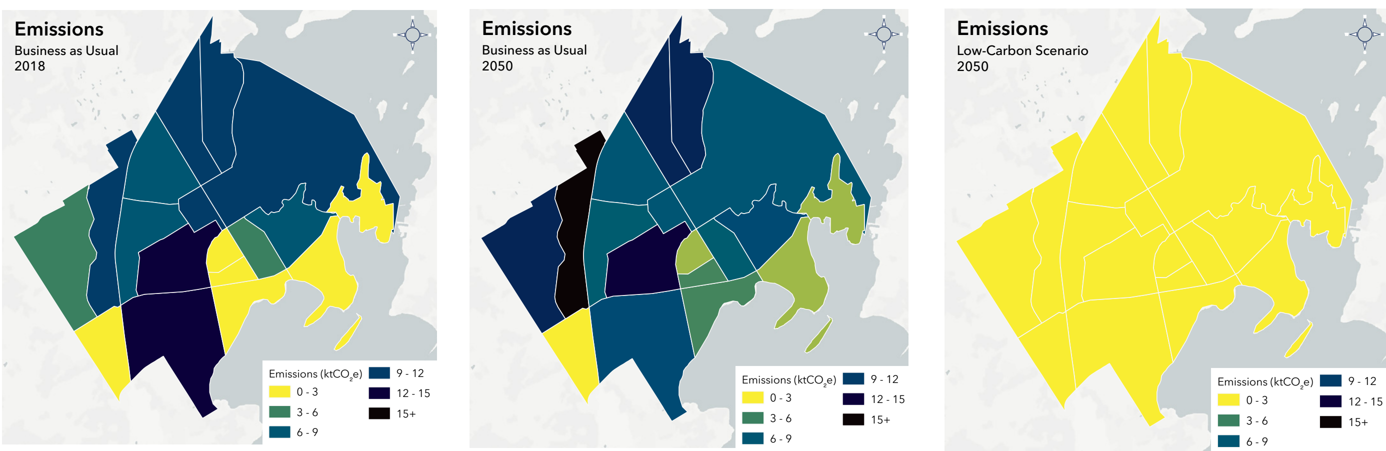


Figure 4. Emissions in Orillia, from 2018 (left), 2050 in the Business-as-Planned scenario (middle) and the Low-Carbon scenario (right).

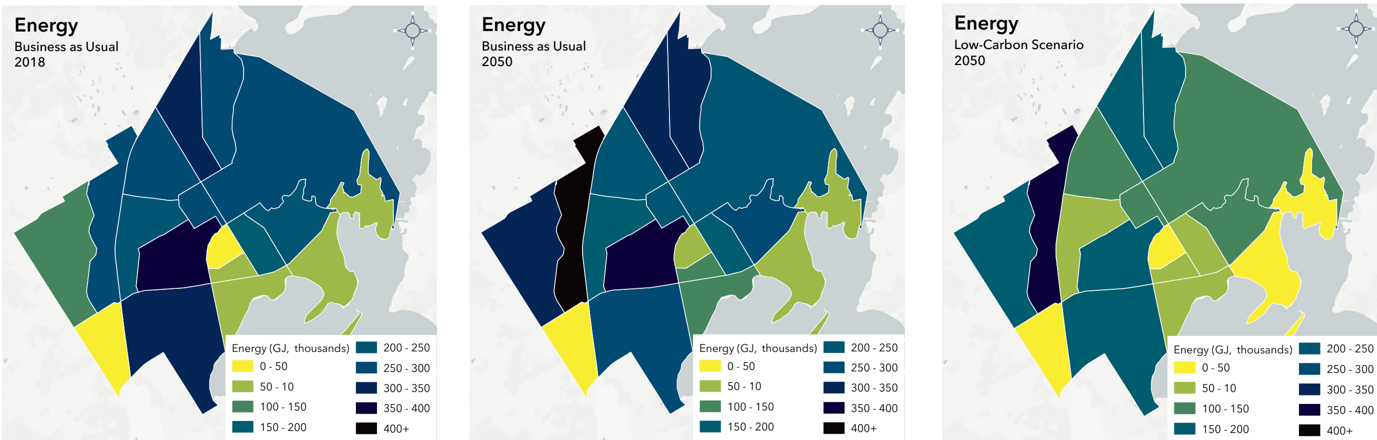


Figure 5. Energy in Orillia, from 2018 (left), 2050 in the Business-as-Planned scenario (middle) and the Low-Carbon scenario (right).

The Low-Carbon Pathway for Orillia is based on the hierarchy of the Reduce-Improve-Switch framework, a similar approach to Reduce-Reuse-Recycle (from the waste sector) and Avoid-Shift-Improve[24] (from the transportation sector). It focuses on the concept of reducing energy consumption and improving the efficiency of the energy system (supply and demand) and then fuel switching to low-carbon or zero-carbon renewable sources.

The energy system is complex, and so the application of the Reduce-Improve-Switch approach acts as a guide rather than a prescription. Many actions have cross-cutting impacts. For example, building retrofits can reduce the amount of energy required for space heating (through envelope improvements) while simultaneously improving the efficiency of the energy used in the building (through equipment upgrades). Additionally, solar photovoltaics (PV) could be installed on the roof, facilitating a switch to a zero-carbon renewable source. In general, whether it be buildings, transport, or waste, the objective is to first reduce the amount of energy needed by as much as possible (through reduced consumption and efficiencies) and then fuel switch away from fossil fuels to low- or zero-carbon fuel sources to supply the remainder of the demand.

Figure 6 illustrates the transformation of the energy system in Orillia across the relevant sectors, as well as showing a point-in-time comparison by sector and fuel. Fossil fuels are nearly phased out by 2050 (light and dark blue) and total energy consumption is more than cut in half due to efficiency gains in transportation and buildings. The energy system is electrified, using mostly locally generated electricity, and the remainder is provided by the provincial grid. The charts illustrating end-use highlight the importance of retrofits and the efficiency of the electric engine in limiting growth in electricity consumption as electrification occurs.

[24] GIZ. (2011). Sustainable urban transport: Avoid-shift-improve. Retrieved from http://www.sutp.org/files/contents/documents/resources/E_Fact-Sheets-and-Policy-Briefs/SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf

EMISSIONS | **ENERGY**

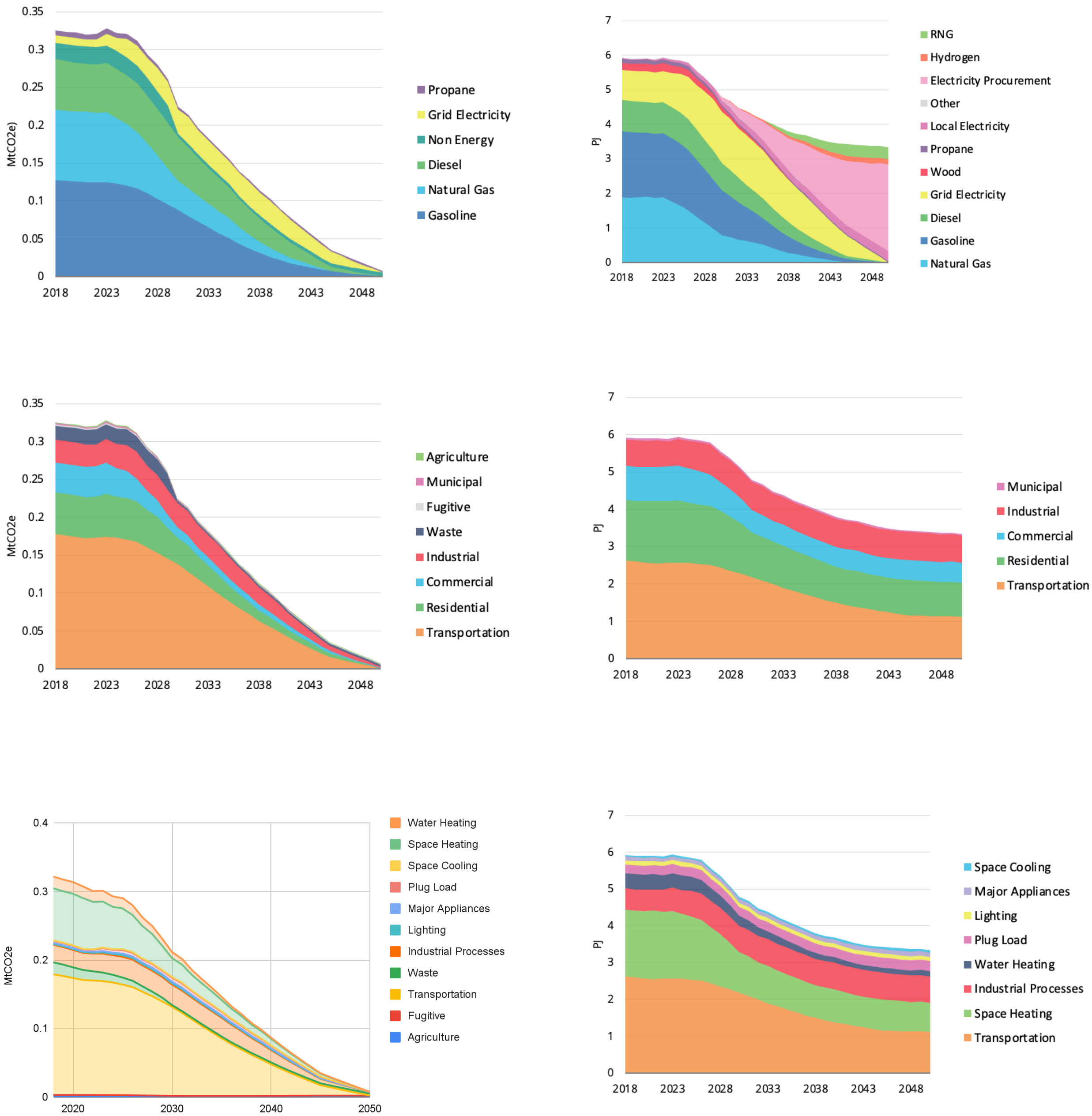


Figure 6. GHG emissions and energy by energy type, sector, and end-use (2018–2050)—Low-Carbon Pathway.

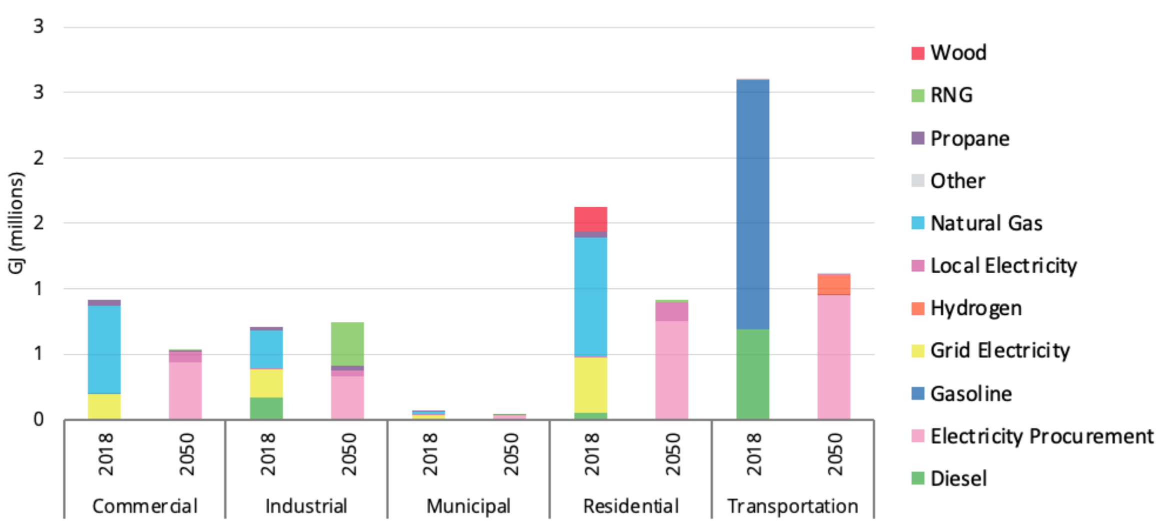


Figure 7. Total energy for NZ40, 2018 and 2050.

Managing population growth is one of the City's major issues. I see the City's Climate Change Action Plan helping to guide future development to preserve and enhance our green spaces, contribute to an active transportation network, and enhance our surrounding waterways. The City has an opportunity to be a leader in our fight against climate change by demonstrating, through their actions, a commitment to the plan. Policies need to be in place to ensure all development follows best practices, which will contribute to a reduction in greenhouse gas emissions. I want to live in a community where I can be proud of the steps we are taking to address climate change.

Lee Hanson, member of the CBSC

2.3 Efficiency First: The Negawatt

It is important to distinguish between the vital roles that reducing energy consumption (using less energy overall) and increasing energy efficiency (using the least amount of energy) play in a climate-friendly, low-carbon future.

Reducing electricity consumption is the top priority in the Reduce-Improve-Switch framework. Electricity that is saved or avoided is called a negawatt. Negawatts can be generated from behaviour changes or land-use and mobility patterns that result in walking or cycling rather than driving. Reducing electricity consumption also reduces peak load demands on utilities and makes the transition to renewable energy easier and more affordable.

The next important action is to "improve", which is another way to generate negawatts. This refers to maximizing energy efficiency improvements and can include building retrofits such as replacing windows and doors, adding insulation, and replacing heating systems with more efficient systems, such as heat pumps. It also includes moving from gas and diesel engine vehicles to electric vehicles, which have motors that are up to three times more efficient.

Electric or gas hot water systems can be replaced with heat pumps, and gas cooktops can be replaced with electric or induction stoves.

The final step in the Reduce-Improve-Switch paradigm is to switch to zero carbon electricity sources, such as rooftop solar PV, solar and wind farms, or off-site renewable energy obtained through power purchase agreements. The more negawatts that are "generated", the less zero-carbon electricity is required, which reduces both capital and operating costs for the electricity system, resulting in a triple-win situation.

Retrofits and Negawatts[25]

A key challenge of decarbonization is managing the impact of electrifying heating and transportation on peak electrical demand. While the analysis for Orillia did not evaluate the impact on peak demand on an hourly basis, an analysis of the aggregate impact of deep retrofits and fuel switching on a major portfolio of buildings in Ontario provides insight on the critical role of retrofits. When this portfolio is heated with natural gas, the electricity demand peaks at 70 MW on a mid-summer afternoon. After full electrification and retrofitting, these same buildings peak at 74 MW on a winter morning when the buildings are ramping up for the workday. Improving the thermal envelope—the insulation and window upgrades—keeps the peak from being much higher as a result of the electrification of heating. Retrofits generate energy savings for homeowners and businesses, but the uncounted dividends are the negawatts that can be used to power heat pumps without requiring major investments in the electrical grid.

2.4 Orillia's Big Climate Moves

As a proud member of the Orillia community that recently renewed our own commitment to environmental accountability in our strategic plan, Georgian College is pleased to see the City of Orillia's new Climate Change Action Plan. Energy, water, and waste reduction targets are critical in combating climate change and together, we can develop impactful plans that lead to meaningful change for all.

Dr. Mary Louise Noce, Dean, Orillia Campus, Georgian College, member of the CBSC

The Big Moves are the focal points for major emissions reductions in the community and the major drivers in Orillia's Climate Future. This plan identifies the following three Big Moves:

Big Move 1: Local renewable energy: Solar panels are installed on new and existing buildings during construction and retrofits, respectively. Additional renewable energy is procured at the community scale through local power purchase agreements and renewable energy credits.

Big Move 2: Transportation: In line with federal targets, all new light- and medium-duty vehicle purchases will be electric by 2035. Transit ridership will increase 10-fold by 2050 and will double for short trips.

[25] Ibid.

Big Move 3: Buildings: The vast majority of buildings in Orillia will undergo deep retrofits to improve efficiency and reduce energy demand. New buildings will be built to increasingly efficient standards, with all new buildings meeting net-zero standards by 2030. All buildings will install efficient electric heating and cooling systems.

In addition to these Big Moves, this plan identifies the following additional moves to make the transition to net-zero emissions a success for the municipality and community: waste and governance. The details of these moves are discussed in the sections that follow.

Implementing the Actions: A Complete Package

Every action modelled for this plan must be implemented to reach the net-zero target. Even small actions can play a critical role in bringing the whole plan together. For example, maximizing building solar PV is a high-cost investment that will not greatly reduce GHG emissions in itself. However, if Orillia invests in its own solar energy capacity, then the city can transition transportation and heating from fossil fuels to electric systems without relying so heavily on Ontario's dirty electricity grid (see Figure 11 for more details on the Ontario grid). So, this action with a seemingly small impact on GHG emissions unlocks a suite of opportunities to move away from high-emissions fuel sources and reduce GHG emissions in other sectors. It also gives Orillia control over its own electrification strategies rather than waiting for major upgrades to the grid.

Safe Bets Versus Wild Cards[26]

The Canadian Institute for Climate Choices defines safe bets as emission-reducing technologies and solutions that are already commercially available and face no major constraints to widespread implementation. Wild cards are solutions that may come to play a significant and important role on the path to net-zero, but whose ultimate prospects remain uncertain. The actions explored in Orillia's Climate Future are primarily safe bets. Given the Canadian and European governments' emphasis on green hydrogen,[27] a limited deployment was modelled to explore the implications of hydrogen relative to electrification and to position Orillia to take advantage of green hydrogen if this becomes a viable option.

[26] Ibid.

[27] Government of Canada. (2020). The Hydrogen Strategy. https://www.nrcan.gc.ca/climate-change/the-hydrogen-strategy/23080

2.4.1 THE LOW-CARBON PATHWAY: BY WEDGE (ACTIONS) AND WATERFALL (CUMULATIVE REDUCTIONS)

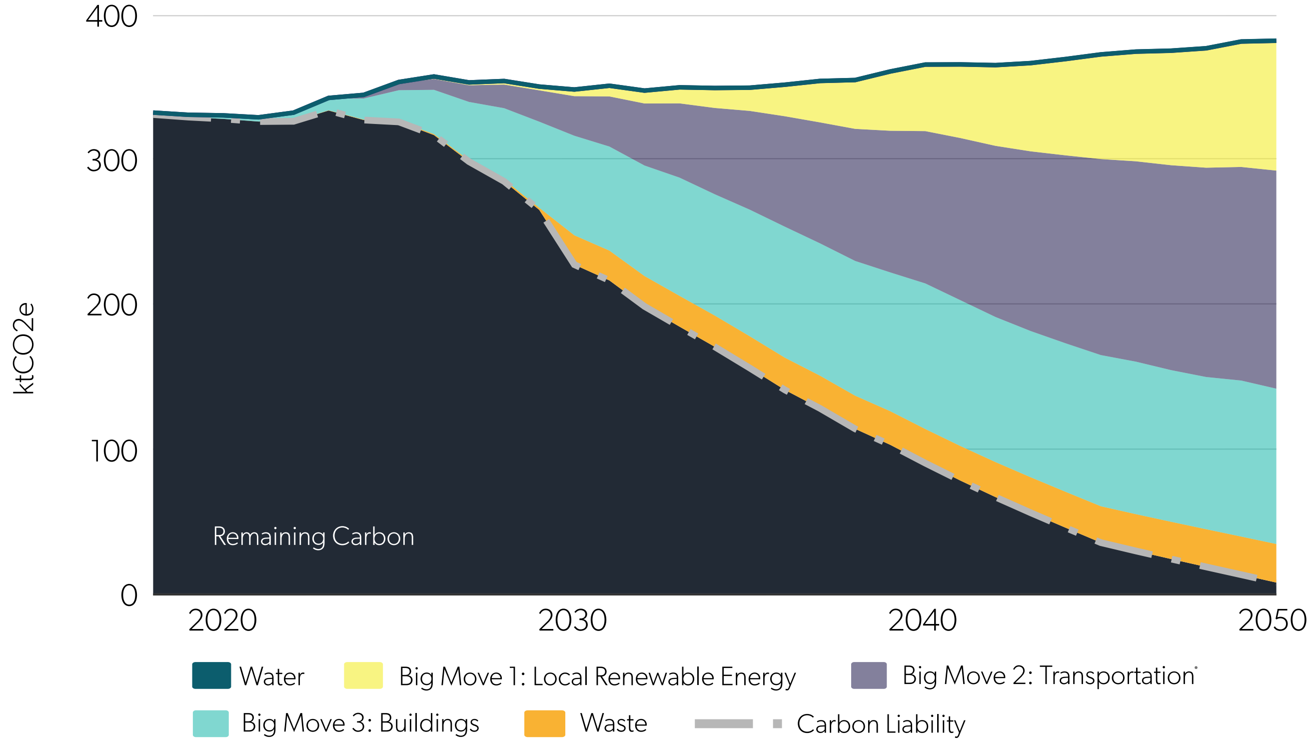
The following two figures (figure 8 on the following page) illustrate the story of Orillia's Low-Carbon Pathway.

The first, called a wedge diagram, groups the emissions reductions effects of all actions in each Big Move and the additional moves over time. Each colourful wedge shows how much impact each Move will have on reducing emissions from the business-as-usual scenario. The grey area at the bottom of the graph shows the remaining carbon emissions. By the time the graph reaches 2050, the grey area has shrunk to almost nothing, and this is a reflection of the small amount of emissions left at the end of the low-carbon pathway.

The second figure is a waterfall graph. Generally, this type of bar chart shows the story of how something changes from a set period in time, in much the same way as a "before and after" photo. The bar on the left is the starting point, or the "before" setting. The bars in the middle show change over time. The bar on the far right shows the final "after" setting. In Figure 8, the bar on the left shows Orillia's total cumulative emissions of 10,400 ktCO2e for 2022-2050 if the city were to follow the business-as-usual scenario. That's Orillia's "before" setting. Each of the middle bars shows the emissions that are removed from that total in each time period if the community follows the low-carbon pathway. So, for the period of 2022-2025, the emissions only go down by a small amount. But in each of the following time periods, the bars show a more significant change.

The final bar shows Orillia's cumulative emissions from 2022-2050 if the city follows the low-carbon pathway and carries out all of the actions. That's the final "after" picture.

There are two main take-aways in this figure. One, by implementing all of the actions, Orillia cuts its contribution to climate change by more than half. That's a significant change. Two, the actions with the biggest impacts take a long time to get going. Taking action now means the steepest reductions will not be visible until 2040. Change will feel slow at first and that may be discouraging. But with patience and dedication, the city will build momentum and reach its goals.



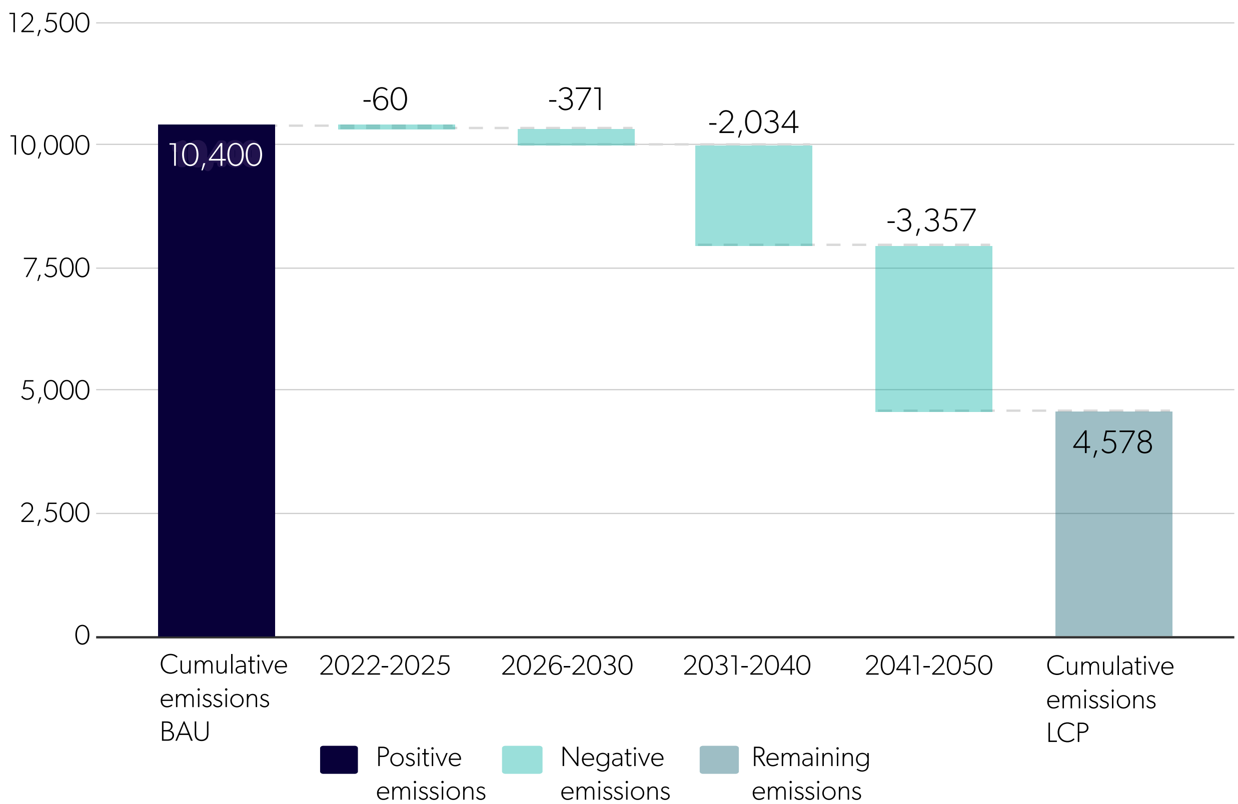


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Figure 8. Two views on the low-carbon pathway—by Big Move (wedge) and by cumulative emissions (waterfall).

Table 5. The impact of the Big Moves.

	GHG REDUCTION BY BIG MOVE (KTCO2E)			
	2022-2025	**2026-2030**	**2031-2040**	**2041-2050**
Remaining Emissions	1,313.2	1,392.4	1,500.2	372.6
Big Move 1: Local Renewable Energy	2.4	13.4	228.3	720.3
Big Move 2: Transportation	6.4	84.4	711.2	1,343.1
Big Move 3: Buildings	49.9	248.7	873.2	1,039.9
Waste	1.0	24.4	220.9	252.7
Water	0.0	0.1	0.3	0.6
Total reductions	60	371	2,034	3,357

Table 6. Explanation of Action table categories.

ACTION	LOW-CARBON PATHWAY OBJECTIVE	RECOMMENDED NEXT STEPS	POTENTIAL PARTNERS	MUNICIPAL ROLE
Number and name of the program or action recommended.	Identifies the sector or asset being addressed to achieve the low-carbon scenario (as modelled).	Identifies which of the following for consideration in implementation: **Program/Process:** An ongoing activity undertaken by the municipality that demonstrates leadership and/or feasibility to the community with staff and financing to support the effort. **Policy:** A policy developed by the municipality, and approved by Council. **Initiative:** A study or project, undertaken by the municipality, private sector, not-for-profit sector, or other sectors, individually or collaboratively, with a specific focus, that is implemented for a set time period. **Infrastructure:** Investment in physical infrastructure by the municipality.	Identifies potential partners for implementation of the action.	Describes the municipality's role in action implementation.

Table 7. Explanation of the Outcomes tables.

LOW-CARBON PATHWAY OUTCOMES	GHG IMPACT (CUMULATIVE REDUCTION) KT	GHG EMISSIONS REDUCTIONS RATING	COST RATING	INCREMENTAL SOCIETAL CAPITAL COST ($, 2018, UNDISCOUNTED)	REPORTING METRICS	TIMING
Describes the end-state of the action associated with the low-carbon pathway.	Cumulative number of GHG emissions reductions in kilotonnes.	Describes the cumulative GHG emissions reduction impact for each action, compared to the business-as-planned scenario **Low:** <100 kt - **Medium:** 100-500 kt **High:** 500+ kt	**$:** <$1,000,000 **$$:** $1,000,000-$25,000,000 **$$$:** $25,000,001-$50,000,000 **$$$$:** $50,000,001-$100,000,00 **$$$$$:** >$100,000,000 Costs and Savings are Relative to the Business-as-Usual Scenario: The financial analysis tracks projected costs and savings associated with low-carbon measures that are above and beyond the assumed business-as-usual costs and investments.	Lists the capital cost, in $2018, and the financial return.	The method and measurement unit for measuring the impact of the action taken. All metrics should be analyzed on an annual basis for those that are being actively implemented.	Recommended start and completion date for the Action. *Start date denotes when planning for the action Begins.

The City of Orillia's Climate Action Plan is an excellent example of how communities play a vital role in the transition to a clean energy future. Each has a unique opportunity to approach net-zero from a different perspective, and we see this in how Orillia is leveraging its own innovation, strengths, infrastructure, industries, and services to reduce its carbon footprint. As an energy leader, Enbridge Gas is pleased to partner with the city on conservation initiatives and can provide communities with guidance and expertise. Additionally, we invest in low- and no-carbon clean energy solutions including hydrogen, hybrid heating systems, renewable natural gas, and geothermal with great success. We believe that in working together, doing what we can, when we can, at every level and from every angle, we will achieve our collective goal. Congratulations to the Orillia community for taking this important step for climate action.

Enbridge Gas, member of the CBSC

2.5 BIG MOVE 1: Generating Renewable Energy: Solar for the Sunshine City

2.5.1 Overview

This section outlines the actions associated with Big Move 1: Generating Renewable Energy, and the impacts these actions will have on reducing emissions in Orillia's low-carbon future.

Each colourful wedge in the figure below shows the GHGs Orillia will not emit because of that wedge's actions. In this particular diagram, the actions associated with Big Move 1 are broken out and displayed individually. For context, the combined impacts of Big Moves 2&3 are also included.

The grey slope at the bottom are the GHGs still being emitted in each year. By 2050, the combined actions will have addressed nearly all of Orillia's emissions.

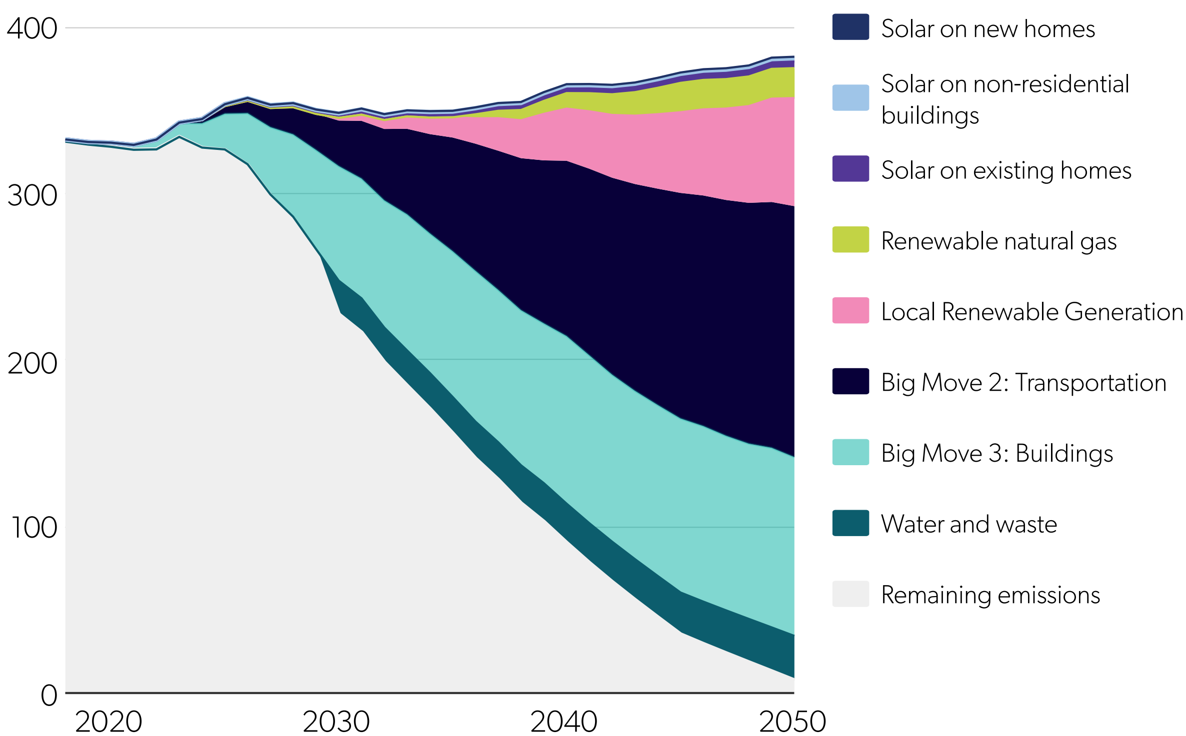

Figure 9. Big Move 1 renewable energy wedge.

Renewable energy replaces fossil fuel and non-renewable energy sources from the grid. The renewable energy actions recommended for the community Climate Action Plan mirror those recommended in Orillia's corporate plan and include the following:

1. **Local Generation:** Local renewable energy generation on individual homes and properties would provide the greatest financial and economic benefits for the community. Local generation involves building and maintaining solar PV on roofs and other sites. Solar power does require an initial capital investment and its use is governed by provincial policy.

Why Solar?

Solar is a key technology for decarbonising the energy system. Solar costs have dropped rapidly and as a result are reliable and affordable. Solar is accessible to homeowners or businesses. Each installation has the impact of lowering consumption from the grid as the electricity is used locally, which helps create space for electrifying heating and transportation. Solar can be installed in a variety of configurations and locations-complimenting other uses, such as on roofs and over parking lots. Because solar is decentralised, it also increases the resilience of the community to extreme weather events. Installing solar requires a capital investment and a location to install it. A solar garden is a strategy to enable broader participation for those without land and with limited capital. A solar garden is a large solar installation installed by an energy cooperative, which can include investment in small financial increments. From an electricity system perspective, solar is considered intermittent power and needs to be balanced with other sources of generation and/or energy storage. Orillia Power Generation's hydro power capacity complements solar generation.

2. **Advocacy for a Decarbonized Ontario Electricity Grid:** Presently, Ontario has no concrete plan to decarbonize its electricity grid before 2030.[28] Many cities in Ontario have developed similar plans to decarbonize their corporate and community operations and are advocating for a zero-emissions provincial electricity grid.

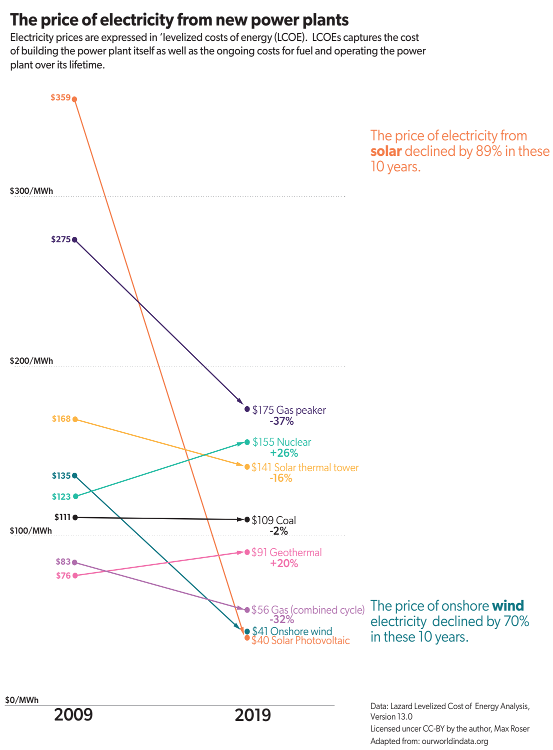

Figure 10. The cost of solar PV is decreasing.

[28] The IESO currently has a study underway to explore potential pathways for decarbonising the provincial electricity system. For more information, see: https://ieso.ca/Sector-Participants/IESO-News/2022/03/Pathways-to-Decarbonization-Study-Underway

A GHG Intensive Provincial Electricity Grid?

Ontario's electricity system is relatively clean compared to the electricity systems in other provinces, but it is projected to become more GHG intensive per unit of electricity generated (Figure 11) due to nuclear retirements and the addition of gas generation. This trend has wide-ranging implications for Orillia's ability to rapidly reduce GHG emissions, as electrification of transportation and heating is the primary pathway.

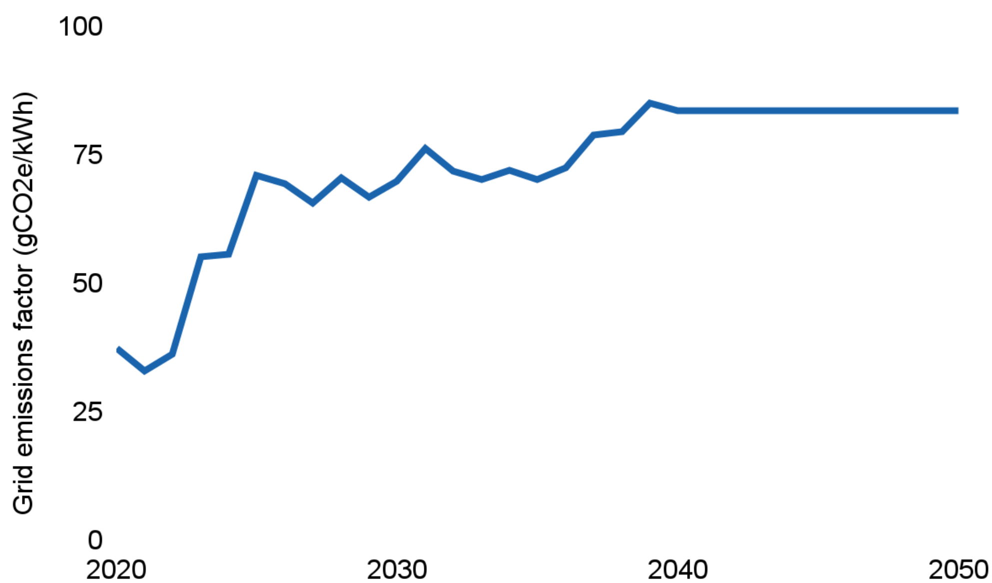

Figure 11. Projection of the Ontario grid's GHG emissions intensity.

3. **Renewable Energy Certificates (RECs):** Renewable energy certificates are used to procure the clean attributes of renewable electricity generated off-site. If the City finds that generating its own solar power is infeasible for logistical, financial, and/or policy reasons, then RECs could be used to offset the City's remaining corporate emissions. Ontario has announced that it is creating a Clean Energy Credit registry to facilitate this process.[29]
4. **Power Purchasing Agreements (PPAs):** A power purchase agreement is used to directly purchase electricity from an off-site provider. In this case, the desired energy would be renewable electricity. The City would have to investigate and/or create the policy conditions needed to develop a PPA and investigate if Orillia Power Generation could enter into a PPA with a provider. Some cities have also established renewable energy cooperatives as a way of increasing renewable supply while retaining local control.

[29] Barretto, C. (2022). Ontario to create voluntary clean energy credit market. Retrieved from: https://cassels.com/insights/ontario-to-create-voluntary-clean-energy-credit-market/?utm_source=Mondaq&utm_medium=syndication&utm_campaign=LinkedIn-integration

2.5.2 Targets: Big Move 1

Table 8. Solar PV targets

	2023–2025	2026–2030	2031–2040	2041–2050
Solar PV installed (MW)	12.05	17.06	17.6	15.44

2.5.3 Implementation: Big Move 1

Table 9. Implementation Actions

ACTION	LOW-CARBON PATHWAY OBJECTIVE	RECOMMENDED NEXT STEPS	POTENTIAL PARTNERS	MUNICIPAL ROLE
1.1 Residential solar program	Maximize new residential building solar PV Maximize existing building solar PV	Develop an expedited permitting process. Develop a financing program (i.e. Solar Colchester, Halifax's Solar City). Incorporate a requirement for solar into a green development standard (see also: action 3.3).	FCM, local solar installers	Program development and delivery.
1.2 Community solar program	Maximize new non-residential solar PV	Work with OPG or a cooperative to develop a solar garden to advance equity outcomes.	OPG, renewable energy cooperative	Provide access to municipal land or roof space.
1.3 Business solar program	Maximize new non-residential solar PV	Identify feasible locations or roof spaces. Coordinate with OPG and businesses.	OPG, renewable energy cooperative	Provide incentives to businesses such as reduced development cost charges.
1.4 Renewable natural gas generation	Fuel switch to RNG	Work with OPG to develop a RNG project from organic waste streams.	OPG, FCM, Enbridge	Undertake a feasibility study.
1.5 Advocate for a zero emission grid	Purchase RECs	Actively engage with other levels of government and IESO.	Other municipalities, Clean Air Partnership, businesses	Coordinate with other municipalities.
1.6 Purchase Clean Energy Credits (RECs)	Fuel switch to RNG Purchase RECs	Purchase green electricity and RNG on behalf of the community	OPG	Develop an opt out rider on municipal taxes to purchase green electricity.

2.5.4 Outcomes: Big Move 1

Table 10. Low-Carbon Pathway Outcomes

LOW-CARBON PATHWAY OUTCOMES	GHG IMPACT (CUMULATIVE REDUCTION) KTCO2E	GHG EMISSIONS REDUCTIONS RATING	COST RATING	INCREMENTAL SOCIETAL CAPITAL COST ($, 2018, UNDISCOUNTED)	REPORTING METRICS	TIMING
Maximize new non-residential solar PV	21	Low	$$	16 M Return: Yes	kW of solar PV installed Number of solar installations	Begin: Immediately End: 2050
Maximize existing building solar PV	84	Low	$$$$	68.7 M Return: Yes	kW of solar PV installed Number of solar installations	Begin: Immediately End: 2050
Maximize new residential building solar PV	15	Low	$$	14.5 M Return: Yes	kW of solar PV installed Number of solar installations	Begin: Immediately End: 2050
Fuel switch to RNG	190	Medium	$$$	27.6 M Return: No	% of fuel that is renewable in the community	Begin: 2035 End: 2045
Purchase RECs	655	High	$$$$	69.3 M Return: No	Number of MWs of RECs purchased to offset emissions	Begin: 2030 End: 2050

2.5.5 INSPIRATION: BIG MOVE 1

Community-owned renewable power

Community renewable energy will play a critical role in the path to net-zero for municipalities across Canada. From an equity perspective, this approach can provide local, affordable energy to those who traditionally cannot invest in renewables such as renters, businesses, and low-income households.[30] There are many ways that communities can approach renewable power generation. Many ownership models exist, such as co-operatives, investment funds, and solar gardens. Co-operative business models are enabled by legislation in all provinces and territories.[31] Municipalities can help establish community projects by providing land, expediting permitting and approval processes, and enabling citizen participation or even having an ownership stake in the system.[32] The ownership design can be made as specific as each community requires; community-owned local renewable power is positioned for growth as communities increasingly become electrified while energy prices rise and local populations continue to grow.

Community District Energy in Revelstoke, British Columbia[33]

The City of Revelstoke's biomass-fired community energy system uses wood waste from a local timber mill to provide heat to downtown core buildings through a district energy loop. In 2001, community members began volunteering to create a biomass energy project with the timber mill's waste wood, which was originally incinerated. The community group created a wholly owned subsidiary of the municipality — the Revelstoke Community Energy Corporation — which owns and operates the energy system. The initial investment was $5.6 million, with an estimated payback period of five years. Operating since 2005, the community energy system offsets over 3,700 tonnes of greenhouse gas emissions (GHGs) every year, improves local air quality, increases job security and lowers energy costs.[34,35]

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30 Solar Energy Industries Association. 2016. Community Solar.

31 Government of Canada. An Information Guide on Co-operatives. 2015. Strategic Policy Sector, Innovation, Science, and Economic Development Canada.

32 ICLEI Canada, 2018. On the money: Financing tools for local climate action. Partners for Climate Protection.

33 Ibid.

34 B.C. Ministry of Community & Rural Development. N.d. Green Communities: Integrated Resource Recovery Case Study: Revelstoke Community Energy System.

35 Biomass Energy Resource Center. 2009. Community District Energy: City of Revelstoke.

2.6 BIG MOVE 2: Transportation: How We Will Get Around

2.6.1 Overview

This section outlines the actions associated with Big Move 2: Transportation, and the impacts these actions will have on reducing emissions in Orillia's low-carbon future.

Each colourful wedge in the figure below shows the GHGs Orillia will not emit because of that wedge's actions. In this particular diagram, the actions associated with Big Move 2 are broken out and displayed individually. For context, the combined impacts of Big Moves 1&3 are also included.

The grey slope at the bottom are the GHGs still being emitted in each year. By 2050, the combined actions will have addressed nearly all of Orillia's emissions.

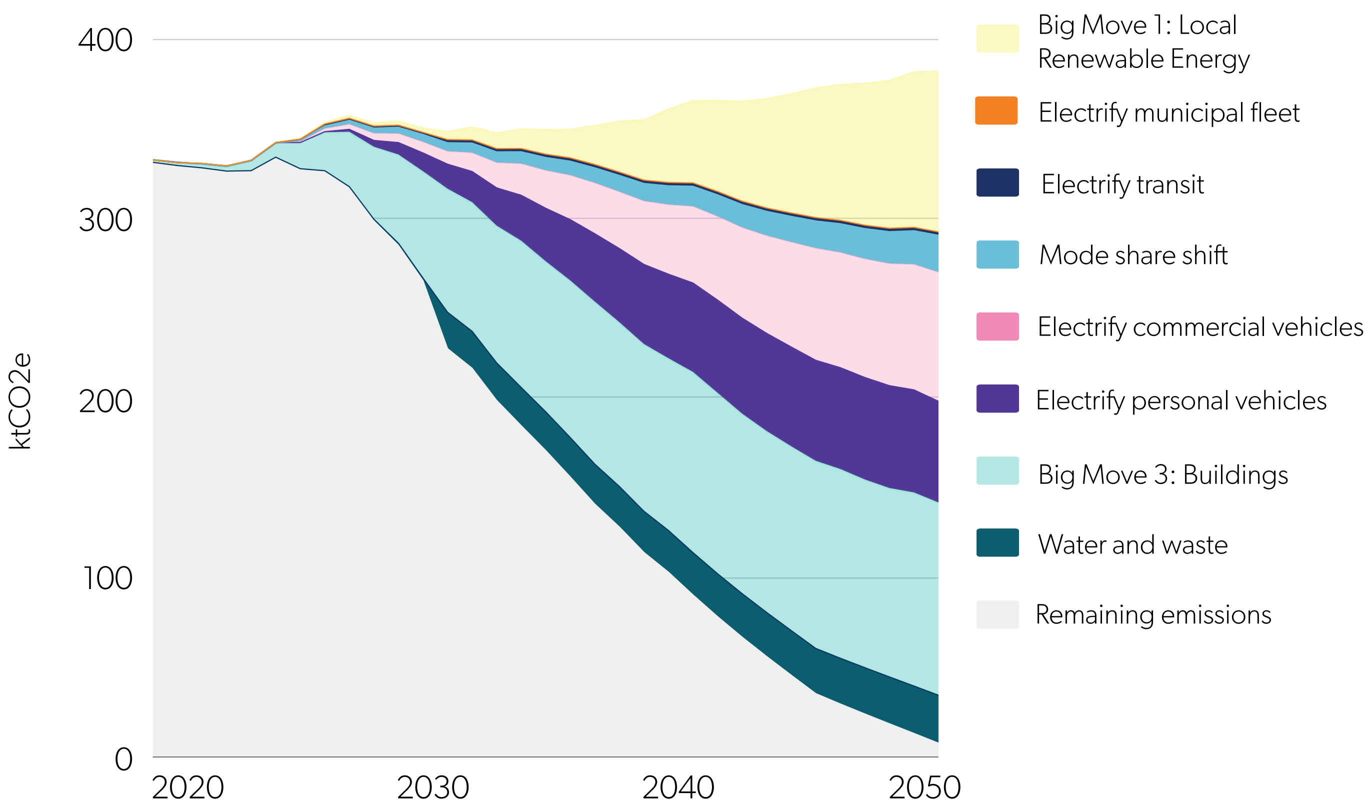

Figure 12. Big Move 2 transportation wedges.

Transportation accounted for 56% of emissions in Orillia in 2018. By 2050, this proportion is expected to decrease to 49% due to an uptake in low-emissions vehicles; however, this decrease does not contribute greatly to Orillia's low-emissions target. To meet Orillia's emissions reductions targets, reducing transportation-related emissions needs to be a priority. This can be achieved by prioritizing the following three modes of transportation:

1. **Transitioning to low-emissions vehicles:** Low-emissions vehicles are key to reducing emissions from personal use vehicles, commercial vehicles, and transit.
2. **Improved and accessible transit:** Transit has a lower emissions-per-passenger footprint than personal-use vehicles. Even when all vehicles are low-emissions, transit can provide a safe, affordable option for residents.
3. **Investing in the active transportation system:** Like transit, a well-designed active transportation system can provide a safe and affordable option for residents to move around Orillia. Active transportation promotes physical well-being and equity while reducing traffic congestion and personal stress.

2.6.2 Targets: Big Move 2

Table 11. EV and mode share targets

			2016	2025	2030	2040	2050
Share of total personal vehicles that is electric	**BAU**		0%	3%	6%	13%	14%
	LC		0%	4%	27%	85%	100%
Share of total energy used for transit that is electric	**BAU**		0%	1%	2%	4%	5%
	LC		0%	2%	14%	58%	82%
Mode share	**BAU**	Bike	2%	2%	2%	2%	2%
		Personal Vehicle	88%	89%	89%	90%	90%
		Transit	4%	4%	4%	4%	4%
		Walk	7%	6%	6%	5%	5%
Mode share	**LC**	Bike	2%	2%	4%	7%	10%
		Personal Vehicle	88%	87%	83%	73%	63%
		Transit	4%	4%	7%	12%	17%
		Walk	7%	6%	7%	9%	11%

2.6.3 Implementation: Big Move 2

Table 13. Implementation Actions

ACTION	LOW-CARBON PATHWAY OUTCOME	RECOMMENDED NEXT STEPS	POTENTIAL PARTNERS	MUNICIPAL ROLE
2.1 Private charging stations	Electrify personal use vehicles Electrify commercial vehicles	Integrate EV charging into an Orillia Green Standard. Provide an incentive for EV charging in multi-unit retrofits.	Households, building owners, local business owners.	Provide incentives.
2.2 Public charging stations	Electrify personal use vehicles Electrify commercial vehicles	Ensure equitable access to charging stations across the City. Partner with OPG on EV charging stations in public locations and on-street parking.	OPG, Infrastructure Canada, EV charging station providers.	Install infrastructure; partner with a third party provider.
2.3 On-demand transit	Mode-share shift*: Transit	Evaluate on-demand transit options using electric vehicles.	Orillia Transit	Provide or contract on-demand transit.
2.4 Fleet electrification	Electrify commercial vehicles	Coordinate fleet owners and operators to accelerate EV uptake.	Organisations with fleets (university, college, hospital, private businesses).	Coordinate a fleet electrification initiative.
2.5 E-bike Rebate Program	Mode-share shift*: Active Transportation	Provide an incentive for all residents, with greater incentives for low-income households, to purchase e-bikes.	FCM, bike shops.	Provide the incentive, identify approved bike businesses to participate, administer the incentive application process.
2.6 Transit investments	Mode-share shift*: Transit	Implement the "Aggressive Scenario" in the MMTP[36] Provide free or low-cost transit to select demographics such as youth, seniors, and individuals living below a determined income threshold. Provide a workplace transit pass program.	Municipality.	Increase investment in transit.
2.7 EV Policy	Electrify municipal fleet Electrify transit	Implement a policy to only purchase EVs for the municipal and transit fleet unless an exception can be justified.	Municipality.	Adopt a policy.

[36] In the MMTP, the middle scenario was chosen through the plan development process and was costed. However, public engagement and a review of the local context in Orillia for this energy and emissions plan highlights the imperative for enhanced investment in transit.

ACTION	LOW-CARBON PATHWAY OUTCOME	RECOMMENDED NEXT STEPS	POTENTIAL PARTNERS	MUNICIPAL ROLE
2.8 A Cycling City	Mode-share shift*: Active Transportation	Provide physically-separated bike lanes for commuting. Partner with schools on bike training and promotion. Provide bicycle fix-it stations and end-of-trip facilities where possible and ensure all active transportation corridors are well lit. Ensure expedited winter maintenance of cycling pathways	Municipality, Sustainable Orillia. Council's Active Transportation Committee	Develop and implement an enhanced cycling network plan.
2.9 A "15 Minute" Orillia	Various. The combination of actions taken in low-carbon city planning needs to ensure that everyone living in the city has access to essential urban services within a 15 minute walk or bike.	Meet with the planning department to incorporate targets for mixed use development where feasible. Define essential urban services.	Orillia's Planning Department	Designate number of homes within a 15 minute walking or cycling distance for essential urban services.

Transitioning to Low-Emissions Vehicles

The Government of Canada has set a mandatory target for all light- and medium-duty vehicle sales across the country to be electric by 2035. Due to the lifecycle length of the average vehicle, there will still be gas and diesel emissions from light- and medium-duty vehicles by 2050. To minimize these straggling emissions, Orillia can set the conditions for electric vehicle uptake prior to the 2035 target, with 80% of vehicle purchases being electric by 2030.

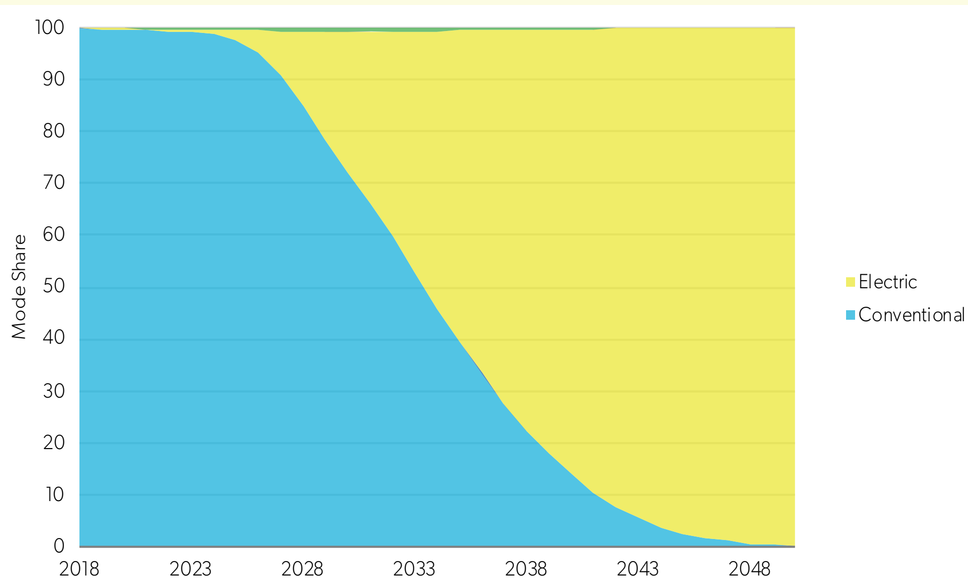

Figure 14. EVs as a share of the total private vehicle fleet in the low-carbon scenario.

2.6.4 Outcomes: Big Move 2

Table 14. Low-Carbon Pathway Outcomes.

<table>
<tr><th>OUTCOME</th><th>GHG IMPACT (CUMULATIVE REDUCTION) KT</th><th>GHG EMISSIONS REDUCTIONS RATING</th><th>COST RATING</th><th>INCREMENTAL SOCIETAL CAPITAL COST ($, 2018, UNDISCOUNTED)</th><th>REPORTING METRICS</th><th>TIMING</th></tr>
<tr><td>Electrify personal use vehicles</td><td>936</td><td>High</td><td>$$</td><td>$20.7 M
Return: Yes</td><td>% of new vehicles registered that are electric</td><td>Begin: Immediately
End: 2035 (all purchases electric)</td></tr>
<tr><td>Electrify commercial vehicles (electric and hydrogen for heavy-duty)</td><td>905</td><td>High</td><td>$$$</td><td>$27.8 M
Return: Yes</td><td>% of new vehicles registered that are electric</td><td>Begin: Immediately
End: 2035 all purchases electric for light- and medium- duty; 2045 all purchases electric and hydrogen for heavy-duty</td></tr>
<tr><td>Electrify transit</td><td>37</td><td>Low</td><td>$$</td><td>$4.3 M
Return: Yes</td><td>%/# of buses electric</td><td>Begin: Immediately
End: 2040</td></tr>
<tr><td>Electrify municipal fleet</td><td>9</td><td>Low</td><td>$$</td><td>$1.9 M
Return: Yes</td><td>%/# of fleet vehicles electric</td><td>Begin: Immediately
End: 2023 (all procurement electric)</td></tr>
<tr><td>Mode-share shift*: Transit</td><td rowspan="2">258</td><td>Medium</td><td>$$$$</td><td>$65.5 M
Return: Yes</td><td>Mode share</td><td>Begin: Immediately
End: 2050</td></tr>
<tr><td>Mode share shift*: Active Transportation</td><td>Medium</td><td>$$$$</td><td>$65.5 M
Return: Yes</td><td>Mode share</td><td>Begin: Immediately
End: 2050</td></tr>
</table>

2.6.5 Inspiration: Big Move 2

Zoning Bylaw Amendment in Port Moody, B.C.

The City of Port Moody, British Columbia, introduced an amendment to their Zoning Bylaw to require electric vehicle charging infrastructure for residential units (minimum one Level 2 charger for each unit) and commercial parking spaces (20% to include Level 2 chargers).[37]

[37] City of Port Moody. No Date. Electrical Vehicle Charging Planning Requirements (webpage). Retrieved online, February 25, 2022. https://www.portmoody.ca/en/business-and-development/electrical-vehicle-charging-planning-requirements.aspx

Zero Fares on Intercity Transit

Starting on January 1, 2020, Olympia, Washington began a five-year free transit fare pilot for its bus and Dial-a-Ride services. The rationale behind the pilot was that it was the easiest and most effective and efficient way to eliminate the inefficiencies associated with fare collection, although Intercity also acknowledges the pilot's positive impact on accessibility, congestion reduction, and the environment.[38] After just one month of the program, Olympia saw a 20% increase in ridership compared to the previous year, which is equivalent to over 60,000 more riders.

Pilot Program Encourages Residents to Purchase E-Bikes in Saanich, B.C.

In October 2021, in an effort to reduce local GHGs and increase active transportation, the District of Saanich on southern Vancouver Island launched a pilot program offering rebates to residents interested in purchasing a new electrically assisted bicycle (e-bike).[39] The District estimates that this program will save between 1,000 and 2,000 tCO2e by 2030.

The program was designed to be accessible to residents of all income levels. Applicants must reside in Saanich and the rebate is applied after the purchase for bikes bought at locally participating bike stores. One e-bike incentive per household is allowed, and the incentive ranges from $350 to $1,600. All residents are eligible for the $350 rebate, but proof of income is required for a larger rebate. Residents can pre-register at saanich.ca/ebike. The District partnered with the Transportation ACES program for advice on equity considerations and the UBC REACT Lab to measure the impacts on travel behaviour and GHG emissions.

[38] Intercity Transit. No Date. FAQ (webpage). Retrieved on February 25th, 2022. https://www.intercitytransit.com/zerofare-faqs

[39] District of Saanich. 2021. Saanich launches new pilot program to help more residents switch to e-bikes. Retrieved online, February 25, 2022. https://www.saanich.ca/EN/main/news-events/news-archives/2021/saanich-launches-new-pilot-program-to-help-more-residents-switch-to-e-bikes.html

Figure 15. A map showing 15 minute walk times (yellow) and bike times (blue) from the Museum of Art and History at 30 Peter St. South in Orillia, Ontario.

Bike and Electric Scooter Sharing in Edmonton, AB

Edmonton is one of the first northern Canadian cities to offer bike, e-bike, and e-scooter sharing stations. The City developed a process to accept applications for the Active Transportation Vehicle Share Program and provided licences to three service providers in 2021. The City also developed parking and riding rules and continues to explore the appropriate number of service providers required to service the city while maintaining safety and enforcement.[40]

[40] City of Edmonton. 2021. Bike and Electric Scooter Sharing (webpage). Retrieved online, February 25, 2022. https://www.edmonton.ca/transportation/cycling_walking/bike-electric-scooter-sharing

Cycling in Copenhagen, Denmark

In Copenhagen, intelligent transport systems optimize the city's traffic signals to benefit bicyclists and buses. The Danish have also significantly invested in cycling infrastructure, including separated cycle lanes along many streets. In 2019, 62% of all trips to and from Copenhagen for work or study were by bike. In total, 1.4 million kilometres are cycled in the city on an average weekday.[41]

What does transit have to do with equity?

A vehicle-based transit system constrains the mobility of those without a car, which can include people with a low income, youth, and the elderly. Further, the general bias towards investment in vehicular infrastructure causes damage to both youth and elderly because of safety issues and exposure to air pollution, to which they are particularly vulnerable. Air pollution from traffic has resulted in cases of neurological disorders including Parkinson's disease, Alzheimer's disease and other dementias, acute bronchitis in children, asthma, and respiratory illness, among other impacts. Transit and active infrastructure are important strategies to support an equitable approach to mobility.

Walking and cycling in all types of weather conditions in all types of weather

Canadian-led research conducted by the Clean Air Partnership indicates that weather is not the deterrent to active transportation uptake that it is often made out to be. The researchers noted that despite being the wettest Canadian city, Vancouver has the greatest active mode share of any other city in Canada. Vienna and Berlin, which were also analysed in the study, have very low amounts of annual sunshine, and yet they boast some of the highest active modes recorded.

A key factor that impacts active mode share is the availability of infrastructure, especially mode-specific infrastructure that allows for separation from other modes, such as vehicular traffic. The ability to switch modes (e.g. bringing a bike on transit) also has an impact, as does trip length. Trip length is impacted by population density and planning decisions about whether to create mixed-use neighbourhoods or separate residential and commercial areas.

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[41] Kirschbaum, E. August 8 2019. "Copenhagen has taken bicycle commuting to a whole new level," Los Angeles Times (online new article). Retrieved online, February 25, 2022. https://www.latimes.com/world-nation/story/2019-08-07/copenhagen-has-taken-bicycle-commuting-to-a-new-level

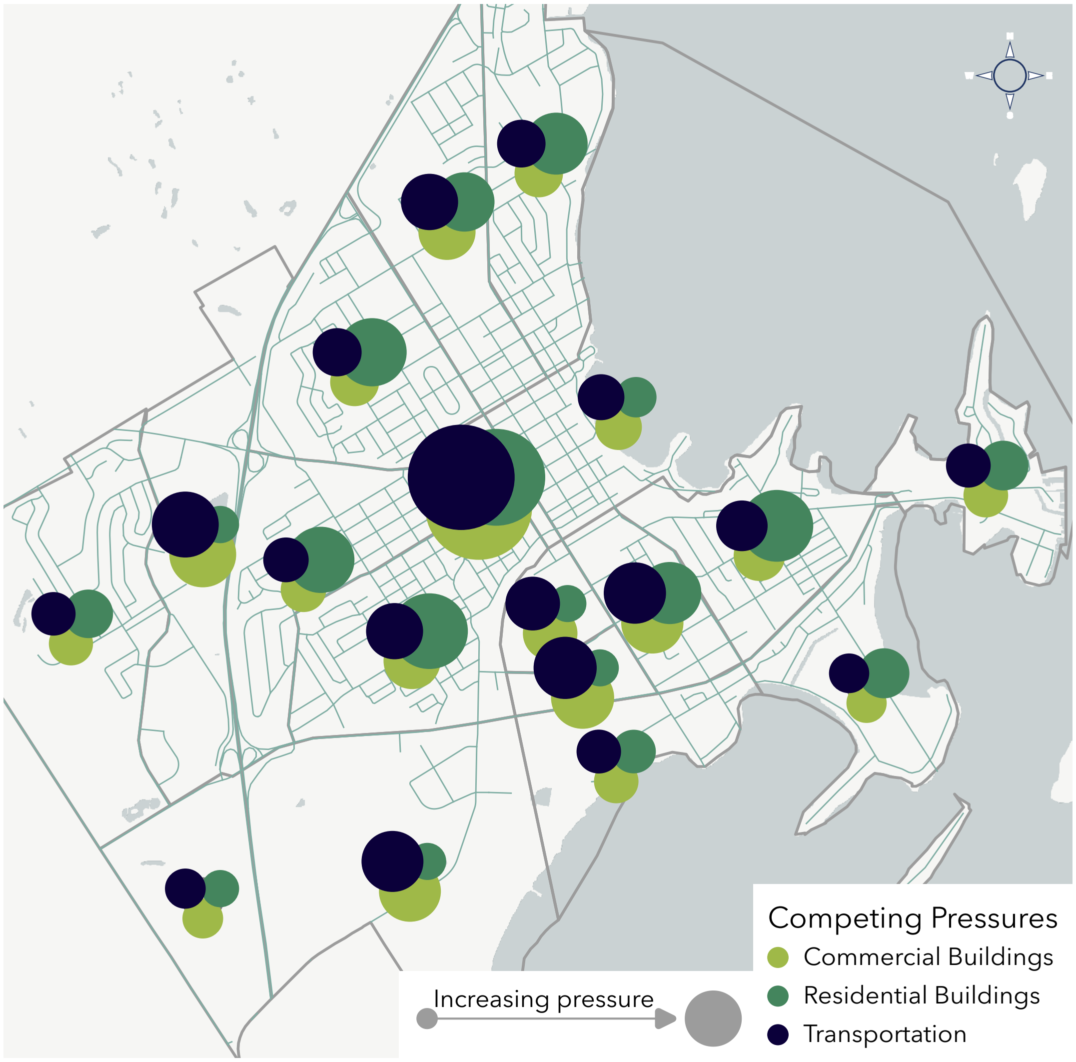


Figure 16. A map of the competing pressures of commercial and residential buildings as they relate to transportation needs, in Orillia.

In any city, the fossil fuels used to heat buildings and run vehicles exert pressure on the city's overall emissions profile. But where those pressures are felt most intensely differs by city, and differs by region within one city. In Orillia, commercial and residential buildings and transportation pressures exist in each region but are clustered in pockets. The above map (Figure 16) shows how the pressure exerted by these three elements compare within each transportation zone and how they are distributed across the city. Larger bubbles indicate that the pressure from that element is greater than in other regions, and show where types of decarbonization actions will be concentrated. For example, residential retrofits will be most intense in a ring around the centre of the city. Commercial retrofits will be more concentrated to the south of the centre and the city's outskirts. More low-carbon transit options will be required in the city centre, and in places with large clusters of commercial buildings.

2.7 BIG MOVE 3: BUILDINGS: WHERE AND HOW WE LIVE

2.7.1 Overview

This section outlines the actions associated with Big Move 3: Buildings, and the impacts these actions will have on reducing emissions in Orillia's low-carbon future.

Each colourful wedge in the figure below shows the GHGs Orillia will not emit because of that wedge's actions. In this particular diagram, the actions associated with Big Move 3 are broken out and displayed individually. For context, the combined impacts of Big Moves 1&2 are also included.

The grey slope at the bottom are the GHGs still being emitted in each year. By 2050, the combined actions will have addressed nearly all of Orillia's emissions.

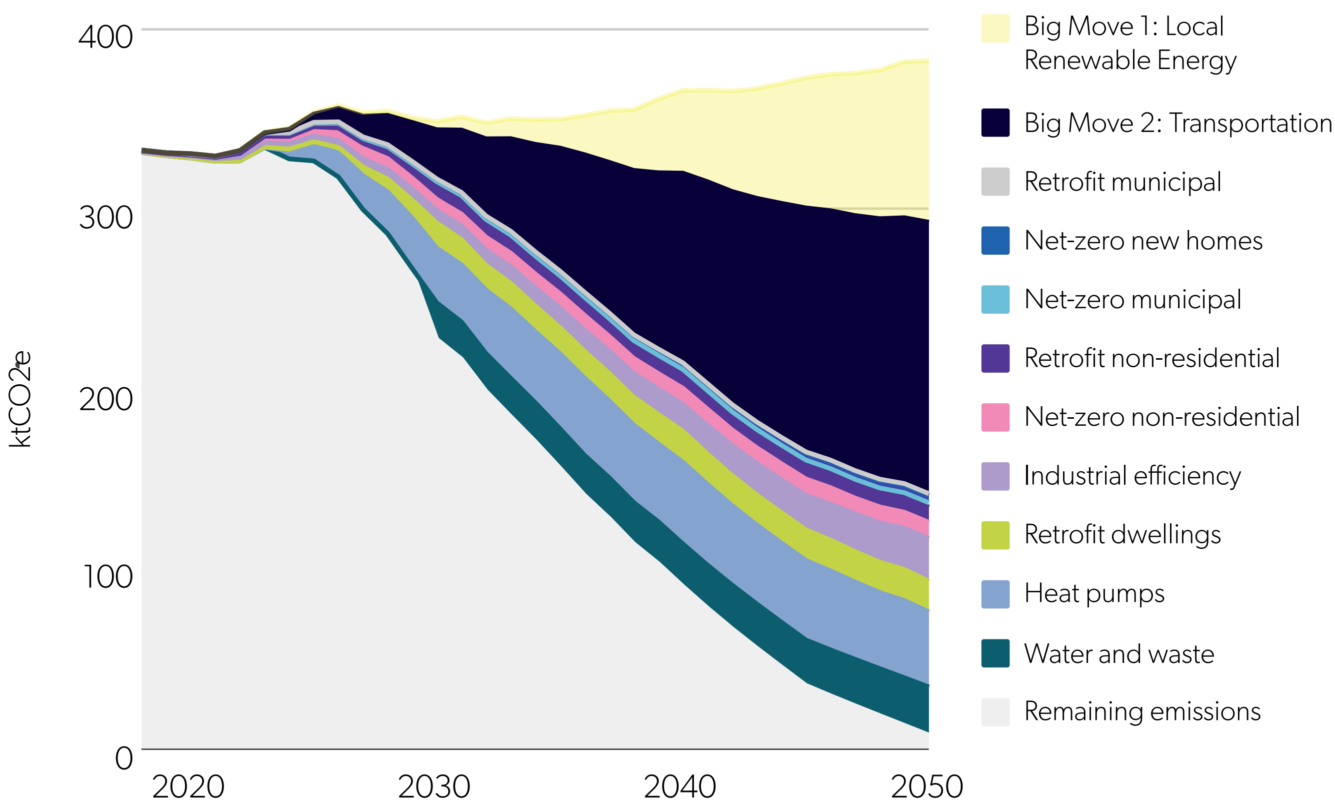


Figure 17. Big Move 3: Building wedges.

Buildings account for more than 40% of total community emissions in Orillia. This is expected to increase to 45% of the emissions share by 2050 based on current policies and plans. To achieve Orillia's emissions reduction target, both existing and new buildings will need to be addressed in the following ways:

1. **Deep retrofits for existing building stock:** To drastically decrease emissions associated with the operation of existing buildings in Orillia.
2. **High standards for new builds:** To ensure new buildings are not future sources of emissions. As buildings are long-lasting assets, decisions made today about their building materials and heating systems create a lock-in to their future energy use and emissions.

2.7.2 Targets: Big Move 3

Table 15. Retrofits and new construction

BUILDING SECTOR/ TYPE	RETROFIT SCHEDULE	RETROFIT DETAILS
Residential—single and multi-unit	Pre-1980 buildings: 65% retrofit by 2030 (4,100 homes) 85% retrofit by 2040 (1,300 homes) 95% retrofit by 2050 (600 homes) Post-1980 buildings: 40% by 2030 (1,500 homes) 65% by 2040 (1,000 homes) 95% by 2050 (1,200 homes)	Target 50% thermal and 25% electrical savings for each building
Commercial and institutional	Pre-1980 buildings: 65% retrofit by 2030 85% retrofit by 2040 95% retrofit by 2050 Post-1980 buildings: 40% by 2030 65% by 2040 95% by 2050	Target 50% thermal and 30% electrical savings for each building
Industrial		Target 30% electrical savings for each building
Municipal	100% retrofit by 2040	Achieve 50% TEDI and 10% EUI reduction

What Constitutes a Deep Retrofit?

Toronto's Net-Zero Existing Buildings Strategy defines a GHG reduction retrofit as meeting two criteria:[42]

1. A minimum upgrade package performance of 50% reduction in GHG emissions, reflecting established best practice in retrofit activities.

2. A near-net-zero pathway of at least an 80% reduction in GHG emissions, including a complete or near-complete fuel switch to electricity or other zero-carbon fuel source.

A deep retrofit typically includes improvements to the envelope and fuel switching from natural gas to electricity. The combination of the efficiency of heat pumps and the improved performance in the thermal envelope can reduce total electricity consumption. An additional benefit is that the improved performance of the building envelope can reduce the size of the HVAC equipment required thereby reducing capital costs, to "tunnel through the cost barrier."

Scaling Deep Retrofits

Deep retrofits target energy savings greater than 50%. Retrofit programs in Canada have typically focused on retrofitting one building at a time. This can make the process costly for building owners and timely at a community scale. To retrofit buildings at the scale required to slow climate change, one potential solution, the Energiesprong program, is emerging from the Netherlands. The process involves using prefabricated façades and building envelopes, efficient heating and cooling systems, and insulated roofs, sometimes fitted with solar PV. These retrofits can be applied to one or many buildings (in close proximity) at a time. Energiesprong retrofits can be completed in as few as 10 days.

[42] Integral, WSP, Windfall Ecology Centre and Reep Green Solutions (2021). The City of Toronto's Net Zero Existing Buildings Strategy. Retrieved from: https://www.toronto.ca/legdocs/mmis/2021/ie/bgrd/backgroundfile-168402.pdf

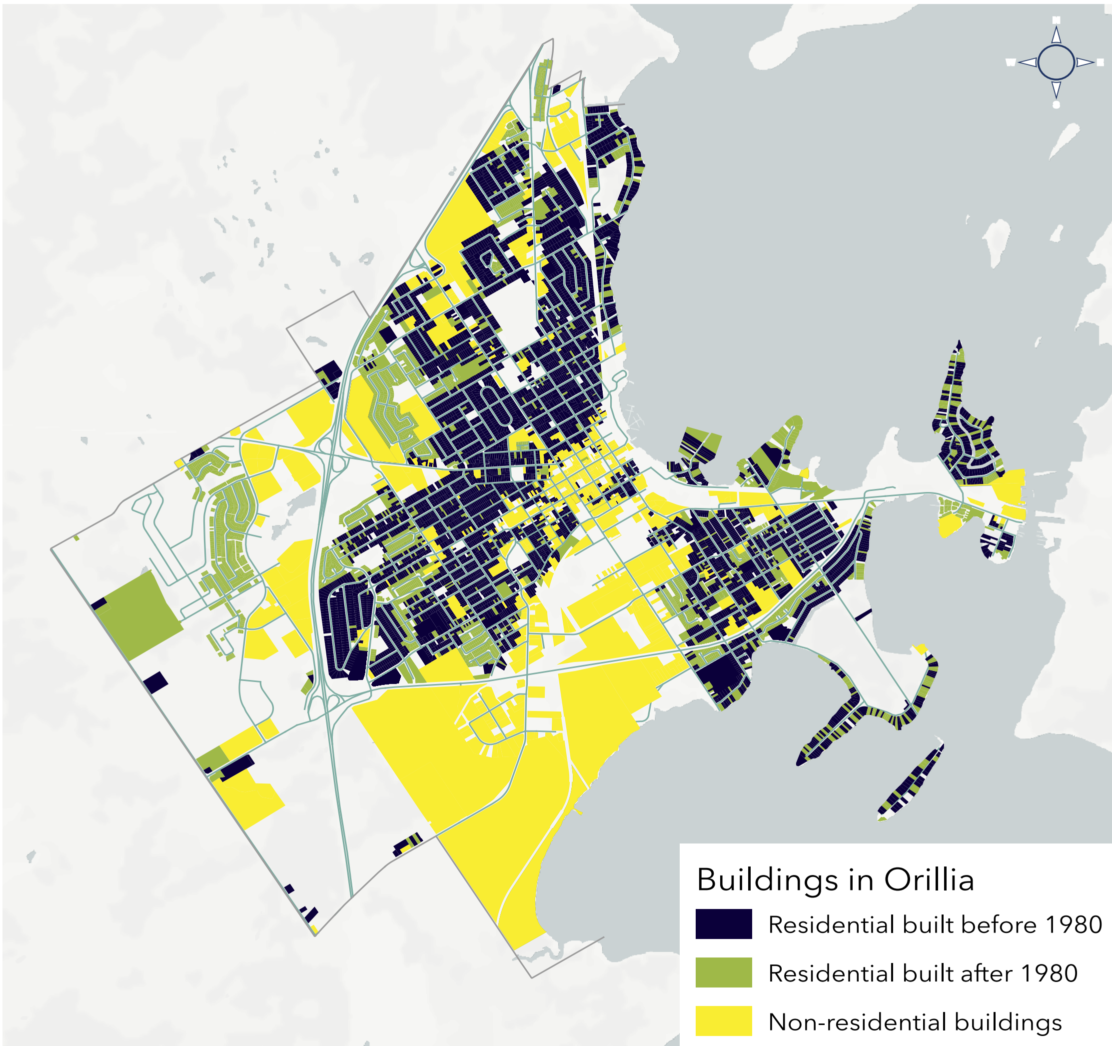


Figure 18: Map of buildings in Orillia, pre and post 1980.

2.7.3 Implementation: Big Move 3

Table 16. Implementation Actions

ACTION	OBJECTIVE	RECOMMENDED NEXT STEPS	POTENTIAL PARTNERS	MUNICIPAL ROLE
3.1 Orillia Retrofit Savings Program: Residential and Non-Residential	Retrofit residential buildings Retrofit non-residential buildings	Develop LIC retrofit program focussed on deep climate retrofits Develop an affordable, social housing stream for rental housing with incentives. Develop a commercial stream for multi-unit and non-residential buildings.	OPG, contractors, equipment suppliers, BILD, Efficiency Capital, FCM, Clean Air Partnership, Sustainable Orillia.	Develop and deliver the program.
3.2 Solar Neighbourhoods Pilot Program	Retrofit residential buildings	Develop a pilot neighbourhood retrofit program.	OPG, HydroOne, neighbourhood association, FCM, Sustainable Orillia.	Coordinate the pilot program and report on results.
3.3 Orillia Green Building Standard	New residential buildings energy-use intensity reduction New non-residential buildings energy-use intensity reduction	Develop a green standard policy for site planning, including a climate minimum performance standard.	Clean Air Partnership, BILD, CHBA.	Implement the new policy standard.

2.7.4 Outcomes: Big Move 3

Table 17. Low-Carbon Pathway Outcomes

ACTION	GHG IMPACT (CUMULATIVE)	GHG REDUCTIONS RATING	COST RATING	SOCIETAL INVESTMENT	REPORTING METRICS	TIMING
Retrofit residential buildings	362	Medium	$$$$$	$283.1 M Return: No	% buildings retrofit	Begin: Immediately End: 2050
Retrofit non-residential buildings	179	Medium	$$$$	$100 M Return: No	% buildings retrofit	Begin: Immediately End: 2050
Retrofit municipal buildings	10	Low	$$	$7.9 M Return: No	% buildings retrofit	Begin: Immediately End: 2040
Convert heating systems to heat pumps	965	High	$$$$$	$493.7 M Return: No	% heating systems converted	Begin: Immediately End: 2050

ACTION	GHG IMPACT (CUMULATIVE)	GHG REDUCTIONS RATING	COST RATING	SOCIETAL INVESTMENT	REPORTING METRICS	TIMING
New residential buildings energy-use intensity reduction	69	Low	$$	$22.8 M Return: Yes	% buildings conforming to standards/ voluntary measures	Begin: Immediately End: 2030
New non-residential buildings energy-use intensity reduction	212	Medium	$$$	$35.7 M Return: Yes	% buildings conforming to standards/ voluntary measures	Begin: Immediately End: 2030
New municipal buildings energy-use intensity reduction	73	Low	$	$276 k Return: Yes	% buildings conforming to standards/ voluntary measures	Begin: Immediately End: 2030

2.7.5 Inspiration: Big Move 3

Toronto Home Energy Loan Program[43]

The Toronto Home Energy Loan Program (HELP), offered by the City of Toronto, lends money to homeowners to cover the upfront cost of energy efficiency improvements. The loan can be up to $75,000 or 10 per cent of current assessment value of the home, which is paid back through the property tax bill. The interest rate is fixed at two per cent for a five-year term, 2.75 per cent for a 10-year term, or 3.54 per cent for a 15-year term. From January 2014 to December 2016, HELP funded 125 projects totalling $2.1 million, saving homeowners an average of $560 per year, and reducing 395 tonnes of GHGs annually. An easy application process, good customer support, and transferability to future owners were identified as key factors in the program's success. However, the program faced several challenges during implementation. For instance, only half of mortgage lenders gave consent, which is required to ensure that enrollment in the program does not breach the homeowner's mortgage terms. In addition, the marketing and promotion of the program was labour-intensive and difficult to sustain over time. Nonetheless, the program demonstrates the potential of LICs to reduce barriers and encourage energy-efficiency retrofits in Canada's building stock.[44]

43 ICLEI Canada, 2018. On the money: Financing tools for local climate action. Partners for Climate Protection.

44 City of Toronto. 2017. Home Energy Loan Program and High-rise Retrofit Improvement Support Program Evaluation. Report for Action PE18.4.

Sundance Cooperative Housing

Sundance Cooperative Housing in Edmonton is a mixed-income community that houses 150 people in 59 units.[45] The cooperative is undertaking a deep energy retrofit, based on a feasibility study that produced a comprehensive refinancing and revitalization plan focusing on building envelope refurbishment and repair and meeting current building code requirements.

Research, development, and design were completed in 2019, and construction is currently underway. To limit disruption to residents and to create cost efficiencies, new, energy efficient exterior wall panels were designed and constructed off-site and installed over existing exterior walls. Building system upgrades, such as heating systems, are also being completed.[46] The project has a $10 million budget, including a $2.5 million grant from the Federal Government. The retrofit project is expected to reduce energy use and GHG emissions by up to 80%.[47]

TowerWise Retrofit Project, Toronto Community Housing

In 2014, Toronto Community Housing (TCH) and the Toronto Atmospheric Fund (TAF) signed an agreement to implement energy retrofits within 7 TCH multi-unit buildings that included 1,237 households. The buildings were built in the 1960s and 1970s and ranged from 4 to 19 stories high.[48] The primary aim of the project was to reduce GHG emissions by 30% and utility costs by 20%.

TAF provided $4.2 million in funding, including $1.2 million in grants and utility incentives, and $3 million in financing. TCH and TAF entered an Energy Savings Performance Agreement to share the revenues from energy savings. Funding was also sourced from the Federation of Canadian Municipalities, the City of Toronto, Toronto Community Housing Corporation, Enbridge Gas Distribution, Union Gas Limited, and Ecobee.[49]

Retrofits included double-glazed windows, gas-absorption heat pumps, low flow toilets and faucets, high-efficiency refrigerators, boilers, motors, lighting and other facility upgrades. When the project was complete, there was a higher than projected cost savings and emissions reductions, improved indoor environmental quality, and reduced overheating in the winter.

[45] CBC News. August 5, 2021. 'Wrapping these buildings in a nice, warm sweater': Edmonton retrofit first of its kind. Online news article retrieved on February 25, 2022. https://www.cbc.ca/news/canada/edmonton/wrapping-these-buildings-in-a-nice-warm-sweater-edmonton-retrofit-first-of-its-kind-1.6128524

[46] Sundance Cooperative. No date. Sundance Housing Cooperative: Creating a Sustainable Future. Retrieved online, February 25, 2022. https://sundancecoop.org/sundance-retrofit-project/

[47] Natural Resources Canada. 2019. Sundance Housing Rehabilitation Project. Retrieved online, February 25, 2022. https://www.nrcan.gc.ca/science-and-data/funding-partnerships/funding-opportunities/current-investments/sundance-housing-rehabilitation-project/21926

[48] Federation of Canadian Municipalities. No Date. Case study: Energy retrofit delivers multiple benefits, Improved air quality and resident comfort. Retrieved online, February 25, 2022. https://fcm.ca/en/case-study/case-study-energy-retrofit-delivers-multiple-benefits

[49] Toronto Housing. No Date. TowerWise Retrofit Project. Retrieved online, February 25, 2022. https://www.torontohousing.ca/Pages/TowerWise-Retrofit-Project.aspx

Toronto Green Standard

The Toronto Green Standard (TGS) stipulates Toronto's sustainable design requirements for new private and City-owned developments. The TGS consists of four increasingly stringent energy performance tiers with supporting guidelines that promote sustainable site and building design.

Tier One of the Toronto Green Standard is a mandatory requirement of the planning approval process. Financial incentives are offered through a Development Charge Refund Program for planning applications that meet higher-level voluntary standards in Tiers Two through Four.[50] The mandatory tier becomes increasingly stringent over time, achieving near-zero by 2030. Version 4 of the Toronto Green Standard was adopted by Council in July 2021 and reflects the most recent requirements and guidelines. It will come into effect in May 2022 and is aligned with the City's goal of reaching net-zero emissions by 2040.

Whitby Green Standard

Like the Toronto Green Standard, Whitby's Green Standard has four tiers of performance. The first tier is mandatory and the subsequent tiers are voluntary with financial and non-financial incentives. To support education and uptake, the Town has released a standards reference guide, site plan application checklist, and a plan of subdivision checklist. The Standard is a component of reaching Whitby's target of reducing emissions by 80% by 2050 in the community,[51] a target that is currently being updated.

2.8 Additional Moves: Waste & Governance

2.8.1 MANAGING WASTE

Waste made up 2% of overall community emissions in Orillia in 2016. While small overall, this number will increase by 63% in a Business-as-Usual Scenario and should be addressed in Orillia's emissions reductions efforts to avoid future growth in the sector.

Orillia has a baseline solid waste diversion rate of 65%. With a robust system already in place to handle waste diversion, behaviour change and education through zero-waste programming can provide the push required to further increase the diversion rate. This aligns with the rapid uptake of zero-waste programs across the country. The federal single-use plastic ban is also expected to contribute to reduced waste generation overall.

[50] City of Toronto. No Date. Toronto Green Standards (webpage). Retrieved online on February 25, 2022. https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/

[51] Town of Whitby. No Date. Whitby Green Standard (webpage). Retrieved online on February 25, 2022. https://www.whitby.ca/en/work/whitby-green-standard.aspx#Will-the-Whitby-Green-Standard-delay-the-current-development-process

2.7.1.1 Implementation: Waste

Table 18. Waste Implementation Actions

ACTION	OBJECTIVE	RECOMMENDED NEXT STEPS	POTENTIAL PARTNERS	MUNICIPAL ROLE
4.1 Zero waste strategy	Waste diversion (90% diversion rate)	Develop a zero waste strategy.	Sustainable Orillia Council's Waste Management Advisory Committee	Lead, finance and implement a zero waste strategy
4.2 ICI waste	Waste diversion (90% diversion rate)	Investigate strategies to reduce ICI waste including reuse and recycling programs.	ICI waste service providers	Coordinate an ICI waste strategy
4.3 Orillia's free store	Waste diversion (90% diversion rate)	Develop a feasibility study. Identify an operating partner. Identify a location.	Sustainable Orillia Council's Waste Management Advisory Committee	Fund the development of a free store
4.4 Capture methane	Methane recovery (75% capture rate)	Commission a methane capture project	n/a	Finance and implement a methane capture project

2.7.1.2 Outcomes: Waste

Table 19. Low-Carbon Pathway Outcomes

ACTION	GHG IMPACT (CUMULATIVE)	GHG REDUCTIONS RATING	COST RATING	COSTS (CAPITAL)	REPORTING METRICS	TIMING
Waste diversion (90% diversion rate)	182	Medium	n/a	TBD	Waste diversion rate	Begin: Immediately End: 2050
Methane recovery (75% capture rate)	317	Medium	$$	$2.9 M Return: No	% methane recovered	Begin: 2029 End: 2030 (system implemented)

2.7.1.3 Inspiration: Waste

Hornby Island and Chicago both offer innovative solutions to help their residents reduce waste.

Chicago, Illinois Rewards Recyclers

As part of Sustainable Chicago 2015 Goal 20, the City partnered with Recyclebank to trial a unique incentive program for recycling. Selected blue carts were retrofitted with an ID chip that reads the weight of the recycled materials collected by that household. Points are earned for every pound of recyclables diverted from the waste stream and can be redeemed for discounts at local and national businesses.[52]

Hornby Island, B.C. Offers a Free Store for All

Hornby Island offers a Free Store for residents to share and recycle goods. It is volunteer-run and has been operating for nearly 40 years.[53]

2.7.2 AN EMPOWERED CITY

Climate action requires major new initiatives and to support this effort, the City of Orillia will need to consider new management approaches and capacities.

Table 20. Capacity Actions

ACTION	OBJECTIVE	RECOMMENDED NEXT STEPS	MUNICIPAL ROLE
5.1 Permanent advisory committed to council or the Mayor	Create an independent body that will advise Council and Mayor on climate action.	Approve a bylaw Establish a terms of reference and appoint committee members.	Council motion, terms of reference, host committee meetings.
5.2 Carbon Budget - Community	Implement a carbon budget to manage the GHG targets.	Create a carbon budget policy. Create a carbon budget mechanism aligned with financial policies. Assign GHG targets to departments Incorporate responsibility for GHG management into job responsibilities.	Implement a carbon management system.
5.3 Orillia's Green Revolving Loan Fund	Develop a funding mechanism that is ring fenced for climate action and can receive a share of savings.	Develop terms of reference and capitalization for a revolving fund.	Create and coordinate the revolving loan fund.

[52] City of Chicago. August 1, 2009. "CITY OF CHICAGO PARTNERS WITH RECYCLEBANK Recycling Rewards Program Will Help Promote Sustainability by Increasing Recycling Participation in Chicago." (Press Release). Retrieved online February 25, 2022. www.cityofchicago.org%2Fdam%2Fcity%2Fdepts%2Fdoe%2Fgeneral%2FRecyclingAndWasteMgmt_PDFs%2FBlueCart%2FRecycleBankPressRelease.pdf

[53] Wilson, C. November 11 2014. "Hornby Island Free Store recycled for new outlet," Times Colonist. Retrieved online on February 25, 2022. https://www.timescolonist.com/business/hornby-island-free-store-recycled-for-new-outlet-4615744

ACTION	OBJECTIVE	RECOMMENDED NEXT STEPS	MUNICIPAL ROLE
5.4 Climate Lens for Staff Reports	Calculate and incorporate the climate impact of City decisions.	Research tools to assist in calculating climate impacts for staff to use in their reports.	Research and development.
5.5 Municipal investments	Ensure that short and long term investments are aligned with Orillia's low-carbon pathway objectives.	Develop and apply an ESG (Environmental, social, and governance) policy for municipal investments and reserves.	Create and implement ESG policy.

What is a carbon budget?

The easiest way to think of a carbon budget (or carbon accounting) is to think of it just like the city's financial budget. With a financial budget, each year, Council has a set amount of money in the city budget and a variety of areas to spend it, so it has to prioritize what is most important with its funds.

With a carbon budget, the city has a certain amount of carbon to "spend" if it wants to do its part to reduce the impacts of climate change. However, unlike a financial budget where there may be opportunities to bring in more money, the carbon budget remains static — it is the total net carbon the city can emit. Each year, or every few years (depending on the overall emissions reduction target), the amount of carbon the city can release decreases and continues on this downward trajectory until the budget is zero (or very close to it). A carbon budget operates like a bathtub filling up with water - the amount of space is fixed and can only hold so much before it overflows.

In Canada, the City of Edmonton is the first city to adopt a carbon budget (2021) as a part of its journey to a low-carbon future.

What is a Green Revolving Loan Fund?

Green revolving loan funds, also known as revolving loan funds, are funds from municipal, provincial or federal sources that finance a variety of emission reduction projects. The savings generated from the initial projects are then re-loaned for other projects, creating an "evergreen" source of capital that can be used again and again well into the future.

Sufficient capital is required to seed the fund, which may be a challenge for smaller communities. The fund administration requires staff time and expertise for it to be successful, however, only one-time funding is required; once initiated, the program will generate its own funds.

What is a Green Bond?

Bonds are a trusted financing tool used by all levels of government since the 1900s, with green bonds being a newer version. Green bonds are debt securities whose proceeds are earmarked for environmental or climate-related projects, such as public transit or low-carbon infrastructure investments. They offer the same financial terms as other bonds, which means that investors do not have to choose between financial returns and environmental benefits. There are a few types of green bonds, but most are treasury-style retail bonds with a fixed interest rate and redeemable in full on maturity, usually within 10 to 30 years.

The City of Pittsburgh's Green Initiatives Trust Fund[54]

The City of Pittsburgh's Green Initiatives Trust Fund provides a continuous and secure source of funding from energy-saving measures, which is used to finance future energy-efficiency projects within the city, such as energy audits, aggregated energy purchases, renewable energy generation, efficiency upgrades at city-owned facilities, and other green initiatives in the Pittsburgh Climate Action Plan. Although there are no formal criteria for funding, the city focuses on projects with a payback period of less than half of the operational life expectancy of the equipment or measure. The Fund has helped energy projects to be evaluated and approved more quickly through the decision-making bodies of the municipality. Established in 2008, the Fund was initially seeded with $100,000 US and topped up with savings from aggregated energy purchases and energy savings each year. From 2008 to 2012, the Fund financed solar thermal installations, a solar photovoltaic installation, installation of 4,000 LED street lights, and retrofits to various city facilities, including the City-County building, totalling $2.45 million US.[55]

[54] ICLEI Canada, 2018. On the money: Financing tools for local climate action. Partners for Climate Protection.

[55] Green Initiatives Trust Fund: City of Pittsburgh. Better Buildings Solution Centre: US Department of Energy.

City of Ottawa's 2017 Green Bond[56]

The City of Ottawa is the first Canadian municipality to issue a green bond, enabled through its Green Debenture Framework. The framework identifies eight types of projects for which proceeds can be used:[57]

1. Renewable energy
2. Energy efficiency
3. Pollution prevention and control
4. Clean transportation
5. Sustainable water management
6. Sustainable management of natural resources
7. Climate change adaptation and resilience
8. Green buildings

The first bond was issued in November 2017, with proceeds used to fund a light-rail transit system. The issuance was highly successful; it cost less than comparable non-green bonds and was oversubscribed, with twice as many bids as expected. The 30-year bond was issued at $102 million, making Ottawa the fifth-largest bond issuer in Canada in 2017.[58]

[56] ICLEI Canada, 2018. On the money: Financing tools for local climate action. Partners for Climate Protection.

[57] City of Ottawa. (n.d.) Investor Relations: Green Bonds.

[58] Bonds and Climate Change: Canada Report. 2017. Climate Bonds Initiative & Smart Prosperity Institute.

Part 3:

The Opportunity

Part 3: The Opportunity

The COVID-19 pandemic and related supply chain issues have brought greater light to the problem of sustainability. Thanks to the efforts of the Orillia Climate Future Committee, Orillia has begun discussing ways to reduce our carbon footprint. There has been an exciting exchange of ideas, including looking at garbage and recycling differently and considering the opportunity to turn waste into building products. This is an opportunity for us to extract resources from our own garbage dumps, reducing further burdens to the fragile environment around us.

Technology is rapidly changing, and Orillia has the opportunity to be at the forefront by adopting a local circular economy that will secure future prosperity for our residents and businesses. We live in an exciting time, where robotics and artificial intelligence can replace cheap offshore labour pools, reducing the disastrous ecological consequences that the shipping of materials has on our oceans.

Allan Lafontaine, Executive Director, Orillia District Chamber of Commerce

3.1 Financial Analysis

3.1.1 FINANCIAL CONCEPTS

The direct, community-wide financial impacts of Orillia's net-zero pathway were assessed; however, direct financial impacts should be seen as a secondary benefit of reducing GHG emissions. First and foremost, GHG reductions are a critical response to the global climate emergency. In addition, most measures included in the pathways provide economic and social goods to the community, such as net job creation and positive health outcomes, which are only reflected in this financial analysis as the cost of carbon emitted.[59]

Key concepts that are used to analyse the financial impacts of the pathway are summarized below.[60]

Costs Are Relative to the Do Nothing Scenario

This financial analysis tracks projected costs and savings associated with low-carbon measures that are above and beyond the costs in the BAU Scenario.

Discount Rate

The discount rate is the baseline growth value an investor places on their investment dollar. A project is considered financially beneficial by an investor if it generates a real rate of return equal to or greater than their discount rate.

An investor's discount rate varies with the type of project, duration of the investment, risk, and the scarcity of capital. The social discount rate is the discount rate applied for comparing the value to society of investments made for the common good, and as such, it is inherently uncertain and

[59] The Social Cost of Carbon is an estimate of the damage caused to society by climate change including impacts on health and lost jobs.

[60] Detailed financial assumptions are described in the Data, Methods and Assumptions Manual.

difficult to determine. Some argue that a very low or even zero discount rate should be applied in the evaluation of climate change mitigation investments. A 3% discount rate was applied for this analysis.[61]

Net Present Value

The net present value (NPV) of an investment is the difference between the present value of the capital investment and the present value of the future stream of savings and revenue generated by the investment.

Five aggregate categories are used to track the financial performance of the low-carbon actions in this analysis: capital expenditures, energy savings (or additional costs), carbon cost savings (assuming the carbon price reaches $170/tonne CO2e in 2030 and is held constant thereafter), operation and maintenance savings, and revenue generation (associated with renewable energy production facilities and some transit actions). Administrative costs associated with implementing programs, as well as any energy system infrastructure upgrades that may be required are excluded. Similarly, the broader social costs, such as health costs or damages from climate change, that are avoided from mitigating climate change are not included in this financial analysis.

Abatement Cost

The abatement cost of an action is the estimated cost for that action to reduce one tonne of GHG emissions, which is calculated by dividing the action's NPV by the total GHG emissions reductions (tCO2e) resulting from the action. For example, if a project has a NPV of $1,000 and generates 10 tCO2e of savings, its abatement cost is $100 per tCO2e reduced.

Amortization

The costs of major capital investments are typically spread over a period of time (e.g. a mortgage on a house commonly has a 25-year mortgage period). Amortization refers to the process of paying off capital expenditures (debt) through regular principal and interest payments over time. In this analysis, we have applied a 25-year amortization rate to all investments.

Energy and Carbon Cost Projections

Energy cost projections were derived from[62]:

- The Independent Electricity System Operator's (IESO) Long-Term Energy Plan (electricity);
- The US Energy Information Administration (propane); and
- The Canada Energy Regulator (all other fuels).

The financial analysis is sensitive to electricity and natural gas costs. Electricity costs are projected to increase more rapidly than natural gas. If natural gas costs increase more rapidly, then the financial benefit of many of the actions increases.

An escalating cost of carbon based on federal regulation was applied out to 2030, then held constant, which represents a conservative assumption. An alternative assumption is that carbon taxes continue to increase as climate change becomes more and more severe, which would increase the financial benefit of this scenario.

[61] Environment and Climate Change Canada. (2016). Technical update to Environment and Climate Change Canada's social cost of greenhouse gas estimates. Retrieved from http://ec.gc.ca/cc/BE705779-0495-4C53-BC29-6A055C7542B7/Technical%20Update%20to%20Environment%20and%20Climate%20Change%20Canadas%20Social%20Cost%20of%20Greenhouse%20Gas%20Estimates.pdf

[62] For more details on the financial assumptions see the TransformTO Data, Methods and Assumptions Manual.

3.1.2 THE BIG PICTURE

Table 21. Summary of financial results.

NET IMPACTS OVER THE PERIOD, UNDISCOUNTED, $ MILLIONS	
Total incremental capital investment, 2022-2050	$1,069
Average annual investment	$38
Total savings, 2022-2050	-$3,109
Net cost, 2022-2050	-$2,040
FINANCIAL INDICATORS, $	
Capital cost (undiscounted) to reduce each tonne of GHG	$86
Abatement cost per tonne of GHG (undiscounted)	-$165
Average annual household savings on home energy (undiscounted), 2050 over 2018	-$3,958
Investment $/person-year of employment	$146,900

The financial impacts of the scenarios were explored in detail. For context, if Ontario's GDP is assigned to Orillia based on a per capita allocation, the investments in the Low-Carbon Pathway hover around 2–3% of annual GDP for a decade.[63] The investments in the Low-Carbon Pathway generate financial returns on a net basis beginning in 2031.

The line in Figure 22 represents the net of the investments and savings. For illustrative purposes, in an early year in a net-zero scenario, investments might total $40 million, while savings total $7 million, resulting in a net cost of $33 million. Later in the study period, investments might total $29 million, while savings total $129 million, resulting in net savings of $100 million. There are many underlying dynamics at play that result in these curves. In the post-investment period after 2050, the benefits continue for as long as the measures deliver savings.

[63] Ontario's GDP was calculated at $58,000 per capita, and based on a population of 33,000, Orillia's GDP is estimated at $1.9 billion.

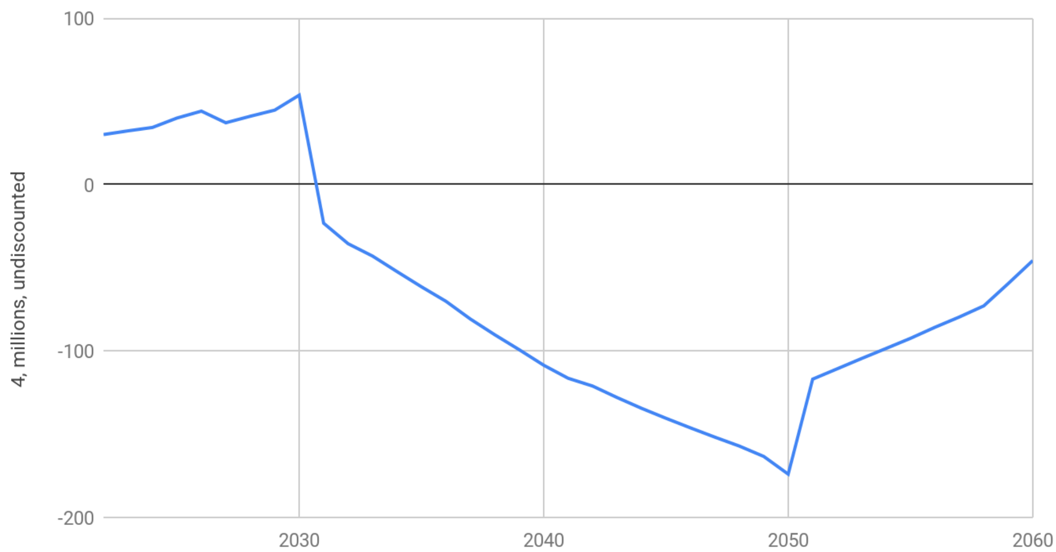


Figure 22. Net annual community-wide costs/savings for the Low-Carbon Pathway.

Figure 22 shows the present value of the major components of the three scenarios: investments; operations and maintenance savings; fuel and electricity savings; avoided costs of carbon; and revenue from transit and local energy generation. It is important to highlight that although capital investment for the plan ends in 2050, the NPV includes the energy, maintenance, and carbon costs savings as well as revenue projected over the full life of the measure, which, in some cases, extend as far as 2089.

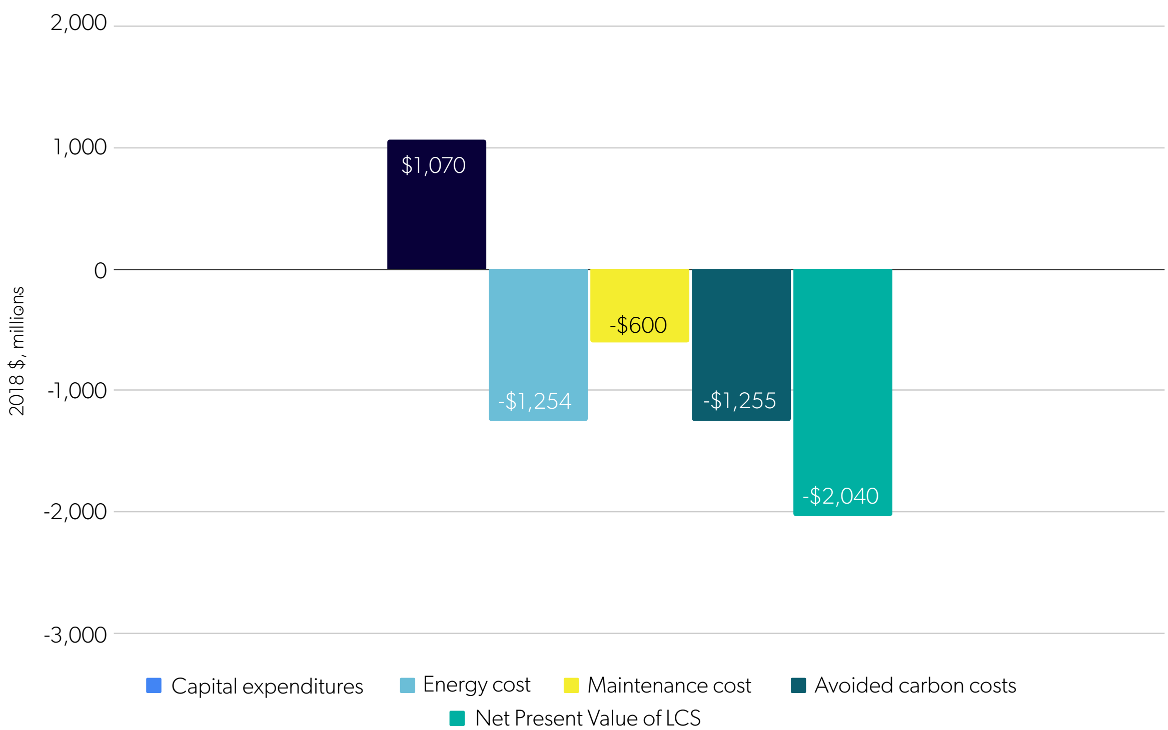


Figure 23. Present values of investments and returns for the BAU (2022–2050). Costs appear above the x-axis, while revenue and savings appear below it.

3.1.3 ABATEMENT COSTS

Abatement costs indicate whether a measure generates financial returns over its lifetime. A negative abatement cost indicates an action generates financial returns, while a positive abatement cost indicates the cost of an action exceeds financial returns. The width of each bar on the x-axis indicates the amount of GHG emissions that it saves.

The marginal abatement cost for the actions in the Low-Carbon Pathway are provided in Figure 24. Municipal retrofits have the highest marginal abatement cost at $734 for every tonne of GHG reduced. Heat pumps follow with a marginal abatement cost of $393. Both of these are interesting examples because, unlike other actions, GHG emission reductions are not always the primary motivator for these projects. In addition, these actions deliver significant benefits (improved health in the case of active transportation and ecology and shade in the case of trees) that are not factored into the calculation as financial benefits.

Solar PV on commercial buildings and households generates financial returns (savings) of $732 and $532 per tonne of GHG reduced, respectively. Electrification of vehicles consistently generates savings: personal vehicles (savings of $418/tCO2e), transit (savings of $213/tCO2e), and the City fleet (savings of $297/tCO2e). Reduced water consumption generates financial savings but very little GHG reductions, resulting in a large negative abatement cost.

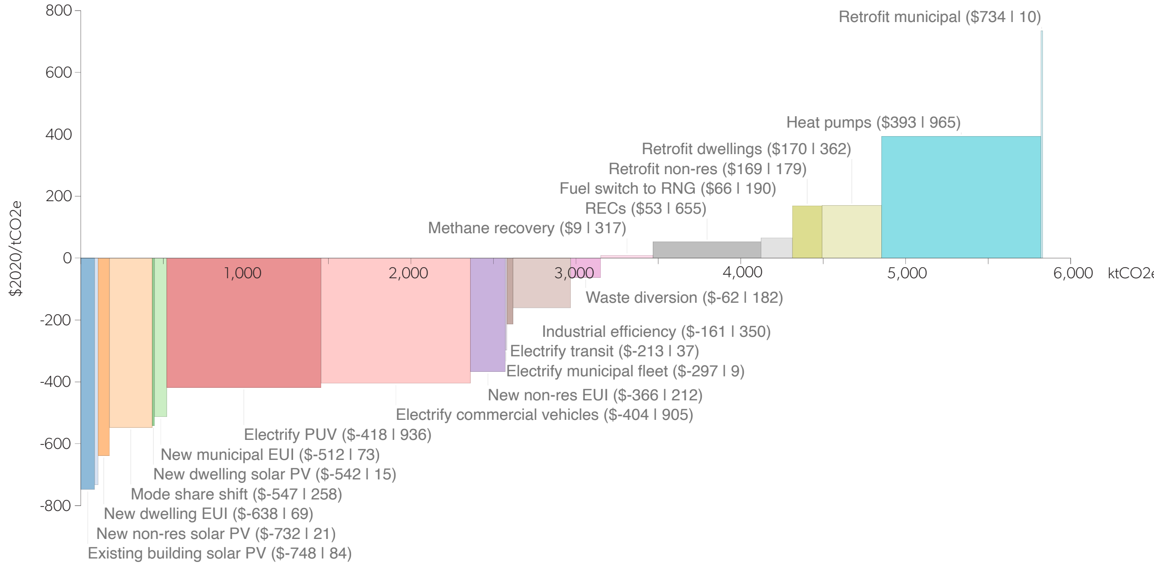


Figure 24. Marginal abatement cost curve (MACC) for the City's Low-Carbon Pathway.

Using Abatement Costs to Guide Policy

Figure 24 illustrates an abatement curve of actions. Actions on the left save money and are therefore financially interesting to investors. Actions in the middle have a net present value that is either slightly negative or slightly positive and may require credit enhancements to be compelling. Finally, on the right, those actions that are NPV negative will require subsidies. A capital-constrained public sector must concentrate on the expensive projects while relying on the private sector for the rest. A capital-rich public sector can invest in projects that are more expensive and those that may generate more interesting financial returns.

The Criticality of a Systems Approach

The abatement costs provide an important insight: the electrification of transportation generates financial savings, which, given the deployment of appropriate financial mechanisms, can be used to finance building retrofits, which are more costly. Building retrofits are critical to minimizing the burden on the grid to enable electrification of transportation.

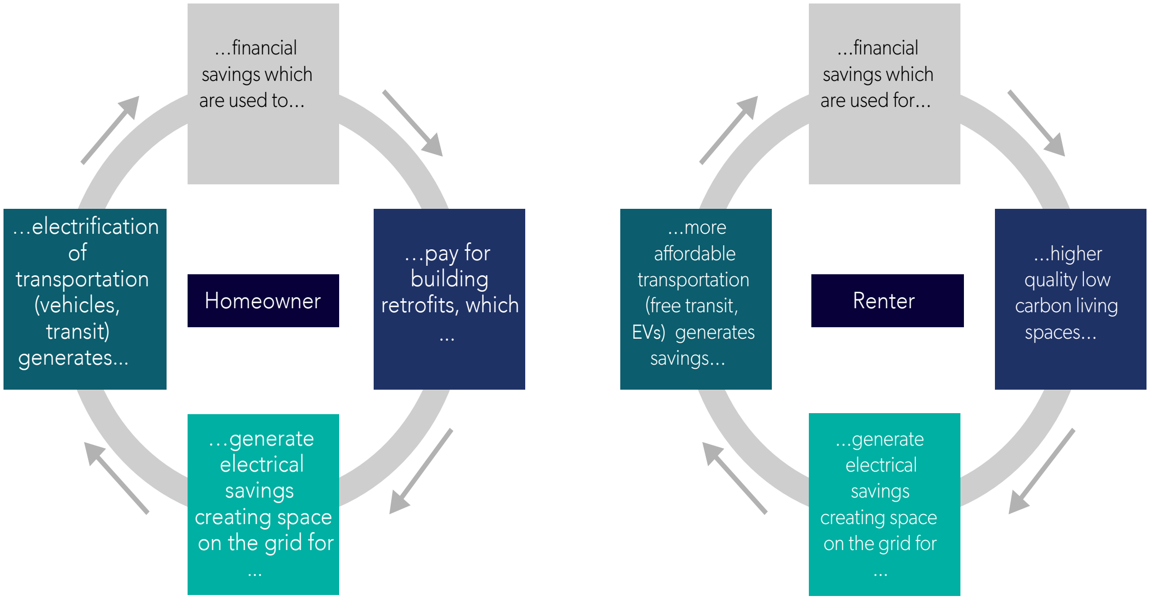


Figure 25. The electrification feedback cycle.

While a marginal abatement cost curve (MACC) illustrates the financial profile of the suite of actions, it is an imperfect indicator. The presentation of the MACC implies that the actions are a menu from which individual actions can be selected. In fact, many of the actions are dependent on each other, for example, the district energy cost increases without retrofits. Another important message is that in order to achieve the City's target, all the actions need to be undertaken as soon as possible. While there can be a tendency to wait for technological improvements, this has the effect of reducing the value of the savings that can be achieved for households and businesses and the new employment opportunities that can be created.

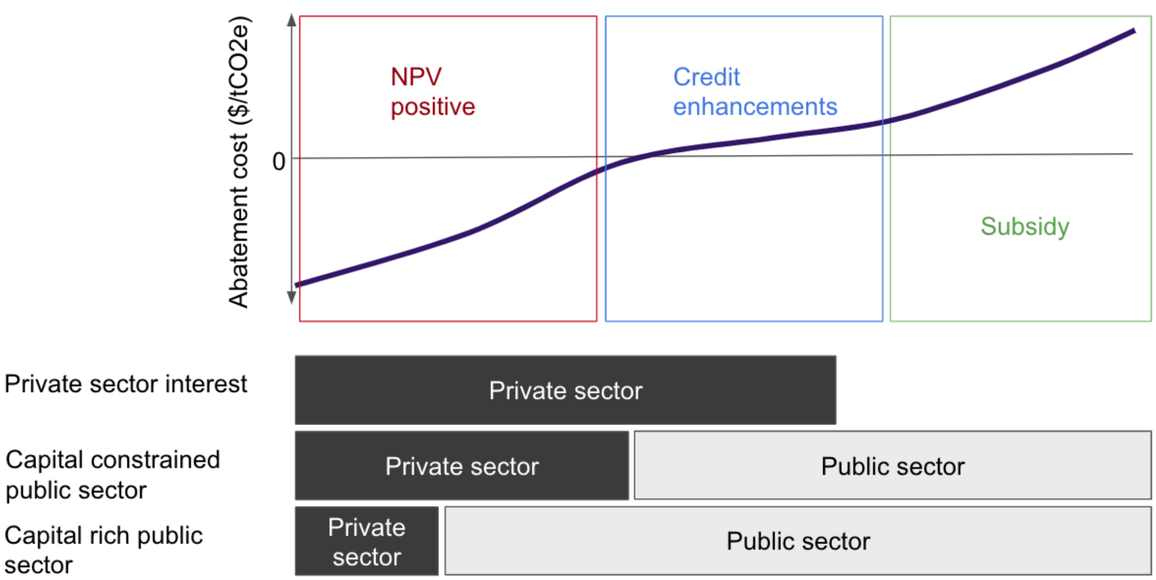


Figure 26. Aligning the abatement costs with investor interest.

The annual costs, savings, and revenue associated with fully implementing the actions in the Low-Carbon Pathway are shown in detail in Figure 27, with capital expenditures shown in full for the years in which they are incurred. As is characteristic of low-carbon transitions, the capital expenditures in the early years of the transition are significantly greater than the savings and revenues generated, and by 2031, savings are beginning to exceed investments in the Low-Carbon Pathway.

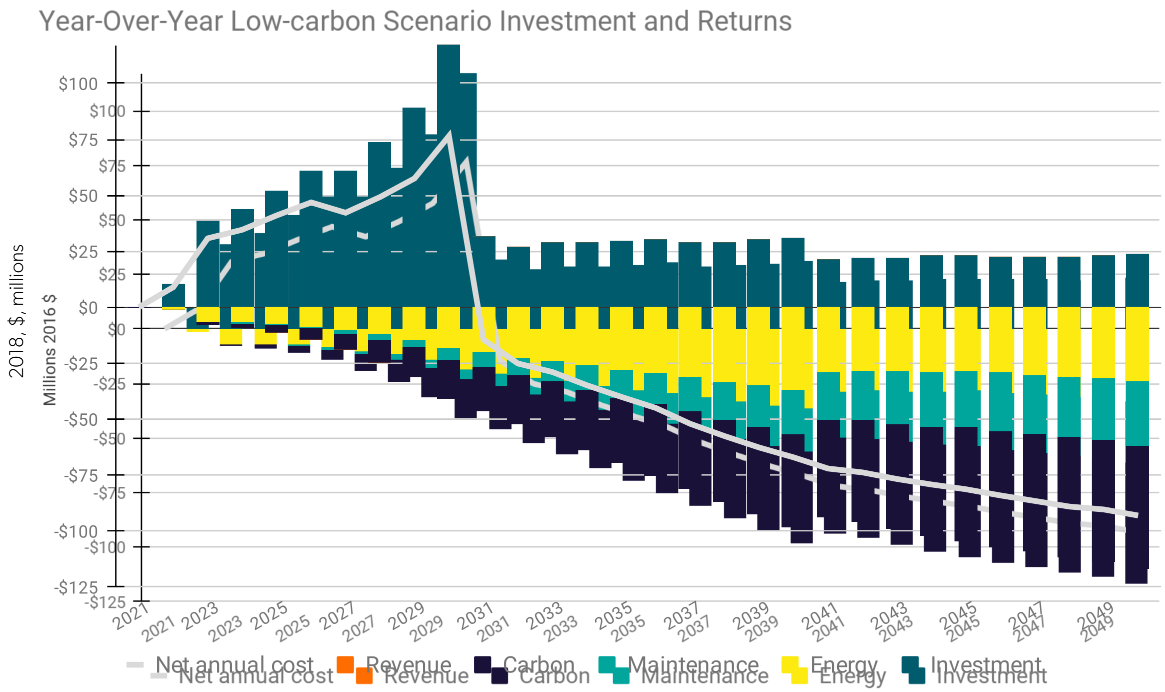


Figure 27. Year-over-year investments and returns in the Low-Carbon Pathway over the BAU Scenario, 2022 –2050.

The stacked area charts in Figure 27 represent the investments in the year they are made, which results in spikes and peaks depending on which actions are implemented in which year. For example, retrofits scale up until 2030, resulting in a peak in investments in that year. There is also an incremental capital expenditure relative to the BAU Scenario in 2030 when EVs are added, reflecting the early retirement of ICE vehicles—expenditures on vehicles are greater in the NZ40 scenario than the background replacement rate in the Do Nothing Scenario. Because of the early replacement, fewer vehicles are purchased in the NZ40 scenario than the Do Nothing Scenario between 2038 and 2044, resulting in a reduction in capital expenditures in this category. Similar blips can be observed in the NZ50 scenario but later on in the time period. The investment in transit and the building stock in the NZ scenarios is apparent relative to the BAP Scenario.

CASH **AMORTIZED**

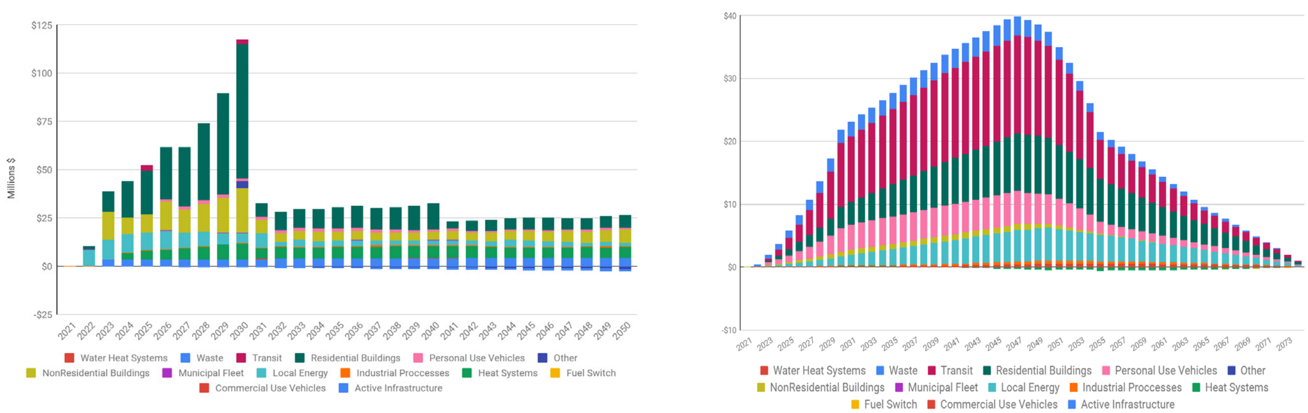


Figure 28. Incremental capital investments in the Low-Carbon Pathway over the BAU Scenario by action area, undiscounted.

Figure 28 presents costs and revenues, but with the capital expenditures amortized over 25 years with 3% interest. With this approach, which would presumably reflect actual approaches for financing the transition, the annualized capital payments are about equal to the savings and revenue generation right from the beginning of the program. By 2045, the annualized capital payments begin to decline as the earliest investments are paid off. On an annual basis, the Low-Carbon Pathway has an annual deficit, and annual savings only exceed annual costs by a small amount after 2070, as illustrated by the blue line. Amortization reduces the requirement for capital in the short term and evens out the trajectory, resulting in a longer tail of payments out until 2070 (Figure 29).

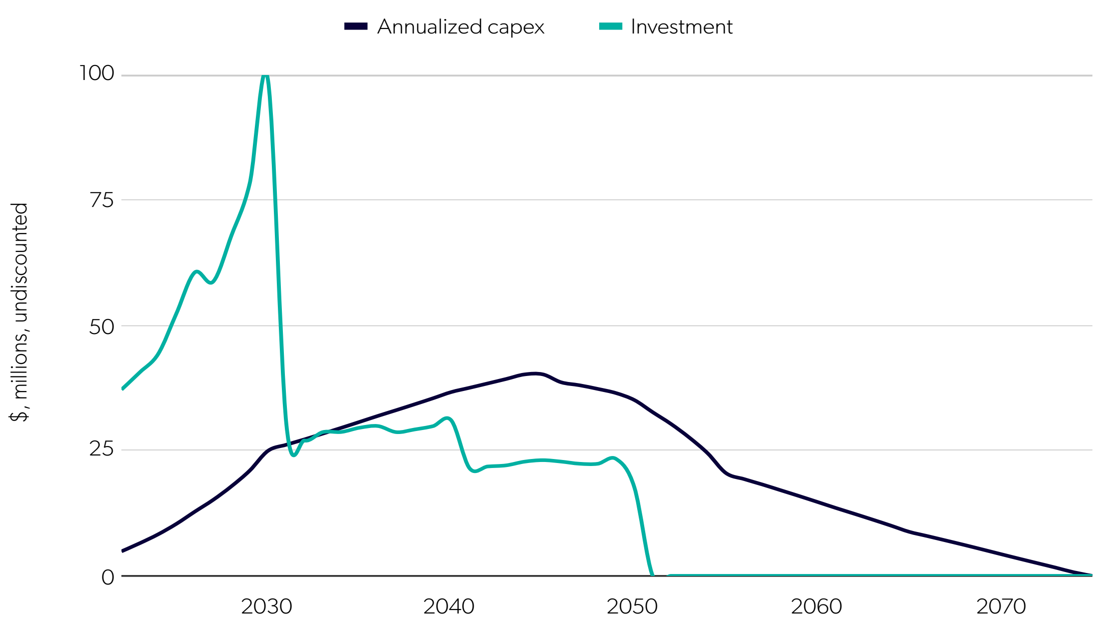


Figure 29. Impact of amortization on capital requirements for the Low-Carbon Pathway.

Household expenditures on energy—natural gas, electricity, gasoline, and diesel—are projected to decline slightly in the BAU and decline significantly in the Low-Carbon Pathway (Figure 30). In the BAU, household energy expenditures are relatively flat because vehicles become more efficient due to national fuel efficiency standards and because of decreased heating requirements as the climate becomes hotter due to climate change. The Low-Carbon Pathway involves shifting away from natural gas and gasoline to electricity, a more costly energy source. However, the increased cost is offset by the increased efficiency of homes as required by building codes, and in the case of electric vehicles, the cost is offset by the high efficiency of electric motors compared to internal combustion engines. The carbon price also adds to the cost of using fossil fuels for heating and transport. In the low-carbon scenarios, an average household in 2050 spends less on fuel and electricity (household energy and transportation expenditures) than they would have in the BAU Scenario. Depending on the business, policy, and financing strategies used in the implementation of the actions, these savings will be partly offset by the incremental capital expenditures required.

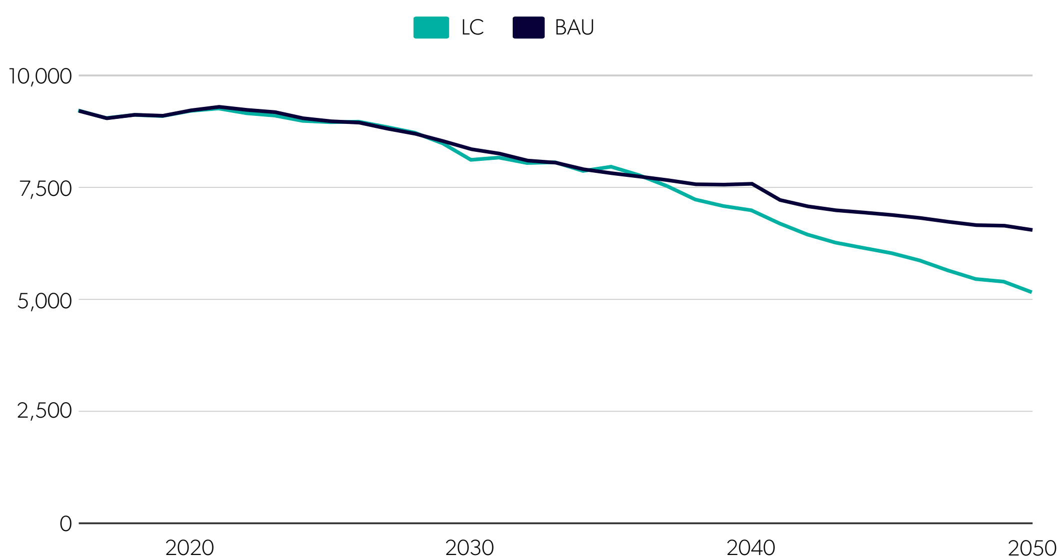


Figure 30. Average annual household expenditures on residential energy for the BAU and low-carbon scenario.

The Impact of the Carbon Tax

The carbon price is currently projected to climb to $170/tCO2e by 2030. This has the impact of increasing the cost of gasoline and natural gas relative to electricity. As a result, gasoline will be more expensive than electricity on a per-unit-of-energy basis by 2028 (note that the carbon price has not been factored into the electricity cost as it is negligible). This benefit is compounded by the fact that electric vehicles can go further per unit of energy than gasoline vehicles. Natural gas is still more affordable than electricity on a per unit basis over the period. Heat pumps, however, are three times more efficient than natural gas heating and home heating with an electric heat pump becomes more affordable than heating with natural gas in 2027 (Figure 31).

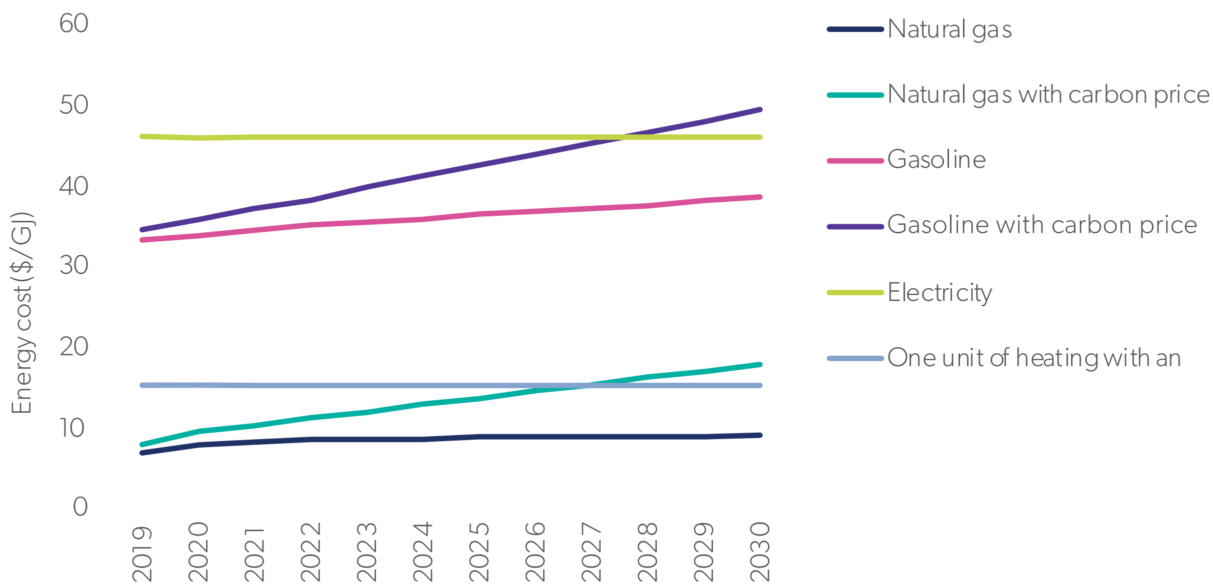


Figure 31. Projections of relative energy costs for gasoline, electricity, and natural gas.

Transitioning to a low- or zero-carbon economy is expected to have four categories of impacts on labour markets: additional jobs will be created in emerging sectors, some employment will be shifted (e.g. from fossil fuels to renewables), certain jobs will be reduced or eliminated (e.g. combustion engine vehicle mechanics), and many existing jobs will be transformed and redefined. The Low-Carbon Scenario adds person-years of employment over the BAU between 2022 and 2050 (Figure 32). As seen in the figure, this amounts to approximately 260 jobs annually, with the majority in residential and commercial building retrofits and infrastructure investments.

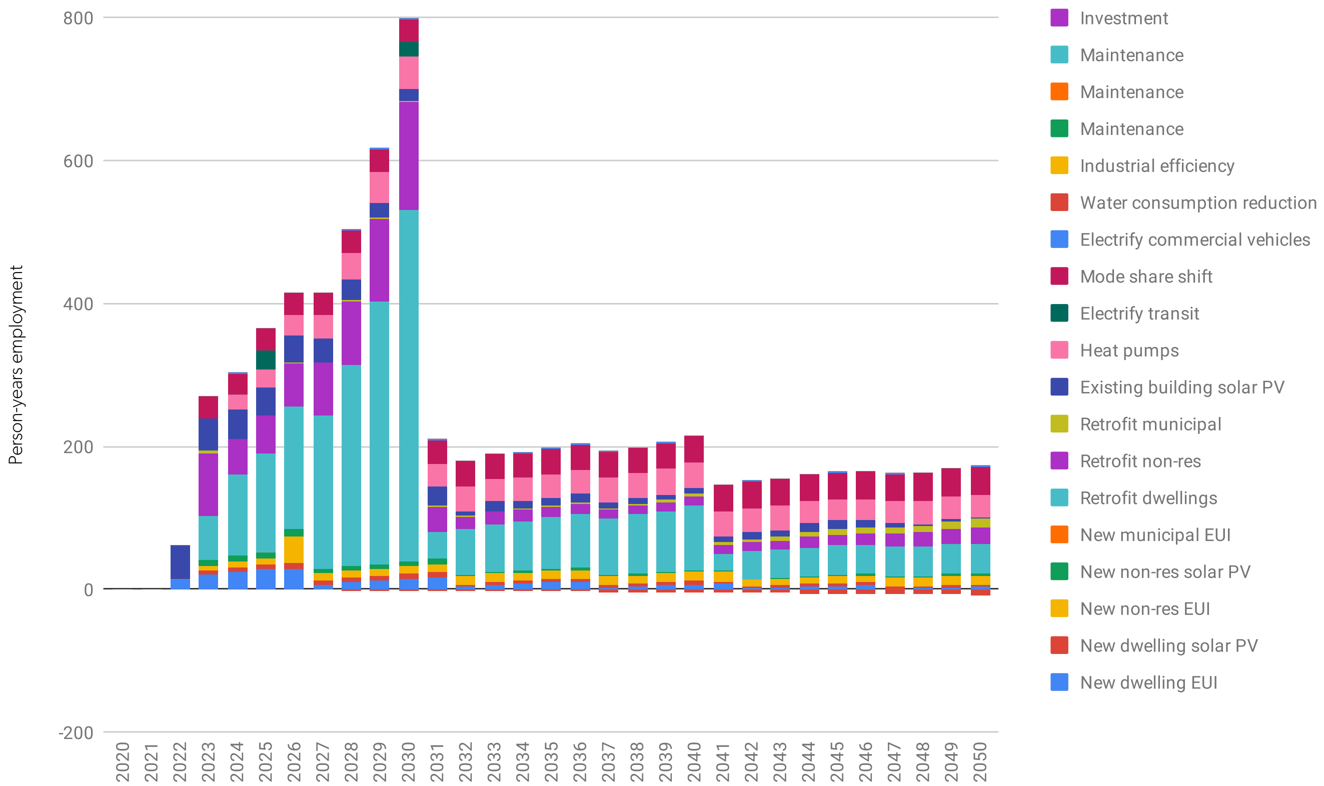


Figure 32. Annual person-years of employment generated in the Low-Carbon Scenario.

3.1.4 THE SOCIAL COST OF CARBON: A CITY FOR FUTURE GENERATIONS

Climate change represents a burden on future generations; the complexity of the climate system makes impacts difficult to anticipate. The burden to act increases the longer action is delayed, and as a result, people are turning to litigation as a potential solution to climate inaction. In 2015, twenty-one youth from across the United States filed a landmark constitutional climate change lawsuit against the federal government in the U.S. District Court for the District of Oregon. The youth successfully asserted that, in causing climate change, the federal government violated the youngest generation's constitutional rights to life, liberty, and property, and failed to protect essential public trust resources.[64] This exceptional case in the United States brought youth to the forefront of climate change action, and in Canada, the environmental non-profit, EcoJustice, has launched a judicial review against the British Columbia provincial government, "alleging it has failed in its legal duty to disclose emissions reduction plans to fight climate change."[65] The claims have not been tested in court at the time of this report's publication.

The social cost of carbon (SCC) is a new concept used in regulatory processes in Canada and the US to reflect the impacts of climate change on society. The SCC attempts to add up the quantifiable costs and benefits of a tonne of carbon dioxide. While the estimates of SCC are highly uncertain, it is one of the best ways to reflect future damages to ensure that decision-making which has implications for future emissions accounts for those implications.

The SCC includes assumptions about future conditions including population size, economic growth, rate of climate change and the impact of climate change on those conditions, drawing on the results of integrated assessment models. The discount rate for climate change is a concept representing societal need to act on climate change now despite it being less prevalent today than in the future. The discount rate, as a monetary value, is a significant assumption within the models. Discounting reflects the idea that people would rather have $100 now than $100 in ten years. From an ethical perspective, a higher discount rate indicates that future generations are worth less than current generations; for this reason the Stern Review[66] recommended a discount rate of 1.4%, well below traditional discount rates. As Stern pointed out in a subsequent article "A 2% pure-time discount rate means that the life of someone born 35 years from now (with given consumption patterns) is deemed half as valuable as that of someone born now (with the same patterns)".[67] The Government of Canada recommends 3% in circumstances where environmental and human health impacts are involved.[68]

The Low-Carbon Pathway (LCP) analysis presents the SCC for remaining emissions and avoided GHG emissions. The Government of Canada reports on estimated damage associated with lower probability and high-cost damages using a 3% discount rate. This cost reflects less likely

64 Our Children's Trust. (2016). Landmark US federal climate lawsuit. Retrieved November 14, 2016, from https://www.ourchildrenstrust.org/us/federal-lawsuit

65 Labbé, S. (March 31, 2022) B.C. climate plan fails to detail how it will hit emission targets, allege court documents. Times Colonist. Retrieved from: https://www.timescolonist.com/local-news/bc-climate-plan-fails-to-detail-how-it-will-hit-emission-targets-allege-court-documents-5218357

66 Stern, N. (2006). The Stern review on the economic effects of climate change. Cambridge University Press.

67 Stern, N. (2015). Economic development, climate and values: making policy. Proc. R. Soc. B, 282(1812), 20150820. https://doi.org/10.1098/rspb.2015.0820

68 Environment and Climate Change Canada. (2016). Technical update to Environment and Climate Change Canada's social cost of greenhouse gas estimates. Retrieved from http://ec.gc.ca/cc/BE705779-0495-4C53-BC29-6A055C7542B7/Technical%20Update%20to%20Environment%20and%20Climate%20Change%20Canadas%20Social%20Cost%20of%20Greenhouse%20Gas%20Estimates.pdf

impacts of increased temperatures that result in greater damage, as described within the 95th percentile of the SCC analysis.

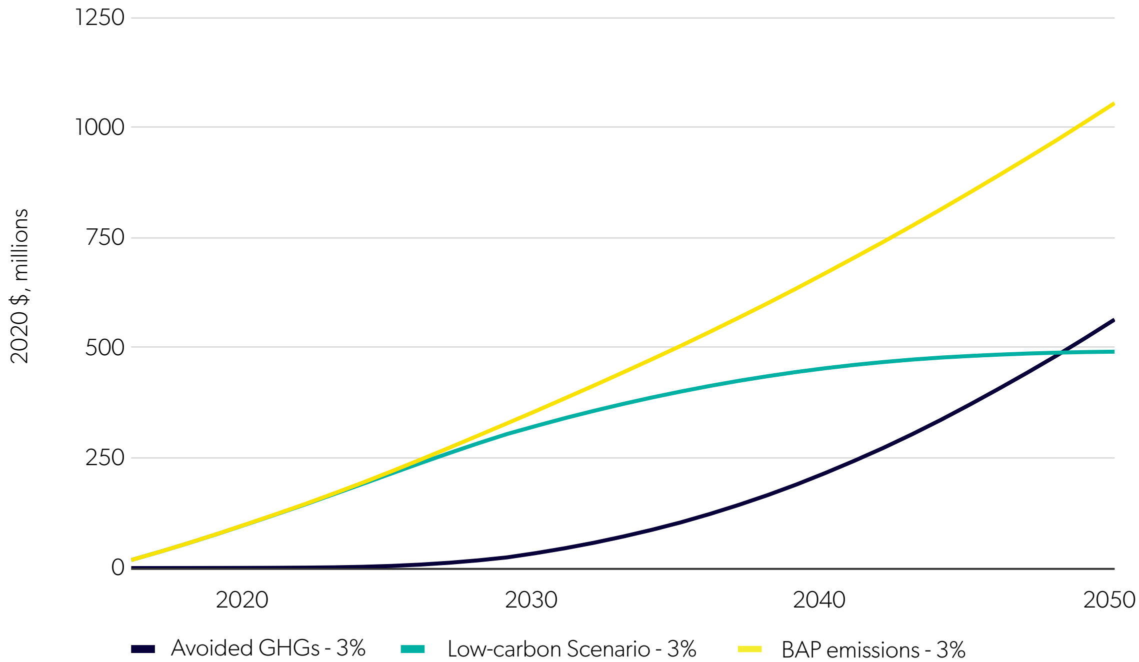
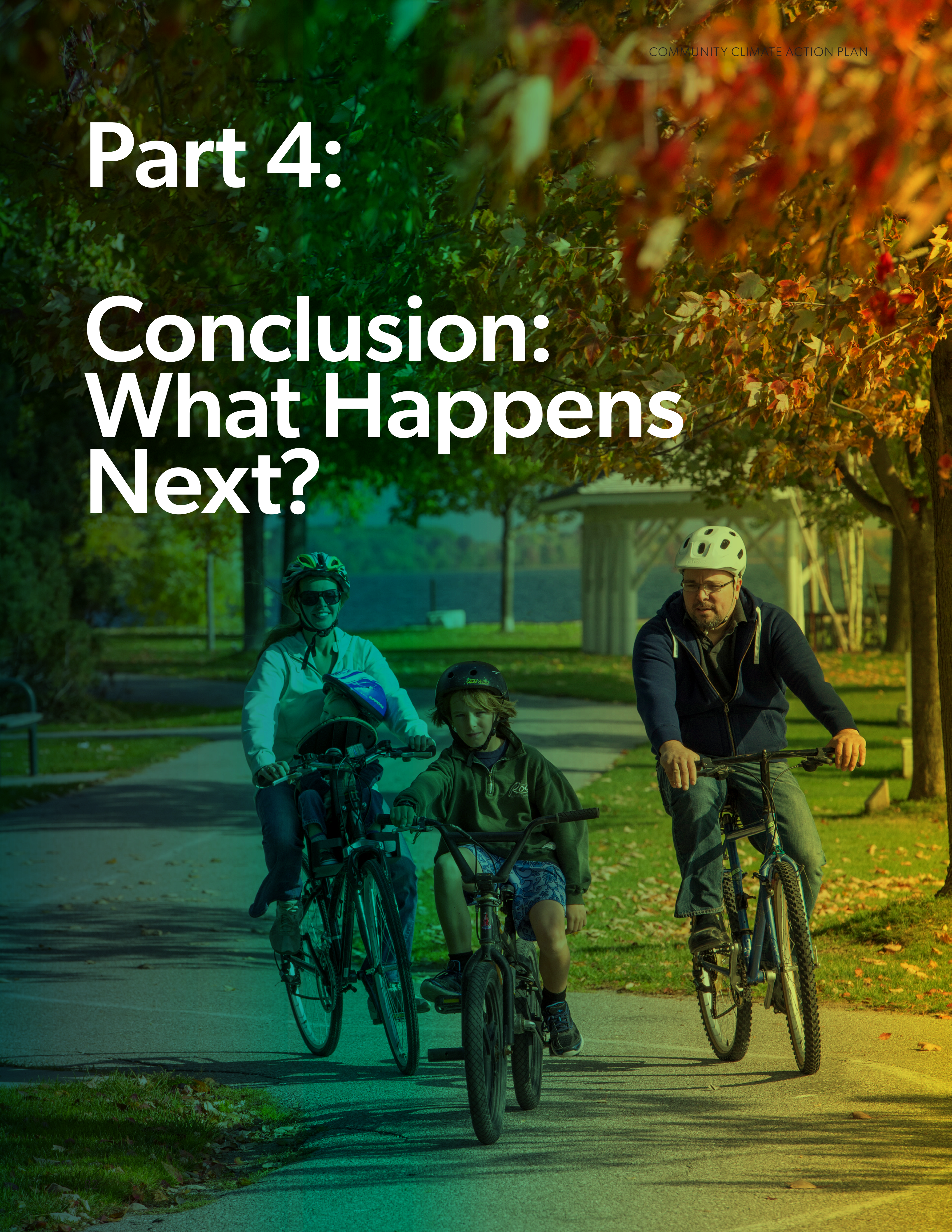


Figure 33. Social cost of carbon, in $2020 cumulative at a 3% discounting rate, 95th percentile.

The results of the SCC both for remaining emissions and avoided emissions associated with the BAU and the LCP are illustrated in Figure 33. The value of the avoided emissions, as represented by the SCC, in 2050 is $127 million in 2020 dollars. LCP actions taken and policies enacted result in avoided emissions equivalent to $1.7 billion in savings.

Part 4:

Conclusion: What Happens Next?



Part 4: Conclusion: What Happens Next?

Decarbonizing Orillia and reaching the net-zero target in Orillia's Climate Future will require investment. But these new investments will not only achieve GHG emissions reductions, they also synergistically support other City objectives, such as economic development, improved health and equity outcomes, and climate resilience.

Taking responsibility for climate change by acting now will alleviate some of the pressure felt by future generations. Efforts and investments made today are important aspects of Orillia's equitable approach to climate action. The City is actively working to ensure programs and policies address the disproportionate impacts of our changing climate on equity-deserving groups and future generations.

The investments are organized around three focal points that streamline Orillia's climate action. These three Big Moves address the major drivers in Orillia's Climate Future and lead the city to net zero emissions by 2050.

Big Move 1: Renewable Energy actions enhance Orillia's local energy generation capacity. By maximizing solar PV on buildings within the city, Orillia takes control of its clean electricity production and creates an energy source that supports and enables so many other decarbonization actions. This move takes the "Sunshine City" moniker and turns it into climate action and economic opportunity.

Big Move 2: Transportation actions focus on decarbonizing a high-emissions activity that we engage in every day. Rather than managing traffic jams and fuel prices, Orillia will be a city of electric vehicles and frequent, reliable public transit. Investments that improve access to active transportation will create a healthier, more vibrant city. People of all ages will be able to get around the city more easily, and they will breathe cleaner air while doing so.

Big Move 3: Buildings actions will transform where we live into modern dwellings that are easier and more affordable to keep comfortable. Deep, coordinated retrofits will maximize the benefits of updated housing while mitigating the disruption and cost. Investments in commercial and industrial retrofits will improve conditions in key economic sectors in the city.

Additionally, Orillia will create and take advantage of robust waste diversion programs to further reduce waste and the emissions it produces. An investment in methane capture will reduce methane emissions and could create an alternative fuel source.

Finally, Orillia will institute the governance, management, and leadership structures needed to initiate and sustain long-term decarbonization actions. These structures include loans and other investment mechanisms to support the city in its efforts to reach net zero.

Creating the net-zero city that Orillia envisions will take dedication. But the benefits are vast, and will be felt by the city's residents, neighbouring communities, and the global community of cities that have committed themselves to the same future.

The Sunshine City will shine even brighter in 2050.

Orillia's Climate Future

Our Community Climate Action Plan
Appendices




SSG

Orillia's Climate Future

ORILLIA

Contents

Appendix A: Definitions

Base year: The starting year for energy or emissions projections.

Biogas (renewable natural gas): Methane captured from bacterial decomposition of sewage, manure, waste, plant crops, or other organic waste products. It can be used as a natural gas replacement.

Building retrofit: Changes to the structure or systems of an existing building to achieve energy and water consumption reductions.

Business-as-Usual (BAU): A scenario illustrating energy use and greenhouse gas emissions if no additional plans, policies, programs, and projects are implemented.

Capacity factor: The ratio of a power plant's actual output over a period of time to its potential output if it were possible to operate continuously over the same period of time.

Carbon dioxide equivalent (CO2e): A measure for describing the global warming potential of a greenhouse gas using the equivalent amount or concentration of carbon dioxide (CO_2) as a reference. CO2e is commonly expressed as million metric tonnes of carbon dioxide equivalent (MtCO2e).

Cooling degree days (CDD): The number of degrees that a day's average temperature is above 18 oC, requiring cooling.

Deep energy retrofit: A whole-building analysis and construction process minimizing building energy use by 50% or more compared to the baseline energy use.

Distributed generation: Technologies that generate electricity on-site through solar photovoltaic (PV) systems, combined heat and power (CHP) systems, and/or other technologies.

District energy systems: Providing heating and/or cooling to multiple buildings from centralized energy systems.

Emissions: Greenhouse gas emissions measured in grams, kilograms, or metric tonnes (CO2e), unless otherwise indicated.

Emissions intensity: The ratio of emissions released per unit of electricity generated, measured in gCO2e/kWh.

Energy efficiency improvement: An improvement in the ratio of energy consumed to the output produced or service performed. This improvement results in the delivery of more services for the same energy inputs or the same level of services from less energy input.

Electric vehicles (EVs): An umbrella term describing a variety of vehicle types that use electricity as their primary fuel source for propulsion or as a means to improve the efficiency of a conventional internal combustion engine.

Energy storage: Technologies that store energy for consumption at a later time. Energy storage includes electric systems, such as batteries, and thermal systems, such as hot and cold water storage tanks.

Feed-in-Tariff: A policy mechanism designed to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers. The energy produced is sold to the grid rather than consumed directly (termed, "net-metering").

Geoexchange energy: Low-temperature thermal energy collected by heat pumps from soil and water near the Earth's surface. Used in building heating.

Geothermal energy: High-temperature thermal energy collected from deep in the Earth for use in building heating and industrial applications.

Greenhouse gases (GHG): Gases that trap heat in the atmosphere by absorbing and emitting solar radiation, causing a greenhouse effect that unnaturally warms the atmosphere. The main GHGs are water vapour, carbon dioxide, methane, nitrous oxide, and ozone.

Heat pump: A device that transfers heat energy from a source of heat to a target area using mechanical energy.

Heating degree days (HDD): Number of degrees that a day's average temperature is below 18oC, requiring heating.

HVAC: Heating, ventilation, and air conditioning systems, referred to in the context of a building.

Indicator: An observable or measurable result that shows evidence of whether an impact has occurred and the nature of that impact. It provides a metric one can use to quantify and define the scale of a resulting change.

Net-metering: This is an electricity billing mechanism that allows consumers who generate some or all of their own electricity to use that electricity anytime, instead of when it is generated.

Passive house buildings: Buildings designed and constructed to stringent standards resulting in up to 90% increased energy efficiency as compared to a typical building's energy use.

Re-commissioning: A process of examining and optimizing a building's HVAC systems after a building has been fully operational for a period of time.

Renewable energy: Energy that comes from resources that are naturally replenished on a human timescale, such as sunlight, wind, moving water, and geothermal heat.

Solar photovoltaic (PV): Also known as solar electric systems or solar panels, these are systems that convert sunlight into electricity. Any excess electricity produced can be sold to the utility through a process called net-metering.

Vehicle kilometres travelled (VKT): Distance travelled by vehicles within a defined region over a specified time period.

GHG emissions	Energy
1 ktCO2e = 1,000 tCO2e	1 MWh = 1,000 kWh
1 tCO2e = 1,000 kgCO2e	1 MWh = 3.6 GJ
1 kgCO2e = 1,000 gCO2e	1 GJ = 278 kWh
	1 GJ = 1,000,000 J
	1 MJ = 0.001 GJ
	1 TJ = 1,000 GJ
	1 PJ = 1,000,000 GJ

Appendix B: Public Engagement

Engagement Objectives

Principally, the Engagement Plan seeks to:

1. Build understanding about the process necessary to undertake meaningful climate action;
2. Facilitate inclusive conversations among interested or affected parties in order to document community concerns and aspirations;
3. Use community input to select the CCAP GHG emissions reduction target; and
4. Use community input as part of a collaborative problem-solving process with all interested or affected parties, in order to address the challenges of achieving the City's GHG emissions reductions targets.

This requires the City of Orillia to deliver certain outputs (tangible deliverables) and outcomes (changes in understanding, perspective, relationships, level of trust, etc.). Both the outputs and outcomes will support the City and interested or affected parties in reviewing and adjusting the CCAP.

Engaging with key interested or affected parties will provide opportunities to address concerns, discuss implications, and articulate the journey ahead. This will ensure that the CCAP created is feasible, ambitious, equitable, and effective.

The following are the recommended objectives for this Engagement Plan. These have been informed by SSG's experience and the pre-engagement interviews.

Objective 1: To inform, and more importantly, to engage interested or affected parties about the pressing need for ambitious climate action.

- Output: A community-based interested or affected parties committee, with internal and external members, is established.
- Outcome: Interested or affected parties understand the extent of planning and fiscal opportunities/needs necessary for the CCAP to succeed.
- Outcome: Interested or affected parties understand the history resulting in the current need for a new strategy.
- Outcome: Interested or affected parties know how to get engaged.
- Outcome: Interested or affected parties are motivated and participate in engagement opportunities.
- Output: Communications materials are created to educate and inform interested or affected parties about the strategy process and opportunities for input.

Objective 2: To involve interested or affected parties in the development of the engagement process.

- Outcome: Interested or affected parties say they have been meaningfully involved in the development of the engagement plan for the CCAP.
- Outcome: Interested or affected parties accept changes as necessary.
- Output: Interviews with key interested or affected parties form the pre-engagement process.
- Output: A pre-engagement interview summary.

Objective 3: To inform the community, including the Chippewas of the Rama First Nation, of the specific targets and actions required to create meaningful and feasible greenhouse gas emission reductions while engendering a sense of responsibility for continuing this work through to its long-term completion. Suggested outcomes include:

- Outcome: The community understands both the changes, planning, and financial investment required for the climate action plan to succeed, as well as the increasing costs of inaction. Conversely, they are also aware that the change is achievable and that financial and "quality of life" benefits will be realized as the CCAP is achieved.
- Outcome: Community participants know how to get engaged, are motivated to identify opportunities, and become partners in the realization of the CCAP.

Objective 4: To involve the community, including the Chippewas of the Rama First Nation, and City staff in gathering feedback to inform the modelling, to select appropriate low-carbon actions, and to determine how to implement the CCAP. This will ensure that the CCAP is customized to Orillia's operational realities, strategic vision, expertise, and culture. It will also ensure all impacts to the Chippewas of the Rama First Nation impacts are considered.

- Outcome: The Chippewas of the Rama First Nation understand and accept changes, challenges, or trade-offs that are required to create an ambitious CCAP.
- Output: A series of criteria and/or options will be used to make decisions about low-carbon action selection.
- Output: A series of assumptions to be used in the creation of low-carbon scenarios.
- Output: Online survey or crowdsourcing activity distributed through optimal communications channels seeking feedback on scenario narratives and modelling results.
- Output: The CCAP is based on an accurate description of Orillia's "current state". This foundation will ensure that the low-carbon actions proposed in the CCAP will correctly describe the type, extent, and speed of change required to achieve the emissions reduction goals.
- Output: Regular updates (e.g. bimonthly) to mailing list subscribers and social media followers on project progress.
- Output: Launch event and CCAP information session.
- Output: BAU results workshop.
- Output: Contact lists of the Chippewas of the Rama First Nations members who wish to continue the dialogue on CCAP implementation.
- Outcome: The City of Orillia identifies and collaborates with its implementation partners to maximize the impact of the CCAP and to benefit all participants justly and equitably.

Objective 5: To involve the CBSC to lay the groundwork for a future implementation body that will be responsible for the long-term implementation of the strategy.

- Outcome: The CBSC transitions into a long-term body that is responsible for the oversight of plan implementation.
- Output: Terms of reference or planning document (like a memorandum of understanding) for the new implementation body.

Objective 6: To collaborate with the Chippewas of the Rama First Nation to identify how the CCAP can advance reconciliation and identify how the City and the First Nation can work together to implement low-carbon actions and advance the goal of the CCAP.

- Outcome: Local Indigenous population will have an opportunity to provide input to shape the CCAP.
- Output: A CCAP that is responsive to local First Nations concerns and based on a nation-to-nation engagement process.
- Output: The City and the Chippewas of the Rama First Nation will have a foundation on which to potentially work as implementation partners.

Objective 7: To inform the Chippewas of the Rama First Nation and interested or affected parties about how their involvement will shape the City's climate action choices and to provide feedback to those interested or affected parties on the development of the CCAP and its implementation progress over the long term.

- Outcome: Interested or affected parties will understand the impact of their participation in shaping the CCAP and in acting as champions for the implementation of the plan.
- Outcome: Interested or affected parties can see they have impacted decision-making.
- Output: The City of Orillia will provide regular and clear information on the progress of the CCAP on the City of Orillia's website, including updates on appropriate communications to interested or affected parties summarizing input and how it influenced plan decisions.
- Output: Final presentation to the CBSC and City Council.

PHASE 1: PRE-ENGAGEMENT INTERVIEWS + ENGAGEMENT DESIGN

Project initiation: June–July 2021

ACTIVITY	SSG ROLE	CITY ROLE	OBJECTIVES	TIMEFRAME
Pre-engagement interviews and summary report	Conduct interviews of individuals identified by City (30-minute to 1-hour phone or video call). Analyse interviews.	Identify participants and invite them.	1	June–July
Engagement Plan design	Draft Engagement Plan.	Refine and approve.	All	July
CCAP engagement materials, including a dedicated project logo, promotional materials that can be shared online (e.g. social media, City's website), and content for the CCAP webpage.	Prepare communications materials for the CCAP engagement process.	Provide support and guidance.	1, 3, 7	Ongoing

PHASE 2: ACTIVE ENGAGEMENT PERIOD

June 2021–January 2022

ACTIVITY	IAP2 SPECTRUM LEVEL
Public Communications Updates	Inform Promise to the public: We will keep you informed on the plan's progress and opportunities for you to become involved.
Internal Technical Committee (ITC) Workshop 1: The Process Task force members will become acquainted with each other and the project goals and process. The project approach and scenario modelling method will be introduced. Participatory workshop exercises will be hosted to build relationships, develop CAG project values, and explore themes to be addressed by the CCAP.	Involve Promise to the public: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.
CBSC Workshop 1: Introduction to the Process CAG members will become acquainted with each other and the project goals and process. The project approach and scenario modelling method will be introduced. Participatory workshop exercises will be hosted to build relationships, develop CAG project values, and explore themes to be addressed by the CCAP.	Involve Promise to the public: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.

ACTIVITY	IAP2 SPECTRUM LEVEL
CBSC & ITC Workshop 2. Where We're Headed: Opportunities and Targets Orillia's energy and emissions outlook will be presented to provide the scale of the emissions reductions challenge. The CAG will identify emissions areas to focus on and will present emissions reduction opportunities in each emissions sector for consideration in CCAP development. Varying emissions reduction targets will be debated, and preferred targets will be documented. The ITC will further explore corporate targets and what steps need to occur to get there, including corporate vehicles, waste, buildings, and energy generation. Feedback is incorporated to the CEEP.	Involve Promise to the public: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.
Online Community Survey: Online survey to give community members a chance to weigh in on vision statements and provide feedback. their low-carbon action and adaptation priorities. The results will be used as inputs into the action prioritization process.	Consult Promise to the public: We will seek your advice on the variety of options presented.
Launch Event: Town Hall 1—CCAP Inventory and BAU (Co-Hosted with Sustainable Orillia): The first public event, the Town Hall, will introduce the community to the CCAP process, share information about public input opportunities, and enable participants to share their vision for Orillia's future. Event hosting is shared with Sustainable Orillia. A possible guest speaker to kick-off the event with messaging on climate change.	Involve Promise to the public: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.

ACTIVITY	IAP2 SPECTRUM LEVEL
ITC 2: Base Year Energy and Emission Inventory and BAU Modelling Results A description of the project process and modelling approach will be presented. Base-year energy and emissions inventory data and Business-as-Usual Scenario modelling results will be reviewed. Emissions reduction challenges and opportunities will be discussed with regard to City powers. The second half of the project will be refining projects and policies to include in the October CAP. Proposed Attendees: Representatives from building approvals, community planning/ short-term planning, transportation, environmental services. Recommended to have directors or leadership committee to understand modelling approach.	Involve Promise to the public: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.
October Council Meeting: Corporate Climate Plan, draft Climate Emergency declaration. A presentation to Council on the recommended Corporate Plan and a recommended Climate Emergency.	Involve Promise: We will incorporate your preferences and feedback to the extent possible, and seek advice in formulating alternatives.
Focus Group 1: Youth (Lakehead University) 8–15 people. The group will have a short presentation on the community's target and significant climate actions. A tailored list of low-carbon actions are presented and feedback is solicited to make them more inclusive.	Involve Promise: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.
Focus Group 2: Equity-Seeking Interest Groups 8–15 people. The group will have a short presentation on the community's target and significant climate actions. Recommended Invitees: Renters advisory board, social housing operators, community-based non-profits.	Involve Promise: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.

ACTIVITY	IAP2 SPECTRUM LEVEL
ITC Workshop 3: Low-Carbon Scenario Actions & Assumptions Potential low-carbon actions and their assumptions for modelling will be identified and discussed by sector. Recommended Attendees: Directors or senior representatives from building approvals, community planning/short-term planning, transportation, environmental services. Representatives from building approvals, community planning/ short-term planning, transportation, environmental services.	Involve Promise to the public: We will incorporate your preferences and feedback to the extent possible, and seek advice in formulating alternatives.
CBSC Workshop 3: Low Carbon Actions and Scenario development: This workshop will review climate actions associated with a climate target. SSG and the team will solicit CBSC input on considerations for scenario development.	Involve Promise to the public: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.
CBSC Workshop(s) 4a4b: Low-Carbon Scenarios This set of workshops will review the estimated impacts of climate actions for the City and community. Workshops with: CBSC, ITC, and Council.	Involve. Promise to the public: We will incorporate your preferences and feedback to the extent possible and seek advice in formulating alternatives.

PHASE 3: FINAL REPORT + PRESENTATION

By Spring 2022

ACTIVITY	TIMEFRAME
Draft Presentation to Council. Update council on work done so far, draft elements of the low-carbon trajectory, and request to move to an open house.	Spring 2022
Community Open House: The plan is presented to the public along with technical reports. This event could potentially take place in person, if COVID guidelines allow. In the event that it is online, a digital, interactive Zoom-style event will be prepared.	Spring 2022 2–3 week open house period
Final Presentation to Council + Feedback Received Final details of the low-carbon plan and engagement results will be presented to Council. SSG, Sustainable Orillia, Youth Groups, and the Chippewas of the Rama First Nation invited.	Spring 2022
Celebratory Launch and Gala (Co-hosted with Sustainable Orillia)	TBD

Appendix C: Financial Analysis

PURPOSE OF THIS DOCUMENT

This document provides a summary of the projected costs, revenues, and savings associated with the implementation of the low carbon pathway modelled for Orillia's Community Climate Change Plan, on the whole and on an action-by-action basis. It also provides an overview of some of the energy transition's broader economic impacts, such as on jobs and household energy costs.

DISCLAIMER

Reasonable skill, care, and diligence have been exercised to assess the information acquired during the preparation of this analysis, but no guarantees or warranties are made regarding the accuracy or completeness of this information. This document, the information it contains, the information and basis on which it relies, and the associated factors are subject to changes that are beyond the control of the author. The information provided by others is believed to be accurate but has not been verified.

This analysis includes strategic-level estimates of capital investments and related revenues, energy savings, and avoided costs of carbon represented by the proposed Community Climate Change Plan. The intent of this analysis is to help inform project stakeholders about the potential costs and savings represented by Orillia's Community Climate Change Plan in relation to the modeled Business-as-Usual scenario. It should not be relied upon for other purposes without verification. The authors do not accept responsibility for the use of this analysis for any purpose other than that stated above and do not accept responsibility to any third party for the use, in whole or in part, of the contents of this document.

This analysis applies to the City of Orillia and cannot be applied to other jurisdictions without further analysis. Any use by the City of Orillia, its sub-consultants, or any third party, or any reliance on or decisions based on this document, are the responsibility of the user or third party.

Overview

This analysis describes the projected costs (capital investment), returns (operational and maintenance savings, energy savings, carbon cost savings, and revenues), and job creation opportunities associated with implementing the recommended low carbon pathway outlined in Orillia's Community Climate Change Plan (the "Plan"). The analysis also calculates marginal abatement costs, which identifies net cost per tonne of greenhouse gas (GHG) emissions reduced.

The following five categories of costs and returns are included in this financial analysis:

1. Capital costs;
2. Maintenance costs and savings;
3. Revenues;
4. Energy costs and savings; and
5. Carbon cost savings.

Administration, education, and marketing costs associated with actions are not included in the analysis. Nor are any of the costs or avoided costs associated with adding central energy infrastructure projected to be required with population growth and business-as-planned energy use. Similarly, any land purchases for renewable energy infrastructure are excluded.

In addition, where defensible cost and returns can not be identified for particular actions, they are excluded from the financial analysis. As a result, the following actions from the Plan's low carbon scenario are not included in this financial analysis:

- Active transportation infrastructure required to increase the active transportation mode share;

The table below highlights the key findings from the financial analysis of the low carbon scenario recommended in the Framework. A glossary of terms is included in the summary.

Table 1. Summarized financial reporting

Financial Metric	Measurement Unit	Key Results
Total incremental capital investment, 2022-2050	2016 dollars, Cumulative	$1.07 billion
Total savings and revenues*	2016 dollars	$3.11 billion
Net return of the investments*	2016 dollars	$2.04 billion
Capital cost (undiscounted) to reduce each tonne of GHG	2016 dollars	$86
Abatement cost (NPV) per tonne of GHG	2016 dollars	-$165
Top MACC actions	Marginal abatement cost/savings ($/tonne CO2e)	**1.** Water consumption reduction **2.** Adding solar PV to existing residential buildings **3.** Adding solar to new non-residential buildings **4.** Net-zero new construction **5.** Modeshare shift
Employment	Person years of employment	7,282 person-years of employment, or an average of 260 full-time equivalent jobs annually
Annual savings on household energy expenditures	2016 dollars	$3,958

*Over the lifecycle of the investment/asset

Key Financial Concepts

The following are key concepts that are used to analyze the economic and financial impacts of the Framework.

Costs are relative to the BAP

This financial analysis tracks projected costs and savings associated with low-carbon measures that are above and beyond the assumed 'business-as-usual' costs. The financial assumptions used to develop the analysis were shared with municipal government staff for input and revision.

Discount Rate

The discount rate is the baseline growth value an investor places on their investment dollar. A project is considered financially beneficial by an investor if it generates a real rate of return equal to or greater than their discount rate.

An investor's discount rate varies with the type of project, duration of the investment, risk, and the scarcity of capital.

Some argue that the evaluation of climate change mitigation investments should be based on the application of a very low or even zero discount rate to reflect the value to society. This approach is referred to as applying a social discount rate. A social discount rate is the discount rate applied for comparing the value to society of investments made for the common good and as such, it is inherently uncertain and difficult to determine.

In this project, we evaluate investments in a low-carbon future with a 3% discount rate.

Net Present Value

The net present value of an investment is the difference between the present value of the capital investment and the present value of the future stream of savings and revenue generated by the investment.

Five aggregate categories are used to track the financial performance of the low-carbon actions in this analysis: capital expenditures, energy savings (or additional costs), carbon cost savings, operation and maintenance savings, and revenue generation associated with renewable energy production facilities and some transit actions. Carbon cost savings assume that the carbon price will increase in line with current federal plans, reaching $170/tonne CO2e in 2030 and held constant thereafter.

Administrative costs associated with implementing programs, as well as any energy system infrastructure upgrades that may be required are not included, including associated land purchases. Similarly, the broader social costs that are avoided from mitigating climate change are not included in the financial analysis.

Marginal Abatement Cost

The marginal abatement cost of an action is the estimated cost for that action to reduce one tonne of GHG emissions and is calculated by dividing the action's net present value ('NPV') by the total GHG emissions it reduces (tCO2e) over its lifetime. For example, if a project has a net present value of $1,000 and generates 10 tCO2e of savings, its abatement cost is $100 per tCO2e reduced. The abatement cost is marginal because it captures the incremental cost above the business-as-planned activity and cost.

Amortization

The costs of major capital investments are typically spread out over a period of time (e.g. a mortgage on a house commonly has a 25-year mortgage period). Amortization refers to the process of paying off capital expenditures (debt) through regular principal and interest payments over time. In this analysis, we have applied a 25-year amortization rate to all investments where noted.

Industrial Emissions

Financial analysis of the industrial sector includes only the low carbon investments for secondary manufacturing. Primary industry (e.g. oil refinery) investments and net returns have not been estimated in this analysis.

A Note on Framework Motivation and Co-Benefits

The direct financial impacts of the Framework provide important context for local decision-makers. However, it is important to note that the direct financial impacts are a secondary motivation for undertaking actions that reduce GHG emissions. First and foremost, GHG emissions reductions are a critical response to the global climate crisis.

Note that most measures included in the Framework provide additional benefits to the community, such as cleaner air and positive health outcomes. These benefits are not fully captured in this analysis.

Financial Analysis Results

The investments required to implement the low-carbon pathway outlined in the Plan yield a positive financial return (net return) of $2.04 billion over the lifecycle of the investments. Capital investments of $1.07 billion across various sectors in the community are required between 2022 and 2050 to implement the Plan and generate the returns.

The overall returns translate to a weighted average return of $165 per tonne of CO2e reduced. Table two summarizes the net present value and marginal abatement cost by action and for the overall low-carbon pathway recommended in the Plan. All measures that have a positive abatement cost, or net financial loss, are highlighted in purple, and all measures with a negative abatement cost, or net financial return, are highlighted in green.

The most expensive action is retrofitting existing municipal-owned buildings, at $734 per tonne of CO2e avoided. This second most expensive action is adding heat pumps at $393 per tonne of CO2e avoided. The third most expensive action is retrofitting existing residential buildings at $170 per tonne of CO2e avoided.

Reducing water consumption has the lowest cost per tonne of GHG reduction, at an estimated savings of $8,719 per tonne of CO2e avoided. Beyond this, several actions relating to solar PV installations have high returns/savings. These include:

- Adding solar PV to new residential buildings - $748 per tonne of CO2e avoided;
- Adding solar to new non-residential buildings - $732 per tonne of CO2e avoided;
- Adding solar PV to new residential buildings - $542 per tonne of CO2e avoided; and

Aside from rooftop solar installations, the most cost-effective actions per tonne of GHG emissions avoided are net-zero new residential buildings ($638 per tonne of CO2e avoided), mode share shift ($547 per tonne of CO2e avoided), and net-zero new municipal buildings ($512 per tonne of CO2e avoided).

Table 2. Net present value and marginal abatement costs by action.*

LOW-CARBON ACTION	CUMULATIVE EMISSIONS REDUCTION (KT CO2EQ)	NET PRESENT VALUE	MARGINAL ABATEMENT COST ($ / T CO2 EQ)
Water consumption reduction	1	-$8,151,477	-$8,719
Existing building solar PV	84	-$62,454,381	-$748
New non-res solar PV	21	-$15,537,539	-$732
New dwelling EUI	69	-$44,236,037	-$638
Mode share shift	258	-$141,312,236	-$547
New dwelling solar PV	15	-$7,968,713	-$542
New municipal EUI	73	-$37,655,604	-$512
Electrify PUV	936	-$391,047,069	-$418

[1] This average is weighted in terms of actions that reduce more tonnes of GHGs influence the average more than actions that reduce less tonnes of GHGs. The net present value of the measures includes credit for the avoided costs of carbon ($170/tonne CO2e by 2050); if that credit were excluded, the net savings per tonne of GHG mitigated would be correspondingly lower.

LOW-CARBON ACTION	CUMULATIVE EMISSIONS REDUCTION (KT CO2EQ)	NET PRESENT VALUE	MARGINAL ABATEMENT COST ($ / T CO2 EQ)
Electrify commercial vehicles	905	-$365,679,209	-$404
New non-res EUI	212	-$77,746,850	-$366
Electrify municipal fleet	9	-$2,654,004	-$297
Electrify transit	37	-$7,951,584	-$213
Industrial efficiency	350	-$56,176,173	-$161
Waste diversion	182	-$11,363,624	-$62
Methane recovery	317	$2,889,685	$9
RECs	655	$34,744,182	$53
Fuel switch to RNG	190	$12,533,922	$66
Retrofit non-res	179	$30,381,741	$169
Retrofit dwellings	362	$61,528,985	$170
Heat pumps	965	$379,560,900	$393
Retrofit municipal buildings	10	$7,491,741	$734
TOTAL	5,831	-$700,803,343	-$120

*This table calculates the marginal abatement cost of actions out to 2050 and thus the total figures for NPV and marginal abatement cost differ from those outlined above which describe the results throughout the lifecyle of the investment.

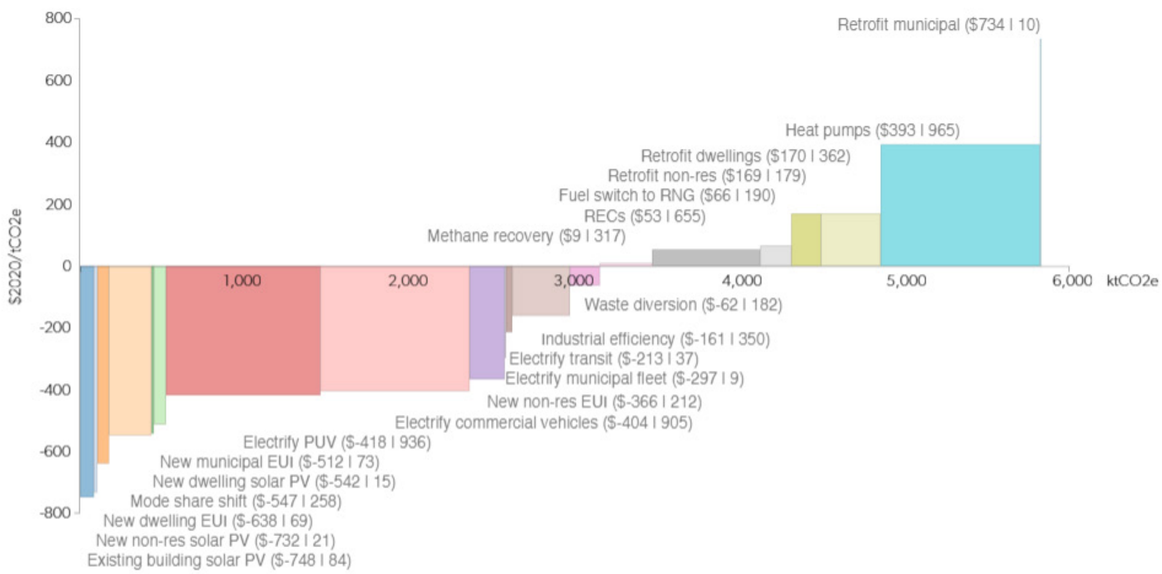
Marginal Abatement Cost

Marginal abatement costs are the estimated costs for each action to reduce one tonne of GHG emissions and are calculated by dividing each action's net present value by the total GHG emissions it reduces (tCO2e) over its lifetime. For example, if a project has a net present value of $1,000 and generates 10 tCO2e of savings, its abatement cost is $100 per tCO2e reduced.

The marginal abatement cost curve (Figure 1) illustrates the individual marginal abatement cost of each of the actions included in the Plan. Note that although the presentation of the cost curve implies that each action has a unique marginal abatement cost, individual actions cannot be neglected without impacting the overall financial and GHG reduction outcomes of the broader set of actions. For example, if building retrofits are not completed, the amount of renewables required to meet the targets laid out in the Plan will increase drastically, which among other practical concerns, will change the financial cost of this action. Similarly, delaying actions will impact savings that households and businesses can achieve through the actions.

The marginal abatement cost curve provided useful insights when developing the Plan, particularly the recommendations for implementation. For example, it makes apparent which actions will be necessary but costly, and may not be financially appealing for the private sector to undertake on its own. This highlights where subsidies, incentives, or in some cases, regulations, from the municipal government or other funders or regulators may be powerful tools to spur action. The cost curve will remain useful as implementation gets underway, including programs, policies, and initiatives being planned and launched, and as they are reviewed and adjusted over time based on changing conditions and lessons learned. Note, however, this analysis is a snapshot of current assumptions which are expected to change over time in the case of changes in carbon tax rates and pricing changes driven by market economics.

Figure 1. Marginal abatement cost curve for the actions included in the Plan.



Present and Net Present Values

The majority of the actions recommended in the Plan have positive net present values, as does the entire program of actions, or overall low-carbon pathway. Table 3 shows the present value of the major components of the Plan including capital investments, operations and maintenance savings, energy cost savings, avoided costs of carbon, and revenue. After discounting at 3%, the capital investments in the program have a present value of $1.07 billion by 2050 when investments are complete, and the savings, avoided cost of carbon, and revenue have a net return of $2.04 billion at the end of the lifecycle of the investments /assets.

Even though capital investment for the plan ends in 2050, the net present value includes the ongoing energy, maintenance, carbon costs savings, and projected revenue out to the end of the lifecycles of the assets as the investments made between 2022-2050 will continue to generate financial returns beyond the initial investment dates.

Table 3. Summary of financial results (Note: negative number = savings; positive number= cost)

FINANCIAL CONSIDERATION	NET PRESENT VALUE (DISCOUNT RATE 3%)
Capital investments	$1.07 billion
Operations & maintenance savings	$600 million

FINANCIAL CONSIDERATION	NET PRESENT VALUE (DISCOUNT RATE 3%)
Energy cost savings	$1.25 billion
Carbon price savings	$1.26 billion
Revenue from local generation and services	n/a
Net return of actions	$2.04 billion

Cash Flow Analysis

The annual costs, savings, and revenue associated with fully implementing the low carbon scenario are shown in detail in Figure 2, with capital expenditures shown in full in the years in which they are incurred. As is characteristic of net-zero transitions, the capital expenditures in the early years of the transition are significantly greater than the savings and revenues generated, but, by 2031, the annual benefits exceed the annual investments and the cumulative benefits are greater than the cumulative costs.

Figure 2. Year-over-year low-carbon scenario investments and returns

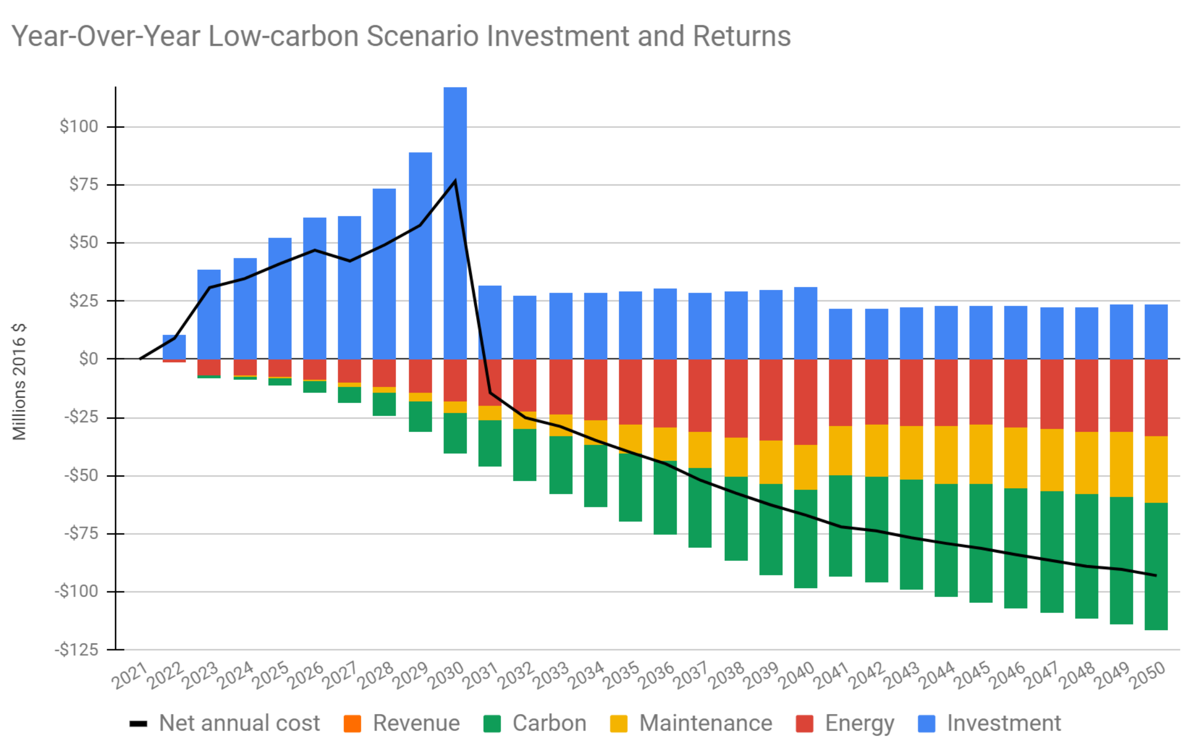
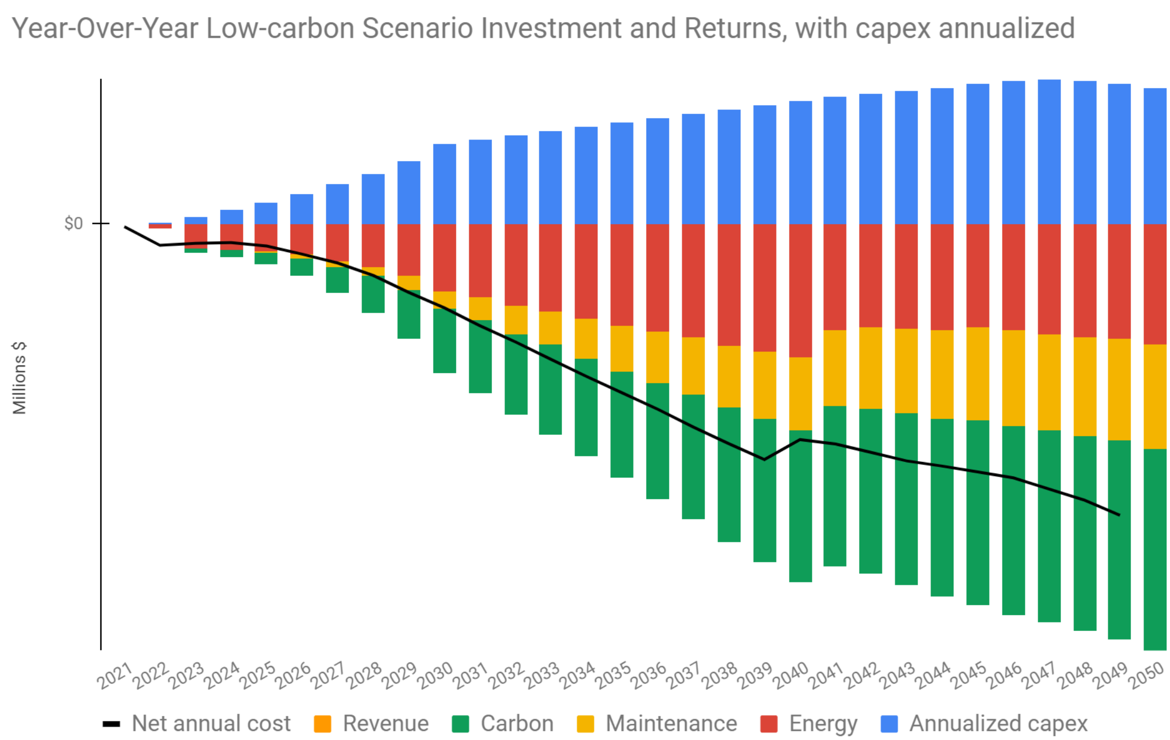


Figure 3 presents the same costs and benefits, but with the capital expenditures amortized over 25 years at a three per cent discount rate. With this approach, which presumably better reflects actual approaches for financing the transition, the savings and revenue generation throughout the scenario (2022-2050) are greater than the annualized capital payments. After 2050 (not shown in Figure 5), the benefits and revenues continue, resulting in continuing growth in the net annual benefit.

Figure 3. Year-over-year low-carbon scenario investments and returns, with capital investments, annualized



Cost Savings for Households

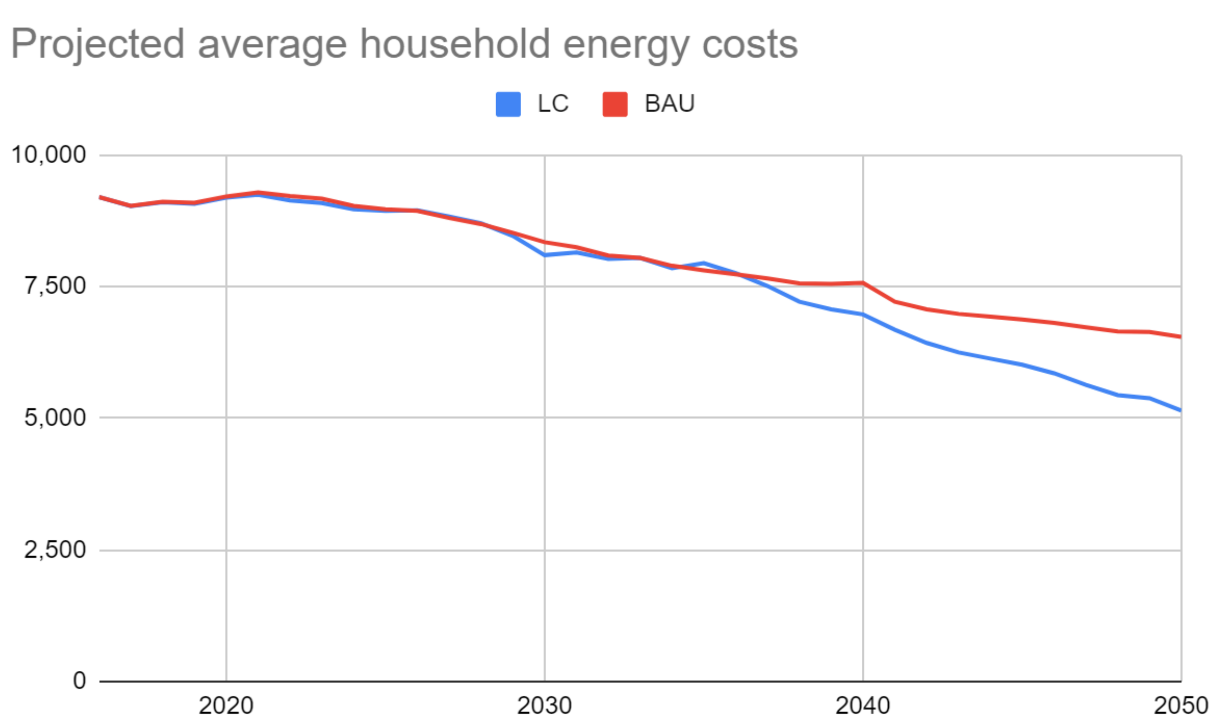
Household expenditures on energy are projected to decline slightly in the business-as-usual scenario and decline more significantly in the low-carbon scenario. The baseline financial modelling and assumptions record an average household energy cost of over $9,200 in 2016. In the business-as-usual scenario, household energy costs are expected to decline to around $6,500 by 2050. Expenditure decreases can be attributed in part to vehicles becoming more efficient due to national fuel efficiency standards and the transition to electric vehicles that will happen in the business-as-usual scenario, and because of decreased heating requirements as the climate becomes milder due to climate change. These factors outweigh the increasing carbon tax being levied on fossil-fuel-derived sources of energy.

The low-carbon scenario involves shifting away from natural gas, diesel, and gasoline to electricity, which is currently more expensive than natural gas in Orillia. The increased cost of electricity, however, is offset by the increased efficiency of homes and electric vehicles, as well as the avoided carbon price.

In the low-carbon scenario, an average household in Orillia is expected to spend just over $5,100, on household energy costs by 2050. This is 21% less per household than the 2050 cost in the business-as-usual scenario and 44% lower than 2016 energy costs.

Between 2022 and 2050, the low-carbon scenario will save the average Orilla household over $11,000 in gross cumulative household energy expenditures, not including the cost to undertake efficiency improvements.

Figure 4. Projected household energy costs in Orillia in the business-as-usual and low-carbon scenarios, 2016-2050



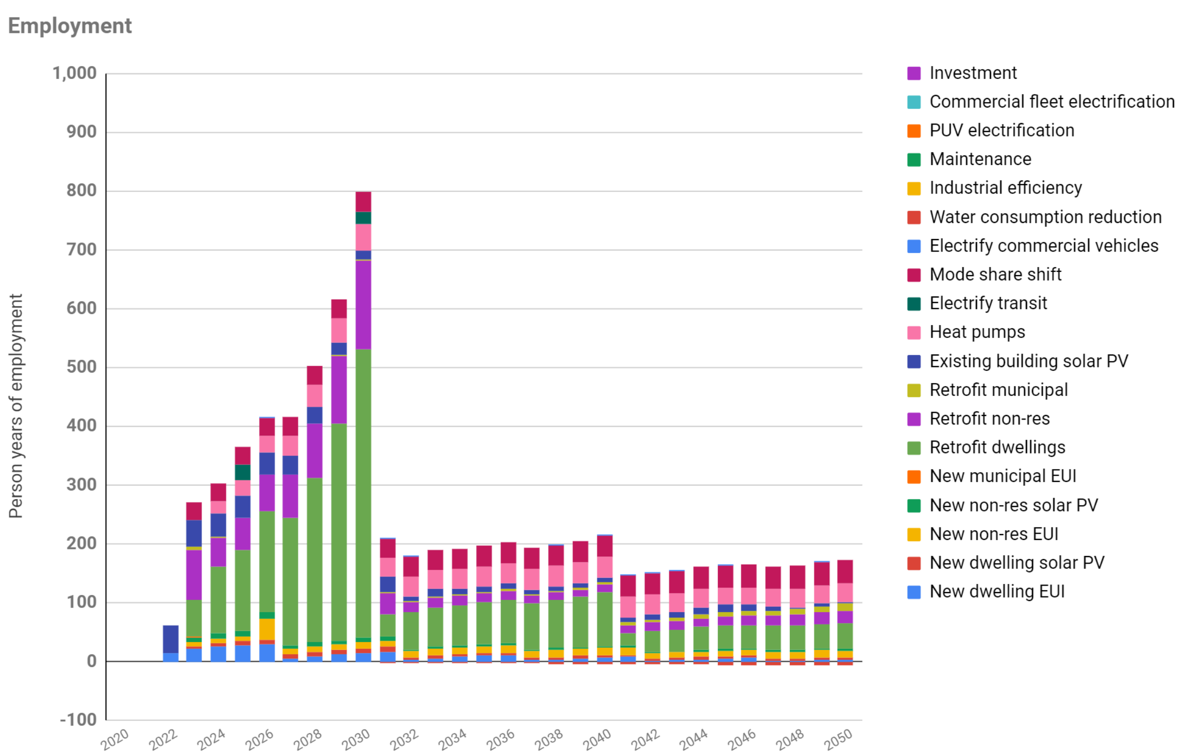
New Job Opportunities

Transitioning to a low- or zero-carbon economy is expected to have four categories of impacts on labour markets: additional jobs will be created in emerging sectors, some employment will be shifted (e.g., from fossil fuels to renewables), certain jobs will be reduced or eliminated (e.g., combustion engine vehicle mechanics), and many existing jobs will be transformed and redefined.

According to the direct job multipliers from Census Canada, implementation of the Plan will create more than 7,200 person-years of employment between 2022 and 2050. That is equal to an average of 260 full-time equivalent jobs per year above the jobs that would be created in the business-as-usual scenario. These jobs are primarily created by building retrofits.

There is a larger increase in jobs per year above the business-as-usual scenario between 2023 and 2030, than in the later years of the low-carbon scenario. This is due to the plan's recommendation for Orillia to complete the bulk of retrofits by 2030.

Figure 5. Projected increases in person years of employment in the low-carbon pathway compared to the business-as-planned scenario



Key Financial Assumptions

Land Use	Capital Investment Assumption
Land use intensification	Capital costs associated with land-use intensification encompass standard investment in the community, such as new housing developments. Generally speaking, with more infill development, new infrastructure spending decreases.
Decrease share of single-detached housing	

New Buildings	
New residential buildings with heat pumps	The cost for new construction of buildings on a $/m2 is estimated to be: Single-detached: $1,776 / m2 Double/row: $1,426 / m2 Apt 1-6 storey: $2,314 / m2 Apt 7-12 storey: $2,422 / m2 Apt > 12 storey: $2,395 / m2 Commercial: $2,494/ m2 Industry: $3,229 / m2 A residential air-source heat pump has a capital and installation costs of approximately $8,485 (non-residential is ~$10,075) and annual operating cost of approximately $160 annually (~$400 annually for non-residential).
New industrial building efficiency	
New commercial building efficiency with heat pumps	
Existing Buildings	
Retrofits of homes and heat pumps	The average cost of a 50% energy efficiency retrofit is assumed to be: Residential (per unit): $45,000 Non-Res ($/m2) : $275 Industrial upgrades average the following in 2022 and 2050 per GJ/year Lighting system: $134₂$59 Space heating: $25 ₂$34 Water Heating: $32 ₂$49 Motive: $66 ₂$176 Process heat: $27 ₂$43
Retrofits of commercial and industrial buildings	

Industrial improvements (process motors/efficiency)	
Renewable Energy	
Solar	Groundmount solar PV is assumed to cost about $1,625 per kw/year in 2022, their maintenance costs are assumed to be $20 per kw/year.
Transport	
Establish local electric bus service	Today electric buses cost approximately $630,000, and are expected to cost less than a diesel bus by 2031. A fast charger costs about $140,000, and is assumed to be needed on a 1:20 ratio with electric buses. Electric bus maintenance costs are approximately 30% lower than for diesel buses. The cost of a personal electric vehicle is approximately $33,500 in 2022 and is expected to decrease to $32,000 by 2030, dropping below the cost of an average combustion engine vehicle by 2025. As of today, maintenance costs for an EV are assumed to be half of those for combustion engine vehicles. Heavy duty combustion engine vehicles are not expected to reach cost parity with their electric counterparts by 2050.
Electrify municipal fleets	
Electrify personal vehicles	
Net-zero commercial transport activity	

Appendix D: Corporate Climate Action Plan

DISCLAIMER

Reasonable skill, care and diligence has been exercised to assess the information acquired during the preparation of this analysis, but no guarantees or warranties are made regarding the

accuracy or completeness of this information. This document, the information it contains, the information and basis on which it relies, and factors associated are subject to changes that are beyond the control of the authors. The information provided by others are believed to be accurate but have not been verified.

This analysis includes strategic-level (i.e. high-level) estimates of costs and revenues that should not be relied upon for design or other purposes without verification. The authors do not accept responsibility for the use of this analysis for any purpose other than that stated above and does not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This analysis applies to Orillia and cannot be applied to other jurisdictions without analysis. Any use by theCity, its sub-consultants or any third party, or any reliance on or decisions based on this document, are the responsibility of the user or third party.

Glossary of Terms

BAU: Business-as-Usual Scenario

BEV: Battery Electric Vehicle

CAFE: Corporate Average Fuel Economy

CEEP: Community Energy and Emissions Plan

DE: District energy

EPA: Environmental Protection Agency

EV: Electric vehicle

FCM: Federation of Canadian Municipalities

GHG: Greenhouse gas

GJ: Gigajoule

HV: Heavy-duty vehicle

ICI: Institutional, commercial, and industrial

IESO: Independent Electricity System Operator

IPCC: Intergovernmental Panel on Climate Change

J: Joule

kWh: Kilowatt hour

ktCO2e: Kilotonnes carbon dioxide equivalent

MTSA: Major Transit Station Area

MW: Megawatt

NEB: National Energy Board

O&M: Operations and maintenance

OPO: Ontario Planning Outlook

PACE: Property Assessed Clean Energy

PJ: Petajoule

PV: Photovoltaics

RNG: Renewable natural gas

SCC: Social cost of carbon

tCO2e: Tonnes carbon dioxide equivalent

TGS: Toronto Green Standard

TJ: Terajoule

UNFCCC: UN Framework Convention on Climate Change

WWTP: Wastewater Treatment Plant

ZEV: Zero Emission Vehicle

Executive Summary

The Corporate Climate Action Plan (CAP) is the first part of a comprehensive climate action plan for the City, with part 2 focussing on community actions. Together, these two documents will form a comprehensive strategy, Orillia's Climate Future.

The CAP identifies a pathway to net-zero GHG emissions for City operations by 2040, including the following targets.

1. Buildings

1.1 Existing buildings:

- By 2030, the City will reduce heating consumption by 50%, and by 2040, the City will reduce non-heating energy use by 20–50% through retrofit and renovation.

1.2 Recreational buildings:

- By 2030, the City will reduce energy consumption in arenas and swimming pools by 20–50%, and by 2040, the City will reduce GHG emissions in arenas and swimming pools by 100%.

1.3 Building heat consumption:

- By 2040, the City will meet all heating demand in corporate buildings using 100% clean electricity.

1.4 New buildings:

- After 2023, all new buildings will meet Passive House or equivalent according to the building use case, and meet net-zero GHG standards.

2. Vehicle Fleet

2.1 Light-duty vehicles:

- After 2023, the City will purchase electric light-duty vehicles where available/possible, with the goal of solely purchasing electric vehicles by 2030.

2.2 Medium and heavy-duty vehicles:

- The City will delay procurement of medium-duty pick-up trucks until a new fleet of electric pick-ups are available in 2025.
- By 2025, the City will convert 100% of utility and maintenance ATVs to electric.
- By 2030, the City will convert 50% of heavy-duty vehicles (e.g. snow removal, dump truck) to electric or hydrogen-powered.
- By 2040, the City will only procure zero-emission vehicles (electric or hydrogen).

3. Clean Electricity

- By 2040, the City will develop the capacity to generate 6–8 MW of renewable energy, or engage in another strategy to purchase renewable energy and/or its benefits.

KEY IMPLICATION: A CARBON BUDGET

The Corporate CAP embeds the consideration of GHG emissions capital and operating budgets, infrastructure planning, and fleet management.

In order to align financial and GHG management, Orillia will apply a carbon budget. Like a financial budget, the carbon budget aims to limit the emissions the City "spends." The carbon budget is designed to be applied in 4-year intervals to line up with the City's financial budgeting process. The carbon budget assigns a cap of GHGs the City can emit in each four year period. The suggested carbon budget, which is to begin in 2021, is provided below:

Carbon Budget[2]	
4-year period	Budget
2021-2024	9,982
2025-2028	9,055
2029-2032	6,886
2033-2036	4,075
2037-2040	3,567

KEY IMPLICATION: CITY BUDGET

The transition to net-zero corporate emissions will require investments over and above what is currently allocated to the maintenance of current buildings and fleet. However, if retrofits are planned to coincide with building maintenance and upgrades already scheduled, then those costs can be reduced. For example, if a building facade needs to be updated in 2032 for structural or integrity reasons, then installing insulation at the same time would be less expensive than installing insulation at a separate time. Combining these efforts also limits the disruption to municipal staff and to the public. The CAP also identifies investments in renewable energy to ensure the availability of clean electricity by 2040.

The following table provides estimates of the investments needed to make Orillia's corporate operations net-zero by 2040. The bulk of the retrofits take place between 2031–2035. Expediting these retrofits would reduce GHG emissions more quickly and help save on energy costs.

Table 1. Estimated Total Investment Cost (2021-2040)

	2021-2025	2026-2030	2031-2035	2036-2040	Total
Twenty year investments (in millions, $2018)					
Buildings	4.6	7.9	15.2	0.2	27.9
Fleet	3.7	3.4	2.7	2.5	12.3
Renewable energy	4.5	6.1	1.0	1.0	12.6
Total investment	53				

[2] Note that this carbon budget assumes the phasing out of emissions from electricity beginning in 2030 with zero emissions from electricity by 2040.

	2021-2025	2026-2030	2031-2035	2036-2040	Total
Fuel Cost Savings (in millions, $2018)					
Buildings	0.07	0.4	1.4	1.9	3.8
Fleet	0.25	1.2	1.8	2.1	3.6
Renewable energy[3]	0.6	3.1	4.6	5.1	13.5
Total Fuel Cost Savings	21				
Carbon Cost Avoided (in millions, $2018)					
Fleet and Buildings	0.08	0.6	1.5	1.9	4.1
Renewable Energy	.03	.3	.52	.65	1.5
Total Carbon Cost Savings					5.6
20 Year-Transition Total	27				

The estimates of energy consumption, GHG emissions, and selected financial flows (i.e. fuel costs, vehicle O&M costs, carbon costs, capital investments), will inform and guide the City's efforts to reduce its corporate emissions, and can support subsequent decision-making processes for specific buildings and vehicles.

[3] The total for fuel cost savings is high-level and does not account for the nuance of hourly electricity supply and demand. This analysis is outside the scope of this report.

Introduction

The Corporate Climate Action Plan (CAP) consists of targets and actions designed to reduce the greenhouse gas emissions of the Corporation of the City of Orillia. The Corporate CAP will work in tandem with the forthcoming Community Climate Action Plan (CCAP) to create a comprehensive framework for climate action in Orillia. Together, these two documents will form Orillia's Climate Future.

The Corporate CAP addresses municipal buildings and the City's vehicle fleet. These assets use energy to keep the lights on and the engines running. In turn, these energy sources release greenhouse gas emissions into the atmosphere. For example, the City burns natural gas to keep buildings warm in the winter, and diesel to run heavy-duty vehicles; both of these energy sources release carbon dioxide.

This plan describes a pathway to decarbonize these assets. Infrastructure such as street lights and the wastewater treatment plant will be addressed in the Community CAP.

In 2018, the City's buildings and vehicle fleet emitted 2,400 tCO2e of carbon dioxide. If the City took no action on climate change and Orillia continued to grow at its projected rate, by 2040 the City's buildings and vehicle fleet would emit roughly 3,150 tCO2e.

This pathway will shift the City from its current corporate energy use and emissions trajectory to net-zero emissions by 2040. Net-zero means that Orillia either releases no GHGs or offsets the emissions it does release.[4] The actions outlined in the plan will decarbonize building and fleet assets as much as possible to reduce corporate emissions and then develop or purchase renewable energy to offset any remaining emissions.

The target aligns with changes required to keep global average temperature increases to less than 1.5 ∘C above pre-industrial levels. This goal of 1.5∘C was agreed upon by the world's countries in 2015 as the way to collectively avoid the worst climate impacts.[5] The target also supports Orillia's declaration of a climate emergency.

Though 2040 seems far from now, some aspects of this plan will need to be implemented in the very near term to meet the target. These aspects include actions like large building retrofits, which can be timed to coincide with renovations that are already scheduled. Others, like the development or purchase of renewable energy, may evolve over the next fifteen years as technologies advance and the province changes the electricity grid's energy mix.

Decarbonizing buildings and the vehicle fleet and investing in renewable energy is projected to cost about $2.9 million per year in 2018 dollars from now until 2040. However, as assets move to cleaner energy sources, the City will save money on fuel costs and carbon costs. After accounting for these deferred costs, the projected net cost of the plan is roughly $1.5 million per year.

[4] Canada has joined more than 120 countries in a pledge to move to a net-zero economy. For more information, see Canada's Climate Plan

[5] The decision to limit global warming to 1.5∘C less than pre-industrial levels was reached at the Paris Climate Agreement in 2015. For more information see the Paris Agreement: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Scope of the Corporate Climate Action Plan

The scope of the CAP considers the following corporate assets and activities:

1. Building retrofits and efficiency measures
    - This includes activities related to reducing energy consumption and GHG emissions associated with municipal buildings.
2. Fuel-switching
    - For buildings that require space heating and cooling and water heating, the goal is to switch to electric sources, and primarily electric air source heat pumps.
3. Electrifying the corporate fleet
    - The analysis includes the light, mid-size, and heavy vehicles in the city's operations as well as equipment.
4. Generating or purchasing clean electricity
    - To offset emissions associated with use of Ontario's electricity grid, the plan outlines four strategies to either generate or purchase renewable energy.

Water and wastewater, while corporate functions, are addressed in the Community Climate Action Plan.

Orillia's Current Reality: Corporate Energy and Emissions Inventory

Corporate Inventory

The City maintains 35 municipal buildings. These include buildings like fire halls, pools, arenas, and the Opera House. Smaller buildings, like the outdoor washroom facilities at Moose Beach and Couchiching Park, require very little energy.

The fleet is made up of more than 80 vehicles that include small cars for daily needs and heavy-duty machinery like snow plows and dump trucks. These heavier vehicles may not be deployed as often as the smaller cars, but they have much larger fuel tanks and burn through more gas and diesel on a per vehicle basis.

Though the graphs in this overview include energy consumption and emissions from street lights and wastewater processing, the Corporate CAP will focus on buildings and the vehicle fleet.

ENERGY CONSUMPTION

In 2018, Orillia consumed approximately 103,000 GJ of energy. Electricity accounted for 58% of this total, followed by natural gas at 33% and diesel and gas the remaining 9%.

At present, electricity is sourced from Ontario's grid. Electricity is used to light buildings, traffic lights, and street lamps and to power water filtration and wastewater treatment systems. Natural gas is primarily used to heat indoor spaces and the recreation centre swimming pool.

Diesel and gasoline were used exclusively in Orillia's corporate fleet to power light-, medium-, and heavy-duty vehicles.

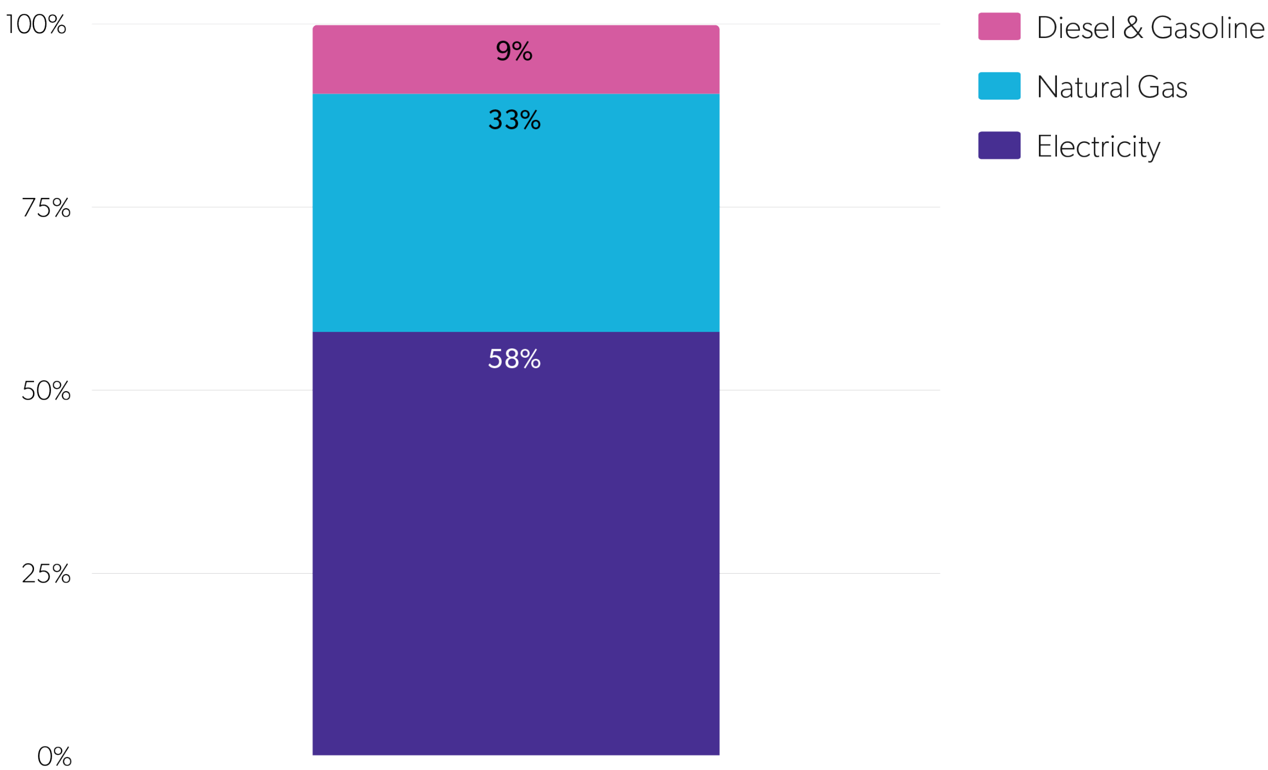


Figure 1. Orillia Corporate Energy Consumption, fuel-type, 2018.

GHG EMISSIONS

In 2018, Orillia's corporate emissions totalled approximately 2,800 tCO2e. Natural gas in buildings comprised 60% of Orillia's GHG emissions, which made it the largest emitting fuel-type in the corporate inventory. The City uses natural gas to heat indoor spaces and the recreation centre swimming pool.

Lights in buildings, traffic lights, and street lights use electricity that results in emissions from Ontario's electricity grid. Finally, diesel and gasoline consumption in the vehicle fleet made up 25% of the total emissions.

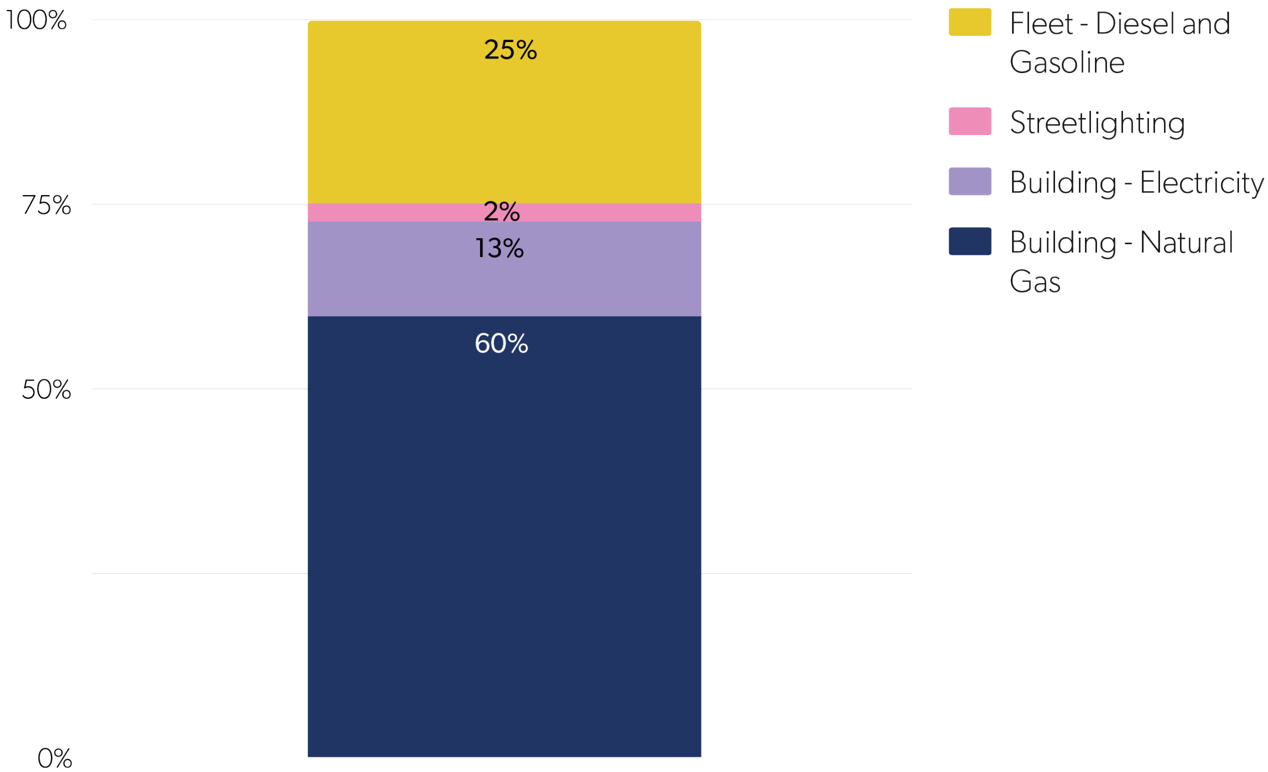


Figure 2. Orillia Corporate GHG Emissions by Sector 2018.

Business-As-Usual for the Next 20 years

The Business-as-Usual (BAU) scenario predicts a future where Orillia's population increases as projected but the City takes no action on climate change. It serves as a reference point for the City's potential energy consumption and GHG emissions in 2040. It is important to note that the BAU scenario does not include street lighting and wastewater processes as these are covered in a separate plan.[6]

[6] As a result of these items not being included, GHG emissions start approximately 200 tCO2e lower than the inventory year.

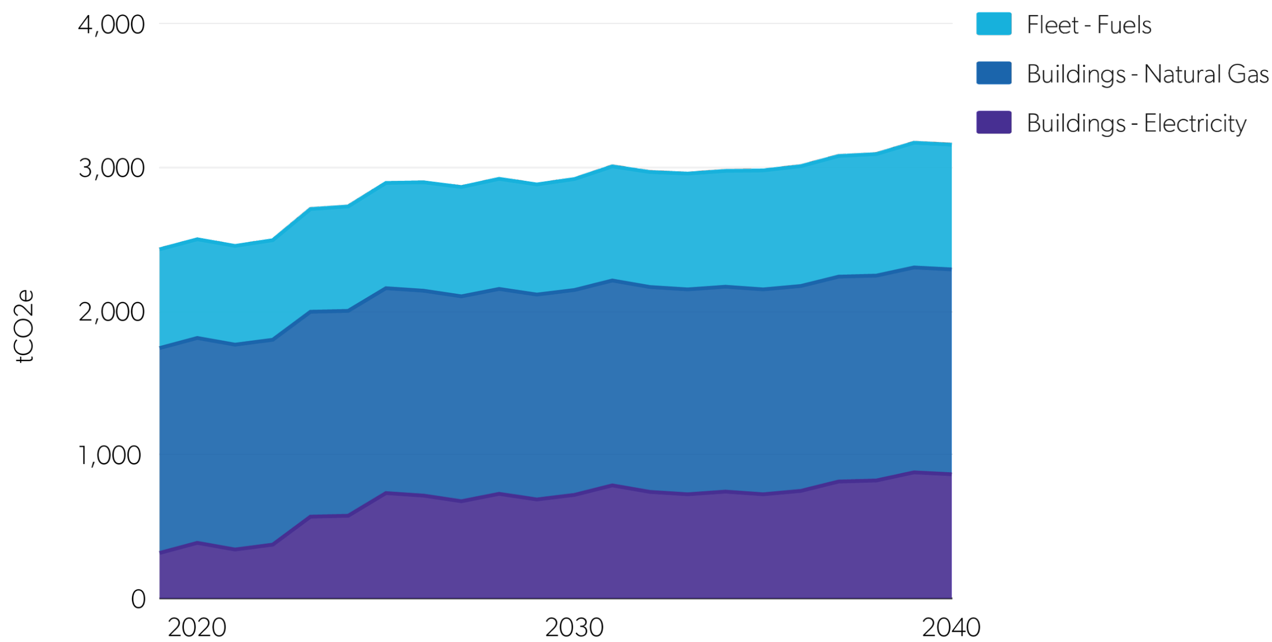


Figure 3. Business-as-usual GHG emissions for Orillia's Corporate Activities, 2018-2040. Note that street lighting and wastewater treatment are not included in this projection.

The BAU projects that GHG emissions will grow by 30% from roughly 2,400 tCO2e in 2018 to 3,150 tCO2e in 2040. This growth reflects additional vehicles needed for Orillia's fleet and increased emissions from the city's use of electricity from Ontario's grid.[7] In the BAU, natural gas continues to be the dominant emitter.

In the BAU, the City continues to buy gas and diesel rather than electric vehicles, and as such emissions from the fleet are projected to grow by 26%.

A Climate-Friendly Future: The Net-Zero Transition

Net-Zero is a short way of saying that a place, business, or organization emits as little carbon dioxide as possible, and then offsets any emissions it does produce. Balancing emissions can be thought of like balancing a bank account—in this case the City reduces its carbon "expenses" as much as possible and then either generates or purchases enough renewable energy to cover the remainder.

The Corporate CAP embeds the consideration of GHG emissions capital and operating budgets, infrastructure planning, and fleet management.

In order to align financial and GHG management, Orillia will apply a carbon budget. Like a financial budget, the carbon budget aims to limit the emissions the City "spends." The carbon

[7] The Atmospheric Fund of Ontario (and the IESO) projects that Ontario will increase its natural gas electricity generation over the next 15 years, which will lead to an increase in average GHG emissions. Grams of emissions per kilowatt hour increase from 50 to approximately 80 in 2040 and beyond. The forecasted emissions factor must be factored into the NZS to help to avoid underestimating the effects of interventions in the future.

budget is designed to be applied in 4-year intervals to line up with the City's financial budgeting process. The carbon budget assigns a cap of GHGs the City can emit in each four year period. The suggested carbon budget, which is to begin in 2021, is provided below:

Carbon Budget[8]	
4-year period	Budget
2021-2024	9,982
2025-2028	9,055
2029-2032	6,886
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2037-2040	3,567

Decarbonizing Building and Vehicle Fleet Assets

THE BUILDINGS ENERGY AND EMISSIONS NET-ZERO TRAJECTORY

To meet the net-zero target, the City will need to retrofit its existing buildings to reach at least 50% energy savings by 2040. A retrofit timeline has been identified to ensure that the upgrade activities disrupt the public and corporate operations as little as possible. For example, retrofits are not scheduled to occur in all recreational facilities or public amenities at once. Staff buildings should remain open to ensure that municipal work is not affected.

Buildings

1.1 Existing buildings:

- By 2030, the City will reduce heating consumption by 50%, and by 2040, the City will reduce non-heating energy use by 20–50% through retrofit and renovation.

1.2 Recreational buildings:

- By 2030, the City will reduce energy consumption in arenas and swimming pools by 20–50%, and by 2040, the City will reduce GHG emissions in arenas and swimming pools by 100%.

1.3 Building heat consumption:

- By 2040, the City will meet all heating demand in corporate buildings using 100% clean electricity.

1.4 New buildings:

- After 2023, all new buildings will meet Passive House or equivalent according to the building use case, and meet net-zero GHG standards.

The timeline has also been set up to ensure that larger buildings which consume more energy and are already scheduled to undergo normal renovations are targeted first. This process identified Brian Orser Arena and Barnfield Point for retrofits by 2025. Targeting larger buildings

[8] Note that this carbon budget assumes the phasing out of emissions from electricity beginning in 2030 with zero emissions from electricity by 2040.

first can help reduce energy costs, which frees up funding to renovate buildings that come up later in the timeline.

Figure 4 illustrates the timeline for building retrofits which was evaluated in this analysis. For a list of planned municipal building retrofits, see Appendix 2.

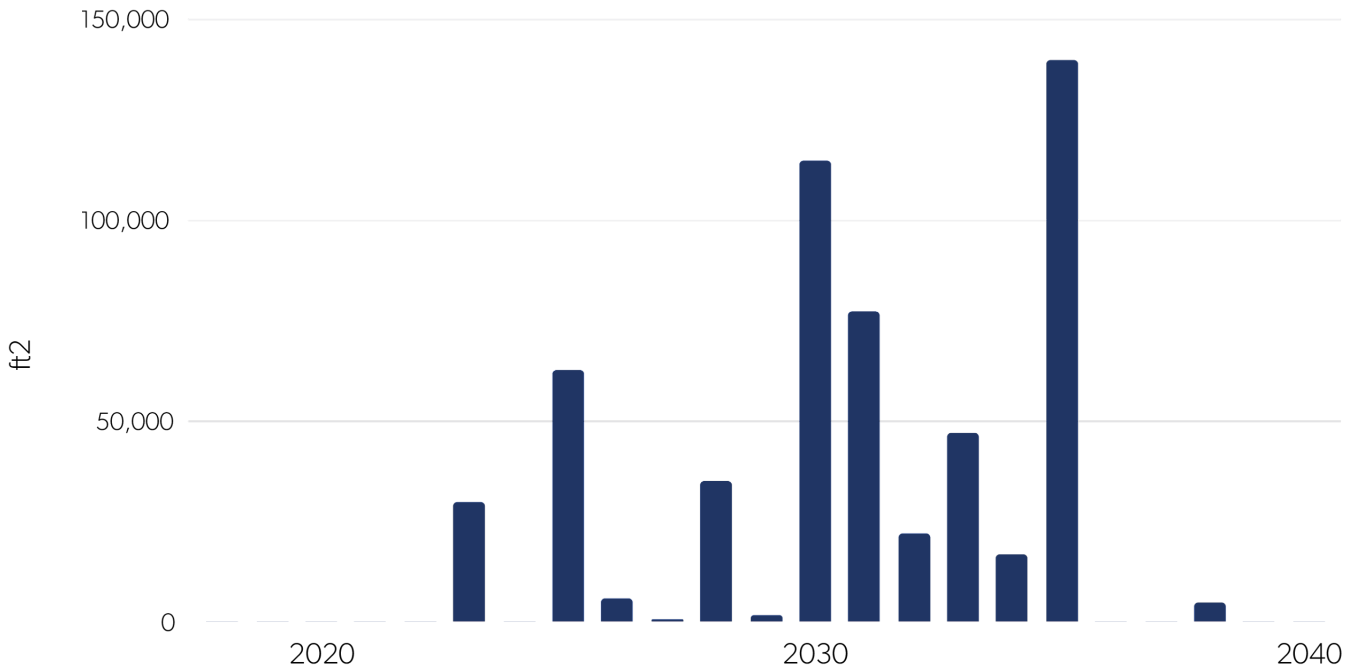

Figure 4. Building Retrofits and fuels-switching, by building type and target year, 2023-2040

Buildings energy consumption

The City's retrofit and fuel-switching activities will reduce energy consumption by 50%. By 2040, all natural gas heating systems will be replaced by air source heat pumps and an electric system will heat the swimming pool.

It is important to note that similar to the BAU scenario, the wastewater treatment buildings are not included in this analysis as they will be covered in the Community Climate Action Plan.

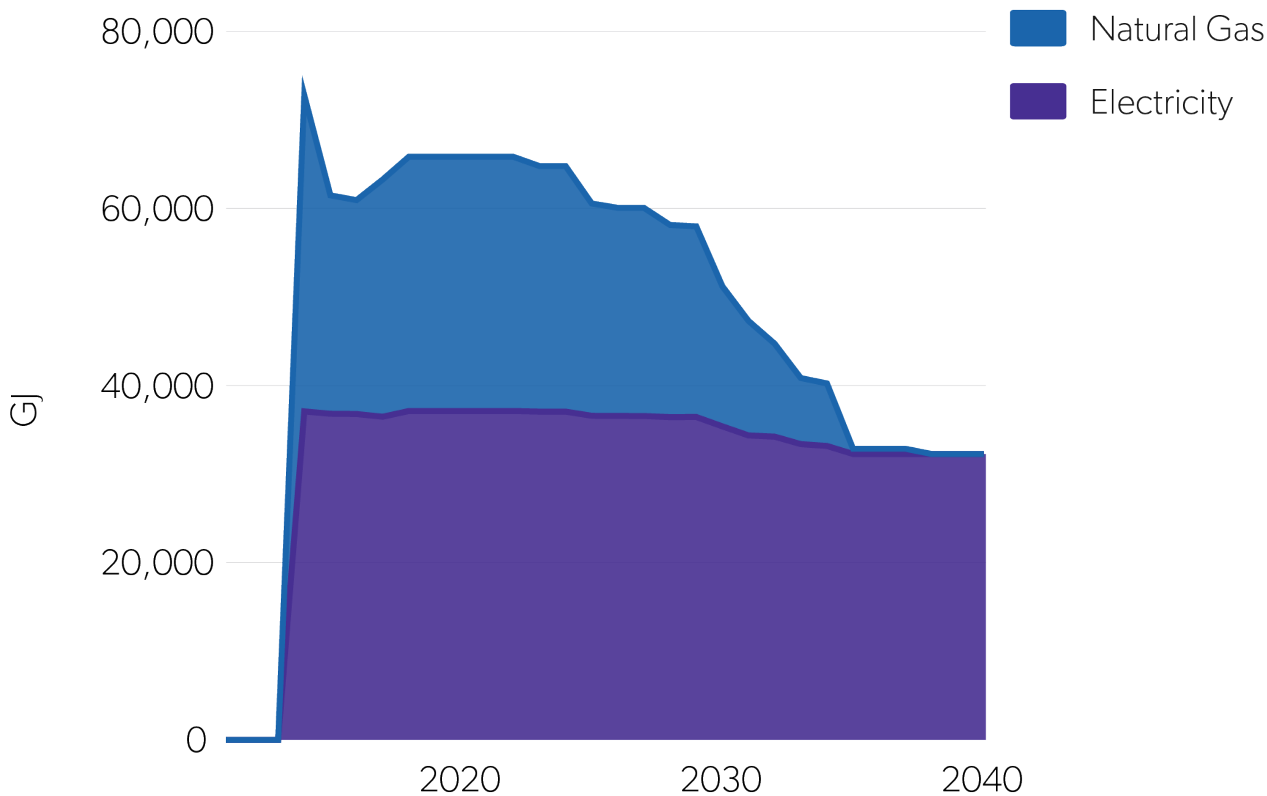

Figure 5. Buildings energy consumption (GJ), 2018-2040

Buildings GHG emissions

By 2040, the City's retrofit efforts will reduce corporate GHG emissions by 57%. Annual emissions from municipal buildings will fall below 1,000 tCO2e. These remaining emissions reflect emissions from Ontario's grid. Though heat pumps are overall much more efficient than natural gas heating systems, they still rely on electricity to power them, and that electricity comes from Ontario's grid. As Ontario has no immediate plans to decarbonize its own grid, to reach net-zero corporate emissions, Orillia will need to develop or purchase renewable energy. The four suggested clean energy options are outlined in the Clean Electricity section.

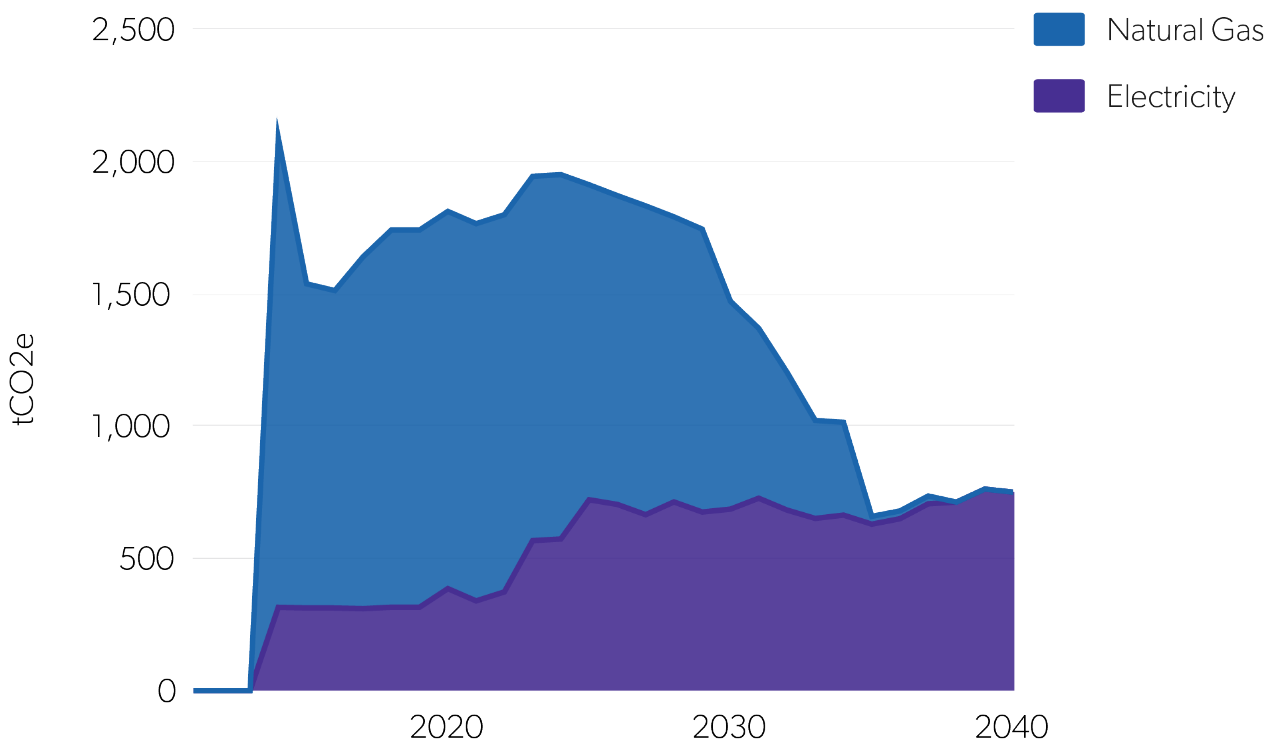

Figure 6. GHG emissions in Buildings (tCO2e), Net-Zero Transition 2018-2040.

THE FLEET ENERGY & EMISSIONS TRAJECTORY

Figure 8 shows how Orillia's fleet will grow from just under 100 vehicles in 2018 to 130 in 2050. Fleet growth is based on a simple linear projection that is aligned with overall community population growth. The assumption here is that by 2040 more vehicles will be required to meet the needs of the city.

2. Vehicle Fleet

2.1 Light-duty vehicles:

- After 2023, the City will purchase electric light-duty vehicles where available/possible, with the goal of solely purchasing electric vehicles by 2030.

2.2 Medium and heavy-duty vehicles:

- The City will delay procurement of medium-duty pick-up trucks until a new fleet of electric pick-ups are available in 2025.
- By 2025, the City will convert 100% of utility and maintenance ATVs to electric.
- By 2030, the City will convert 50% of heavy-duty vehicles (e.g. snow removal, dump truck) to electric or hydrogen-powered.
- By 2040, the City will only procure zero-emission vehicles (electric or hydrogen).

By 2030, the City will replace all gas powered light vehicles with electric vehicles. Though some heavy-duty vehicles still be diesel-powered, most of them will be transitioned out by 2035.

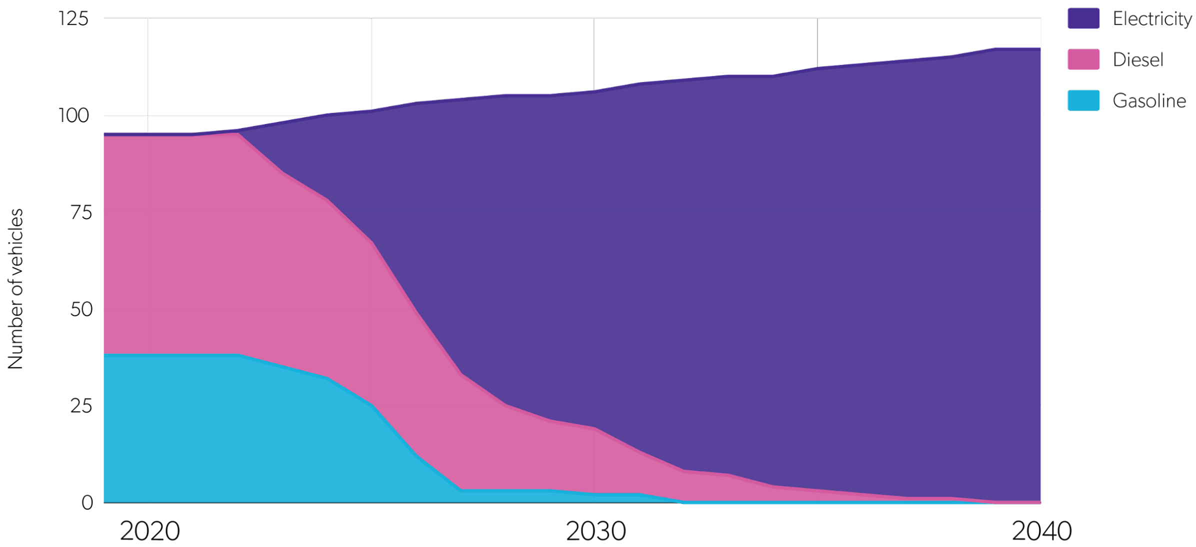

Figure 7. The fleet transition timeline, # of vehicles, 2018-2040.

Fleet energy consumption

By transitioning to electric for its light-duty vehicles, the City will reduce its energy consumption from approximately 9,600 GJ in 2018 to approximately 5,000 GJ in 2030. Once full electrification is reached, the City's energy consumption will decline further to approximately 4,000 GJ by 2050.[9] The City will reduce its energy consumption by more than 50%, which will also help reduce the City's operating costs.

[9] Some heavy-duty vehicles may remain diesel-powered after 2040 depending on whether electric heavy-duty vehicles of the necessary types have been developed and released for public sale.

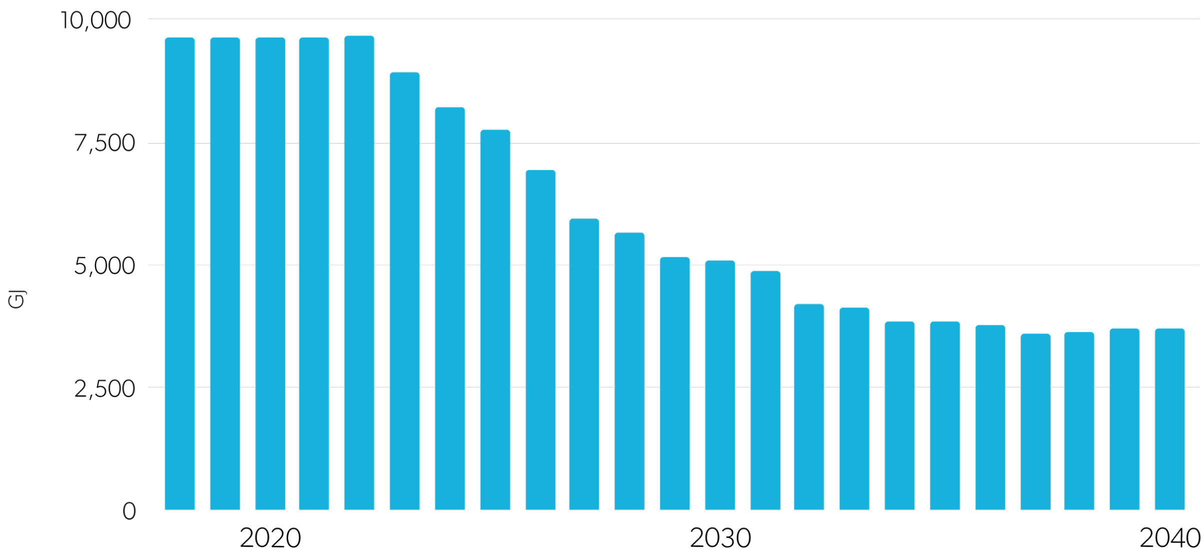

Figure 8. Corporate fleet projected energy consumption (GJ), 2018-2040.

Fleet GHG emissions

By 2030, the City's corporate fleet GHG emissions will drop by 66%. By 2035, they will drop by 85% as nearly all diesel heavy-duty vehicles are replaced. Electric vehicles are charged using Ontario's electricity grid, and as such the remaining emissions in the corporate fleet result from charging the vehicles. These emissions can be offset by pursuing one of the four clean electricity strategies outlined in the Clean Electricity section.

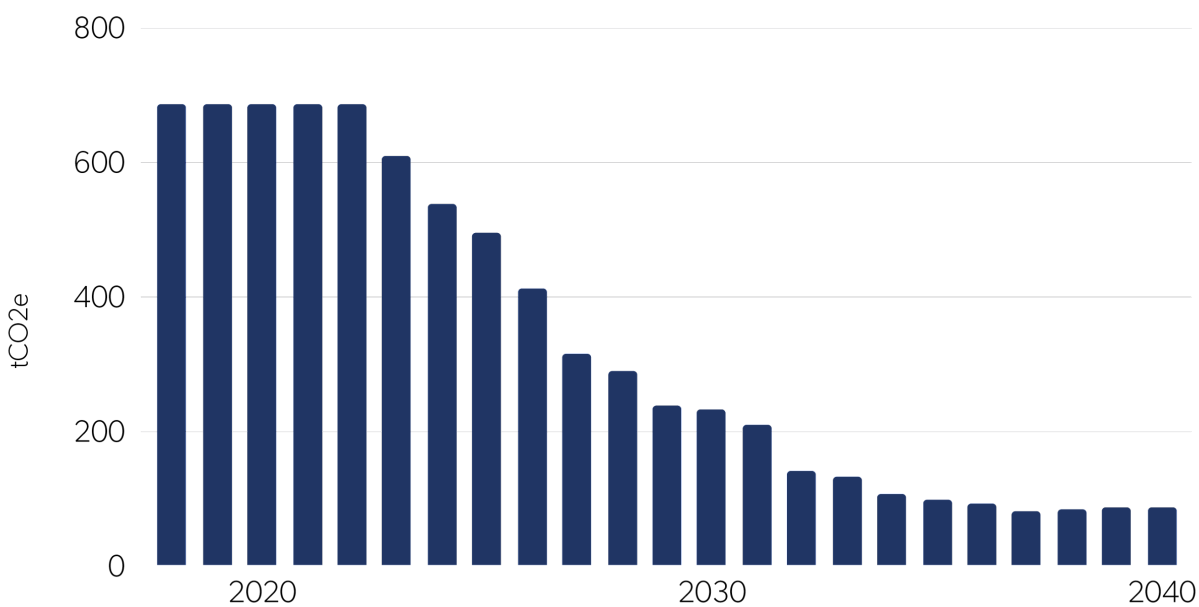

Figure 9. Corporate Fleet projected GHG emissions (tCO2e) , 2018-2040.

ENERGY AND EMISSIONS FROM ASSETS BY 2040

By 2035, the City will depend on electricity to power 92% of its buildings and vehicle fleet. By 2040 that number is closer to 100%. As the City switches to higher efficiency heat pump systems to heat buildings, the overall demand for energy will decline by 51%. Electric vehicles are also more energy efficient than their gas and diesel counterparts.[10]

Thanks to the City's fuel-switching efforts, there is virtually no natural gas in the building stock and very little diesel in the fleet.

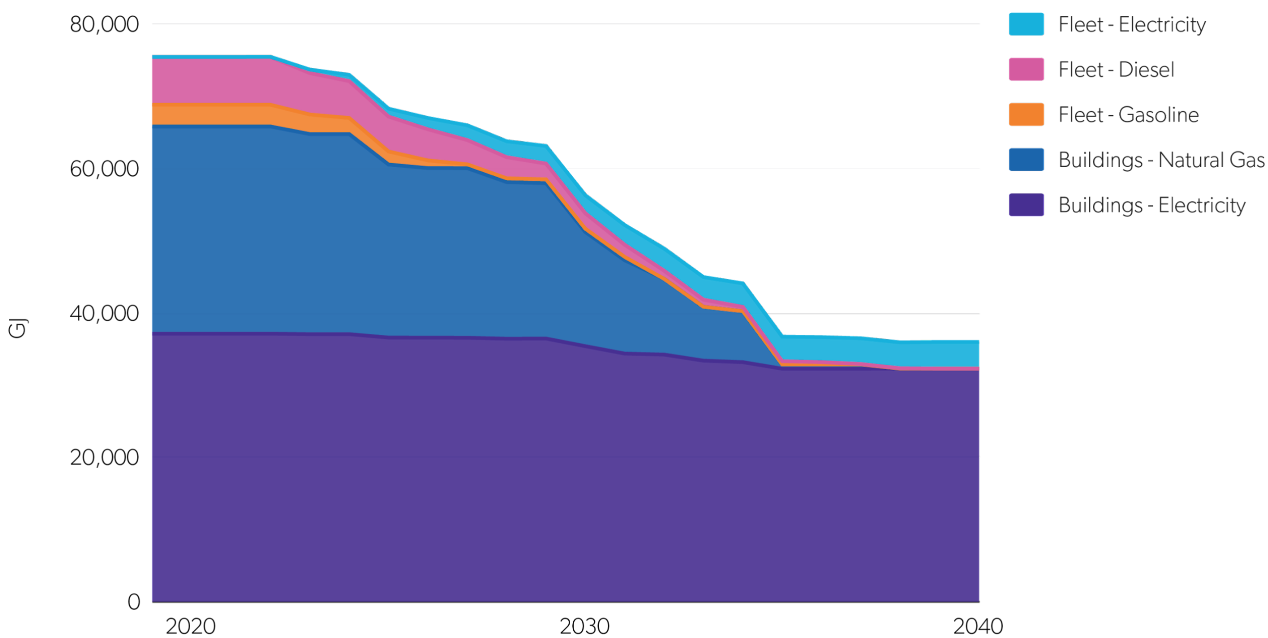

Figure 13. Energy Consumption by Buildings and Fleet (GJ) , Net-zero scenario, 2018-2040.

[10] Electric vehicles convert over 77% of the electrical energy from the grid to power at the wheels, whereas the internal combustion energy vehicles convert about 12%–30%. US Department of Energy (n.d.) All-electric vehicles. Retrieved from: https://fueleconomy.gov/feg/evtech.shtml

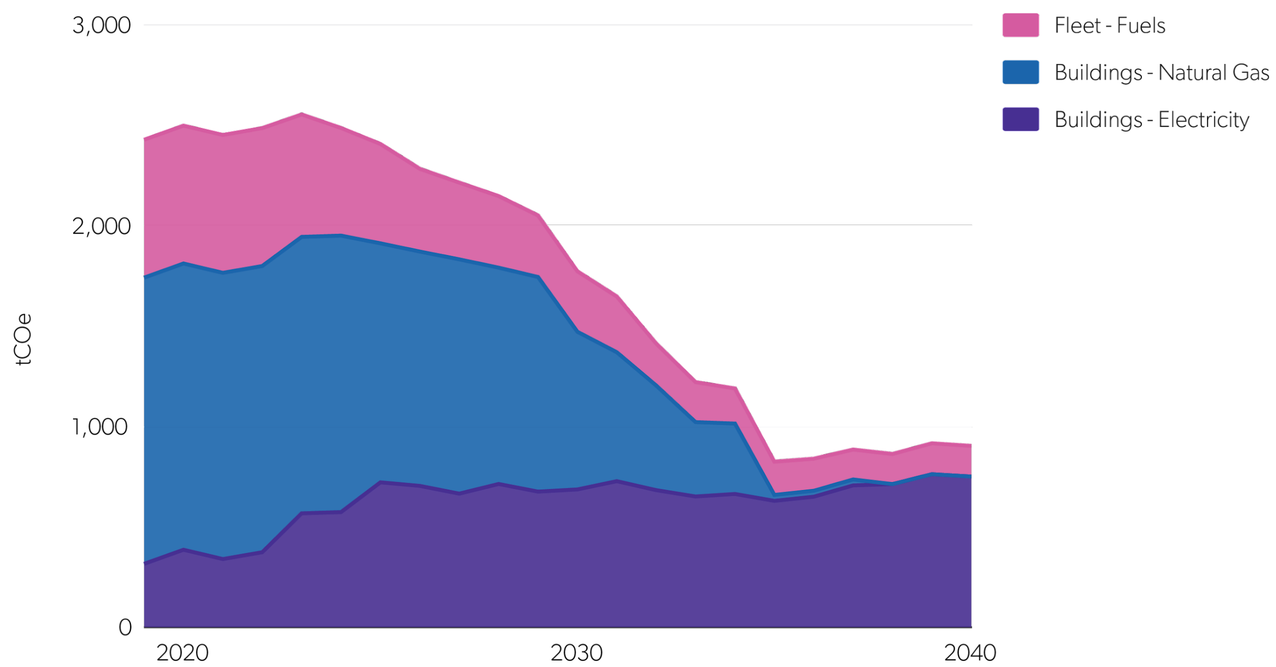

Figure 14. GHG emissions by Buildings and Fleet (tCO2e), Net-zero scenario, 2019-2040.

As the City transitions to systems that rely more heavily on the Ontario electricity grid, the emissions associated with that electricity use will go up. Ontario phased out its coal plants in 2014; aside from its reliance on natural gas plants to meet peak demand, the grid is now mostly fossil-free. For example, in 2019, only 6% of Ontario's electricity was supplied by natural gas or oil.[11] However, this percentage is expected to increase through to 2040. As Ontario's population grows and more people and municipalities switch to electric systems, natural gas plants will be called upon to meet the increased demand.[12]

The City will need to generate or procure approximately 8 MW of renewable energy to offset the remaining emissions in corporate activities and to align with the carbon budget targets. Figure 15 below shows how solar PV generation eliminates approximately 550 tCO2e by 2030, and 840 tCO2e. Clean electricity, the third pillar of the strategy, offsets the emissions left over after all efficiency improvements have been carried out.

[11] IESO, 2019 Year in Review. Retrieved on Sept. 2, 2020, from: www.ieso.ca/en/Corporate-IESO/Media/Year-End-Data.

[12] IESO, Annual Planning Outlook (January 2020).

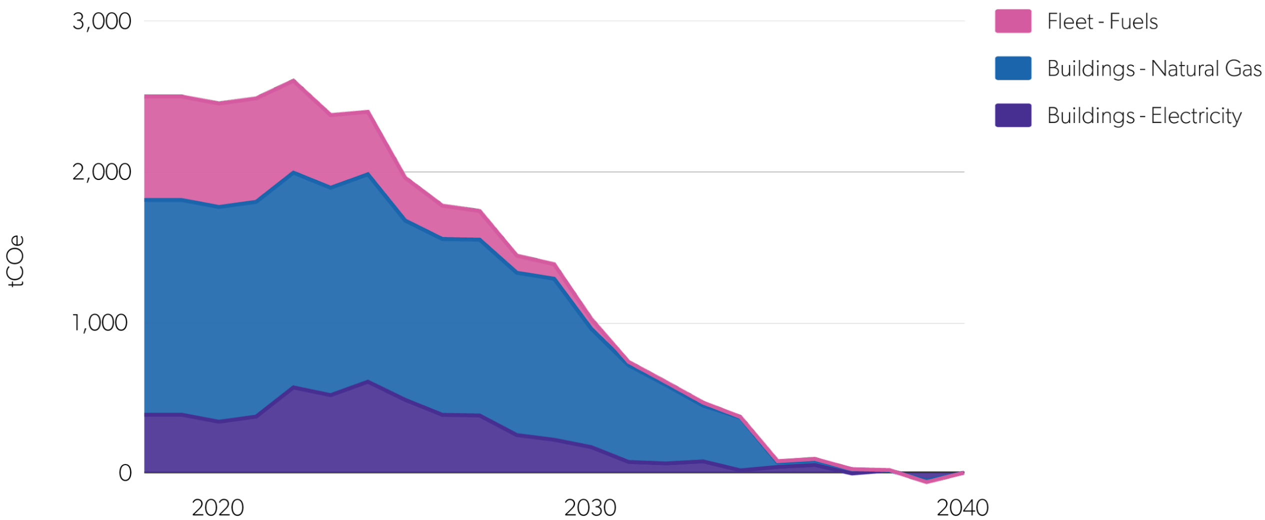

Figure 15. GHG emissions of buildings and fleet (tCO2e) with renewable energy generation, Net-zero scenario, 2018-2040.[13]

Clean Electricity

Clean electricity is a key part of the path to decarbonizing the City's operations.

To reach Orillia's target of net-zero corporate emissions, the City will need to either generate or purchase 6 MW of renewable energy by 2030, and then as much as 8MW by 2040. The steady increase between now and 2040 reflects increases in electricity demand as the City retrofits buildings and buys electric vehicles for its fleet.[14]

Clean Electricity

By 2040, the City will develop the capacity to generate 6–8 MW of renewable energy, or engage in another strategy to purchase renewable energy and/or its benefits.

[13] The small dip below zero near 2040 is a result of the staggered building retrofit schedule. As buildings are retrofitted, they over-correct, and when their systems come back online they begin to use electricity and contribute emissions.

[14] The wastewater treatment plant is not included in this analysis as biogas capture from the treatment plant itself would be a more applicable source of clean energy.

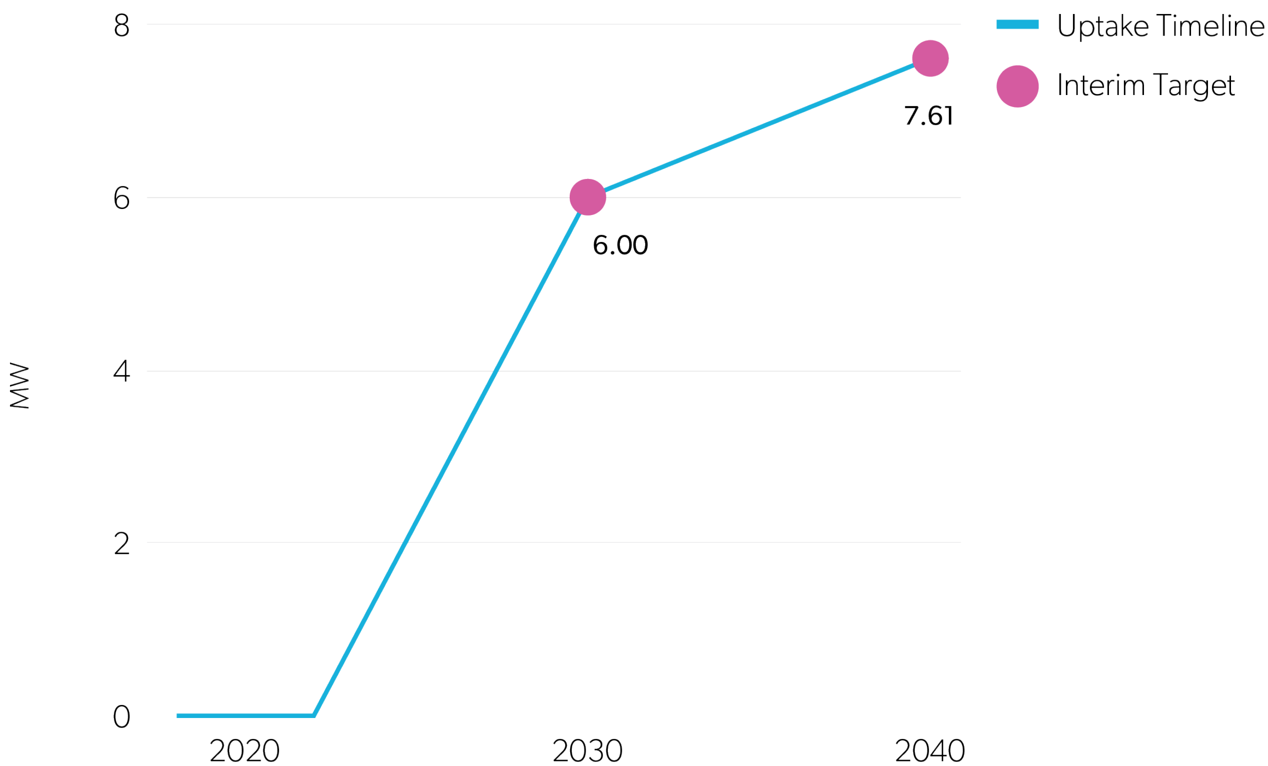

Figure 10. Suggested renewable energy targets.

There is an advantage to developing solar PV in that extra electricity can be sold for revenue. Installing solar PV can also buffer peak demand for electricity during day-time periods. As of now, the Ontario electricity grid meets Orillia's peak demand, and Ontario's electricity grid relies on its high-emitting gas plants to generate that extra power.

However, the policy framework needed to operate such a scheme is not currently in place. Ontario's "Feed-in-Tariff" (FIT) program, where extra electricity could be sold back to the grid, is currently on hold.[15]

That said, Ontario's net metering program could allow extra electricity to be fed back into the grid in exchange for a credit on the City's electricity costs.

Given this context, there are four strategies that the City can consider to either produce or purchase the clean electricity needed to reach the target.

Strategy 1. Local Generation

Local generation on municipal sites would provide the greatest financial and economic benefits for the community and the City. Local generation involves building and maintaining solar PV on roofs and other sites. Solar power does require an initial capital investment and its use is governed by provincial policy.

[15] "Feed in Tariff Program. Accessed 2021. Government of Ontario. Retrieved from: Archived - Renewable energy development in Ontario: A guide for municipalities: 4.0 Feed-In Tariff Program | Ontario.ca

Strategy 2. Advocacy for a Decarbonized Ontario Electricity Grid

At present, Ontario has no plans to decarbonize its electricity grid before 2030.[16] That said, many cities in Ontario have developed similar plans to decarbonize both their corporate and community operations and are advocating for a zero-emissions provincial electricity grid. It is possible that Ontario will phase out its gas plants by 2040, which would eliminate the emissions Orillia is responsible for when the City makes use of Ontario's electricity.

Strategy 3. Renewable energy certificates

Renewable energy credits (RECs) are a mechanism used to procure the clean attributes of renewable electricity that is being generated off-site. If the City finds that generating its own solar power is infeasible for logistical, financial, and/or policy reasons, then RECs could be used to offset the City's remaining corporate emissions. Examples of organizations that provide RECs in Ontario are Bullfrog Power and Blue Earth Renewables.[17,18]

Strategy 4. Power purchasing agreements (PPA)

A Power Purchase Agreement (PPA) is a mechanism to directly purchase electricity from an off-site provider. In this case, the desired energy would be renewable electricity. The City would have to investigate and/or create the policy conditions needed to develop a PPA. Orillia Power Generation could prove advantageous as it could enter into a PPA with a provider. Some cities have also established renewable energy cooperatives.

Investing in Orillia's Decarbonized Corporate Operations

Decarbonizing Orillia's buildings and vehicle fleet will cost money. As will investing in the development or purchase of renewable energy. However, these investments can be worked into the routine costs of operating buildings and maintaining vehicles. For instance, the City can incorporate retrofits into established building maintenance and upgrade plans, and gas vehicles can be swapped out for electric when they reach the end of their useful life.

Over the next twenty years, total investments into the decarbonization plan will cost roughly $53 million (in 2018 dollars). Though some years will see higher investments than others, particularly as large City buildings come up for retrofit, this total amounts to an average of $2.9 million per year. That said, as buildings are transitioned to electricity-powered heat pumps and as diesel and gas vehicles are phased out, the operating costs for these assets will actually decrease. After fuel cost savings and reduced carbon taxes[19], the total net investment drops to $27 million, or $1.5 million per year. Please note this assessment only takes into account Clean Electricity Strategy 1: Local Generation as it is the strategy over which the City would have the most financial control.

[16] According to its October 2021 report, the IESO will not phase out its natural gas power plants before 2030. However, it has stated that given enough time and resources it would consider phasing them out at some point in the future. Source: Independent Electricity System Operator. (2021) Decarbonization and Ontario's Electricity System: Assessing the impacts of phasing out natural gas generation by 2030. Toronto.

[17] Power Purchase Agreements | Bullfrog Power

[18] Our Approach | BluEarth Renewables

[19] For more information on Canada's carbon pricing, see the Government of Canada's page on its carbon pollution pricing system.

For a comparison of investments and cost savings in five-year periods between now and 2040, see Table 1.

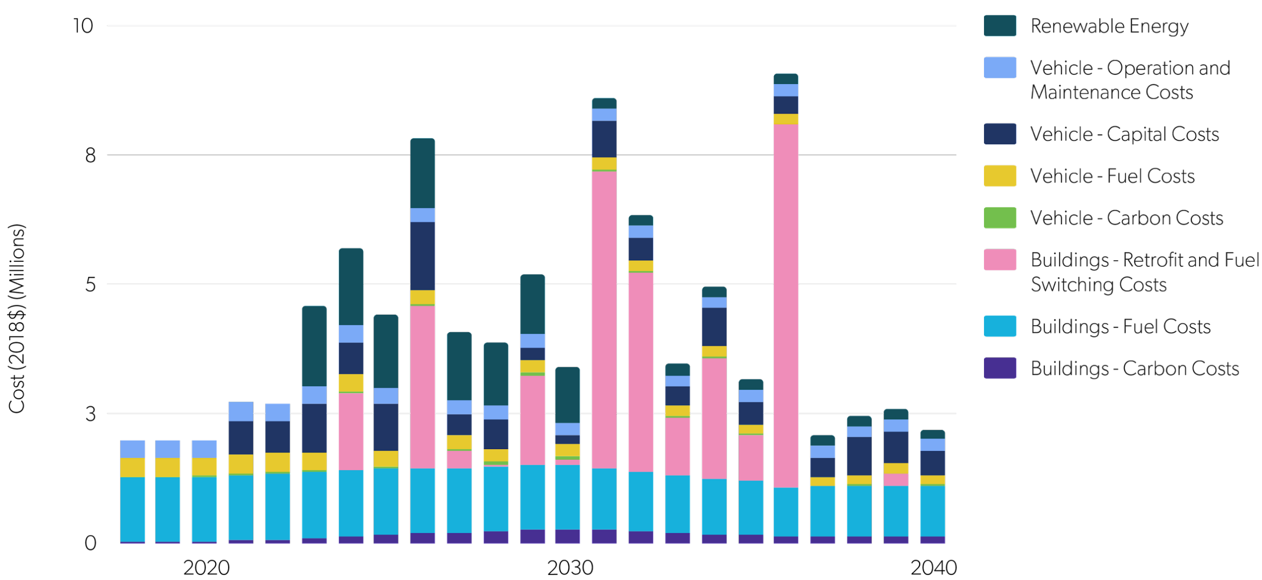

Figure 16. Costs by sector in 2018 Dollars, 2018-2040.

Table 1. Estimated total investment cost (2021-2040).

	2021-2025	2026-2030	2031-2035	2036-2040	Total
Twenty year investments (in millions, $2018)					
Buildings	4.6	7.9	15.2	0.2	27.9
Fleet	3.7	3.4	2.7	2.5	12.3
Renewable energy[20]	4.5	6.1	1.0	1.0	12.6
Total investment	53				
Fuel cost savings (in millions, $2018)					
Buildings	0.07	0.4	1.4	1.9	3.8
Fleet	0.25	1.2	1.8	2.1	3.6
Renewable energy	0.6	3.1	4.6	5.1	13.5
Total fuel cost savings	21				
Carbon cost avoided (in millions, $2018)					
Fleet and buildings	0.08	0.6	1.5	1.9	4.1
Renewable energy	.03	.3	.52	.65	1.5

[20] The total for fuel cost savings is high-level and does not account for the nuance of hourly electricity supply and demand. An analysis of this detail is outside the scope of this report.

	2021-2025	2026-2030	2031-2035	2036-2040	Total
Total carbon cost savings	5.6				
20-year transition total	27				

Financial Modelling

Table 2 breaks down the key financial items that have been modelled to arrive at these investment costs. Table 3 outlines what is not included and why. For an indepth look at key data points and assumptions used to develop the financial summary, see Appendix 4.

Table 2. Items included in the financial summary.

Asset	Expenditures
City buildings	Fuel costs Retrofit & fuel switching capital cost Carbon costs
Vehicle fleet	Fuel costs Vehicle capital costs Operations and maintenance costs Carbon costs
Renewable energy	Capital costs of solar PV generation

Table 3. Items not included in the financial summary.

Assets and investments	Rationale
Electric vehicle charging infrastructure	Charging infrastructure is often handled by a mix of private and public actors, so it is difficult to put a fixed price on its development.
Grid upgrades	The ability of the grid to incorporate these changes has not yet been evaluated.
Electricity storage equipment	The need for energy storage will depend on provincial energy policy and on the renewable energy generation approach that is chosen.
Evaluation of energy tariff structures (fixed costs vs variable costs; peak demand charges; etc)[21]	The future of the electricity tariff structure is uncertain and decided by political bodies that are beyond the scope of this report.
BAU building asset management capital costs	Routine costs of managing buildings that are not affected by the decarbonization plan have not been incorporated into the financial model.

[21] Energy costs are modelled using projected consumption and projected average energy prices.

Plan Limitations & Items Out of Scope

The quantitative analysis presented in this report is designed to support high-level strategic planning.

The likely impacts of the low-carbon pathway described in this corporate action plan are subject to a number of caveats. Financial costs and savings are, like so many municipal processes, subject to the uncertainties that come with long-term scenarios.

The analysis presented here is not an engineering study, which would likely be required as a subsequent step to inform many of the specific investments considered in this analysis.

That being said, the quantification of key variables, including energy consumption, GHG emissions, and selected financial flows (i.e. fuel costs, vehicle O&M costs, carbon costs, capital investments), acts as a guide in the City's efforts to reduce its corporate emissions, and can support subsequent decision-making processes for specific buildings and vehicles.

The following list identifies aspects of the plan that will need to be fine-tuned when the City approaches actions like specific building retrofits and vehicle purchases:

- Buildings
- A proposed retrofit schedule for the corporate building portfolio was developed in consultation with staff. As the city moves forward with implementation and more information becomes available, such as building energy audits, the schedule can be adapted accordingly.
- The capital costs of building deep energy retrofits and fuel switches are estimated using high-level cost intensities (per floor area), without knowledge of specific building conditions, HVAC systems, asset management plans, etc. Refined retrofit costs will vary on a building-by-building basis, informed by building energy audits.
- Building energy tariffs—the structures that natural gas and electricity utilities use to charge for the provision of energy—contain fixed and variable components. They can also depend on hourly demand patterns. Given the uncertainty of how these tariffs may evolve in the coming decades and the detailed analysis required to project hourly demand, this analysis uses a simplified energy consumption and average energy price approach to project energy costs.
- This analysis holds climatic assumptions fixed over the time horizon considered, and does not reflect the trend of increasing cooling degree days and decreasing heating degree days.
- Vehicles
- Subsequent green fleet implementation plans will analyze the usage patterns of specific vehicle roles and match them with specific electric commercially-available offerings.

Conclusion

The Corporate Climate Action Plan is a viable pathway for Orillia to achieve net-zero GHG emissions by 2040 in terms of buildings, fleet, and energy generation. The driving force of this analysis is the recognition that climate change will dramatically change the quality of life for Orillia residents and businesses, while also recognizing that future generations and marginalized communities will endure greater effects of climate change.

The net-zero sectoral targets for buildings (2040), fleet (2030), and renewable energy generation (2040) are considered evidence-based targets that apply a carbon budget to ensure reductions are aligned on an appropriate downwards trajectory. The targets reflect an aggressive emissions reduction while also respecting staff and corporate capability to reasonably achieve the targets.

The financial summary indicates that the investment required to achieve the transition is challenging, but does result in positive co-benefits namely reduced fuel expenditures, reduced maintenance costs for fleet, and avoided cost of carbon pricing. Ensuring that the city financial budget is not overburdening the city financial budget and ensuring city employees and the public did not lose access to facilities was considered a priority in the transition of buildings.

Next Steps

The strategic-level analysis in this paper will need to be further substantiated by detailed analysis on a building-by-building level, more information on the availability of electric vehicles, and scoping of renewable energy generation opportunities. The guiding targets and analysis in the CAP will ensure that GHG emissions align with the decision making.

Suggested next steps:

6. Adopt a net-zero by 2040 target for corporate emissions.
7. Begin implementation planning by completing detailed analysis on buildings, fleet, and renewable energy to create a 4-year work plan in line with the city budget.
8. Identify financial instruments and grant money that can be available to help this transition.
9. Align targets and outcomes of the CAP for the Community Climate Action Plan (CCAP) for alignment.
10. Create a detailed implementation in the CCAP that further identifies corporate timelines.

Appendix 1: Glossary

Base year: the starting year for energy or emissions projections.

Biogas (renewable natural gas): methane captured from bacterial decomposition of sewage, manure, waste, plant crops, or other organic waste products. It can be used as a natural gas replacement.

Building retrofit: changes to the structure or systems of an existing building to achieve energy and water consumption reductions.

Business-as-usual (BAU): a scenario illustrating energy use and greenhouse gas emissions if no additional plans, policies, programs, and projects are implemented.

Capacity factor: the ratio of a power plant's actual output over a period of time to its potential output if it were possible to operate continuously over the same period of time.

Carbon dioxide equivalent (CO2e): a measure for describing the global warming potential of a greenhouse gas using the equivalent amount or concentration of carbon dioxide (CO2) as a reference. CO2e is commonly expressed as million metric tonnes of carbon dioxide equivalent (MtCO2e).

Cooling degree days (CDD): the number of degrees that a day's average temperature is above 18oC, requiring cooling.

Deep energy retrofit: a whole-building analysis and construction process minimizing building energy use by 50% or more compared to the baseline energy use.

Distributed generation: technologies that generate electricity on-site through solar photovoltaic (PV) systems, combined heat and power (CHP) systems, and/or other technologies.

District energy systems: provision of heating and/or cooling to multiple buildings from centralized energy systems.

Emissions: greenhouse gas emissions, measured in grams, kilograms, or metric tonnes (CO2e), unless otherwise indicated.

Emissions intensity: the ratio of emissions released per unit of electricity generated, measured in gCO2e/kWh.

Energy efficiency improvement: an improvement in the ratio of energy consumed to the output produced or service performed. This improvement results in the delivery of more services for the same energy inputs or the same level of services from less energy input.

Electric vehicles (EVs): an umbrella term describing a variety of vehicle types that use electricity as their primary fuel source for propulsion or as a means to improve the efficiency of a conventional internal combustion engine.

Energy storage: technologies that store energy for consumption at a later time. Energy storage includes electric systems such as batteries as well as thermal systems, such as hot and cold water storage tanks.

Feed-in-Tariff: A policy mechanism designed to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers. The energy produced is sold to the grid rather than consumed directly (termed, "net-metering").

Geoexchange energy: low-temperature thermal energy collected from soil and water near the

Earth's surface by heat pumps for use in building heating.

Geothermal energy: high temperature thermal energy collected from deep in the Earth for use in building heating and industrial applications.

Greenhouse gases (GHG): gases that trap heat in the atmosphere by absorbing and emitting solar radiation, causing a greenhouse effect that unnaturally warms the atmosphere. The main GHGs are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Heat pump: a device that transfers heat energy from a source of heat to a target area using mechanical energy.

Heating Degrees Days (HDD): number of degrees that a day's average temperature is below 18oC, requiring heating.

HVAC: heating, ventilation and air conditioning systems, referred to in the context of a building.

Indicator: an observable or measurable result that shows evidence of whether an impact has occurred and the nature of that impact. It provides a metric by which one can quantify and define the scale of a resulting change.

Net-metering: This is an electricity billing mechanism that allows consumers who generate some or all of their own electricity to use that electricity anytime, instead of when it is generated.

Passive House buildings: buildings designed and constructed to stringent standards resulting in up to 90% increased energy efficiency as compared to a typical buildings' energy use.

Re-commissioning: a process of examining and optimizing a building's HVAC systems after a building has been fully operational for a period of time.

Renewable energy: energy that comes from resources which are naturally replenished on a human timescale, such as sunlight, wind, moving water, and geothermal heat.

Solar photovoltaic (PV): also known as solar electric systems or solar panels, these are systems that convert sunlight into electricity. Any excess electricity produced that a building does not use can be sold to the utility through a process called net-metering.

Vehicle kilometres travelled (VKT): distance traveled by vehicles within a defined region over a specified time period.

GHG emissions	Energy
1 ktCO2e = 1,000 tCO2e	1 MWh = 1,000 kWh
1 tCO2e = 1,000 kgCO2e	1 MWh = 3.6 GJ
1 kgCO2e = 1,000 gCO2e	1 GJ = 278 kWh
	1 GJ = 1,000,000 J
	1 MJ = 0.001 GJ
	1 TJ = 1,000 GJ
	1 PJ = 1,000,000 GJ

Appendix 2: Orillia’s Corporate Buildings Inventory

Table 1: Orillia's Corporate Buildings Inventory

#	Building Name	Primary Activity	Year of Retrofit
1	Barnfield Point	Recreation	2023
2	Brian Orser Arena	Recreation	2025
3	City Centre	Office	2031
4	Couchiching Park Concession (140 Canice St.)	Recreation/Concession	2025
5	Couchiching Park Greenhouse (140 Canice St.)	Recreation/Concession	2038
6	Couchiching Park Washroom (140 Canice St.)	Washroom	2038
7	Fire Hall 1	Office/ Operations	2028
8	Fire Hall 2	Office/ Operations	2026
9	Forest Home Community Centre (995 Memorial Ave)	Office / Recreation	2028
10	Homewood Park (68 Woodside Dr)	Utility Room	2025
11	Kitchener Park Washroom - Concession (25 Kitchener St)	Washroom	2025
12	Leacock Swanmore Hall (Café) (50 Museum Dr)	Public Facing / Recreation	2028
13	Leacock Swanmore Hall, Admin Office (50 Museum Dr)	Office	2028
14	Library - 36 Mississaga St	Public facing	2033
15	McKinnell Square Park – 135 Dunedin St.	Utility Room	2025
16	MOC - Admin / Garage (20 James St.W) (Public Works)	Operations	2025
17	MOC - Electrician / Storage (188 Jarvis St)	Utility Room	2025
18	Moose Beach Washroom (450Atherley Rd)	Washroom	2025
19	Museum (50 Museum Dr)	Office / Public	2028
20	Orillia Opera House (20 Mississaga St. W)	Public	2032
21	Parks -Garage/Equip Storage (30 James St.W)	Storage	2025
22	Port (6 Centennial Dr) (new May 2017)	Operations	2034
23	Regan House (Scouts Valley)	Recreation	2025
24	Rotary Place - Field Washroom (100 University Ave)	Washroom	2025
25	Rotary Place Arena (100 University Ave)	Arena	2030
26	Sir Sam Steele Bldg.	Public Recreation	2026

#	Building Name	Primary Activity	Year of Retrofit
27	Tudhope Park - Jerry Udell Wshrm and Rowing Club (450 Atherley Rd)	Washroom / Storage	2034
28	Tudhope Park Admin Bldg (450Atherley Rd)	Office	2025
29	WDS - Admin Office - NEW 2016 (100 Kitchener St)	Office	2025
30	WFP - Filter Bldg (188 Jarvis St) (Stripper/Air scrubber Bldg.) *	Operations	2029
31	WFP - Filtration Bldg (200BaySt)**	Operations	N/A
32	WFP - Generator Bldg (188JarvisSt)*	Operations	2029
33	WWTC - Admin Bldg (40 Kitchener St)**	Operations / Office	N/A

*These process buildings are mostly electric and a conservative 10% efficiency upgrade is considered alongside heat pumps for space heating of the buildings.

**The WWTP will be covered in greater detail in/fuel switching the Community Climate Action Plan and in consultation with the current and ongoing Wastewater Management Plan (2021).

Appendix 3: Energy and GHG transition (2018-2040)

Table A1.1. Emissions targets under a net-zero by 2045 pathway, in tCO2e.

	Net-Zero By 2040	Business as Usual
2018	2,429	2,429
2019	2,327	2,429
2020	2,226	2,499
2021	2,125	2,453
2022	2,024	2,492
2023	1,923	2,709
2024	1,822	2,727
2025	1,720	2,891
2026	1,619	2,896
2027	1,518	2,862
2028	1,417	2,920
2029	1,316	2,880
2030	1,214	2,918
2031	1,093	3,006
2032	971	2,967
2033	850	2,956
2034	729	2,975
2035	607	2,978
2036	486	3,008
2037	364	3,079
2038	243	3,092
2039	121	3,171
2040	0	3,157

Appendix 4: Summarized Financial Assumptions

Retrofit Cost Intensity for 50% retrofit intensity	
$ / sq. ft	50
Source: Frappé-Sénéclauze, T., Heerema, D., Tam Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.https://www.pembina.org/reports/retrofit-strategy-bc-report-2017.pdf	

Cost Intensity of Heat Pump	
$ / sq. ft	Included in above figure
Source: Frappé-Sénéclauze, T., Heerema, D., Tam Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.https://www.pembina.org/reports/retrofit-strategy-bc-report-2017.pdf	

Carbon Price																							
$/tonne CO2eq	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	20	20	30	40	50	65	80	95	110	125	140	155	170	170	170	170	170	170	170	170	170	170	170
source:	Government of Canada. Greenhouse Gas Pollution Pricing Act																						
	Government of Canada. A Healthy Environment and a Healthy Economy. Backgrounder.																						

Electricity																							
$/GJ	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Commercial	27.78	27.78	28.34	28.48	28.62	28.78	28.92	29.06	29.20	29.35	29.51	29.65	29.79	29.83	29.86	29.88	29.93	29.95	29.97	29.99	30.04	30.06	30.09
source:	Base year informed by actual electricity bills; NEB Canada's Energy Future 2020, End - Use Prices, Reference Case																						
	*Linear extrapolation applied after 2040																						

Natural Gas																							
$/GJ	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Commercial	7.31	7.31	7.40	7.48	7.55	7.60	7.64	7.67	7.70	7.73	7.77	7.80	7.83	7.87	7.90	7.93	7.96	8.00	8.03	8.06	8.09	8.13	8.16
source:	Base year informed by actual NG bills; NEB Canada's Energy Future 2020, End - Use Prices, Reference Case																						
	Linear extrapolation applied after 2040																						

Appendix E: Modelling Results

Data, Modelling Scope, Method, and Process

March 2022

Summary

This Data, Methods, and Assumptions (DMA) Manual details the modelling approach used to provide community energy and emissions benchmarks and projections and provides a summary of the data and assumptions used in scenario modelling. The DMA makes the modelling elements fully transparent and illustrates the scope of data required for future modelling efforts.

Accounting and Reporting Principles

This municipal greenhouse gas (GHG) inventory baseline development and scenario modelling approach correlates with the Global Protocol for Community-Scale GHG Emissions Inventories (GPC). The GPC provides a fair and true account of emissions via the following principles:

Relevance: The reported GHG emissions shall appropriately reflect emissions occurring as a result of activities and consumption within the municipal boundary. The inventory will also serve the decision-making needs of the municipality, taking into consideration relevant local, subnational, and national regulations. Relevance applies when selecting data sources and determining and prioritizing data collection improvements.

Completeness: The inventory will account for all emissions sources within the inventory boundary. Any exclusions of sources shall be justified and explained.

Consistency: Emissions calculations shall be consistent in approach, boundary, and methodology.

Transparency: Activity data, emissions sources, emissions factors, and accounting methodologies require adequate documentation and disclosure to enable verification.

Accuracy: The calculation of GHG emissions should not systematically overstate or understate actual GHG emissions. The accuracy should be enough to give decision makers and the public reasonable assurance of the integrity of the reported information. Uncertainties in the quantification process should be reduced to the extent possible and practical.

I. Modelling Scope

1. Geographic Boundary

The geographic boundary of the modelling assessment is the municipal boundary of the City of Orillia (Figure 1).

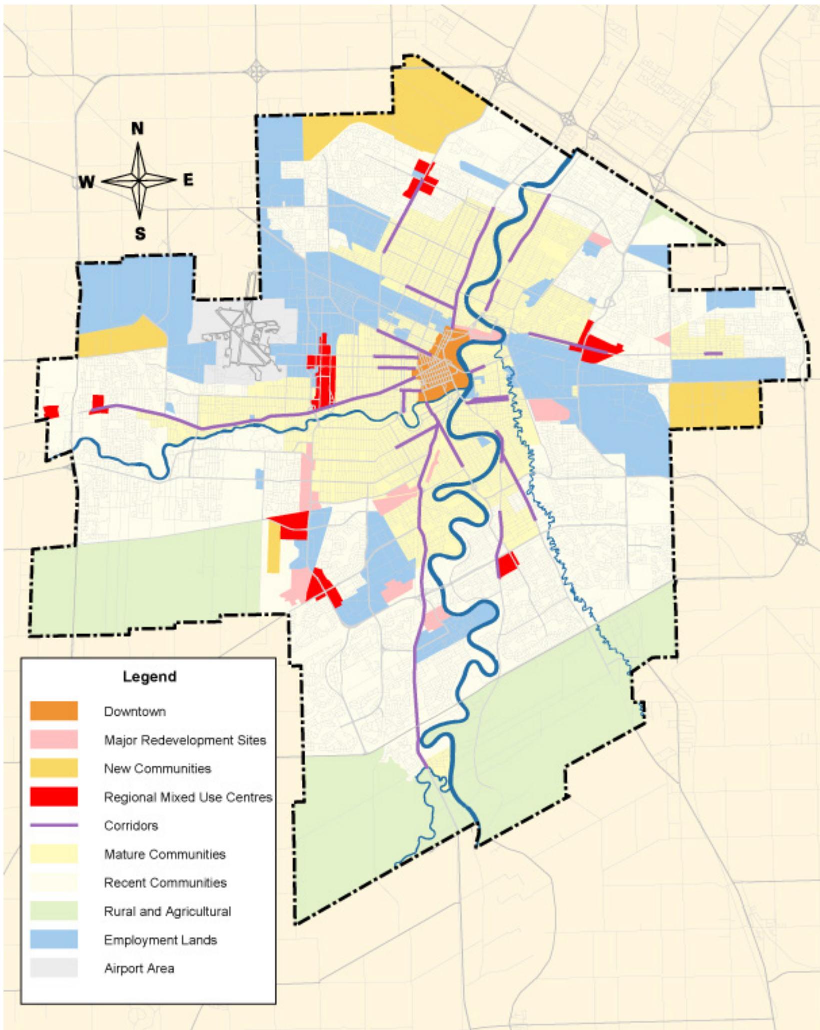

Figure 1. City of Orillia boundaries that will be used in the modelling process.[22]

2. Time Scope

- The assessment will cover the years from 2018 (base year) to 2050 (target year).
- The year 2018 will be used as a base year within the model. The rationale for using this as the base year is that:
- Census data is a key data source for the model. At the time of modelling, the most recent census year for which data is available is 2016.

[22] Winnipeg Urban Structure. Our Winnipeg. Retrieved in 2021.

- The model requires a calibration of a base year system state (known as the initial conditions) using as much observed data as possible to develop an internally consistent snapshot of the city.
- One-year increments are modelled from the 2016 baseline year until the 2050 target year. The first simulation period/year is 2016.
- The forecasts of energy use and emissions will extend to 2050.

3. Emissions Scope

The emissions assessed are those from the stationary energy (buildings), transportation, and waste sectors. The inventory will include Global Protocol for Community Greenhouse Gas Emissions Inventories (GPC) Scope 1 and 2 and some aspects of Scope 3 emissions. Refer to Table 1 and Table 2 for GPC scope definitions and a list of included GHG emission sources by scope.

Table 1. GPC scope definitions.

SCOPE	DEFINITION
1	All GHG emissions from sources located within the municipal boundary.
2	All GHG emissions occurring from the use of grid-supplied electricity, heat, steam, and/or cooling within the municipal boundary.
3	All other GHG emissions that occur outside the municipal boundary as a result of activities taking place within the boundary.

Table 2. Sources included in the Orillia model.

	SCOPE 1	SCOPE 2	SCOPE 3	NOTES[23]
Stationary energy				
Residential buildings	Y	Y	Y	
Commercial and institutional buildings and facilities	Y	Y	Y	
Manufacturing industries and construction	Y	Y	Y	
Energy industries	N	N	N	NR
Energy generation supplied to the grid	N			Additional renewable electricity is included beyond what is currently included in emissions factors projections.
Agriculture, forestry, and fishing activities	N	N	N	NR
Fugitive emissions from mining, processing, storage, and transportation of coal	N			NR
Fugitive emissions from oil and natural gas systems	Y			

[23] N/A= Not applicable; Not included in scope; ID= Insufficient data; NR= No relevant or limited activities identified

	SCOPE 1	SCOPE 2	SCOPE 3	NOTES[23]
Transportation				
On-road	Y	Y	Y	
Railways	N	N	N	NR
Waterborne navigation	N	N	N	NA
Aviation	N	N	N	NR
Off-road	N	N		NR
Waste				
Disposal of solid waste generated in the city	Y		Y	
Disposal of solid waste generated outside the city	N			NA
Biological treatment of waste generated in the city	Y		N	
Biological treatment of waste generated outside the city	N			NA
Incineration and open burning of waste generated in the city	N		N	NA
Incineration and open burning of waste generated outside the city	N			NA
Wastewater generated in the city	Y		N	
Wastewater generated outside the city	N			NA
Industrial processes and product use (IPPU)				
Industrial processes	N			ID
Product use	N			ID
Agriculture, forestry, and other land use (AFOLU)				
Livestock	N			NR
Land	N			NR
Aggregate sources and non-CO2 emissions sources on land	N			NR
Other Scope 3			N	NA

4. Emissions Factors

Table 3. Emissions accounting framework and global warming potential.

CATEGORY	BASELINE DATA/ASSUMPTION	SOURCE
Emissions accounting framework		
Accounting framework	Global Protocol for Community-Scale GHG Emission Inventories (GPC)	Global Protocol for Community-Scale GHG Emission Inventories (GPC)
Emissions scope	Scope 1, 2, and partial Scope 3	See GPC emissions scope table for Scope 3 items included.
Sectors	Stationary energy (buildings) Transportation Waste	See GPC emissions scope table for sectors and subsectors included.
Boundary	Municipal boundary of the City of Orillia	City of Orillia
Reporting	GPC BASIC and partial BASIC+	Global Protocol for Community-Scale GHG Emission Inventories (GPC)
Transportation methodology	GPCinduced activity method	Global Protocol for Community-Scale GHG Emission Inventories (GPC)
Baseline year	2018	N/A
Projection year	2050	N/A
Global warming potential (GWP)		
Greenhouse gases	CO2 = 1 CH4 = 34 N2O = 298	Myhre, G. et al., 2013: Anthropogenic and Natural Radiative Forcing. Table 8.7. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Table 4. Emissions factors for fuels in the Orillia model.

CATEGORY	BASELINE DATA/ASSUMPTIONS	SOURCE
Emissions factors		
Natural gas	49 kg CO2e/GJ	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Tables A6-1 and A6-2.

CATEGORY	BASELINE DATA/ASSUMPTIONS	SOURCE
Electricity	2016: CO_2: 28.9 g/kWh CH_4: 0.007 g/kWh N_2O: 0.001 g/kWh 2050: CO_2: 82.32 g/kWh CH_4: 0.02 g/kWh N_2O: 0.00 g/kWh	National Energy Board. (2016). Canada's Energy Future 2016. Government of Canada. Retrieved from https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016pt/nrgyftrs_rprt-2016-eng.pdf
Gasoline	g / L CO_2: 2316 CH_4: 0.32 N_2O: 0.66	NIR Part 2 Table A6–12 Emission Factors for Energy Mobile Combustion Sources
Diesel	g / L CO_2: 2690.00 CH_4: 0.07 N_2O: 0.21	NIR Part 2 Table A6–12 Emission Factors for Energy Mobile Combustion Sources
Fuel oil	Residential g/L CO_2: 2560 CH_4: 0.026 N_2O: 0.006 Commercial g/L CO_2: 2753 CH_4: 0.026 N_2O: 0.031 Industrial g/L CO_2: 2753 CH_4: 0.006 N_2O: 0.031	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Table A6–4 Emission Factors for Refined Petroleum Products
Wood	Residential kg/GJ CO_2: 299.8 CH_4: 0.72 N_2O: 0.007 Commercial kg/GJ CO_2: 299.8 CH_4: 0.72 N_2O: 0.007 Industrial kg/GJ CO_2: 466.8 CH_4: 0.0052 N_2O: 0.0036	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Table A6–56 Emission Factors for Biomass

CATEGORY	BASELINE DATA/ASSUMPTIONS	SOURCE
Propane	g/L ! transport CO2: 1515.00 CH4: 0.64 N2O: 0.03 ! residential CO2: 1515.000 CH4 : 0.027 N2O: 0.108 ! all other sectors CO2: 1515.000 CH4: 0.024 N2O: 0.108	NIR Part 2 Table A6–3 Emission Factors for Natural Gas Liquids Table A6–12 Emission Factors for Energy Mobile Combustion Sources
Waste/ WW	wastewater emissions factors CH4: 0.48 kg CH4/kg BOD N2O: 3.2 g / (person * year) from advanced treatment 0.005 g /g N from wastewater discharge landfill emissions are calculated from first order decay of degradable organic carbon deposited in landfill derived emission factor in 2016 = 0.015 kg CH4 / tonne solid waste (assuming 70% recovery of landfill methane), .05 kg CH4 / tonne solid waste not accounting for recovery	CH4 wastewater: IPCC Guidelines Vol 5 Ch 6, Tables 6.2 and 6.3, we use the MCF value for anaerobic digester N2O from advanced treatment: IPCC Guidelines Vol 5 Ch 6 Box 6.1 N2O from wastewater discharge: IPCC Guidelines Vol 5 Ch 6 Section 6.3.1.2 Landfill emissions: IPCC Guidelines Vol 5 Ch 3, Equation 3.1

5. Model Assumptions

The modelling assessment uses a series of data assumptions to model the three scenarios: business-as-usual, business-as-planned, and net-zero scenarios. Appendix A details the data assumptions used in the City of Orillia's energy and emissions assessment.

II. Modelling Method

1. About CityInSight

CityInSight is an integrated, spatially-disaggregated energy, emissions, and finance model developed by Sustainability Solutions Group and whatIf? Technologies. The model enables bottom-up accounting for energy supply and demand, including renewable resources, conventional fuels, energy-consuming technology stocks (e.g. vehicles, heating systems, dwellings, and buildings), and all intermediate energy flows (e.g. electricity and heat).

CityInSight incorporates and adapts concepts from the system dynamics approach to complex systems analysis. Energy and GHG emissions are derived from a series of connected stock and flow models. The model accounts for physical flows (e.g. energy use, new vehicles, and vehicle kilometres travelled) as determined by stocks (e.g. buildings, vehicles, and heating equipment). For any given year within its time horizon, CityInSight traces the flows and transformations of energy from sources through energy currencies (e.g. gasoline and electricity) to end uses (e.g. personal vehicle use and space heating),energy costs, and GHG emissions. The flows evolve based on current and future geographic and technology decisions/assumptions (e.g. EV uptake rates). An energy balance is achieved by accounting for efficiencies, conservation rates, and trade and losses at each stage in the journey from source to end use. The characteristics of CityInSight are described in Table 5.

The model is spatially explicit. All buildings, transportation, and land-use data are tracked within the model through a GIS platform and by varying degrees of spatial resolution. Where applicable, a zone-type system can be applied to break up the city into smaller configurations. This enables consideration of the impact of land-use patterns and urban form on energy use and emissions production from a baseline year to future dates using GIS-based platforms. CityInSight's GIS outputs can be integrated with city mapping systems.

Table 5. Characteristics of CityInSight.

CHARACTERISTIC	RATIONALE
Integrated	CityInSight is designed to model and account for all sectors that relate to energy and emissions at a city scale while capturing the relationships between sectors. The demand for energy services is modelled independently of the fuels and technologies that provide the energy services. This decoupling enables exploration of fuel switching scenarios. Physically feasible scenarios are established when energy demand and supply are balanced.
Scenario-based	Once calibrated with historical data, CityInSight enables the creation of dozens of scenarios to explore different possible futures. Each scenario can consist of either one or a combination of policies, actions, and strategies. Historical calibration ensures that scenario projections are rooted in observed data.
Spatial	The configuration of the built environment determines people's ability to walk and cycle, the accessibility of transit, the feasibility of district energy, etc. Therefore, CityInSight includes a full spatial dimension that can include as many zones —the smallest areas of geographic analysis—as are deemed appropriate. The spatial component to the model can be integrated with City GIS systems, land-use projections, and transportation modelling.
GHG reporting framework	CityInSight is designed to report emissions according to the GHGProtocol for Cities (GPC) framework and principles.

CHARACTERISTIC	RATIONALE
Economic impacts	CityInSight incorporates a full financial analysis of costs related to energy (expenditures on energy) and emissions (carbon pricing, social cost of carbon), as well as operating and capital costs for policies, strategies, and actions. It allows for the generation of marginal abatement curves to illustrate the cost and/or savings of policies, strategies, and actions.

2. Model Structure

The major components of the model (sub-models) and the first level of modelled relationships (influences) are represented in Figure 2. These sub-models are all interconnected through various energy and financial flows. Additional relationships may be modelled in CityInSight by modifying inputs and assumptions specified directly by users or in an automated fashion by code or scripts running "on top of" the base model structure. Feedback relationships are also possible, such as increasing the adoption rate of non-emitting vehicles in order to meet a particular GHG emissions constraint.

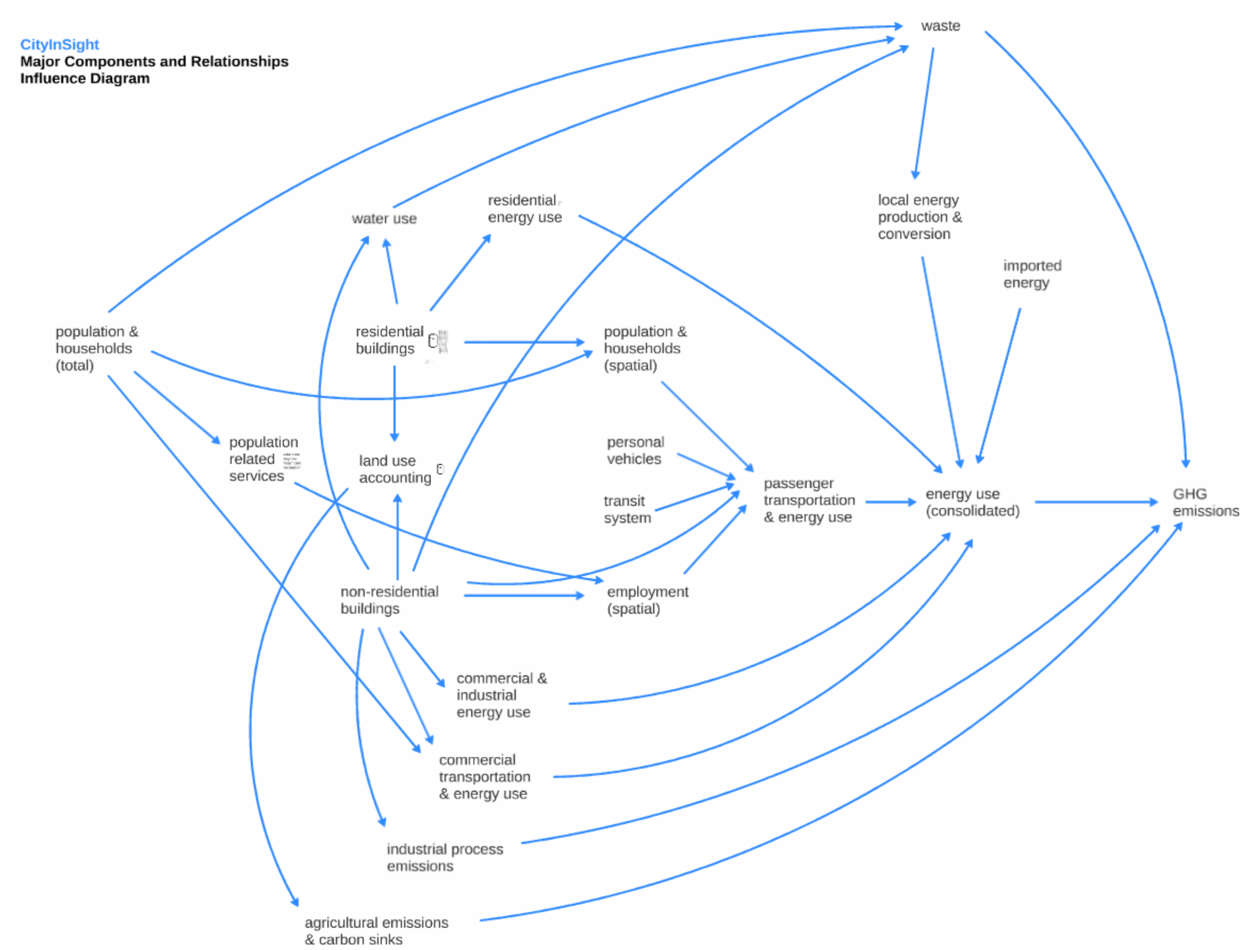

Figure 2. Representation of CityInSight's structure.

3. Stocks and Flows

Within each sub-model are a number of stocks and flows that represent energy and emissions processes in cities. For any given year, various factors shape the picture of energy and emissions flows in a city, including the population and the energy services it requires, commercial floor space, energy production and trade, the deployed technologies that deliver energy services (service technologies), and the deployed technologies that transform energy sources to currencies (harvesting technologies). The model creates an explicit mathematical relationship between the factors—some contextual and some part of the energy consuming or producing infrastructure—making up the energy flow picture.

Some factors are modelled as stocks (i.e. counts of similar things classified by various properties). For example, population is modelled as a stock of people classified by age and gender. Population change over time is projected by accounting for the natural aging process, inflows (births, immigration), and outflows (deaths, emigration). The fleet of personal-use vehicles, an example of a service technology, is modelled as a stock of vehicles with a similarly classified fuel consumption intensity classified by size, engine type, and model year. As with population, projecting change in the vehicle stock involves aging vehicles and accounting for major inflows (new vehicle sales) and major outflows (vehicle discards). This stock-turnover approach is applied to other service technologies (e.g. furnaces, water heaters) and harvesting technologies (e.g. electricity generating capacity).

4. Sub-Models

The stocks and flows that make up each sub-model are described below.

POPULATION, HOUSEHOLDS, AND DEMOGRAPHICS

- City-wide population is modelled using the standard population cohort-survival method, which tracks population by age and gender on a year-by-year basis. It accounts for various components of change such as births, deaths, immigration, and emigration.
- Population is allocated to households and these are placed spatially in zones via physical dwellings (see the land-use accounting sub-model).
- The age of the population is tracked over time and is used for analyzing demographic trends, generational differences, and implications for shifting energy-use patterns.
- The population sub-model influences energy consumption in various sub-models:
- School enrollment totals (transportation)
- Workforce totals (transportation)
- Personal vehicle use (transportation)
- Waste generation

BUILDING LAND-USE ACCOUNTING

Land-use accounting identifies buildings in space and over time, through construction, retrofits, and demolitions. In the baseline, this is often directly informed by building-related geospatial data. Land-use accounting consists of the following elements:

- Quantitative spatial projections of residential dwelling units by:
- Residential structure type (single detached, semi detached, row house, apartment, etc.);
- Development type (greenfield, intensification); and
- Population assigned to dwelling units.

- Quantitative spatial projections of non-residential buildings by:
- Non-residential structure type (retail, commercial, institutional);
- Development type (greenfield, intensification);
- Classification of buildings into archetypes (such as school, hospital, industrial—see Table 2).[24] This allows the model to account for differing intensities that would occur in relation to various non-residential buildings; and
- Job allocation to zones via non-residential floor area, using a floor-area-per-worker intensity.
- Land-use accounting takes the following "components of change" into account year over year:
- New development;
- Removals/demolitions; and
- Year of construction.
- Land-use accounting influences other aspects of the model, notably:
- Passenger transportation: The location of residential buildings influences where home-to-work and home-to-school trips originate, which in turn,influences their trip length and the subsequent mode selected. Similarly, the location and identification of non-residential buildings influences the destination for many trips. For example, buildings identified as schools would be identified in home-to-school trips.
- Access to energy sources by buildings: Building location influences access to energy sources. For example, a rural dwelling may not have access to natural gas or a dwelling may not be in proximity to an existing district energy system. It can also be used to identify suitable projects. For example, the location and density of dwellings is a consideration for district energy development.
- Non-residential building energy: The identification of non-residential building archetypes influences their energy consumption based on their use type. For example, a building identified as a hospital would have a higher energy-use intensity than a building identified as a school.

Table 6. Non-residential archetypes represented in the model.

CATEGORY	UNIT
Education	College, university School
Government buildings and space	Municipal building Fire station Penal institution Police station Military base or camp

[24] Where possible, this data comes directly from the municipality.

CATEGORY	UNIT
Healthcare	Retirement or nursing home
	Special care home
	Hospital
Community and culture	Greenspace
	Recreation
	Community centre
	Museum, art gallery
	Religious institution
Commercial space	Restaurant
	Hotel, motel, inn
	Retail
	Commercial retail
	Commercial
	Commercial residential
	Retail residential
	Warehouse commercial
	Warehouse
	Warehouse retail
Utilities	Energy utility
	Water pumping or treatment station
Transportation	Transit terminal or station
	Airport
	Parking
Agriculture	Industrial farm
	Barn
	Greenhouse
Industry and manufacturing	Vehicle and heavy equipment service
	Industrial generic
	Manufacturing plant, miscellaneous processing plant
	Chemical manufacturing plant
	Printing and publishing plants
	Food processing plant
	Textile manufacturing plant
	Furniture manufacturing plant
	Refineries—all types
	Fabricated metal product plant
	Asphalt manufacturing plant
	Concrete manufacturing plant
Miscellaneous large surfaces	Golf course
	Surface infrastructure

RESIDENTIAL AND NON-RESIDENTIAL BUILDING ENERGY

Building energy consumption is closely related to the land-use accounting designation it receives based on where the building is located, its archetype, and when it was constructed. Building energy consumption is calculated in the model by considering:

- Total energy-use intensity of the building type (including the proportion from thermal demand) is built from energy end uses in the building. End uses include heating, lighting, and auxiliary demand. The energy intensity of end uses is related to the building or dwelling archetype and its age.
- Energy use by fuel is determined based on the technologies used in each building (e.g. electricity and heating system types). Heating system types are assigned to building equipment stocks (e.g., heating systems, air conditioners, water heaters).
- Building energy consumption in the model also considers:
- Solar gains and internal gains from sharing walls;
- Local climate (heating and cooling degree days); and
- Energy losses in the building.
- Building equipment stocks (e.g. water heaters and air conditioners) are modelled with a stock-turnover approach that captures equipment age, retirements, and additions. In future projections, the natural replacement of stocks is often used as an opportunity to introduce new (and more efficient) technologies.

The model has residential and non-residential building energy sub-models. They influence and produce important model outputs such as:

- Total residential energy consumption and emissions and residential energy and emissions by building type, end use, and fuel;
- Total non-residential energy consumption and emissions and residential energy and emissions by building type, end use, and fuel; and
- Local/imported energy balance (i.e how much energy will need to be imported after considering local capacity and production).

Figure 3 details the flows in the building energy sub-model at the building level.

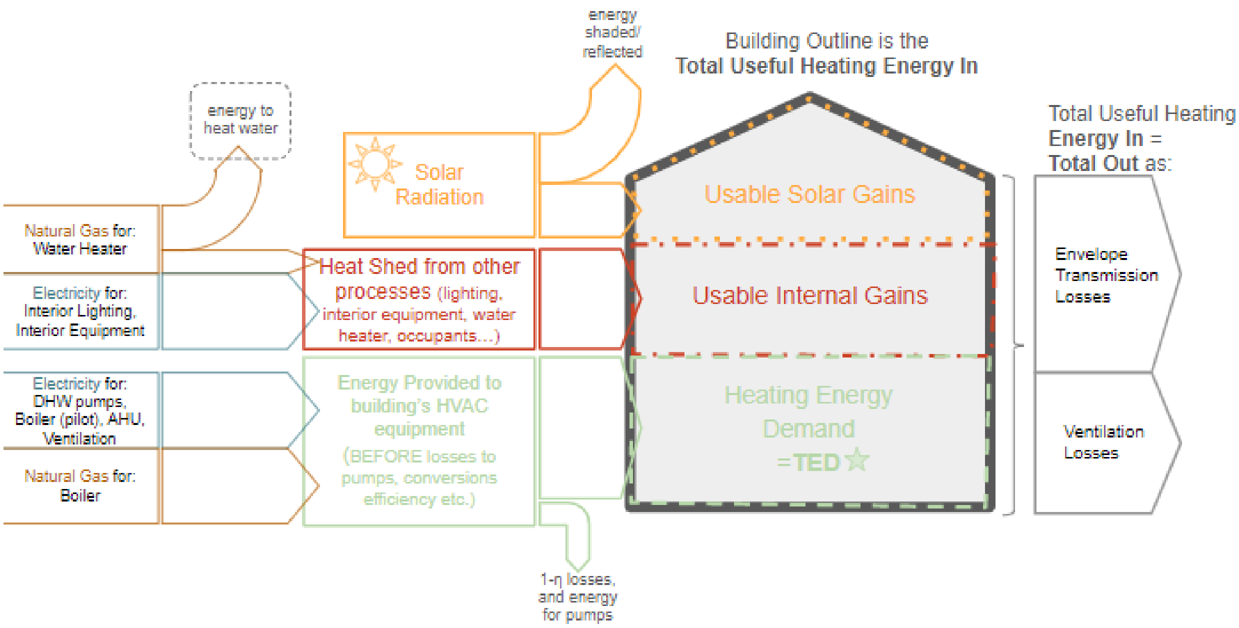

Figure 3. Building energy sub-model schematic.

TRANSPORTATION

CityInSight includes a spatially explicit passenger transportation sub-model that responds to changes in land use, transit infrastructure, vehicle technology, travel behaviour changes, etc. The sub-model has the following features:

- CityInSight uses the induced method for accounting for transportation-related emissions; the induced method accounts for in-boundary trips and 50% of transboundary trips that originate or terminate within the city boundary. This shares energy and GHGs between municipalities.
- The model accounts for "trips" in the following sequence:

1. Trip generation. Trips are divided into four types (home-work, home-school, home-other, and non-home-based) that are each produced and attracted by different combinations of spatial influences identified in the land-use accounting sub-model: dwellings, employment, classrooms, and non-residential floor space.
2. Trip distribution. Trips are distributed by the number of trips specified for each zone of origin and zone of destination pair. Origin-Destination (O-D) matrix data is based on local travel surveys and transportation models.
3. Mode share. For each origin-destination pair, trips are shared over walk/bike, public transit, and automobile.
   a. Walk/bike trips are identified based on a distance threshold of ~2 km for walking and ~5–10 km for biking.
   b. Transit trips are trips with an origin or destination within a certain distance to a transit station.
4. Vehicle distance. Vehicle kilometres travelled (VKT) are calculated based on the number of trips by mode and the distance of each trip based on a network distance matrix for the

origin-destination pairs.

- VKT is assigned to a stock of personal vehicles based on vehicle type, fuel type, and fuel efficiency. The number of vehicles is influenced by the total number of households identified in the population sub-model. The model also uses a stock-turnover approach to model vehicle replacements, new sales, and retirements.
- The energy use and emissions associated with personal vehicles are calculated using the VKT of the stock of personal vehicles and their type, fuel, and efficiency characteristics.
- The personal mobility sub-model is one of the core components of the model. It influences and produces the following important model outputs:
- Total transportation energy consumption by fuel, including electricity consumption.
- Active trips and transit trips by zone distance.

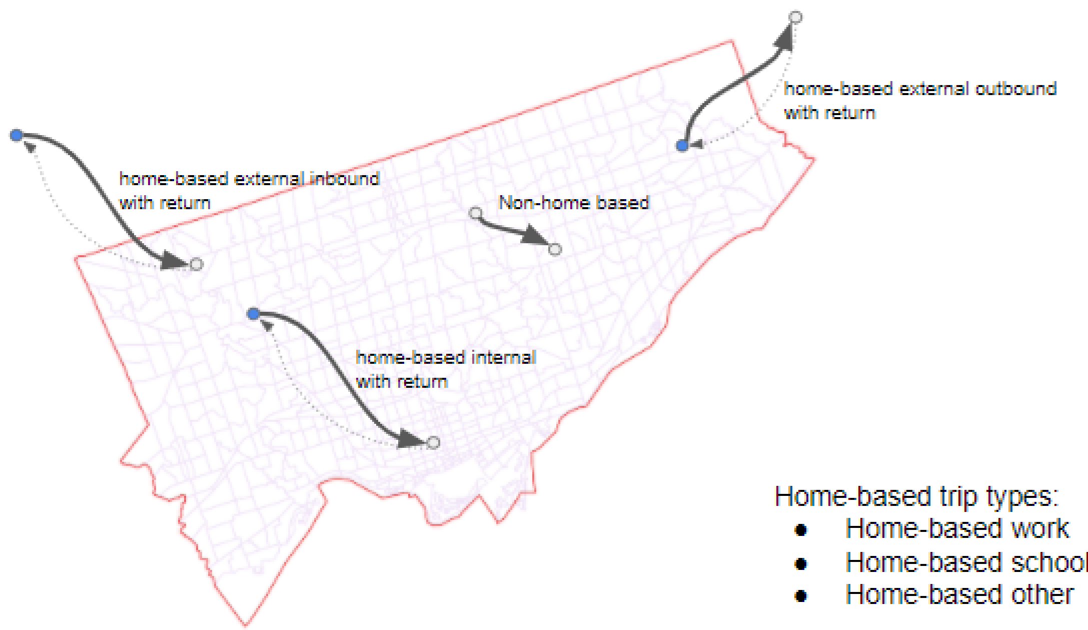

Figure 4. Trips assessed in the personal mobility sub-model.

WASTE

Households and non-residential buildings generate solid waste and wastewater, and the model traces various pathways to disposal, compost, and sludge. If present in the city, the model can also capture energy recovery from incineration and biogas. Waste generation is translated to landfill emissions based on first order decay models of carbon to methane.

LOCAL ENERGY PRODUCTION

The model accounts for energy generated within city boundaries. It models energy produced from local sources (e.g. solar, wind, biomass) alongside energy imported from other resources (e.g. the electricity grid and the natural gas distribution system) and accounts for conversion efficiency. Local energy generation can be spatially defined.

FINANCIAL AND EMPLOYMENT IMPACTS

Energy-related financial flows and employment impacts are captured through an additional layer of model logic. Costs are calculated as new stock is incorporated into the model through energy flows (annual fuel costs) and other operating and maintenance costs. Costs are based on a suite of assumptions that are inputted into the model. See Section 6 for financial variables tracked within the model.

The model calculates employment based on non-residential building archetypes and their floor area. Employment related to investments is calculated using standard employment multipliers and is often expressed as person-years of employment per million dollars of investment.

5. Energy and GHG Emissions Accounting

CityInSight accounts for the energy flows through the model, as shown in Figure 6. Source fuels crossing the geographic boundary of the city are shown on the left. The four "final demand" sectors—residential, commercial, industrial, and transportation—are shown towards the right. Some source fuels are consumed directly in the final demand sectors (e.g. natural gas used by furnaces for residential heating and gasoline used by personal vehicles for transportation). Other source fuels are converted to another energy carrier before consumption in the final demand sectors (e.g. solar energy converted to electricity via photovoltaic cells and natural gas combusted in heating plants and the resulting hot water distributed to end-use buildings via district energy networks). Finally, efficiencies of the various conversion points (e.g. end uses, local energy production) are estimated to split flows into either "useful" energy or conversion losses at the far right side of the diagram.

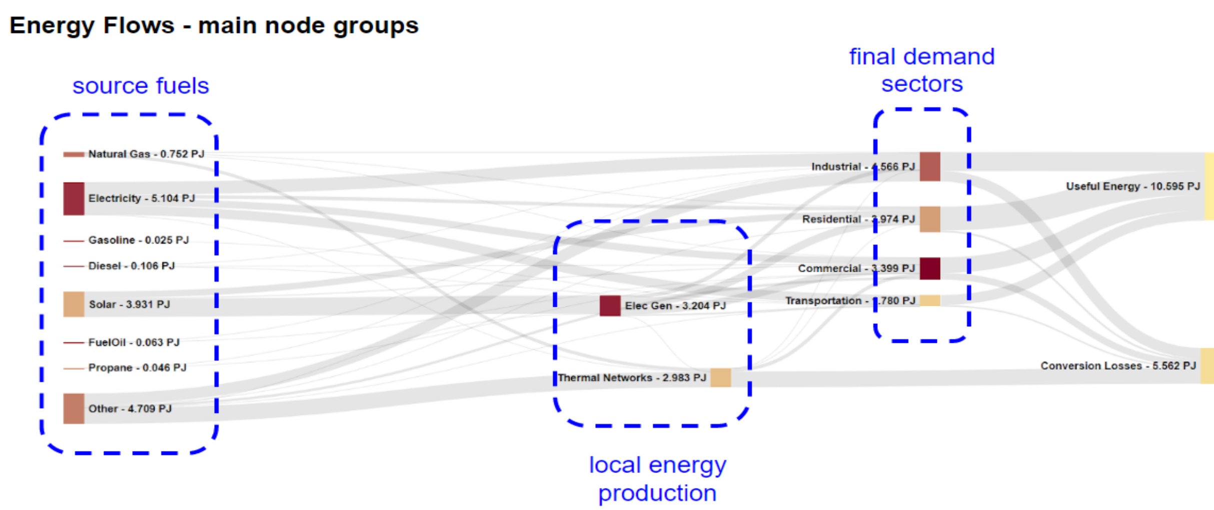

Figure 5. Energy flow Sankey diagram showing main node groups.

Figure 5 above shows the potential for ambiguity when energy is reported. For example, which of the energy flows circled are included and how do you prevent double counting? To address these ambiguities, CityInSight defines two main energy reports:

- Energy demand (shown in Figure 6). Energy demand includes the energy flows just before the final demand sectors (left of the dotted red line). Where the demand sectors are supplied by local energy production nodes, the cut occurs after the local energy production and before demand.

- Energy supply (shown in Figure 7). Energy supply includes the energy flows just after the source fuel nodes (left of the dotted red line). Where the source fuels supply local energy production nodes, the cut occurs between the source fuels and local energy production.

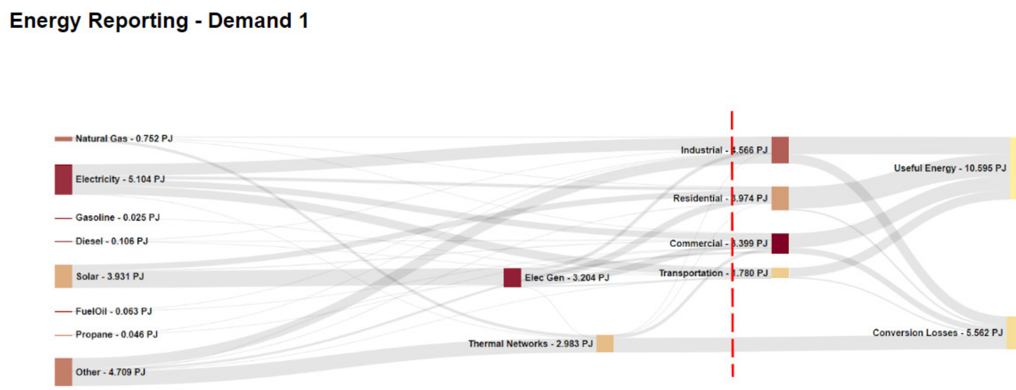

Figure 6. Energy demand report definition.

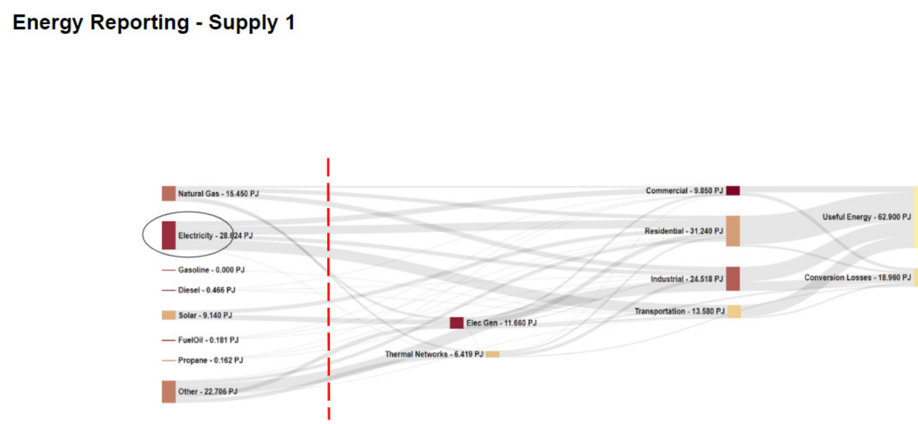

Figure 7. Energy supply report definition.

In the integrated CityInSight energy and emissions accounting framework, GHG emissions are calculated after energy consumption is known.

6. Financial Accounting

The model also expresses a financial analysis for most of its stocks and flows. Costs and savings modelling considers:

- Upfront capital expenditures related to new stocks such as new vehicles or new building equipment;
- Operating and maintenance costs (annualized costs, such as vehicle maintenance, associated with stocks);
- Energy costs related to energy flows in the model and accounting for fuel and electricity costs; and
- Carbon pricing calculated based on emissions generation.

The expenditure types evaluated in the model are summarized in Table 7. Financial assumptions will be included in further iterations of the Winnipeg model.

Table 7. Categories of expenditures.

CATEGORY	DESCRIPTION
Residential buildings	Cost of dwelling construction and retrofitting and operating and maintenance costs (non-fuel).
Residential equipment	Cost of appliances and lighting, heating and cooling equipment.
Residential fuel	Energy costs for dwellings and residential transportation.
Residential emissions	Costs resulting from a carbon price on GHG emissions from dwellings and transportation.
Commercial buildings	Cost of building construction and retrofitting and operating and maintenance costs (non-fuel).
Commercial equipment	Cost of lighting, heating, and cooling equipment.
Commercial vehicles	Cost of vehicle purchase and operating and maintenance costs (non-fuel).
Non-residential fuel	Energy costs for commercial buildings, industry, and transport.
Non-residential emissions	Costs resulting from a carbon price on GHG emissions from commercial buildings, production, and transportation.
Energy production emissions	Costs resulting from a carbon price on GHG emissions for fuel used in the generation of electricity and heating.
Energy production fuel	Cost of purchasing fuel for generating local electricity, heating, or cooling.
Energy production equipment	Cost of the equipment for generating local electricity, heating, or cooling.
Municipal capital	Cost of the transit system additions (no other forms of municipal capital assessed).
Municipal fuel	Cost of fuel associated with the transit system.
Municipal emissions	Costs resulting from a carbon price on GHG emissions from the transit system.
Energy production revenue	Revenue derived from the sale of locally generated electricity or heat.
Personal use vehicles	Cost of vehicle purchase and operating and maintenance costs (non-fuel).
Transit fleet	Costs of transit vehicle purchase.
Active transportation infrastructure	Costs of bike lane and sidewalk construction.

FINANCIAL REPORTING PRINCIPLES

The financial analysis is guided by the following reporting principles:

6. Sign convention: Costs are negative; revenue and savings are positive.
7. The financial viability of investments will be measured by their net present value.

8. All cash flows are assumed to occur on the last day of the year and, for purposes of estimating their present value in Year 1, will be discounted back to time zero (the beginning of Year 1). This means that even the initial capital outlay in Year 1 will be discounted by a full year for purposes of present value calculations.

9. We will use a discount rate of three percent in evaluating the present value of future government costs and revenues.

10. Each category of stocks will have a different investment horizon.

11. Any price increases for fuel, electricity, carbon, or capital costs included in our analysis will be real price increases, net of inflation.

12. Where a case can be made that a measure will continue to deliver savings after its economic life (e.g. after 25 years in the case of the longest lived measures), we will capitalize the revenue forecast for the post-horizon years and add that amount to the final year of the investment horizon cash flow.

13. When presenting the results of the financial analysis, we will round them to the nearest thousand dollars unless additional precision is meaningful.

14. Only actual cash flows will be included in the financial analysis.

7. Inputs and Outputs

The model relies on a suite of assumptions that define the various stocks and flows within the model for every time step (year) in the model.

BASE YEAR

For the baseline year, many model inputs come from calibrating the model with real energy datasets. This includes real building and transportation fuel data and city data on population, housing stock, and vehicle stock. Other assumptions come from underlying relationships between energy stocks and flows identified through research, like the fuel efficiency of personal vehicles or the efficiency of solar PV.

FUTURE PROJECTIONS

CityInSight is designed to project how the energy flow picture and the emissions profile will change in the long term by modelling potential changes in:

- the context (e.g. population, development patterns) and
- emissions reduction actions that influence energy demand and the composition of stocks.

Potential changes in the system are also based on a suite of input assumptions and are frequently referred to as “actions”. Actions are intervention points in the model that change the relationship between a certain stock and flow at a certain time. Action assumptions can be based on existing projections and on proposed policy design and can be as wide ranging as the stocks and flows present in the model.

Stock-turnover models enable users to directly address questions about the penetration rates of new technologies over time that are constrained by assumptions such as new stock, market shares, and stock retirements. Examples of projection outputs include energy mix, mode split, vehicle kilometres of travel (VKT), total energy costs, household energy costs, and GHG emissions. Energy, emissions, capital, and operating costs are outputs for each scenario. The emission and financial impacts of alternative climate mitigation scenarios are usually presented relative to a reference or "business as planned" scenario. For example, an action may assume that starting in 2030, all new personal vehicles will be electric. This assumption would be input into the model, and, starting in 2030, every time a vehicle reaches the end of its life, rather than be replaced with a gas- or diesel-powered vehicle, it is replaced with an electric vehicle. As a result, the increase in the electric vehicle stock means greater VKT allocated to electricity and less to gasoline, thereby lowering emissions.

8. Spatial Disaggregation

As previously discussed, a key feature of CityInSight is the geocoded stocks and flows that underlie the energy and emissions in the community. All buildings and transportation activities are tracked within a discrete number of geographic zones specific to the city. This enables consideration of the impact of land-use patterns and urban form on energy use and emissions production from a baseline year to future years in the study horizon. CityInSight outputs can be integrated with city mapping and GIS systems. This feature allows CityInSight to support the assessment of a variety of urban climate mitigation strategies that are out of reach of more aggregate representations of the energy systems. Some examples include district energy, microgrids, combined heat and power, distributed energy, personal mobility (the number, length, and mode choice of trips), local supply chains, and EV infrastructure.

For stationary energy use, the foundation for the spatial representation consists of land use, zoning, and property assessment databases routinely maintained by municipal governments. These databases have been geocoded in recent years and contain detailed information about the built environment that is useful for energy analysis.

For transportation energy use and emissions, urban transportation survey data characterizes personal mobility by origin, destination, trip time, and trip purpose. This, in turn, supports the spatial mapping of personal transportation energy use and greenhouse gas emissions by origin or destination.

III. Modelling Process

CityInSight is designed to support the development of a municipal strategy for greenhouse gas mitigation. Usually, the model is engaged to identify a pathway for a community to meet a greenhouse gas emissions target by a certain year or to stay within a cumulative carbon budget over a specified period.

1. Data Collection, Calibration, and Baseline

The CityInSight engagement begins with an intensive data collection and calibration exercise in which the model is systematically populated with data on a wide range of stocks and flows in the community that affect greenhouse gas emissions. From this data, a picture emerges that begins to identify where opportunities for climate change mitigation are likely to be found in the modelled community.

The calibration and inventory exercise helps establish a common understanding among affected and interested parties about how the greenhouse gas emissions in their community are connected to the way they live, work, and play. Relevant data are collected for variables that drive energy and emissions,such as characteristics of buildings and transportation technologies, and these datasets are reconciled with observed data from utilities and other databases. The surface area of buildings is modelled in order to accurately estimate energy performance by end use. Each building is tracked by vintage, structure, and location, and a similar process is used for transportation stocks. Additional analyses at this stage include local energy generation, district energy, and the provincial electricity grid. The primary outcome of this process is an energy and GHG inventory for the baseline year, with corresponding visualizations.

2. The Base Year and Reference Projection

Once the baseline is completed, a reference projection—referred to as the business-as-planned scenario—to the target year is developed. The reference projection is based on a suite of input assumptions inserted into the model that reflect the future conditions. This is often based on existing municipal projections for buildings and population and historical trends in stocks that can be determined during model calibration. In particular, the project allocates future population and employment to building types and spaces. During this process, the model is calibrated against historical data, providing a technology stock as well as a historical trend for the model variables. This process ensures that the demographics are consistent with the municipality's GIS and transportation modelling.

The projection typically includes approved developments and official plans combined with the simulation of committed energy infrastructure to be built, existing regulations and standards (e.g. renewable energy and fuel efficiency), and communicated policies. The projection incorporates conventional assumptions about the future development of the electrical grid, uptake of electric vehicles, building code revisions, changes in climatic conditions, and other factors. The resulting projection serves as a reference line against which the impact and costs of GHG mitigation measures can be measured. Sensitivity analyses and data visualizations are used to identify key factors and points of leverage within the reference projection.

3. Low-Carbon Scenario and Action Plan

The low-carbon scenario—referred to as the net-zero scenario—uses a new set of input assumptions to explore the impacts of emissions reduction actions on the emissions profile. This begins with developing a list of candidate measures for climate mitigation in the community and is supplemented by additional measures and strategies identified through the engagement process. For many actions, CityInSight draws on an in-house database that specifies the performance and cost of technologies and measures for greenhouse gas abatement.

The low-carbon scenario is analyzed relative to the reference projection. The actions in the low-carbon scenario are grouped together to ensure that there is no double counting and that the interactive effects of the proposed measures are captured in the analysis.

IV. Addressing Uncertainty

There is extensive discussion about the uncertainty in models and modelling results. The assumptions underlying a model can be from other locations or large datasets that do not reflect local conditions or behaviours, and in cases where they do accurately reflect local conditions, it is still exceptionally difficult to predict how the conditions and behaviours will respond to broader societal changes and what those changes will be (the "unknown unknowns").

The modelling approach identifies four strategies for managing uncertainty related to community energy and emissions modelling:

1. Sensitivity analysis: From a methodological perspective, one of the most basic ways of studying complex models is the sensitivity analysis, which quantifies uncertainty in a model's output. During thes assessment, each of the model's input parameters is drawn from a statistical distribution in order to capture the uncertainty in the parameter's true value (Keirstead, Jennings, & Sivakumar, 2012).
    a. Approach: Each of the variables will be increased by 10–20% to illustrate the impact that an error of that magnitude has on the overall total.
2. Calibration: One way to challenge untested assumptions is to use backcasting to ensure the model can forecast the past accurately. The model can then be calibrated to generate historical outcomes, which usually refers to "parameter adjustments" that "force" the model to better replicate observed data.
    a. Approach: The model calibrates variables for which there are two independent sources of data. For example, the model calibrates building energy use (derived from buildings data) against actual electricity data from the electricity distributor.
3. Scenario analysis: Scenarios are used to demonstrate that a range of future outcomes is possible given the current conditions that no one scenario is more likely than another.
    a. Approach: The model will develop a reference scenario.
4. Transparency: The provision of detailed sources for all assumptions is critical to enabling policy-makers to understand the uncertainty intrinsic in a model.
    a. Approach: The assumptions and inputs are presented in this document.

Appendix A: Model Assumptions

Table 8. Summary of business-as-usual (BAU) and low carbon scenario assumptions modelled for the City of Orillia's Community Climate Action Plan.

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Population and Employment				
Population	Population growth according to City projections	Land Needs Assessment: Hemson Consulting Report. Prepared December 2020	Same as BAU	Land Needs Assessment: Hemson Consulting Report. Prepared December 2020
Employment	Employment growth according to City projections	Same as BAU	Same as BAU	City
Buildings				
New buildings growth				
Building growth projections	Dwelling projections according to Environics data.	Land Needs Assessment: Hemson Consulting Report. Prepared December 2020	Current approach is to maintain the current Orillia Boundary and ensure population and dwelling growth falls within it.	Same as report.
Demolition Rate	.3% of ground-based units demolished per year (may be refined)		.3% of ground-based units demolished per year (may be refined)	Conservative assumption
New buildings energy performance				
Residential	Energy performance under code improves by 10% every five years over the preceding five-year period.	Adapted from the Report by the Environmental Commissioner of Ontario. Conservation: Let's Get Serious 2015-2016. And, based on correspondence with Brendan Hayley, Policy Director at Efficiency Canada.	Progressive Green Standard, align with TGS benchmarks - Energy performance under code improves by 25% every five years over the preceding five-year period. - Solar PV is added to all new construction by 2030 (net - Zero)	Toronto: https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard Whitby: https://www.whitby.ca/en/work/whitby-green-standard.aspx
Multi-residential	No improvements to new building standards	Assume base rate of 5% improvement every 5 years		

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Commercial & Institutional	No improvements to new building standards	Assume base rate of 5% improvement every 5 years	Include rooftop PV. All new buildings are substantially more efficient and electric by 2030. Efficiency improvements are modelled as follows: 2022: NECB 2020 2024: 25% better 2026: 50% better 2030: 60% better	
Industrial	No improvements to new building standards	Assume base rate of 5% improvement every 5 years		
Existing buildings retrofitting				
Residential	Existing building stock efficiency increases at 1%/ year 2016-2050. A light renovation occurs resulting in 10% improvement of TEDI	Pembina, Pathway Study on Existing Residential Buildings in Ottawa, 2019 (at 22).	Pre-1980 Buildings 65% retrofit by 2030 85% retrofit by 2040 95% retrofit by 2050 95% of all existing buildings are retrofit by 2050	Research: - Pembina: 40-80% energy reductions involved air sealing and re-insulation, mechanical ventilation, fuel source conversions. Moderate (30-50%) reductions involving lighting retrofits, daylighting, controls, mechanical systems. Shallow retrofits (10-20%) include recomissionsing, fixture replacements, weatherization. https://www.oeb.ca/sites/default/files/2019_Achievable_Potential_Study_20191218.pdf
Multi-residential			Post 1980 Buildings 40% by 2030 65% by 2040 95% by 2050	
Commercial and institutional			Same as above (#5)	

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Industrial			Retrofit to lighting and thermal heating demand. (See Industrial process below)	
Municipal			100% retrofit by 2040, achieve 50% TEDI, 10% EUI reduction	Corporate Climate Action Plan (2021)
End use				
Space heating	Fuel shares for end use unchanged; held from 2016-2050.	Canadian Energy Systems Analysis Research. Canadian Energy System Simulator. http://www.cesarnet.ca/research/caness-model .	Generally follow retrofit schedule (existing), TGS (new construction) - retrofit activities shifts to on-demand water heating, and heat pumps for space heating (not applicable to primary industry) - heat-pumps applied to all new construction after 2025 (in-line with TGS standard) - 15% of large institutional buildings choose ground-source / geoexchange heat pumps	TAF Recommendations Report; Accelerating Heat pump adoption 2018
Water heating				
Space cooling				
Projected climate impacts				
Heating and cooling degree days	Heating Degree days are expected to decrease, and cooling degree days will increase	Climateatlas.ca - BCCAqv2 downscaled climate data from Pacific Climate Impacts Consortium	Same as BAU	
Energy Generation				
Low- or zero-carbon energy generation (community scale)				

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Rooftop Solar PV	Existing solar PV hold constant held constant	IESO active generation contract list (as of March 2020) http://www.ieso.ca/en/Power-Data/Supply-Overview/Distribution-Connected-Generation	8 MW by 2040 for Corporate Energy - Of applicable rooftops: 40% of rooftops have solar PV by 2030 75% by 2050 Solar PV accounts for 50% of building (both residential and commercial) electricity energy demand, post-fuel switching for space and water heating	
Ground mount solar	0 MW held constant	IESO active generation contract list (as of March 2020) http://www.ieso.ca/en/Power-Data/Supply-Overview/Distribution-Connected-Generation	- Investigate up to 10 MW by 2030, in-boundary - See Actions around Renewable Energy Certificates / Power Purchase Agreements (#28/#29)	
District Energy Generation	Lakehead University has Geothermal Heating System No further DE expansion	https://www.lakeheadu.ca/about/sustainability/sustainable-building/orillia	- Likely no DE Expansion recommended. Rely more on building-level heat pumps. However, a thermal energy density scan can give more insight. - 10-15% of large new buildings use ground-source heatpumps (rest can use air-source).	District Energy 101: https://www.integralgroup.com/district-energy-101/
Wind	None	IESO active generation contract list (as of March 2020) http://www.ieso.ca/en/Power-Data/Supply-Overview/Distribution-Connected-Generation	- See Actions around Renewable Energy Certificates / Power Purchase Agreements (#28/#29)	Wind generation will occur outside of Orillia
Energy Storage	None		Reduce curtailment of in-boundary generation; targets or ranges still TBD	
Transport				
Transit				

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Expanded transit	Current Stock is 14 Diesel Buses. Transit Modal Share held constant Existing transit service unchanged 2016-2050; no expansion of transit assumed 2016-2050.	2016 Data from Orillia Transit	To reflect direction from MMTP - Modehsare results (Action #15)	Lakehead University is assumed to have a U-pass system in place
Electrify transit system	No electrification anticipated		100% of rolling transit is electric by 2030	City of Halton Hills, City of Richmond Hill CEEP
Active				
Mode share	Modal Share held constant from VKT 2016 Status Quo Modeshare: Driving: 87% Other: 5% Walking: 5% Cycling: 1% Transit: 1%	Multi-Modal Transportation Master Plan (2019). City of Orillia. Retrieved from: 1_Orillia_MMTMP_20191125.pdf	Aggressive Change: Driving 66% Transit 10% Walking and cycling 10% Other 9%	Multi-Modal Transportation Master Plan (2019). City of Orillia. Retrieved from: 1_Orillia_MMTMP_20191125.pdf
Private/personal use				
Electrify municipal fleet	No change to municipal fleets.		Procurement of zero-emission vehicles after 2023	Corporate Action Plan (2021)
Electrify personal vehicles	14% new sales by 2030, then held constant	Axsen, J., Wolinetz, M. (2018). Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada. Transportation Research Part D: Transport and Environment Volume 65, Pages 596-617	80% by 2030, 100% new sales EV by 2035	Aligned with new federal target of 100% of vehcle sales to be EV by 2035 (assuming a 13-year vehicle life cycle)

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Electrify commercial vehicles	EVs make up 15% of new light duty sales, 18% medium duty sales and 1% heavy duty sales by 2030; share holds constant from 2030 to 2050.	https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/whats-sparking-electric-vehicle-adoption-in-the-truck-industry	light duty: 80% by 2030, 100% new sales EV by 2035 med duty: 80% by 2030, 100% new sales EV by 2035 heavy duty: post 2045 everything is equally shared electric/ hydrogen,	california mandate: all heavy duty electric by 2045 https://www.greencarreports.com/news/1128652_california-mandate-electric-trucks-all-ev-by-2045
Vehicle fuel efficiencies / tailpipe emission standards	CAFE Fuel standards: Vehicle fuel consumption rates reflect the implementation of the U.S. Corporate Average Fuel Economy (CAFE) Fuel Standard for Light-Duty Vehicles, and Phase 1 and Phase 2 of EPA HDV Fuel Standards for Medium- and Heavy-Duty Vehicles. ------ Light duty: 2015: 200gCO2e/km 2025: 119 gCO2e/km 2030: 105gCO2e/km Heavy Duty: 20% reduction in emissions intensity by 2025, relative to 2015, 24% reduction in emissions intensity in 2030 relative to 2015	EPA. (2012). EPA and NHTSA set standards to reduce greenhouse gases and improve fuel economy for model years 2017-2025 cars and light trucks. Retrieved from https://www3.epa.gov/otaq/climate/documents/420f12050.pdf http://www.nhtsa.gov/fuel-economy SOR/2010-201. Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations. Available from: http://laws-lois.justice.gc.ca SOR/2018-98. Regulations Amending the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations and other Regulations Made Under the Canadian Environmental Protection Act, 1999. Available from: https://pollution-waste.canada.ca	Same AS BAU, and reflects actions 17&18	

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Vehicle stock	All vehicle stock unchanged other than natural turnover. The total number of personal use and corporate vehicles is proportional to the projected number of households in the BAU.	Personal vehicle stock changes between 2016 and2050. Commercial vehicle stock unchanged between 2016 and2050. The total number of personal use and corporate vehicles is proportional to the projected number of households in the BAU.	Personal vehicle stock changes between 2016 and2050. Commercial vehicle stock unchanged between 2016 and 2050. The total number of personal use and corporate vehicles is proportional to the projected number of households in the BAU.	CANSIM and Natural Resources Canada's Demand and Policy Analysis Division.
Water and Waste				
Waste, Wastewater, and Water				
Waste generation	173 kg / person / year - no change (2020)	https://www.orillia.ca/en/living-here/resources/Environmental_Services/2020-SWM-Annual-Report.pdf	Zero Waste Programming/ Behavioural Change Program - 5% less waste per person by 2030 - 10% by 2050	
Water use reduciton	N/A		By 2050, 25% reduction in water / wastewater consumption (behaviour change, leak detection system, greywater re-use)	
Waste diversion	Baseline waste diversion rate 62% (2016), 65% (2019) Hold 2019 rate constant	https://www.orillia.ca/en/living-here/resources/Environmental_Services/2020-SWM-Annual-Report.pdf	90% Waste Diversion by 2050	

CATEGORY	BAU ASSUMPTION	SOURCE	LOW CARBON ASSUMPTION	SOURCE
Waste treatment	Waste is treated in Boundary Landfill gas capture of 75% (2016) and held constant Wastewater: Methane recovery of 32% (2016) rest of methane is flared (held constant)	Communications with City of Orillia environmental services	95% of landfill and wastewater methane is captured	
Industry and Agriculture				
Industrial efficiencies	No change.		20% improvement of industrial performance by 2050 Fuel switch remaining diesel fuel oil use to electricity	IESO: Achievable Potential Study. The report describes potential with upper and lower boundaries.
Agriculture	No change.		no major agricultural activity within Orillia	
Sequestration	Carbon Sequestration rates from 2016 and reflect community growth and rates of de-forestation		100 - 200 trees per year until 2050	Conservative assumption
Renewable Energy Procurement				
Purchases of Renewable Electricity Certificates	N/A	N/A	In 2030, The community purchases offsets to offset 100% emitting electricity sources by 2050	
Renewable Natural Gas	N/A	N/A	Starting in 2035, begin procuring RNG to offset community natural gas use. 100% by 2045	