CITY OF Thunder Bay
Superior by Nature

Climate-Forward City:

Thunder Bay Net-Zero Strategy

– Draft –

earthcare Thunder Bay

SSG

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How to Read the Net-Zero Strategy

Climate-Forward City: Thunder Bay Net-Zero Strategy is a proactive and dynamic guide for collaborative action on energy use and greenhouse gas emissions in Thunder Bay. This Strategy provides a vision for the community and highlights the scale of changes needed to respond to the climate emergency. It is not intended to be prescriptive or provide a step-by-step set of instructions. Rather, this Strategy is a living document that provides one technically feasible pathway to achieve community-wide net-zero emissions by 2050.

Responding to, and mitigating, climate change is a complex challenge. This Strategy has been developed with a recognition that our response will need to be flexible as new strategies, policies, and technologies are introduced. Some of the targets we think are impossible today may emerge as a feasible option sooner than imagined. To respond to this dynamic, the Strategy is built to be flexible and responsive to changing policies, opportunities, technologies, and needs of the community.

Throughout the Strategy, "the City of Thunder Bay," "the City," or "the Corporation of the City of Thunder Bay" refers to the municipal corporation, while "the city" (lower case "c") refers to the whole community.

Terms and Acronyms

BAP	Business-as-planned
EV	Electric vehicle
FCM	Federation of Canadian Municipalities
GHG	Greenhouse gas
IESO	Independent Electricity System Operator
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt hour
$ktCO_2e$	Kilotonnes carbon dioxide equivalent
NG	Natural Gas
NZS	Net-Zero Strategy
PJ	Petajoule
PV	Photovoltaic
RNG	Renewable natural gas
tCO_2e	Tonnes carbon dioxide equivalent
TJ	Terajoule
VKT	Vehicle kilometres travelled
WWTP	Wastewater Treatment Plant

Executive Summary

For over two decades the City of Thunder Bay has demonstrated considerable leadership in climate action and community sustainability. This Net-Zero Strategy (NZS) is a continuation of these efforts and a critical first step in Thunder Bay's response to the climate emergency declared by City Council in January 2020. It is a technically feasible, evidence-based, and community-informed pathway for the entire city to achieve net-zero greenhouse gas (GHG) emissions by 2050. The NZS presents a roadmap for the community's decarbonization and recommends a set of near-term tactics to kick-start implementation.

This is a community-based strategy. The NZS is a guide to collaborative, dynamic, and immediate action to reduce GHG emissions in Thunder Bay. The NZS articulates a net-zero vision for the community and highlights the scale of changes that are needed to respond to the climate emergency. The NZS provides one comprehensive and technically-feasible pathway to achieve community-wide net-zero GHG emissions by 2050.

Addressing energy use and GHG emissions production in Thunder Bay will require the involvement of a wide range of stakeholders including residents, businesses, not-for-profit organizations, institutions, and all levels of government.

The City of Thunder Bay, as one party amongst others, will steward the implementation of the NZS, committing to supporting and helping the community access the information and tools they need to assume collective ownership of the Strategy.

Responding to, and mitigating, climate change is a complex challenge. This Strategy has been developed with a recognition that the response will need to evolve as new strategies, policies, and technologies are introduced. Some of the targets we think are impossible today may emerge as a feasible option sooner than imagined. The NZS is therefore built to be flexible and responsive to the changing policies, opportunities, technologies, and needs of the community and stakeholders.

THE CHALLENGE

Most citizens of Thunder Bay are aware of the dangers of climate change to the natural environment, residents' well-being, livelihoods, and future generations.[1] Recognizing the need to plan for the projected impacts of a changing climate, the City developed a Climate Adaptation Strategy to address a likely much warmer Lake Superior, which will bring more extreme weather events, including hail and ice storms, rainstorms in shoulder seasons, and drought in the summer (see Part 2. The Net-Zero Context).

This strategy addresses the need to also mitigate the severity of these events by becoming a net-zero GHG city by 2050. This proposed target is aligned with the global target set by the Intergovernmental Panel on Climate Change to increase the likelihood of avoiding catastrophic climate change.[2]

[1] 95% of residents of Thunder Bay believe that our climate is changing and 86% are at least "somewhat worried" about the issue. Galway, L. P., Buse, C., Gislason, M., & Parkes, M. (2020). Perspectives on Climate Change in Thunder Bay.

[2] 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 [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

The challenge facing the city is to design the net-zero transition in a way that increases social equity and supports the local economy.

THE OPPORTUNITY

Forging a net-zero city offers many opportunities for Thunder Bay. The NZS provides an investment opportunity of $3.8 billion using present value analysis, and the returns have a present value of $4.6 billion, resulting in an overall positive financial impact on the community in the range of $900 million. Benefits go beyond the 2050 time horizon to reach a range of $1.7 billion when all investments pay off. Further increases in carbon pricing increase the positive value of the net-zero program as was announced by the federal government in January 2021.[3]

Thunder Bay has the benefit of learning from several other municipalities that have already developed pathways toward ambitious climate change mitigation. Many countries, cities, and businesses across the world are committing to net-zero by 2050 or earlier. During the development of this strategy, the Government of Canada announced a target of net-zero emissions by 2050, accompanied by supporting policies, strategies, and funding. Industries in Thunder Bay have also begun the process of ramping up their decarbonization efforts.

The move toward net-zero will require a significant upfront investment, but these investments will result in reduced operating costs for many businesses and households and provide opportunities for new and existing businesses. In particular, this strategy is dependent upon efficiency measures for buildings and vehicles, resulting in local jobs and operating cost savings that will benefit the local economy. Thunder Bay is also well-positioned for growth in the renewable energy sector, with significant opportunities to install solar and wind power.

The Net-Zero Ambition

Net-zero by 2050 means that the greenhouse gas emissions (GHGs or 'carbon') produced in Thunder Bay are equal to, or lower than, the GHGs sequestered in 2050. When emissions and sinks reach this balance, the city has effectively reached net-zero GHG emissions.

The GHG emissions that are not able to be eliminated by 2050 are termed the "carbon gap" and must be addressed in future iterations of this plan or through further efforts or new technologies for carbon sequestration.

THE TRAJECTORY

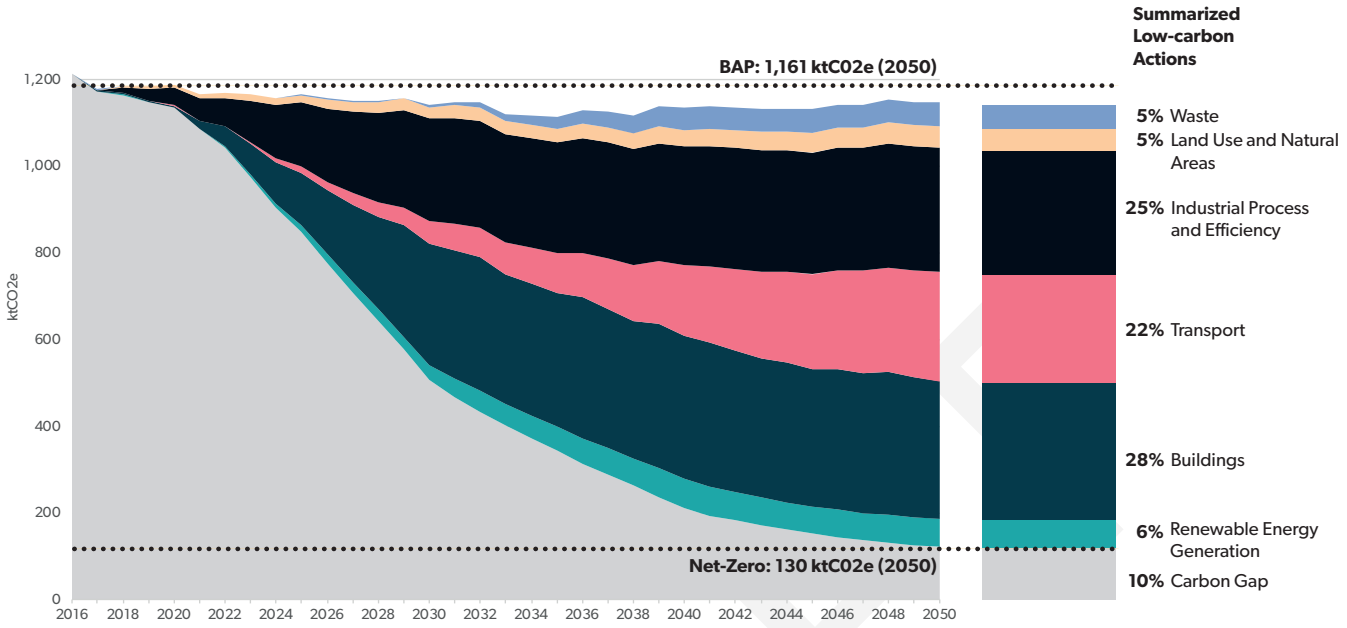
Achieving the targets in the NZS dramatically alters Thunder Bay's energy consumption and emissions compared to 2016 or a business-as-planned (BAP) future, as illustrated below. By 2050, the net-zero trajectory reduces GHG emissions by approximately 90% compared to 2016 levels. Energy consumption is also projected to decline by 57%.

This diagram illustrates emissions reductions associated with the net-zero trajectory. In 2016, Thunder Bay emitted approximately 1,200 ktCO_2e (Carbon dioxide equivalent)[4], and by 2050 the city will aim to emit 130ktCO_2e, representing the carbon gap. The emissions reduction of each action is interdependent with the other actions. Each colour in the wedge

[3] This net-present value does not include primary industry (i.e. pulp and paper)

[4] There are many different greenhouse gases. In order to measure total emissions, we convert each gas that is not carbon dioxide into a calculation of carbon dioxide equivalent (in order to compare apples to apples instead of apples to oranges).

diagram represents the impact of implementing all actions evaluated. If not all the actions are implemented, the emissions reduction effectiveness of other actions will also be impacted.



Summarized net-zero trajectory, 2016-2050

WHAT WE NEED TO ACCOMPLISH

In order to achieve net-zero emissions by 2050, Thunder Bay must reduce GHG emissions across all sectors. The following table outlines the relative contribution each of the Strategy's focus areas will contribute to achieving net-zero in 2050, along with the most significant targets that will enable these reductions. Detailed targets are available throughout the rest of the strategy.

Table 1. Focus areas, their proportion of GHG emissions reductions in 2050, and major targets that help achieve a net-zero Thunder Bay.

FOCUS AREA	PROPORTION OF GHG EMISSION REDUCTIONS IN 2050	SIGNIFICANT TARGETS
Energy efficient buildings & Low-carbon industry	28% --- 25%	100% of buildings are retrofit for energy efficiency and switch to electric heat pumps and electric water heating. Combined heat-and-power systems are switched to low carbon sources by 2040 90% or more of new buildings meet net-zero standards or equivalent by 2030 All municipal buildings are zero-emission by 2035
Low-carbon transport	22%	65% of trips within the city are done by transit, walking, and cycling by 2030 100% of vehicle sales are EVs by 2040 100% of Heavy duty commercial vehicles use low-carbon fuels by 2040 Transit is 100% electric by 2035
Renewable energy	6%	Rooftop solar is incorporated on 50% of buildings by 2050. 290 MW of ground-mount solar and 250MW of wind generated-energy are added to the grid by 2040.
Waste	5%	95% of organic waste is sent to an anaerobic digester.
Land use and natural areas	5%	90% of new development occurs inside a targeted intensification area near the central city. 100,000 trees are planted within the municipal boundary by 2050
Carbon Gap	10%	

MORE INFORMATION: TECHNICAL PAPERS, FINANCIAL PATHWAY

The NZS is supported by four ancillary reports: A financial pathway, a technical report on the business as planned (BAP) scenario, a data, methods & assumptions manual for the modelling procedure, and a technical report on renewable energy supply and constraints in the Thunder Bay region. The supplementary reports will be available alongside the NZS on the EarthCare Thunder Bay website.

Message from the Mayor

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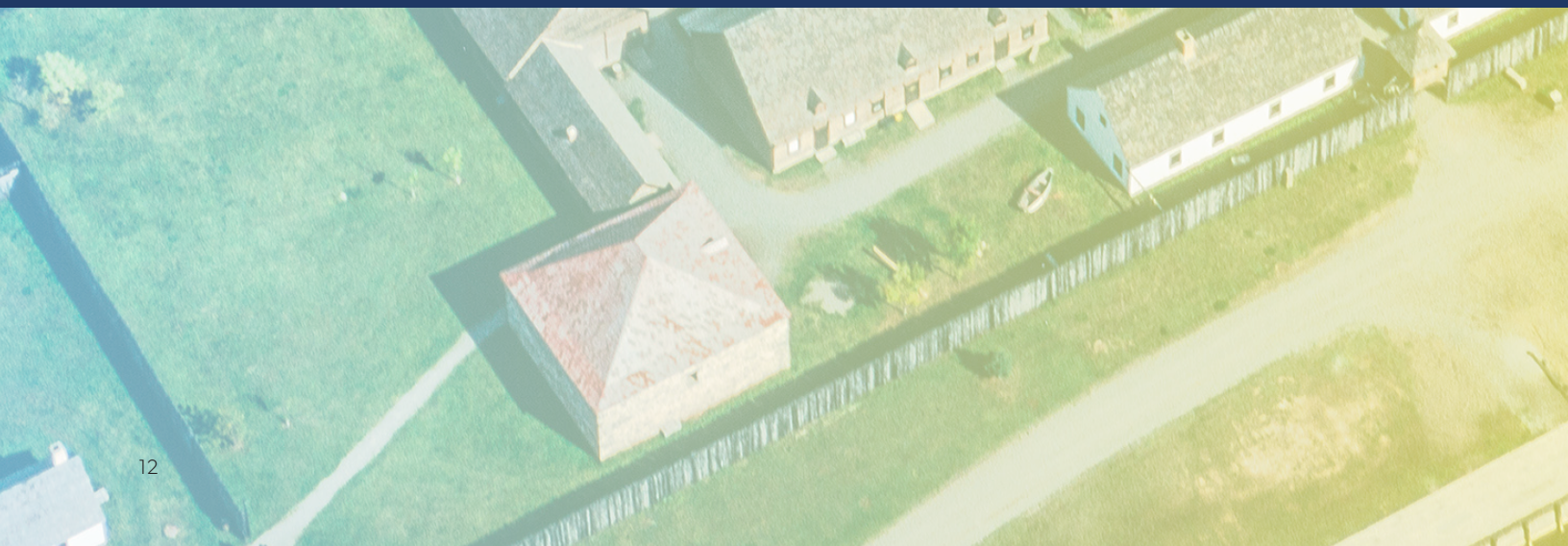

Part 1. Welcome

This document was prepared on the traditional territory of the Ojibwa Anishinabek, which includes Fort William First Nation, signatory to the Robinson-Superior Treaty of 1850, and the Métis peoples. We respectfully acknowledge these nations as the caretakers of the lands and waters on which the City of Thunder Bay is now present.

The Net-Zero Strategy lays out a pathway for Thunder Bay to improve its relationship with the land and the people with whom we share it as we work together to protect our communities from the impacts of climate change.

GENERAL ACKNOWLEDGEMENT

The City of Thunder Bay (The City) would like to acknowledge the community members, the Stakeholder Advisory Committee, the EarthCare Advisory Committee, and City staff from across the Corporation that contributed to the development of the Net-Zero Strategy. The City is grateful to all leaders and community members who have contributed their time to help build this strategy, and who have demonstrated their commitment to forging a resilient, net-zero city.

PROJECT TEAM

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IN FLANDERS
OUR DUTY DONE

Part 2: Setting the Stage

Introduction

Targeting Net-Zero GHG Emissions[5]

Net-zero by 2050 means that the greenhouse gas emissions (GHGs or 'carbon') produced in Thunder Bay are equal to, or lower than, the GHGs sequestered in 2050. When emissions and sinks reach this balance, the city has effectively reached net-zero GHG emissions.

Thunder Bay will be joining jurisdictions and cities such as Canada, the City of Toronto, City of Vancouver, City of Edmonton, the City of Montreal, and the City of Halifax. Thunder Bay will also be joining northern communities such as Kenora, Sault Ste. Marie, and Sudbury in ambitiously targeting net-zero GHG emissions.

The Net-Zero Strategy (NZS) is a response to a major challenge that represents significant opportunities for Thunder Bay. The NZS evaluates opportunities to improve energy efficiency, reduce GHG emissions, and encourage economic development. The NZS is a comprehensive, long-term plan that looks at energy use across the community, including the residential, commercial, industrial, transportation, and public sectors. The NZS identifies opportunities within these sectors and assists with articulating municipal priorities for related initiatives happening both within and outside the community.

This strategy will help our community:

- Improve energy efficiency;
- Reduce energy consumption and reduce GHG emissions;
- Study the impact of future growth on energy needs;
- Foster renewable energy production;
- Support and guide economic development; and
- Advance climate action.

The NZS is a bold plan, made with the help of many voices.

[5] This iteration of the strategy leaves a "carbon gap" of 10% GHG emissions remaining in 2050, which will need to be addressed in future iterations of this strategy through increased ambition of targets or greater efforts for carbon sequestration or the purchase of offsets.

PURPOSE STATEMENT

The purpose of this strategy is to accelerate climate innovation, action, and to set targets against which to measure progress. In some cases, the path to achieving these targets is not yet clear, but bold and ambitious targets will help galvanize and stimulate innovative and creative solutions. The community of Thunder Bay has the capacity and technology to take many of the steps needed to achieve the targets set out in this strategy.

SCOPE

Time Scale: This strategy is on a 30-year time horizon, but many initiatives must take place sooner, reflecting the urgency of action on climate change. That is why, while we are strategizing for the next 30 years (to 2050), our near-term actions focus on what can be initiated or completed in the next five years.

Geography: The geographic scope of the strategy is the municipal boundaries of the City of Thunder Bay. This includes electricity consumed in the City but generated outside of city borders. The analysis considers the wider geography scales in terms of challenges and solutions and recognizes the need to connect and align with regional and provincial partners to achieve common goals.

City Role: The Corporation of the City of Thunder Bay is directly responsible for a small share of Thunder Bay's emissions, yet plays a unique leadership role in taking climate action and organizing community efforts. The City of Thunder Bay will steward the implementation of the NZS and coordinate stakeholder groups, businesses, and funding opportunities when available. An overview of the roles and responsibilities of the City, community, and other levels of government can be found in Part 5. From Planning to Implementation.

Municipal, provincial, federal, and international policies influence future emissions within Thunder Bay. The City does not act in isolation and will need consistent provincial and federal support to help realize the net-zero vision.

The Net-Zero Context

A CHANGING CLIMATE

Increased GHG emissions, both from natural sources and human activities, will result in increased global temperatures. An increase in the annual mean temperature has already been observed in Thunder Bay and additional warming is unavoidable in this century. Over the period of 1948-2016, the annual mean temperature in Ontario increased by 1.3°C. This is projected to increase by an additional 1.5°C to 2.3°C by 2050.[6]

Rising annual global temperatures increase the likelihood of widespread local impacts and disruptions.

Thunder Bay is already experiencing the consequences of climate change through the increasing severity of precipitation, snow, ice storms, and wind events, greater temperature fluctuations and extremes, and the growing presence of vector-borne diseases.

[6] "Canada's Changing Climate Report" 2019. Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON.

Responding to the threat of climate change requires targeted efforts to reduce GHG emissions at local, provincial, national, and global levels. Recognizing the need for urgent action, the City of Thunder Bay unanimously declared a climate emergency on January 13, 2020, deepening its commitment to preventing climate change. The NZS describes a path to respond to the climate emergency while building on the City's other sustainability commitments.

ECONOMIC AND SOCIAL CONTEXT

The economic and social context for climate action has changed in important ways since Thunder Bay declared a climate emergency in January of 2020:

- The COVID-19 pandemic and measures taken in response to it have sharply changed the economic backdrop in Thunder Bay and globally. In Canada, companies started considering mass-layoffs of workers, which was largely prevented by the "Canada Emergency Wage Subsidy". Despite efforts from the government, the country's unemployment rate was 13.5% in May 2020, the highest since 1976.[7] Gross Domestic Product (GDP) is one key indicator of financial performance; Canada's GDP fell by nearly 16% in April 2020 compared to previous year levels.[8] Business activity generally dropped amid concerns over maintaining operations with reduced revenue, and non-residential construction investment declined. Although these trends are slowly improving, COVID-19 continues to have a significant impact on individuals, organizations, and businesses in Thunder Bay.
- Global net-zero commitments by countries and businesses were announced with increased frequency in 2020.[9] Widespread momentum towards climate action benefits Thunder Bay by incentivizing the City to act and be a leader. Global commitments show that investments are trending towards low-carbon technologies including renewable energy generation, zero waste, electric vehicles, and zero-carbon buildings. Business models that are incompatible with net-zero targets are losing appeal with investors.[10]
- Costs of key low-carbon technologies have continued to fall. For example, the average price for lithium-ion battery packs for vehicles has fallen 89% in 10 years according to Bloomberg Finance, moving quickly to price parity with fossil fuel-powered vehicles.[11] This could have a real effect on Thunder Bay's largest emitting sector, transportation, as it eases the transition to electric buses, corporate and industrial fleets, and private vehicles. The effect of cost decreases is also being replicated in other areas of low-carbon technology, notably local renewable energy generation and battery storage.

[7] "Unemployment Statistics" May 2020. Statistics Canada. Retrieved from: www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410028703&pickMembers%5B0%5D=3.1&pickMembers%5B1%5D=4.1&cubeTimeFrame.startMonth=05&cubeTimeFrame.startYear=2020&referencePeriods=20200501%2C20200501.

[8] "Canadian Economic Dashboard and COVID-19" n.d. Statistics Canada. Retrieved from: www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2020009-eng.htm.

[9] "Commitments to net-zero double within a year" 2020. UNFCC. Retrieved from: Commitments to Net Zero Double in Less Than a Year | UNFCCC

[10] "Net-zero: a fiduciary approach" 2021. BlackRock. Retrieved from: https://www.blackrock.com/corporate/investor-relations/blackrock-client-letter.

[11] "Battery Pack Prices Cited Below $100/kWh for the First Time in 2020, While Market Average Sits at $137/kWh. "2020. Bloomberg NEF. Retrieved from: Battery Pack Prices Cited Below $100/kWh for the First Time in 2020, While Market Average Sits at $137/kWh | BloombergNEF (bnef.com)

THE CO-BENEFITS OF DECARBONIZATION

Figure 1. Thunder Bay residents are able to walk freely and enjoy a summer afternoon when more public space is offered to them.

Beyond the reduction in greenhouse gases and direct financial and employment impacts that are outlined in this report, there are many other "co-benefits" which the NZS presents for the businesses and residents of Thunder Bay, namely: improvements in public health and social well-being. Depending on the manner in which the NZS is implemented, it also presents an important opportunity to redress social inequities.

In terms of public health and social wellbeing, the transportation sector's shift provides some great examples. Reducing the amount of combustion engine emissions in the community will significantly improve local air quality and associated illnesses. The reduction in engine-related noise will also help reduce stress. Increasing active transportation infrastructure will support improved public health due to increased physical activity, it will also increase community interactions which can support a sense of social wellbeing.

In terms of improving social equity, this can be achieved if NZS programs are designed to support vulnerable community members; for example, a retrofit program tailored for low-income residents living in inefficient older buildings can help improve their comfort and reduce instances of energy poverty, freeing up resident income for other life necessities. Improved and accessible transit and active transportation infrastructure and programs can help low-income, senior, and differently-abled residents to have access to these options and their associated health and economic benefits.

Finally, the many new potential jobs that may be developed due to NZS implementation can be targeted at members of the community that have been historically underemployed through subsidized training or retraining programs.

Co-benefits

The number of co-benefits and the extent to which they can be attained will vary from community to community, but increasing studies show they are numerous. The figure below was developed by The Lancet and University College London Institute for Global Health Commission. Some dimensions of climate planning weren't explored in the NZS such as nuclear energy or ocean carbon sequestration, but increased energy efficiency, renewable energy, and low carbon transportation all have environmental, health, and social benefits.

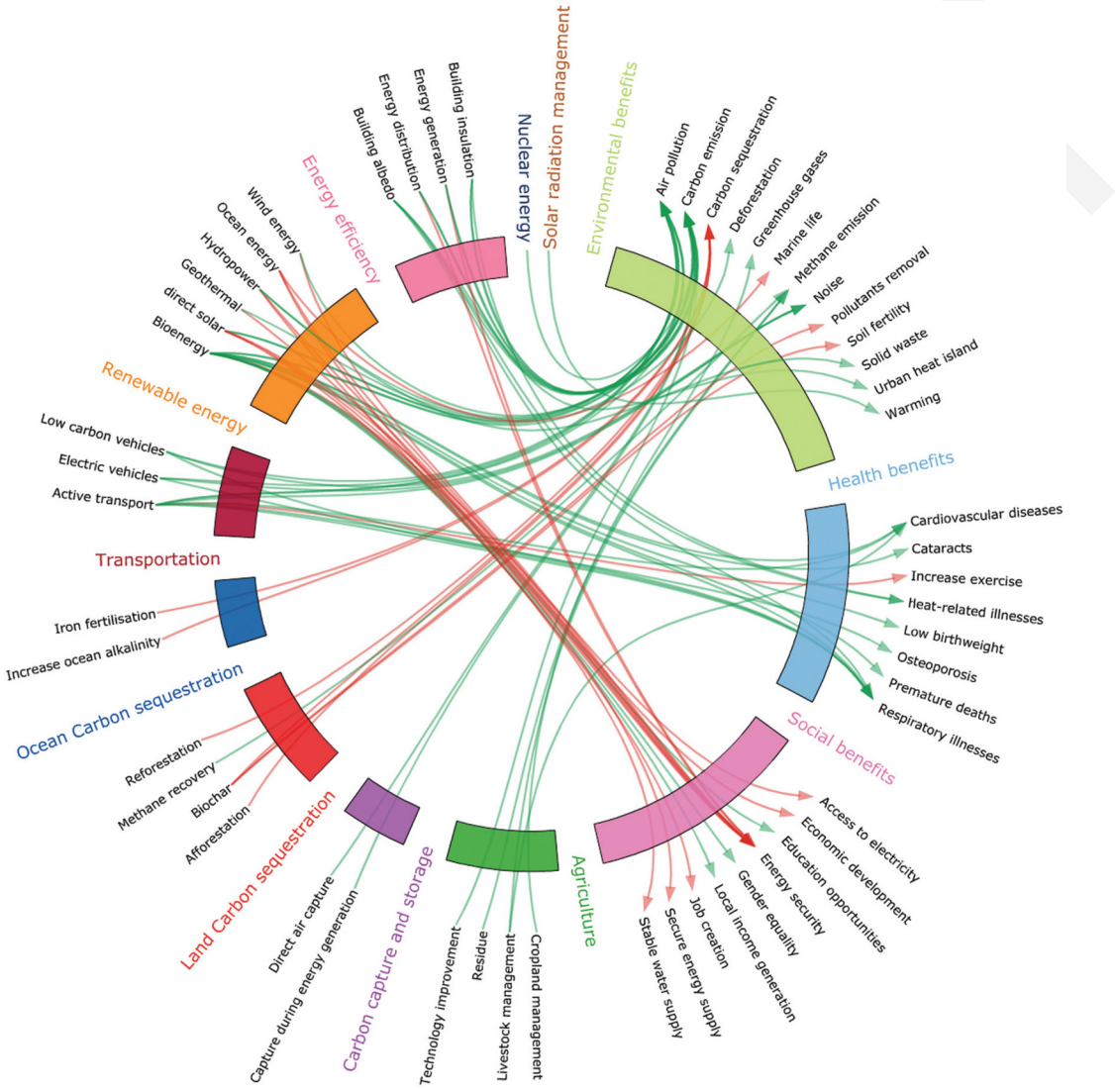


Figure 2. Illustration of co-benefits of climate change mitigation techniques[12]

[12] The Lancet Commissions. (2015). Health and climate change: policy responses to protect public health. Retrieved from http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(09)60935-1.pdf

Thunder Bay Policy Precedents

For over two decades the City of Thunder Bay has demonstrated considerable leadership in climate action and community sustainability. The NZS notably builds on six years of implementation of the EarthCare Sustainability Plan (2014-2020) and provides a renewed focus on the community-wide efforts required to reduce energy consumption and GHG emissions in Thunder Bay.

The NZS also provides one potential pathway to respond to the climate emergency while directly supporting the fifth goal under the Lead pillar of the City of Thunder Bay's Corporate 2019-2022 Strategic Plan to "Further [previous] commitments to sustainability and climate adaptation."[13]

THE CLIMATE ADAPTATION STRATEGY (2015)

Together, the Climate Adaptation Strategy and the NZS form a robust climate action plan and respond to the City's climate emergency declaration by accelerating efforts to mitigate and adapt to climate change. The Climate Adaptation Strategy recognizes that the local natural environment, economy, and overall well-being of citizens are at risk from climate change. Forty-five potential adaptation strategies are identified to make the city "climate-ready." Highlighted actions that relate to the NZS include:

- Evaluate existing projects that address climate change impacts to identify opportunities for accelerated implementation.
- Assess and prioritize actions from the Urban Forest Management Plan using a climate change lens on an annual basis.
- Identify new and existing best management practices for land-use planning and design which address climate change impacts to the community, and review annually.
- Identify and implement incentives to promote the adoption of green infrastructure on private, commercial, and institutional properties.

Other Significant Policy Precedents

- **1997:** The City signs on to join FCM's '20% Club' thereby committing to reducing corporate and community emissions by 20% of 1990 levels within 10 years of joining.
- **2003:** The City joins the Partners for Climate Protection (PCP) program, a joint milestone-based initiative between FCM and ICLEI Governments for Local Sustainability to support community GHG reduction
- **2004:** City Council unanimously passes a resolution to support the creation of the City's first Community Environmental Action Plan (CEAP). The Thunder Bay Zero Waste Action Team (ZWAT) and community partners establish a CEAP Steering Committee.
- **2005:** EarthWise Thunder Bay (now EarthCare) is created to facilitate the creation and implementation of the CEAP. The City hires the first EarthWise Thunder Bay Coordinator (Sustainability Coordinator).
- **2007:** GHG Inventories are developed for the City of Thunder Bay and the community.
- **2008:** The City adopts its first CEAP, committing to a Corporate GHG reduction target

[13] "One City, Growing Together" (2019). City of Thunder Bay. Retrieved from: https://www.thunderbay.ca/en/city-hall/strategic-plan.aspx.

of 35% below 2005 levels by 2017 and community GHG reduction target of 10% below 2005 levels by 2017.

- **2009:** Baseline year for GHG and energy reduction targets in the EarthCare Sustainability Plan.
- **2010:** The City establishes an Energy Management Committee for the Corporation.
- **2011:** The City adopts the 2011-2014 Strategic Plan, with strategic goals to implement the CEAP and reduce GHG emissions. The City adopts the Urban Forestry Management Plan and develops its first Corporate Energy Management Plan.
- **2012:** The City establishes a Corporate Green Team.
- **2013:** EarthWise is rebranded to EarthCare Thunder Bay.
- **2014:** The EarthCare Sustainability Plan (2014-2020) is adopted, replacing the CEAP and previous GHG reduction target, committing to a Corporate and community GHG reduction target of 20% below 2009 levels by 2020. The Corporate Energy Management Plan is updated. The City adopts the Solid Waste Management Strategy.
- **2015:** The City adopts Climate-Ready City: City of Thunder Bay Climate Adaptation Strategy.
- **2016:** The Corporation of the City of Thunder Bay exceeds its emissions reduction target at 24% below 2009 levels. The City adopts the Thunder Bay Stormwater Management Plan.
- **2019:** The City adopts a new Official Plan that includes goals to mitigate climate change and reduce GHG emissions. The City adopts a new Transportation Master Plan that includes recommendations to support climate change mitigation and adaptation. The City approves the Corporate Energy Management Plan (2019-2024) with a target of 2-5% reduction in energy consumption per year. The City adopts a new Strategic Asset Management Policy that includes consideration of the social, economic, and environmental risks and vulnerabilities of municipal infrastructure assets including risks relating to climate change and the actions that may be required.
- **2020:** The City declares a climate emergency.

A Plan Built by Many Voices

The NZS was developed with critical input from a committed and informed multi-stakeholder advisory group, staff from across the City, and members of the broader community. Due to Covid-19, all project-related engagement had to be redesigned in March, 2020 to become 100% virtual.

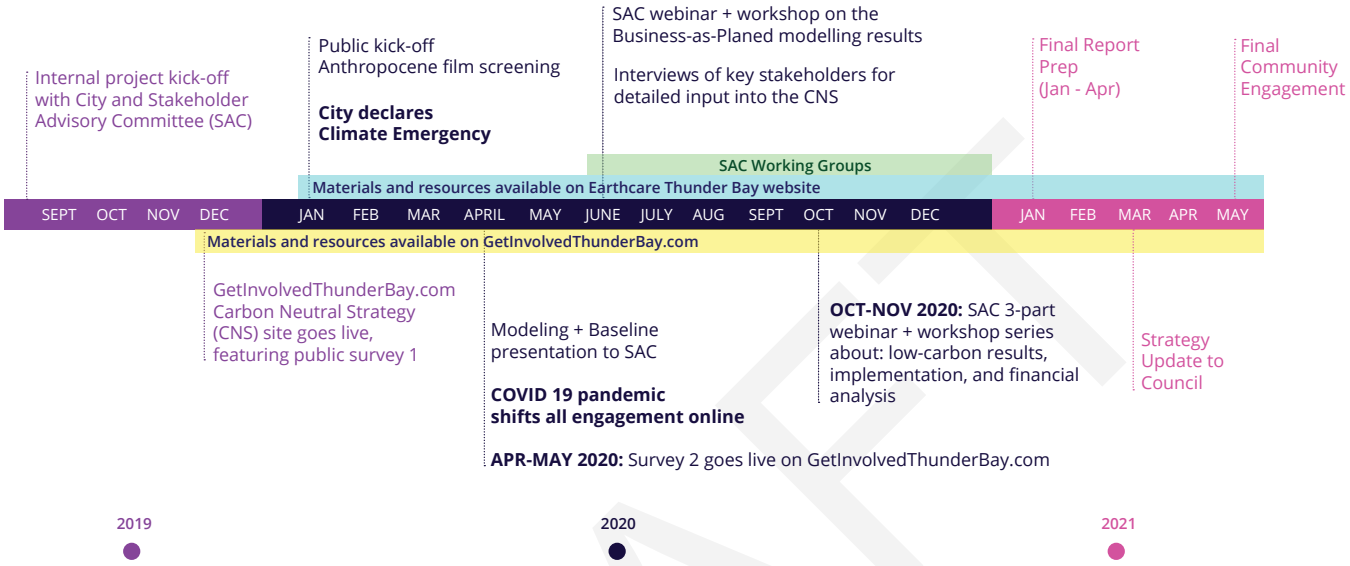


Figure 3. Project timeline.

STAKEHOLDER ENGAGEMENT

A Stakeholder Advisory Committee (SAC) was formed at the outset of the NZS development, with representation from across City departments, public institutions, utilities, industry, businesses, environmental groups, and First Nations partners, amongst others. The SAC's mandate was to inform the development of the plan and ensure it reflects the range of community interests.

A list of contributing organizations is provided in Appendix A.

The SAC met six times between September 2019 and November 2020; these meetings were supported with seven one-on-one interviews with key stakeholders. These meetings informed stakeholders on the state of the project and received input on project aspects including the baseline, business-as-planned, and net-zero scenario results, the financial analysis results and the near-term implementation strategy and monitoring program.

The EarthCare Advisory Committee was also consulted on the implementation framework included in the NZS and was provided with regular updates on the development of the Strategy.

Participants helped define the low-carbon actions included in the NZS and the actions prioritized in the recommended near-term tactics (see Part 3. From Business-as-Planned to Net-Zero), as well as identifying associated community partners.

COMMUNITY ENGAGEMENT

Soon after the project kick-off in September 2019, the City launched a project website to inform the public about the project, project timelines, and opportunities for engagement.

The website hosted two surveys over the course of the project. The first survey received 80 responses to determine the level of ambition of the community to take climate action and generally their views on climate change. In response, the vast majority of respondents felt Thunder Bay should make mitigating climate change a top priority in the city due to potential impacts on future generations; this supports the findings of a more robust study undertaken by Dr. Lindsay Galway at Lakehead University.[14]

The first phase of surveying also provided insights on opportunities and challenges as described below

Significant challenges in climate change mitigation include:

- 50% indicated that Thunder Bay's reliance on personal vehicles and the sprawling urban pattern presents a challenge to increase transit use and walking/cycling
- Obtaining widespread public support for meaningful climate action; and,
- Lack of information and availability of public education

Opportunities for this strategy include:

- The opportunity to expand Thunder Bay's economy. Several respondents said climate action could provide an opportunity to build green infrastructure and create jobs in green industries.
- Renewable Energy expansion, for example, could create jobs and reduce energy costs.
- An opportunity to reinvent Thunder Bay and build a reputation for sustainable, climate-friendly development in the northern context.
- Abundance of open space allows for more opportunities for a better cycling and walking network.
- Strong community spirit and a desire to be a leader in sustainability can push Thunder Bay to the net-zero target.

[14] Read more about Climate Change Communications Strategies here: Home - Climate Change Thunder Bay Connection (climatechangetbay.com).

Physical copies of the first survey were also provided at the project's signature kick-off event: a film screening of the award winning Anthropocene, which visually chronicles the current era of human devastation of the global environment. This January 2020 event was sold out and featured key speakers from the community, including a youth climate activist and the Mayor, who helped to introduce the project.

The second survey had 134 participants and helped to provide a sense of the community's top four priorities they would like to see reflected in the NZS. They were:

1. Reducing the most GHG emissions;
2. Lifestyle, health, and well-being impacts;
3. Creating jobs and local economic activity; and
4. Fair and unbiased actions.

Finally, EarthCare Thunder Bay's broader network was kept up-to-date and advised on opportunities to provide input into the project via the monthly EarthCare Newsletter.[15]

[15] EarthCare Thunder Bay is a partnership between the City and the community to work on issues of community sustainability, climate adaptation, and greenhouse gas reduction. The EarthCare network includes an Advisory Committee of Council, five active working groups, and associated community partners.

Part 3. From Business-as-Planned to Net-Zero

In a Climate Emergency, Every Moment is Critical

In 2016, Thunder Bay emitted approximately 1,200 $ktCO_2e$ (one-million, two-hundred thousand tonnes of carbon dioxide equivalent). Modelling results indicate that if no additional policies, actions, or strategies to address energy and emissions are implemented other than those currently underway or planned, this total decreases slightly to 1,160 $ktCO_2e$ by 2050. The decrease results from better fuel efficiency standards in vehicles in the future, some building renovations occurring, and reduced heating needs as the climate warms.

Thunder Bay has declared a climate emergency and has recognized that "Business as Planned'' isn't enough to avoid the catastrophic effects of climate change. The Net-Zero Strategy (NZS) is a response to the City's climate emergency declaration; it sets the pathway for an aspirational future in which Thunder Bay achieves net-zero greenhouse gas emissions —or reduces approximately 90% of GHG emissions from 2016 levels—by 2050. This strategy details one pathway to achieve this vision and will demonstrate Thunder Bay's climate leadership in developing a sustainable economy and community.

To better understand the scale of the ambition, removing 1,000 $ktCO_2e$ (or 1 $MtCO_2e$) is equivalent to removing emissions from 216,000 cars driven for an entire year, or planting a forest that is 1.3 million acres...10 times the size of Thunder Bay![16]

Further Reading:

The Business-as-Planned Scenario Summary. Available on EarthCare Thunder Bay. https://www.thunderbay.ca/en/city-hall/resources/Documents/EarthCare/Baseline-Business-As-Planned-Scenario_2016-2050.pdf

[16] The United States Environmental Protection Agency, 2020. Greenhouse Gas Equivalencies Calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Strategy Paradigm: Reduce-Improve-Switch

At the heart of the NZS are a series of high-impact energy actions that have been carefully reviewed and analyzed by the consulting team, City staff, and stakeholders. The objective was to identify all possible options first and then eliminate those options with unacceptable environmental impacts, significant economic or technical challenges, and/or little energy/emissions benefit. Ultimately, 31 sectoral targets grouped into five focus areas are modelled for the final net-zero pathway[17]:

A. **Land Use and Natural Areas**

B. **Energy Efficiency in Buildings and Industry**

C. **Renewable Energy Generation and Procurement**

D. **Transport**

E. **Water and Waste**

The analysis orders the actions according to a philosophy of 'Reduce, Improve, Switch'. Avoiding energy consumption is the top priority, followed by maximizing energy efficiency improvements, and finally by switching to low-carbon energy sources for the remaining demand. The strategy also prioritizes improvements to long-lasting infrastructure that can 'lock in' energy consumption patterns for many decades and takes advantage of opportunities to align proposed investments with the natural turnover of infrastructure and buildings.

The remainder of Part 3 follows the paradigm by laying out the pathway to net-zero emissions and illustrating the dependence of one target/action upon the next. The remainder details the focus areas and targets that must be reached in order to achieve net-zero emissions.

The Net-Zero Pathway

By 2050, the net-zero pathway, as modelled, reduces GHG emissions by approximately 90% compared to 2016 levels; Energy consumption also declines by 57%. The summary "wedges diagram" below (Figure 5) illustrates that the emissions reduction of each action is interdependent with the other actions. The wedge diagram shows the impact of implementing all actions evaluated. If all the actions are not implemented, the emissions reduction effectiveness of other actions will also be impacted. The diagram also shows that electric vehicles, shifts in industry, residential and non-residential retrofits will account for 50% of the GHG reductions in the NZS.

[17] The Net-Zero Pathway was developed using CityInSight, an integrated energy, emissions and finance model developed by Sustainability Solutions Group and whatIf? Technologies.It is an integrated, multi-fuel, multi-sector, spatially-disaggregated energy systems, emissions, and finance model for cities.

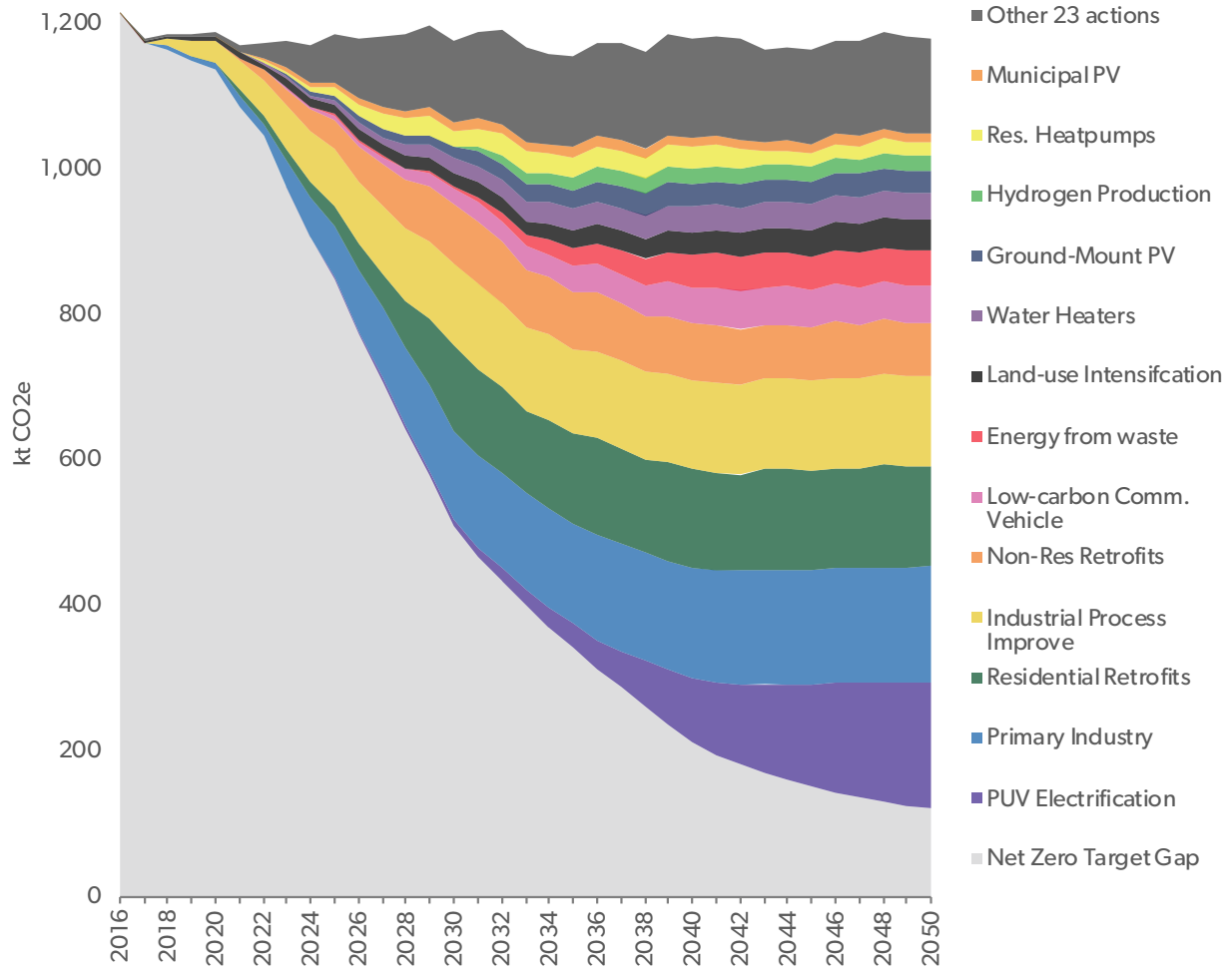


Figure 4. Wedge diagram illustrating emissions reductions associated with the net-zero trajectory.

Further Reading:

Appendix B: 'Detailed Sectoral Targets and GHG reductions in the Net-Zero Strategy'

Appendix C: 'The Net-Zero Strategy Energy and GHG Emissions Transition: Additional Technical Analysis'.

NZS STRATEGY FRAMEWORK

The NZS is summarized in this section according to the following framework:

- **Community Vision:** To achieve net-zero GHG emissions by 2050. The vision is also the most important response to the City's climate emergency declaration.
- **Focus Areas:** These outline the sectors and categories in Thunder Bay where climate change interventions need to occur (i.e. land use, buildings, transportation, industry, and waste).
- **Objectives:** The overall community based objective for the respective focus area.
- **Sector-Specific Targets:** Within each focus area, there are strategic outcomes required to achieve net-zero emissions (i.e. 100% emissions-free transit).
- **Recommended Near-Term Tactics (2021-2025):** These are recommended near-term tactics, or strategies, for the City and community to explore to kick-start action in Thunder Bay. They reflect community input as well as necessary actions to enable net-zero emissions by 2050.[18]

FOCUS AREA: LAND USE AND NATURAL AREAS

Table 2. Land use and natural areas, targets, and priority actions.

Objective 1: Neighbourhoods are complete, compact, and walkable.

Objective 2: Thunder Bay's forests and greenspaces are protected and provide essential ecosystem services.

Land-use targets

1. 90% of development occurs within the targeted intensification zone (See Appendix C, Figure 25)
2. Houses in 2050 are 30% smaller than the 2016 average (168 m^2).
3. Starting in 2022, single detached homes represent 20% or less of new construction.

Natural Areas Sectoral Targets

1. 100,000 additional trees are planted in the city's boundary by 2050
2. Carbon sequestration is increased by limiting greenfield development (compliment of target #1)

[18] These priorities were identified in the phase 2 community crowdsourcing survey. See the data on www.GetInvolvedThunderBay.ca.

Objective 1: Neighbourhoods are complete, compact, and walkable.

Objective 2: Thunder Bay's forests and greenspaces are protected and provide essential ecosystem services.

Recommended Near-Term Tactics*

- Update municipal land use policies to enable increased mode shifts to transit, walking, and cycling.
- Update/use zoning regulations to facilitate local renewable energy generation in appropriate locations.
- Leverage Canada's commitment to investing in tree-planting initiatives to reduce costs associated with community greening.
- Explore opportunities for enhanced carbon sequestration on city-owned and private land.

* Specific near-term actions for the Corporation are provided in Appendix D.

Compact Land Use

Land-use policies are a powerful tool for reducing GHG emissions, as they lock in reductions over the long term. For instance, a policy that promotes densification in the short term will have a direct impact on transportation over the long term. Dependence on private vehicles decreases in densely populated areas, while transit becomes more viable and active transportation modes such as walking, and biking become preferred.

Aligned with densification is the replacement of older, less efficient buildings with more efficient buildings in intensification zones. An assumption of approximately a 7% replacement rate was used in modelling. This results in an overall improvement in the energy efficiency of the building stock when new buildings are completed.

Smaller dwellings and shared walls increase the efficiency of the dwelling stock. Less energy is required to heat or cool with the reduced total volume and surface area that loses energy to the environment.

The City of Thunder Bay's Official Plan, approved in 2019, was developed using four overarching approaches – environmental sustainability, climate adaptation, economic diversification, and healthy community principles – and includes the following goals that align with the NZS:[19]

- Protect, preserve and enhance the quality of the natural environment and mitigate climate change;
- Promote the growth of emerging economic sectors, new businesses and employment opportunities at appropriate locations, and encourage the strengthening of existing business functions;
- Support initiatives with an environment first approach that maximizes the connectivity between neighbourhoods, land uses, and green spaces;
- Promote energy conservation and efficiency, and support the creation of energy through

[19] The City of Thunder Bay. 2019. Official Plan. Retrieved from: https://www.thunderbay.ca/en/business/resources/Documents/Building-and-Planning/Official-Plan/Official-Plan-2019---Text.pdf

renewable and alternative sources;

- Reduce greenhouse gas emissions; and,
- Promote a cost-effective, reliable, accessible, and integrated multi-modal transportation system.

Natural Areas

Concentrating development in a smaller area leaves more space for natural habitat and carbon sequestration. This includes open lands, grasslands, and forested areas.

The NZS targets an additional 100,000 trees in Thunder Bay's boundary by 2050. The Federal government plans to plant 2 billion trees across the country and has allocated $3.15 billion to achieve this goal.[20]

FOCUS AREA: ENERGY EFFICIENT BUILDINGS AND INDUSTRY

Table 3. Building sector targets and priority actions.

Objective 3: New buildings are net-zero ready.
Objectives 4-6: Existing residential, commercial, municipal, and industrial buildings are retrofit to achieve deep energy savings and reduced emissions.
Building Sector Targets*
1. Starting in 2022 new dwellings are increasingly efficient. By 2030, 90% of new construction meets net-zero standards.
2. Starting in 2022, new commercial buildings are increasingly efficient, aligning with the GHG intensities identified in the Toronto Green Standard.
3. 100% of dwellings built before 1980 are retrofitted by 2030; 100% of dwellings built after 1980 are retrofitted by 2040.
4. 80% of all commercial buildings are retrofitted by 2030.
5. 100% of all municipal buildings, old and new, are net-zero by 2035

[20] Canada Tree Planting Program. n.d. Government of Canada. Retrieved from: www.canada.ca/en/campaign/2-billion-trees.html.

Objective 3: New buildings are net-zero ready.

Objectives 4-6: Existing residential, commercial, municipal, and industrial buildings are retrofit to achieve deep energy savings and reduced emissions.

Recommended Near-Term Tactics**

- Develop green building standards that enable and incentivize net-zero construction and renovation in the community.
- Develop strategies that enable and encourage rooftop solar PV installations.
- Develop a residential retrofit program to reduce barriers for homeowners.
- Explore initiatives that assist business owners in undertaking commercial retrofit projects.
- Create an online hub of resources for homeowners and businesses interested in undertaking retrofit projects.
- Promote and support low-carbon building initiatives that utilize local, renewable resources.
- Support local colleges and trade organizations to ensure local skilled labour is being trained, or retrained, in smart, green, and resilient design and construction.

* New buildings and retrofit activities switch space-heating and water-heating from fossil fuels to electricity-based and other low-carbon sources.

** Specific near-term actions for the Corporation are provided in Appendix D.

In 2016, buildings (residential, commercial, and industrial) and industrial processes represented nearly 50% of Thunder Bay's community GHG emissions. The actions in this section detail the interventions needed to increase the efficiency of the building stock and fuel switch away from fossil fuels.

New Buildings

The NZS envisions an incremental transition to high-performance, net-zero energy new construction by 2030. Net-zero buildings are super-insulated, have efficient HVAC systems, and take advantage of passive solar heating, ambient heat sources (e.g. air source heat pumps), and thermal mass. More high-performance buildings completed sooner means fewer retrofits later on. The National Building Code update is expected to include provisions for a national energy step code that is aligned with the NZS.

Electric Heat Pumps: Efficient Electric Heating and Cooling

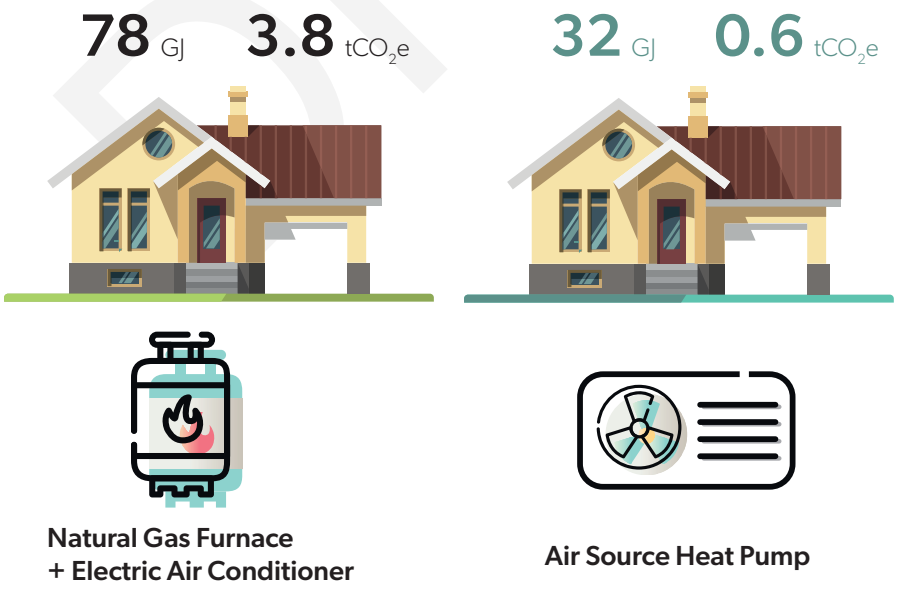
Currently, the primary energy source for space and water heating in Thunder Bay is a fossil fuel: natural gas. As a result, space heating is the most carbon intense activity in the buildings sector. To achieve net-zero emissions by 2050 a significant amount of space and water heating will need to be switched to other sources of renewable energy. Electric heat pumps (air source or ground source) are primed to lead this transition.

With the help of electrical power, heat pumps leverage the outside or underground ambient temperature to balance indoor air or water temperature. As a result, a typical heat pump is more than twice as efficient as the most efficient natural gas furnace.

Air source heat pumps were once considered impractical for northern climates due to their inefficiency in very cold weather; however, technological improvements in recent years have changed this. They will need to be paired with energy-efficient homes to perform at their peak.

Though heat pumps are still more expensive to buy than a gas furnace, heat pumps typically more than pay for themselves over their lifetime as a result of reduced energy use. When powered by emissions-free electricity, heat pumps represent a technically feasible pathway for decarbonizing buildings.

One year of home heating and cooling for the average Thunder Bay household.



Existing Buildings

Improving energy performance in existing buildings is a greater challenge given that the building design is already 'locked in'. Up-front costs of deep retrofits can be high, but this investment can be recovered over time through avoided energy costs. As illustrated in Figure 6, deep retrofits usually include upgrades to the building envelope, windows, doors, and heating and cooling systems. Reliable project financing can enable large energy efficiency investments in homes, commercial properties, and municipal/institutional buildings.

The NZS envisions building retrofits in all sectors, achieving an average of 50% electrical and thermal energy savings by 2050, without prescribing specific strategies for achieving this outcome.

The municipality will strive to retrofit most of its existing buildings by 2035, thus reducing the City's energy consumption by half.

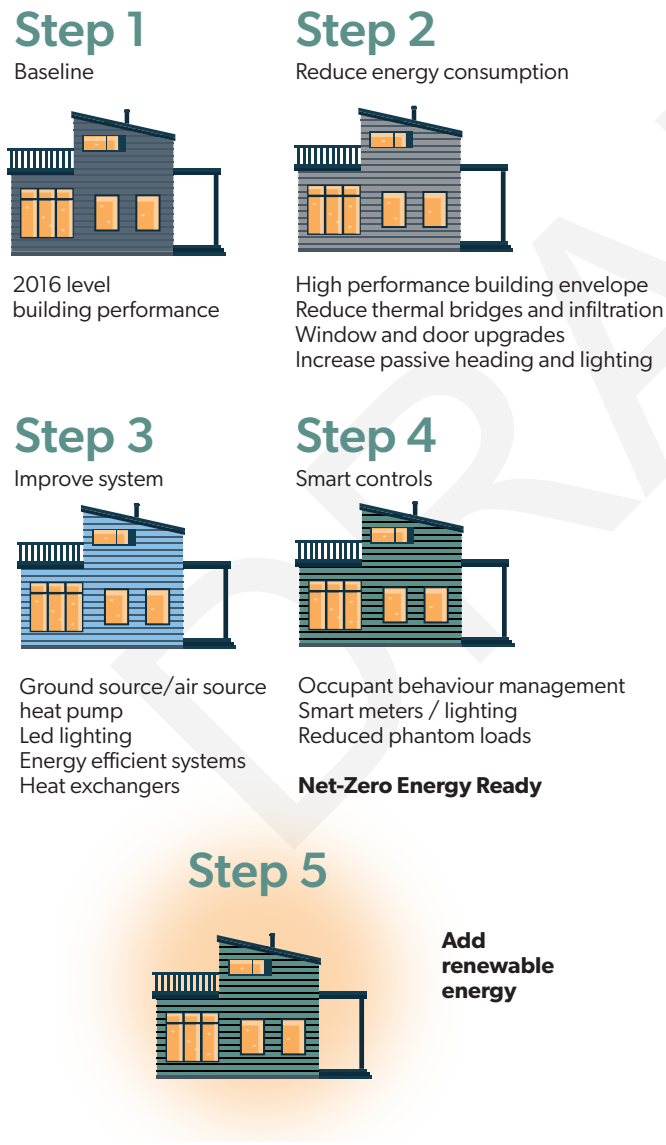


Figure 5. Achieving net-zero energy and GHG emissions buildings through efficiency measures, fuel switching, and renewable energy.

Table 4. Low-carbon industry targets and priority actions.

Objective 7: Industrial processes are increasingly efficient.

Objective 8: Combined heat-and-power systems are fueled by low carbon sources.

Industry Sector Targets

1. 84% of all industrial buildings are retrofitted by 2030.
2. Industrial process efficiency is increased by 50% by 2050.
3. The capacity factor of biomass systems in the industrial process is increased by 10% by 2030, using sustainable biomass feedstock.
4. Natural gas in industrial/institutional combined-heat-and-power systems is fuel switched to low-carbon sources.

Recommended Near-Term Tactics*

- Establish an industrial energy efficiency and decarbonization working group to develop a sector-specific implementation strategy, collaborate on low-carbon initiatives, and share best practices.
- Identify new and existing incentives for deep energy efficiency improvements in the industrial sector.
- Advocate for funding to switch natural gas for renewable natural gas and other renewable energy sources in combined heat and power engines. Incrementally begin transition during the 5-year period.
- Leverage Canada's commitments to Building Canada's Clean Industrial Advantage to improve industrial efficiency and reduce costs.

* Specific near-term actions for the Corporation are provided in Appendix D.

Low-Carbon Industry

Industry was responsible for 21% of the GHG emissions in Thunder Bay in 2016. Retrofits in industrial buildings will reduce both electricity and thermal energy consumption by 50% by 2050, including the installation of heat pumps for space heating and on-demand water heaters.

The NZS envisions heat demand for processes decreasing by 50% and the capacity factor of the existing combined-heat-and-power (CHP) system increasing by 10%.[21] Renewable natural gas (RNG) and hydrogen are also used in the industrial sector (further discussions of these two sources are in the Focus Area: Renewable Energy).

Industrial emissions are regulated by the provincial and federal governments and are not easily influenced by municipalities. Reducing industrial emissions will require support from other levels of government and industrial partners. The Government of Canada's strengthened climate plan, A Healthy Environment and a Healthy Economy, outlines many commitments to "[build] Canada's clean industrial advantage" that align with the NZS vision.[22]

[21] Capacity factor refers to the ability of an energy production facility, in this case a combined heat and power plant to run to its full extent.

[22] "A Healthy Environment and A Healthy Economy" (2020). Government of Canada. Retrieved from: https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf.

District Energy: Part of the Net-Zero Solution

District energy systems are energy systems that supply power via underground pipes to multiple buildings or facilities. These are local energy generation and distribution solutions, which means local control of the energy supply. Because of the scale of these systems, they can also potentially lower the costs businesses and residents have to pay to access renewable energy. As a result, the decarbonization and expansion of existing, as well as the development of new district energy systems, can be an important part of a community's net-zero pathway.
Thunder Bay has made use of this technology at several locations across the city where natural gas is often the primary fuel source, including:

- Resolute Forest Products (biomass + natural gas-based),
- Canada Malting (natural gas-based),
- Thunder Bay Regional Health Sciences Centre (natural gas-based),
- City of Thunder Bay Water Pollution Control Plant (renewable natural gas/biogas based), and
- City of Thunder Bay Solid Waste & Recycling Facility (renewable natural gas/ biogas based).

The decarbonization and expansion of these systems are critical steps in the NZS. In terms of building new district energy systems, the city was assessed for areas that met the best practice energy density requirements. District energy systems are most cost-effective when they serve energy-dense areas. A preliminary rule is that areas with an energy density of greater than 150 megajoules per square metre are viable sites for district energy. Typically, this defines a neighbourhood that includes large buildings with multiple uses, high residential density and compact neighbourhoods.[23]

As the city is not projecting significant growth out to 2050, new district energy was considered an uneconomical solution. Improved efficiency combined with electric heat pumps was selected as the more economical solution.
Investment costs are high, so it takes a high-density neighbourhood to justify the cost; low-rise residential is not feasible, and in a post-retrofit world, the feasibility is lower still.

Further Resources: District Energy Planning, Seven Steps to Success. Retrieved from: District Energy 101: 7 Steps to Success - Integral Group

[23] (Moller, B., & Werner, S. (2016). Quantifying the Potential for District Heating and Cooling in EU Member States).

FOCUS AREA: RENEWABLE ENERGY GENERATION AND PROCUREMENT

Table 5. Renewable energy targets and priority actions.

Objective 9: Rooftop solar PV is deployed to assist with meeting building electricity needs.

Objective 10: Thunder Bay is a leader in renewable energy generation and produces enough energy to meet its needs.

Objective 11: Natural gas is replaced with low-carbon fuels.

Energy Sector Targets:

1. 290 MW of ground-mount solar capacity is added by 2050.
2. 50% of existing buildings install rooftop solar PV by 2030 and all new buildings after 2021 have rooftop solar PV.
3. 250 MW of wind capacity is installed by 2050.
4. Renewable Natural Gas (RNG) and hydrogen are generated locally to displace remaining natural gas use by 2050.

Recommended Near-Term Tactics*

- Advocate for a zero-emissions provincial electricity grid as soon as possible.
- Create an online hub of resources for homeowners and businesses interested in installing rooftop solar PV.
- Assess the availability of sustainable biomass in the region to support innovative fuel switching solutions.
- Research opportunities for energy co-generation and/or district heating in existing and future facilities and operations.
- Establish a renewable energy cooperative.
- Participate in the development of the Provincial low-carbon hydrogen strategy.
- Collaborate with regional energy providers to explore new, renewable energy production opportunities and develop a plan for increased renewable generation and storage.

* Specific near-term actions for the Corporation are provided in Appendix D.

Fuel-switching is an important part of the NZS where many activities move away from fossil fuels to low-carbon sources, with an emphasis on electricity. The NZS envisions more electric space heating, electric vehicles, and electric processes in industry. To move there, Thunder Bay needs a supply of clean electricity now and in the future. Future demand particularly can be met through local generation. Preliminary analysis indicates that the renewable electricity supply in Thunder Bay and its surrounding area exceeds the total electricity consumption in 2016.[24]

[24] Ancillary report: Supply and Constraints Analysis (see Appendix F).

Distributed Renewable Energy Generation: Solar and Wind Energy

Ground-mounted solar PV systems can be installed on available land within and outside the city boundaries that do not compete with other land uses. Larger solar installations can be located in sites with complementary land uses such as on parking lots, unused rooftops or in utility right of ways.

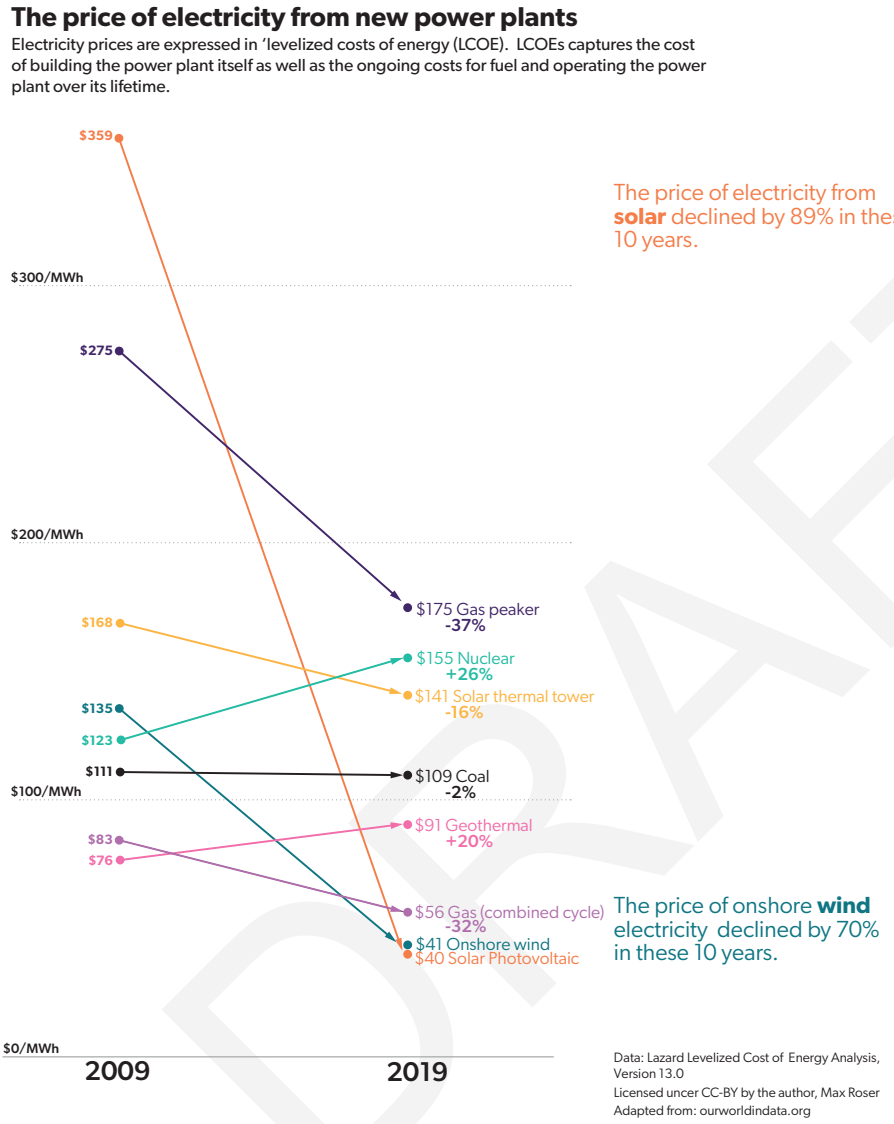


Figure 6. Renewable energy has become the most cost-effective method of electricity generation in the last 10 years.

Wind turbines need to be installed where wind speeds are sufficient to make the projects viable. One such example is the 100MW wind farm operating north-east of the city.[25]

Each of the sources of renewable electricity comes with its own set of constraints. Ontario's electricity market and the grid's capacity to effectively integrate intermittent energy sources are significant constraints. Balancing storage capacity and demand during peak hours is a technical challenge.

[25] Green Power Generation" n.d. Enbridge. Retrieved from: Green Power Generation - Enbridge Income Fund.

Renewable Natural Gas and Hydrogen

Where possible, renewable natural gas (RNG) and hydrogen should be produced locally. Additional RNG can be procured over the grid/pipeline. RNG is typically generated through anaerobic digestion or landfill gas capture, is considered net-zero, and can be blended with existing natural gas infrastructure without intervention.

Hydrogen energy is assumed to be green hydrogen where it is produced through electrolysis, a process that is powered by renewable electricity.[26] Hydrogen is used primarily in the industrial sector but can also be blended with the natural gas distribution network at a rate of between 5 to 15% of total volume.[27] Fuel-cells may be another opportunity to transport and use hydrogen in individual buildings or in heavy-vehicles. Although this technology is still in its infancy, the Province and Canada have made commitments to accelerating hydrogen initiatives in their respective climate plans.

Thunder Bay is well-positioned to begin this transformation locally by producing RNG using anaerobic digestion of biosolids and other organics. Subsequent development of green hydrogen can commence in the city through electrolysis, using local renewable electricity or the grid.

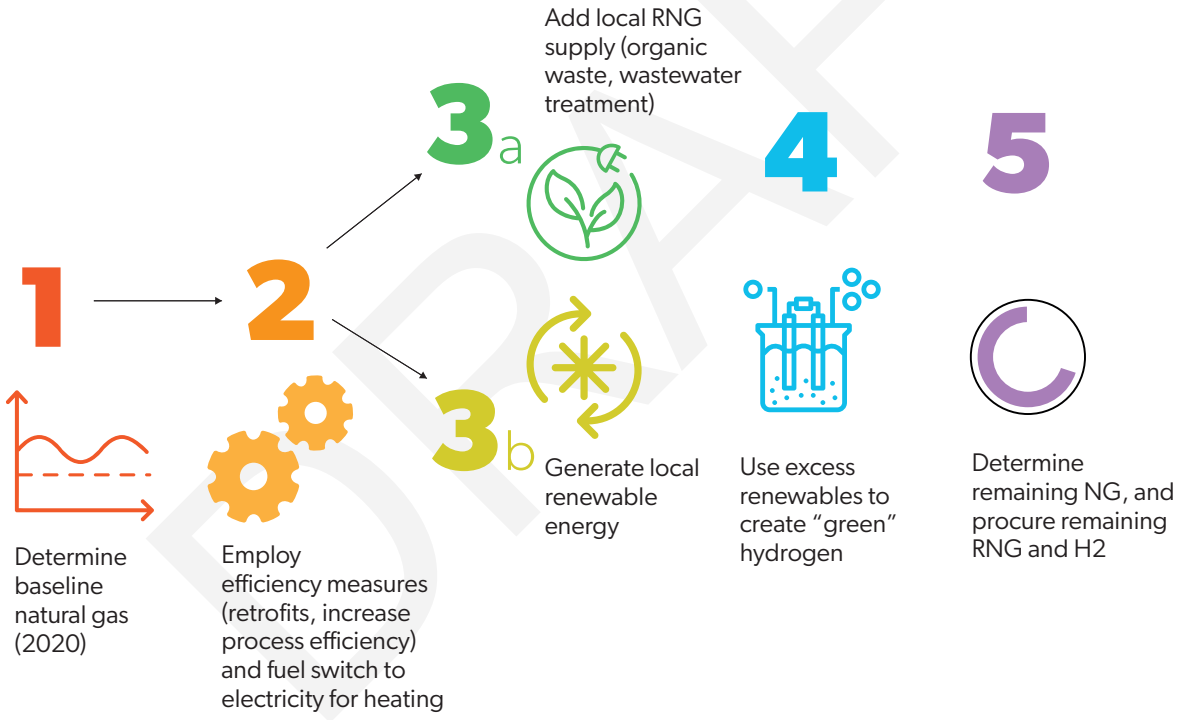


Figure 7. Fuel Switching in the NZS

[26] Hydrogen displacement of natural gas represents approximately 2% of the total reductions. It is thus speculative of changes that may be made as Ontario begins to develop a hydrogen strategy. "Ontario Low-Carbon Hydrogen Strategy - Discussion Paper." 2020. Ministry of Environment, Conservation, and Parks. Ontario Low-Carbon Hydrogen Strategy - discussion paper | Environmental Registry of Ontario.

[27] M. W. Melaina, O. Antonia, and M. Penev (2013). Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues www.nrel.gov/docs/fy13osti/51995.pdf.

Wood and Thunder Bay's Net-Zero Transition

Forests have been at the heart of Thunder Bay's economy since the 19th century, and they will continue to have an important role in its economy in a net-zero future.

As a source of carbon sequestration….

First and foremost, effectively managing Thunder Bay's existing trees and planting more trees is critical to capturing and storing carbon emissions to achieve net-zero emissions by 2050. Not only do trees sequester carbon, but they also purify the air and improve mental health when planted within urban areas, and support a thriving tourism industry surrounding the city.

As a source of energy…

Biomass is a source of energy with significantly lower emissions than fossil fuels; however, it is not a zero-carbon source of energy. Burning wood for power produces carbon dioxide and NOx, and particulate matter.

Ontario has sustainable forestry practices in place; however, burning harvested wood for energy is not aligned with a climate emergency approach.[28] If a tree is planted to replace the harvested one, this carbon dioxide will only be removed from the atmosphere over 60 or 70 years. Climate scientists have made it clear that the timing of emission reductions is critically important; reductions over the next decade are much more critical than reductions sixty years from now if the worst effects of global warming are to be avoided.[29] For this reason, only biomass that would otherwise be combusted should be used for energy.

A preliminary review of available data suggests there is a small amount of forestry waste within the region of Thunder Bay that is being burned onsite, which could be considered for local energy use.[30] A more comprehensive review of local sustainable biomass supply should be conducted before exploring new biomass initiatives.

As a building material…

Residential and commercial buildings consume 31% of the total energy used in Thunder Bay. The NZS identifies several targets to reduce energy consumption and improve energy efficiency in the building sector, including net-zero new construction and extensive retrofits of existing buildings. This presents a significant opportunity for the use of regional wood and wood products in new construction and retrofitting initiatives.

Generally, building with wood instead of non-wood alternatives such as concrete, metals, or plastics, can have a positive impact on emissions by reducing a building's carbon footprint.[31]

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[28] See for example International Business Times Weekly, "Over 500 Scientists From US, Europe and Asia Urge World Leaders to Stop Burning Trees for Energy" February 13, 3021. Retrieved from: https://www.ibtimes.sg/over-500-scientists-us-europe-asia-urge-world-leaders-stop-burning-trees-energy-55542.

[29] See generally: IPCC, Special Report: Global Warming of 1.5∘C (2018). Retrieved from: https://www.ipcc.ch/sr15/.

[30] Available data from the Ministry of Natural Resources and Forestry indicates that a significant amount of wood waste is burned annually within 50 km of the city in the Black Spruce Forest (≈ 2,500 slash burn piles) and Dog River-Matawin Forest (≈ 2,200 slash and burn piles). In addition, about 60,000 green tonnes of wood residue are produced from the Lakehead Forest, but not burned onsite. The energy potential of these three sources alone is 669,925.35 GJ/year, or 21.24MW of capacity. It is very likely that more sustainable woody biomass is available.

[31] Bergman et al., (2014) The Carbon Impacts of Wood Products. Forest Products Journal, 64(7).

A building's carbon footprint, or embodied carbon, refers to the carbon emissions attributed to the extraction, manufacture, transportation, and assembly of the materials used in construction, as well as building maintenance, repair, and decommissioning. While operational emissions - the emissions that result from the energy used to operate a building - can be reduced over time, embodied emissions are "locked-in" during construction.

There are several ways to reduce embodied carbon, including choosing low-carbon structural materials, reducing total materials used in building design, and repurposing used materials as much as possible.[32] The City will explore strategies to reduce embodied carbon in new construction and building retrofits and encourage the use of regional wood and wood products.

As an opportunity for continued leadership…

Thunder Bay is a leader in research and innovation in the forest bioeconomy with world-class research facilities, pilot manufacturing sites, and demonstration facilities.

Sustainable forest management, low-carbon forest products, and skilled forestry professionals have an important role to play in the net-zero transition. The NZS supports continued research, development, and innovation in the forest bioeconomy to develop new and novel solutions on the path to net-zero.

FOCUS AREA: LOW-CARBON TRANSPORTATION

Table 6. Low-carbon transportation targets and priority actions.

Objective 12: Public transit is convenient, accessible, and low carbon.
Objective 13: Residents in Thunder Bay drive less and walk or cycle more.
Objective 14: Vehicles are powered with low-carbon energy.

[32] Urban Land Institute Green Print. (n.d.). Embodied Carbon in Building Materials for Real Estate. Retrieved from: https://americas.uli.org/wp-content/uploads/ULI-Documents/Greenprint-Embodied-Carbon-Report_FINAL.pdf.

Sector Targets: Active Transport and Transit

1. The mode share of public transit increases to 10% by 2035.
2. The municipal transit fleet is converted to 100% electric by 2035.
3. Private vehicle trips (home to work) are reduced by 10% by 2050.
4. 65% of trips within (start and conclude) the city is walking, cycling or public transit by 2030.
5. E-mobility service (bikes and vehicles) are launched by 2021.
6. Active transportation zones are created in the downtown core(s) to incentivize active movement and disincentivize vehicle travel.

Sector Targets: Vehicle Electrification

1. 100% of private vehicle sales are electric vehicles (EV) by 2040.[33]
2. 100% of heavy commercial vehicles are powered by low-carbon fuels by 2040, light-duty commercial vehicles are electric by 2050.
3. The active-transportation zones restrict the use of fossil-fuel powered vehicles by 2030.
4. The municipal fleet (i.e. corporate vehicles, service vehicles, public works) is 100% electric by 2040.

Recommended Near-Term Tactics*

- Expand electric vehicle charging infrastructure and require charging stations in new construction of homes and businesses.
- Develop a municipal transit and fleet decarbonization strategy.
- Develop a commercial fleet decarbonization strategy.
- Explore mechanisms that incentivize the use of electric vehicles (e.g. free parking).
- Develop a zero-emissions vehicle technology and training cluster with the local colleges and trade organizations.
- Develop a shared mobility service (e.g. EV-car share, bike-share, or e-bike share)
- Advocate for increased electric vehicle and bicycle rebates from other levels of government.
- Continue implementing the City of Thunder Bay's Transportation and Active Transportation Master Plan.

* Specific near-term actions for the Corporation are provided in Appendix D.

Transportation represented the largest source of emissions in Thunder Bay in 2016, and this is projected to continue in the BAP scenario until 2050. The benefits of the NZS approach to transportation include reduced air pollution, increased community health, and improved accessibility.

[33] This target generally follows the Federal Government's goals for vehicle sales across Canada.

Improved Transit

The NZS envisions 10% growth in transit ridership as a result of increased frequency during peak times and the expansion of the transit network so that it reaches 80% of the population. Additionally, the NZS includes 100% of the municipal fleet being electrified by 2040.

Figure 8. Electric Buses are being deployed in Edmonton, Alberta.[34]

Active Transportation and Trip Reduction

Thunder Bay residents have an affinity for nature and the outdoors. The NZS supports this lifestyle by assuming a continued increase in cycling and walking, with enabling infrastructure investments in:

- Pedestrian priority corridors,
- Trail expansions,
- Active-transport zones with car-free corridors,
- City-wide complete street standards,
- Fort-to-Port cycling connection, and
- Winter cleaning of active transport pathways.

These and many other improvements are identified in the Transportation Master Plan and Active Transportation Plan (2020-2050) and contribute to the NZS' target mode shares.

[34] See the City of Edmonton website: www.edmonton.ca/projects_plans/transit/electric-buses.aspx .

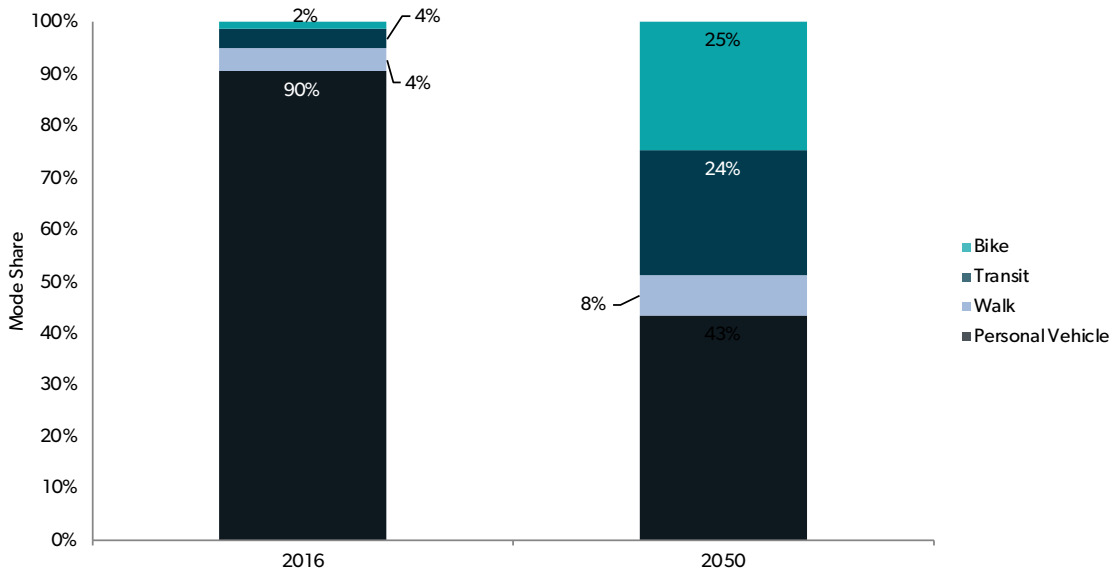


Figure 9. Mode share, 2016 and 2050 for trips taken within Thunder Bay with low-carbon actions.

The NZS includes recommendations for establishing a car share program, e-bike share system, and an increase in private e-bikes. Car share programs have been successful in many North American cities, including Pogo in Edmonton, Calgary Car Share, and Communauto in Toronto, Ottawa, Montreal, and Quebec City. Communauto has begun to roll out electric vehicles in its fleet.

Car-free zones are present in many European cities, regardless of climate, and are being increasingly considered in cities across Canada. The application to major trip-destinations like downtown Thunder Bay could be effective if carefully designed. Summer markets and increased rates for paid parking in the city core may be a more feasible disincentive to private vehicle use in the short term.

Vehicle and Fleet Actions

Emissions from private and commercial vehicles are a challenging and important focus area for the NZS and advancing EV adoption is a key part of the solution. With EV prices dropping and the increasing availability of models suited to northern climates, and various commercial and private needs, rapid electrification is becoming more viable.

The target for EVs follows the lead of the Government of Canada, however the city can still play a role to accelerate the EV transition through key interventions.

Leadership in Electric Vehicle Adoption

Coordinated actions are required to accelerate the EV transition in Thunder Bay. Plug n' drive, a leading non-profit whose aim is to achieve this acceleration offers the following suggestions[35]:

- A mature, regional DC fast charging network ('Level 3' charging) will alleviate EV range anxiety. Several privately-owned charging networks are already emerging in Canada, including those owned by Tesla, Electrify Canada (Volkswagen), FLO, and Petro-Canada. The municipality can support the build-out of EV charging infrastructure by participating directly in projects, assisting in site selection and design, and addressing infrastructure hurdles.
- A branded marketing campaign partnering with employers, dealerships, automobile associations, etc. will bring attention to the viability of EVs. Motorists need to be made aware of, and helped to navigate grants, subsidies, and incentive programs for EV purchases.
- Awareness campaigns need to extend to neighbouring municipalities, so that visitors know that Thunder Bay has the infrastructure needed for painless EV visits.
- The City can also show leadership by revising certain bylaws and plans to accommodate and promote EV ownership. Transportation and land-use policies can be updated to include provision for charging infrastructure and assignment of priority parking.
- Incentives could be offered to EV purchasers in the form of property tax rebates, vehicle registration fee rebates, or free parking (if applicable).
- Promotional and rebate partnerships with car dealerships can help accelerate EV ownership. Partnerships with taxi companies can help transition their fleets to EVs.
- Leading an EV bulk buying program would reduce EV costs further and grant access to EVs for more of Thunder Bay's residents.[36]

[35] "Accelerating the Deployment of Plug-In Electric Vehicles in Canada and Ontario" 2018. Plug n' Drive Canada. Retrieved from: www.plugndrive.ca/wp-content/uploads/2017/07/160159_ElectricVehicleReport_R001.pdf

[36] For example, Boulder, Colorado pioneered an extremely successful EV bulk purchase program starting in 2016: www.bouldercounty.org/environment/sustainability/transportation/electric-vehicles/.

FOCUS AREA: WASTE

Table 7. Waste targets and priority actions.

Objective 15: Waste is appropriately managed to reduce methane emissions.

Objective 16: Municipal water and wastewater processes are increasingly efficient.

Sector Targets

1. 95% of solid organic waste is rerouted to an anaerobic digester.
2. The landfill capture rate of methane is increased to 80% by 2040.
3. Pumping efficiency for wastewater is increased by 30% by 2030.

Recommended Near-Term Tactics*

- Increase organic diversion rates.
- Develop a centralized anaerobic digester system.
- Increase the City's landfill gas-capture rate.

* Specific near-term actions for the Corporation are provided in Appendix D.

In 2016, waste emissions represented 4% of Thunder Bay's GHG emissions. This reflects the work the City and community has already done in regard to wastewater treatment where methane is captured and used, as well as the landfill gas capture system employed by the City. This work continues in the NZS and is envisioned to go further and capture solid organic waste.

Reduced Waste and Waste to Energy

The NZS envisions an anaerobic digester in order to capture methane from organic waste and convert it to RNG. The current grid-connected landfill gas capture system is one potential location for an anaerobic digester.

Improved organic waste diversion by businesses and residents would improve the viability of an anaerobic digester. Enbridge and the Ontario Energy Board have jointly invested in the province's largest anaerobic digester and RNG production facility in Niagara, Ontario in the Fall of 2020. The facility is capable of handling 8,000 tonnes of organic waste.[37]

[37] Ontario's Largest RNG Plant. 2020. Enbridge. www.enbridge.com/stories/2020/october/enbridge-and-partners-break-ground-ontarios-largest-rng-plant.

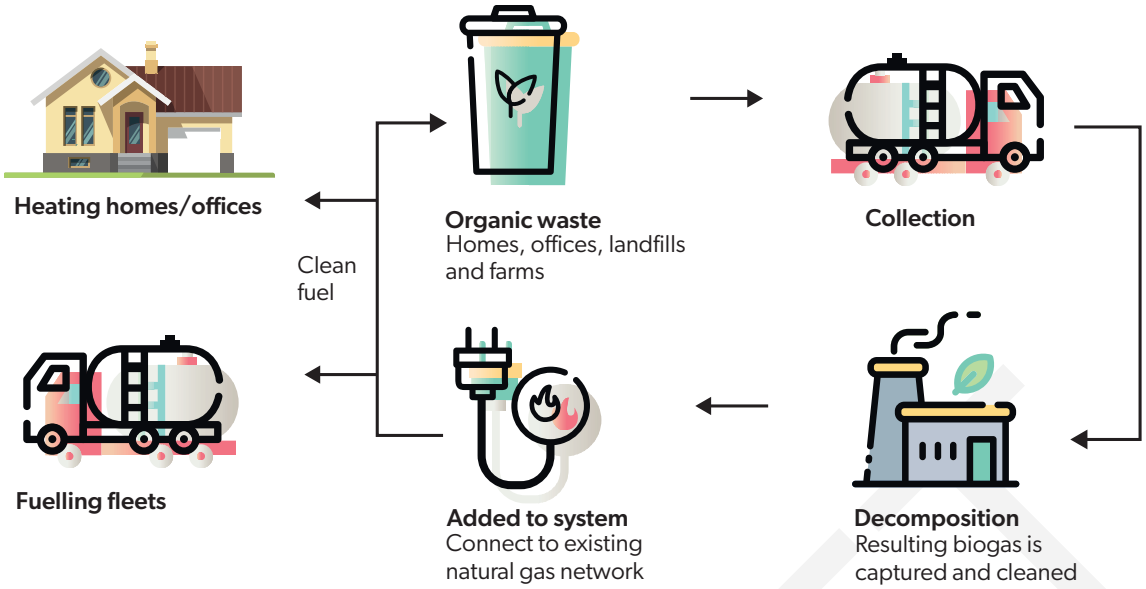


Figure 10. RNG inputs and outputs in a city.[38]

NET-ZERO STRATEGY: EMISSIONS AND ENERGY USE SUMMARY

The NZS achieves approximately 90% GHG emissions reductions from 2016 levels and in comparison, to a business-as-planned (BAP) scenario through technically feasible and community-informed solutions. The NZS features a steep decline of 55% emission reduction in the next decade, reflecting an aggressive approach to implementation; stakeholders believed this to be an appropriate response to the climate emergency declaration (see Figure 12).

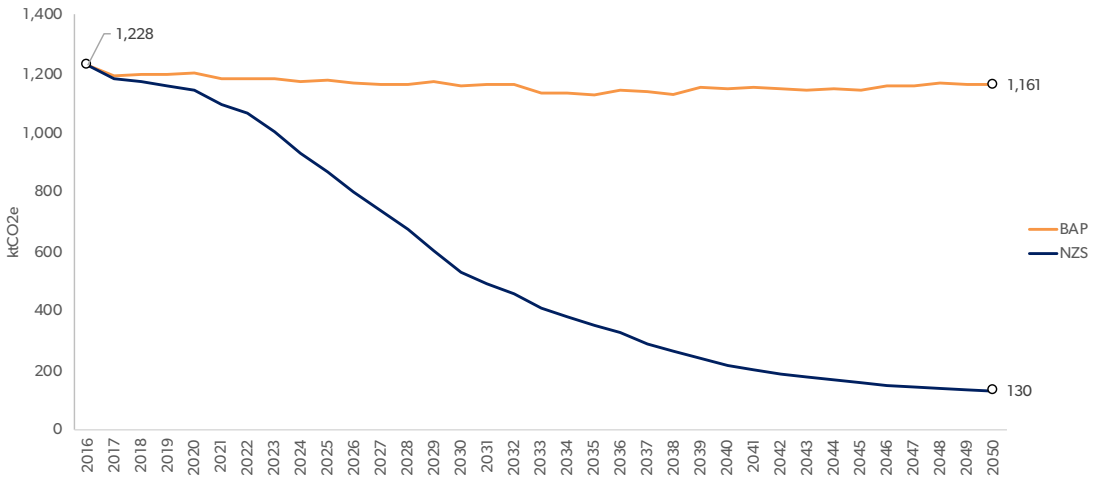


Figure 11. Thunder Bay's GHG emission totals in BAP vs. NZS, 2016 - 2050.

According to the framework of the strategy, GHG emissions decline to 532 $ktCO_2e$ in 2030, a 55% decline from 2020.

[38] Renewable natural gas development. Nd. Enbridge. Retrieved from www.enbridgegas.com/Natural-Gas-and-the-Environment/Enbridge-A-Green-Future/Renewable-Natural-Gas.


OMNIA


HOITO
RAVINTOLA
RESTAURANT

Part 4. Financial Impacts

The Financial Transition

Below is a brief overview of the anticipated financial impacts if the Net-Zero Strategy (NZS) is implemented as modelled. A more detailed overview of the financial impacts is provided as an ancillary report to the NZS.[39]

As compared against the BAP scenario, the targets in the NZS represent significant savings of energy, carbon, and maintenance costs as well as increased revenue from renewable energy generation and transit (see Figure 15 note that savings and revenue are shown as negative in the chart).[40] Financial modelling projects a positive return on investment of about $1.7 billion dollars in net present value.[41]

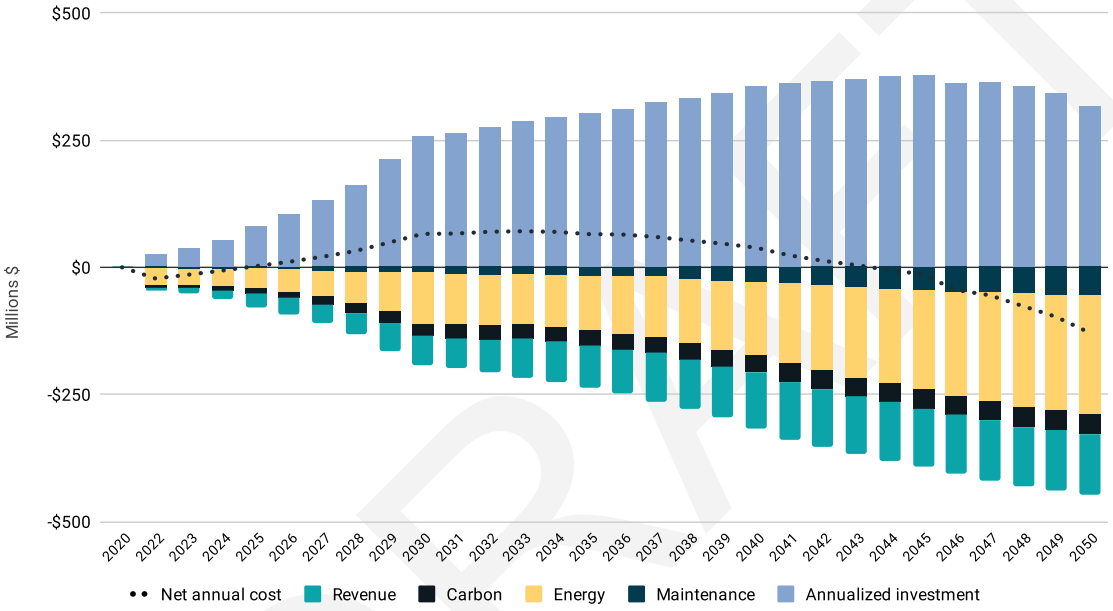


Figure 14. Annualized capital expenditures vs. savings and revenue from the net-zero scenario, 2020-2050.

The positive net present value of the net-zero pathway will require capital investments totaling $5.1 billion (see the blue bars in Figure 15) spread out over the 2021-2050 period (with a $3.8 billion present value). The Thunder Bay economy currently generates about $5 billion in GDP every year. The low-carbon transition would require an annual investment, from the public or private sector, of 2.5-3.0% of the community's annual economic output.[42]

The largest investments are projected for buildings, totaling $3.8 billion (present value $2.1 billion) over the period. To meet emission reduction targets, $2.8 billion of the building

[39] See 'Net Zero GHG Emissions Financial and Economic Analysis Summary' (December 2020), available on the City of Thunder Bay website.

[40] This financial analysis does not include primary industry (i.e. pulp and paper) as financial data was not available.

[41] Upon the completion of the strategy, the federal government launched a plan to increase the carbon tax to $170/tonne by 2030. Modelling in the strategy assumes $50/tonne. Retrieved from: www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview.html.

[42] Statistics Canada. Table 36-10-0468-01 Gross domestic product (GDP) at basic prices, by census metropolitan area (CMA) (x 1,000,000) www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610046801.

investment program is required to be completed over the next ten years, representing an average annual incremental investment of $280 million over the 2021-2030 period. This level of investment will require unprecedented levels of cooperation from nearly all stakeholders in Thunder Bay. Over the past ten years, building investment in Thunder Bay has averaged $244 million per year. The NZS will require a sustained period in which building investments are double their recent historical levels. The upgrading of Thunder Bay's buildings has the potential to be the central pillar of a post-COVID economic recovery strategy due to the associated local job creation and social equity impacts.

A JUST TRANSITION

While the required investments are manageable from the perspective of the Thunder Bay economy, and while they will pay for themselves over the long term (see Figure 15 above), they could be large for particular people, sectors, or areas. The risk of localized impacts should be a key focus for the City. The proposed pathway will require new jobs to be filled, as the need for other jobs is reduced. With the right policies in place, the NZS can be delivered without adding further costs to energy bills and with limited impacts to public finances. Significant positive impacts on health and the environment are expected.

- **Jobs and the just transition.** The NZS involves considerable opportunities for job creation. For example, the action of retrofitting residential buildings alone would require over 14,000 extra full-time workers. An important challenge for the City, with support from community organizations and other levels of government, is to identify where jobs may be lost (e.g. in combustion engine vehicle maintenance) and to support workers to transition being a part of the new low-carbon workforce (e.g. retrofits, renewable energy generation, etc.). This can be carried out with existing businesses in Thunder Bay or new industries that emerge during this transition.
- **Energy bills.** The NZS can be implemented without large increases in consumers' energy bills, especially when combined with deep and targeted energy retrofits. Indeed, policy can be designed to ensure that vulnerable customers benefit from lower energy bills. Motorists also stand to see significant cuts in the costs of driving as they shift to electric vehicles, or even greater savings when also using active or public transit.
- **Health and environment.** There are a host of health and environmental benefits attached to the targets in the NZS. For example, more walking and cycling can improve health and contribute to cleaner air.

The required investment program is projected to spur Thunder Bay's economic growth and provide significant co-benefits. With the recent increase in the national price on carbon and projected improvements in low-carbon technologies, the economic benefits projected in this analysis are likely underestimated.

WHO IS PAYING?

How will the NZS be financed? The City, community, private sector, and other levels of government all have roles to play. The actions and strategies proposed to meet the targets outlined in the net-zero pathway will be subject to the City's democratic decision-making process. Due to the nature of this type of planning exercise, these decisions will be made on an ongoing basis throughout the implementation of the Plan.

The City may be able to provide start-up funding or assist with financing and take an organizational role in many actions but will not be paying for implementing each action. The City will not necessarily need to raise taxes to fund the NZS. The majority of the investment will originate from the private sector, community, other levels of government, and via innovative financing tools (i.e. green bonds).

Examples of investments that have been made in Canada and Ontario that respond to the targets in the NZS include:

1. **Waste:** The province of Ontario, Enbridge Utilities, and Niagara Falls are paying an estimated $42 million for the largest anaerobic digester in Canada that will create a source of local renewable natural gas.[43]
2. **Building efficiency, heat-pumps:** The cities of Perth-Andover and Saint-John, New Brunswick, along with their local hydro utility, have created heat-pump rental programs to reduce the cost of heat pumps and increase take-up.[44]
3. **Solar energy:** Private investment of $170 million has installed 120 MW of solar energy beside the City of Edmonton Airport.[45]
4. **Wind energy:** Enbridge and partners have funded a wind farm north of Thunder Bay.46
5. **Hydrogen energy:** Enbridge and the City of Markham, Ontario are funding a $5.2 million hydrogen fuel blending program.[47]
6. **Energy efficiency:** The Province of British Columbia and BC Hydro are offering building efficiency grants for British Columbia residents.[48]
7. **Energy efficiency:** Resolute Pulp Mill has made a $26 Million investment to reduce its GHG emissions by 43ktCO_2e annually.[49]
8. **Electrifying public transit:** Canada and Ontario are investing over $48.6 million in 14 public transit projects in Oakville. Projects include the replacement of 57 diesel buses with EV buses.[50]

[43] "Enbridge and partners break ground on Ontario's largest RNG plant."2020. Enbridge. Retrieved from: Enbridge and partners break ground on Ontario's largest RNG plant - Enbridge Inc.

[44] "Heat Pump Financing in Atlantic Canada." 2019. Daikan Air Intelligence. Retrieved from: daikinatlantic.ca/2019/08/23/the-guide-to-heat-pump-financing-in-atlantic-canada/.

[45] "Solar Farm in Edmonton Airport. 2019. CBC. Retrieved from: www.cbc.ca/news/canada/edmonton/solar-farm-the-size-of-313-football-fields-to-be-built-at-edmonton-airport-1.5640710.

[46] "Green Power Generation" n.d. Enbridge. Retrieved from: Green Power Generation - Enbridge Income Fund.

[47] "Enbridge Gas announces a $5.2M Hydrogen Blending Pilot Project"2020. Cision Canada. Retrieved from: Enbridge Gas announces a $5.2M Hydrogen Blending Pilot Project to further explore greening of the natural gas grid (newswire.ca).

[48] "Double the Rebate Offer." n.d. Province of British Columbia. Retrieved from: Double the Rebate Offer - Better Homes BC.

[49] "Sustainability, Climate Change & Energy" n.d. Retrieved from: www.resolutefp.com/Sustainability/Climate_Change_and_Energy/.

[50] "Canada and Ontario invest in modern, green public infrastructure for residents of Oakville" 2020. Retrieved from: https://news.ontario.ca/en/release/57810/canada-and-ontario-invest-in-modern-green-public-transit-for-residents-of-oakville.

Part 5. From Planning to Implementation

Community-Wide Implementation

Achieving the NZS' vision and targets will hinge upon community collaboration and support from the provincial and federal governments. The City will lay the groundwork, but there are numerous ways in which businesses and residents will need to be involved in the NZS implementation.

A non-exhaustive framework of the roles and responsibilities is provided below:

WHAT WILL THE CITY DO?

- Use the CEEP to participate in energy planning more formally in Ontario.
- Foster energy literacy and act as a resource for the community through education and outreach initiatives.
- Design and implement policies that support the goals of the CEEP, including:
    - Apply a climate lens in City decision making;
    - Integrate energy and GHG considerations into municipal plans and strategies.
    - Prioritize infrastructure funding that reduces GHG emissions.
- Work with a variety of funders and investors to boost investment in building energy efficiency, low-carbon transportation, renewable energy generation, and zero-carbon heating.
- Lobby on behalf of Northwestern Ontario by calling on the provincial and federal governments to enact tougher policies, regulations, and increase funding for local mitigation efforts.

The Corporation of the City of Thunder Bay committed to reducing corporate emissions by 20% below 2009 baseline year by 2020. In 2015, the Corporation exceeded this target and continues to meet reduction targets set out within the Corporate Energy Management Plan of a 2% to 5% reduction in energy consumption per year.

In 2018, the Corporation utilized 555,630 gigajoules (GJ) of energy at a cost of approximately $13,307,050 and continues to exceed its reduction target by reducing greenhouse gas (GHG) emissions by 26% compared to the baseline year of 2009.

Read More from the Corporate Energy Management Plan: COTB Corporate Energy Management Plan 2019-2024 (thunderbay.ca)

WHAT CAN COMMUNITY BUSINESSES AND INSTITUTIONS DO?

- Integrate energy and emissions considerations into business practices (ex., set a GHG target, voluntarily disclose carbon information, or apply a climate lens on procurement).
- Implement energy efficiency standards for new and existing buildings.
- Swap vehicle fleets from gas/diesel to electric where possible and encourage low carbon deliveries.
- Provide vehicle charging stations on site.
- In the case of manufacturers, switching fossil-fueled process heating systems to low or zero carbon fuels.

WHAT CAN RESIDENTS DO?

- Support government climate mitigation and lobbying efforts for more stringent climate goals and sectoral goals.
- Continue to participate in CEEP governance and implementation, by bookmarking the project's webpage and signing up for any public engagement opportunities.
- Invest in net-zero initiatives, for example through the purchase of green bonds that may be issued by the City in the future.
- Participate in pilot projects that reduce GHG emissions or generate clean energy.
- Access any low-cost funding made available from community partners to implement energy efficiency or fossil-fuel switching actions.
- Walk, cycle, or use public transport instead of driving.
- Reduce household waste.

WHAT DO THE FEDERAL AND PROVINCIAL GOVERNMENTS NEED TO DO?

- Create public policy that clearly sets the Independent Electricity System Operator and local utilities on a path to decarbonize the provincial electricity grid.
- Provide a clear framework to decarbonize heating for buildings and improve building energy efficiency.
- Regularly review and update the Carbon Tax to ensure it is effectively supporting decarbonization by 2050.
- Provide funding to local governments, industry, and businesses to support their efforts towards meeting ambitious local climate targets.
- Update minimum building energy efficiency standards for residential and non-residential construction.
- Enable rooftop solar generation through policy to allow net-metering, and virtual net-metering.
- Provide infrastructure funding to support low carbon fleets in corporate operations and transit services which includes charging infrastructure.

Further Reading

Appendix D: Near-Term (2021-2025) Implementation Action Tables for the Corporation of the City of Thunder Bay.

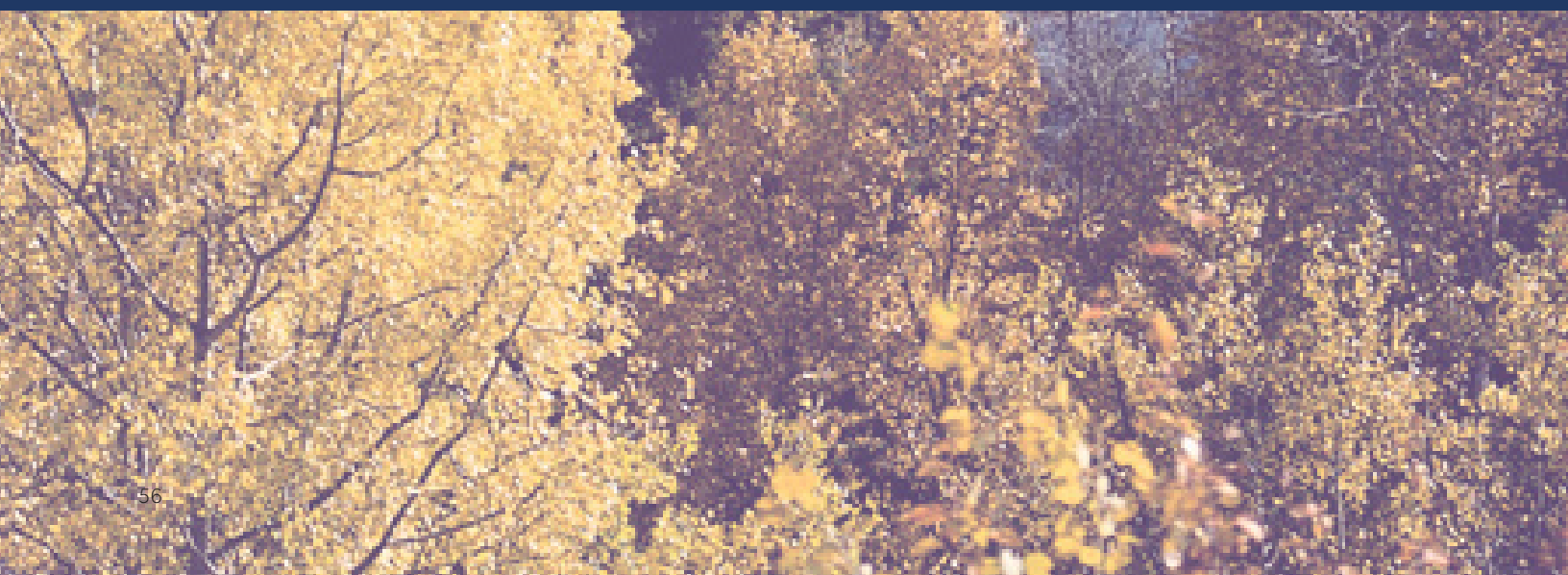
Municipal Stewardship

The City of Thunder Bay will act as both a leader and a partner in the implementation of the NZS. A series of near-term (2021-2025) action tables have been developed to kick-start implementation and lay the groundwork for accomplishing long-term objectives (see Appendix D).

MONITORING AND EVALUATION

The NZS is a living document that will require ongoing monitoring and evaluation. A five-year monitoring and evaluation cycle has been recommended to guide future initiatives as well as regular updates to the net-zero pathway. The NZS's pathway, which includes sectoral targets and recommended tactics, is based on a set of assumptions that will require periodic re-validation as actions are implemented. A five-year monitoring and evaluation cycle will reduce the levels of uncertainty in the modelling assumptions and ensure that the NZS remains up-to-date in the face of policy changes and technological developments.

The City will also review work-to-date and prioritize actions on a yearly basis. Prioritization of actions is expected to change from year to year based on the City of Thunder Bay's existing decision-making processes, evaluation, annual review, budget, and external factors.



Part 6. Conclusions

The NZS is a continuation of efforts beginning with the EarthCare Sustainability Plan and Climate Adaptation Strategy and cements the City's reputation as leader in the north. The NZS launches the City on a pathway to net-zero GHG emissions by 2050, while unlocking opportunities for new economic ventures and decreased costs for citizens and businesses.

Actions and pathways to a low-carbon future for the buildings, mobility, and waste sectors point to a better future for Thunder Bay. This will be achieved through early action and investments shaped by the City's climate emergency declaration. The NZS demonstrates that achieving net-zero emissions is ambitious, but achievable. Strong and enduring collaboration across the community, region, businesses, government, and residential groups will be instrumental and the NZS provides the necessary information to empower decision-makers.

Thunder Bay has already laid the foundation necessary to work with all stakeholders to measure, manage, and adjust its climate action progress. In working together, the City with its citizens and businesses can transition together to a low-carbon and prosperous community.

THUNDER BAY IN 2050

By 2050, Thunder Bay will become a community of climate leaders. These climate leaders will keep their well-insulated homes comfortable by using affordable and efficient heat pumps; rethink their mobility by taking transit, riding bikes, and walking for local trips; and drive electric vehicles only when they must. Energy generation will increasingly occur within the community, coming from multiple sources and enriching the community. There will be enough energy to share. Citizens will choose to reduce waste whenever possible but know that any waste they do produce will be put to good use. Climate actions will be just and cut across the community to ensure that all citizens have access. Actions will respect the natural environment that surrounds Thunder Bay. Each decision will be weighed to ensure there are no additional GHG emissions in the community. The City and its citizens will recognize that actions piloted and completed in Thunder Bay have had a positive impact on the country and the globe, and that those positive impacts carry into future generations. Thunder Bay's climate leaders will look back on the hard decisions made in 2021 and shortly thereafter as ultimately worthwhile.

Shifts and adjustments will have been required as the strategy is adopted and implemented. The City will have welcomed new ideas, partnerships, and public policy, and wherever possible, will have pushed its limits to achieve net zero emissions.

APPENDIX A. Stakeholder Advisory Committee Membership

Representatives from the following organizations participated in consultation:

- Arbora Management Services
- Centre for Research & Innovation in the Bio-economy
- Citizens United for a Sustainable Planet
- Confederation College
- Digital Engineering Inc.
- Domansky LTD.
- EarthCare Advisory Committee
- EcoSuperior
- Enbridge
- Fort William First Nation
- Hydro One
- Kozar Engineering Inc.
- Lakehead University
- Nokiiwin Tribal Council
- Resolute Forest Products
- St. Joseph's Care Group
- Synergy North
- Thunder Bay Chamber of Commerce
- Thunder Bay Community Economic Development Commission
- Thunder Bay District Health Unit
- Thunder Bay Regional Health Sciences Centre

City of Thunder Bay Representation

- Amanda Nason, Communications Officer – Infrastructure and Operations
- Darrik Smith, Mobility Coordinator – Engineering
- Decio Lopes, Senior Planner – Planning Services
- Lee Amelia, Coordinator Waste Diversion – Environment
- Lindsay Menard, Process Engineer – Environment
- Shahrzad Borjian, Planning and Scheduling Analyst – Transit Services
- Vanessa DeGiacomo-Zwaresh, Energy Analyst – Facilities, Fleet & Energy Management
- Wendy O'Connor, Communications Officer – Infrastructure and Operations

APPENDIX B. Detailed Sectoral Targets and GHG Reduction in the Net-Zero Strategy

Legend:

FOCUS AREA + TARGET # + TARGET DESCRIPTION	MODELLED START + END DATE	ESTIMATED GHG REDUCTION IN 2050 (TCO2E)	REDUCE/ IMPROVE/ SWITCH CATEGORY
Objective: The overarching Strategy objective the target(s) will help accomplish.			
Focus Area (A-E): A: Land use + natural areas B: Energy efficiency in buildings + industry C: Renewable energy generation + procurement D: Transport E: Water + waste Target #: 1-31	Start - End	Anticipated reduction in GHGs in 2050 if target is met.	Reduce: Avoiding energy consumption is the top priority. Improve: Maximizing energy efficiency improvements follows reducing. Switch: Switching to low-carbon energy sources addresses remaining demand.

FOCUS AREA + TARGET # + TARGET DESCRIPTION	MODELLED START + END DATE	EST. GHG REDUCTION IN 2050 (TC02E)	REDUCE/ IMPROVE/ SWITCH CATEGORY
Objective 1: Neighbourhoods are complete, compact, and walkable.			
A.1: 90% of all new construction, including residential, commercial, and industrial will occur in the Targeted Intensification Zone.	2021 - 2050	45	Reduce: Increase density in urban areas thereby reducing urban sprawl.
A.1a: 6.5% of buildings that exist today are demolished.	2021- 2050		Reduce: Demolition of older buildings as the city grows. This is expected to occur without intervention.
A.2: Houses are 30% smaller than the 2016 average (168 m2).	2050	2	Reduce: Housing footprints are smaller and require less energy.
A.3: 20% or less of new construction is single-detached.	2050		

Objective 2: Thunder Bay's forests and greenspaces are protected and provide essential ecosystem services.			
A.4: 100,000 trees are planted within the municipal boundary.	2050	4	Improve: Increase carbon sequestration potential.
A.5: Greenfield development is limited (supporting Target A.1).	2050	GHG reductions included in A.1	Reduce: Conserve greenfields as natural areas to maintain carbon sequestration potential.
Objective 3: New buildings are net-zero ready.			
B.6: 90% of new residential construction is net-zero (for rooftop solar see C.16)	2022-2030	10	Improve: New buildings require less energy and are net-zero ready. Switch: Space and water heating are electric.
B.7: Increase efficiency of new commercial and industrial buildings in line with Toronto Green Standard (for rooftop solar see C.16).	2022-2030	18	Improve: Increased energy efficiency in commercial buildings.
Objectives 4-6: Existing residential, commercial, municipal, and industrial buildings are retrofit to achieve deep energy savings and reduced emissions.			
B.8: 100% of dwellings built before 1980 are retrofitted.	2022 - 2030	178	Improve: Existing housing stock is retrofit to achieve 50% energy savings compared to BAP. Switch: Space and water heating is electrified.
B.8a: 100% of dwellings built after 1980 are retrofitted.	2030 - 2040		
B.9: 84% of commercial buildings are retrofit.	2022 - 2030	79	Improve: Existing commercial and industrial buildings are retrofit to achieve 50% energy savings compared to BAP. Switch: Space and water heating is electrified.
B.11: 84% of industrial buildings are retrofit.			
B.10: 100% of municipal buildings are retrofit.	2022-2035	11	Improve: Existing municipal buildings are retrofit to achieve thermal savings of 75% and electrical savings of 50%. Switch: Space and water heating is electrified.

Objective 7: Industrial processes are increasingly efficient.			
B.12: Minimize process heat demand up to 50% (primary and secondary industry[51]).	2022 - 2050	126	Reduce: Reduce energy use by making industrial processes more efficient.
B.13: Maximize woody biomass capacity factor of existing CHP systems (primary industry).	2021 - 2030	141	Improve: Increase capacity of existing power supply.
B.13a: Electrify remaining process heat (primary industry).	2030 -2 050		Switch: Natural gas is switched with electricity.
Objective 8: Combined heat-and-power systems are fueled by low carbon sources.			
B.14: Fuel switch remaining natural gas to low-carbon sources in secondary industrial/institutional CHP systems.	2022 - 2050	1	Switch: Natural gas is switched with low-carbon fuel.
Objective 9: Rooftop solar PV is deployed to assist with meeting building electricity needs.			
C.16: 50% of buildings (residential, commercial, industrial, municipal) have solar PV installed.	2022 - 2050	18	Switch: Roof-top PV is installed to help meet the community's energy needs.
Objective 10: Thunder Bay is a leader in renewable energy generation and produces enough energy to meet its needs.			
C.15: Install 290 MW of solar.	2022 - 2040	45	Switch: Install ground-mounted PV systems for local energy generation.
C.17: Install 250 MW of wind.	2022 - 2040	37	Switch: Wind turbines are installed to help meet the community's energy needs.

[51] Secondary industry refers to industry that does not deal directly with natural resource extraction and processing (e.g. primary industry).

Objective 11: Natural gas is replaced with low-carbon fuels.			
C.18: Increase procurement of RNG. (107.5 TJ from local sources, i.e. landfill and wastewater, 33.9 TJ procured from external sources)	2025 - 2050	7	Improve: Increase local production of RNG. Switch: Offset natural gas use with imported RNG.
C.18: Procurement and local production of hydrogen. 380 TJ of hydrogen is in use.	2035 - 2050	21	Switch: Offset natural gas consumption with locally produced hydrogen, the procure remainder.
Objective 12: Public transit is convenient, accessible, and low carbon.			
D.19: Increase transit mode share up to 10%. Transit network reaches 80% of the population.	2021 - 2035	6	Reduce/Improve: Reduce vehicle trips by increasing transit use through transit improvements.
D.20: Convert municipal transit fleet to 100% electric.	2021 - 2035	4	Switch: Transition fleet to EV buses.
Objective 13: Residents in Thunder Bay drive less and walk or cycle more.			
D.21: Linearly reduce private vehicle trips (home to work) by 9%.	2021 - 2050	3	Reduce: Enhance home-based work and flexible work policies to reduce vehicle travel.
D.22: 65% of trips within the city are carried out on foot or by bike. This applies to trips up to 2km for walking and 5km for cycling.	2021 - 2030	4	Reduce/Improve: Reduce vehicle trips by improving active transportation infrastructure and programming.
D.23: 10% of trips within the city and/or up to 10km are completed by electric car or bike share service.	2021 - 2050	2	Switch: Switch from fossil fuel based transportation to electric cars/bikes.
D. 24: 50% fewer vehicle trips, 50% less vehicle ownership in designated Active Transportation Zones.	2021 - 2031	11	Reduce: Reduce vehicle trips in the downtown cores by establishing active transportation zones that prioritize active transportation and public transit.

Objective 14: Vehicles are powered with low-carbon energy.			
D.25: 100% of light-duty vehicle sales per year are zero-emissions by 2040.	2021 - 2040	148	Switch: Electrify personal-use vehicles.
D.26: All heavy-duty vehicles are hydrogen-based (or alternative low-carbon fuel).	2026 - 2040	52	Switch: Electrify freight and delivery vehicles.
D.26a: Light-duty commercial vehicles are 100% electric.	2021 - 2050		
D.28: 100% of the municipal fleet is electric.	2021 - 2040	2	Switch: Electrify municipal fleet.
Objective 15: Waste is appropriately managed to reduce methane emissions.			
E.29: 95% of solid organic waste is rerouted to an anaerobic digester.	2021 - 2050	49	Reduce: GHGs released into the atmosphere via decomposing organic waste.
E.30: Increase landfill methane capture rate to 80%	2021 - 2040		Improve: Existing landfill gas capture system to increase capture rate.
Objective 16: Municipal water and wastewater processes are increasingly efficient.			
E.31: 30% increase in water and wastewater pumping efficiency.	2021 - 2030	1	Reduce/Improve: Reduce energy consumption by improving efficiency.

APPENDIX C. The Net-Zero Energy and GHG Emissions Transition: Technical Analysis

Total Energy Demand by Source

Assuming full implementation of all the actions described above, Thunder Bay's total energy consumption in 2050 would be 11.2 petajoules, 15.1 petajoules less than 2016's energy use and 14.2 petajoules less than the Business-as-planned (BAP) scenario by 2050 (Figure 16).

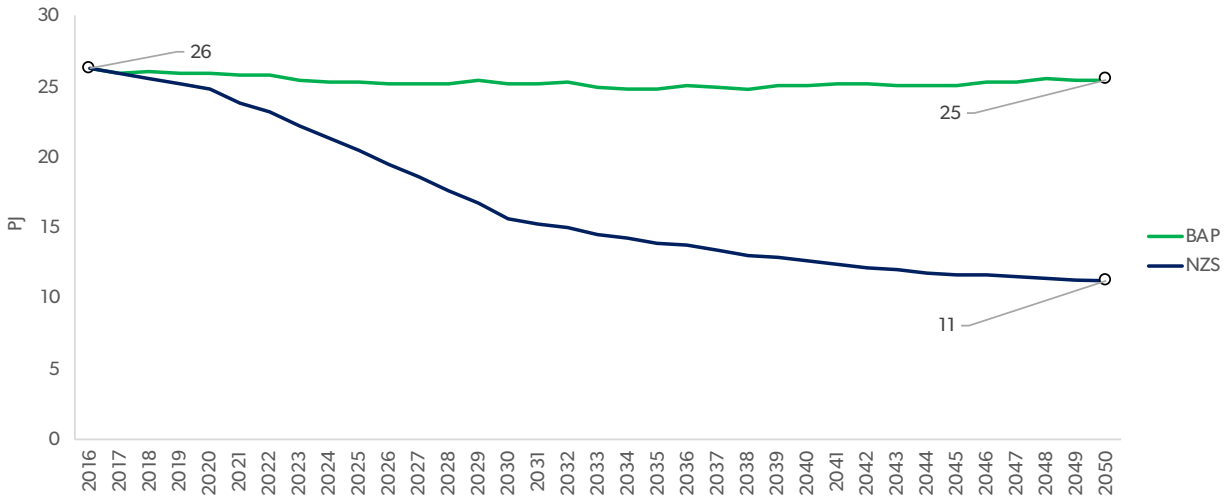


Figure 15. Net-zero (blue) versus BAP scenario (green) total community energy use, 2016-2050.

The targets in the Strategy will drive dramatic reductions in natural gas, gasoline, and Ontario grid electricity consumption (Figure 16). As electric vehicles gain market share through 2030, gasoline demand is replaced by electricity. While originally coming from the grid, grid energy is increasingly replaced by local renewable sources such as solar and wind. Energy from the district energy systems increases as the CHP plant in the primary industrial sector increases its capacity factor and replaces natural gas for heat processes with biomass.

In 2050, Thunder Bay can produce all of its energy locally and has displaced all natural gas; gasoline consumption has decreased by 92% and diesel by 54%. Energy comes from local solar PV plants and wind farms, and combined heat-and-power systems accounts for 48% of the total energy demand. The ancillary report, Supply and Constraints Analysis, reviews the city's potential wind and solar capacity.

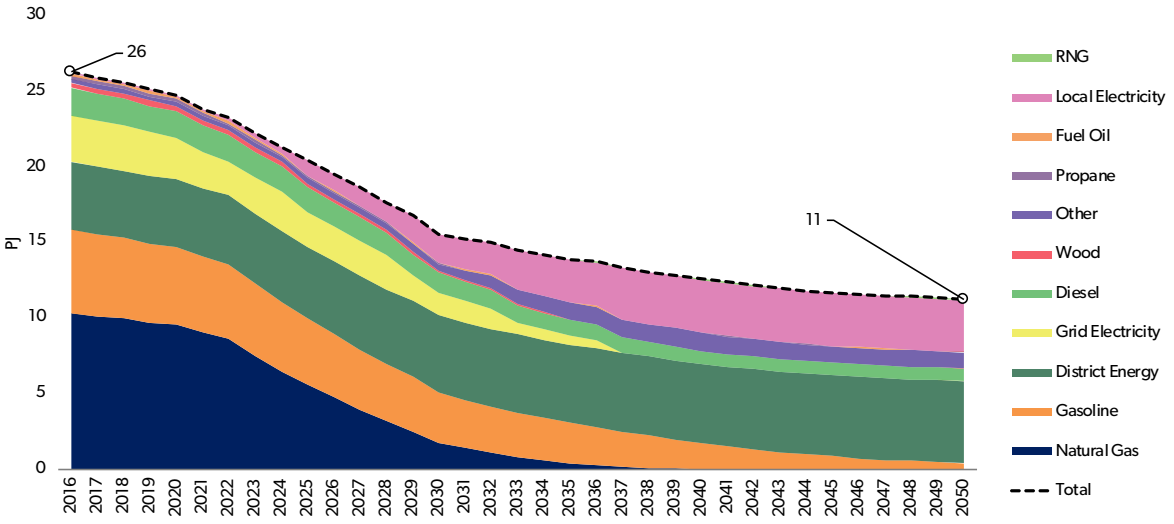


Figure 16. Community energy use by source (petajoules), 2016-2050.

'Other' in this context is primarily hydrogen energy for the industrial sector and geothermal energy for the residential sector.

Where Energy is Used

Commercial buildings use 81% less energy in 2050 than in 2016, while residential buildings use 71% less (Figure 18). Transportation energy use accounts for 5.3 petajoules, 69% less than 2016, mostly due to transformation of personal vehicles to electric, and the impressive energy efficiency of EVs[52]. Though it increases its overall share of total energy consumption from 40% in 2016 to 61% in 2050, the industrial sector reduces its own energy demand by 35%. The agriculture sector is a small sector and consumes only 0.001 petajoules in 2050.

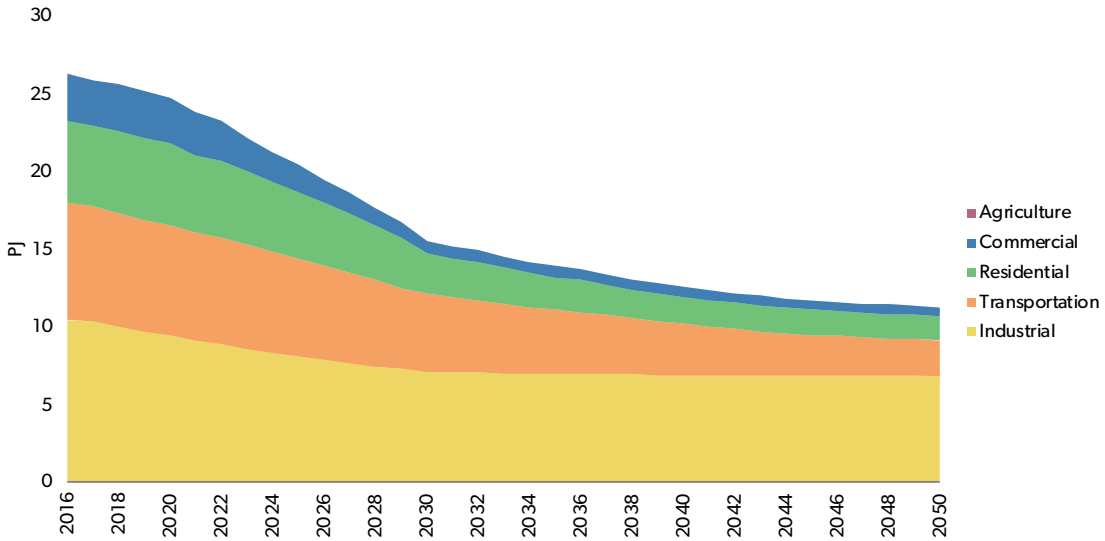


Figure 17. Community energy use by sector (petajoules), 2016-2050.

[52] 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

How Energy is Used

Transportation and space heating drive major reductions in energy use by 2050 (Figure 19), accounting for 35% and 29% of the total decrease respectively. In line with the previous chart, industrial processes show a 33% decrease in energy use through the evaluation period.

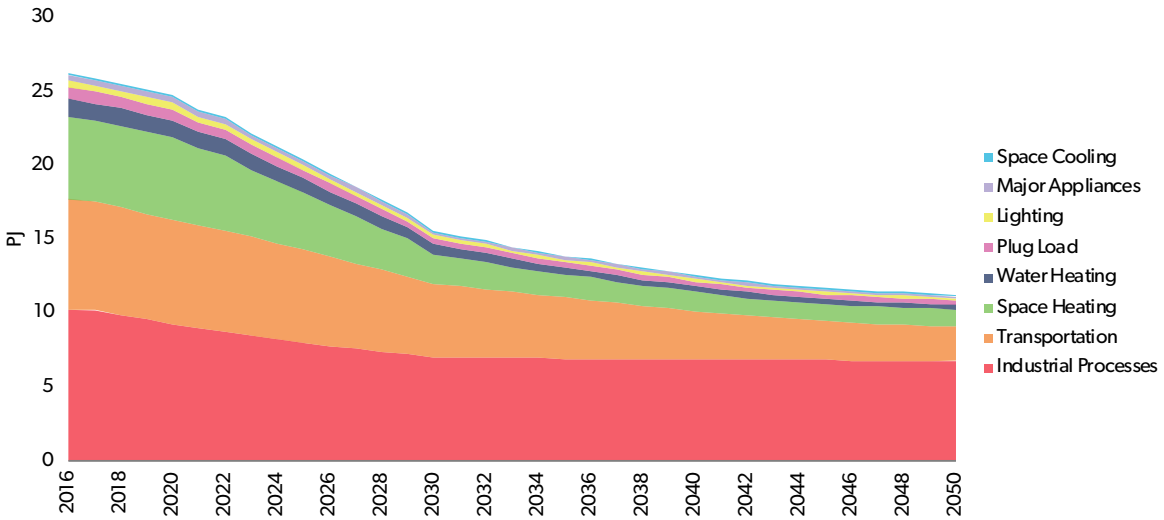


Figure 18. Community energy use by end use (petajoules), 2016-2050.

Total Emissions, by Source

As energy demand decreases under the NZS, so too do the emissions (Figure 20). This scenario achieves a 90% reduction from 2016 emissions levels and an 89% reduction in 2050 compared to BAP levels. This is an impressive outcome over a 30-year time period in an energy supply market currently dominated by fossil fuels. These reductions are enough to meet the Federal Government's commitment to achieve net-zero GHG emissions by 2050.

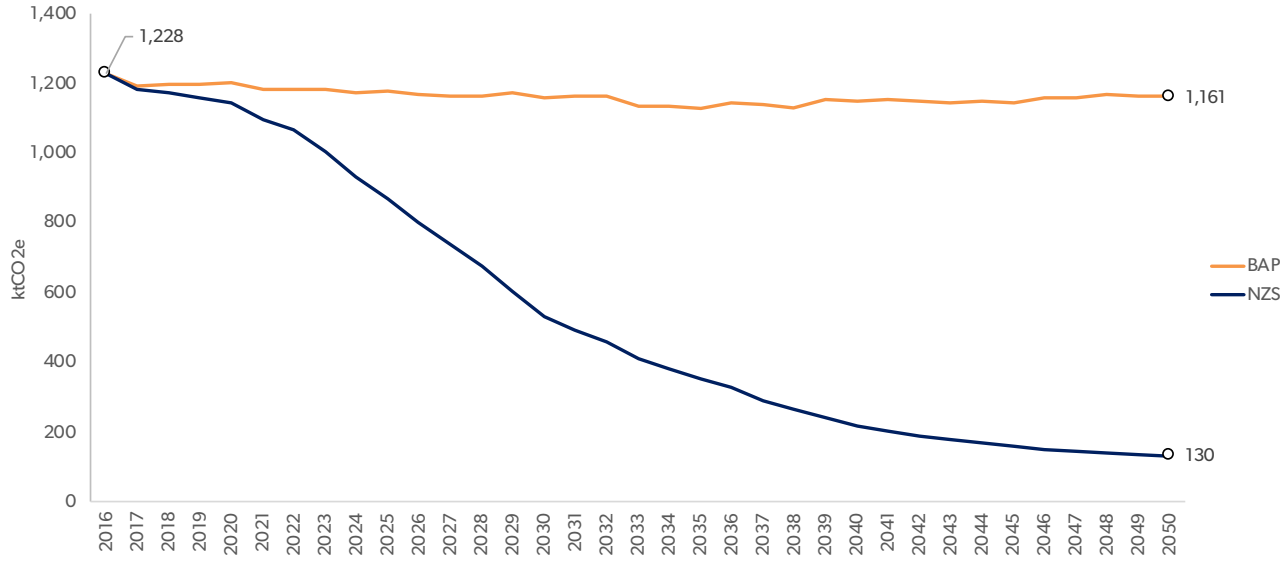


Figure 19. Projected total community emissions ($ktCO_2e$), 2016-2050.

Similar to the energy trend, natural gas and grid electricity emissions are completely removed from the inventory of Thunder Bay in 2040, and emissions from diesel, fuel oil, and gasoline are reduced by 52%, 86%, and 92% respectively compared with 2016. In contrast, the increase in district energy and local electricity consumption does not translate into higher emissions for those energy sources as they are considered emissions-free. Emissions from other sources[53] decrease by 83% through the evaluation period.

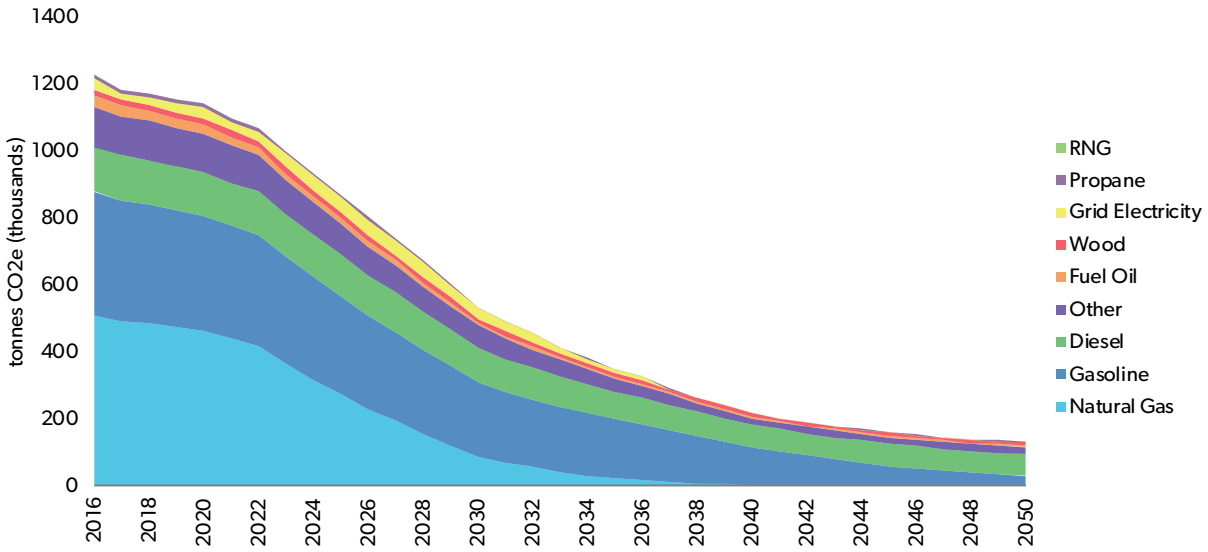


Figure 20. Net-zero pathway emissions by energy source (kilotonnes of CO_2e), 2016-2050.

The targets applied in the NZS will reduce emissions in all sectors. The greatest decrease in terms of net emissions are obtained in the transportation, industrial, residential, and commercial sectors with reductions of 409, 244, 227 and 117 ktCO_2e respectively. However, transportation remains the largest source of GHG emissions as gasoline and diesel consumption is still present in Thunder Bay in off-road vehicles.

Waste emissions are reduced by 68% whereas fugitive emissions[54] are removed completely from the community in 2040.

[53] Emissions "Other" mainly include non-energy such as waste and fugitive as explained in the following section.

[54] Fugitive emissions are those attributable to losses in energy transmission (e.g. natural gas escape).

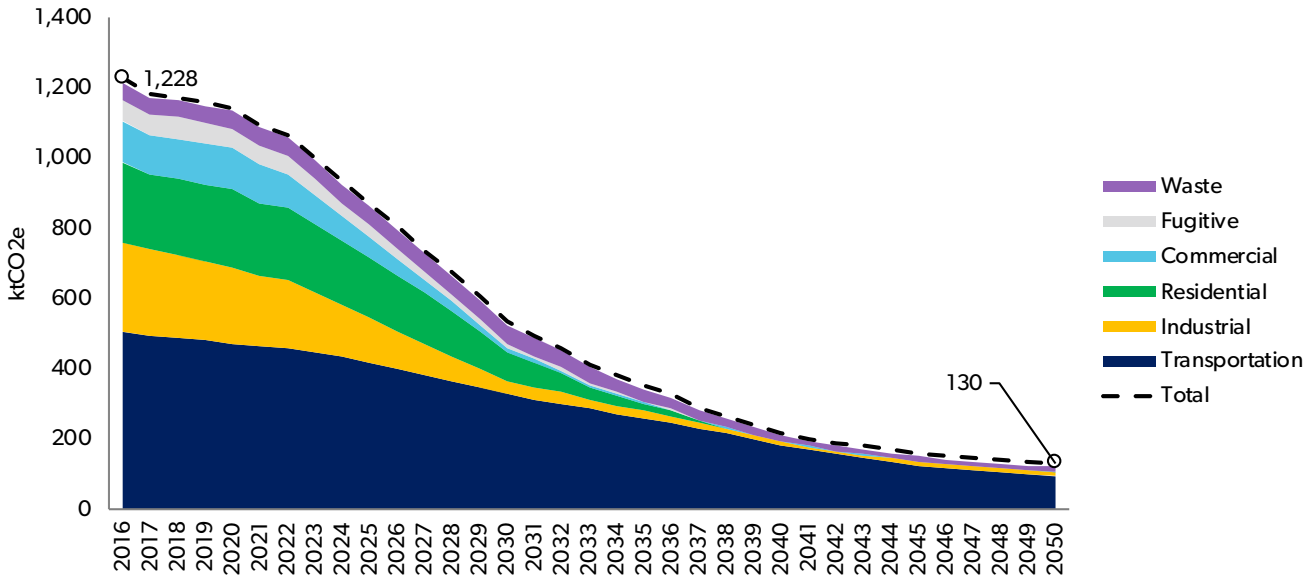


Figure 21. Net-zero pathway emissions by sector ($ktCO_2e$), 2016-2050.

Transportation Fuel Emissions

The transformation of the transportation sector is dramatic over the 2016-2050 time period resulting in reduced emissions by 81% from 2016 and 74% compared to the BAP scenario in 2050 (Figure 22).

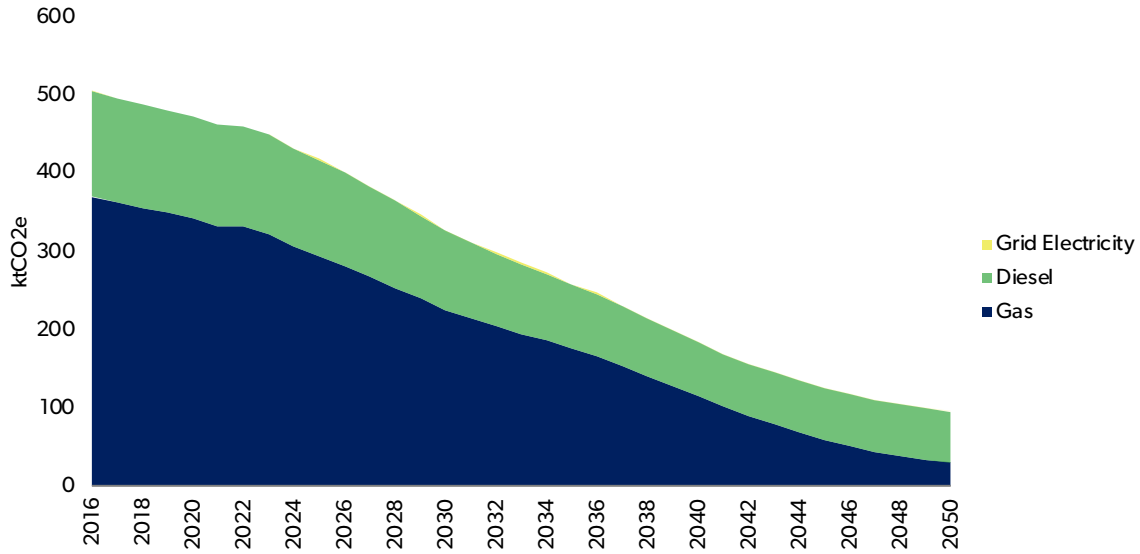


Figure 22. Net-zero pathway transportation sector emissions by fuel type, 2016-2050.

A major driver for this decrease is the shift from internal combustion engines to electric vehicles, especially the electrification of cars and light trucks for gasoline, and the transformation to hydrogen-based heavy trucks for diesel (Figure 24). Getting people out of cars and using active transportation or transit also contributes and keeps overall costs down. Several actions help achieve this target, including establishing two active transportation zones and developing targeted intensification zones (see Figure 25). The targeted intensification zones were identified

to increase the compactness of the community and avoid greenfield development, which reduces vehicle trips and enables higher rates of transit use and active transport.

Remaining transportation emissions from gasoline and diesel in 2050 mainly come from off-road vehicles in Thunder Bay.

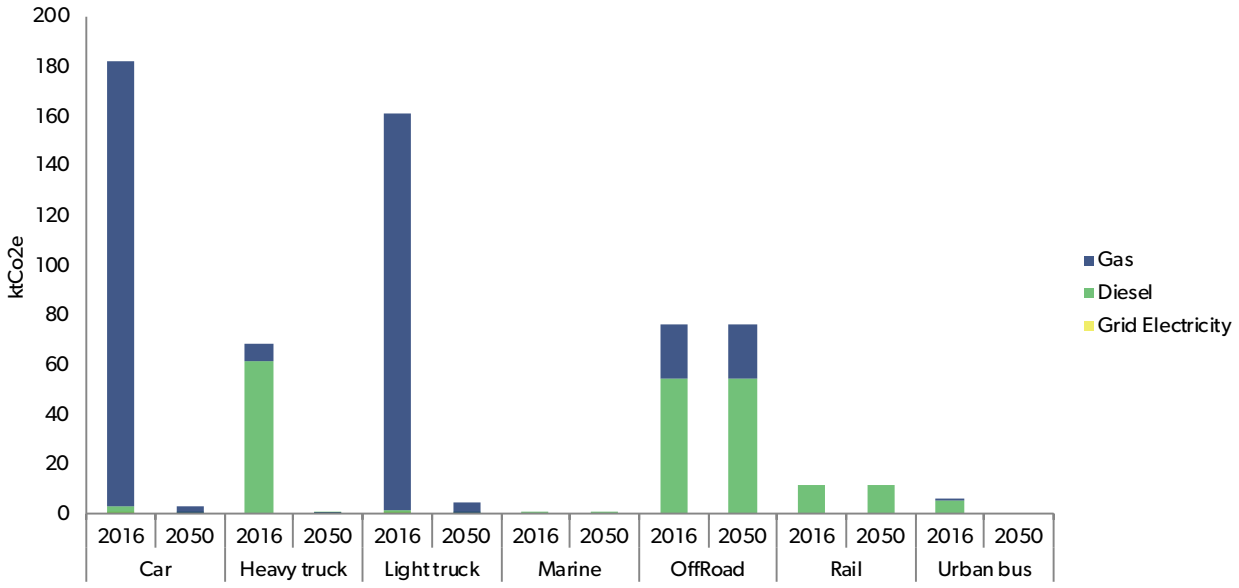


Figure 23. Transportation Emissions, by fuel and type, 2016 & 2050

Transportation emissions in the net-zero scenario by fuel type and vehicle type, 2016-2050.

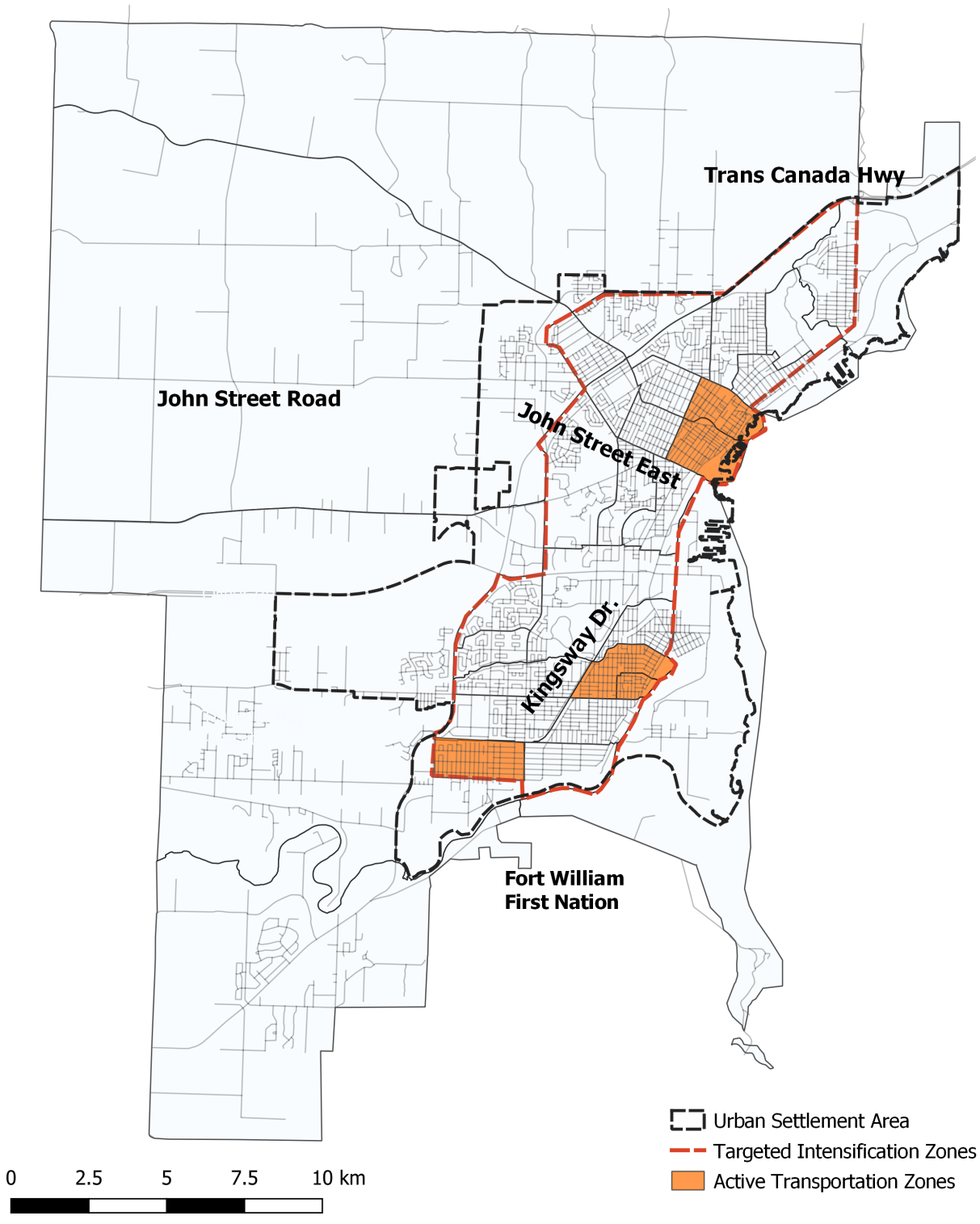


Figure 24. Active transportation and targeted intensification zones in Thunder Bay.

Buildings Emissions Sources

Implementation of new building energy performance requirements, deep energy retrofits of existing buildings, and efficiency improvements in the industrial sector along with fuel switching reduce emissions from buildings by 99.7% between 2016 and 2050. The largest gains are made in the space heating sector, followed by improvements in industrial processes where natural gas is replaced by electricity and biomass.

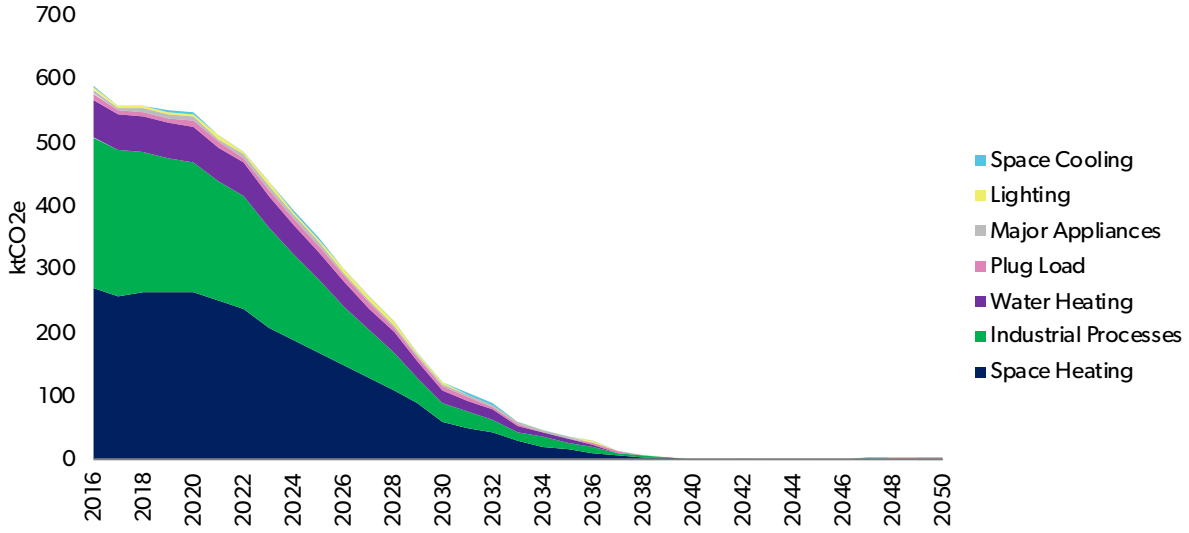


Figure 25. Net-zero pathway building sector emissions by end use, 2016-2050.

Waste Emissions

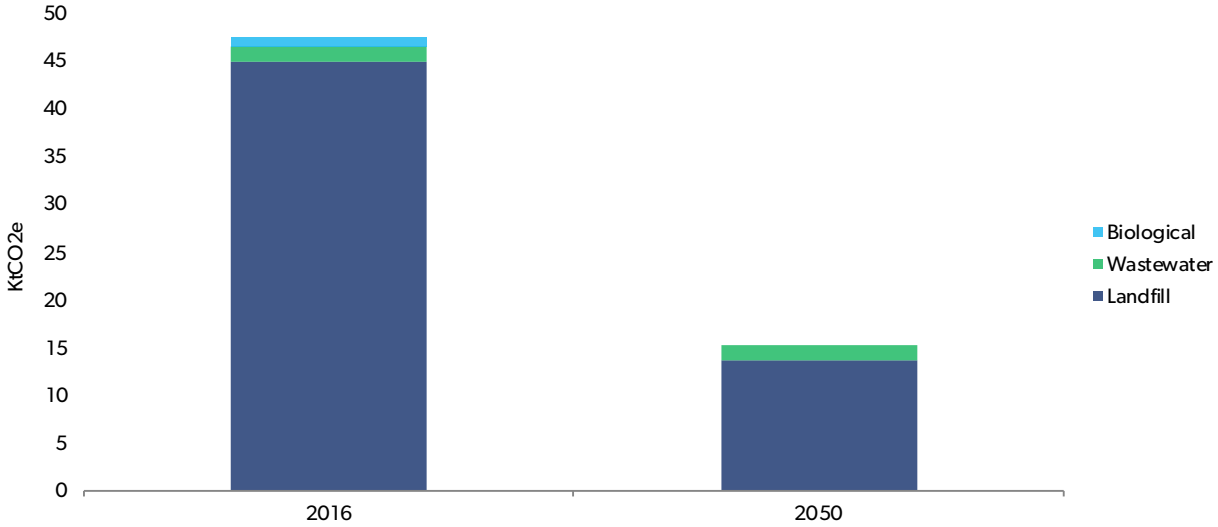


Figure 26. Net-zero pathway waste sector emissions by end use, 2016-2050.

Waste GHG emissions decline by approximately 70% in the NZS and will represent a projected 12% of GHG emissions by 2050. The City has already begun action on landfill waste and wastewater by capturing methane emissions through a landfill gas capture system and a wastewater treatment process that transforms methane to biogas. The NZS increases these efforts by diverting 95% of organic waste to an anaerobic digester where most GHG emissions are captured. The landfill gas capture system will also increase its capture rate from 15% to 80% by 2050, and water consumption rates decline by 25% due to behaviour change and improved technology.

APPENDIX D. Near-Term (2021-2025) Implementation Action Tables for the Corporation of the City of Thunder Bay

Legend

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
As identified in Appendix B: Detailed Sectoral Targets for the Net-Zero Pathway.	Specific projects or action areas that support associated targets.	Key milestones that are expected to be achieved by undertaking the priority actions.	Departments required for successful implementation.	Anticipated start date of each action.			

Note: Supporting departments and their roles will be identified and defined prior to initiating each action. All timelines and resources required are subject to annual review and subject to approval. Actions should be viewed as a starting point and are expected to change over time.

Table 8. Near-term actions to support Strategy implementation and integration in Corporate operations.

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
Implementation and Integration							
	Assign full time resources at the City to facilitate the implementation of the Strategy.	Resource assigned (1.0 FTE)	EarthCare	x			

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
	Establish a streamlined community GHG inventory and reporting process.	Reporting system/ strategy in place	EarthCare, Multiple Departments	x			
	Develop a 'climate lens' policy for municipal decision making to ensure City investments, policies, and programs support GHG reduction.	Creation of a Climate Lens Policy	EarthCare, Multiple Departments, City Council		x		
	Develop KPIs for monitoring and evaluation.	KPIs developed	EarthCare	x			
	Update Environment/ Community Sustainability Policy (04-02-02) in line with above.	Update, or integration, of Environment Policy	EarthCare		x		
	Assess finance mechanisms available to support Strategy implementation (ex, municipal bonds).	Finance mechanisms identified	EarthCare, Finance		x		
	Engage community stakeholders to help develop implementation strategies for the community and prioritize future work.	EarthCare Energy Working Group re-activated	EarthCare	x			
	Develop annual Action Plan outlining initiatives and priorities for upcoming year.	Annual Action Plan delivered to Council	EarthCare, Multiple Departments				x

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
	Promote energy and climate literacy in the Corporation and community.	Corporate Energy Workshop Update Community Engagement Strategy	EarthCare, Facilities, Fleet, & Energy Management				x

Table 9. Land Use and Natural Areas

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
A.1, A.3, A.5	Explore how the Zoning By-law can be used to support NZS implementation.	Zoning By-law update/ recommendations	Planning Services	x			
A.1, A.3, A.5	Assess policies that promote compact, mixed-use development to increase density, reduce sprawl, and reduce transportation GHGs.	Policy recommendations	Planning Services		x		
A.5	Identify mechanisms that provide incentives for the preservation, establishment, and maintenance of green infrastructure.	Policy/program recommendations	Parks & Open Spaces, Engineering, Planning Services		x		

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
A.4	Integrate NZS principles into Urban Forestry Management Plan and operations.	Updated Urban Forestry Management Plan	Parks & Open Spaces		x		

Table 10. Energy Efficiency in Buildings and Industry

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
B.6, B.7	Develop green building standards[55] to enable net-zero ready construction.	Green Building Standards adopted	Multiple Departments			x	
B. 6, B.10	Update Facility Design Standards policy (09-05-01) to enable net-zero ready construction.	Policy update	Multiple Departments		x		
B.6, B.7, B.8, B.9	Assess policies and strategies that address embodied carbon.	Policy recommendations	Multiple Departments	x			

[55] For more information and guidance on municipal green building standards, visit: https://www.cleanairpartnership.org/wp-content/uploads/2020/10/GDS-toolkit.pdf.

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
B.8, B.9	Conduct a feasibility study for establishing a Local Improvement Charge or alternative financing mechanism to support building retrofits.	Feasibility study/ business case	Multiple Departments	x			
B.10	Continue implementing the Corporate Energy Management Plan to achieve 5% reduction in energy consumption per year.	Annual energy consumption and GHG report (O. Reg. 507/18).	Facilities, Fleet & Energy Management				x
B.10,	Integrate NZS principles into next iteration of the Corporate Energy Management Plan.	Updated Conservation and Demand Management Plan (O. Reg. 507/18).	Facilities, Fleet & Energy Management			x	
B.10	Integrate NZS principles into existing energy audit process to determine net-zero readiness and create a priority retrofit list.	Priority retrofit list	Facilities, Fleet & Energy Management		x		
B.10	Identify municipal buildings that can support solar panel installations and create a priority list.	Feasibility study/ priority solar PV list	Facilities, Fleet & Energy Management, Synergy North			x	
B.9, B.11, B.12, B.13, B.14	Support the establishment of an ICI Energy Efficiency and Decarbonisation Working Group	Working group created	EarthCare	x			

Table 11. Renewable energy generation and procurement.

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
C.15, C.16, C.17, C.18	Identify mechanisms available to the Corporation to support local renewable energy generation.	Policy/program recommendations	EarthCare			x	
C.15, C.17, C.18	Assess opportunities for municipal owned renewable energy projects and partnerships.	Projects identified	EarthCare, Facilities, Fleet & Energy Management, Synergy North			x	
C.15, C.16, C.17, C.18	Advocate for changes to the energy system that support local renewable energy generation and non-wires solutions.	Communication with Province and Canada	Intergovernmental Affairs Committee				x

Table 12. Transport.

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
D.19, D.21	Continue implementing the Transportation Master Plan.	Increased sustainable modeshare	Transit, Infrastructure & Operations				x
D.21, D.22	Continue implementing the Active Transportation Plan Priority Route Networks.	Increased active modeshare, expansion of AT network (e.g., pedestrian and trail, cycling and trail)	Infrastructure & Operations				x
D.20, D.28	Review Corporate fleet policies, plans, and procedures. Update to include zero-emission vehicle targets.	Net-zero emissions vehicle target established	EarthCare, Facilities, Fleet & Energy Management		x		
D.20, D.28	Identify priority locations for installation of EV charging infrastructure for Corporate fleet, Transit, employees, and the public.	Expansion of EV charging network	Multiple Departments		x		
D.20	Develop a transit electrification strategy.	Electrification strategy	Transit, Facilities, Fleet & Energy Management		x		
D.19	Assess alternative transit fare structures to increase ridership.	Increased ridership	Transit, Finance				x
D.22, D.23, D24	Establish a bike share program (or support the launch of a private program).	Bike share program	Engineering, EarthCare		x		
D.22, D.24	Establish an Active Transportation Zone, and supporting policy, that prioritizes non-emitting travel.	Active Transportation Zone	Engineering, EarthCare, Planning Services			x	

Table 13. Waste and Wastewater

FOCUS AREA & SUPPORTING TARGET(S)	PRIORITY ACTIONS	MILESTONES	KEY PARTNERS	IMMEDIATE 2021	SHORT TERM 2022-2023	MEDIUM TERM 2023-2025	ONGOING
E.29, E.30	Integrate NZS principles into solid waste management operations.	Policy or policy recommendations developed	EarthCare, Environment	x			
E.29	Establish residential organics collection program (anticipated Provincial regulation).	Organics program established	Environment, Ontario			x	
E.29	Assess opportunity for partnerships with regional municipalities/ communities to establish an organic waste hub.	Partnership Commitment	EarthCare, Environment			x	
E.29	Assess feasibility of rerouting organics to an anaerobic digester.	Feasibility Study	Environment		x		
E.30	Increase existing landfill gas capture rate.	Technical Analysis & Monitoring	Environment, Synergy North, Tormont				x
E.31	Identify opportunities to reduce energy use in water and wastewater pumping process.	Technical Analysis	Environment				x

Financing the Near-Term Actions for the Corporation

A comprehensive review of available financing mechanisms to support Strategy implementation is included as an action item for the Corporation in Table 8. However, preliminary investigation reveals a number of potential financing and funding opportunities that could be leveraged to support the action items listed in Tables 9-13. While some projects will require additional expenditures, many of the actions listed above can be integrated into existing operations thereby reducing the cost of implementing GHG reduction initiatives.

INTERNAL FINANCING OPPORTUNITIES

The following is a non-exhaustive list of internal financing mechanisms available to the City:

I. Federal Gas Tax Fund

The federal Gas Tax Fund (GTF) is a permanent source of funding that can be used to fund municipal sustainability projects. The City receives over $6,000,000 annually from the GTF and

estimates indicate it will receive the following funds over the next three years[56]:

2021: $6,844,700

2022: $6,844,700

2023: $7,142,296

Funds could be allocated to infrastructure projects, public transit, community energy systems, solid waste management, and capacity building. Municipalities can pool, bank, and borrow against this funding, providing significant financial flexibility. On March 25, 2021, Deputy Prime Minister Freeland introduced Bill C-25 which would permanently rename the GTF to the Canada Community-Building Fund and provide an additional $2.2 billion to communities across Canada this year.

II. Energy Management Reserve Fund

Internal revolving energy funds like the existing Energy Management Reserve Fund can be leveraged to support energy efficiency programs and initiatives within the Corporation. A revolving fund uses the energy savings from implementing energy efficiency measures and invests them into a capital reserve fund dedicated to energy and emissions reduction projects.

The Corporate Energy Management Committee is in the process of reviewing the framework and application process for use of the Energy Management Reserve Fund to encourage uptake of the program.

III. Green Bonds

Under the Municipal Act, municipalities may raise revenues by accruing debt within reasonable limits. Some municipalities have begun issuing Green Bonds, or debentures, to finance environmental or climate-related projects. For example, the City of Ottawa has issued $602 million in Green Debentures since 2017 with plans to issue an additional $280 million in 2021.[57]The proceeds from these debentures have been used to fund stage 2 of Ottawa's Light Rail Transit (LRT) project.

In addition, Ontario is currently the largest issuer of Canadian dollar Green Bonds, with nine green issues totaling $8.0 billion.[58]The net proceeds of the Bonds are allocated to eligible projects throughout the province. Projects in the following categories are generally considered eligible: clean transportation; energy efficiency and conservation; clean energy and technology; forestry, agriculture, and land management; and climate adaptation and resilience. To date, Green Bond proceeds have helped fund 23 projects across three categories.

EXTERNAL FUNDING OPPORTUNITIES

The following is a non-exhaustive list of external funding opportunities available to the City:

[56] Association of Municipalities of Ontario. (2021). 2019-2023 Allocations. Retrieved from: https://www.gastaxatwork.ca/about-the-fund/allocations/2019-2023-allocations.

[57] Green Bonds City of Ottawa, retrieved from: https://ottawa.ca/en/business/research-and-data/investor-relations/green-bonds-city-ottawa#:~:text=The%20Green%20Debenture%20Program%20will,annually%20from%202022%20to%202025.

[58] Province of Ontario Green Bonds, retrieved from: https://www.ofina.on.ca/greenbonds/greenbonds.htm

I. Canadian Infrastructure Bank Growth Plan[59]

On October 1, 2020, Canada released a spending package of $10 billion to be administered by the Canada Infrastructure Bank (CIB) called the Growth Plan. The three year Growth Plan aims to strengthen Canada's economic growth and accelerate Canada's transition to the low carbon economy. Three initiatives in the Growth Plan relevant to the Net-Zero Strategy are:

1. $1.5 billion for zero-emission buses: To target the accelerated adoption of an estimated 4,000 zero-emission buses (ZEBs). Repayment of CIB's loans under the initiative are sourced solely from actual savings generated by the lower cost of operating ZEBs.
2. $2.5 billion for clean power: To support the generation, storage, and transmission of clean power. Transmission includes interprovincial and regional systems which moves clean power between Provinces.
3. $2 billion for energy efficient building retrofits: To help finance upfront capital costs of retrofits using long-term savings from efficiencies and operating cost savings as a repayment source.

In addition, $500 million has been allocated for project development and early works to shorten critical paths to construction.

II. Green Municipal Fund[60]

The Green Municipal Fund (GMF) is a $1 billion program delivered by the Federation of Canadian Municipalities (FCM) and funded by the Government of Canada. FCM offsets up to 50-80% of eligible project costs incurred by municipalities completing environmental projects. Funding is available in the form of grants and low interest loans for studies, pilot projects, and capital projects intended to reduce GHG emissions. As of March 2021, 63 funding opportunities are available under GMF.

III. Anticipated Federal Climate Funding

On December 11, 2020, Canada introduced a strengthened climate plan, A Healthy Environment and a Healthy Economy, to help achieve the national net-zero target. The proposed plan is supported by an initial $15 billion in investments in addition to the $60 billion committed under the Pan-Canadian Framework. These planned investments align with the goals set out in the NZS, signaling that there will be a number of opportunities to leverage federal funding for local climate action.

Canada has also introduced a proposed Federal Greenhouse Gas Offset System designed to encourage GHG emissions reductions/removals.[61] If passed, municipalities would be eligible to receive credits for reducing or removing GHG emissions. The first federal offset protocols being developed are: (1) landfill methane management, (2) improved forest management, (3) enhanced refrigeration systems, and (4) enhanced soil organic carbon.

[59] Canada Infrastructure Bank. (2020). $10B Growth Plan: Investing in New Infrastructure. Retrieved from: https://cib-bic.ca/wp-content/uploads/2021/03/Growth-Plan-101.pdf.

[60] For more information on the Green Municipal Fund visit: https://fcm.ca/en/programs/green-municipal-fund.

[61] Canada Gazette, Part I, Volume 155, Number 10: Greenhouse Gas Offset Credit System Regulations (Canada). Retrieved from: https://canadagazette.gc.ca/rp-pr/p1/2021/2021-03-06/html/reg1-eng.html

APPENDIX E. List of Ancillary Reports

- Baseline Inventory, Business-As-Planned Scenario and Energy Maps (2016-2050), May 2020
- Data, Methods, and Assumptions Manual, May 2020
- Net-Zero GHG Emissions Financial and Economic Analysis Summary, December 2020
- Supply and Constraints Analysis: Local Renewable Energy and Biomass, October 15, 2020
- **Access: EarthCare Thunder Bay - City of Thunder Bay**

APPENDIX F. Glossary

Air pollution	Degradation of air quality with negative effects on human health or the natural or built environment due to the introduction, by natural processes or human activity, into the atmosphere of substances (gases, aerosols) which have a direct (primary pollutants) or indirect (secondary pollutants) harmful effect.
Anthropogenic emissions	Emissions of greenhouse gases (GHGs), precursors of GHGs and aerosols caused by human activities. These activities include the burning of fossil fuels, deforestation, land use and land-use changes (LULUC), livestock production, fertilization, waste management and industrial processes.
Carbon dioxide	A naturally occurring gas, CO_2 is also a by-product of burning fossil fuels (such as oil, gas, and coal), of burning biomass, of land-use changes (LUC) and of industrial processes (e.g., cement production). It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a global warming potential (GWP) of 1.
Carbon price	The price for avoided or released carbon dioxide (CO_2) or CO_2-equivalent emissions. This may refer to the rate of a carbon tax, or the price of emission permits. In many models that are used to assess the economic costs of mitigation, carbon prices are used as a proxy to represent the level of effort in mitigation policies.
Carbon sequestration	The process of storing carbon in a carbon sink. This is more likely to be in natural lands, forested areas, and soils at the moment. The future may permit carbon sequestration technology.
Climate change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.' The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes.
Decarbonization	The process by which countries, individuals or other entities aim to achieve a zero-fossil carbon existence.
Equality	A principle that ascribes equal worth to all human beings, including equal opportunities, rights, and obligations, irrespective of origins.

Equity (Climate Change)	Equity is the principle of fairness in burden sharing and is a basis for understanding how the impacts and responses to climate change, including costs and benefits, are distributed in and by society in more or less equal ways. It is often aligned with ideas of equality, fairness and justice and applied with respect to equity in the responsibility for, and distribution of, climate impacts and policies across society, generations, and gender, and in the sense of who participates and controls the processes of decision-making. Intergenerational equity. Equity between generations acknowledges that the effects of past and present emissions, vulnerabilities and policies impose costs and benefits for people in the future and of different age groups.
Feasibility	The degree to which climate goals and response options are considered possible and/or desirable. Feasibility depends on geophysical, ecological, technological, economic, social, and institutional conditions for change. Conditions underpinning feasibility are dynamic, spatially variable, and may vary between different groups.
Fossil fuels	Carbon-based fuels from fossil hydrocarbon deposits, including coal, oil, and natural gas.
Green (natural) infrastructure	The interconnected set of natural and constructed ecological systems, green spaces, and other landscape features. It includes planted and indigenous trees, wetlands, parks, green open spaces and original grassland and woodlands, as well as possible building and street-level design interventions that incorporate vegetation. Green infrastructure provides services and functions in the same way as conventional infrastructure.
Greenhouse gas (GHG)	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself and by clouds. This property causes the greenhouse effect. Water vapour (H2O), carbon dioxide (CO_2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary GHGs in the Earth's atmosphere. Moreover, there are a number of entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).
Heat Pump	An electrical device that extracts heat or cool from the outside air or ground to heat or cool an interior space. Heat pumps have significantly higher energy efficiency than even the most efficient natural gas furnace.
Methane (CH4)	One of the six greenhouse gases (GHGs) to be mitigated under the Kyoto Protocol and is the major component of natural gas and associated with all hydrocarbon fuels. Significant emissions occur as a result of animal husbandry and agriculture, and their management represents a major mitigation option.
Mode share	The relative proportion of trips taken by a certain mode of transportation choice. The share generally reflects yearly travel data.

Net-zero emissions	Net-zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period. Where multiple greenhouse gases are involved, the quantification of net-zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon)
Net-zero energy	Refers to a community-scale system or aspect of the built environment that produces as much energy as it consumes. This can be a neighbourhood or building.
Pathways	The temporal evolution of natural and/or human systems towards a future state. Pathway concepts range from sets of quantitative and qualitative scenarios or narratives of potential futures to solution-oriented decision-making processes to achieve desirable societal goals. Pathway approaches typically focus on biophysical, techno-economic, and/or socio-behavioural trajectories and involve various dynamics, goals, and actors across different scales. 1.5°C pathway. A pathway of emissions of greenhouse gases and other climate forcers that provides an approximately one-in-two to two-in-three chance, given current knowledge of the climate response, of global warming either remaining below 1.5°C or returning to 1.5°C by around 2100 following an overshoot. Adaptation pathways. A series of adaptation choices involving trade-offs between short-term and long-term goals and values. These are processes of deliberation to identify solutions that are meaningful to people in the context of their daily lives and to avoid potential maladaptation.
Photovoltaic	A device that generates electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid.
Scenario	In this report, the term 'scenario' refers to a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions.
Well-being (Climate)	A state of existence that fulfils various human needs, including material living conditions and quality of life, as well as the ability to pursue one's goals, to thrive, and feel satisfied with one's life. Ecosystem well-being refers to the ability of ecosystems to maintain their diversity and quality.