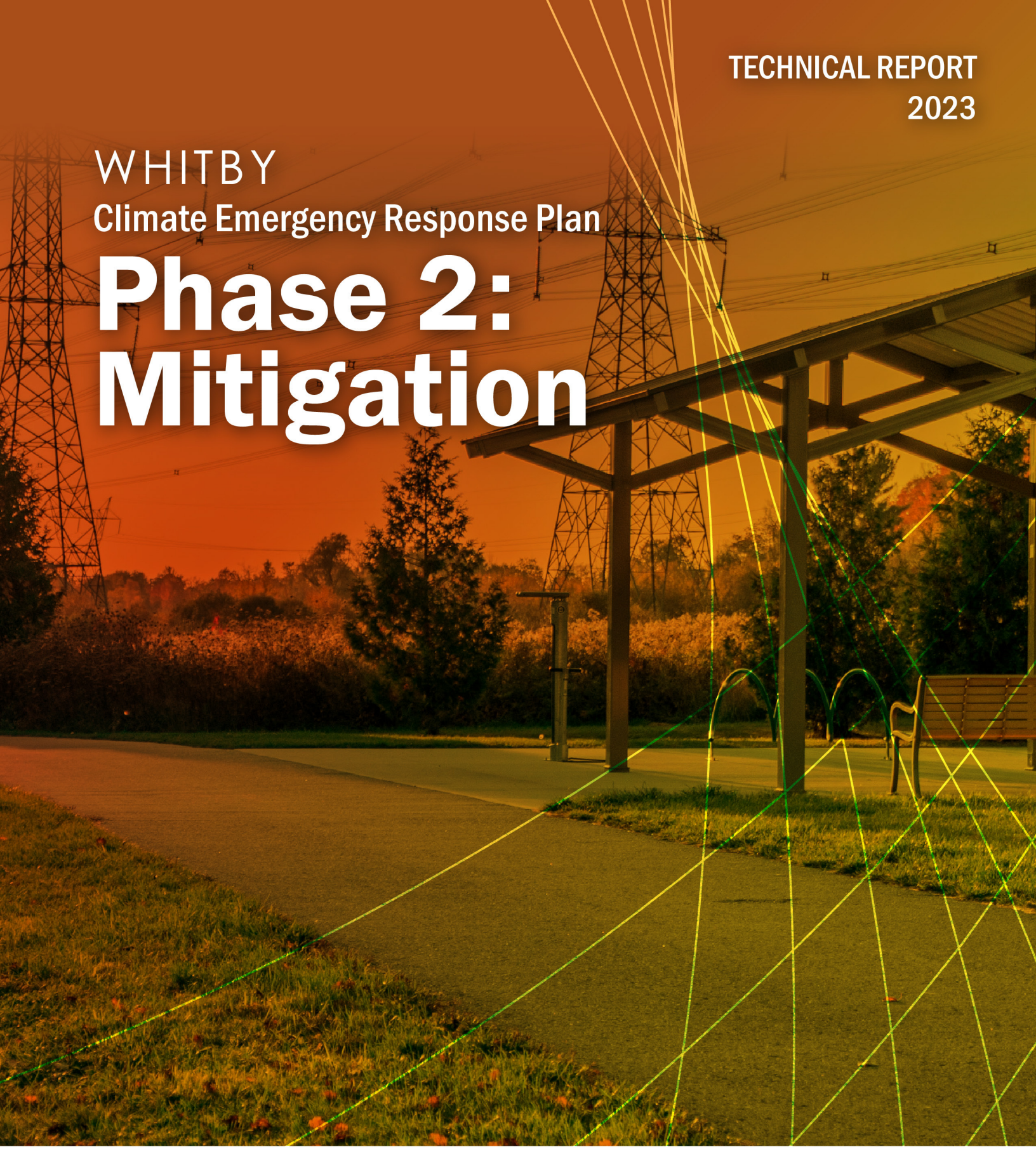
TECHNICAL REPORT
2023

WHITBY

Climate Emergency Response Plan

Phase 2: Mitigation



whitby.ca/ClimateChange

Whitby

Acknowledgements

Land Acknowledgement

We acknowledge the corporation of the Town of Whitby is located on the Lands of the Great Mississauga Nations who are signatories to the Williams Treaty. These communities include the Mississaugas of Scugog Island, First Nations of Alderville, Beausoleil, Curve Lake, Hiawatha, Chippewas of Georgina Island, and Rama. We believe it is important that we learn and work to reconcile the impact we, and those before us, have had on the original inhabitants of this land. On behalf of the Town of Whitby, we want to thank them for sharing this land and all its resources. At the Town of Whitby, our goal is to respectfully share in the responsibility of the stewardship and protection of these ancestral lands and waters and continue towards truth and reconciliation as we move forward as friends and allies with all First Nations, Inuit, and Métis people.

Project Team Acknowledgement

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We also acknowledge the many members of the community, the Whitby Sustainability Advisory Committee, Clean Air Partnership, The Atmospheric Fund, and Town of Whitby staff for their input, guidance, and support.

Abbreviations

BAU:	business-as-usual
BAP:	business-as-planned
CDD:	cooling degree day
CERP:	Climate Emergency Response Plan
EV:	electric vehicle
GHG:	greenhouse gas
GJ:	gigajoule
GPC:	GHG Protocol for Community-Scale GHG Inventories
HDD:	heating degree day
IPCC:	Intergovernmental Panel on Climate Change
kWh:	kilowatt-hour
MP:	Member of Parliament
MPP:	Member of Provincial Parliament
$MtCO_2e$:	megatonnes of carbon dioxide equivalents
MW:	megawatt
PJ:	petajoule
PPA:	power purchase agreements
PV:	photovoltaic
SBTN:	Science-Based Target Network
tCO_2e:	tonnes of carbon dioxide equivalents
UNFCCC:	United Nations Framework Convention on Climate Change

Units

Greenhouse gas emissions

1 $MtCO_2e$ = 1,000,000 tCO_2e

One megatonne of carbon dioxide equivalents ($MtCO_2e$) is equal to one million tonnes of carbon dioxide equivalents (tCO_2e).

Energy

1 MJ = 0.0001 GJ

1 GJ = 278 kWh

1 MWh = 1,000 kWh

1 GWh = 1,000,000 kWh

Disclaimer

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Letter From Mayor Elizabeth Roy

Climate change is an increasingly visible and undeniable challenge facing the Town of Whitby and communities around the world.

In 2019, Whitby Council formally declared climate change an emergency, recognizing the need to take immediate action to drastically reduce greenhouse gas emissions.

The Climate Emergency Response Plan answers that call to action. The Climate Emergency Response Plan, directly aligns with the priorities of the Community Strategic Plan endorsed by Council in June of 2023. Specifically, with Objective 2.1: "Demonstrate environmental leadership in sustainability and addressing climate change" of Strategic Pillar 2: Whitby's Natural & Built Environment.

Due to the complexity and different approaches necessary to fully understand the response needed to address climate change, the Climate Emergency Response Plan was divided into two phases: Phase 1: Resilience and Phase 2: Mitigation. Phase 1 involved the development of a Resilience Plan, which was approved by Council in September 2022.

Phase 2 of the Climate Emergency Response Plan has involved developing a Mitigation Plan to support every sector of our community in achieving net-zero emissions by 2045.

Although the Mitigation Plan relies on collective actions across the whole community, Whitby Council, staff, and departments will play a key role in implementing the actions and monitoring the success and progress of emission reductions. The Mitigation Plan is the first step in the low-carbon transition, but adaptive management and immediate action will be required to meet net-zero emissions by 2045.

Changing weather patterns and severe weather events present a significant threat to Whitby's quality of life and economic prosperity. Together, we can chart a path forward that educates our community about climate change, reduces risk, and eliminates greenhouse gas emissions, to ensure that our town, our natural resources, and our well-being are safeguarded for generations to come.

Sincerely,

Elizabeth Roy

Mayor

Executive Summary

The Town of Whitby Climate Emergency Response Plan (CERP) was developed in two phases. Phase 1: Resilience[1] focused on climate adaptation and identifies specific risks to the Town of Whitby (Town) and the community from climate change. It also identifies actions the Town and community can take to reduce the impacts and associated risks of climate change and provides a high-level overview of the costs and economic impacts of these actions, as well as the costs of inaction.

Phase 2: Mitigation focuses on climate mitigation and identifies the sources of greenhouse gas (GHG) emissions in Whitby, as well as the flow of energy across the community. It models the size of the climate challenge in Whitby and provides guidance and recommendations to reach the Town's community GHG emissions reduction target of net-zero by 2045.

The Mitigation Plan will enable the Town to take a leadership role in addressing climate change and promoting a sustainable future for its community. Achieving net-zero emissions is a collective responsibility, and the entire community, as well as regional, provincial, and federal organizations and governments will have to collaborate to implement the actions.

The Mitigation Plan's key insights include.

1. **Whitby has set a target to achieve community-wide net-zero greenhouse gas emissions by 2045.**

   The Town's net-zero emissions by 2045 target aligns with the Zero Carbon Whitby Framework and Region of Durham's reduction targets. Achieving a community-wide net-zero target requires significant emission reductions across all sectors. The Mitigation Plan models emission reductions and provides implementation actions for the following five key sectors: decarbonizing buildings, generating renewable energy, enhancing low-carbon transportation, reducing waste emissions, and reducing industrial and agricultural emissions.

2. **The Mitigation Plan was developed using input from interested and affected parties.**

   The Consultant project team used the International Association of Public Participation (IAP2) engagement framework to develop an Engagement Plan. Using a variety of engagement techniques, the project team gathered feedback from over 250 members of the public, including representatives from the Town and Region of Durham staff, residents, youth, non-profit organizations, and equity-deserving community members.

3. **The projected cumulative emissions eliminated by 2045 by the low-carbon scenario's modelled actions is 0.75 $MtCO_2e$, which equates to a 89% reduction in emissions.**

   While the low-carbon scenario includes major initiatives to improve energy efficiency and reduce emissions across the key sectors, in 2045 Whitby will have approximately 0.089 $MtCO_2e$ (or 89,013 tCO_2e) of residual GHG emissions. This means the Town will need to adaptively manage the Plan, and develop a strategy to address residual emissions.

[1] The CERP Phase 1: Resilience Plan can be accessed by visiting http://www.whitby.ca/climatechange.

4. **Equity is embedded into the targets and implementation actions.**

   The 2045 net-zero emissions target aligns with the United Nations Framework Convention on Climate Change's recommendation for wealthier countries and jurisdictions to achieve net-zero before 2050. The local equity impacts of Whitby's low-carbon scenario were analyzed using a co-benefits and co-harms analysis. The Implementation Plan prepared to support the Implementation Plan has been designed to maximise these health outcomes and economic prosperity while achieving maximum GHG emission reductions.

5. **The Mitigation Plan is a smart investment.**

   While substantial investments are required, the low-carbon scenario generates significant financial returns. Implementing Whitby's low-carbon scenario will result in a net benefit of $1.7 billion to the community and will decrease the average annual energy cost per household by $4,395 (72% reduction) by 2045.

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Responding to the Climate Emergency

A Call for Action

The world is in the grips of a climate emergency. Globally, regionally, and locally we have already experienced the severe strains of climate change on our natural, economic, and social systems. In 2023, the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report provided a dire warning about the impact global climate change will have on people and our planet. The Panel urged governments to take action to limit global warming to 1.5 degrees Celsius (°C) above pre-industrial levels.[2]

Following the IPCC's Sixth Assessment Report, in July 2023, the United Nations Secretary delivered a speech stating "the era of global warming has ended; the era of global boiling has arrived."[3] Immediate action is required. The actions taken in the next 10 years will be pivotal in setting society up to successfully address climate change, and stay within the IPCC's recommendation to limit warming to 1.5°C. Addressing climate change will require unprecedented changes to global energy systems, including vast changes to buildings, land use, transportation, and waste systems.

We have the solutions we need to start addressing the climate crisis, and many countries and cities have already undergone significant transitions to reduce their GHG emissions and adapt to climate change. Local governments and communities can continue to be catalysts for change, using their local expertise, commitment to community, and place-based action to reduce emissions. The Mitigation Plan has been developed as Phase 2 of the Town of Whitby's (Town) Climate Emergency Response Plan (CERP), which is the primary mechanism to respond to a changing climate across the community.

[2] Calvin, Katherine, Dipak Dasgupta, Gerhard Krinner, Aditi Mukherji, Peter W. Thorne, Christopher Trisos, José Romero, et al. "IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (Eds.)]. IPCC, Geneva, Switzerland." IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland., 2023, 1–34. https://doi.org/10.59327/ipcc/ar6-9789291691647.001.

[3] US Secretary-General Antonio Guterres speaks about climate change at UN headquarters in New York City. CNBC Television, 2023.

What Is a Climate Mitigation Plan?

A climate mitigation plan is a strategic document outlining actions that a government, business, organization, or residents need to take to reduce GHG emissions and address the impacts of climate change. It is a high-level plan outlining overall goals and objectives, and the strategies and actions necessary to achieve them.

Climate mitigation plans differ from feasibility studies. A mitigation plan acts as a guide for administrative bodies to reduce climate change impacts in their communities. In contrast, a feasibility study serves as a standard initial phase in executing strategic plans, and plays a pivotal role in evaluating various aspects of a project's potential outcomes, such as economic, technical, operational, and organizational factors.

WHITBY'S CLIMATE IS CHANGING

Whitby is already experiencing the impacts of climate change. In the summer of 2023, while this document was being written, Canada was experiencing a record-setting wildfire season and above-normal temperatures. Almost all Canadian provinces and territories endured forest fires during this time, with over 165,000 square kilometres of land being burned.[4] Locally, Whitby received air quality warnings from Environment Canada and Air Quality Ontario as a result of the wildfires in Quebec.[5] Not only are these air quality warnings a stark reminder of the impending and existing impacts of climate change, but they also highlight the disproportionate impacts these hazards have on at-risk community members' health, safety, and livelihoods.

Climate projections completed by the Climate Atlas of Canada show that if GHG emissions continue to increase at the current rate, Whitby will experience higher annual temperatures, increased annual precipitation, shifts in seasonal frost dates, a longer frost-free season, and more days above 30°C.[6] Figure 1 (next page) shows some of the projected climate changes in Whitby between 2021 and 2080.

[4] Calculated September 2023 from: Canada, Natural Resources. n.d. "Canadian Wildland Fire Information System | National Wildland Fire Situation Report." Cwfis.cfs.nrcan.gc.ca. https://cwfis.cfs.nrcan.gc.ca/report.

[5] Advertiser, Ajax News. 2023. "'High Levels of Air Pollution': Durham Air to Be Affected by Wildfire Smoke." DurhamRegion.com. June 27, 2023. https://www.durhamregion.com/news/high-levels-of-air-pollution-durham-air-to-be-affected-by-wildfire-smoke/article_222cc4b6-aa08-5340-9125-9218c1cf554b.html.

[6] "Municipality Oshawa | Climate Atlas of Canada." n.d. Climateatlas.ca. Accessed October 27, 2023. https://climateatlas.ca/data/city/449/annual_meantemp_null_85/line.

	1976-2005	2021-2050			2051-2080		
Change	Mean	Low	Mean	High	Low	Mean	High
Number of +30°C days per year	7	8	23	40	25	49	74
Date of Last Spring Frost	April 29	April 2	April 19	May 7	March 20	April 10	April 30
Date of First Fall Frost	Oct. 14	Oct. 8	Oct. 27	Nov. 16	Oct. 18	Nov. 7	Dec. 1
Frost-Free Season (days)	165	161	187	216	178	209	243
Mean annual temperature	7.4°C	8.2°C	9.5°C	10.9°C	10.2°C	11.7°C	13.4°C
Annual precipitation	830mm	718 mm	884 mm	1061 mm	742 mm	910 mm	1094 mm

Figure 1. Projected climate changes for Whitby, 2021-2080, based on Climate Atlas of Canada's High Carbon Climate Future projections for Oshawa.[7]

These projected changes will drive a wide range of climate hazards in Whitby. The Phase 1: CERP analysis focused on the most significant of these hazards. Based on spatial analysis and consultation with the Project Advisory Group and the public, the Resilience Plan's analysis found flooding[8] and heat to be the highest priority hazards within Whitby. Additional hazards such as disease, agricultural impacts, and severe storms were identified as having serious potential impacts to people and places in Whitby.

These projected climate changes will also lead to behavioural changes among community members, which in turn will impact energy use trends. For example, an increase in the number of extreme heat events (+30°C) and length of the frost-free season will lead to an increase in the number of cooling degree days (CDDs).[9] These hotter periods lead to increased demand for cooling buildings, which directly impacts energy consumption and GHG emissions. Although heating degree days[10] (HDDs) will decline due to shorter frost seasons and warmer winter temperatures, the impacts of the increased CDDs will exceed the reductions of energy use and GHG emissions during the winter months.[11]

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[7] Data and graphic adapted from: "Municipality Oshawa | Climate Atlas of Canada." n.d. Climateatlas.ca. https://climateatlas.ca/data/city/449/annual_meantemp_null_85/line.

[8] Flooding can take three forms: coastal, riverine, and overland.

[9] A cooling degree day (CDD) is a measurement designed to quantify the demand for energy needed to cool buildings. It is the number of degrees that a day's average temperature is above 18°C, which is the temperature above which buildings need to be cooled.

[10] A heating degree day (HDD) is a measurement designed to quantify the demand for energy needed to heat a building. It is the number of degrees that a day's average temperature is below 18°C, which is the temperature below which buildings need to be heated.

[11] "Municipality Oshawa | Climate Atlas of Canada." n.d. Climateatlas.ca. Accessed October 27, 2023. https://climateatlas.ca/data/city/449/hdd_2030_85/line.

Climate Action in Whitby

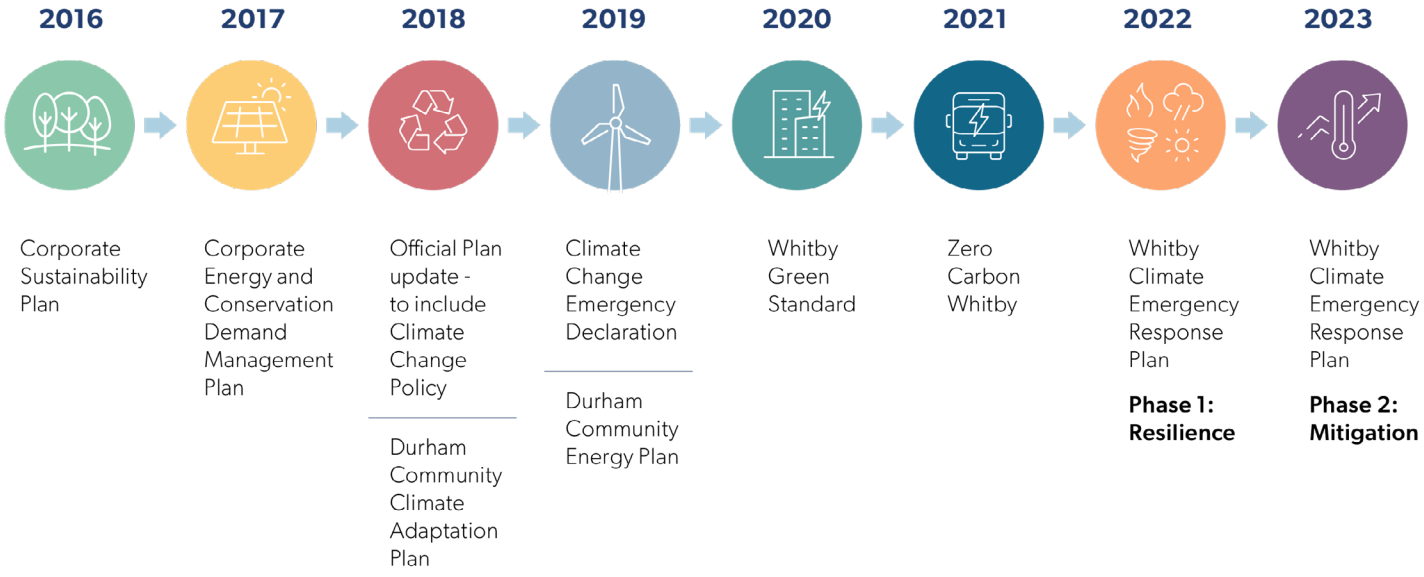

Figure 2. The Town and Region's climate plans, policies and programs 2016 - 2023.

In June 2019, the Town's Council declared a climate emergency, recognizing the need for immediate, transformative action to reduce Whitby's GHG emissions and ensure the community is prepared for the inevitable impacts of climate change (Figure 2).

The Town and the Region of Durham have developed several plans to address the climate emergency. Durham has developed the Community Climate Adaptation Plan[12], which is a high-level strategic plan to help improve the resilience of the entire region. Additionally, the Community Energy Plan[13] outlines a pathway to reduce GHG emissions across the entire region, and the Durham Standard[14] sets energy performance requirements for new regional facilities and buildings.

Since 2016, the Town has implemented several climate mitigation plans and programs. The Whitby Green Standard was developed to improve efficiency and resilience of new development across the community. The Town is supporting the Region of Durham to develop an incentive program to encourage developers to build higher-energy performance residential buildings.

The Zero Carbon Whitby Framework was developed to identify a pathway to net-zero emissions for the Town's corporate operations,[15] and many of the Town-led actions have been incorporated into the modelling undertaken for the development of the CERP: Mitigation Plan. Taking action on corporate emissions has allowed the Town to demonstrate leadership in its climate change response efforts. As a result, the Town is now well-prepared to embark on the next stage of climate action: community adaptation and mitigation.

[12] Durham Region's Community Climate Adaptation Plan can be accessed by visiting: https://www.durham.ca/en/living-here/adaptation-and-resilience.aspx#Reports-and-Updates.

[13] Durham's Community Energy Plan can be accessed by visiting: https://www.durham.ca/en/citystudio/resources/Durham-Community-Energy-Plan-Part-1.pdf.

[14] The Durham Standard can be accessed by visiting: https://pub-durhamregion.escribemeetings.com/filestream.ashx?DocumentId=1238.

[15] The Zero Carbon Whitby: The Corporate Plan to Reduce Greenhouse Gas Emissions and the Zero Carbon Whitby: The Costing Study to Eliminate Greenhouse Gas Emissions 2022-2025 can be accessed by visiting http://www.whitby.ca/climatechange.

THE NEXT PHASE OF CLIMATE ACTION: THE CLIMATE EMERGENCY RESPONSE PLAN

Recognizing the need for a detailed, community-level plan to identify ways to adapt to climate change and reduce GHG emissions across the community, in 2022 the Town began developing the CERP.

The CERP was developed in two phases. Phase 1: Resilience[16] focused on climate adaptation and identifies specific risks to the Town and the community from climate change. It also identifies actions the Town and community can take to reduce the impacts and associated risks of climate change and provides a high-level overview of the costs and economic impacts of these actions, as well as the costs of inaction. The Resilience Plan was approved by the Town's Council in 2022 and is currently in the implementation phase.

Phase 2: Mitigation focuses on climate mitigation and identifies the sources of GHG emissions in Whitby, as well as the flow of energy across the community. The development of the Mitigation Plan included modelling the size of the climate challenge in Whitby. The Plan provides guidance and recommendations to meet the Town's community-wide GHG emissions reduction target of net-zero by 2045.

Phase 2 develops a pathway to dramatically reduce emissions. Implementing the Mitigation Plan's low-carbon scenario will result in improved energy efficiency in all sectors (i.e., residential, institutional, commercial and industrial [ICI] buildings; transportation; and municipal operations) and will create opportunities for economic growth and community development. The low-carbon scenario and Implementation Plan is rooted in Whitby's unique local context, including the work already underway through the CERP Phase 1: Resilience Implementation Plan and Zero Carbon Whitby Framework, and the Town's current programs and initiatives.

Once the Mitigation Plan is approved by Council and implementation commences, there will be opportunities to integrate actions from both the Resilience and Mitigation Plans. Several actions identified in the CERP Phase 1: Resilience - Implementation Plan have already been updated based on the modelling and engagement results in the Mitigation Plan. For example, the Governance and Leadership actions identified in the Resilience Plan have been updated to include climate mitigation.

The Town will need to review and update the CERP Phase 1: Resilience and CERP Phase 2: Mitigation Plans every five years. This will allow the Town to track, monitor, and report on progress towards the goals and update the targets and modelled scenarios (identified as Action 1.7 in the CERP Phase 1: Resilience - Implementation Plan). Together, CERP Phase 1: Resilience and Phase 2: Mitigation will guide the next steps of climate action in Whitby.

[16] The CERP Phase 1: Resilience Plan can be accessed by visiting http://www.whitby.ca/climatechange.

Whitby's Greenhouse Gas Emissions Target

In September 2022, the Town's Council set a science-based target to reach net-zero community emissions by 2045. To meet this target, Whitby will need to eliminate 0.84 megatonnes of carbon dioxide equivalent emissions ($MtCO_2e$) by 2045 (or 841,079 tonnes of carbon dioxide equivalents [tCO_2e]) across the community.[17]

In addition, Council approved the following short-term and medium-term targets:

- 20 percent GHG emissions reduction by 2025; and
- 40 percent GHG emissions reduction by 2030.

What Does the Size of This Undertaking Mean?

Achieving the community 2045 reduction target is equivalent to 187,166 average gas-powered cars being driven for a year,[18] or using an equivalent of 358,257,045 litres of gas.[19] For comparison, the average Canadian uses 1,268 litres of gas per year.[20]

Developing the Equity-Based Reduction Target

Science-based targets (SBTs) are specific, measurable, and time-bound goals grounded in scientific data. They serve as actionable objectives that enable local governments to align with broader societal sustainability objectives and adhere to global constraints on natural resources and emissions. To be considered science-based, targets must align with the Paris Agreement's goal to prevent a global temperature increase above 1.5°C. The Paris Agreement includes commitments from all major emitting countries, including Canada, to cut emissions by 2050.

However, the United Nations Framework Convention on Climate Change (UNFCCC) recognizes that not all countries and cities have equal capacity to reduce emissions by 2050. The Framework therefore recommends that wealthy countries and jurisdictions achieve net-zero targets before 2050 to allow poorer countries a fair and equitable opportunity to reduce poverty without additional limitations from decarbonization.

The Town's community-wide targets align with the equity-based target adopted in the Town's Zero Carbon Whitby Framework, the corporate framework for reducing GHG emissions. The Zero Carbon Whitby Framework applied the Science-Based Target Network's (SBTN) recommendation to develop the corporate target of net-zero GHG emissions by 2045. The Town followed the SBTN's methodology and three principles of science (driven, equity, and completeness) to develop the community-wide equity-based targets (Table 1, next page).

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[17] It should be noted that the targets approved by Council were relative to the 2019 baseline emissions, as the Climate Emergency Response Plan Phase 2: Mitigation-Interim Report Number: (CAO 18-22) presented the targets relative to the 2019 baseline emissions. However, as part of the development of the Mitigation Plan, an updated baseline inventory was completed for 2020. The year 2020 was used because it is the most recent year with a robust set of data from the census. The baseline emissions and model calibration are discussed in detail in the Understanding Whitby's Climate Impact section.

[18] The United States Environmental Protection Agency's August 2023 equivalency calculator assumed the weighted average combined fuel economy of cars and light trucks was 22.9 miles per gallon and the average vehicle miles travelled was 11,520 miles per year.

[19] Calculated August 2023 from: US EPA. 2015. "Greenhouse Gas Equivalencies Calculator." United States Environmental Protection Agency. Accessed August 28, 2015. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results.

[20] Government of Canada. 2023. "CER – Provincial and Territorial Energy Profiles – Canada." Canada Energy Regulator. Accessed August 23, 2023. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-canada.html#:~:text=Canadians%20are%20some%20of%20the.

Table 1. Summary of Town's community targets and the Mitigation Plan's alignment with the Science-Based Target Network's three principles.

SBTN'S REQUIREMENTS	THE TOWN'S COMMUNITY TARGETS ALIGNMENT
PRINCIPLE 1: SCIENCE DRIVEN	
Do you have a clear heating target of 1.5°C?	☑ Net-zero by 2045 aligns with the IPCC's recommendations for a 1.5°C target
Do you have a defined carbon budget and have you calculated an agreed overshoot?	☑ The Zero Carbon Whitby Framework's Carbon Budget
Are you clear on which scenario your target follows and where the starting point is?	☑ Modelled a low carbon scenario and developed climate actions to meet each target ☑ 2020 Baseline Year
PRINCIPLE 2: EQUITY	
Does your target look at the national-level considerations for equity, such as those listed in your country's Nationally Determined Contribution (NDC)?	☑ Co-benefits and co-harms analysis completed ☑ Aligns with Canada's NDC Just Transition and 30% reduction target by 2030
Does your target consider historical emission contributions and intergenerational emissions?	☑ Actions identified in the Mitigation Plan will reduce the burden on intergenerational emissions
PRINCIPLE 3: COMPLETENESS	
Is your target city-wide focused on one sector (i.e., energy)?	☑ City-wide target ☑ All sectors ☑ Measures emission and energy reductions
What scope does your target focus on (i.e., scope 1, scope 2, and scope 3)? Or a combination of scopes?	☑ Measures emission reductions for scope 1, scope 2, and scope 3
Does your target focus on some or all of these GHGs: Carbon Dioxide (CO_2), hydroflourocarbons (HFCs), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), sulfur hexaflouride (SF_6)?	☑ Scenario modelled ☑ CO_2 ☑ CH_4 ☑ N_2O ☑ Mitigation Plan reports on carbon dioxide equivalent

While the Town's interim targets for 2025 and 2030 achieve a smaller reduction than recommended by the OPCC and C40,[21] these targets are tailored to Whitby's specific context and emissions portfolio, reflecting what is realistically achievable. By adopting these targets, Whitby is committing to accelerating its emissions reduction efforts by aligning with the UNFCCC's recommendation for net-zero by 2045. There are opportunities for the Town to reduce emissions in line with the OPCC and C40 interim targets which have been detailed in the "Addressing Residual Emissions" section of this Plan. In addition, updating the community-wide targets can be further explored during the CERP update every five years.

How Does the Town Track Progress To Its Targets?

There are multiple programs for cities and towns to develop and track progress to their targets. The Town already shares progress on its climate actions with the following programs:

The Cities Race to Zero is a global campaign to build momentum and leadership in climate action in line with the Paris Agreement goals. The campaign relies on global partners to ensure cities are aligned on the science-based targets required to achieve net-zero GHG emissions.

The Global Covenant of Mayors is an international alliance of cities, local governments, and partners driving climate action in their communities by collaborating with city and regional networks, national governments, and international institutions.

The Carbon Disclosure Project (CDP) is a not-for-profit global disclosure system for local, regional and state level governments, investors, and companies. The CDP evaluates progress against similar jurisdictions to assist cities and towns in identifying gaps and opportunities, and benchmarking performance.

[21] The SBTN recommends local governments align their SBT targets with methodologies from the One Planet City Challenge (OPCC) and the C40 Cities Climate Leadership Group, both of which meet the Carbon Disclosure Project's (CDP) requirements. The key distinctions between the OPCC, C40, and the Town's interim targets lie in the Town's use of scope 1, scope 2, and scope 3 emissions to establish the 2025 and 2030 targets, with a 2020 baseline. In contrast, the OPCC and C40 only require scope 1 and scope 2 emissions and use 2018 and 2015 baselines, respectively.

Creating a Community-Informed Plan

Community Engagement

Climate change will affect all community members, with a disproportionate impact on at-risk community members. To ensure the Mitigation Plan responds to the community's needs, we engaged with key interested and affected parties to understand their challenges and perspectives.

An Engagement Plan based on the International Association for Public Participation (IAP2) framework was carried out to gather input from key groups, including Town staff, residents, youth, non-profit organizations, and equity-deserving community members. Engagement objectives included:

- To inform community members about the creation of the Mitigation Plan and how they can participate in the process.
- To involve community members in determining their preferred engagement style for the Mitigation Plan.
- To involve diverse community members in documenting their lived experiences with climate change, and sharing feedback on the Plan's goals, and their preferred approach to climate action in Whitby.
- To involve the Project Team members in documenting their approach to climate action in Whitby, their local climate change concerns, and challenges and opportunities for the Mitigation Plan.
- To inform interested and affected parties about how their feedback and participation shaped the Plan.

Engagement activities included pre-engagement interviews, monthly meetings with the Project Team members, presentations to the Town and Region of Durham's existing advisory committees, engagement with the Whitby Sustainability Advisory Committee, focus group discussions, and a community survey.

KEY INSIGHTS

Engagement by the Numbers

- 152 community members participated in the Community Survey: Resilience Plan, which engaged community members on mitigation actions related to buildings.[22]
- Seven Whitby Advisory Committees and Durham Advisory Committees were engaged.[23]
- 66 community members participated in the Community Survey: Mitigation Plan.
- Seven community members participated in the Equity and Social Services Focus Group.
- 14 meetings were hosted with members of Whitby's CERP Project Team.
- One one-on-one meeting was held with a representative from Elexicon Energy.

What We Heard

In the community engagement sessions, we commonly heard the following recommendations and considerations which were used to inform the Mitigation Plan:

1. The community of Whitby needs to act urgently to address climate change. This includes raising awareness of climate change and climate actions by providing education on these topics, and recruiting community champions to participate in climate action events.
2. The Town should leverage and expand funding support for all community members to implement climate actions, with priority given to equity-deserving and at-risk community members.
3. The Town should expand active transportation networks to support community members in adopting active transportation for shorter trips.
4. The Town should position themselves as a leader in climate action by implementing the Zero Carbon Whitby Framework's actions, and share lessons learned and success stories from Town-led actions to encourage community members to take action.
5. The Town should increase awareness campaigns and provide educational materials highlighting programs and showing the benefits and costs of different climate actions.

[22] The Community Survey: Resilience Plan was designed to engage participants on mitigation strategies related to buildings. The feedback received from these survey questions informed the Mitigation Plan.

[23] These committees included: Accessibility Advisory Committee, Active Transportation and Safe Roads Advisory Committee, Whitby Diversity and Inclusion Advisory Committee, Whitby Sustainability Advisory Committee, Durham Region Roundtable on Climate Change, Durham Environmental Advisory Committee, and Durham Agricultural Advisory Committee.

Technical Modelling

Employing the CityInSight methodology, the SSG project team used data from the Town, provincial and federal governments, and other sources to develop a baseline and three scenarios of Whitby's community emissions. Future emissions were modelled out to 2045 and 2050, which allowed us to model the full emission reduction potentials of climate actions such as industrial operations.

There are four modelled aspects that allow us to understand Whitby's current energy use and emissions, and the future energy use and emissions resulting from policy decisions and practices within the community:

- A **baseline year** was used to develop a community-wide GHG inventory for 2020 using data for buildings, transportation, population, and energy consumption from utilities, the Town, and other sources. The year 2020 was used because it is the most recent year with a robust set of data from the census.
- A **business-as-usual (BAU) scenario** was used to account for the projected population growth, new building growth, transportation patterns, and decreased GHG emissions resulting from improvements to the electricity grid, federal fuel efficiency standards, and heating and cooling requirements in buildings. This scenario projects the emissions and energy use if no additional plans, policies, programs, and projects are implemented within Whitby.
- A **business-as-planned (BAP) scenario** was used to project emission and energy reductions based on locally available utility, transportation, and demographic data, and projections for population and empowerment changes. The scenario uses current policies and practices to project the emissions and energy levels in 2045. It assumes no additional policies or climate action interventions are completed beyond the existing policies, and serves as a benchmark for measuring the effectiveness of Whitby's existing efforts.
- A **low-carbon scenario** was used to project emission and energy reductions in order to mitigate the effects of climate change. The scenario uses a combination of current policies and practices, such as those identified in the Zero Carbon Whitby Framework, and additional measures such as increasing renewable energy generation, improving energy efficiency, and reducing the consumption of fossil fuels, to develop a pathway to the Town's climate targets. This scenario goes beyond the BAP scenario by identifying additional policies and climate action interventions.

Model Calibration: Eliminating Uncertainties in Baseline and Business-as-Usual, Business-as-Planned, and Low-Carbon Scenarios

During the first stages of the modelling process, the CityInSight model was set up with energy stocks, energy use data and initial model parameters, and was calibrated to the base year.[24] During calibration, the model generates historical outcomes, known as parameter adjustments, that ensure the model can replicate observed data. In addition, variables for which there are two independent data sources are calibrated in the model. For example, the model calibrated building energy use (derived from buildings data) against actual electricity data from the electricity distributor.

While 2020 was shaped by unprecedented changes caused by the COVID-19 pandemic, including changes to gasoline purchases, commercial energy use, and residential energy use, the model calibration process and use of independent data sources allowed us to develop modelling results that are unique to Whitby and reduce data anomalies.

Although gasoline purchases declined in 2020, the transportation emissions were calculated based on trips per kilometre using the origin-destination matrix from the Town and Region of Durham. The model was calibrated using the 2011 origin-destination matrix and projections were based on the 2031 origin-destination matrix, which means the mode-share emissions for the baseline year and future projections would not have been impacted by the COVID-19 pandemic. Between 2019 and 2021, the decrease in energy use in commercial buildings was offset by an increase in energy use in residential buildings. As a result, the total electricity consumption (kWh) and natural gas remained consistent during this period.

[24] For additional model details see the Ancillary Report: Data, Methods, and Assumptions Manual.

Understanding Whitby's Climate Impact

To develop a low-carbon scenario, we must first understand the community's current energy use and associated emissions (the baseline), and the potential energy use and emissions trajectory resulting from changes in demographics, practices, policies, and legislation (the BAU and BAP scenarios).

Our Starting Point: Whitby's Baseline Energy and Emissions

In 2020, the community of Whitby emitted a total of 0.84 $MtCO_2e$. Based on Whitby's population, this is the equivalent of 130 gigajoules (GJ) of energy use per capita (or per person) and 6.16 tCO_2e per capita which are below the average Canadian and Ontario per capita emissions and energy use (Table 2).

Whitby's per capita emissions and energy use are lower than the Canadian and Ontario averages due to differences in the emissions portfolios. While the transportation and stationary emissions are the largest contributors at all levels, Ontario and Canada's averages are higher due to more emissions derived from fugitive emissions, agriculture, manufacturing, and industrial sectors.

Table 2. 2020 per capita emissions and energy use comparison for Canada, Ontario, and Whitby.

	CANADA[25]	ONTARIO[26]	WHITBY
2020 per capita emissions (tCO_2e/capita)	17.7	10.1	6.16
2020 per capita energy use (GJ/capita)	300	209	130

The baseline emissions show the amount of GHG emissions produced in each sector and the required reductions needed to achieve net-zero emissions. Figure 3 (next page) illustrates the community-wide GHG emissions by sector for Whitby in 2020. Notably, 58% of the total community emissions are derived from only two sectors: transportation and residential buildings.

[25] Canada, Environment and Climate Change. 2022. "Greenhouse Gas Sources and Sinks in Canada: Executive Summary 2022." Www.canada.ca. April 14, 2022. https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2022.html.

[26] Government of Canada, Canada Energy Regulator. 2022. "CER – Provincial and Territorial Energy Profiles – Ontario." Www.cer-Rec.gc.ca. July 28, 2022. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-ontario.html#:~:text=Ontario.

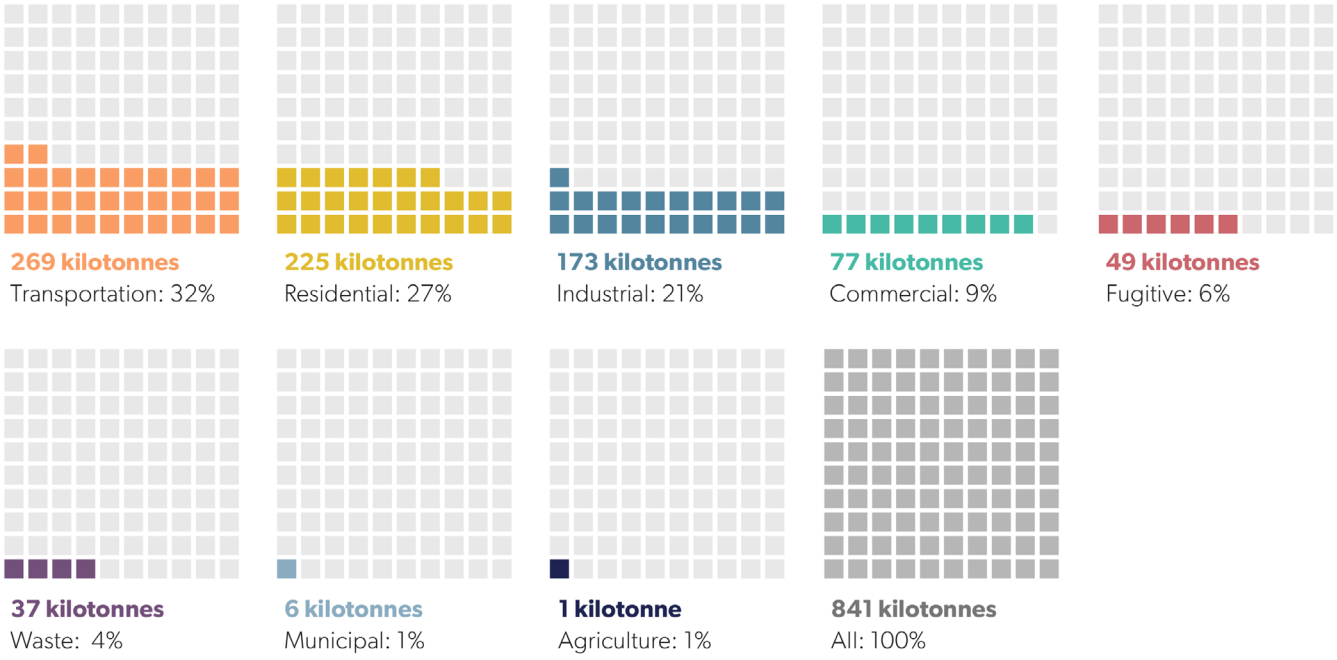

Figure 3. Whitby's 2020 GHG emissions ($ktCO_2e$).

Whitby's Future Energy Use and Emissions

BUSINESS-AS-USUAL SCENARIO ENERGY USE AND EMISSIONS

Once the baseline was completed, a business-as-usual (BAU) scenario was modelled to project population and economic growth (Figure 4, next page), and the community-wide energy use and emissions to 2045. The BAU scenario assumes that the Town, other levels of government, and other sectors, such as industrial and local businesses, do not implement any of the energy- and emissions-reducing measures they have committed to. Essentially, the scenario is used to illustrate a "climate inaction" scenario.

Based on the BAU scenario, Whitby's emissions and energy use are projected to change between 2020 and 2045 as follows:

- Community emissions increase by 68%, from 0.84 $MtCO_2e$ to 1.4 $MtCO_2e$;
- Per capita emissions decrease by 12%, from 6.16 tCO_2e/person to 5.5 tCO_2e/person;
- Community energy use increases by 65%, from approximately 17.75 million GJ to 29.24 million GJ; and
- Per capita energy use decreases by 13% relative to the baseline, from 130.02 GJ/person to 113.12 GJ/person.

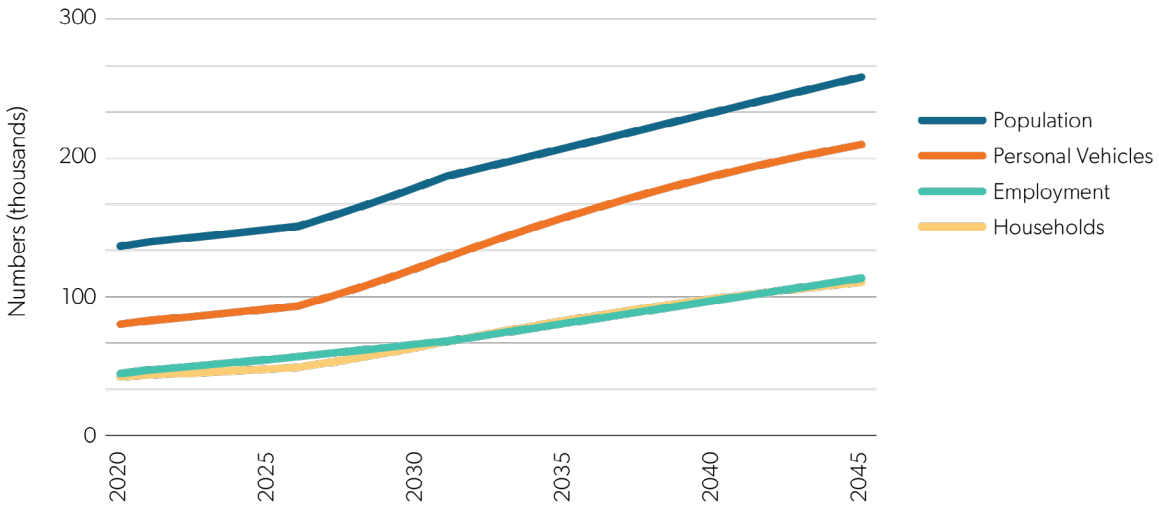

Figure 4. Projected population, number of personal vehicles, number of households, and employment (in full-time equivalent person-years) from 2020 to 2045.

BUSINESS-AS-PLANNED ENERGY USE AND EMISSIONS

Once the baseline and BAU scenarios were completed, a business-as-planned (BAP) scenario was modelled to projected future energy use and resulting emissions based on local and regional projects and initiatives,[27] and provincial and federal regulation and legislation. Examples of the assumptions modelled from each level of government include:[28]

- **Local:** The Town's Whitby Green Standard was used to project energy performance improvements in new buildings outlined in the Tier 1 to Tier 4 performance requirements.
- **Regional:** The Region of Durham's Transportation Master Plan was used to project mode-share shifts, a measure of transit and active transportation uptake, based on planned and funded infrastructure projects.
- **Provincial:** Electricity grid emissions factors were updated based on provincial policy, and increases in the grid emissions factor of electricity were based on current provincial policy.
- **Federal:** Electric vehicle (EV) adoption timelines were projected based on the federal government's light-duty vehicle targets.

[27] These include projects and initiatives that are already underway or are approved with dedicated funding.

[28] Additional assumptions are documented in the Ancillary Report; Data, Methods and Assumptions, which was developed as part of the project to create the Mitigation Plan.

In the BAP scenario, Whitby's emissions and energy use are projected to change between 2020 and 2045 as follows:

- Community emissions increase by 4% relative to the baseline, from 0.84 $MtCO_2e$ to 0.87 $MtCO_2e$;
- Per capita emissions decrease by 44% relative to the baseline, from 6.1 tCO_2e/person to 3.38 tCO_2e/person;
- Community energy use increases by 13% relative to the baseline, from 17.75 million GJ to 20.06 million GJ; and
- Per capita energy use decreases by 40% relative to the baseline, from 130.02 GJ/person to 77.6 GJ/person.

What Does This Tell Us About Whitby's Climate Impact?

Even with the work being undertaken at each level of government, Whitby's emissions are projected to increase by 2045 compared to the 2020 baseline. This is largely due to the anticipated population growth, and new buildings, vehicles, and employment required to accommodate these new residents. Between 2020 and 2045, Whitby's population was modelled to increase by 89%, from 136,352 to 258,512 (see Ancillary Report: Data, Methods and Assumptions for data sources).

A deeper dive into the BAP emissions sources and energy use illustrates where action needs to be taken in Whitby to reduce GHG emissions during this time of intense urbanization and growth.

Emissions Sources

Under the BAP scenario, by 2045, buildings are projected to contribute 75% of the total community emissions in Whitby, making buildings the largest emissions source. Between 2020 and 2045, building emissions are projected to increase by 37%, from 0.48 $MtCO_2e$ to 0.66 $MtCO_2e$. When looking at the building emissions relative to the total emissions across the community (0.87 $MtCO_2e$), 26% of projected 2045 emissions come from residential buildings (0.22 $MtCO_2e$), 20% from industrial buildings (0.17 $MtCO_2e$), 8% from commercial buildings (0.07 $MtCO_2e$), and less than 1% combined from municipal (i.e., Town-owned) and agricultural buildings.

The transportation sector is projected to be the second-largest source of emissions in the BAP scenario. Emissions from transportation are projected to contribute 16% of the total community emissions in 2045 (0.14 $MtCO_2e$). However, total emissions from the transportation sector are projected to decrease by 48% from 2020 to 2045, mostly attributable to the federal mandate on EV passenger vehicles.

The remaining emissions are from fugitive,[29] waste, and agriculture, contributing 6%, 2%, and 0.5%, respectively, of the projected 2045 emissions (Figure 5, next page).

[29] Fugitive emissions are unintentional emissions generated from a leakage of gases or vapours from pressurized containers.

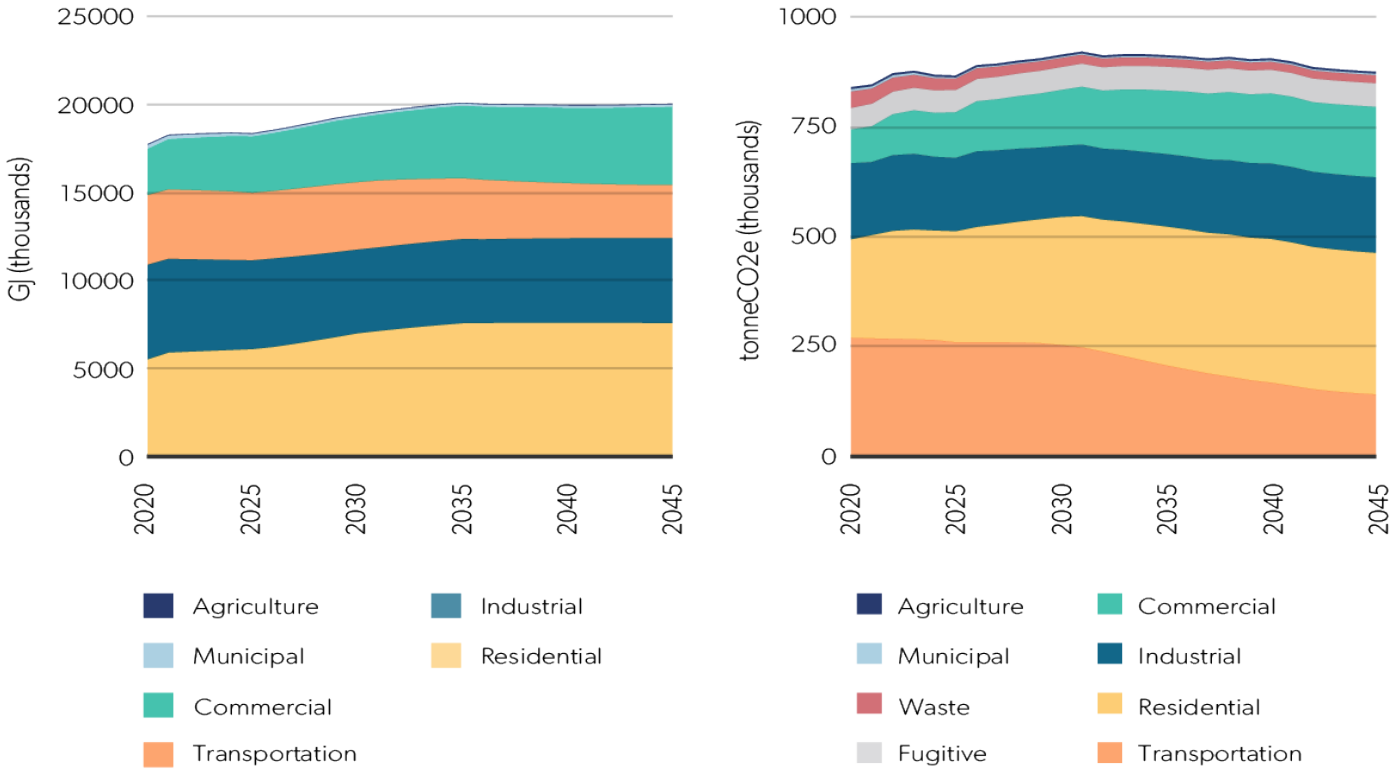

Figure 5. Projected energy use (left) and emissions (right) by sector between 2020 and 2045 in the business-as-planned scenario in Whitby.

Energy Sources

In 2045, energy use in Whitby is projected to increase by 13% relative to the 2020 baseline (from 17.75 million GJ to 20.05 million GJ), which is mostly attributed to Whitby's population growth and new construction (Figure 6). Natural gas is expected to make up 44% of the total energy use, due to its continued use in buildings for space heating and cooling. Electricity use from the grid is projected to make up 41% of total energy use, largely due to its use in buildings, EV charging, and industrial processes. The remaining fuel sources of biomass, diesel, district energy, fuel oil, gasoline, local electricity generation, propane, and wood are projected to contribute less than 5% each.

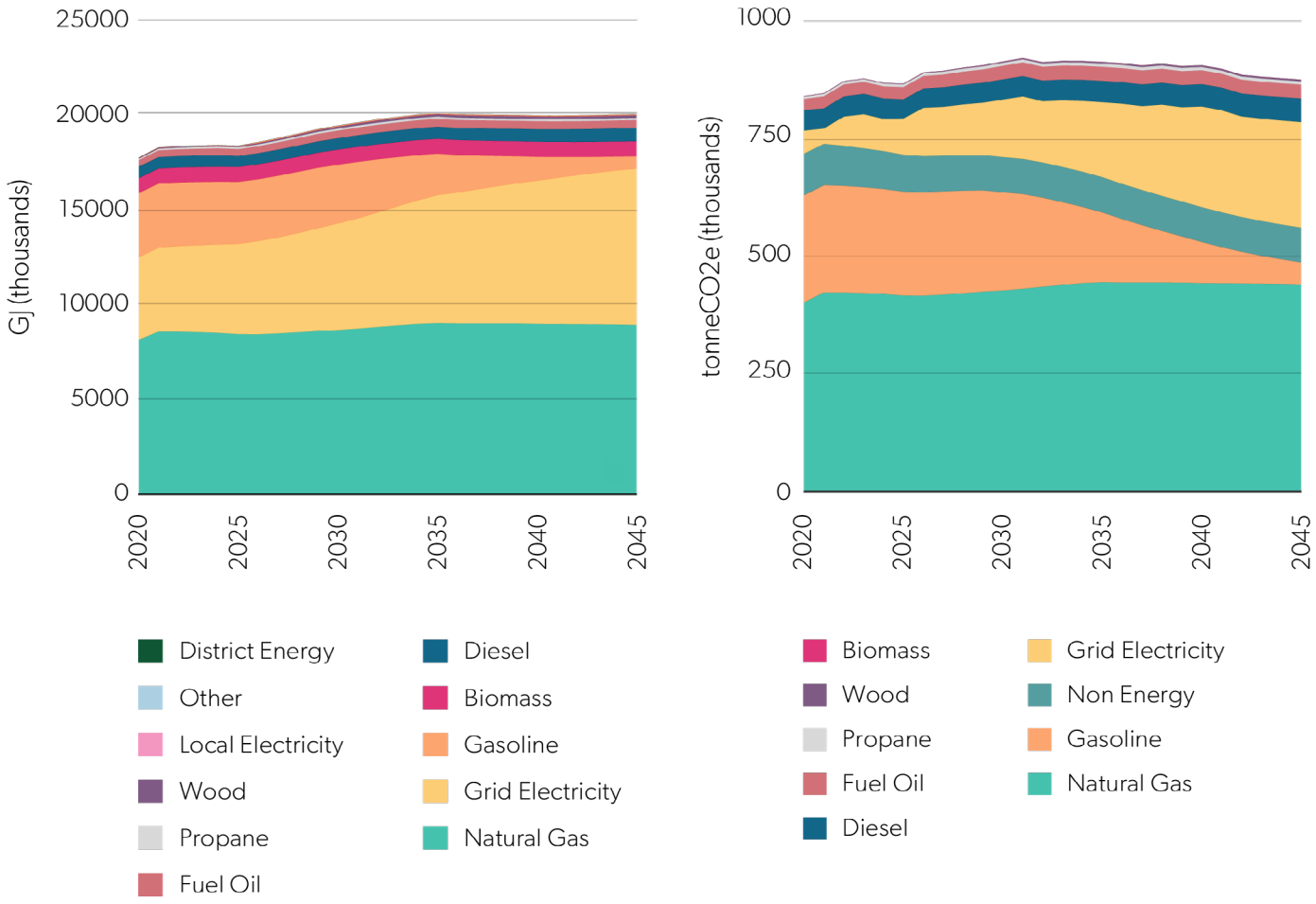

Figure 6. Projected energy use (left) and emissions (right) by fuel type between 2020 and 2045 in the business-as-planned scenario in Whitby.

Transitioning to a Low-Carbon Future

The BAP scenario highlights existing efforts in Whitby to reduce community GHG emissions and demonstrates where additional actions are required in the low-carbon scenario to reach the net-zero target by 2045 and interim targets for 2025 and 2030.

To model the most effective way to meet the Town's community targets, potential actions were identified from SSG's climate actions catalogue, identified within the Town's existing plans, and researched specifically for Whitby. The appropriateness and feasibility of these actions were determined with the following considerations:

- The necessity of the action to reduce emissions;
- The sequencing of actions to optimize emission reductions using the "avoid, reduce, improve, and replace" prioritization of climate actions;
- The co-benefits, co-harms, and equity impacts of the action;
- Suggestions and concerns heard through engagement activities; and
- Alignment with local, regional, provincial, and federal regulations.

Climate Action Sequencing: Avoid, Reduce, Improve, and Replace

The Mitigation Plan has been designed to sequence climate actions in the order of the planning hierarchy of: avoid and reduce, improve, and replace.[30] This approach means that climate actions are prioritized in the following order: avoiding and reducing activities that contribute to energy consumption, maximizing energy efficiency improvements, and switching to low-carbon energy sources for the remaining demand. This means that for every kWh of electricity saved through energy efficiency improvements is a kWh that does not need to be generated—this ultimately reduces the burden on the electricity grid.

[30] Addressing residual emissions focuses on the final two categories: remove and offset.

Summary of the Low-Carbon Scenario Modelling

The low-carbon scenario is projected to reduce Whitby's annual emissions by 20% by 2030, 48% by 2035, and 89% by 2045, relative to 2020.[31] The projected cumulative emissions eliminated by 2045 by the low-carbon actions is 0.75 $MtCO_2e$.

Even though the low-carbon scenario includes major actions to improve energy efficiency across all sectors and shifts to renewable energy sources using current technology, in 2045, approximately 0.08 $MtCO_2e$ of residual GHG emissions are projected to remain (Figure 7, next page). It should be noted that the full emission reduction potential of some actions would not be realized until 2050. For example, many of the local industrial sectors have 2050 decarbonization strategies which means the full emission reductions are not achieved until 2050. When taking into consideration the actions that take longer to achieve their full emission reduction potential, the low-carbon scenario decreases emissions by 93% by 2050, relative to 2020.

The largest emissions contributors are transportation and buildings. Although the low-carbon scenario achieves significant reductions in both of these sectors, there are still residual emissions that will need to be addressed beyond 2045. The low-carbon scenario projects that the transportation sector will still produce emissions, as the replacement of heavy trucks is projected to start in 2035 when low-emission vehicle options are expected to be more widely available. However, the scenario does not assume that trucks will be retired before the end of their lifecycle, so some will be replaced with low-emission vehicles after 2045.

In the low-carbon scenario, small amounts of emissions are expected to remain in the buildings sector from natural gas. It is likely that new technologies, and potentially even new fuel sources, will address these remaining emissions before 2045 (Figure 8, page 30). Additionally, the scenario projects that the industrial sector will also continue to produce emissions, as many of the industrial sectors in Whitby have decarbonization strategies for 2050 instead of 2045.

[31] The following section reports on GHG emission reductions relative to 2030, 2035 and 2045. These were selected to align with the Town's 2030 interim target, to provide a benchmark during the CERP update, and to align with the net-zero by 2045 target.

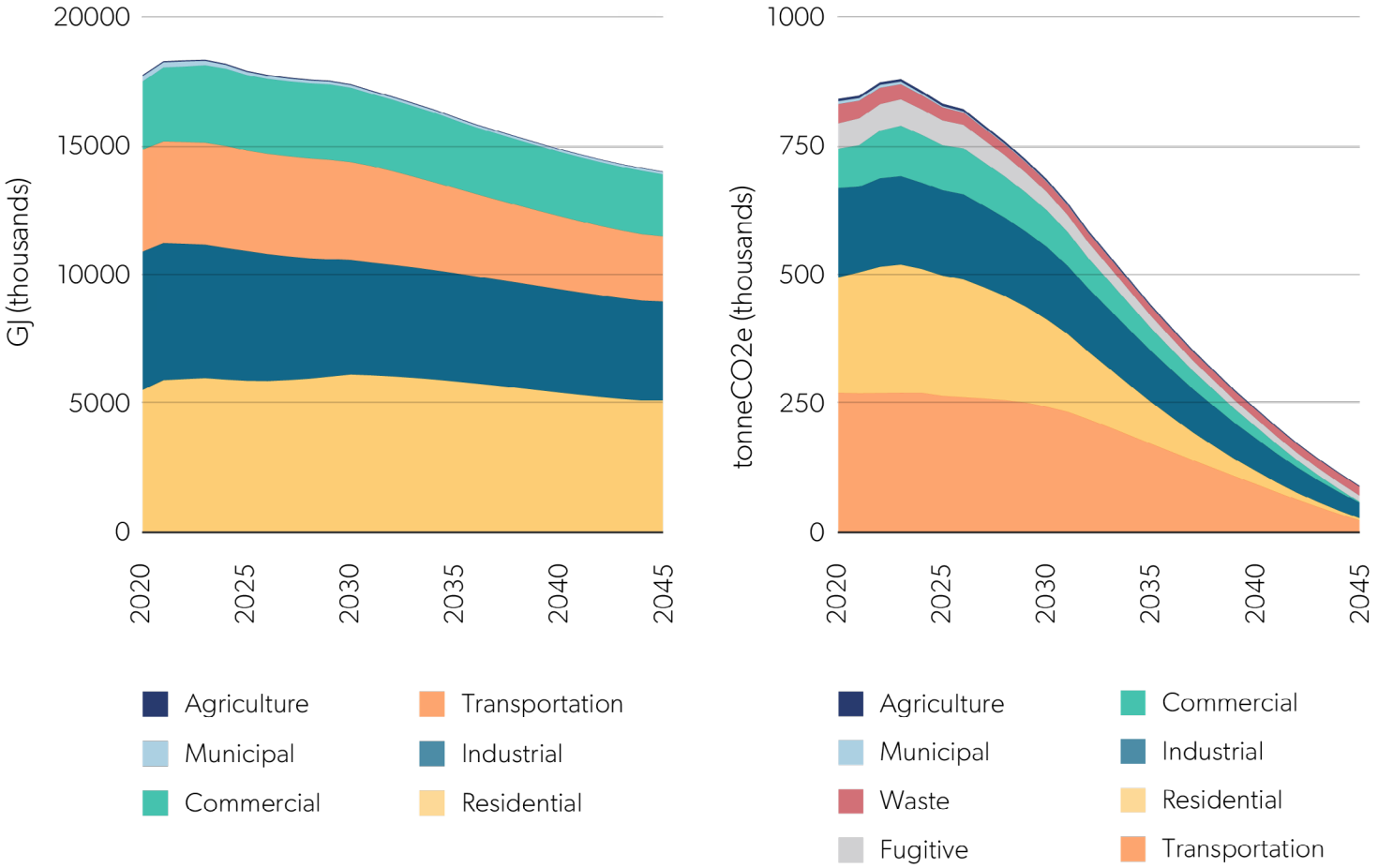

Figure 7. Projected energy use (left) and emissions (right) by sector between 2020 and 2045 in the low-carbon scenario in Whitby.

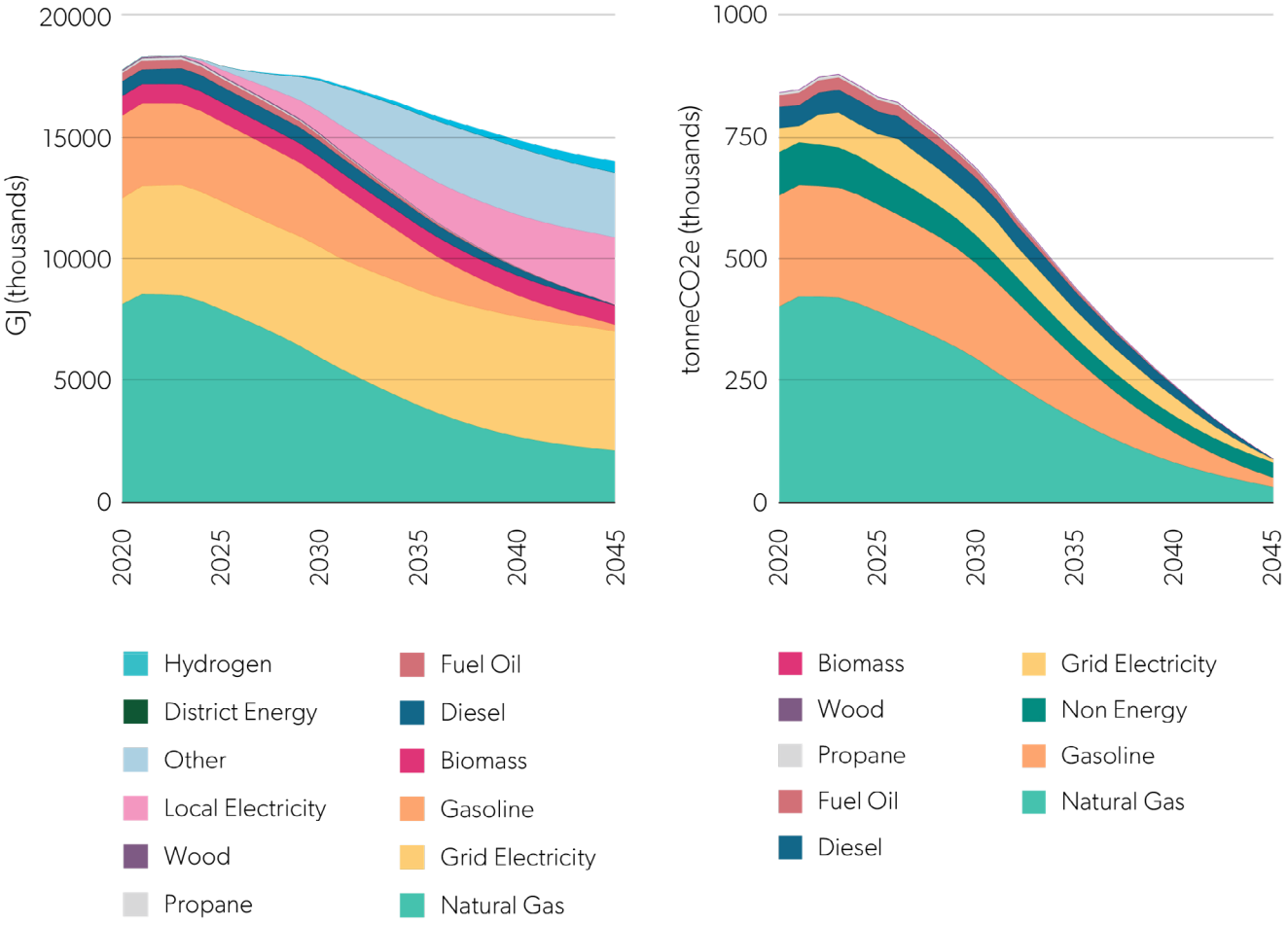

Figure 8. Projected energy use (left) and emissions (right) by fuel type between 2020 and 2045 in the low-carbon scenario in Whitby.[32]

[32] Non-energy includes emissions from waste, fugitive, and agricultural livestock production.

Figure 9 illustrates the projected emissions across the BAU, BAP, and low-carbon scenarios. In the low-carbon scenario the decrease in emissions between 2020 and 2045 is a result of all of the modelled actions for buildings, transportation, energy, waste, industrial, and agricultural sectors.

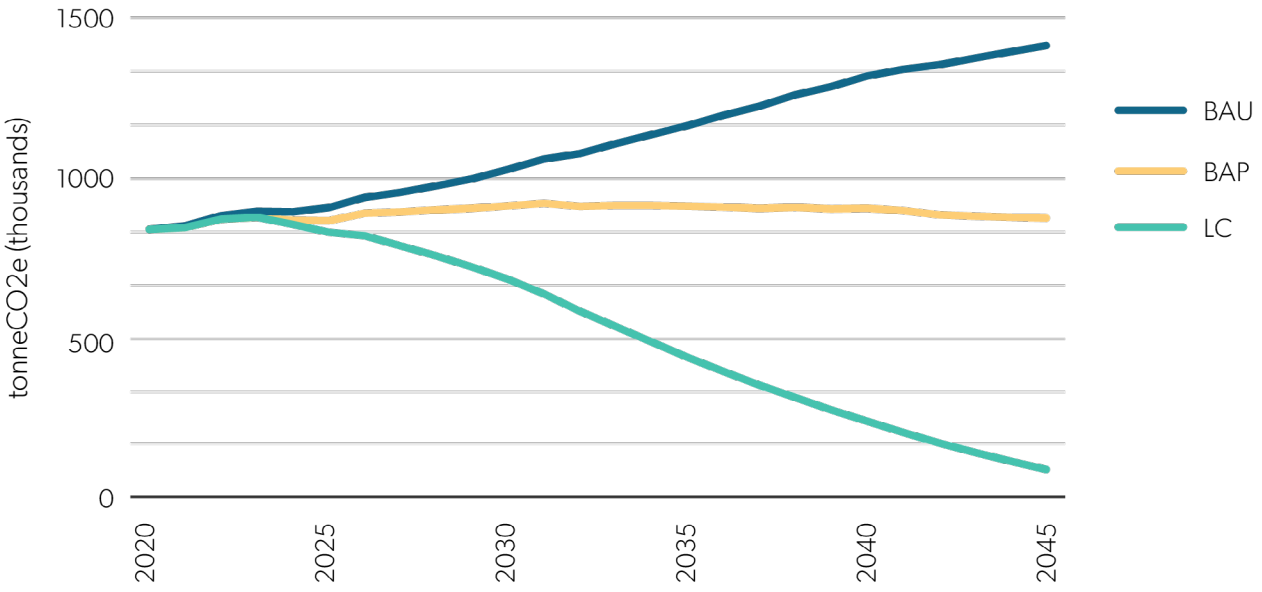

Figure 9. Whitby's projected emissions from 2020 to 2045 for the business-as-usual (BAU), the business-as-planned (BAP), and low-carbon (LC) scenarios.

In 2045, Whitby would still be emitting approximately 89,013 tCO_2e (or 0.089 $MtCO_2e$) of residual emissions—this is known as the carbon liability. To meet net-zero emissions by 2045, the Town will need to identify and implement opportunities to accelerate planned actions and identify new actions, support carbon sequestration and carbon capture, and/or purchase carbon offsets. These opportunities are further explained in the "Addressing Residual Emissions" section of the Plan.

Whitby's Low-Carbon Actions

With a low-carbon scenario modelled, we now know how to best prioritize collective community action to put Whitby on the path toward the net-zero emission target by 2045. The low-carbon scenario models the projected future emissions, whereas the Implementation Plan presents the low-carbon pathway outlining the steps and strategies required to achieve these future emissions. Climate actions are grouped into the sectoral changes known as Big Moves, which includes:

- Decarbonizing buildings;
- Generating renewable energy;
- Enhancing low-carbon transportation;
- Reducing waste emissions; and
- Reducing industrial and agricultural emissions.

The Town will need to undertake additional actions related to Governance and Leadership, and will need to address residual emissions—these actions are detailed in the following sections.

While the direction of the low-carbon scenario is driven by the target of net-zero emissions by 2045, the specific strategies identified in the Implementation Plan focus on the 2030 interim targets and setting the stage for long-term emission reductions. These strategies were influenced by several factors, including:

- Research on best practices;
- Industry-leading expertise and knowledge;
- Input from the Project Team; and
- Input from the community received from community focus groups and survey responses.

The climate actions across the Big Moves are meant to support one another and are designed to maximize GHG reductions, financial return and community co-benefits. Although adaptive management will be important as technologies and conditions change, the Implementation Plan will not generate the same outcome if only some actions are completed or if they are implemented out of order from the recommended sequencing in the Implementation Plan. For example, completing building retrofits before renewable energy installations reduces the capital cost for installing solar photovoltaic (PV) and increases the GHG reductions, and adding solar PV before vehicle electrification ensures that clean electricity is available for EV charging.

Implementing the Zero Carbon Whitby Framework and Costing Study

The Mitigation Plan modelled municipal initiatives related to Town-owned buildings, new construction, and fleet. These targets and associated climate actions align with the actions identified in the Zero Carbon Whitby Framework, thereby preventing redundant investments while showing the cumulative impact of the GHG emissions in the context of the community-wide emissions target. The actions from the Zero Carbon Whitby Framework have already been presented to the Town's Council. Although these will require future investments, they are not incremental investments beyond what is identified in the Zero Carbon Whitby Framework's Costing Study.

Understanding the Climate Action Impacts

The wedge diagram (Figure 10) illustrates how Whitby's low-carbon actions for decarbonizing buildings, generating renewable energy, enhancing low-carbon transportation, reducing waste emissions, and reducing industrial and agricultural emissions work together to reduce emissions between 2020 and 2045. The key feature of the wedge diagram is that each modelled climate action is represented using a wedge in which the size shows the magnitude of emissions reductions that can be achieved through implementation of the action.

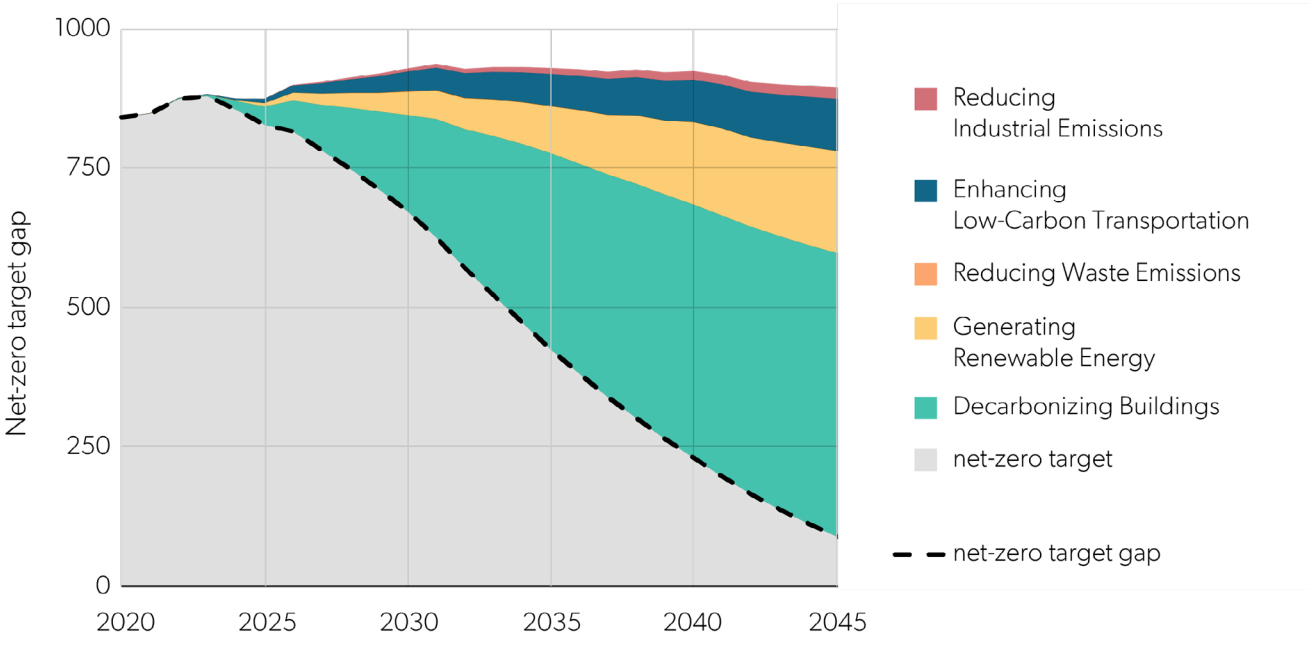

Figure 10. The emissions reduction impact of each sector in the low-carbon scenario.

Figure 11. Diagram summarizing Whitby's Low-Carbon Actions.

The Town's Role in Climate Action

The first step in implementing the Implementation Plan is establishing the Town's roles and responsibilities. In addition to the Governance and Leadership actions identified in the Implementation Plan, the Town will play an important role in promoting community involvement, and monitoring and evaluation.

It is recommended that the Town manage the implementation of the Plan using four full-time equivalent positions (three existing positions and one new position), however exploring additional staffing within the Sustainability Division will bolster the team's ability to implement actions within the recommended time frame. The recommended positions include:

- Director of Strategic Initiatives (existing position), responsible for championing the CERP Phase 1: Resilience and CERP: Phase 2: Mitigation Plans across the Town administration and strategic decision-making, and integrating the Plans into other strategic initiatives at the Town.
- Project Manager, Sustainability and Climate Change (existing position), responsible for providing project management and strategic-level guidance to the Sustainability Division by ensuring the actions required by the Town are integrated into the appropriate policies and procedures, the department's annual work plans and budgets, and ensuring the relevant project leads, sponsors, and supporters take ownership of their actions.
- Climate Change Coordinator (existing position), responsible for implementing the CERP Phase 1: Resilience Plan.
- An additional Climate Change Coordinator (new position), responsible for implementing the CERP Phase 2: Mitigation Plan.

GOVERNANCE AND LEADERSHIP

Action 1.1 Update the Governance and Leadership actions outlined in the Climate Emergency Response Plan (CERP) Phase 1: Resilience - Implementation Plan to include climate change mitigation considerations.

The CERP Phase 1: Resilience - Implementation Plan identified Governance and Leadership actions to incorporate adaptation and resilience considerations into the Town's operations, governance, and decision-making processes. These actions have been updated to include climate change mitigation considerations as identified in the CERP Phase 2: Mitigation - Implementation Plan.

MONITORING AND EVALUATION

Action 1.2 Monitor and report on climate change mitigation.

Monitoring and evaluating the Mitigation Plan and the Implementation Plan is key to adaptively managing the Plan's implementation and ensuring there are opportunities to respond to advancements in technology and resources (i.e., funding). To ensure sufficient monitoring and reporting of the Mitigation Plan and Implementation Plan, the following sub-actions have been included in the Implementation Plan:

1.2.1 Program/Initiative: Convene a "CERP: Resilience and Mitigation Roundtable" of Town staff, Region of Durham staff, and Elexicon Energy representatives to:

- Determine the allocation of both Implementation Plan's actions into departmental work plans;
- Identify internal operational and capital funding opportunities for each sub-action;
- Determine the Town's role in each sub-action and identify internal leads;
- Build and leverage external partnerships; and
- Adaptively respond to changes in sub-actions, external funding opportunities, and technological developments.

1.2.2 Program: With support of the Project Manager, Sustainability and Climate Change, dedicate two staff members (one existing position and one new position beginning 2026) from the Town's Strategic Initiatives department to oversee the implementation of CERP Phase 1: Resilience and CERP Phase 2: Mitigation, and develop annual work plans identifying activities, budgets and schedules to achieve the sub-actions.

1.2.3 Program: Track, update, and share annual progress and reporting on CERP Phase 2: Mitigation Plan's implementation. Activities can include tracking the annual progress on each of the Implementation Plan's tracking metrics and GHG inventories to the Annual Sustainability Report, investigating opportunities to update implementation actions, and submitting applications for third-party certification programs (i.e., Carbon Disclosure Project).

1.2.4 Program: Complete an annual GHG inventory according to the GHG Protocol for Community-Scale (GPC) GHG Inventories, the standard accounting protocol for GHG emissions, to enable the Town to track its progress against targets and support reporting to CDP and the annual indicator report.

Tracking and monitoring greenhouse gas emissions

Tracking and monitoring the progress of achieving the Mitigation Plan's low-carbon pathway can be conducted through completing the annual GHG inventory according to the GPC and remodelling the baseline and three scenarios (BAU, BAP, and low-carbon scenario) to project future GHG emissions during the 5-year update of CERP.

The GPC provides calculation guidance by emission source and tracking changes and goal setting methodologies. Completing the annual GHG inventory will provide a general insight into the progress made towards achieving in-term community targets. This annual GHG inventory will be reported through CDP and summarized in the Annual Sustainability Report.

The remodelling of the baseline and three scenarios to project future GHG emissions during the 5-year update of CERP will provide a more detailed means of tracking GHG emissions reductions and will allow the Town to identify additional actions to progress toward achieving the community reduction targets of net-zero by 2045.

FUNDING AND GRANT APPLICATIONS

Action 1.3 Monitor and apply for additional funding.

1.3.1 Program/Initiative: The Town's Climate Change Coordinator will monitor and apply for funding and grant opportunities.

Several financial tools can be used to facilitate the low-carbon transition, including:

1. **Federation of Canadian Municipalities (FCM):** The FCM is an advocacy group that offers grants and loans for municipal projects related to climate mitigation, resilience, and environmental projects. The Implementation Plan details some of the programs available related to the sub-actions.
2. **Property Assessed Clean Energy (PACE) programs:** PACE programs are an important tool for encouraging uptake of energy efficiency upgrades. Funding the PACE and commercial PACE (C-PACE) program can be done using a combination of funding sources, including federal funding, the FCM, private capital, and the Town's budget.
3. **Incentive Programs:** Incentives programs, such as the Canada Greener Homes Grant, provide building owners with non-repayable sums of money (directly or as a rebate) to purchase efficient appliances and products, or to perform energy audits or retrofitting.
4. **Revolving Loan Funds:** Revolving funds, or green revolving funds and community revolving funds, provide a unique opportunity to pay for future projects using the savings achieved through efficiency improvements. For example, North Cowichan uses two funding streams to fund the Climate Action and Energy Plan - Corporate Energy and Emission Reduction projects, and the Climate Action Community Grants for community-driven projects.

PROMOTING COMMUNITY INVOLVEMENT

Promoting community involvement is woven into each Big Move's climate actions. Town staff play a pivotal role in acting as a facilitator between partners to initiate and launch programs, and to build community awareness in order to encourage community participation during implementation.

Decarbonizing Buildings

In 2020, buildings were responsible for 78% of the total energy use and 55% of the total emissions in Whitby . These emissions come from all types of buildings including homes, schools, offices, stores, and municipal and industrial spaces. If current trends continue as projected in the business-as-usual scenario, by 2045, building energy is projected to increase by 70% (24 million GJ) and GHG emissions by 93% (932,128 tCO_2e) (Figure 12). To avoid this substantial increase, the low-carbon scenario modelled actions to retrofit existing buildings, electrify heating and cooling systems (known as fuel switching), and construct new, net-zero buildings (Table 3, next page).

The low-carbon scenario projects building emissions to decrease by 92% by 2045. With the exception of industrial buildings, all building sectors are projected to achieve 95% or higher GHG emissions reductions. The 2045 GHG emissions reduction achieved by industrial buildings is less than that achieved by the other sectors, as many of Whitby's industrial organizations have decarbonization strategies for 2050. When modelled to 2050, the industrial sector is projected to achieve a 97% reduction in emissions.

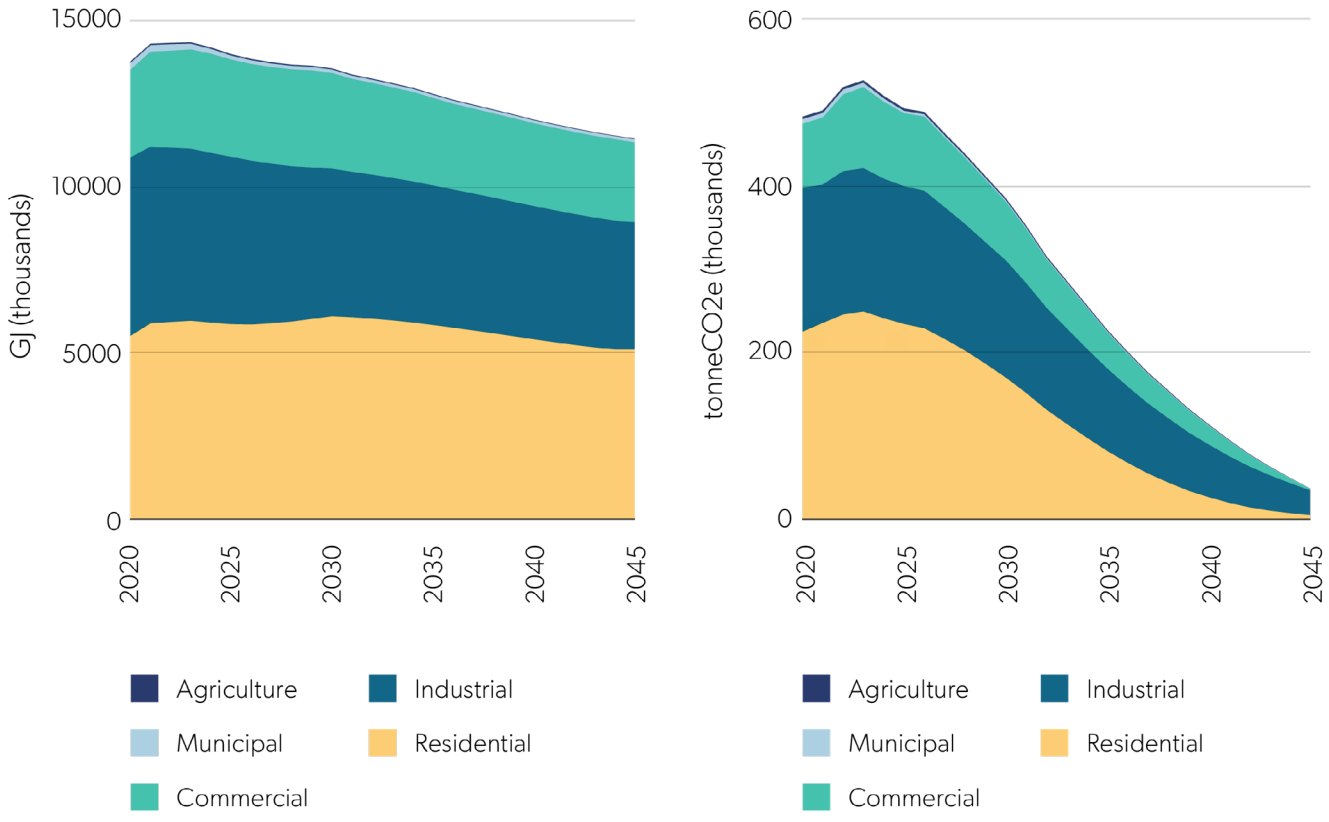

Figure 12. Whitby's low-carbon scenario's building energy use by building sector (left) and emissions by building sector (right) for 2020 to 2045.

What Does Decarbonizing Buildings Mean?

The pathway to decarbonize Whitby's buildings uses two strategies: improved building design and fuel switching.

For existing buildings, building retrofits will address design aspects that hinder the buildings' energy performance. Thermal energy and electrical use can be reduced with improved insulation, air sealing, window replacements, roof repairs, and appliance upgrades. Given that a uniform approach for retrofits is not feasible, performing energy audits will ensure that correct work is done to optimize efficiency improvements based on the building type and design. Energy efficiency in new construction can be optimized using design strategies, and high-efficiency appliances.

The second strategy for building decarbonization focuses on fuel switching, specifically away from natural gas to electric heating sources. Air- and ground-source heat exchange systems (heat pumps) typically have a 1:3 ratio for the amount of electricity required to the heating and cooling delivered, meaning that for every one unit of electricity required to power the system, three units of heating or cooling are delivered. These high-efficiency systems will contribute to reducing natural gas emissions by 92% (370,472 tCO_2e) by 2045 for all buildings. As the technology improves, the need for backup gas furnaces or integrated electric heating will decline—cold-climate air-source heat pumps are already a viable option for −30°C weather.

Table 3. Summary of the Implementation Plan's actions and low-carbon scenario's modelled targets for decarbonizing buildings.[33] *Actions marked with an asterisk (*) are actions already approved under the Zero Carbon Whitby Framework.*

Action 2.1 Develop a deep retrofit program for all non-municipal buildings in Whitby, including residential, institutional, commercial, and industrial (ICI) buildings (note: integrate with Action 2.3).	
2045 Modelled Low Carbon Target:	By 2045, residential and ICI buildings are retrofitted to achieve a 50% reduction in thermal energy and a 30% reduction in electrical savings. Forty percent of existing buildings are retrofitted by 2030, 85% by 2040, and 100% by 2045.

Action 2.2 Implement the deep retrofits for municipal buildings as identified in the Zero Carbon Whitby Framework.*	
2045 Modelled Low Carbon Target:	By 2045, municipal buildings are retrofitted to achieve the long-term goal of eliminating GHG emissions associated with operations of buildings for all Town-owned facilities.

[33] Detailed descriptions of each sub-action, internal impacts, project leads, sponsors and supports, timeframe, and metrics have been provided in the Implementation Plan.

Action 2.3 Develop a retrofit program for electric heat pumps and water heaters for residential and non-residential buildings (note: integrate with Action 2.1).	
2045 Modelled Low Carbon Target:	By 2045, 100% of heat load in existing residential, institutional, commercial, and industrial (ICI) buildings are served by heat pumps, and 100% of water heaters are served using electric sources.

Action 2.4 Develop programs to support all new non-municipal buildings in Whitby in achieving net-zero standards, including residential, institutional, commercial, and industrial (ICI) buildings.	
2045 Modelled Low Carbon Target:	By 2045, residential and ICI buildings are built to achieve net-zero standards in accordance with the Canadian Home Builders Association Net Zero Home Labelling Program, PassiveHouse Canada, and/or Zero Carbon Building Standards.

Action 2.5 Construct all new municipal buildings to meet net-zero standards as identified in the Zero Carbon Whitby Framework.*	
2045 Modelled Low Carbon Target:	By 2045, all new municipal buildings will achieve at least Tier 3 of the Whitby Green Standard (i.e., Net-Zero Standard).

What Is a Deep Retrofit?

A deep retrofit program is designed to improve the energy efficiency of a building and as a result improve building quality. These programs are designed to overhaul all systems of the building, such as replacing existing HVAC systems with electric heat pumps, replacing the roof, and maximizing solar gain through reconfiguring windows. A deep retrofit typically reduces a building's energy consumption by 50% or more. Further reductions in energy consumption can be achieved through minor retrofits such as insulation improvements and installation of LEDs.

The low-carbon scenario's modelled building actions are projected to achieve the emissions reductions outlined in Table 4 by 2045.

Table 4. Greenhouse gas emissions reductions achieved by the low-carbon scenario's building actions, projected for 2030, 2035, and 2045.

	CUMULATIVE GHG EMISSIONS (TCO2E) ELIMINATED BY:		
2020 BASELINE YEAR	2030	2035	2045
483,285	97,842 (20% reduction)	227,193 (53% reduction)	447,008 (92% reduction)

Generating Renewable Energy

As illustrated in Figure 13, which summarizes the low-carbon modelling for fuel switching and energy generation, the reduction in fuel emissions is driven by the retiring of natural gas and gasoline products in buildings and transportation. While some emissions are projected to remain in circulation in 2045, the local renewable energy generation from solar PVs will offset these energy use amounts and therefore lower the total emissions.

Generating renewable energy is a complementary action to fuel switching in buildings, and ensures that our buildings and transportation sectors can operate emissions-free. In the low-carbon scenario, renewable energy is placed on available building rooftops and parking lots (Table 5, next page).[34] The use of ground-based wind and solar farms were not recommended as a potential action due to the rapid urbanization and conversion of agricultural land to urban land forms. While not modelled, Whitby has opportunities to further investigate the use of community-scale district energy and power purchase agreements as identified in the Town's Community Strategic Plan Action 2.1.2.

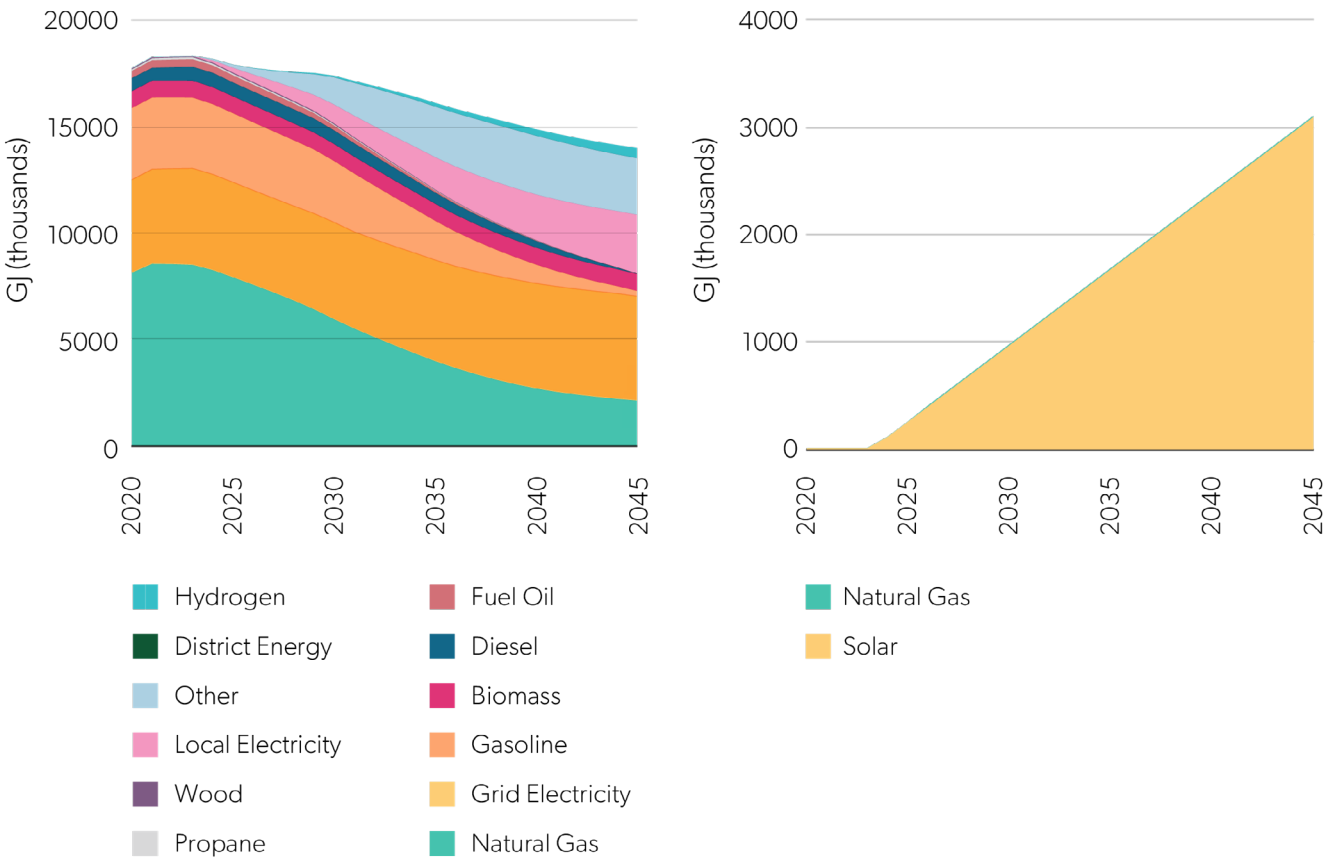

Figure 13. Whitby's low-carbon scenario energy use by fuel type (left) and energy generation by fuel type (right) for 2020 to 2045.

[34] Beginning in 2030, a percentage of the annual renewable energy generation will be derived from the Dockside Development to provide space heating and water heating to the new development site.

What Are Power Purchase Agreements?

With the limited opportunities for ground wind farms and solar farms in Whitby, a power purchase agreement (PPA) could be explored in the future as an opportunity to further reduce GHG emissions. A PPA is a long-term agreement between a seller (the owner of renewable energy infrastructure, which could be any third party) and the buyer (the Town, utility, or ratepayer). The seller is responsible for coordinating the financing, design, construction, maintenance and operations of the system while the buyer agrees to a set price to purchase the power. A PPA is mutually beneficial for the seller and buyer, and could address equity impacts of the upfront capital costs for PV installations.

Table 5. Summary of the Implementation Plan's action and low-carbon scenario's modelled targets for generating renewable energy.

Action 3.1 Increase local renewable energy generation through installation of rooftop solar photovoltaics (PVs) and ground-mount solar PV, and investigating new technology.	
2045 Modelled Low Carbon Target:	By 2045, 481 MW of solar capacity is installed on residential, institutional, commercial, and industrial (ICI), and municipal buildings' available rooftops (maximum capacity achieved), and install 160 MW of ground mount PV capacity on existing parking municipal and private lots.

Enhancing the Redundancy of the Energy System

The CERP Phase 1: Resilience - Implementation Plan detailed several strategies to enhance the redundancy of the energy system, many of which have been integrated into the sub-actions in the Mitigation Plan. By adding energy storage along with renewable energy generation, communities will be more resilient to power outages from extreme weather events and better able to supply essential services. On-site energy storage captures excess power produced by the solar PV system during sunny periods, and stores it for use during periods of low sun. In turn, this reduces the need to draw power from the grid, and enhances resilience during grid power outages.

The low-carbon scenario's renewable energy actions are projected to achieve the renewable energy generation amounts outlined in Table 6 by 2045.

Table 6. Renewable energy generation achieved by the low-carbon scenario's renewable energy actions, projected for 2030, 2035, and 2045.

	CUMULATIVE RENEWABLE ENERGY (GJ) GENERATED BY:		
2020 BASELINE YEAR	2030	2035	2045
17,251	51,753	87,103	121,604

Enhancing Low-Carbon Transportation

In 2020, transportation emissions (generated from the use of diesel, gas, and grid electricity) accounted for approximately 31% of the total emissions. Whitby residents commute frequently throughout the Region of Durham and Greater Toronto Area (GTA) and, as a result, are heavily reliant on public and private transportation. If current trends continue, the business-as-usual (BAU) scenario projects the total emissions from transportation to increase by 43%, and the business-as-planned (BAP) scenario projects a decrease by 48%. Even with the federal mandate for electric vehicle adoption, a 48% decrease does not meet Whitby's target for net-zero emissions.

The low-carbon scenario includes transportation actions to electrify transit services; electrify personal, commercial, and municipal vehicles; expand transit; increase active transportation; and decrease kilometers travelled. Achieving these targets will require extensive collaboration with the Region of Durham, federal and provincial governments, and local businesses.

Vehicle emissions result from travel in personal and commercial fleet vehicles, the movement of goods, and mass transportation such as transit. Emissions from vehicles are expected to decrease drastically in the BAP scenario, mostly due to an increased uptake in electric vehicles (EVs), including SUVs, and small trucks in line with federal policy. When charged using infrastructure connected to renewable energy sources, EVs are emissions-free. However, even when using an emitting power source, EV motors are significantly more efficient than those of gasoline and diesel vehicles, decreasing the amount of energy required. Widespread adoption of EVs will require planning for and building charging infrastructure throughout Whitby, and coordination with local partners and industry specialists to prepare for a shift from gasoline to electricity. New technologies are also being refined for medium- and heavy-duty vehicles to become non-emitting, but no target date for their uptake is currently outlined at the federal level.

Active transportation (e.g., cycling, walking) and transit (e.g., buses) use can help reduce transportation emissions when personal vehicle trips can be avoided. Well-designed active transportation and transit networks and supportive programming can help decrease congestion, promote active and healthy lifestyles, and complement urban intensification and mixed-use developments while decreasing emissions.

These initiatives identified in Table 7 (page 44) are projected to decrease energy use by 33% (from 3.5 million GJ to 2.3 million GJ) and decrease emissions by 92% (from 269,464 tCO_2e to 21,709 tCO_2e) (Figure 14 and Figure 15, next page). The remaining emissions are a result of increased grid electricity for vehicle charging and the associated emissions factors related to grid electricity in 2045, and remaining medium- and heavy-duty vehicles.

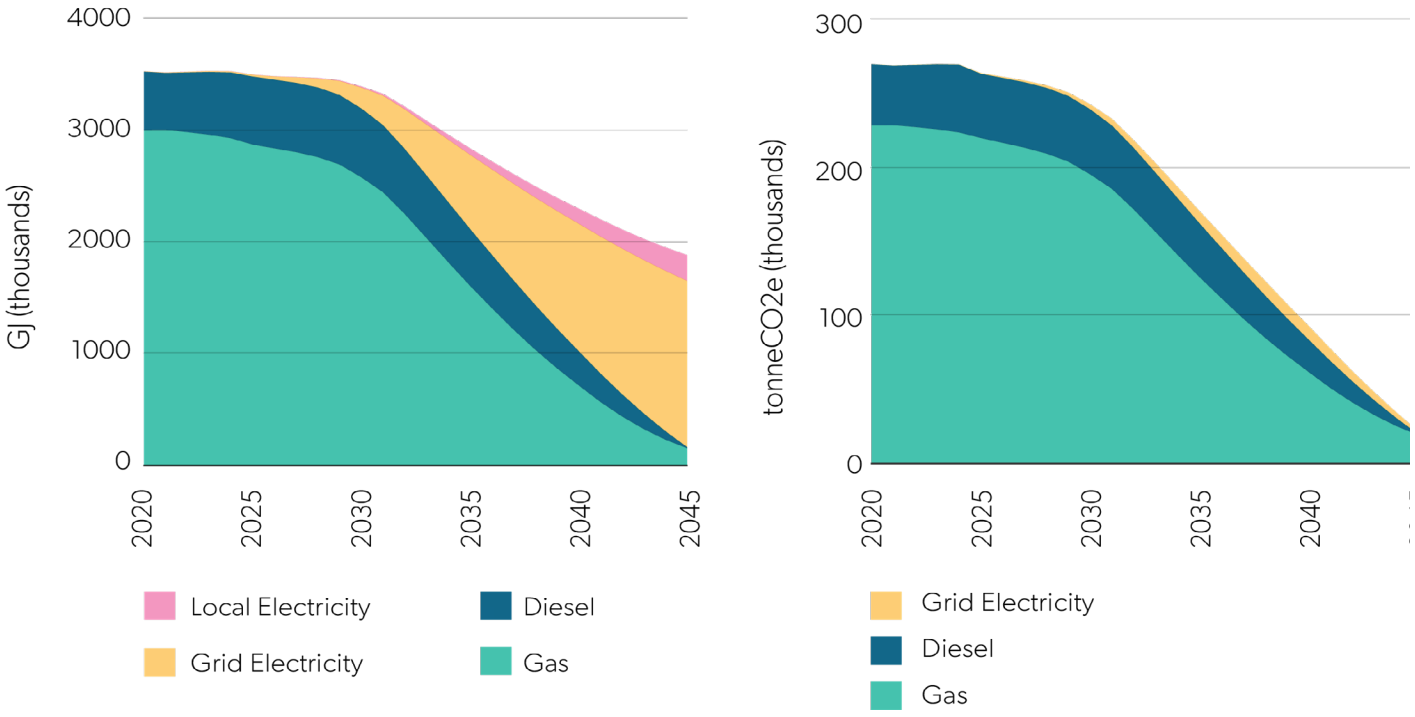

Figure 14. Whitby's low-carbon scenario's transportation energy use by fuel type (left) and emissions by fuel type (right) for 2020 to 2045.

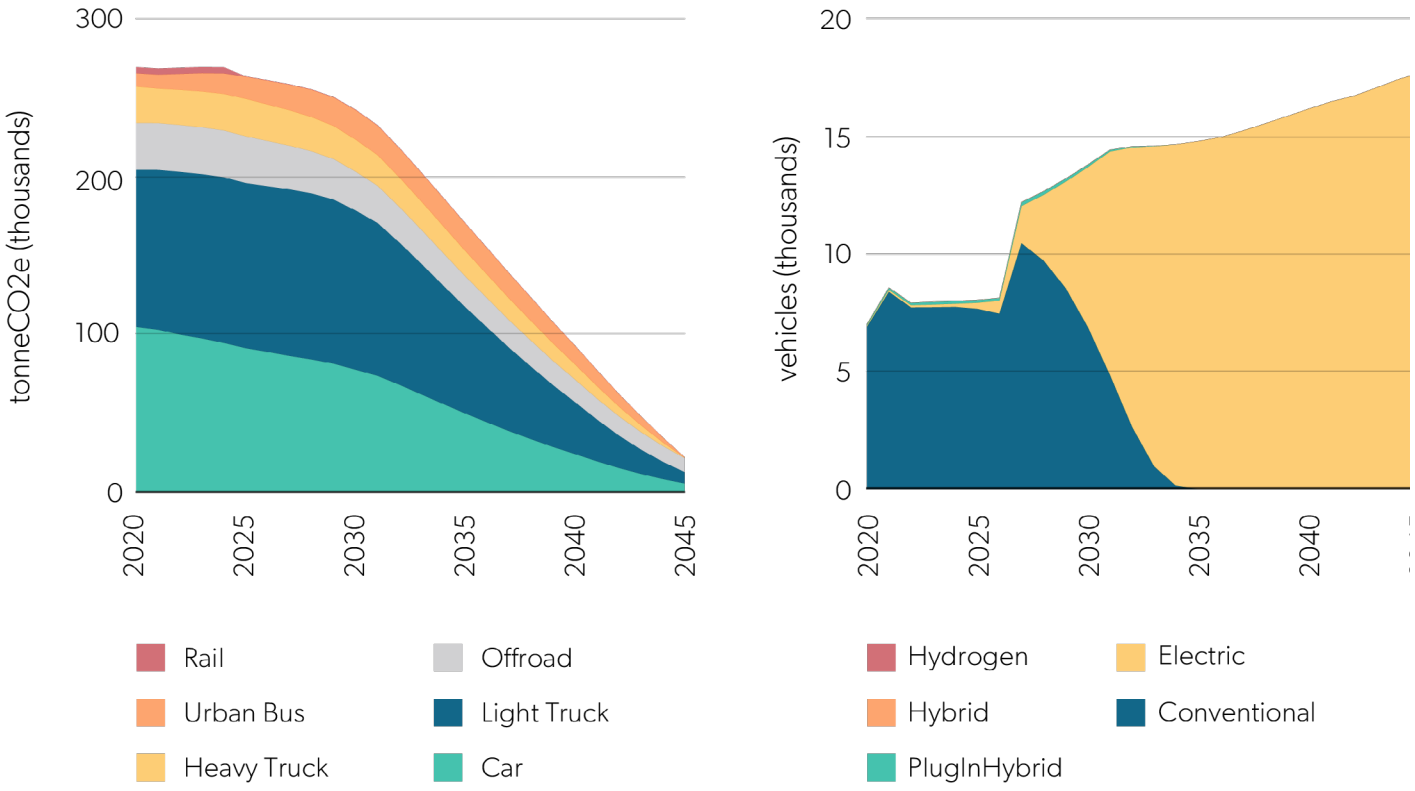

Figure 15. Whitby's low-carbon scenario's transportation emissions by mode (left) and new vehicle stock (right) for 2020 to 2045.

Table 7. Summary of the Implementation Plan's actions and low-carbon scenario's modelled targets for enhancing low-carbon transportation. Action marked with an asterisk (*) are actions already approved under the Zero Carbon Whitby Framework.

Action 4.1 Electrify the regional transit fleet.	
2045 Modelled Low Carbon Target:	Electrify bus fleet to achieve 30% electrification by 2024, 66% electrification by 2030, and 100% electrification by 2040.

Action 4.2 Electrify Town of Whitby municipal fleet.*	
2045 Modelled Low Carbon Target:	By 2045, all municipal fleet vehicles are electric and charging infrastructure supports a five-vehicle-to-one-charging-station ratio as identified in the Zero Carbon Whitby Framework.

Action 4.3 Electrify personal use vehicles.	
2045 Modelled Low Carbon Target:	Beginning in 2026, 25% of all new light-duty vehicle purchases are electric. Beginning in 2030, 75% of all new light-duty vehicle purchases are electric. By 2050, based on federal targets all 100% of all new light-duty vehicle purchases are electric.

Action 4.4 Electrify commercial vehicles.	
2045 Modelled Low Carbon Target:	By 2045, all new commercial light duty vehicle purchases are electric. By 2045, all heavy- and medium-duty vehicles are a combination of hydrogen fuel and electric vehicles.

Action 4.5 Advocate for transit expansion.	
2045 Modelled Low Carbon Target:	By 2045, increase transit trips to 15% of all trips taken within Whitby.

Action 4.6 Increase active transportation.	
2045 Modelled Low Carbon Target:	By 2045, increase active transportation trips to 15% of all trips taken within Whitby.

Action 4.7 Decrease vehicle-kilometers travelled.	
2045 Modelled Low Carbon Target:	By 2045, reduce home-to-work trips by 10% of all trips taken within Whitby.

The low-carbon scenario's transportation modelled actions outlined above are projected to achieve the emissions reductions outlined in Table 8 by 2045.

Table 8. Greenhouse gas emissions reductions achieved by the low-carbon scenario's transportation actions, projected for 2030, 2035, and 2045.

	CUMULATIVE GHG EMISSIONS (TCO2E) ELIMINATED BY:		
2020 BASELINE YEAR	2030	2035	2045
269,463	26,983 (10% reduction)	99,095 (37% reduction)	247,754 (92% reduction)

Reducing Waste Emissions

In 2020, Whitby produced 76,487 tonnes of waste and 57,194 tCO_2e of associated emissions, primarily from methane released from landfills and wastewater treatment (Figure 16). Even as per capita waste decreases, the growing population will lead to a continued increase in overall waste. If current trends continue, the business-as-usual scenario projects waste to increase to 167,074 tonnes (118% increase) and produce 59,780 tCO_2e (4.5% increase) of associated emissions by 2045.

The Town does not operate landfills and uses the Durham York Energy Centre for managing residential waste, while commercial and institutional entities find their own private waste disposal sources. Thus, it is challenging for the Town to have influence over landfills. However, in collaboration with the Region of Durham, the Town has committed to increasing diversion rates and decreasing per capita waste. As a result, the low-carbon scenario prioritizes strategies to improve waste diversion over methane capture at landfills (Table 9, next page).

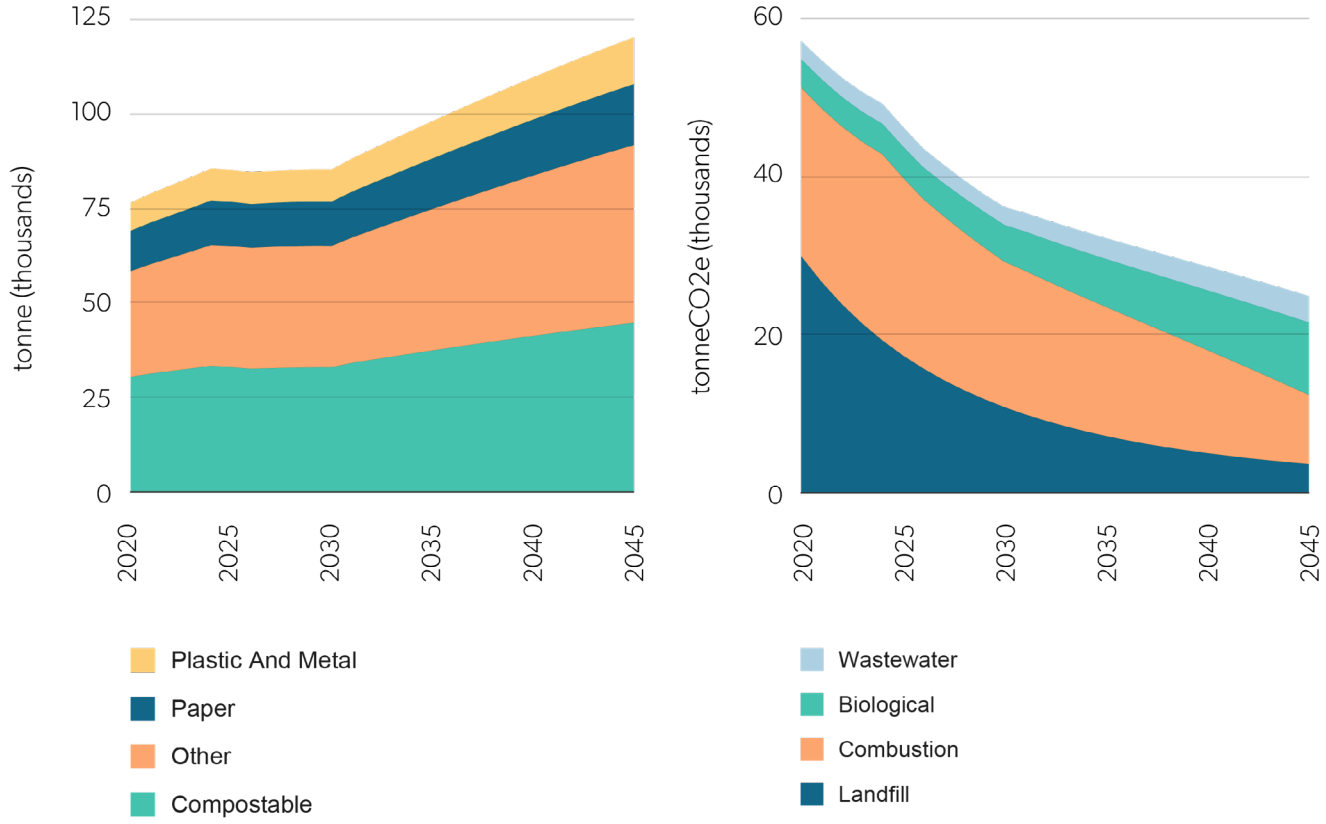

Figure 16. Whitby's low-carbon scenario's waste tonnage (left) and waste emissions (right) by waste stream for 2020 to 2045.

Table 9. Summary of the Implementation Plan's action and low-carbon scenario's modelled targets for reducing waste emissions.

Action 5.1 Increase residential, institutional, commercial, and industrial (ICI) diversion rates, and decrease waste per capita.	
2045 Modelled Low Carbon Target:	By 2045, the residential diversion rates for organics and recycling is 100%. By 2045, ICI diversion rates are 70% for both organics and recycling. Waste per capita is decreased by 20% by 2030, and 30% by 2045.

The low-carbon scenario's waste modelled action outlined above are projected to achieve the emissions reductions outlined in Table 10 by 2045.

Table 10. Greenhouse gas emissions reductions achieved by the low-carbon scenario's waste emissions reductions, projected for 2030, 2035, and 2045.

	CUMULATIVE GHG EMISSIONS (TCO2E) ELIMINATED BY:		
2020 BASELINE YEAR	2030	2035	2045
57,194	21,034 (37% reduction)	24,973 (44% reduction)	32,320 (57% reduction)

Reducing Industrial and Agriculture, Forestry, and Other Land Use Emissions

Many industrial companies are already exploring how they can increase process efficiency to reduce expenditures, and the major industrial organizations, such as Gerdau Steel, within the town have decarbonization strategies in place. In addition, the cumulative impact of the agricultural sector's GHG impact will naturally decrease due to the conversion of agricultural lands to urban lands. Given the limited scale of livestock production in the area, the Town has chosen to prioritize efforts and allocate resources toward advocating for the industrial sector to meet its decarbonization targets, and establishing partnerships with other land use organizations, such as tree nurseries and farms (Table 11, next page).

Land Use Planning: A Tool to Reduce Emissions

The IPCC's Sixth Assessment Report highlights the importance of land use planning on GHG emissions. Compact and mixed-use development foster resource efficiency and scalable decarbonization. The Town of Whitby's Official Plan (OP) sets the vision "to be a healthy, sustainable and complete community providing for balanced residential and employment growth, while maintaining a high quality of life and enhancing its cultural and natural heritage attributes." To achieve this, the OP sets policy directions for land use planning matters regarding long-term growth and development in the municipality—these include intensification; compact, mixed-use development; and transit-oriented development.

As Whitby undergoes intense urbanization, promoting compact development will be pivotal in mitigating emissions and reducing the risk of carbon lock-in from outward expansion onto carbon-rich lands.[35] When coupled with AFOLU, this strategy represents an opportunity to reduce GHG emissions and enhance carbon sequestration. This further supports the CERP Phase 1: Resilience - Implementation Plan's actions related to Natural Spaces, Green Infrastructure and Trees.

[35] IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001.

Table 11. Summary of the Implementation Plan's actions and low-carbon scenario's modelled targets for industrial and AFOLU emission reductions.

Action 6.1 Reduce industrial and agriculture, forestry and other land use (AFOLU) emissions.	
2045 Modelled Low Carbon Target:	By 2045, Gerdau Steel has achieved decarbonization of operations and captured 73,286 tonnes of carbon. By 2045, industrial sector process efficiency has improved by 30% and 50% of industrial processes are electrified. By 2045, livestock CH_4 and N_2O emissions are reduced by 30%. By 2045, agricultural off-road vehicles are 100% electric. **Note:** not all Agriculture, Forestry, and Other Land Use (AFOLU) sectors were modelled, however due to the small cumulative impact of agricultural emissions on the Whitby's emissions the project team opted to expand the sub-actions to explore partnerships with all AFOLU sectors.

Addressing Residual Emissions

The set of modelled actions included in the low-carbon scenario leaves approximately 89,013 tCO_2e of residual emissions, which are the emissions remaining after the climate actions have been implemented to transition to a net-zero community. These residual emissions indicate that Whitby will need to implement actions beyond what's identified in the low-carbon scenario and Implementation Plan. The Town will need to act quickly to begin implementing climate actions, and will need to adaptively manage the Mitigation Plan to respond to additional funding opportunities and technology changes.

Three key strategies can be used to address the remaining emissions:

1. **Explore expediting the actions contained in the Mitigation Plan, and add further actions.**

   Urgent action is needed to achieve both the interim and 2045 targets. In 2030, the majority of emissions will be derived from natural gas used for residential buildings and gas used for transportation. The Town can promote opportunities for the community to increase the replacement of heat pumps on an accelerated timeline compared to the low-carbon scenario, and to switch to active transportation and transit modes more quickly to overcome the slower adoption of personal EVs.

   Additional actions could also include installing a waste treatment system that uses an anaerobic digester. During the low-carbon scenario modelling, a second scenario projected that 95% of organic waste treated using an anaerobic digester would reduce the 2045 emissions by an additional 2%. This action is not included in the modelled low-carbon scenario in the Mitigation Plan as the likelihood of it being implemented during the first phase of the Mitigation Plan's implementation was deemed low. However, if a waste treatment system is determined to be feasible in the future it would further reduce residual emissions in 2045 and can be explored during the update of the CERP.

2. **Additional measures such as carbon sequestration, new regulations, or development of new technologies could be used to address residual emissions.**

   Actions that result in negative emissions that absorb and store carbon dioxide could further reduce residual emissions. This includes increasing tree canopy, restoring ecosystems, and injecting carbon dioxide into concrete. For example, 89,013 tCO_2e is the equivalent of approximately 1.4 million medium-growth coniferous or deciduous trees planted in urban settings and allowed to grow for 10 years.[36] The Climate Emergency Response Plan (CERP) Phase 1: Resilience - Implementation Plan's Natural Spaces, Green Infrastructure, and Trees actions were not modelled as potential negative emissions actions; however, as these actions are implemented, carbon dioxide sequestration can be quantified using the Carbon Budget Model of the Canadian Forest Sector, an open-source carbon drawdown estimation model. The CERP Phase 1: Resilience - Implementation Plan has been updated to reflect this recommendation.

[36] Calculated August 2023 from: US EPA. 2015. "Greenhouse Gas Equivalencies Calculator." United States Environmental Protection Agency. Accessed August 28, 2015. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results.

In addition, adding requirements for life cycle assessments (LCAs) and embodied carbon to version 3 of the Whitby Green Standard can further reduce scope 3 emissions. A study completed on regulating embodied emissions in Ontario recommends whole-building LCA cap reductions every two years to reach a 50% reduction by 2030. For example, the LCA cap for small residential buildings would be set at 200 $kgCO_2e/m_2$ in 2024, 166 $kgCO_2e/m_2$ in 2026, 133 $kgCO_2e/m_2$ in 2028, and 100 $kgCO_2e/m_2$ in 2030.[37]

3. **If additional actions, expedited timelines, and new technology are not available by 2045, the Town could compensate for outstanding emissions by purchasing offsets.**

Offsets are useful in the broader context of reducing emissions because they are designed to fund carbon reduction strategies that are not yet independently financially feasible. In this sense, they fund changes that move another entity closer to decarbonization; however, they should not be viewed as equivalent to implementing actions to reduce emissions locally. Offsets should only be purchased in cases where there is no alternative.

If the Town or high emission industries choose to purchase offsets to address the residual emissions, it is recommended that a procedure is established to ensure that:

- Offsets are purchased as a last resort when alternatives are not available;
- The number of offsets purchased accurately reflects 100% of the residual emissions;
- Offsets are purchased from a reliable entity following best practices in managing offset inventories; and
- Offsets purchased reflect the Town's values and vision, and any preferences it may have for supporting local versus non-local projects or other priority issues.

[37] Popovic, Snezana. 2022. "Mantle Developments - Policy Primer: Regulating Embodied Emissions of Buildings; Insights for Ontario's Municipal Governments." Mantle Developments. Accessed September 13, 2022. https://mantledev.com/publications/policy-primer-regulating-embodied-emissions-of-buildings-insights-for-ontarios-municipal-governments/.

An Equitable and Cost-Effective Transition

Fostering an Equitable Transition

WHAT DOES AN EQUITABLE TRANSITION MEAN?

The Town has committed to an equity-based target of meeting net-zero emissions by 2045. This will require the Town to ramp down its GHG emissions at an accelerated rate and begin addressing residual emissions as we approach 2045. An equity-based target is ambitious, and is designed to enable poorer and developing nations to maintain emissions in the short term so that climate action does not add the challenges of addressing global poverty and energy security. However, the equity impacts at a local scale are equally important.

While reducing GHG emissions will generally improve the quality of life of community members, climate actions need to be developed to minimize the impact on equity-deserving or at-risk community members. Therefore, an equitable transition aims to minimize the negative impacts of climate actions on different communities, and engages individuals who are impacted by these decisions to understand their perspectives, lived experiences, and required support for the transition.

Whitby's low-carbon scenario not only measures the impact of climate actions on cumulative community emissions but also considers how equitable and sustainable the transition will be.

HOW IS EQUITY ANALYZED ACROSS CLIMATE ACTIONS?

Local equity impacts are best understood using a co-benefits and co-harms analysis. Climate co-benefits are *beneficial outcomes* from action that are not directly related to climate change mitigation. Its corollary, co-harms, are *negative outcomes* that could potentially result from climate action.

Planning climate actions that also deliver co-benefits and mitigate co-harms increase the likelihood of success of actions by engaging more diverse communities of interest and by demonstrating compelling short-term value from advancing ecological, social, and economic objectives. Implementing the Mitigation Plan offers a suite of co-benefits associated with improved health outcomes, prosperity, opportunities for equity enhancement, and climate resilience.

Not all co-benefits are equal or can be enhanced at all stages of implementation. There may be instances when the urgency of reducing GHG emissions requires climate actions to continue despite the potential co-harms such as increased retrofit costs could lead to reduced housing availability and affordability. In such cases, the impacts of those co-harms should be carefully considered to minimize the adverse effects as much as possible while still reducing emissions. See Appendix A for a co-benefits and co-harms analysis.

Capturing an Economic Opportunity

Climate inaction is costly. Each year, the impacts of climate change costs Canadians billions of dollars in repair costs, increased operations and maintenance, loss of service delivery, and business interruptions.[38] Specifically, the CERP Phase 1: Resilience financial analysis found that annualized damages from floods and extreme heat in Whitby could increase sevenfold to more than $700 million per year, to 2070, in the absence of climate action. Transitioning to a low-carbon future is a smart investment and will allow Whitby to avoid costs of climate impacts and retrofits in the future.

Smart Investments to Avoid Future Greenhouse Gas Emissions

Every investment spent on infrastructure in Whitby will either lock in new GHG emissions or reduce GHG emissions. Allocating resources to infrastructure with extended payback periods and which contribute to GHG emissions today will result in significant expenses for future retrofits. For example, a new home built in 2024 that generates emissions will likely need to be retrofitted to achieve net-zero emissions within the next decade, while a new home built in 2024 to net-zero ready or net-zero emission standards will avoid future retrofit costs.

Implementing the Mitigation Plan requires investigating all financial tools available to the municipal government and other community stakeholders including individuals, businesses, and other levels of government. The financial analysis developed for the Mitigation Plan does not include incentives and rebates currently available to residents and businesses through local, provincial, and federal programs. The success and impact of the Mitigation Plan will depend on leveraging incentives and rebates across the community.

UNDERSTANDING WHITBY'S INVESTMENTS

Transitioning to the low-carbon scenario requires immediate investments across all community sectors, including the Town, residents, businesses, institutions, and other levels of government. While the Town does not have direct control over external investments, it plans to lead by example, by taking immediate action following the Plan's adoption and sustaining these efforts through 2045 and beyond.

The financial analysis was developed to understand the costs associated with implementing the low-carbon scenario. The analysis examined the total cost across the community and does not allocate costs and savings specifically to the Town or other sectors.

The investments, which are incremental to the business-as-usual investments, total $3.9 billion across various sectors in the community and will stimulate economic activity for existing and new businesses. Much of the investments, for example, in building retrofits, would be directed across multiple entities such as local businesses and suppliers. Figure 17 (next page) shows the investments expected to be made by each economic sector.

[38] ICLEI Canada. 2022. "The Cost of Doing Nothing: Primer Document to Build a Local Business Case for Adaptation." Accessed August 2023. https://icleicanada.org/wp-content/uploads/2022/11/CODN-Primer.pdf.

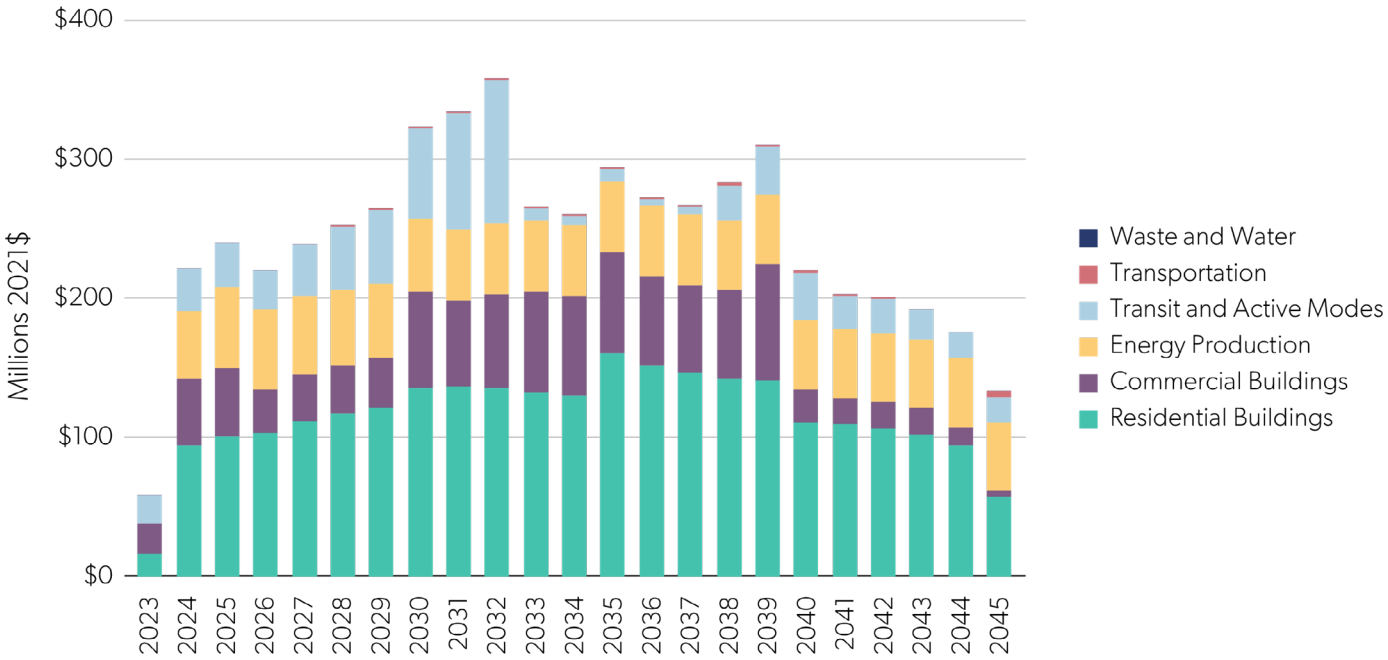

Figure 17. Low carbon investments by economic sector, 2023-2045.

What Are the Town's Costs?

The Implementation Plan summarizes initial internal impacts anticipated for each sub-action. These include resources to initiate the action; internal communications and engagement fees estimated from the Town's previous outreach campaigns; and known costs incurred by the Town to implement Town-led initiatives, such as consulting fees to complete feasibility studies. This is an initial estimate, subject to change as additional investments may be necessary following further study and refinement of actions.

In addition, many of the initial steps of the actions are to investigate opportunities and begin planning for specific sub-actions. As opportunities are investigated, the Town will better understand what additional investments need to be made into programs, which can be integrated into the Town's annual budget review process. These could include additional investments into but not limited to the pilot E-bike library, PACE programs, and circular economy initiatives.

Many of the known investments to be incurred by the Town were presented to Council as part of the Zero Carbon Whitby Framework and Costing Study. These include:

- A $45.4 million investment to complete building retrofits and energy system replacements of the 46 buildings;
- A $23.88 million investment to construct new municipal buildings to net-zero standards;
- A $1.5 million investment for the installation of solar photovoltaic panels on municipal buildings; and
- A $13 million investment to purchase fleet electric vehicles and charging stations.

The key impacts associated with the Mitigation Plan at this time are Town staff time to initiate the actions, internal communications and engagement fees (estimated at $12,000 per event), an additional FTE salary to hire a Climate Change Coordinator to oversee the Mitigation Plan's implementation ($105,000 per year beginning in 2026), and consulting fees associated with feasibility studies and plans.

Understanding Whitby's Return on Investment

While substantial investments are required, the low-carbon scenario generates financial returns. The investments are offset by the cost savings related to avoided energy, operations and maintenance, carbon pricing, and increased generation revenues. This means implementing Whitby's low-carbon scenario will result in a net benefit of $1.7 billion to the community.[39]

One of the largest savings results from avoided fuel and electricity costs associated with personal vehicles and homes. In 2020, the average annual energy cost per household was $6,113; with the low-carbon scenario, this will decrease to $1,718 by 2045.

Electric Vehicles: A Lower Lifetime Cost

With rising gas prices, many households are seeking alternatives to reduce transportation costs. Switching to transit, increasing walking and cycling, and switching to an electric vehicle (EV) are all solutions that can help reduce household expenses related to transportation.

An analysis of popular EVs in the Canadian market show that even when purchasing a new vehicle at a higher-cost than the comparable gasoline model, EVs have a lower lifetime cost. The analysis used the gas price of $1.45/L to model the lifetime costs of different EVs compared to the gasoline models. With this gas price, if the vehicle is owned for eight years and driven 20,000 kilometres per year, electric sedans were between 22% and 32% cheaper, and electric SUVs and crossovers were between 21% and 22% cheaper.[40] The affordability of EVs is predicted to increase further with higher gasoline prices, lower electricity rates, longer vehicle use, and more annual mileage.

Without additional rebates and subsidies, in the next five years, EVs are predicted to have a cheaper purchase cost than gas-powered vehicles; in the meantime, Ontario drivers can lower purchase cost through the federal government's rebate program of up to $5,000 for eligible vehicles.[41]

[39] The net return of actions was calculated using the following formula: The net benefit= (energy cost saving [-$1.4 billion] + carbon tax avoidance [-$3.9 billion] + revenue from local renewable energy generation and services [-$205 million]) - (capital investments [$3.9 billion] + operations and maintenance costs [$504 million]). In the formula financial considerations with a positive number are net financial loss, and financial considerations with a positive number are net financial return.

[40] Clean Energy Canada. 2022. Review of The True Cost: New Analysis from Clean Energy Canada Finds That Electric Vehicles Are in Fact Cheaper, Often Much Cheaper, than Their Gas Counterparts. Clean Energy Canada. https://cleanenergycanada.org/wp-content/uploads/2022/03/Report_TheTrueCost.pdf.

[41] Ibid.

Another benefit of the low-carbon scenario for the community is job creation across all Big Move sectors. This is especially important as Whitby's population continues to grow substantially, as these new residents will need to find work in new and existing roles. According to the direct job multipliers from Census Canada, implementing the low-carbon scenario will result in approximately 45,355 person years of employment generated between 2023 and 2045—this equates to an average of 2,062 full-time equivalent (FTE) jobs annually across all sectors. Table 12 highlights the top five sectors for job growth between 2023 and 2045.

Table 12. Whitby's low-carbon scenario's top five job creation sectors between 2023 to 2045.

	Residential building retrofits	Expanding transit	Commercial building retrofits	Electrifying transit	Rooftop solar installations
Average annual job creation (FTE/year)	715	224	206	201	200

A Snapshot in Time: The Financial Scenario's Limitations

The financial scenario provides a current estimated cost of implementing the Plan, but it is very sensitive to changes in technology and energy prices. As seen in recent years, energy prices can fluctuate widely based on global events. These events cannot be reliably predicted, but could greatly impact the results of the modelled financial scenario. For example, if the change in natural gas prices were to increase while electricity prices remained stable, or vice versa, the price of the scenario would change drastically and may push individuals and governments to make different choices about energy sources.

Beginning the Transition to Net-Zero Emissions

The Mitigation Plan is an ambitious plan that spans every sector of the Whitby community to achieve net-zero emissions by 2045. Although it relies on collective action across the whole community, the Town's Council, staff members, and departments play a pivotal role in advancing the implementation of the actions and monitoring, evaluating and reporting the success and progress of the emissions reductions.

What Does Action Look Like for Different Community Members?

Climate action will not be a uniform approach for all community members or sectors. As highlighted in the Implementation Plan, enhancing programs for equity-deserving community members will be essential for ensuring co-benefits are enhanced and co-harms are mitigated. While climate action will look different for each community member, there are opportunities for community members to get involved based on their unique circumstances, needs, and capabilities. Reviewing the Implementation Plan is a great first step in understanding funding opportunities and community actions.

While not an exhaustive list of all opportunities, here are examples of how community members can get involved in each Big Move (Figure 18, pages 57 - 59):

Big Move: Advocacy

Youth	Homeowners	Renters	Local Businesses
• Engage in citizen advocacy with your local Member of Parliament (MP) and Provincial Parliament (MPP) • Join the Youth Climate Committee • Create or participate in a climate group at your school	• Engage in citizen advocacy with your local MP and MPP to advocate the provincial and federal governments to adopt legislation banning the installation of natural gas appliances	• Engage in citizen advocacy with your local MP and MPP to advocate the provincial and federal governments to adopt legislation banning the installation of natural gas appliances	• Engage in citizen advocacy with your local MP and MPP for the provincial and federal governments, construction industry, and local post-secondary education institutions, to develop a labour and training strategy to meet building retrofit targets

Big Move: Buildings

Youth	Homeowners	Renters	Local Businesses
• Encourage members of your home to attend the Town's engagement events and campaigns to learn more about retrofit programs	• Complete the Energy Audit for the Canada Greener Homes Grant to understand retrofit opportunities • Complete home retrofits through the Durham Greener Homes Program • Review the funding opportunities in the Implementation Plan • Reduce your energy consumption by purchasing energy-efficient appliances, switching to LEDs, and reducing water use	• Engage your landlord to complete the Energy Audit for the Canada Greener Homes Grant to understand retrofit opportunities • Reduce your energy consumption by purchasing energy-efficient appliances, switching to LEDs, and reducing water use	• Install heat pump and energy saving measures through the Durham Greener Buildings Program

Big Move: Renewable Energy

Youth	Homeowners	Renters	Local Businesses
• Encourage members of your home to attend the Whitby's engagement events and campaigns to learn more about renewable energy programs	• Install solar PV on rooftops • Switch to a purchase power agreement with a renewable energy provider	• Engage your landlord to install solar PV on building rooftop	• Install solar PV on parking lots and rooftops

Big Move: Transportation

Youth	Homeowners	Renters	Local Businesses
• Switch your shorter trips to either walking or cycling • Purchase an E-Bike	• Switch your shorter trips to either walking or cycling • Consider purchasing an EV as your next vehicle • Join a local carshare program • Purchase an E-Bike • Install a home EV charger	• Switch your shorter trips to either walking or cycling • Consider purchasing an EV as your next vehicle • Join a local carshare program • Purchase an E-Bike	• Install long-term and short-term bike storage • Install EV chargers using funding from The Atmospheric Fund • Develop/continue to implement a work from home or hybrid working policy • Create a subsidized employee transit program for public transit and/or carpooling

Big Move: Waste

Youth	Homeowners	Renters	Local Businesses
• Participate in community reuse programs • Join the Circular Economy Roundtable	• Participate in community reuse programs • Commit to reducing, reusing, ad recycling products • Join the Circular Economy Roundtable	• Participate in community reuse programs • Commit to reducing, reusing, ad recycling products • Join the Circular Economy Roundtable	• Participate in community reuse programs • Integrate zero waste and diversion practices into your businesses procurement practices • Join the Circular Economy Roundtable

Figure 18. Examples of low-carbon actions youth, homeowners, renters, and local businesses can take to be involved in each Big Move.

With the CERP Phase 1: Resilience and CERP Phase 2: Mitigation Plans developed, the Town can begin to strategize the implementation of the actions detailed in the Mitigation Plan - Implementation Plan. Committing to meaningful actions in the fight against climate change is required, and the Mitigation Plan represents an important step in that direction. With collaboration and a shared vision, the Town can continue on the pathway to reducing community-wide emissions to net-zero by 2045.

Appendix A: Co-Benefits and Co-Harms Analysis

The co-benefits and co-harms presented below are not an exhaustive list but instead offer a glimpse into the potential benefits and drawbacks the town will encounter as a result of the Mitigation Plan. While the list does not encompass every possible outcome, it serves as a reference point for understanding the Mitigation Plan's community impacts outside of GHG emission reduction and investment costs. Areas in which co-benefits and co-harms were not analysed are indicated using the coloured boxes, however this does not mean that co-benefts or co-harms will not emerge in this areas during implementation.

Table 1A. Summary of co-benefits and co-harms analysis completed for each Big Move.

1.1 Co-benefit: Leadership

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions
As municipalities are at the forefront of climate action, residents will look to their local government for leadership. Building new Town-owned buildings to net-zero standards earlier than the residential and ICI buildings will allow the Town of Whitby (Town) to show climate governance and leadership. These new buildings can also serve as an example of the feasibility of net-zero building designs.	The Town leads by example by installing rooftop solar photovoltaics (PVs) on Town-owned buildings.	The Town leads by example by advocating local transit operators to electrify transit operations. Electrifying municipal fleets will demonstrate the Town's leadership and commitment to their net-zero emissions target.	The Town's new waste reduction strategy will demonstrate commitment to reducing waste by developing a strategy for the phase-out and eventual ban on single-use plastics in Whitby.	

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2. ECONOMIC PROSPERITY

2.1 Co-benefit: Increased Employment, Economic Development, and Innovation

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions
As contractors and service providers are required to build, operate, and maintain high-performance buildings, economic activities will increase in the construction and renovation sector to meet growing demand for energy-efficient products and services.	Increased need for contractors and service providers to install, operate, and maintain solar PVs will lead to local job creation and economic growth.	Transit expansion will provide employment opportunities for new and existing residents, including during construction and operations.	New circular economy initiatives will require local expertise, training, and employment.	Improving industrial and agricultural process efficiencies can increase the use of new technologies and methods to reduce costs and optimize resources for auxiliary equipment fuel switching. In addition, these can reduce waste and lead to increased profits.
As more buildings are retrofitted or constructed with sustainable materials and technologies, the demand for goods and services from local suppliers and manufacturers increases.			New circular economy initiatives have the potential to enhance innovation and attract new businesses to the town.	Switching industrial end-uses to electricity leads to improved equipment operating cost, better fuel efficiency of electrified equipment, reduced maintenance, and increased equipment lifetime.

2.1 Co-benefit: Increased Employment, Economic Development, and Innovation

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2. ECONOMIC PROSPERITY

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions
As decarbonizing buildings requires the development of innovative technologies and materials, this can drive local research and development, and support post-secondary institutions enrollment.				

2.2 Co-benefit: Reduced Household Costs

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions

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2. ECONOMIC PROSPERITY				
Energy-efficient buildings reduce energy bills and vulnerability to energy price fluctuations.	Although a high upfront cost is required to install PV systems, on average these systems have a return on investment of 10 years.	Mandated electrification of personal vehicles increases electric vehicle (EV) purchases, leading to reduced charging costs.	Campaigns to encourage waste reduction and diversion can reduce household spending by raising awareness of reducing, reusing, and recycling opportunities.	
Prioritizing building retrofits and initiatives for equity-deserving community members reduces the long-term energy costs and increases affordability.		Travel costs for community members who commute can be reduced through an increase in transit use.		

2.3 Co-Benefit: Improved Infrastructure Quality

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	**Generating Renewable Energy**	**Enhancing Low-Carbon Transportation**	**Reducing Waste Emissions**	**Reducing Industrial and Agricultural Emissions**

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2. ECONOMIC PROSPERITY				
Energy-efficient buildings improve occupant comfort and the quality of infrastructure.		Increasing active transportation infrastructure and transit networks reduces congestion on roadways and wear and tear on road infrastructure.		
Completing structural repairs prior to addressing energy efficiency improvements will ensure investments reap long-term quality infrastructure and reduced economic impacts.				

2.4 Co-harm: Increased Household Costs

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	**Generating Renewable Energy**	**Enhancing Low-Carbon Transportation**	**Reducing Waste Emissions**	**Reducing Industrial and Agricultural Emissions**

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2. ECONOMIC PROSPERITY				
		EVs are currently more expensive to buy and cheaper to operate; however, without additional rebates and incentives to offset the higher purchase cost, some households may not be able to purchase EVs within the low-carbon scenario's projected time frame.		

2.5 Co-harm: Increased Municipal Costs

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions

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2. ECONOMIC PROSPERITY				
		Enhancing its public transit network and transit services may require Durham Region to increase its municipal budget to improve transit frequency and service areas.		
		Improving active transportation infrastructure may require an increased municipal budget to develop adequate infrastructure.		

2.6 Co-harm: Reduced Action Uptake

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	**Generating Renewable Energy**	**Enhancing Low-Carbon Transportation**	**Reducing Waste Emissions**	**Reducing Industrial and Agricultural Emissions**

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2. ECONOMIC PROSPERITY		
	Encouraging and incentivizing the purchase of EVs can reduce people's inclination to use transit and active transportation, as they would prefer to make use of the new vehicle they have invested in. This can limit the projected mode-share shifts for transit.	
	Current supply-chain delays and wait times for EVs can reduce uptake.	

3. ENVIRONMENTAL IMPACT

3.1 Co-benefit: Improved Air and Water Quality

Sector Impacts of the Recommended Actions for Each Big Move:

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3. ENVIRONMENTAL IMPACT				
Decarbonizing Buildings	**Generating Renewable Energy**	**Enhancing Low-Carbon Transportation**	**Reducing Waste Emissions**	**Reducing Industrial and Agricultural Emissions**
Energy-efficient buildings will lead to improved indoor air quality.		Electrifying vehicles and increasing transit use reduces NOx and particulate matter in the air resulting from reduced combustion of petrol in vehicles.	Less organic waste in the landfill reduces odour from decaying food and improves outdoor air quality.	Improvements in livestock breed, feed sources, and manure management reduces agricultural impacts on the natural environment, leading to improved air and water quality.
		Increasing transit networks reduces traffic congestion and improves air quality as less vehicles are on the road, and for shorter amounts of time.		Improvements in livestock breed, feed sources, and manure management protects surface and ground water quality, and prevents soil erosion.
		Improved local air quality leads to better respiratory health outcomes, especially for young children and the elderly.		

3.2 Co-benefit: Reduced Noise Pollution

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	**Generating Renewable Energy**	**Enhancing Low-Carbon Transportation**	**Reducing Waste Emissions**	**Reducing Industrial and Agricultural Emissions**

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3. ENVIRONMENTAL IMPACT

Energy-efficient buildings with increased insulation and envelope performance will reduce noise pollution.		Electrifying vehicles means vehicles no longer rely on diesel and gasoline combustion, reducing traffic-related noise pollution.		

3.3 Co-benefit: Improved Environmental Capital

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions
Using heat exchange systems for localized heating and cooling will eliminate the co-harms of fossil fuel extraction, such as spatial footprint, water pollution, and subsoil disturbances.	Building on previously disturbed land and combining renewable power with other land uses, like agriculture or building solar on rooftops, can minimize land use conflicts.	Expanded transit reduces the impact on existing road infrastructure by reducing use, as well as the surface land footprint required to support vehicle traffic. The reduction of impermeable surfaces will lessen the overland flooding modelled in Phase 1: Resilience.	Circular economy initiatives and material reuse reduces the need to grow, harvest, or extract new raw materials, thereby improving resource conservation.	

4. SOCIAL EQUITY

4.1 Co-benefit: Occupant Comfort and Resilience

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions

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4. SOCIAL EQUITY				
Increased heat pump installations that provide air-conditioning functionality improves comfort during heat waves, especially for at-risk segments of the population (e.g., elderly, young children).	Local renewable energy with on-site energy storage can provide improved energy security and resource conservation during grid power outages, thereby increasing the resilience and adaptability of the system.			
Fuel switching improves occupant comfort during heat waves for all community members.	Solar PVs can be further integrated into networks through the use of grids. This interconnection between small-scale rooftop solar PV systems allows them to provide backup power when larger-scale generation goes down.			

4.2 Co-benefit: Improved Health and Safety

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	**Generating Renewable Energy**	**Enhancing Low-Carbon Transportation**	**Reducing Waste Emissions**	**Reducing Industrial and Agricultural Emissions**

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4. SOCIAL EQUITY				
		Vehicle electrification and mode-share shifts improve local air quality, leading to better respiratory health outcomes, especially for young children and the elderly.	Campaigns to encourage waste diversion and reduction can contribute to social equity by encouraging social responsibility and participation in community waste events.	
		Improved active transportation infrastructure such as biking and walking paths that are well-lit and protected makes it safer to move around in the community.		

4.2 Co-benefit: Improved Health and Safety

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions

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4. SOCIAL EQUITY				
		Increasing active transportation infrastructure leads to more people participating in active transportation for their work/school commute and leisure, thereby increasing opportunities for social interaction and improving physical health.		
		Increasing active transportation infrastructure reduces congestion on roadways and improves productivity and mental health with less time spent in traffic.		

4.3 Co-harm: Decreased Affordability and Accessibility

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions
Increased retrofit costs could lead to reduced housing availability and affordability.				

4.4 Co-harm: Reduced Health and Safety

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4. SOCIAL EQUITY

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions
		Electrifying vehicles means vehicles no longer rely on diesel and gasoline combustion, making them much quieter than gas/diesel vehicles. Pedestrians and cyclists may not be able to hear EVs, potentially leading to accidents, especially in residential areas.		
		At-risk community members may be more inclined to take personal vehicles rather than walking, biking or public transit due to safety concerns.		

4.5 Co-harm: Negative Global Impact

Sector Impacts of the Recommended Actions for Each Big Move:

Decarbonizing Buildings	Generating Renewable Energy	Enhancing Low-Carbon Transportation	Reducing Waste Emissions	Reducing Industrial and Agricultural Emissions
		Increased EVs can lead to international environmental and social impacts due to increased need for lithium, a mined metal used in batteries to power EVs.		

Appendix B: Glossary

Air-source heat pump: A building heating technology that transfers heat from the outside air to heat or cool a building using a refrigeration system and process.

Baseline: The starting year for energy or emissions projections.

Building envelope: Any building component (e.g., window, door, insulation) that physically separates the interior and exterior of a building and shields the inside space from elements such as heat, cold, and precipitation.

Carbon budget: This term refers to three concepts: (1) an assessment of carbon-cycle sources and sinks on a global level through the synthesis of evidence for fossil-fuel and cement emissions, land-use change emissions, ocean and land CO_2 sinks, and the resulting atmospheric CO_2 growth rate. This is referred to as the global carbon budget; (2) the estimated cumulative amount of global carbon dioxide emissions that is predicted to limit global surface temperature to a given level above a reference period, taking into account global surface temperature contributions of other greenhouse gases and climate forcers; and (3) the distribution of the carbon budget defined under (2) to the regional, national, or sub-national level based on considerations of equity, costs, or efficiency.

Clean energy: Energy derived from renewable, zero-emissions sources.

Climate adaptation: Any initiative or action in response to actual or projected climate change impacts which reduces the effects of climate change on built, natural, and social systems.

Climate hazards: The potential occurrence of climate-related physical events, such as extreme weather events (e.g., heat waves, floods), or climate change trends, such as increasing temperatures, that may result in loss of life, injury, or other health impacts, as well as damage to natural, built, or human systems.

Climate impacts: The effects of climate hazards on natural, built, and human systems. This includes the effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure. Impacts generally manifest in some form of damage, disruption, or complete loss and can be generally categorized as physical, social, or economic.

Climate mitigation: Any policy, regulation, infrastructure, or other project-based measure that contributes to the reduction of greenhouse gas concentrations in the atmosphere.

Carbon dioxide (CO_2): A naturally occurring gas and a by-product of burning fossil fuels (e.g., oil, gas, coal), burning biomass, land-use changes, and industrial processes (e.g., cement production). CO_2 is the principal anthropogenic GHG that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a global warming potential of one.

Carbon dioxide equivalent (CO_2e): A standardized measurement of greenhouse gases based on the warming potential of given gases compared with carbon dioxide.

Co-benefits: Benefits that are additional to the primary objective of a climate plan. In this case, the primary objectives are energy efficiency and emissions reductions, and co-benefits include job creation, enhanced equity, and better air and water quality.

Co-harms: Negative impacts that are additional to the primary objective of a climate plan.

Cooling degree days: The number of degrees that a day's average temperature is above 18°C, requiring cooling.

Decarbonization: The process by which countries, individuals, or other entities aim to achieve a zero-fossil-carbon existence. Typically refers to a reduction of the carbon emissions associated with electricity, industry, and transport.

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

District energy systems: A network of hot and cold water pipes that are used to heat and cool connected buildings more efficiently than if each building had its own heating/cooling systems.

Energy efficiency: Using less energy to perform the same task.

Fugitive emissions: Unintentional emissions generated from a leakage of gases or vapours from pressurized containers.

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 (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are several entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Besides CO_2, N_2O, and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Green hydrogen: Hydrogen generated by surplus renewable electricity using electrolysis, which can then be combusted.

Ground-source heat pump: A building heating technology that transfers heat stored in the earth at a somewhat stable temperature into a building when it requires heating, and transfers heat out of a building into the ground when it needs cooling. Also referred to as a geothermal heat pump.

Heating degree days: Number of degrees that a day's average temperature is below 18°C, requiring heating.

Heat pumps: A technology that uses electricity to transfer heat energy from a heat source to a target area using mechanical energy. Heat pumps are capable of providing year-round thermal comfort by providing heating in the winter and cooling in the summer. This technology can also be used as a water heating system.

Lock-in: A situation in which the future development of a system—including infrastructure, technologies, investments, institutions, and behavioural norms—is determined or constrained ("locked in") by historic developments.

Net-zero emissions: Net-zero emissions are achieved when human-caused 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 (e.g., global warming potential, global temperature change potential) chosen to compare emissions of different gases, as well as on the time horizon chosen.

Paris Agreement: The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in December 2015, in Paris, France, at the 21st session of the Conference of the Parties (COP) to the UNFCCC. The agreement, adopted by 196 Parties to the UNFCCC, entered into force on 4 November 2016 and as of May 2018, it had 195 Signatories and was ratified by 177 Parties. One of the goals of the Paris Agreement is "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change." Additionally, the Agreement aims to strengthen the ability of countries to deal with the impacts of climate change.

Pathway: 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.

Renewable energy: Energy that is derived from a source that is not depleted when used or is regularly replenished, such as wind or solar energy. Renewable energy is commonly used interchangeably with "clean energy" and is understood to be derived from zero- or low-emissions energy sources.

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

Scenario: 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. Scenarios are used to provide a view of the potential implications of developments and actions.

Solar farm: A large-scale or centralized solar installation where photovoltaic panels are used to harvest the sun's energy. Solar farms are typically connected to the electricity grid, and energy from the farm is delivered to consumers as part of that system.

Solar photovoltaic (PV) technologies: Technologies that produce electricity from solar radiation.

Wind farm: A large-scale or centralized group of wind turbines that are used to harvest the energy from wind. Wind farms are typically connected to the electricity grid, and energy from wind farms is delivered to consumers as part of that system.