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Noticed 04/12/23

PUBLIC NOTICE – PUBLIC WORKS & SUSTAINABILITY

The Public Works & Sustainability Committee will meet Monday May 1, 2023 at 6:00 p.m. in the Auditorium of Lakewood City Hall at 12650 Detroit Avenue. The meeting is open to the public.

Individuals with disabilities who require accommodations for participation in meetings must request accommodations at least 3 business days ahead of the scheduled meeting. Contact Michelle Nochta at (216) 529-5906 michelle.nochta@lakewoodoh.net.

The meeting will be livestreamed on the City's website at the following link:

www.lakewoodoh.gov/councilvideos

PUBLIC COMMENT PROTOCOL

The public is invited to comment on agenda items in person or by submitting a written comment in advance of the meeting using the eComment platform available [HERE](#). New users must create an eComment account.

The agenda is as follows:

Approval of the minutes of the March 27, 2023 meeting of the Public Works & Sustainability Committee.

RESOLUTION 2023-15 - A RESOLUTION adopting the City of Lakewood Climate Action Plan.
(Referred to PWS 03/20/23)

Tristan Rader, Chair
Tom Bullock, Kyle Baker; Members
PUBLIC WORKS & SUSTAINABILITY COMMITTEE

RESOLUTION NO. 2023-15

BY:

A RESOLUTION adopting the City of Lakewood Climate Action Plan.

WHEREAS, the Community Vision is the City's long-range vision for the community, upon which future policy decisions are predicated, and outlines broad goals, policies, and programs to strengthen the environmental, social and economic well-being of the community; and

WHEREAS, in December 2019, Council approved the Community Vision updates recommended by the Resiliency Task Force; and

WHEREAS, among other items, the Community Vision sets the following goals for supporting healthy living and creating a more ecologically sustainable city:

- Make transportation decisions that aim to reduce greenhouse gas emissions and promote wellness;
- Expand the urban tree canopy responsibly, especially on private property;
- Educate residents on how to prepare their homes for weather extremes;
- Have an overall culture which promotes community health and wellness, respects diversity, and embraces environmental stewardship;
- Protect Lake Erie and the Rocky River as vital sources of drinking water and recreation through storm and sanitary sewer improvements.; and

WHEREAS, The City has taken steps to advance sustainability efforts, including:

- Enacted energy benchmarking Ordinances;
- Implemented recycling programs;
- Adopted a Tree Planting Program with a goal to increase the tree canopy by 10 percent, to 33.5 percent by the year 2035;
- Started the conversion of streetlights to LED fixtures;
- Installed 13 electric vehicle charging ports;
- Constructed 6.5 miles of dedicated bike lanes with an additional 5.2 miles of shared use routes;
- Completed Wastewater Treatment Plant improvements including: digester power generation project, LED lighting replacement, high-efficiency aeration blowers;
- Implemented solar energy projects at City Hall, Winterhurst Ice Rink, and the Wastewater Treatment Plant; and

WHEREAS, the City, through its consultant, Sustainability Solutions Group (SSG), and a robust public involvement process with guidance from a stakeholder Advisory Committee, has

developed a Climate Action Plan that outlines a pathway towards net-zero carbon emissions by 2050 and addresses the climate vulnerabilities of our City; and

WHEREAS, the City desires to adopt the Climate Action Plan as a guiding document for future decisions related to climate change, sustainability, and climate vulnerabilities; and

WHEREAS, as set forth in Section 2.12 of the Third Amended Charter of the City of Lakewood, this Council by a vote of at least two thirds of its members determines that this resolution is an emergency measure and that it shall take effect immediately and that it is necessary for the immediate preservation of the public property, health, and safety and to provide for the usual daily operation of municipal departments in that the Climate Action Plan addresses the pressing issues of climate change, sustainability, and climate vulnerabilities; now, therefore,

BE IT ORDAINED BY THE CITY OF LAKEWOOD, STATE OF OHIO:

Section 1. The City of Lakewood Climate Action Plan as generally attached is hereby adopted.

Section 2. It is found and determined that all formal actions of this Council concerning and relating to the passage of this resolution were adopted in an open meeting of this Council, and that all such deliberation of the Council and of any of its committees that resulted in such formal action were in meetings open to the public in compliance with all legal requirements.

Adopted _____

John Litten, President of Council

Maureen M. Bach, Clerk of Council

Approved _____

Meghan F. George, Mayor

CITY OF LAKEWOOD



CLIMATE ACTION PLAN



Disclaimer

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

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

Acknowledgements

City of Lakewood Team:

Shawn Leininger, Director of Planning and Development

Katelyn Milius, Assistant Director, Planning and Development

Amanda Cramer, City Planner

Kevin Laffey, Urban Planning Intern

Lakewood Advisory Committee:

This Climate Action Plan is the product of many members of the Lakewood community, contributing their time and thoughts, and much of it despite the challenges of the COVID-19 pandemic. The City of Lakewood expresses its appreciation to the many residents, civic leaders, and business partners that served on the Advisory Committee leading this effort. This includes the past work of the Resiliency Task Force that set the ground work for the development of this plan.

Glossary

BAP	Business-as-Planned scenario
EV	Electric vehicle
GCRTA	Greater Cleveland Regional Transit Authority
FMP	Flood Mitigation Assistance Program
GHG	Greenhouse gas emissions
HMGP	Hazard Mitigation Grant Program
IRA	Inflation Reduction Act
IPCC	Intergovernmental Panel on Climate Change
MAC	Marginal abatement cost
MACC	Marginal abatement cost curve
NPV	Net present value
PDM	Pre-Disaster Mitigation Program
PV	Photovoltaic (solar)
SCC	Social Cost of Carbon
SSG	Sustainability Solutions Group
NOACA	Northeast Ohio Areawide Coordinating Agency
NOPEC	Northeast Ohio Public Energy Council
REC	Renewable Energy Certificate
UHI	Urban Heat Island
UNFCCC	United Nations Framework Convention on Climate Change





Letter From the Mayor

We are excited to continue past work to make our community more efficient and sustainable in our use of resources and as a result, better equip us locally to address the effects of Climate Change.

Both the administration and City Council have worked hard to build awareness and momentum for environmental projects that advance sustainability initiatives. This includes undertaking a Climate Action Plan to help us identify where we as a City and as a community can be most effective and equitable in addressing climate impacts. With that, I am pleased to present this report from our consultants at Sustainability Solutions Group (SSG) in support of this endeavor.

Over the last several years, the City has taken the initiative to be a regional leader when it comes to implementing sustainable policies and projects city-wide. We have:

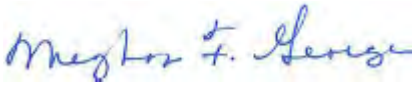
1. Enacted energy benchmarking ordinances;
2. Ensured all 77 of the City's electric energy accounts are 100% green and renewable as of May 31, 2021;
3. Established a tree planting program with a goal to increase the tree canopy by 10% to 33.5% by the year 2035;
4. Converted 1,047 streetlights to LED, approximately 33% of the City's streetlights;
5. Installed 13 electric vehicle charging ports across the city with two more coming to Lakewood High School through a grant from NOACA;
6. Provided 6.5 miles of dedicated bike lanes with an additional 5.2 miles of shared-use routes;
7. Made energy efficiency improvements to our wastewater treatment plant including a digester power generation project, LED lighting replacement, and high-efficiency aeration blowers;
8. Completed solar energy projects at City Hall, Winterhurst Ice Rink, and the wastewater treatment plant; and
9. Improved traffic signal timing to reduce pollution from idling cars.

This Climate Action Plan pulls together a variety of mitigation, adaptation, and resiliency policies and initiatives into a comprehensive plan, sustaining momentum and creating accountability within the City. Our overarching priorities in developing this plan are:

1. To contribute to a cohesive, integrated sustainability initiative that considers people, place, and prosperity in our neighborhoods;
2. To produce realistic metrics to analyze and prioritize City investments, guide prioritization, measure progress, and refine actions;
3. To establish a focused and integrated set of actions and goals that facilitate a measurable shift in outcomes towards an appropriate balance of environmental, economic, and social well-being across our community;

4. To ensure the actions address social and racial equity, making sure that no Lakewood resident is left behind as the community moves forward by involving frontline communities in the planning and decision-making process; and
5. To identify and foster partnerships. Lakewood knows that government is just one group and not necessarily always the most appropriate group to affect change. Through these plans, we expect to bring others to the table and move towards common goals and interests.

We would like to personally thank members of the Climate Action Plan Advisory Committee for their assistance in this endeavor. Thank you to all those who participated in making our community a better place for current and future generations.

A handwritten signature in blue ink that reads "Meghan F. George". The signature is written in a cursive, flowing style.

Meghan F. George

Mayor

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KEY INSIGHTS

Key Insights

Investing in climate actions requires the participation of all levels of government and all sectors of our society. Although the City of Lakewood is the owner of this plan, it cannot accomplish its climate action goals on its own. This is a roadmap for the community of Lakewood, and it requires assistance and involvement from everyone in Lakewood, as well as from outside Lakewood itself.

1. Climate action is a good investment.



From an economic perspective, climate action is a no-regret policy for the City of Lakewood, with many opportunities for new and existing businesses and the creation of new jobs. Implementation of the actions in the Climate Action Plan results in savings of \$2 billion from reduced energy costs and avoided maintenance costs and \$170 million in revenues. The implementation of the plan requires a societal investment of \$1.5 billion over 27 years (from 2023 to 2050, undiscounted), averaging ~\$55 million per year. These investments also generate savings that continue beyond 2050 that are not

included in these results. The net benefit to the community is \$720 million over 27 years—a **climate dividend¹ that averages \$27 million per year.**

2. Households save money.



Household expenditures on energy—natural gas, electricity, gasoline, and diesel—will decline as the plan is implemented. The plan involves shifting away from natural gas and gasoline to electricity, using high-efficiency space heating and cooling with heat pumps, and improving the thermal efficiency of homes. By 2050, the average household is expected to spend 24% less on fuel and electricity than they would if business continued as planned.

These savings can be used to finance the incremental capital expenditures.

For example, a heat pump can be financed by reduced heating costs and EVs can be financed by reduced transportation costs.

3. The Climate Action Plan will improve the quality of life in Lakewood.



The plan will generate a broad range of societal benefits with direct and indirect financial benefits, advancing multiple city and societal objectives while achieving deep GHG reductions. For example, electrifying transportation improves air quality, thereby delivering health benefits and reducing health care costs. Similarly, improving walking and cycling infrastructure will make it easier for residents to get around without vehicles and encourage exercise, which can reduce heart disease. Youth and older adults, in particular, indicated in the 2022 Community Health Needs

Assessment that they did not feel secure walking or cycling.²

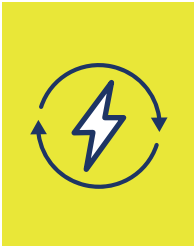
¹ A climate dividend is the financial benefit that comes along with decarbonizing the city.

² The Center for Community Solutions (2022). Lakewood Community Health Needs Assessment. Retrieved from: <https://www.communitysolutions.com/wp-content/uploads/2022/09/Lakewood-CHNA-Report-9.2022.pdf>

Building retrofits to improve energy efficiency will also improve indoor air quality in dwellings and office spaces, which can reduce health care costs and absenteeism at work. Reduced air pollution from the combustion of fossil fuels (on roads, in houses, and in electricity generation) will reduce health problems such as asthma and chronic obstructive pulmonary disease.

Implementing the plan will also create more jobs—over 6,000 person-years of employment compared to continuing business as planned between 2023 and 2050.

4. Electrification is the keystone of the plan.



The plan's primary strategy for reducing GHG emissions is switching heating and transportation systems from fossil fuels to electricity. Achieving Lakewood's net-zero target requires a resilient and flexible electrical distribution system that enables households and businesses to install heat pumps, charge vehicles, and generate and source clean electricity.

5. Building retrofits reduce the impact on the electrical grid.



Combined with local solar generation and electricity storage, building retrofits are expected to reduce annual electricity consumption to create space on the electrical grid for electrifying heating and transportation. The combination of replacing electric baseboards with heat pumps and retrofitting homes and buildings generates electricity savings, or negawatts.³ The negawatts are then used to power heating and transportation. **Building retrofits are also the key strategy for stimulating employment, addressing energy poverty, and improving living conditions for vulnerable populations.**

6. Implementation strategies can be designed to address equity.



Decisions on the type, order, and magnitude of any actions implemented will impact not only emissions reductions but also how people experience physical, social, and economic impacts of climate change and climate policy. Systemic injustice places greater risk from climate impacts on vulnerable communities. As a result, an equity lens must be applied to decision-making on both the approach to implementation and the costs of inaction.

Many actions outlined in this plan will benefit low-income and equity-seeking groups. For example, the Low-Carbon scenario (LC scenario) reduces transportation costs for households and increases accessibility to destinations. This is particularly beneficial for households that are primarily dependent on personal vehicles or public transportation. Implementing the Low Carbon pathway can also reduce energy poverty, when a household's energy costs represent a disproportionate share of their income, and careful policy design can ensure benefits for both renters and homeowners. Since the Low Carbon pathway involves investments, the mechanisms for financing the investments could generate higher returns for investors, which could exacerbate inequality. It is therefore important to consider the impacts on various groups when designing policies to support implementation.

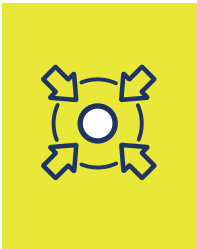
³ Note that the impact on peak electricity demand was not assessed and would require a deeper analysis.

7. A climate lens will avoid malinvestments.



The timeline is tight and the pathway ambitious. Any investments or policies that the City undertakes that result in increased emissions will become malinvestments, stranded investments that are costly to undo. To ensure the City's policies and expenditures align with the Low Carbon pathway, the City can **implement a climate lens**, where each investment is evaluated to identify its contributions to decreasing or increasing emissions. **In the case that an evaluation results in increased emissions, the project or policy should not proceed.**

8. A whole-city approach to climate action.



The next generation of climate action planning focuses on the systematic transformation of the built environment, as opposed to a long list of actions. In particular, this means embedding the consideration of climate into every policy and expenditure in alignment with the LC scenario, a whole-city approach. This approach requires a cultural and organizational transformation so the City itself is a climate mitigation mechanism, applying tools such as a **climate lens and an annual carbon budget.**

9. Natural assets are central to a climate-ready, healthy and vibrant community.



Lakewood has a variety of natural spaces that currently help protect the community against the impacts of climate change by reducing flooding, cooling outdoor spaces, improving water quality, and improving the physical and mental health of residents. **Careful planning to protect these natural assets will ensure they thrive into the future.**



INTRODUCTION

1. Introduction

1.1 The Climate Emergency

Climate change is the greatest long-term global challenge that human society is facing. Human-induced climate change poses risks to health, economic growth, public safety, infrastructure, livelihoods, and the world's biodiversity and ecosystems. As local and global greenhouse gas (GHG) emissions increase, the Earth continues to warm at an unprecedented rate.

In December 2015, the Paris Agreement was adopted at COP21 by 196 countries, including the United States. The U.S. withdrew from the Paris Agreement in 2017 but rejoined in 2021. This legally binding international treaty on climate change set a goal to limit global warming to well below a 2°Celsius, and preferably to a 1.5°Celsius increase, above pre-industrial levels.⁴ However, current global GHG emissions are not on a trajectory to meet these goals.

Despite a temporary decline in global emissions in 2020 due to the COVID-19 pandemic, the world is heading for 3° Celsius or more of warming.⁵ This degree of warming threatens human health, economic well-being, and the survival of the natural systems that humans and eight million other plant and animal species—already increasingly at risk—depend upon.⁶

By developing a Climate Action Plan, the City of Lakewood is preparing for these climate risks and hazards, while reducing GHG emissions. The plan detailed here is based on analysis of energy flows within the community and the sources and sinks of GHG emissions. A baseline inventory of energy and emissions, combined with a projection of energy use and production, was used to explore areas for improvement and change. The plan outlines a pathway to dramatically reduce GHG emissions while increasing energy efficiency and independence in Lakewood.

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

⁵ New UNEP Synthesis Provides Blueprint to Urgently Solve Planetary Emergencies and Secure Humanity's Future. 18 Feb. 2021. <https://unfccc.int/news/new-unesp-synthesis-provides-blueprint-to-urgently-solve-planetary-emergencies-and-secure-humanity-s>

⁶ Ibid.

1.2 The City of Lakewood



Figure 1. Geographic boundary of Lakewood, Ohio.

The City of Lakewood is a vibrant community located on the shore of Lake Erie. It is part of the Greater Cleveland Metropolitan Area and is situated within Cuyahoga County. The city’s population is assumed to remain constant at 50,000 people. Lakewood has a mix of single-family homes and denser apartment blocks, with corridors of commercial activity running through the city.

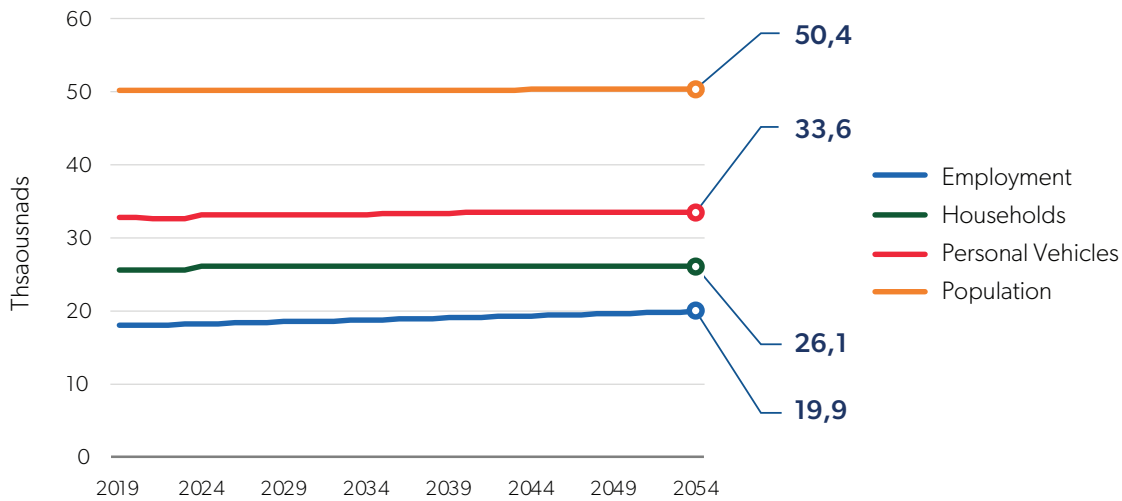


Figure 2. Trends in population, personal vehicles, number of households, and employment (in full-time equivalent person-years) from 2019 to 2050.

1.3 A Changing Climate

Lakewood residents are already feeling the impacts of the climate crisis; they report power outages resulting from air conditioning demand, heavy downpours that cause localized and basement flooding, and more ozone awareness days.

The Link Between Air Pollution and Greenhouse Gas Emissions

The combustion of fossil fuels in furnaces and in vehicles generates greenhouse gasses which accumulate in the atmosphere to cause climate change. The combustion also results in harmful air pollutants, such as nitrous oxides.⁷ When nitrous oxide reacts with sunlight, it forms ozone, particularly during summer months when temperatures are higher and there is more sunlight. While ozone is difficult to detect, you feel stinging eyes, shortness of breath, chest pain, wheezing, and coughing. Active children are at the highest risk from ozone exposure, as well as active adults and people with asthma or other respiratory diseases that make the lungs more vulnerable. Reducing the sources of GHG emissions also reduces harmful air pollutants, resulting in a healthier environment.

The region is already planning for the impacts of the climate crisis. Cuyahoga County's All-Hazards Mitigation Plan calculates risk factors for natural hazards, most of which are expected to worsen with the effects of climate change.⁸ Risk factors are calculated with a combination of scores, on a scale of 1 to 4 that rank the probability, impact, spatial extent, warning time, and duration of each hazard. In Lakewood, **flooding, extreme temperatures, and severe winter storms** are the climate hazards with the highest risk factor scores, meaning they are more likely to occur and affect residents' well-being than other climate-related natural hazards such as drought. The projected changes to average temperatures, days below freezing, and precipitation anticipated in Cuyahoga County are shown in Figure 3.

⁷ Kinney, Patrick L. "Interactions of climate change, air pollution, and human health." *Current environmental health reports* 5 (2018): 179-186.

⁸ Cuyahoga County Office of Emergency Management. 2017. All Hazards Mitigation Plan. Prepared by Baker International.

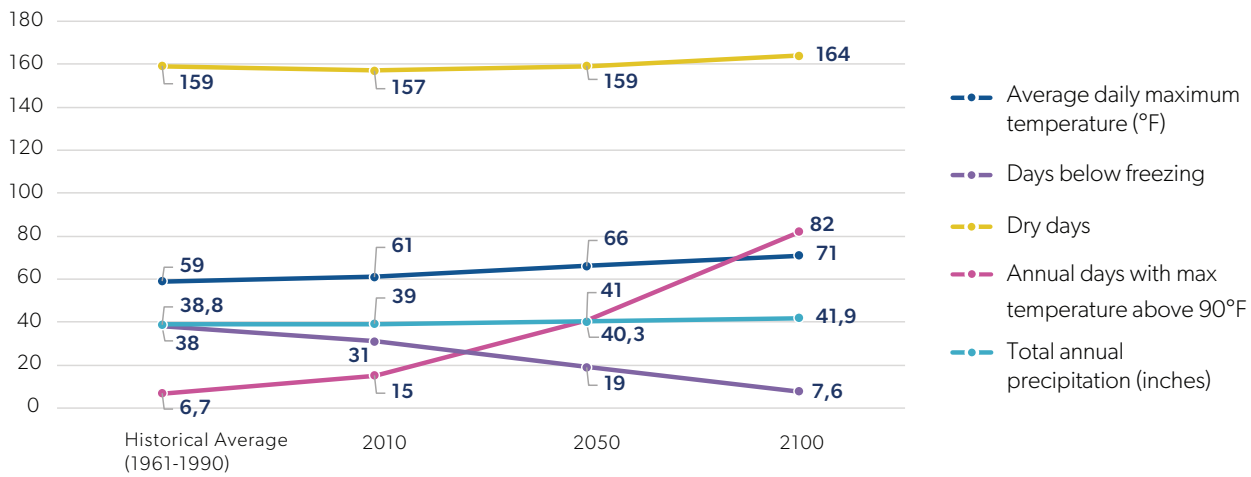


Figure 3. Climate change impacts to 2100 under a high global emissions scenario.⁹

1.3.1 Flooding

Flood damage is a combination of the magnitude of a natural event and the placement and function of human infrastructure. Urban planning, water management, and infrastructure shape what the risk is, who is at risk, and when they will be at risk.

Impact: Lakewood will experience more wet basements, road closures, and damage to sewer and water infrastructure as a result of climate change.

1.3.2 Temperature Extremes

As summarized in the Ohio Wildlife Action Plan, effects include the following:

- Warming occurring in every season, particularly in winter, at higher latitudes, at higher elevations, and inland (away from lake coasts).
- Extreme heat events are increasing.
- Growing seasons are getting longer, with more growing degree days expected.
- The Great Lakes are warming, so lake evaporation rates are increasing.

Specifically, urban areas experience warmer temperatures as a result of the high concentration of buildings, high emissions, and heat-absorbing surfaces such as black roofs and parking lots. On average, these urban heat islands (UHIs) will range between 2° and 22° Fahrenheit warmer than adjacent rural areas. Generally, plants create cooler ambient temperatures than man-made surfaces because of their reflective properties, evapotranspiration, and shading. Although trees provide all three benefits, the difference between trees and other forms of dense natural vegetation at the landscape scale is low. Near buildings, where trees can be placed to lower energy use and greenhouse gas emissions, their value in reducing urban heat islands is particularly high. As the climate changes, the ecosystem is also changing, evidenced by the changes in viability of tree species.¹⁰

⁹ The Climate Explorer, 2022. NOAA. Accessed: https://crt-climate-explorer.nemac.org/climate_graphs/?city=Lakewood%2C+OH&county=Cuyahoga%2BCounty&area-id=39035&fips=39035&zoom=7&lat=41.4819932&lon=-81.7981908&id=pcpn

¹⁰ USDA Forest Service (2022). Climate Change Atlas Tree Species; Current and Potential Future Habitat, Capability, and Migration. Retrieved from: https://www.fs.usda.gov/nrs/atlas/combined/resources/summaries/urban/ua_17668.pdf

Impact: Lakewood will experience an increased urban heat effect, a shift in the tree species that are viable, and negative impacts on heat-vulnerable populations.

1.3.3 Severe Storms

The frequency and intensity of coastal storm events in the Great Lakes region are predicted to increase in the coming decades, exposing at-risk populations to potential hazards, including flooding, erosion, and combined sewer overflows. In NE Ohio, these effects will be felt most by coastal communities such as Lakewood.

Impact: Lakewood will experience more severe shoreline erosion and more frequent power outages due to more frequent and severe storms.

1.3.4 Tornadoes

Although tornadoes are and will remain rare events, most predictive models indicate an increase of tornado activity in Ohio (more than six more tornado days each year by 2090).

1.3.5 Drought

Due to its regional context, Cuyahoga County and its residents are not as subject to some commonly associated risk factors like drought, though the 2012 North American drought and accompanying low tributary discharge was associated with a record-breaking hypoxic event in Lake Erie.¹¹ Similar events are expected to occur more frequently in the future, with potential negative impacts on fish populations, regional tourism, recreation opportunities, and human health.¹²

Mitigation and Adaptation

Actions to address climate change can be grouped into two broad categories: mitigation and adaptation. Mitigation actions serve to reduce the severity of climate change by reducing the concentration of GHGs in the atmosphere. These actions can include reducing or eliminating the use of fossil fuels for heating or transportation or changing how we manage organic waste to reduce methane emissions. Adaptation actions work to reduce the impacts from the climate change we are currently experiencing and expect to experience in the future. Adaptation work involves identifying hazards that result from climate change, such as increased flooding or more frequent and severe heat waves, and helping people and infrastructure prepare for the effects or reduce their exposure to these hazards. Climate mitigation and adaptation work together to address the impacts and the severity of climate change across the community.

¹¹ Zhou, Y., A.M. Michalak, D. Beletsky, Y. Y. Rao, and R. P. Richards, 2015. Record-Breaking Lake Erie Hypoxia during 2012 Drought. *Environmental Science and Technology*, 49: 800-807.

¹² International Joint Commission (2014). A Balanced Diet for Lake Erie: Reducing Phosphorus Loadings and Harmful Algal Blooms. Report of the Lake Erie Ecosystem Priority.

1.4 Net-Zero by 2050

The pathways to an emissions target can vary greatly (Figure 4). Different pathways result in much more (right figure) or much fewer (left figure) emissions being released overall between now and 2050. The cumulative GHG emissions released over the next 30 years is just as significant for staying within the 1.5° Celsius to 2.0° Celsius warming threshold (recommended by the IPCC and UNFCCC Paris Agreement) as reaching net-zero by 2050. Delaying action results in more emissions released by 2050. Delaying action also requires a transition so rapid as the target year approaches that actions may contribute to or create undesirable social and financial impacts. At the same time, it is important for each local government to carefully consider the rate at which it can transition to a low-carbon economy given the constraints in which it operates.

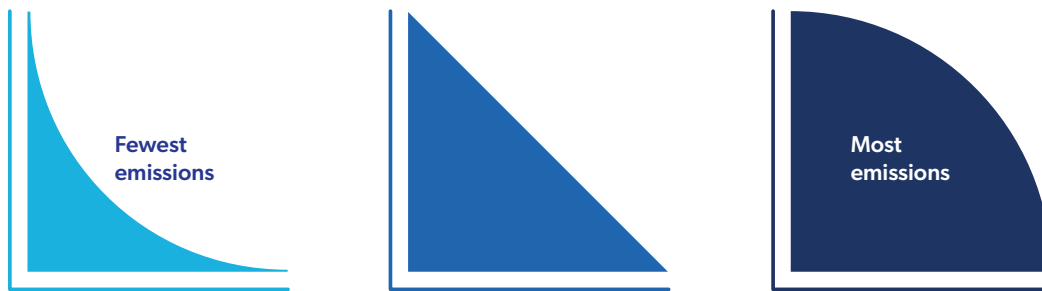


Figure 4. Emissions reductions pathways are associated with the timing of actions and setting interim targets.

The City of Lakewood has undertaken efforts to reduce the emissions from electricity used in municipal buildings, and in 2019 it adopted legislation to power municipal facilities with clean energy by 2025 and the community as a whole by 2035. Lakewood partnered with NOPEC to offset 100% of its municipal electricity use with Renewable Energy Credits (RECs) beginning in 2021. By 2023, all of the residential and private electricity accounts under NOPEC will also use RECs to offset emissions associated with the generation of electricity.

The City of Lakewood has adopted a two-part GHG emissions target:

- **50-52% reduction in greenhouse emissions from 2005 levels by 2030.**
- **Net-zero emissions by 2050.**

This target aligns with the United States' federal emissions reduction target announced in April 2021 (Figure 5). The target is based on the United States' Nationally Determined Contribution in line with Article 4 of the Paris Agreement.

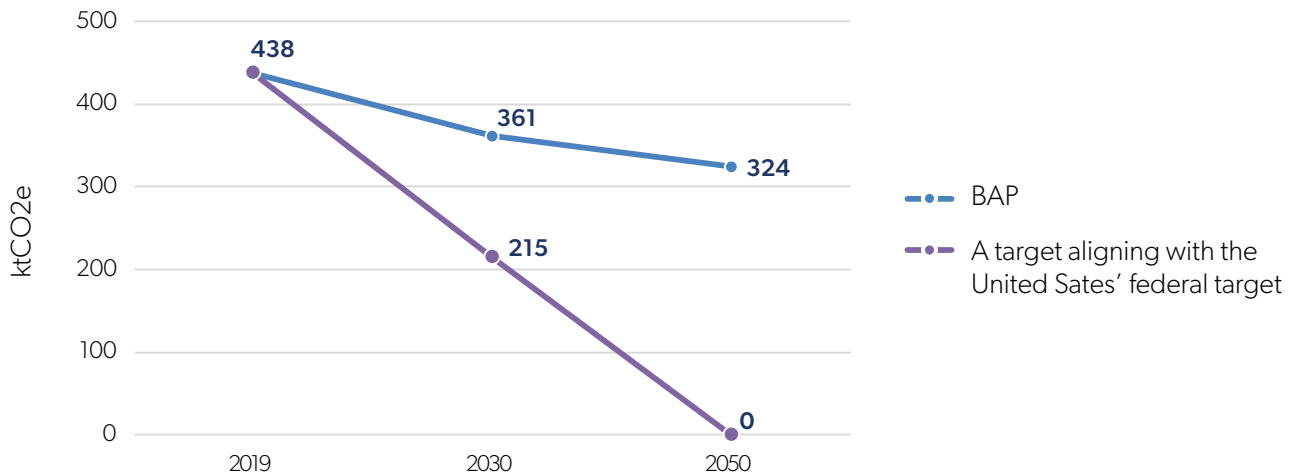


Figure 5. Lakewood's BAP emissions in comparison to the pathway resulting from the U.S. federal emissions targets for 2030 and 2050.

Within the federal emissions target are sector-specific goals to move the country towards carbon neutrality. These goals include the following:

- **Achieving 100% carbon-free electricity by 2035.**
- **Supporting energy efficiency upgrades and electrification in buildings.**
 - A job-creating retrofit program
 - Sustainable affordable housing
 - Wider use of heat pumps and induction stoves
 - Adoption of modern building codes for buildings
- **Reducing carbon pollution from the transportation sector.**
 - 50% of personal and light-duty vehicle sales are electric by 2035.
- **Industry decarbonization.**
 - Researching, developing, demonstrating, commercializing, and deploying very-low-carbon and zero-carbon industrial processes and products
 - Incentivizing carbon capture
 - Incentivizing new sources of hydrogen produced from renewable energy, nuclear energy, or waste
- **Agriculture decarbonization and land management.**
 - Supporting scaling of climate-smart agricultural practices including reforestation, rotational grazing, and nutrient management practices
 - Investing in forest protection and forest management
 - Supporting nature-based solutions and sequestration in waterways through blue carbon

1.4.1 Cumulative Emissions

While GHG emissions targets have typically been put forward in terms of achieving a specified level of annual emissions by some future target year (e.g. 30% below 2010 levels by 2030), it is the cumulative atmospheric emissions over a period of years or decades that determine the degree of global warming that will ensue. Reflecting this scientific reality, the cumulative emissions between the present and the target year are limited according to a set cumulative emissions target. This underscores the importance of defining viable pathways in which annual emissions are continually brought down over time, on a pathway that is feasible and that meets the cumulative limit.

For example, Figure 6 portrays emissions over a 30-year period for seven different pathways. The pathways result in very different cumulative emissions, represented by the area under the curve. The curves that result in more cumulative emissions are also steeper at the end of the time period, and the steepness of the curve is a proxy for the level of disruption.

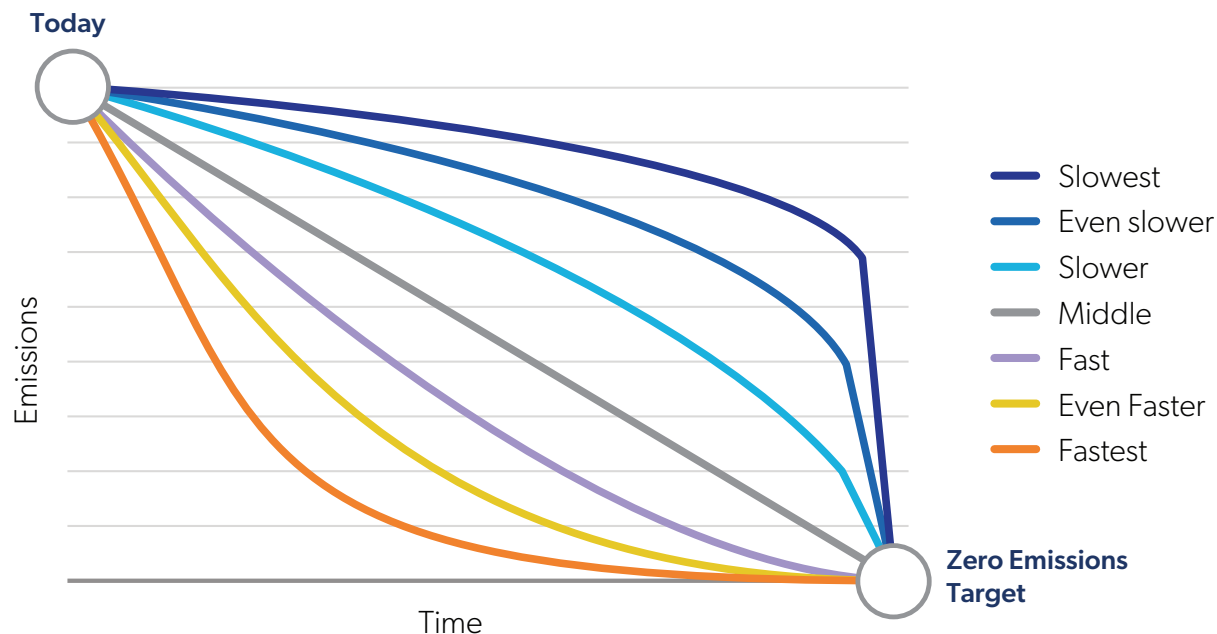


Figure 6. Delayed vs immediate action in meeting a common cumulative carbon emissions budget.

1.5 A Community Working Together

The Lakewood Climate Action Plan was created hand in hand with the public. Community members provided input on how Lakewood should reduce greenhouse gas emissions and prepare for the impacts of climate change.

The consulting team gathered public input through public meetings, a Decarbonization Advisory Group, and focus groups. Public meetings were held at the outset of the project to inform the public about the City's efforts, as well as towards the end of the project to review draft actions and gather input on how they should be implemented.

Additionally, the City created an advisory group that provided input throughout the development of the plan. The group brought together individuals with diverse perspectives, including representatives from utilities, public transit, community health, etc. Members provided input on the Climate Action Plan's target; the majority recommended the City align its plan with the federal target—the target selected for the Climate Action Plan.

Finally, the consulting team ran two focus groups to understand how Lakewood residents have been affected by climate hazards, their concerns about future climate impacts, and how vulnerable members of the community could be affected by climate hazards. The consulting team used this input to design the climate adaptation measures in this plan.

The Decarbonization Advisory Group participated in one focus group, while the other focus group was made up of 10 Lakewood residents of varying ages, backgrounds, professions, and ethnicities. It included three members of the Lakewood Community Relations Advisory Committee, a member of Lakewood's Climate Resiliency Task Force, the manager of a service-learning program, a student, a small business owner, and a member of the Lakewood Chamber of Commerce.



A NET-ZERO LAKEWOOD

2. A Net-Zero Lakewood

2.1 Methodology

Developing the City of Lakewood’s Climate Action Plan involved the following steps:

1. Review and evaluation of:
 - a. Relevant county, state, and federal legislation, goals, and programs;
 - b. The utility and energy context;
 - c. The City of Lakewood’s relevant strategies and plans;
 - d. Lakewood’s physical and natural assets;
 - e. Lakewood’s climate hazards and vulnerabilities;
 - f. Challenges and opportunities specific to the City of Lakewood; and
 - g. The City of Lakewood’s GHG reduction commitments and goals.
2. Input from stakeholders and the public during engagement sessions.
3. Technical modeling of the City of Lakewood’s energy and emissions between now and 2050, as informed by the review and evaluation above, in a Business-as-Planned scenario.
4. Analysis of the hazards and risks posed by climate change to the physical and natural assets in Lakewood.
5. Selection of actions most appropriate to Lakewood’s context and subsequent modeling of an initial LC scenario.
6. Evaluation of the results of the initial LC scenario modeling, additional analysis of options to achieve further reductions, and development of the Low-Carbon pathway.
7. Identification of actions to reduce the climate risk and protect natural carbon sinks.
8. Financial analysis of the Low-Carbon Scenario.
9. Analysis of the co-benefits and co-harms of the LC Scenario.
10. Development of an implementation framework for this Climate Action Plan.

2.2 Lakewood Today

2.2.1 Current Sources of Emissions

Energy use in Lakewood is dominated by residential purposes, primarily for space heating, and transportation. Fossil fuel use dominates these end-uses, with natural gas for heating and gasoline and diesel for transportation. Additionally, the state electricity grid uses carbon-intensive fuels for generation.

Figure 7 shows the GHG emissions by sector for Lakewood in 2019. Due to the carbon intensity of the fossil fuels used in space heating and transportation, residential and commercial buildings and transportation are responsible for the majority of GHG emissions.

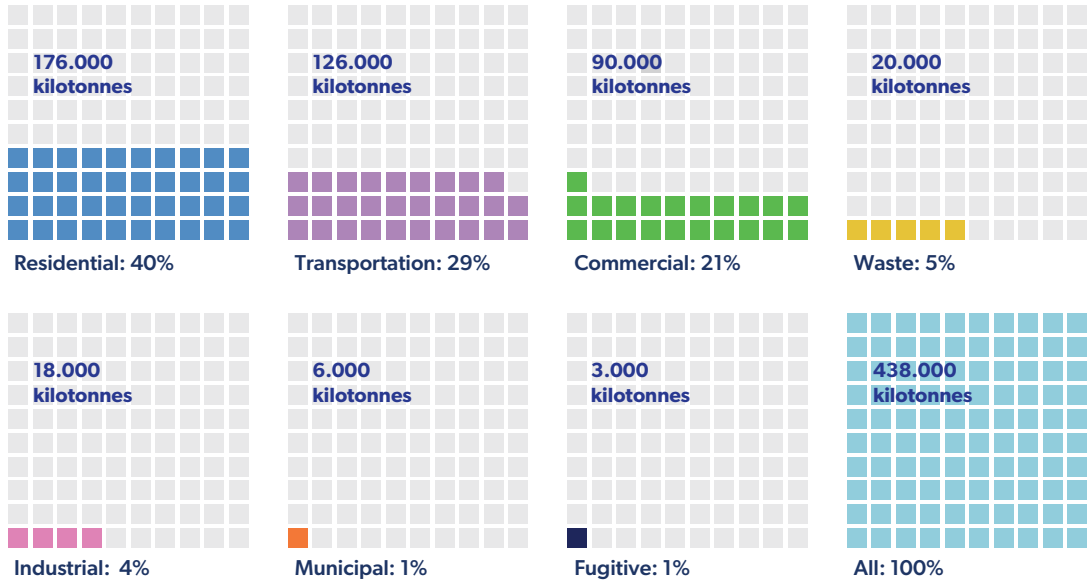


Figure 7. GHG emissions by sector for Lakewood in 2019.¹³

2.2.2 Looking in the Future: The Business-as-Planned Scenario

The City of Lakewood’s population is projected to remain at the same size as it is today. When this trend is combined with improved vehicle efficiency, improved heating equipment efficiency, and decreased heating demand as a result of a warming climate, total energy use declines by 20% by 2050. The Business-as-Planned (BAP) Scenario (Figure 8) tells this story, incorporating assumptions for climate change, a stable population, and the continued use of Renewable Energy Certificates by the municipality and for some private electricity users.

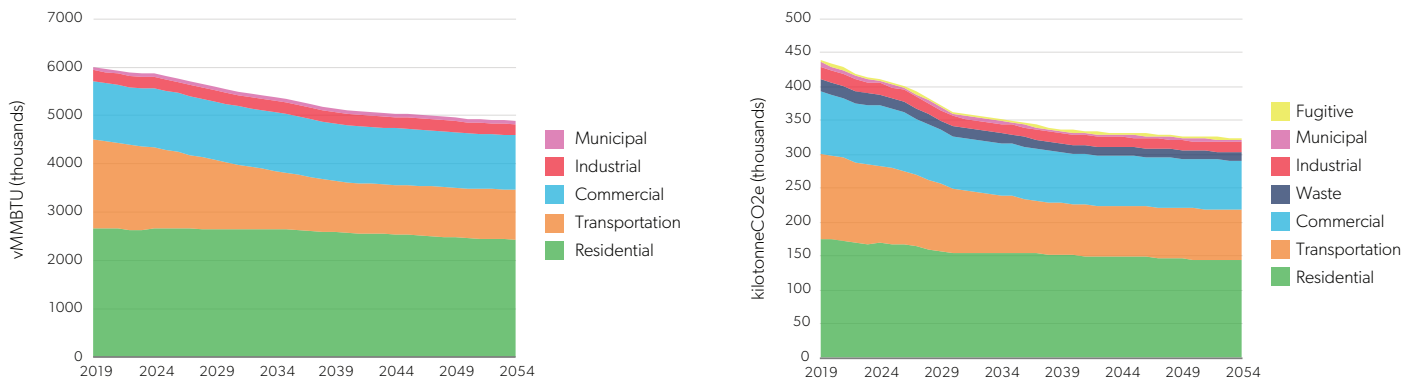


Figure 8. Energy (left) and emissions (right) by sector in the BAP, 2019–2050.

¹³ Fugitive emissions: Unintentional emissions generated from a leakage of gasses or vapors from pressurized containers.

As energy use declines, GHG emissions associated with energy use and other activities in Lakewood also declines (Figure 9). An anticipated 27% reduction in total emissions is the result of reduced space heating needs and reduced consumption of fossil fuels for transportation. GHG emissions from residential and transportation sources continue to dominate into the future, highlighting the largest opportunities for efficiency improvements and emissions reductions.

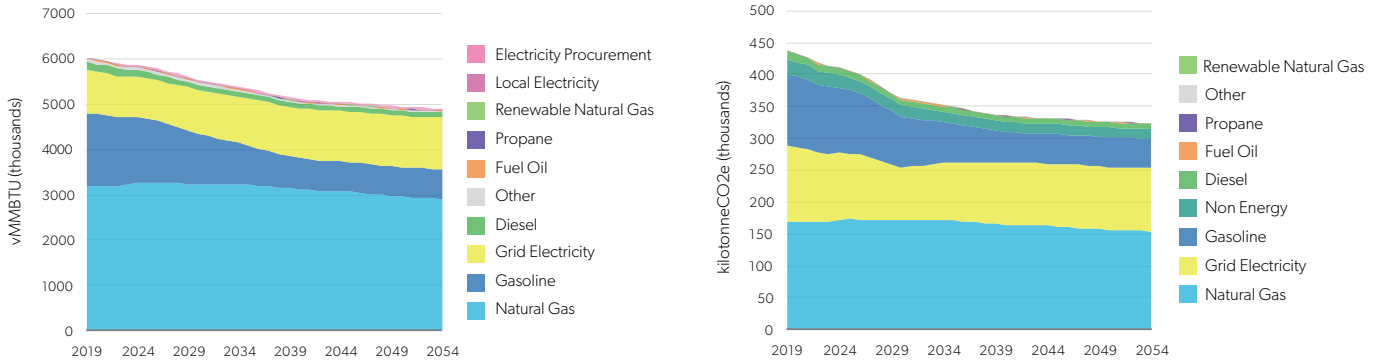


Figure 9. Energy (left) and emissions (right) by fuel in the BAP, 2019–2050.

Renewable Energy Credits (RECs)

Renewable Energy Certificates (RECs) represent the property rights for the environmental attributes of electricity generated from a renewable energy resource. RECs were developed to accelerate new renewable energy projects. RECs do not result in the delivery of renewable energy to the entity purchasing the REC; instead, they represent the delivery of renewable energy added to the grid somewhere. RECs are being used in Lakewood, purchased from NOPEC, for municipal and some private electricity accounts.

There are risks that RECs may not result in actual emissions reductions.¹⁴ A cautious approach is therefore to purchase RECs as both an early move and a 'last resort'. It is an early move to decarbonize electricity as quickly as possible, and it is a 'last resort' in that efficiency measures and local renewable generation take precedence wherever possible.

RECs differ from carbon offsets. Offsets represent a metric ton of emissions avoided or reduced while RECs represent attributes of 1 MWh of renewable electricity generation.

One strategy that Lakewood can use to increase the rigor and value of RECs is to issue an RFP with specific criteria. For example, a recent RFP from the Government of Canada included the following criteria for a purchase of RECs:

- a. Be located in Canada
- b. Be able to connect to the existing Electricity grid and be located where the available capacity of the line, substation, or region of the Electricity grid to which the Facility will connect, under system normal conditions, can accept 100% of the REC Projects Contract Capacity.
- c. Utilize Solar Energy or Wind Energy as the sole source(s) of fuel to generate Electricity.
- d. Have Site Control.
- e. Be separately metered.
- f. Not be a Behind-the-Meter Project.
- g. Be a New Build or be an Expansion but not a Redevelopment. For absolute clarity, a REC Project referred to in a bid that is an Expansion is eligible under this RFP only with respect to the Contract Capacity relating to the Expansion, separately metered.

2.3 A Pathway to Net-Zero

Deep reductions in GHG emissions are required to meet the 2030 and the 2050 emissions targets. A series of modeled actions that target improving efficiencies and reducing overall energy demands, improving existing infrastructure and assets, and decarbonizing fuels are combined into a LC Scenario (LC Scenario). The LC Scenario results in a 93% reduction in total GHG emissions by 2050. Lakewood can monitor new and emerging technologies and continue to identify and engage opportunities to address this remaining 'carbon gap' of 10 ktCO₂e in 2050.

¹⁴ Bjørn, A., Lloyd, S.M., Brander, M. et al. Renewable energy certificates threaten the integrity of corporate science-based targets. *Nat. Clim. Chang.* 12, 539–546 (2022). <https://doi.org/10.1038/s41558-022-01379-5>

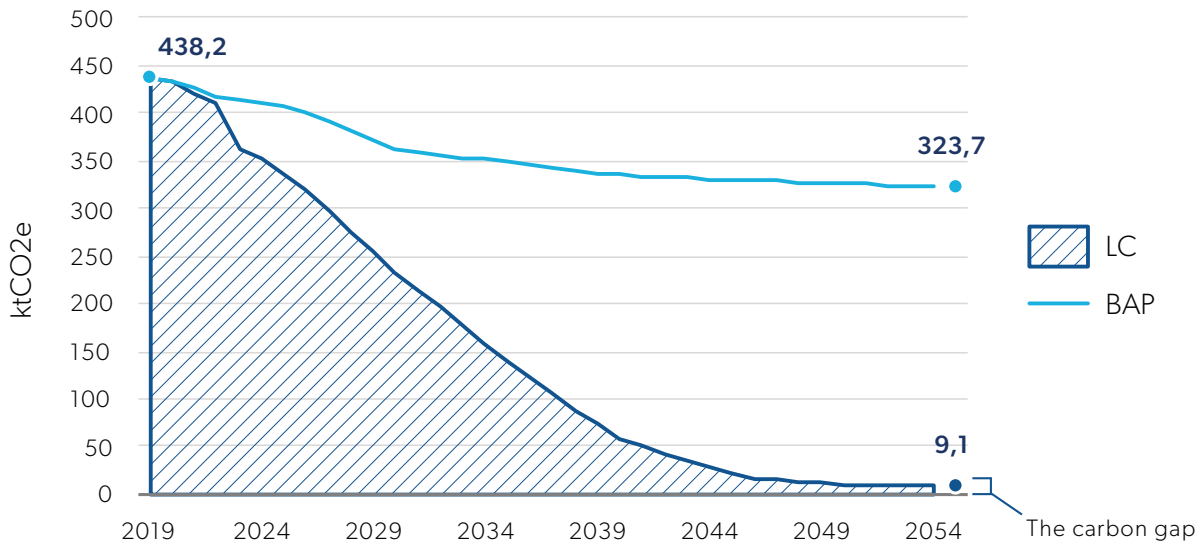


Figure 10. GHG emissions for Lakewood in the BAP and LC scenarios, 2019–2050.

2.3.1 Natural Spaces and the Carbon Gap

Natural spaces in Lakewood are carbon sinks, absorbing and storing carbon that would otherwise end up in the atmosphere (these emissions are not included in the GHG emissions inventory). Lakewood's natural spaces are critical to preventing increasing climate change, and they deliver a range of co-benefits such as providing habitats and reducing the urban heat island effect.

While the current urban tree and forest stock isn't enough to close the carbon gap of ~10 kt CO₂e in 2050, the annual sequestration, combined with the carbon storage in this biomass is an important factor in reaching the net-zero target.

Table 1. Carbon stored and sequestered by Lakewood's tree canopy.

	Currently stored (kt CO ₂ e)	Annual sequestration (kt CO ₂ e/yr)
Rocky River Forest	19	0.6
Public Tree Inventory	11	0.3
Private Tree Canopy	58	1.6
Total	89	2.6

Any loss of existing trees will increase the carbon gap, while expansion of the tree canopy will help reduce it. If Lakewood were to lose all its trees, not only would this release the stored carbon back into the atmosphere, but it would also eliminate the annual sequestration of carbon provided by these trees (Figure 11).

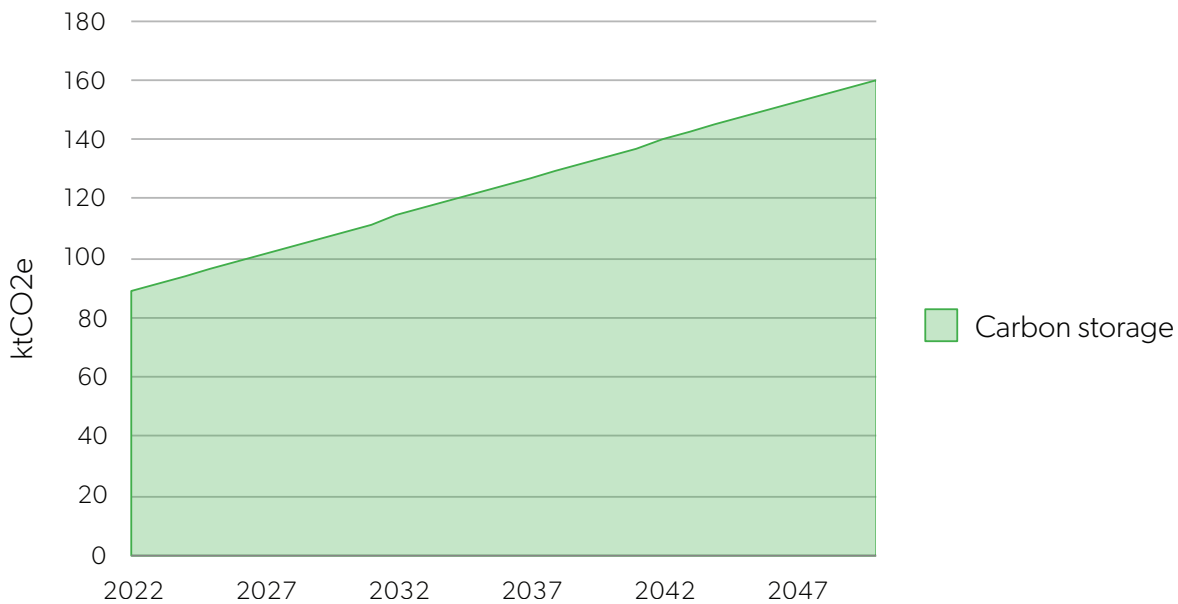


Figure 11. Cumulative carbon sequestered by all trees in Lakewood, assuming no changes in tree canopy by 2050.

Efficiency First

The underlying approach to the LC scenario is to order the actions according to a priority of ‘Reduce, Improve, Switch’: reducing energy consumption is the first step, then maximizing energy efficiency improvements, and finally switching to low-carbon energy sources for the remaining demand. Each kWh of electricity saved through efficiency is a kWh that need not be generated. In an electrified future, each trip shifted from gasoline vehicles to transit or human-powered transportation modes constitutes an efficiency gain, which reduces the burden on the landscape to provide energy. Efficiency gains, therefore, also have land benefits.

2.3.1 The Big Moves

There are four areas that need to make “Big Moves” when it comes to emissions reduction: buildings, transportation, local renewable energy, and water and waste. Implementing actions within these key areas can reduce GHG emissions as demonstrated in Figure 12.

- Buildings:** All buildings, including homes, commercial buildings, municipal buildings, and industrial buildings undergo deep retrofits to reduce energy consumption. New buildings are built to net-zero standards, meaning they will be highly efficient and generate on-site electricity. All buildings, whether new or existing, will switch from fossil fuels to electricity for space heating, space cooling, and water heating.
- Transportation:** All vehicles are zero emission, with personal vehicles leading the way. Cars, SUVs and small trucks are electric, and heavy-duty vehicles are either electric, or use a low-emissions fuel. The share of walking and bicycling trips increases by building and maintaining more trails, sidewalks, and bike lanes. Additionally, transit is expanded and

decarbonized. The final portion of a trip, such as getting from a bus stop to a workplace, or deliveries of goods from warehouses to final destinations, can be completed using shared e-scooters and e-bikes.

3. **Local renewable energy:** Solar panels are installed on new buildings as they are constructed and on existing buildings as they are retrofitted. Additionally, wind generation is added to supply zero-emissions electricity to Lakewood, replacing much of the demand for grid electricity. Electricity purchased with Renewable Electricity Credits is continued into the future.
4. **Water and waste:** Overall waste generation is reduced and waste diversion to recycling and composting facilities is improved. Renewable natural gas is captured from waste sources and used to replace natural gas in some systems during the decarbonization process. Furthermore, water consumption is reduced with efficiency measures including leak detection technology and end-use equipment improvements like smart meters.

The Four **BIG MOVES**



As shown in Figure 12, the result of making these changes is a 93% decrease in GHG emissions by 2050 and an overall decrease in total energy demand by 61%. Residential, commercial, and municipal buildings are almost entirely decarbonized, while industrial emissions are reduced by 75%.

The retrofitting of buildings and the replacement of natural gas as a heating source for homes and buildings with high-efficiency heat pumps removes the primary major source of GHG emissions, with only minor emissions remaining in most sectors.

What is a Deep Retrofit?

A deep retrofit is a set of actions to improve building quality with the express goal of improving the energy efficiency of the building. Minor retrofits include draft sealing, improving the insulation, and changing out lights for LEDs. Major retrofits can include replacing windows and doors, updating heating and cooling systems, and reducing water consumption by installing low-flow faucets. Deep retrofits go a step further, overhauling all systems of a building. This can include reconfiguring the interior of the building, replacing the roof, rearranging windows to maximize solar gain, and replacing existing HVAC systems with electric heat pumps.

A deep retrofit reduces a building’s energy consumption by 50% or more.

The electrification of transportation, the second-largest source of GHG emissions today, further reduces GHG emissions in Lakewood. Even though a small amount of heavy machinery is still expected to use fossil fuels by 2050, it will be replaced with zero-emissions options as these machines are retired.

Emissions from grid electricity and landfills constitute the largest portion of the remaining emissions in the net-zero pathway. The extensive use of renewable electricity is essential to meeting the GHG emissions goals. Emissions from landfills are a result of the biodegradation of organic materials, some of which may continue to emit GHGs for years or decades after they have been deposited, and are very challenging to mitigate.

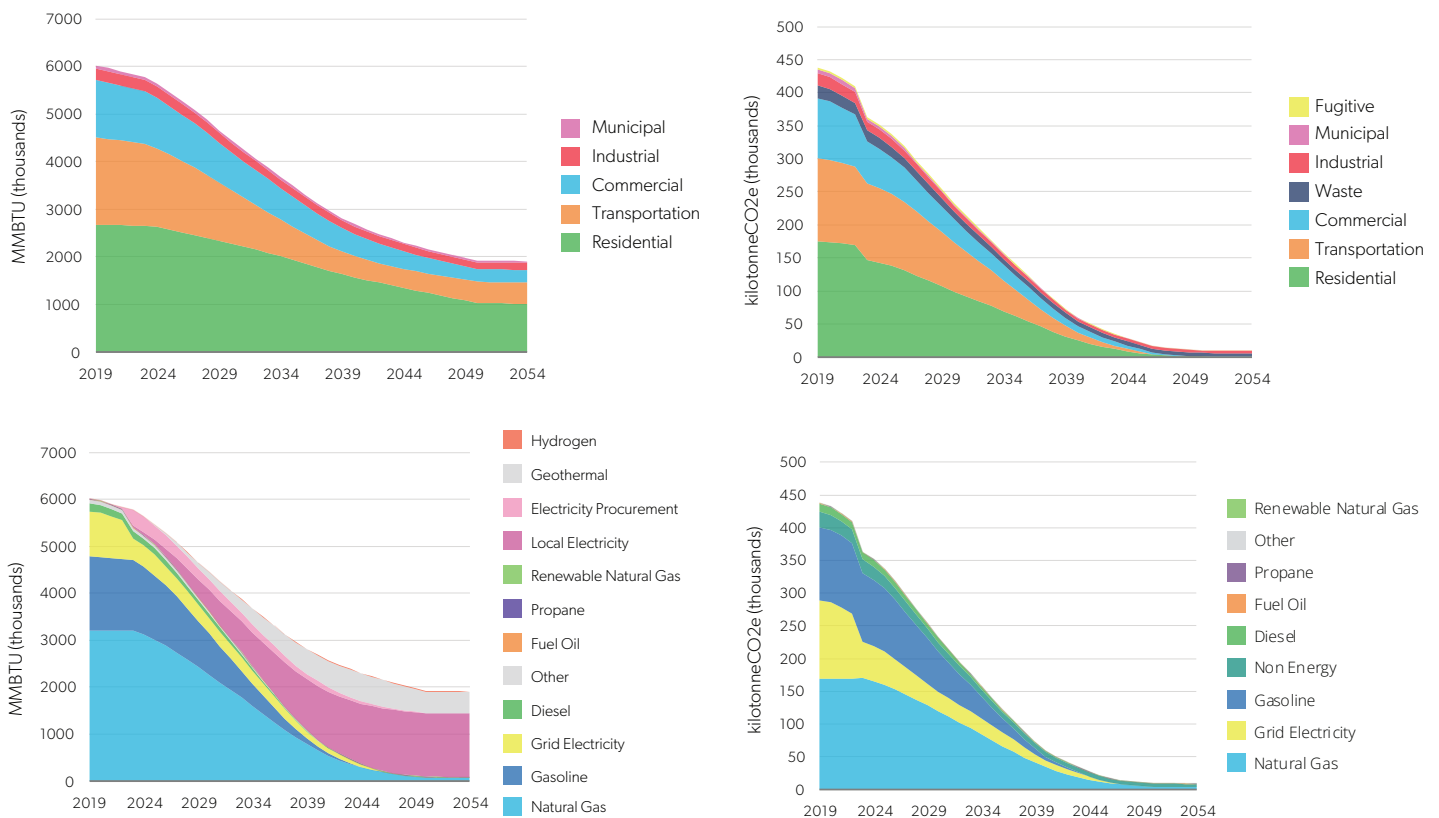


Figure 12. Energy (left) and emissions (right) by sector (top) and by fuel (bottom) in the LC scenario, 2019–2050.

2.3.2 Detailed Actions

Table 2. Modeled actions within the LC scenario, and the associated GHG emissions reductions associated with each action.

SECTOR	MODELED ACTION	GHG REDUCTION (KTCO ₂ E) RELATIVE TO 2050 BAP	CONTRIBUTION TO TOTAL EMISSIONS REDUCTIONS ¹⁵
New buildings			
All new buildings	All new builds are required to meet net-zero ready energy standard by 2030.	87	1.5%
Existing buildings			
Residential buildings	All existing buildings are retrofitted to achieve 60% thermal savings and 25% electrical savings by 2050.	926	16%
Commercial, industrial, and municipal buildings	All existing buildings are retrofitted to achieve 60% thermal savings and 30% electrical savings by 2050.	632	11%
Space heating and cooling, water heating	High-efficiency heat pumps are installed concurrently with building retrofits to provide all space heating and cooling, and water heating.	968	16%
Transportation			
Expand and electrify transit	10% of all trips are made by transit by 2040.	126	2%
Active transportation	10% of trips less than 1.2 miles (2 km, or ~30 mins) are made by walking by 2040. 10% of trips less than 6 miles (10 km, or ~30 mins) are made by biking or e-bikes.	4	0.06%
Electrify municipal fleet	Light-duty vehicle fleet is replaced with EVs, starting in 2024. Heavy-duty vehicles are replaced with zero-emissions options (EV and hydrogen) starting in 2026.	9	0.15%
Electrify personal vehicles	All new vehicles purchased in 2030 onwards are EVs.	360	6%

¹⁵ Relative to the 2050 BAP Scenario emissions.

SECTOR	MODELED ACTION	GHG REDUCTION (KTCO2E) RELATIVE TO 2050 BAP	CONTRIBUTION TO TOTAL EMISSIONS REDUCTIONS
Electrify commercial vehicles	Light-duty vehicle fleet is replaced with EVs, starting in 2024. Heavy-duty vehicles are replaced with zero-emissions options (EV and hydrogen) starting in 2026.	95	2%
Renewable electricity generation			
Solar PV	202 MW of rooftop solar generation by 2050 (equivalent to installing solar on 20,000 homes with 10 kW installations).	1,225	21%
Wind generation	85 MW of wind generation capacity by 2050 (land-based wind turbines range from 2 to 5 MW in size, while offshore turbines can be as large as 15 MW).	812	14%
Renewable Energy Certificates	Continued use of RECs for electricity accounts under NOPEC.	476	8%
Waste, water, and wastewater			
Waste generation and diversion	Reduce food waste generation by 50% by 2030 and other waste by 5% by 2030. Increase waste diversion to 75% by 2030 and organic material diversion to composting to 95% by 2030.	117	2%
Waste and wastewater treatment	Current gas capture is at the maximum amount that is reasonable.	N/A	N/A
Industry			
Industrial efficiencies	50% of fuel use is shifted to electricity by 2040. A 20% improvement in industrial process efficiencies by 2040.	58	1%

The Efficiency of Heat Pumps and Electric Vehicles

A cold-weather heat pump can generate 2-4 units of heat for each unit of electricity consumed.¹⁶ In comparison, a high-efficiency natural gas furnace generates 0.97 units for every unit of natural gas consumed. Similarly, an electric vehicle is five times more efficient than a gasoline one. These efficiencies, combined with avoided energy costs resulting from retrofits, result in financial savings.

Figure 13 (next page) shows the impacts of each of these actions on GHG emissions over time. The actions have cumulative effects over time, and actions to reduce demand occur before actions to improve efficiency and switch to low-carbon fuels. The gray area under the curve represents the cumulative emissions from Lakewood in the LC Scenario.

2.3.2 Per Capita Emissions

Table 3. Per capita emissions in 2019, the BAP and the LC scenarios.

2019	2050 BAP	2050 LC SCENARIO
8.7 tCO ₂ e/person	7.4 tCO ₂ e/person	0.7 tCO ₂ e/person
	↓ 15% from 20	↓ 92% from 2019
		↓ 91% from 2050 BAP

¹⁶ NEEA (2020). EXP07:19 Load-based and Climate-Specific Testing and Rating Procedures for Heat Pumps and Air Conditioners. Retrieved from: <https://neea.org/img/documents/CSA-EXP07-Interim-Testing-Report.pdf>

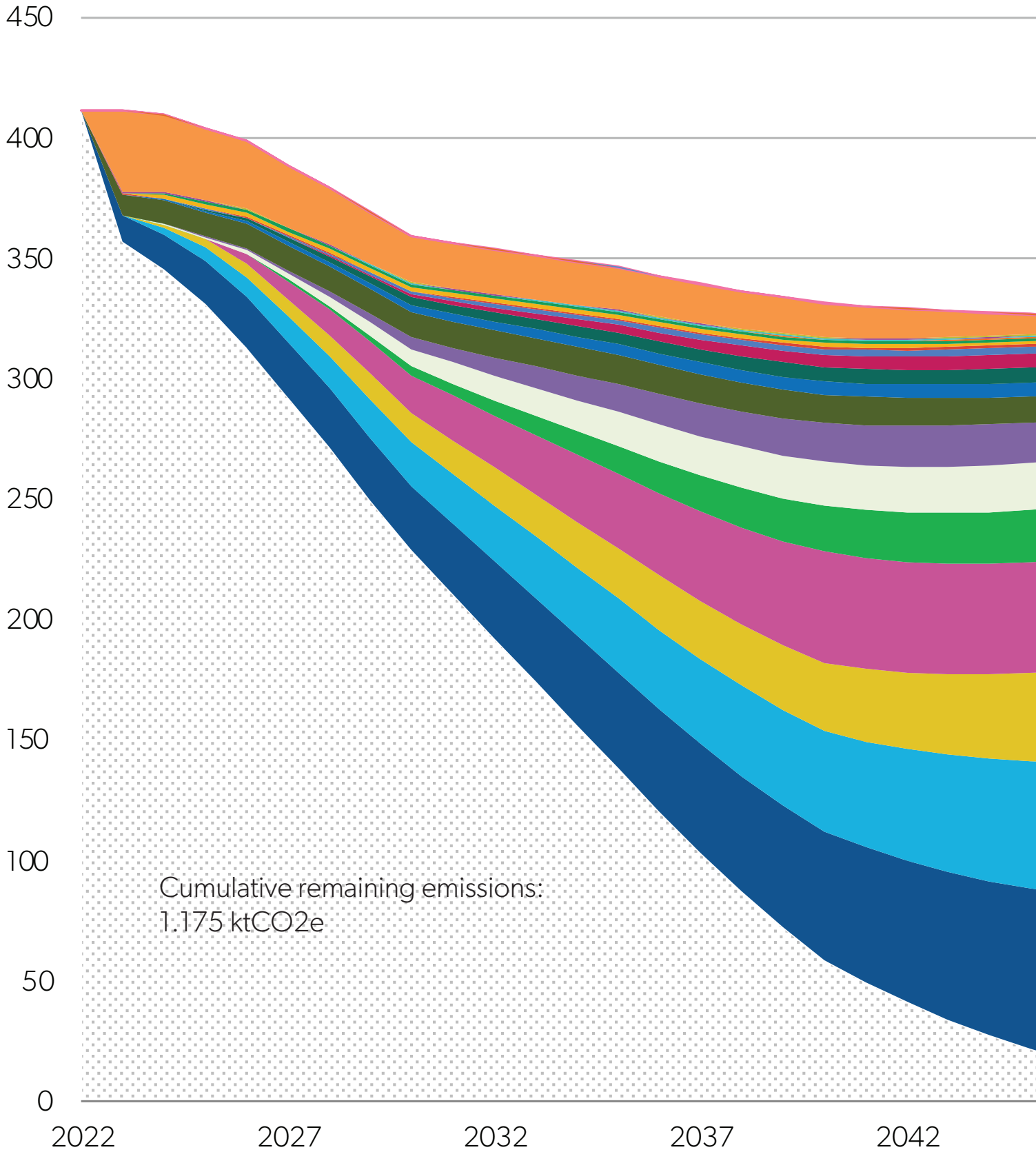


Figure 13. Wedge diagram showing the impact of modeled actions on GHG emissions reductions in the LC Scenario.



2047

- Electrify Appliances
- New Commercial Waterheating Systems
- Expand Active Transportation
- RECs
- Electrify Transit
- New Commercial Heatpump Systems
- Electrify Municipal Fleet
- New Residential Heatpump Systems
- New Commercial Building Codes
- New Residential Building Codes
- Existing Commercial Electrification of Water Heating System
- Industrial Actions
- Electrify CUV
- Expand Transit
- Waste Actions
- Existing Commercial Electrification of Heat Systems
- Existing Residential Heatpump Systems
- Electrify PUV
- Existing Residential Waterheating Systems
- Wind Power Installation
- Commercial Retrofits
- Residential Retrofits
- Rooftop Solar
- Carbon liability



THE COSTS AND OPPORTUNITIES

3.1.5 Amortization

The costs of major capital investments are typically spread over a period of time (e.g. a mortgage on a house commonly has a 25-year mortgage period). Amortization refers to the process of paying off capital expenditures (debt) through regular principal and interest payments over time. In this analysis, we have applied a 25-year amortization rate to all investments.¹⁹

3.2 Overall Costs and Savings

Historically, there has been a discourse that climate action costs money and requires sacrifices; however, an economic analysis of the costs and benefits to the community of Lakewood of implementing the LC Scenario finds the opposite. There are compelling economic reasons to implement a net-zero pathway as quickly as possible with no financial downsides.

Table 4. Summary of financial results, undiscounted (negative number = savings, positive number = cost) 2023–2050.

Financial estimate	LC Scenario (undiscounted)	LC Scenario (3% discount rate)
Total incremental capital investment, 2023–2050	\$1.49 billion	\$978 million
Total savings, 2023–2050	-\$2.03 billion	-\$964 million
Total revenue, 2023–2050	-\$173 million	-\$90 million
Social cost of carbon (SCC)	-\$507 million	-\$286 million
Net benefit, 2023–2050	-\$721 million	-\$64 million
Net benefit with SCC	-\$1.23 billion	-\$340 million
Capital cost (undiscounted) to reduce each tonne of GHG	\$273/tCO ₂ e	
Abatement cost (NPV) per tonne of GHG	-\$26/tCO ₂ e	
Annual household savings on energy, 2050 over 2019	-\$2,300	
Investment \$/person-year of employment	\$284,000	

The implementation of the LC Scenario represents a total investment of \$1.44 billion from 2023–2050, averaging ~\$53 million annually (undiscounted). For comparison, this is approximately 2% of Lakewood’s share of Ohio’s GDP in 2020.²⁰

This capital investment generates savings of \$2.03 billion from energy expense savings and from avoided operations and maintenance costs. Additionally, \$173 million in revenue comes

¹⁹ To manage the complexity of the analysis, a blanket amortization of 25 years was applied across all actions in order to demonstrate the impact of financing the actions.

²⁰ Dividing Ohio’s GDP of 621 billion in 2020 by the population of 11.8 million results in a per capita GDP of \$53,000. Based on a population of 50,848 in 2020, Lakewood’s share of the GDP is \$2.7 billion.

from renewable energy generation, resulting in a net benefit of \$721 million to the community, or \$27 million annually. To put this in context, if Lakewood's population was to remain stable at the current size, the benefit would average \$530 per person per year.²¹ This benefit transfers to the community as a whole, including households, businesses, and the municipality itself. The financial benefit would decrease if the investments are financed as a result of interest payments, while it would increase if natural gas prices increase more rapidly than electricity prices.

The Social Cost of Carbon

Climate change represents a burden on future generations, and the complexity of the climatic system means that these impacts are difficult to anticipate. The burden of action increases the longer action is delayed.

The Social Cost of Carbon (SCC) is a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning.

The SCC is one of the best ways to reflect future damages to ensure that decision-making that has implications for future emissions accounts for those implications.

The discount rate is a significant assumption within the models that calculate SCC. Discounting reflects the idea that people would rather have \$100 now than \$100 in 10 years. From an ethical perspective, a higher discount rate indicates that future generations are worth less than current generations; for this reason, the Stern Review²² recommended a discount rate of 1.4%, well below traditional discount rates. As Stern pointed out in a subsequent article, "A 2% pure-time discount rate means that the life of someone born 35 years from now (with given consumption patterns) is deemed half as valuable as that of someone born now (with the same patterns)."²³ For the purposes of consistency with other processes, a 3% discounting rate is used in this analysis.²⁴

The analysis presents the results of the SCC for the avoided emissions resulting from the actions taken in Lakewood's CAP.

Following convention, the following economic analysis of the LC Scenario designates costs as positive, and savings and revenue as negative.

²¹ This calculation is to ground the total in more tangible terms. As these benefits are for the community as a whole, the savings will be distributed amongst businesses, the City, and households.

²² Stern, N. (2006). *The Stern review on the economic effects of climate change*. Cambridge University Press.

²³ Stern, N. (2015). Economic development, climate and values: making policy. *Proc. R. Soc. B*, 282(1812), 20150820. <https://doi.org/10.1098/rspb.2015.0820>

²⁴ U.S. Government (2021). Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

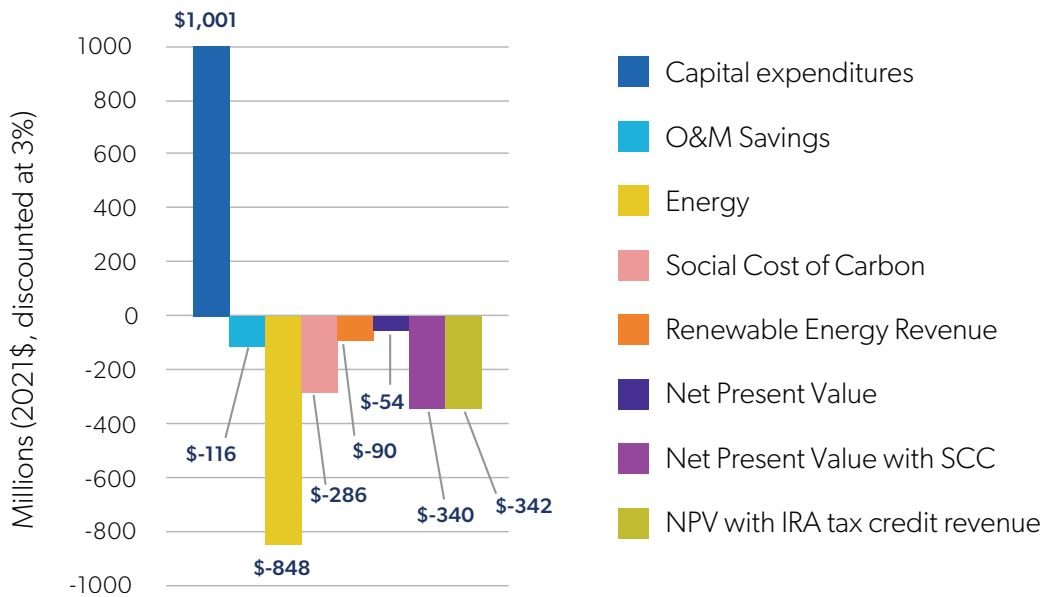


Figure 14. Present values of investments and returns for the LC Scenario, discounted at 3% (costs are positive in this convention, and revenue and savings are negative), from 2021–2050.

The annual costs, savings, and revenue associated with fully implementing the actions in the LC Scenario are shown in detail in Figure 15, with capital expenditures shown in full for the years in which they are incurred. As is characteristic of low-carbon transitions, the capital expenditures in the early years of the transition are greater than the savings and revenues generated, but by 2035, the savings outweigh the costs.

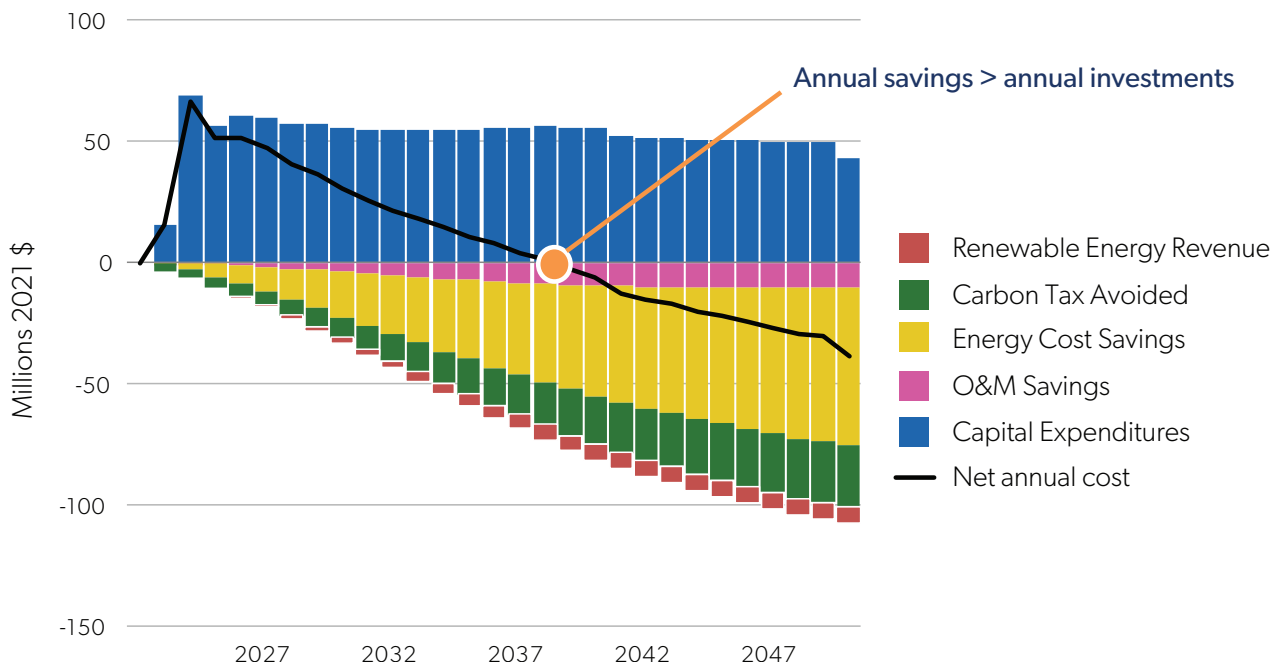


Figure 15. Figure Year-over-year LC Scenario investments and returns including the social cost of carbon, undiscounted. The break-even point occurs in 2034.

The majority of investments are for building retrofits. Lakewood is a community dominated by residential buildings, with little anticipated growth, and so, the need to retrofit existing homes dominates the investment of the LC Scenario. The incremental investment in transportation is negligible because the costs of electric vehicles are projected to reach parity with internal combustion engines as early as 2027. The reduced operation costs represent a major opportunity for cost savings going forward. Figure 16 shows the capital investments on a cash basis and amortized over 25 years with 3% interest. This approach would presumably reflect actual approaches for financing the transition. Amortization has the effect of reducing the annual capital requirements by nearly half for peak investment years, with the result of repayments petering out beyond 2070.

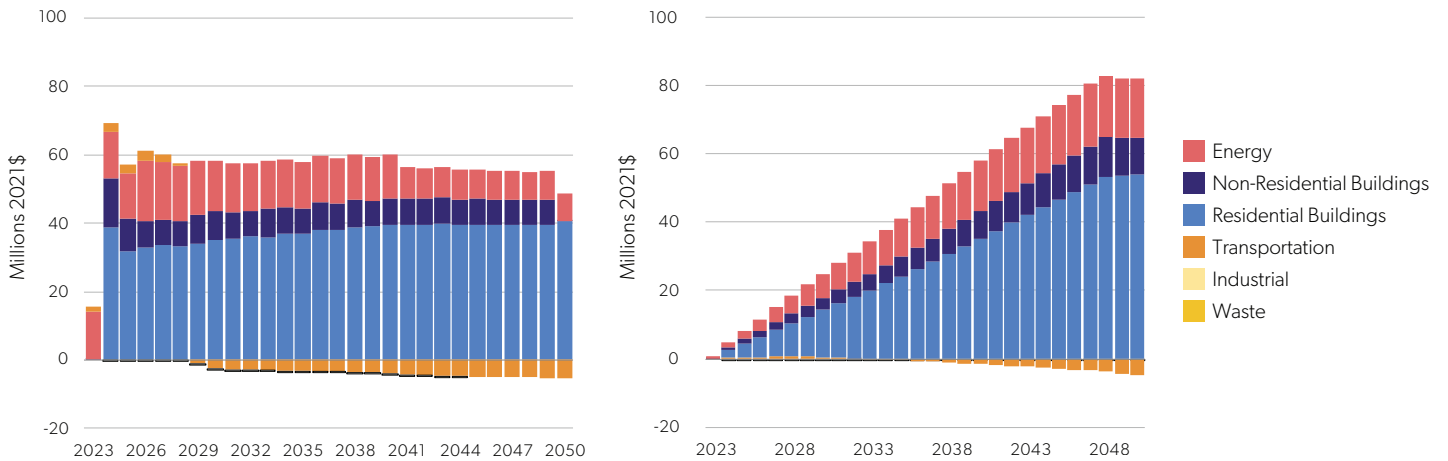


Figure 16. Two views on capital expenditures: on a cash basis and amortized. Note that the amortized capital payments continue post 2050.

Figure 17 illustrates the energy expenditures by sector. All sectors see financial benefits from reduced energy costs through improved energy efficiency and a reduction in total energy demand. Total expenditure savings on energy are nearly \$64 million annually by 2050, or nearly \$1billion over the period.

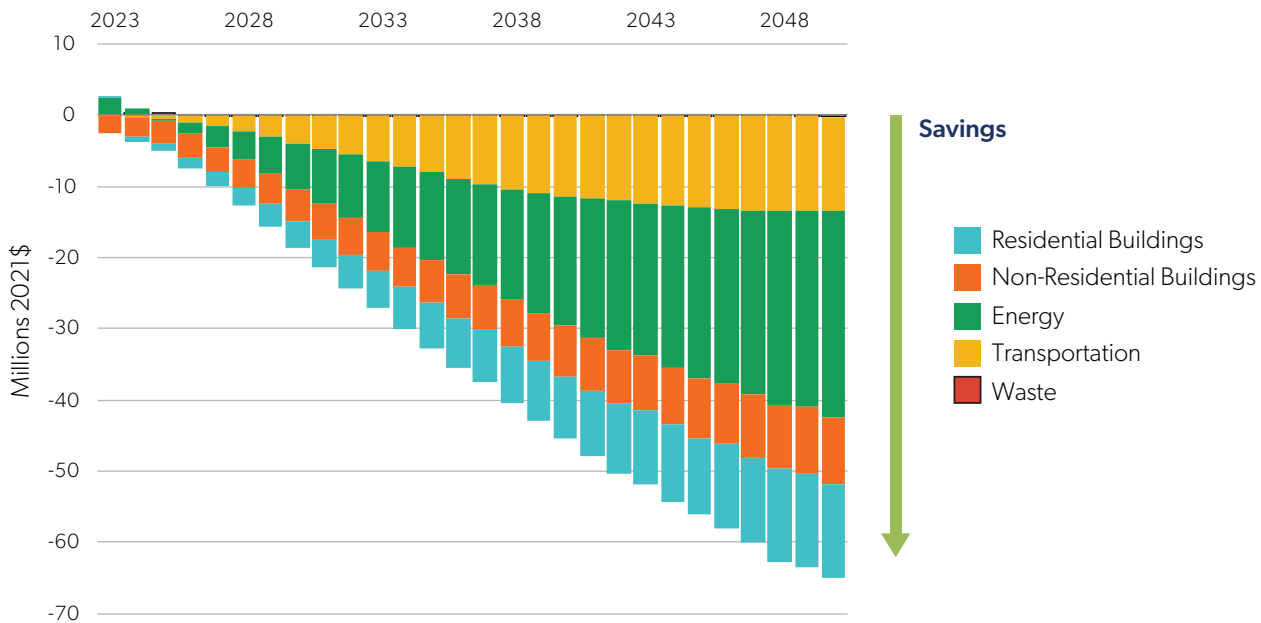


Figure 17. Change in energy expenditures by sector.

3.3 Inflation Reduction Act

The Inflation Reduction Act (IRA) is an extensive, ambitious piece of climate legislation in U.S. history, which is designed to transform the U.S. economy. The IRA reinforces many aspects of Lakewood’s CAP by providing opportunities for the City to raise funds and by providing grants and incentives to individuals and businesses to support low-carbon investments.

Municipalities can apply directly to federal agencies for funding for a range of programs, including²⁵:

- A Greenhouse Gas Reduction Fund which will provide grants, loans, and financial and technical assistance “to enable low-income and disadvantaged communities to deploy or benefit from zero-emission technologies,” including rooftop solar and other GHG reduction activities and provide direct and indirect investment in projects, activities, or technologies;
- Climate Pollution Reduction Grants, which provide grants to implement GHG pollution reductions;

²⁵ Sabin Center for Climate Change Law (2022). Cities & the Inflation Reduction Act. <https://blogs.law.columbia.edu/climatechange/2022/08/22/cities-the-inflation-reduction-act/>

- Clean Heavy-Duty Vehicles, which will fund a program to cover incremental costs associated with replacing non-zero-emissions heavy-duty vehicles with zero-emissions heavy-duty vehicles, as well as for fueling and charging infrastructure, and for workforce development and technical activities;
- A Low Emissions Electricity Program, which will provide funding for technical assistance for domestic electricity generation and use;
- The Neighborhood Access and Equity Grant Program, which will provide funding for highway removal, remediation, or capping; mitigating local impacts of highways; building or improving “complete streets, multi-use trails, regional greenways, or active transportation networks”; and providing “affordable access to essential destinations, public spaces, or transportation links and hubs”;
- The Environmental and Climate Justice Block Grants, which will provide funding for community-led air and other pollution monitoring, prevention, and remediation, and investments in low- and zero-emission and resilient technologies”; mitigation of urban heat islands, extreme heat, wood heater emissions, and wildfires; reducing indoor air pollution; ensuring climate resilience and adaptation; and “facilitating engagement of disadvantaged communities.”
- The State and Private Forestry Conservation Programs, which will support tree planting activities.

The IRA also includes the following tax credits and grants that go directly to consumers for vehicle and building electrification and distributed energy generation²⁶:

- Rebates covering 50-100% of the cost of installing new electric appliances, including super-efficient heat pumps, water heaters, clothes dryers, stoves, and ovens.
- Rebates for households to make repairs and improvements in single-family and multi-family homes to increase energy efficiency.
- Tax credits covering 30% of the costs to install solar panels and battery storage systems, make home improvements that reduce energy leakage, or upgrade heating and cooling equipment. No income limits apply.
- Tax credits covering 30% of the costs of community solar projects—owned by local businesses that sign up families to save on their electric bills—with additional bonus credits of 20% for projects at affordable housing properties and 10% for projects in low-income communities.
- Upfront discounts up to \$7,500 for new EVs and \$4,000 for used EVs, helping middle-class Americans skip the gas pump and save on fuel costs.

The impacts of tax credits on EV purchases and solar PV installations are shown in Figure 14, including a \$7,500 rebate on EVs and a \$900 rebate on solar PV installations.

²⁶ White House. (2022). The Inflation Reduction Act Delivers Affordable Clean Energy for Ohio. Retrieved from: <https://www.whitehouse.gov/wp-content/uploads/2022/08/Ohio.pdf>

3.4 Social Cost of Carbon

Climate change is driving a higher number of extreme weather patterns, resulting in more frequent and more expensive impacts than previous decades. The value of the avoided damage from climate change can be calculated using the SCC. When the SCC is applied to the cumulative emissions between 2023 and 2050, the cost of the damages is \$2.01 billion. In comparison, the cost of the damages declines to \$740 million in the LC Scenario, as illustrated in Figure 18.²⁷

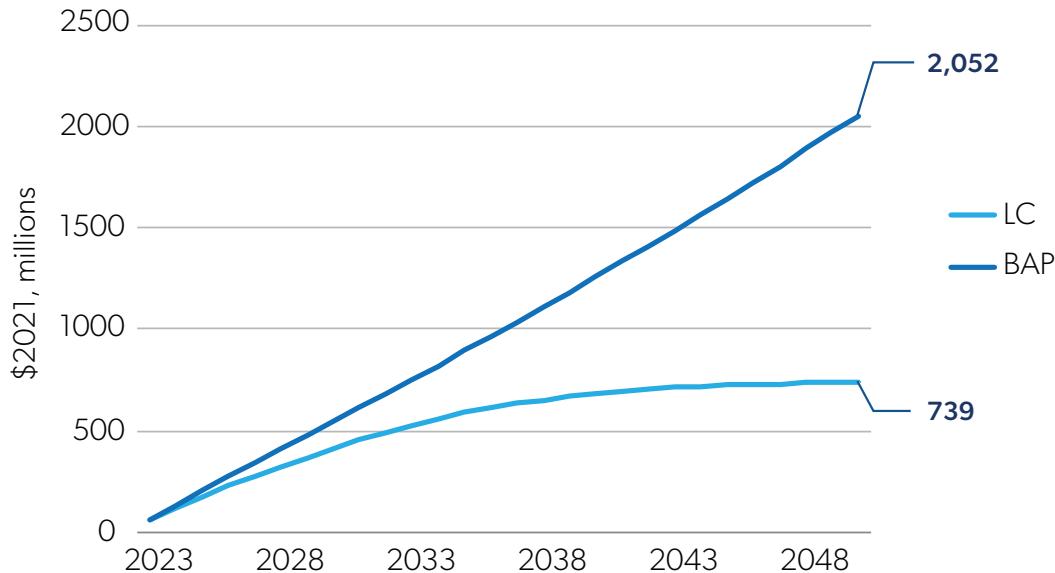


Figure 18. The cumulative Social Cost of Carbon for the BAP and LC scenarios.

3.5 Energy Savings for Households

Household energy expenditures (Figure 19)—natural gas, electricity, gasoline, and diesel—are projected to decline by 24% in the BAP, from \$2,800 in 2016 to \$2,130 by 2050. These savings result from more efficient vehicles due to national fuel efficiency standards and decreased heating requirements as the climate becomes milder due to climate change. **In the LC Scenario, the savings are much greater, and household energy expenditures fall by 46% to \$480 by 2050.** Depending on the business, policy, and financing strategies used in the implementation of the actions, these savings will be partly offset by the incremental capital expenditures required.

Gasoline and diesel expenses are removed through the electrification of vehicles. Furthermore, natural gas furnaces are replaced with electric heat pumps as part of the deep retrofits that minimize the heat required to ensure homes are comfortable both in the summer and in the winter.

²⁷ All values used the 3% discounting rate, 95th percentile, which reflects higher than expected economic damages from climate change. Interagency Working Group on Social Cost of Greenhouse Gases, United States Government (2021). Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

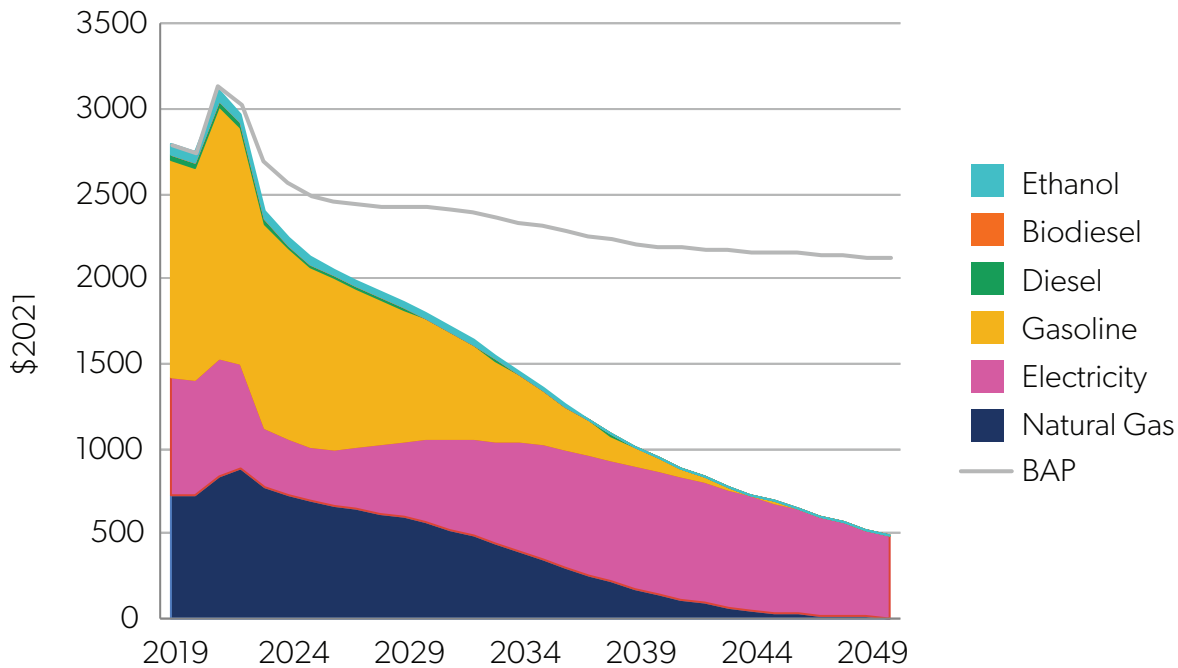


Figure 19. Household energy costs by fuel type for the Net-zero Scenario, compared to the BAP.

Energy Poverty

Household expenditures on energy can result in energy poverty, which can have a range of impacts. For example, households experiencing energy poverty or energy insecurity face challenges such as "pay the rent or feed the kids", "heat or eat", or "cool or eat". In particular, energy insecurity disempowers low-income residents such as single parents, the elderly, persons with disabilities, and others with low or fixed incomes, resulting in stresses such as utility-related debt, shutoffs, inefficient heating systems, antiquated appliances, and extreme home temperatures with have the potential to cause significant health impacts. Children may experience nutritional deficiencies, higher risks of burns from non-conventional heating sources, higher risks of cognitive and developmental behavior deficiencies, and increased incidences of carbon monoxide poisoning.

3.6 Employment Opportunities

Transitioning to a low- or zero-carbon economy is expected to have four impact categories on labor markets: additional jobs will be created in emerging sectors, some employment will be shifted (e.g. from fossil fuels to renewables), certain jobs will be reduced or eliminated (e.g. combustion engine vehicle mechanics), and many existing jobs will be transformed and redefined. The LC Scenario adds 6,060 'person-years of employment', over the BAP scenario between 2023 and 2050 (Figure 20).

Building retrofits present the largest opportunity for new employment, presenting opportunities to partner with local education centers. This could include developing programs that teach the skills required to complete deep energy retrofits and install high-efficiency equipment.

Developing partnerships to expand on local knowledge will help jumpstart this activity.

In addition to building retrofits, improvements can simultaneously be made to accessibility features of public buildings, buildings, and common areas.

The transportation maintenance sector shows small losses in total person-years of employment, since electric vehicles require less maintenance than internal combustion engines.

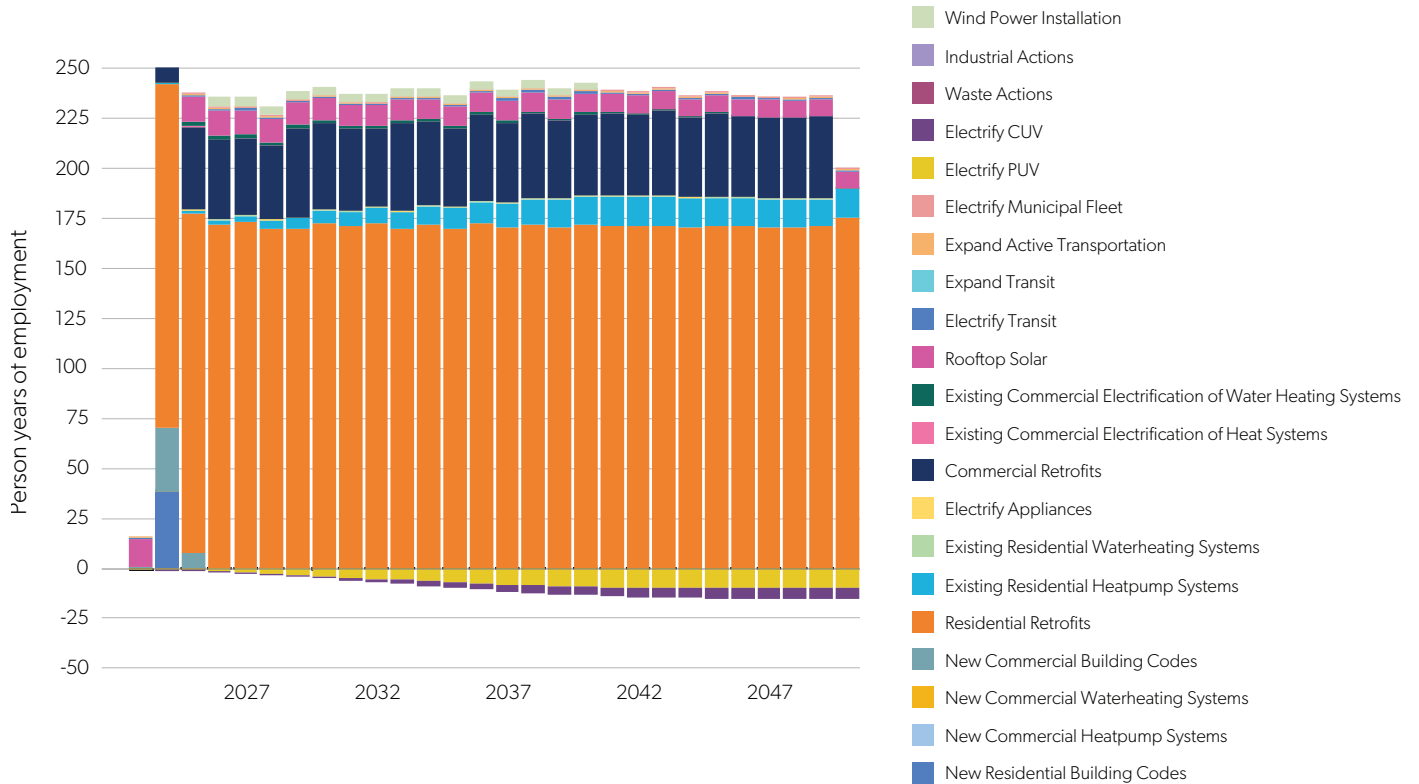


Figure 20. Annual person-years of employment generated in the LC Scenario.

3.7 Marginal Abatement Costs

The Marginal Abatement Cost (MAC) is the incremental cost of one tonne of GHG reductions. The lower the cost, the more affordable the action, and in some cases, the action can be profitable. It is calculated by summing the net present value of capital costs and operating costs over the lifetime of the investments divided by the tonnes of GHGs reduced.

By providing individual costs for actions, MACs can imply that the actions are a menu from which individual actions can be selected. In fact, many of the actions are dependent on each other; for example, energy costs increase without retrofits. Another important message is that in order to achieve Lakewood's target, all the actions need to be undertaken as soon as possible.

Table 5 summarizes the marginal abatement costs for the modeled actions in Lakewood's low-carbon future. The actions with negative abatement costs generate financial returns over their lifetimes. A red, or positive, abatement cost, costs money over the span of the project. This comparison provides one way to view the costs and benefits of the implementation of emissions-reducing actions but should not be the only metric used to measure an action.



Table 5. Marginal abatement costs for modeled actions.

Low-Carbon Action	Cumulative Emissions Reduction (kt CO ₂ eq)	Net present Value	Marginal Abatement Cost (\$/t CO ₂ eq)
Electrify personal-use vehicles	368	-235,390,000	-640
Install rooftop solar	1,100	-192,530,000	-180
Expand transit	121	-98,580,000	-810
Electrify commercial-use vehicles	93	-54,650,000	-590
Electrify heating in commercial buildings	274	-33,680,000	-120
Retrofit commercial buildings	573	-16,150,000	-30
Electrify water heating in residential homes	341	-15,340,000	-40
High-performance new homes	31	-4,930,000	-160
High-performance new commercial buildings	25	-4,870,000	-200
Energy efficiency in industry	48	-2,560,000	-50
Increase active transportation	4	-1,390,000	-390
Electrify municipal buildings	8	-320,000	-40
Reduce waste	116	0	0
Electrify water heating in new commercial buildings	0	240,000	0
Electrify transit	5	1,680,000	340
Install heat pumps in new homes	7	2,310,000	350
Install heat pumps in new commercial buildings	8	3,290,000	430
Electrify appliances	0	3,550,000	0
Electrify water heating in commercial buildings	22	4,700,000	220
Purchase RECs	297	26,340,000	90
Install heat pumps in homes	282	115,490,000	410
Retrofit homes	885	377,980,000	430

Illustrated differently, the Marginal Abatement Cost Curve (Figure 21) gives a visual representation of the financial implications and the emissions reductions associated with each action. The height of the bar indicates the size of the financial costs/savings and the width shows the potential GHG savings.

The action with the highest cost per tonne of CO₂e reduced is residential retrofits. Residential retrofits require costly building envelope improvements and the switch to heat pumps, while maximizing efficiency and reducing GHG emissions, requires switching to electricity that is currently more expensive than natural gas. While these retrofits may require significant capital investment, they provide other benefits. Efficient homes are easier to heat, reduce total energy demand, and can help address energy poverty.

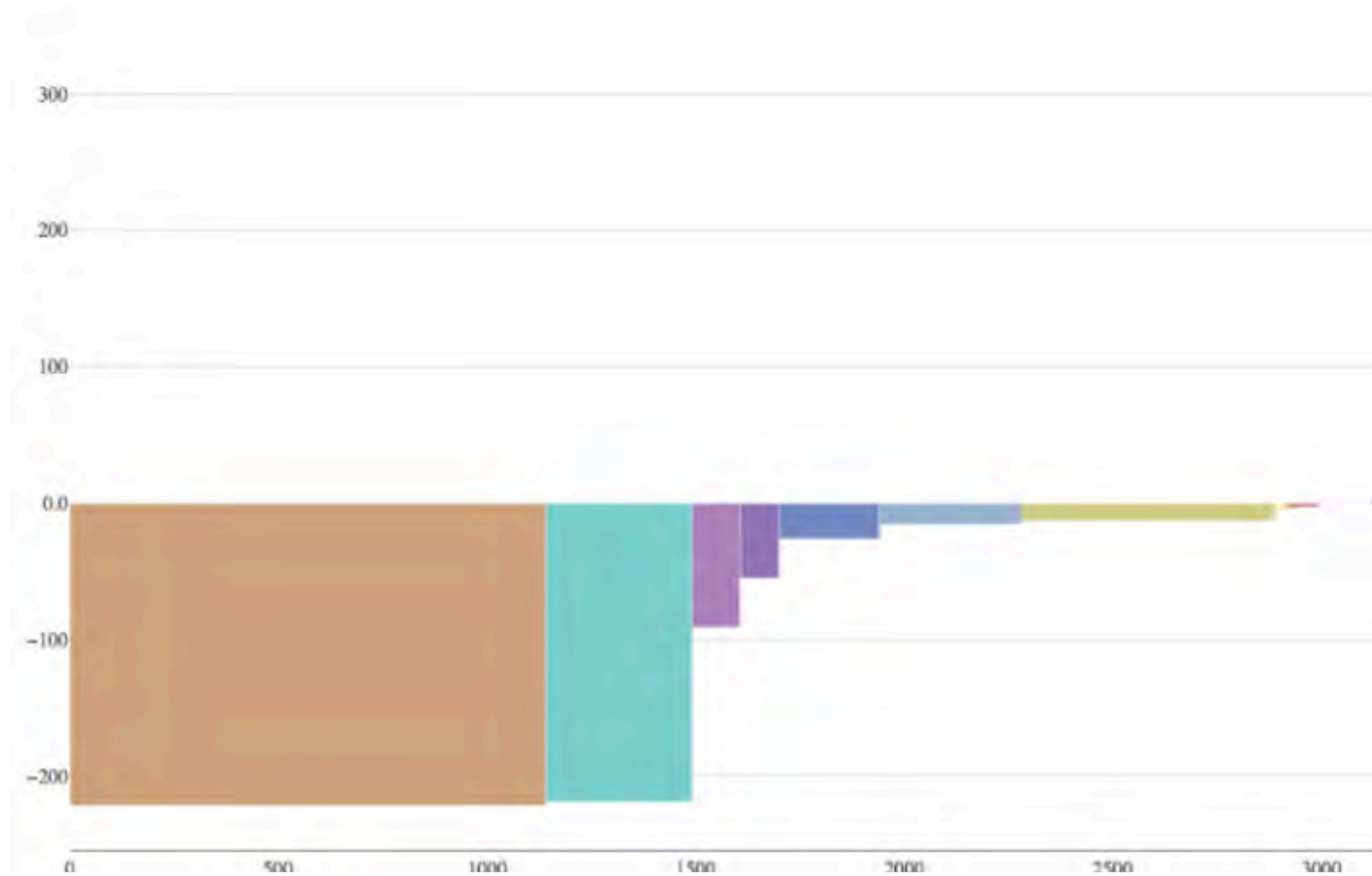
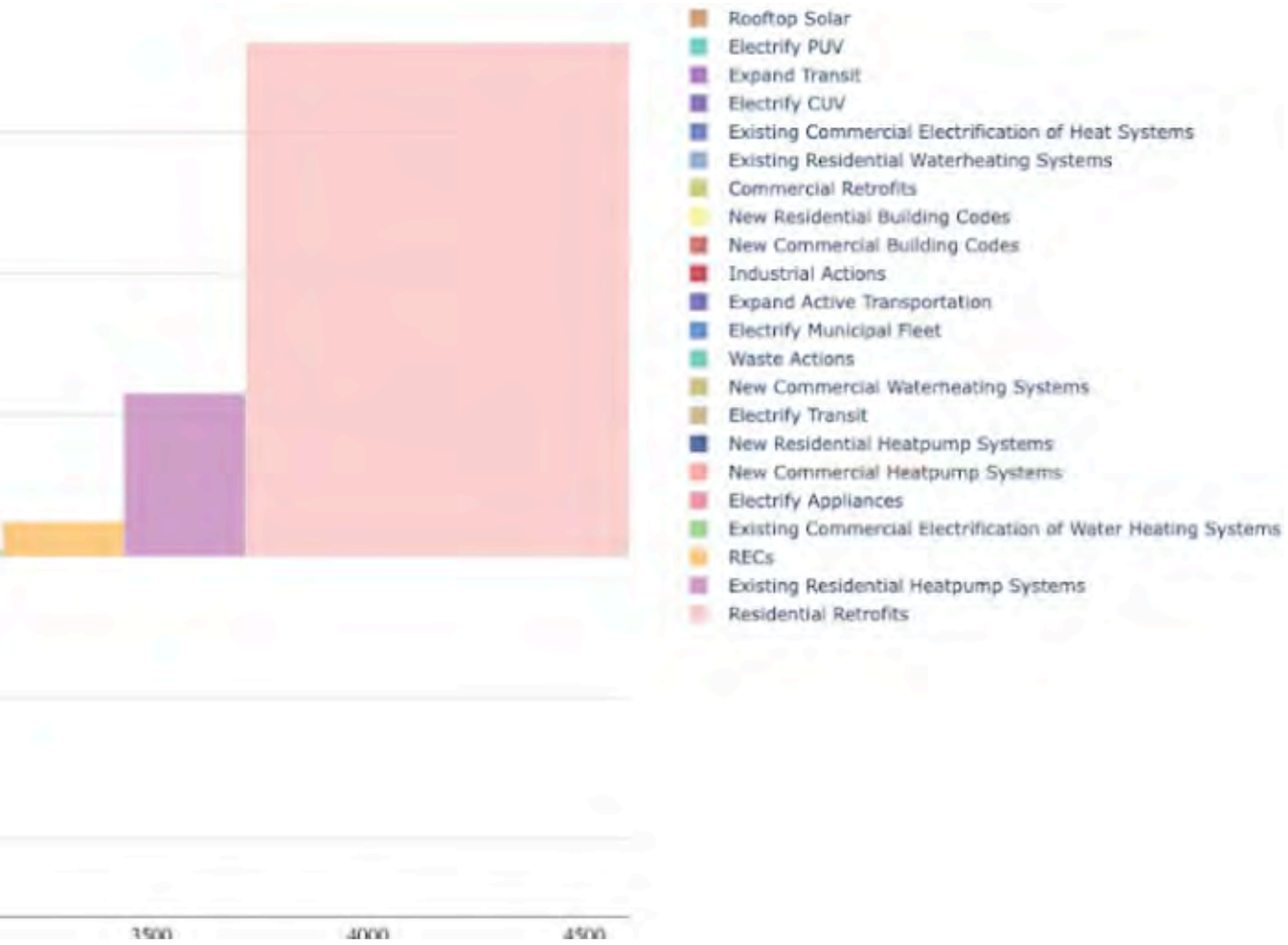


Figure 21. Marginal abatement cost curve, showing the cost per tonne of CO₂e reduced for each action.





**LAKWOOD'S
NATURAL ASSETS
AND CLIMATE
VULNERABILITIES**

4. Lakewood's Natural Assets and Climate Vulnerabilities

This section explains how climate change is likely to affect Lakewood's four primary natural assets: the shoreline, the Rocky River Corridor, forests, and the network of dispersed living infrastructure that permeates the city. The overall vulnerability of each natural system is summarized in terms of the potential impacts of climate hazards based on exposure and sensitivity, as well as its adaptive capacity.

Climate Adaptation Terms

Exposure refers to the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected; for example, assets located in a flood plain or people living in poor-quality housing.

Vulnerability refers to the predisposition to be adversely affected and refers to characteristics of human or social-ecological systems that are exposed to hazardous climatic events or trends. It is a function of sensitivity and adaptive capacity.

Sensitivity refers to the degree to which a system or species is affected.

Adaptive capacity is the potential or capability of a system to adapt to climate change or its impacts.

4.1 Lake Erie Shoreline

Lakewood has a 19,800-foot shoreline along the coast of Lake Erie. The shoreline, which protects homes and infrastructure by acting as a buffer against flooding and controlling erosion, provides a rich habitat for fish and wildlife and filters and treats water.

Lakewood's shoreline is formed from soft sedimentary rock. Much of it is characterized by slopes that rise abruptly from the shoreline, forming steep wave-cut cliffs. The cliffs are subject to rapid and violent wave erosion, which is exacerbated in places by groundwater that fractures the cliff.²⁸ The shoreline is continually rebuilt by sediment that erodes from the cliffs and moves along the shoreline with the waves. How much material is eroded from the cliffs is controlled by the lake level and the severity of storms. Due to this relationship between the shoreline sediment supply and erosion, the shape of the shoreline and the rate at which sediment is moved is also affected by climate change.²⁹ Currently, winter ice helps protect the shoreline from severe erosion by winter storms. According to NOAA,³⁰ the number of days the water along the shoreline is

²⁸ Ford, J.P., 1987. Glacial and surficial geology of Cuyahoga County, Ohio. Ohio. Division of Geological Survey.

²⁹ Mattheus, C.R., 2014. Climate-induced changes in rates of headland-beach progradation along the southern coast of Lake Erie. *Journal of Coastal Research*, 30(4), pp.743-755.

³⁰ NOAA (National Oceanic and Atmospheric Administration). 2019. Great Lakes Environmental Research Laboratory: Historical ice cover. Accessed December 2019. www.glerl.noaa.gov/data/ice/#historical.

covered with ice has declined significantly since 1973. The Great Lakes are frozen for eight to 46 fewer days now than they were in the early 1970s, and ice cover is predicted to decline faster in coming years. For Lakewood, the reduction in winter ice from a warming climate is expected to increase shoreline erosion in winter.³¹

As the climate changes, the shoreline will experience more wave energy and erosion rates will increase, threatening coastal infrastructure. At lower elevations, this will reduce the flood protection provided by the shore and place more infrastructure at risk. At higher elevations, flood risk will be lower but land and property could be impacted by accelerating erosion.

4.2 Rocky River Corridor and Water Resources

The Rocky River is the largest waterway flowing through Lakewood. Lakewood was once home to several historic streams, but many of these were dammed by railroad construction before 1902; though the largest, which flowed north through the modern site of St. Edward High School, passed under the railroad. Between 1956 and 1963, it was also buried and piped to allow for development.



Figure 22. Light blue denotes stream corridors that are now buried in pipes.³²

³¹ ELPC (2019). An Assessment of the Impacts of Climate Change on the Great Lakes Retrieved from: <https://elpc.org/wp-content/uploads/2020/04/2019-ELPCPublication-Great-Lakes-Climate-Change-Report.pdf>

³² U.S. Geological Survey, Berea 1902 [map]. 1:62500. Topographic Quadrangle Map, Berea, OH 1961.

These buried pipes convey water rapidly, but large storms can overwhelm the system. In contrast, before they were buried, the streams and their drainage system slowed and infiltrated water, reducing flood risk. Additionally, because water is cleaned through contact with soil and plants, these streams improved water quality.

The combined sewer overflow is an added complication to Lakewood's water management and presents issues that will be worsened by increasingly intense and unpredictable storm events. A combined sewer system collects rainwater runoff and domestic sewage into a single system, and if the capacity of the combined sewer system is exceeded, then untreated water discharges directly to nearby streams, rivers, and other water bodies.

4.3 Forest and Urban Tree Canopy

Lakewood's urban forest provides shade and helps lower the temperature of the city. Lakewood's tree canopy covers 22.8% of the city and has a fair amount of tree diversity, according to a 2020 evaluation for Lakewood's Tree Action Plan 2021. The top 10 species make up only 59% of the total canopy cover, with maple trees accounting for 26% of the canopy. The

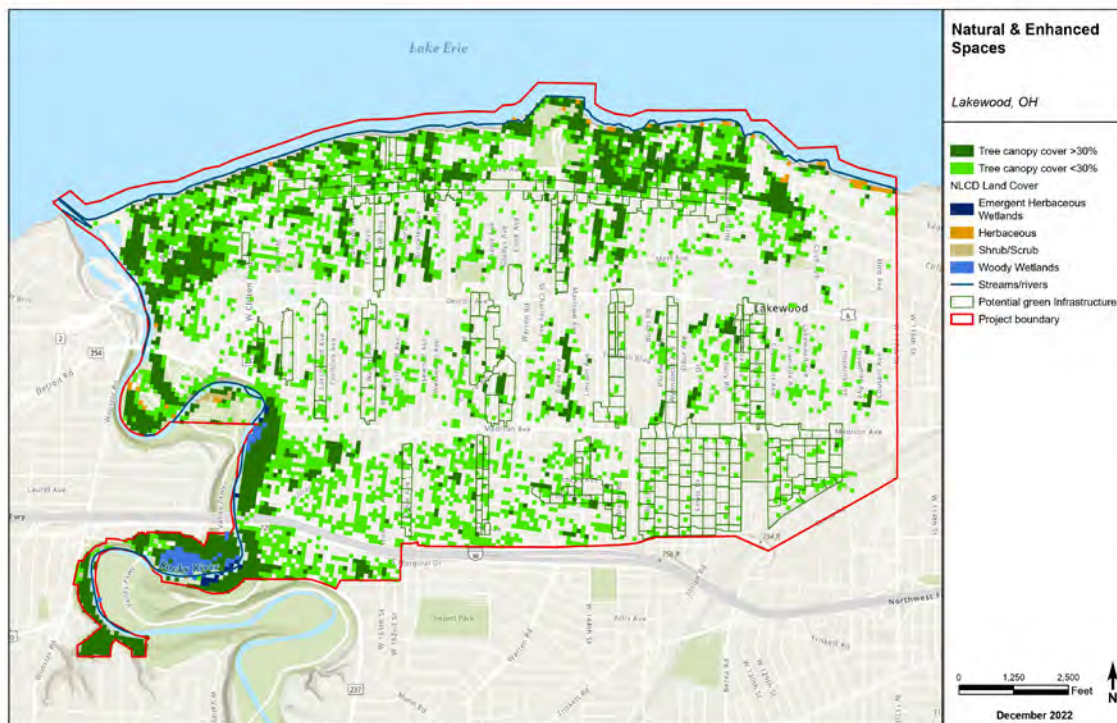


Figure 23. Natural spaces and tree canopy cover across Lakewood.

As described in the Trees and the Carbon Gap section, protecting existing trees or adding forest cover can contribute to decarbonizing the city; however, the distribution of the canopy cover contributes to inequities. Low canopy coverage south of Madison and east of Wascana Avenues results in average daily temperatures more than 2° Fahrenheit hotter than neighborhoods to the north and west. The difference in outdoor temperatures on a hot, sunny day is much greater—a difference of 12° Fahrenheit can be easily felt by residents.

4.4 Dispersed Living Infrastructure

The fourth natural system to highlight is the aggregation of landscape features that offer urban ecosystem services such as water infiltration, pollinator habitat, shade, and aesthetic benefits. This network of vegetation is where life can flourish and includes pocket parks, stormwater planters, street trees, and landscaped areas.

Lakewood has about 2,900 acres of land outside roadways and sidewalks, and nearly 10% of that land area is active or passive greenspace. Other land-use categories, such as school properties, have greenspace with potential to provide ecological benefits and habitat for species if activated by an alternative planting and maintenance regime. For example, turfgrass that is not required for activity space could be restored to forest or grassland habitat. Taken together, this dispersed network of living infrastructure is a natural asset that can support healthy soils and food webs for pollinators and birds.



Climate change is unlikely to have a significant impact on these small areas, though irrigation requirements could change slightly over time. But rather than evaluating these areas as an asset at risk of climate change, living infrastructure is better viewed as a potential asset in the face of climate change to enhance and maintain because of its additional capacity to support life, shade, water infiltration, and other services. One special subset of living infrastructure is stormwater management technologies that use plants and nature-based systems to reduce flows to sewer systems and surface waters. Known as “green infrastructure,” these techniques are deeply integrated into Lakewood’s building code, parking code, and stormwater code. Green infrastructure practices that allow the infiltration of water can be woven throughout the city’s dispersed living infrastructure.

These assets are important to the quality of life in Lakewood today, but each asset faces impacts under climate change scenarios. Priorities for enhancing and protecting these assets are described in the actions and programs outlined in the next section, The Pathway to Net-Zero.





**PATHWAY
TO NET-ZERO**

5. Pathway to Net-Zero

The City of Lakewood has set the target of net-zero emissions by 2050, and the analysis above shows a pathway to achieving this goal. Moving from modeled actions to real-world change requires coordination and participation from all members of the community. The following is a discussion of the priority steps for the **next five years** for the City and for the community.

While not all elements of this plan are under the purview of the municipal government, the City can act as a leader, convener, organizer, and coordinator in many sectors. Below is a description of the modeled actions, the measurable targets from this modeling, and programs that enable the implementation of these targets.

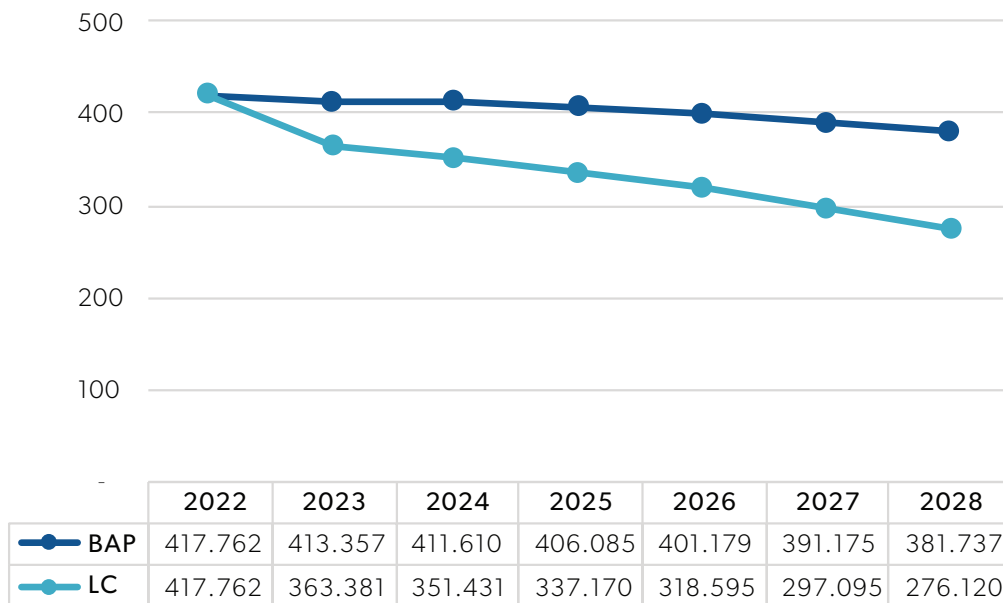


Figure 24. The next five crucial years.

Equity and Climate Change

The energy transition includes major investments in buildings, energy generation, transportation, nature preservation, and waste management. People who cannot access capital to retrofit their house, who do not own a home, who cannot develop a renewable energy project, or who cannot purchase an electric vehicle will continue to be left behind. As people move away from fossil fuels, these legacy systems may become more costly and more unreliable, further increasing the economic burden. People in poverty are also more vulnerable to stress from climate impacts, with less financial capability to respond to severe weather events or provide air conditioning in periods of extreme heat. Without careful planning, the energy transition and climate impacts can continue to exacerbate inequity in Lakewood.

5.1 Efficient, Healthy Buildings for All

GHG emissions from buildings made up 66% of Lakewood’s total emissions in 2019. Space heating and water heating are the biggest energy consumers in this sector and currently rely heavily on natural gas and grid electricity. Lakewood has a stock of older buildings with knob-and-tube wiring and inadequate insulation. By improving the condition of buildings through retrofits and a net-zero building code and by replacing systems that use fossil fuels with high efficiency heat pumps, the city can reduce the emissions from buildings by 95%. Building retrofits will require upgrades to the electrical systems to accommodate the loads for heat pumps and EV chargers, as well as for solar PV generation.

Reduced energy consumption from buildings increases the “space” on the electricity grid for electrification of heating and transportation, minimizing the investments in new capacity, transmission, and distribution.

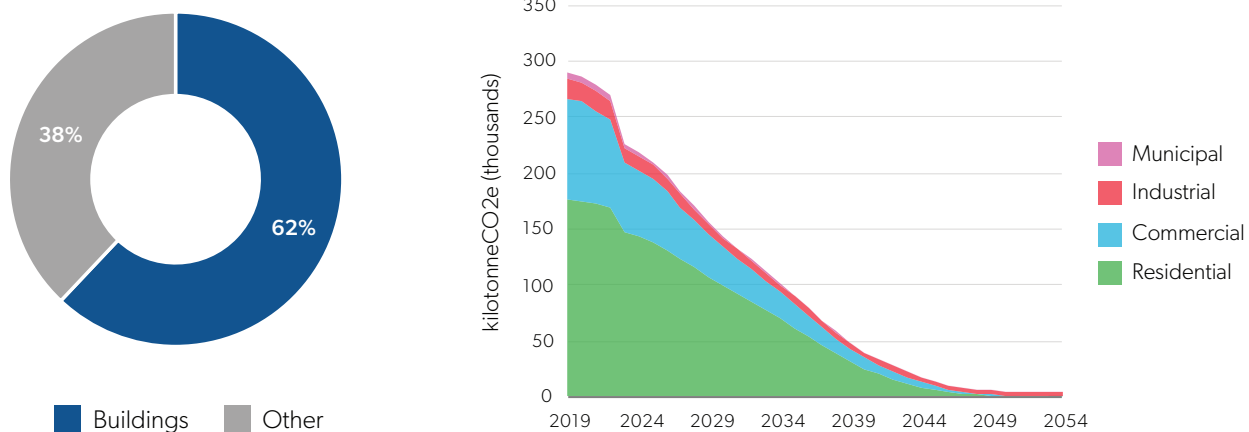


Figure 25. GHG emissions from buildings in 2019 (left) and by sector in the LC Scenario (right).

5.1.2 Existing Buildings

1. Develop a deep retrofit program for all buildings: Building retrofits represent the foremost opportunity to reduce the emissions associated with energy use by buildings, while also improving the quality of homes for everyone in the community. A deep retrofit program will require supporting policies at the municipal level, as well as funding to support both the development and running of a program, and funding to ensure that the program is available to all members of the community.

The “Lakewood” Home Retrofit

Many homes in Lakewood share physical characteristics because they were constructed in a similar era with similar designs. This commonality gives rise to the opportunity of more standardized retrofit packages that could include bulk purchases of heat pumps, windows, doors, or even “retrofit packages” that could be installed by pre-selected contractors, coordinated either by the City or by a third party. The Carbon Co-op is a model in the UK where residents undertaking retrofits share their knowledge, collectively procure equipment or contracts, and participate in work parties to work on each other’s homes.

The Split Incentive and Equity Impacts

Retrofits typically require a capital cost, which improves the efficiency of the building and reduces its operating costs. Renters generally do not have access to capital nor do they have the legal right to make improvements to building envelopes or equipment. In cases where renters pay the utility costs, landlords have no incentive to increase the efficiency of the building. This divergent interest is known as the split incentive and has the implication that most retrofit programs primarily benefit homeowners.

If the building is upgraded, landlords often increase rents, which can increase the cost of the housing market, further increasing the strain on low-income residents.

In each case, the deep retrofit package will include thermal (envelope retrofits), renewable energy, and heat pumps. The program should include four streams:

- Affordable housing
- Residential sector
- Rental properties
- Commercial buildings

Each stream will include different considerations for incentives, loan agreements, and program delivery.

Retrofitting all the buildings in Lakewood will require a skilled labor force that is trained to assess the needs of a building and to complete the retrofit work. Many buildings in Lakewood are older, and retrofits will need to consider upgrades from older electrical systems, including knob-and-tube wiring, to accommodate the electrification of heating and transportation. Lakewood can develop a partnership with local colleges and trade schools, the construction industry, and the County and State to support the development of the workforce.

Everyone Benefits: A Requirement for Retrofits in Rental Housing in Boulder

The City of Boulder adopted its SmartRegs policy in 2010, requiring that all long-term rental properties achieve an energy efficiency standard in order to maintain their rental licenses, a strategy to achieve Boulder's Climate Action Plan. Landlords were able to comply using a prescriptive path from a checklist, a performance path based on the Home Energy Rating System (HERS), or one of several exemptions. The City connects landlords with energy efficiency incentives from utilities, identifies upgrades, and evaluates contractor bids. It also developed a loan program. By 2019, 50% of the units had complied, 17% were exempted, and 32% were pursuing upgrades. The program also effectively addressed the split incentive program, so that both landlords and renters shared the financial benefits of the reduced operating costs.

2. Neighborhood retrofit pilot: As a pilot project, the City can coordinate the retrofit of an entire neighborhood at once in order to achieve efficiencies through bulk purchasing, and other strategies, similar to the EnergieSprong model. The EnergieSprong model provides a turnkey retrofit service to existing buildings to convert them to net-zero or net-zero-ready when renewable energy becomes available.³³ Energiesprong retrofits can be completed in 10 days and have been successful in updating social housing without requiring upfront capital from tenants.³⁴ As another example, Blocpower, a Brooklyn-based company, has partnered with Ithaca and scaled to offer retrofits of an entire city.³⁵

Scaling Up: The Industrialization of Retrofits

In both Europe and North America, the industrialization of retrofits is an increasingly common solution to rapidly retrofit the building stock in order to achieve GHG reduction targets. Energiesprong, a Dutch public-private partnership, has pioneered a semi-industrialized net-zero-energy retrofit package and applied this approach to approximately 5,000 low- and mid-rise multi-family retrofits, with roughly another 100,000 units of multi-family demand aggregated across Europe.³⁶ Similar projects are under development in New York State, California, and Massachusetts.³⁷ The EU has advanced retrofit industrialization programs underway.³⁸ The City of Seattle has developed a mechanism to transform deep retrofits into power purchase agreements, described as Energy Efficiency as a Service (EEaS) contracts. A pilot project for 30 commercial buildings is currently underway.³⁹ Policies to scale up retrofits include integrated design and project delivery, refabrication of building facades and HVAC systems, mass customization tools that manage distinct building characteristics with greater ease, and aggregation of retrofit projects into single portfolios.⁴⁰

³³ Sustainable Buildings Canada. (2016). Energiesprong Summary Report. Retrieved from: <https://sbcanada.org/wp-content/uploads/2017/09/Energiesprong-Summary-Report.pdf>

³⁴ Rocky Mountain Institute (n.d.). "How-to-Guide: Net-Zero Retrofit Technical and Cost Benchmark Studies." Rocky Mountain Institute. https://www.rmi.org/rmi_techno_economic_study_how_to_guide/.

³⁵ Blocpower (2021). Ithaca, NY Selects BlocPower to "Green" Entire City, First Large-Scale City Electrification Initiative in the U.S. Retrieved from: <https://www.blocpower.io/press-release/ithaca-ny-selects-blocpower-to-green-entire-city-first-large-scale-city-electrification-initiative-in-the-u-s>

³⁶ Egarter, A., & Campbell, M. (2020). Prefabricated zero energy retrofit technologies: A market assessment (DOE/GO-102020-5262, 1614689). <https://doi.org/10.2172/1614689>

³⁷ The hub of the U.S. work is a project called REALIZE: <https://rmi.org/our-work/buildings/realize/>

³⁸ An example of one project that is a partnership of major industries is BRESAER: <http://www.bresaer.eu/>

³⁹ A description of the City of Seattle's program is available here: <https://www.bdlaw.com/publications/seattle-launches-energy-efficiency-as-a-service-program-encouraging-deep-energy-efficiency-building-retrofits/>

⁴⁰ Haley, B and Torrie, R. (2021). Canada's Climate Retrofit Mission. Retrieved from: <https://www.energycanada.org/wp-content/uploads/2021/06/Retrofit-Mission-FINAL-2021-06-16.pdf>

What can a Homeowner do?

The action plan for a homeowner is simple in concept but complex to implement. The five steps are:

1. Increase the efficiency of the home by adding insulation, improving windows, and ensuring air sealing.
2. Electrify heating (and cooling) with a heat pump; water heating and cooking: this can involve upgrading the electrical panel, modifying or replacing the ducting system, and adding new wiring.
3. Walk, cycle, and take transit wherever possible.
4. Purchase an electric vehicle.
5. Install a solar system.

Barriers to implementation include knowing what measures to implement, finding a trusted contractor, and financing the improvements.

5.1.3 New Buildings

3. Zero-emissions building coalition: The City can convene developers, builders, consultancies, institutions, and non-profit organizations who are committed to advancing net-zero projects. This coalition can support the City by undertaking pilot projects and identifying strategies to accelerate net-zero projects.

4. Sustainable development checklist: As part of any development application, the City can require enhanced performance using planning process approvals. A tiered approach to the performance requirement would result in a steady increase in the minimum energy and GHG performance, while providing incentives for those projects that exceed the minimum performance. Such a program should target 100% net-zero buildings by 2030.⁴¹ A building performance label can also be tied to the checklist to highlight the best performing homes and buildings.

5. High performance building incentives: The City can identify mechanisms, such as expedited permitting, reduced development charges, and other incentives, to acknowledge improved performance related to IRA.

⁴¹ Example of a tiered approach: City of Toronto (2022). Toronto Green Standard. Retrieved from: <https://www.toronto.ca/legdocs/mmis/2021/ph/bgrd/backgroundfile-168198.pdf>

The Passive House Standard

Compared to a conventionally built residential building, passive house design can yield reductions in GHG emissions. Buildings can reach heating and cooling energy reduction of up to 90%, with an average of 50% total energy savings.

Passive House buildings aim to minimize heating requirements within the structure through multiple techniques. Building orientation encourages south-facing windows, so that solar insolation through the window can warm the interior of the building in colder temperatures, while deciduous trees provide shade and reduce solar insolation through the same windows in the summer. Passive design encourages the use of exterior insulation and high airtightness to reduce heat loss in the structure. Finally, heat recovery systems that use the warm exhaust air to preheat incoming air are critical to reducing overall energy requirements.

Passive House certification is performance based, meaning requirements are based on building performance not on required inclusion of building features. However, generally, standards are achieved through superior ventilation strategies, airtightness, reduced thermal bridging, extensive use of thermal insulation, and high R-value windows and doors.

6. Incentivize a net-zero building code: Building codes are set at the state level, but the City can develop opt-in incentives to encourage net-zero buildings, including priority permitting, planning approval requirements, and tax incentives. Advocacy at the state level can help encourage the adoption of net-zero building codes across Ohio.

5.2 Rethinking Transportation

Transportation is the second-largest contributor to GHG emissions in Lakewood. Personal vehicle use, commercial operations, transit, and heavy transportation were responsible for 29% (126 kt CO₂e) of emissions in 2019. Personal vehicles accounted for the majority of these emissions (84% from cars and 9% from light trucks and SUVs, while heavy trucks made up the remaining 7% of the emissions).

Transportation emissions also come from many small sources, —the emissions total takes into account every personal vehicle, snowblower, lawn mower, and bus. The decarbonization of transportation requires coordination across the entire city to encourage the mass electrification of all vehicle types.

Through the use of electric personal vehicles and zero-emissions heavy vehicles, as well as active transportation and trip avoidance, transportation emissions can be reduced almost entirely. The remaining emissions are primarily from the use of grid electricity to power vehicles, emphasizing the importance of carbon-free renewable electricity in this sector.

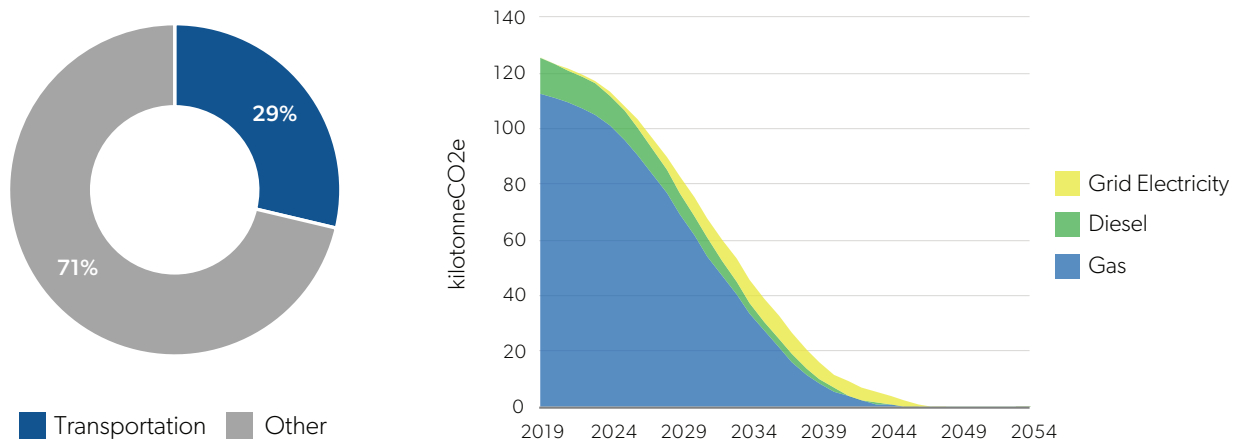


Figure 6. GHG emissions from transportation in 2019 (left) and by fuel in the LC Scenario (right).

5.2.1 Zero-Emissions Vehicles

7. EV charging infrastructure: Unlike gas stations, charging stations do not require storage tanks and careful zoning for watershed protection. They can be installed in parking lots, alongside street parking, and at facilities such as libraries, restaurants, and gyms. Ownership of the charging stations can be dispersed, allowing local businesses to install chargers for their customers, providing financial benefits from the chargers on their properties. The City can coordinate with the electrical utilities on an EV charging partnership to ensure availability of infrastructure and electrical capacity, and it can require electrical infrastructure in new homes and buildings.

Equity and the Cost of Transportation

EVs are not accessible to everyone and even though they are very efficient vehicles, walking, cycling, and transit are more efficient and are lower cost. Prioritizing investments in these modes over private vehicles is the priority from an equity perspective. A car co-operative is a strategy to provide access to vehicles at a lower cost. Some cities require new developments to provide allocated parking spots for car co-operatives to ensure their availability.

8. Zero-emissions transportation education program: The switch to EVs raises questions for many within Lakewood who have concerns about pricing, availability, winter performance, range, and availability of charging infrastructure. By coordinating education programs to encourage and incentivize zero-emissions, the City can encourage the switch from gasoline- and diesel-powered vehicles to more sustainable options.

9. Parking strategy: The City can reduce or eliminate parking fees for zero-emissions vehicles as an immediate strategy to incentivize EVs. Another parking strategy is to remove parking minimums for development approvals in order to encourage density and active transportation.

10. Fleet transformation coalition: The City can convene major vehicle fleet owners to develop an expedited electrification strategy, in coordination with the Vehicle Technology Centre. The strategy can include procurement coordination, leasing strategies, charging station deployment, and pilot projects for heavy vehicles and technologies such as green hydrogen.

5.2.2 Active Transportation and Transit

11. Walking and cycling infrastructure: Infrastructure and maintenance is critical to ensuring that people feel safe to walk and cycle. When people feel safe, cycling increases and demand for bicycles and infrastructure increases, creating a virtuous feedback loop. Electric bikes (e-bikes) are transformational for increasing the number of people who are comfortable cycling and increasing the trips that can be taken by bicycle.

Every vehicular trip shifted to active transportation represents avoided investments that will be required in the electrical grid to support vehicle electrification. This financial value can contribute to justifying investments in active transportation. The best practice is to target ~\$20 per capita to walking and cycling infrastructure.⁴² Similar investments would allow for significant improvements to the active transportation infrastructure.

Since walking and cycling is more accessible to low-income individuals than driving, investing in walking and cycling advances equity, and complete streets offer opportunities to add shade via street trees or barrier plantings. To be successful from an equity perspective, infrastructure improvements must consider connectivity to popular destinations and low-income neighborhoods. Additionally, the design of infrastructure can incorporate elements to make it accessible to those with limited mobility. The City can also include measures to provide accessibility across seasons, such as by ensuring sidewalks and cycling paths are promptly cleared after snow storms or paths are well shaded to protect users during heat waves.

12. Car-free or car-light zones: Clean air zones are a strategy to reduce air pollution and GHG emissions. Barcelona's superblock approach is a strategy applicable to Lakewood. Superblocks aim to ensure that every citizen enjoys access to clean air, humane levels of noise, walkable green and public spaces, community, and multimodal transportation options. Superblocks are a cluster of nine city blocks, three by three, and within the perimeter of the cluster, cars can go no faster than walking pace in only one direction. Only residents and delivery vehicles have any reason to enter, and all through traffic remains on the perimeter of the cluster.

⁴² Cradock, A. et al. (2019). Evidence to Inform a Cycling and Walking Investment Strategy. Retrieved from: https://cdn1.sph.harvard.edu/wp-content/uploads/sites/84/2019/05/Evidence-to-Inform-a-Cycling-and-Walking-Investment-Strategy_2019_04_30.pdf

The Superblock Comes to Lakewood

What might a superblock in Lakewood look like? The principles guiding superblocks in Barcelona are as follows:

Life in the street—Priority use for citizens: Absolute priority for pedestrians on any route, whether walking, resting, or socializing. Vehicles are guests. They will be able to travel, in exceptional cases, at 6 mph and not along straight routes, as they will have to turn at corners.

A single-level street from façade to façade, with asphalt road surfaces a thing of the past: Green hubs will be single-level streets, without barriers or divisions. The current differences in height between pavements and road surfaces will be eliminated and the entire space of the street will be dedicated to social uses and people.

Explosion of greenery: From 1% to more than 10%: Only 1% of the surface area of today's streets is allocated to greenery. At least 10% will be dedicated to greenery in future streets, with trees playing a much bigger role in the landscape. It is estimated that the 21 hubs provided for in the Barcelona Superblock project will have as many as 4,000 new trees. Trees will occupy the central part of streets so they can grow taller and more leafy.

A new environmental infrastructure and more fertile subsoil: Streets will become an environmental infrastructure committed to sustainability, efficiency, and self-sufficiency. This will be achieved by switching over from a compacted and impermeable subsoil linked to the passage of vehicles, to a permeable and fertile subsoil that promotes the growth of greenery and trees and the management of the water cycle.

New furniture to encourage social uses: More urban furniture will be incorporated to promote street life and local-resident activities. More benches, fountains, play areas, and even tables will be provided. The goal is to encourage social uses of streets.

Promoting local commerce: The new model will also help boost the local economy by promoting commercial life from façade to façade, thanks to its single-level paving and the elimination of the barriers caused by traffic lanes.

13. Behavior change: Shifting away from vehicular travel requires a cultural shift and behavior change. Given the impacts of electrification of vehicles on the electricity grid and health, the City can work with relevant partners to help people make lifestyle changes to shift to electric vehicles, transit, walking, and cycling in the context of other incentives.⁴³ The City of Edmonton's Change for Climate⁴⁴ is an example of this type of program.

14. Partnership with NOACA: By coordinating with NOACA on their concurrent decarbonization strategies, Lakewood can ensure fleet expansion and decarbonization plans are aligned with local plans to expand active transportation trail networks, e-bike sharing, rental strategies, and carbon-free last-mile transportation options.

⁴³ The Sustainable Travel Towns initiative is an example of a successful program that supports a cultural shift on transportation. For more details, see: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/738305/ppr776-sustainable-travel-towns-final-report.pdf

⁴⁴ City of Edmonton (n.d.). Change for Climate. Retrieved from: <https://changeforclimate.ca/>

15. E-scooter and e-bike rentals/incentives: Electric bikes and scooters are transformational for increasing the number of people who are comfortable using bike lanes and trails and increasing the trips that can be taken by active transportation. Every vehicular trip shifted to active transportation represents avoided investments that will be required in the electrical grid to support vehicle electrification. The City can support the development of a city-wide rental system, using existing examples of public bike-sharing as blueprints. In addition, some cities are providing grants to low-income households for the purchase of e-bikes.

16. Improve public transit: The City can work with NOACA and the GCRTA to implement key changes that will increase transit mode share. These changes include increasing the frequency and reliability of services, improving transit waiting environments, and increasing transit destinations. In order to ensure transit is accessible to low-income communities, the City can work with NOACA and GCRTA to explore lowering fares or providing subsidies, as well as ensuring low-income neighborhoods are well connected to transit routes.

5.3 Clean Electricity for All

The switch from fossil fuels to renewable electricity is an essential part of the pathway to reduce Lakewood’s GHG emissions. By switching from natural gas for space heating and gasoline and diesel for transportation, we can reduce emissions across the biggest energy-using sectors.

Ohio’s grid electricity relies on the use of fossil fuels for electricity generation. Currently, the City of Lakewood is using RECs to offset these emissions, and this program is being expanded to many residential accounts within Lakewood. RECs are an excellent strategy for immediate action to reduce emissions associated with energy use, but the long-term market stability is difficult to predict. Consequently, local renewable energy, including rooftop solar PV and wind generation, is prioritized in the LC Scenario,. By supplementing the current electricity supply with renewables and local storage, we can reduce the need to expand the existing electricity grid to accommodate the increased demand from electrification of transportation and space heating. Additionally, by diversifying the sources of electricity and adding energy storage, Lakewood will become more resilient to disruptions in electricity supply.

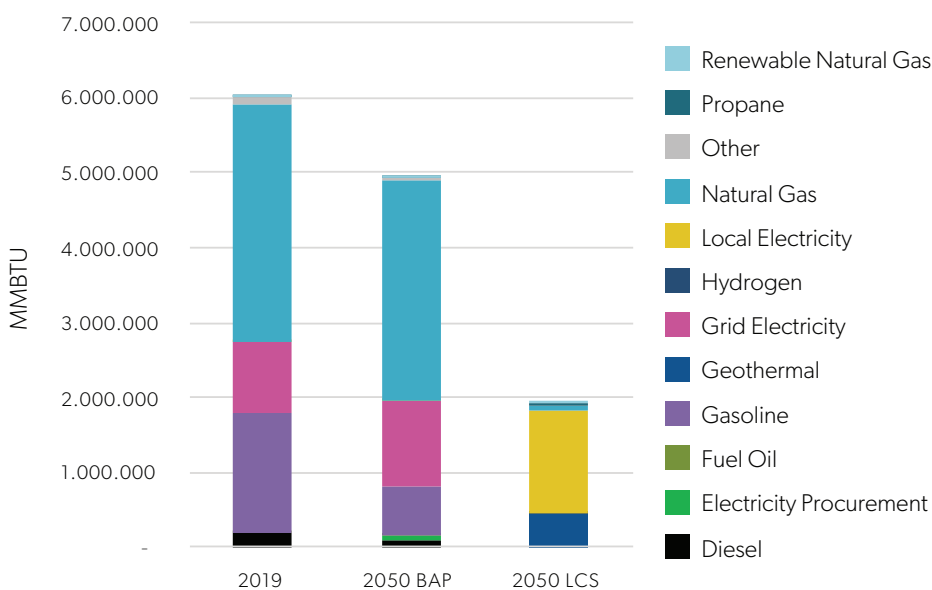


Figure 27. Energy sources by fuel type in the present day, and the BAP and LC scenarios by 2050.

5.3.1 Renewable Energy Generation

17. Rooftop solar PV: The City can set up single desk permitting to expedite solar PV installations. Expanding the local generating capacity of Lakewood will increase the city's resilience to electricity supply disruptions and provide additional capacity to support the electrification of buildings and transportation. The PV installations can be integrated into the building retrofit and new construction programs.

18. Parking lot solar PV: Parking lots are land assets compatible with large-scale urban solar installations.⁴⁵ The City can partner with First Energy and parking lot owners to advance solar installations where appropriate.

19. Community solar gardens: To facilitate solar access for households where it is inaccessible due to physical or financial reasons, solar gardens can be constructed in appropriate locations as a new energy service provided by the City or a renewable energy cooperative.

5.3.2 Wind Generation

20. Wind generation partnerships: Lakewood does not have many large, open areas of undeveloped land for the installation of wind generation facilities. By partnering with neighboring communities, Lakewood can share the costs and benefits of the development of a wind farm.⁴⁶ Some wind farms also follow habitat provision guidance to allow native pollinators and plants to persist.

21. Offshore wind generation pilot project: The City of Cleveland is exploring offshore wind generation in Lake Erie. Lakewood could undertake a similar pilot project to enable the community to benefit from the development of renewable energy and leverage the learnings from the Cleveland Icebreaker Wind project.

5.3.3 Sharing the Benefits

22. Renewable energy co-operatives: Renewable energy co-operatives are a powerful mechanism to increase community capacity, build expertise and excitement, and create new investment opportunities for communities. They are also a key strategy in reducing climate anxiety because they empower communities to take action. Additionally, cooperatives can help create equitable access to local renewable energy and provide opportunities for low-income groups to participate in the energy transition. The City can provide grants to support the establishment of renewable energy co-operatives and sites for installation.⁴⁷

⁴⁵ Coniff, R. (2021). Why Putting Solar Canopies on Parking Lots Is a Smart Green Move. Retrieved from: <https://e360.yale.edu/features/putting-solar-panels-atop-parking-lots-a-green-energy-solution>

⁴⁶ The AREA wind farm in Ellershouse, Nova Scotia, Canada, is an example of this type of partnership between three municipalities.

⁴⁷ A detailed guide on how to support renewable energy co-operatives is available here: <https://www.rescoop.eu/toolbox/community-energy-a-practical-guide-to-reclaiming-power>

Renewable Energy Co-operatives

Renewable energy co-operatives enable broader participation in the energy transition. Households can pool funds to invest in renewable energy projects that can be sited on the roofs of schools or non-profits or non-profit organizations. Revenue from the projects is distributed to the investors based on the size of their investment. Renewable energy co-operatives are common in North America and Europe and have a long track record for major projects. For example, a renewable energy co-operative in Denmark developed an offshore wind farm, which helped to decarbonize Copenhagen's electricity system.

23. Household and neighborhood energy storage: The City can support small- and medium-scale energy storage projects for households and neighborhoods in coordination with electricity utilities. The installations can target low-income neighborhoods to increase resiliency.

24. Workforce development program: Building local capacity and expertise can grow the local clean energy economy. The City can work with the local colleges, trade schools and universities, unions and trades organizations, and industry experts in developing a program to scale up the workforce in alignment with the City's targets.⁴⁸ Ensuring access to all members of the community to training and education programming is essential in ensuring the energy transition is equitable. Partnerships with the West Shore Career- Technical District, the Greater Cleveland Partnership, and Cuyahoga County Workforce Development can jumpstart the workforce development required to retrofit buildings.

5.4 Protected and Enhanced Natural Spaces

Lakewood has four major natural resource assets that can help protect citizens against climatic changes if managed sustainably for ecosystem services. Forests and the urban tree canopy offer cooling relief from urban heat islands and sequester carbon. The Lake Erie shoreline protects coastal infrastructure from erosion driven by increasingly intense storms. The Rocky River and its tributaries provide cultural benefits as well as water quality uplift and water storage. Finally, a dispersed network of activated public lands and green infrastructure can provide pollination services and water infiltration opportunities. Protecting and enhancing these assets requires proactive management that preserves these natural areas and maximizes their ability to help Lakewood and its residents adapt to a changing climate.

25. Zoning to protect natural spaces: Limit development in naturalized spaces, and limit tree cutting to protect natural spaces and reduce impacts from flooding and the urban heat island effect.

26. Wetland and riparian forest management: Protect the Rocky River corridor through activities and policies to regenerate beech-maple forest along the river, and explore opportunities to restore and create new wetlands along the riparian zone in conjunction with MetroParks.

27. Make green infrastructure standard: Continue to encourage the use of green infrastructure by providing incentives for development that includes green infrastructure for parking, roofs,

⁴⁸ For an example of a green workforce development strategy, see: <https://www.nysedra.ny.gov/All-Programs/Clean-Energy-Workforce-Development>

and other spaces. Lead community workshops on building small-scale green infrastructure to improve water quality, increase infiltration, and provide habitat for pollinator species.

28. Incorporate green infrastructure into Lakewood’s stormwater management system and developments (e.g. via incentives for developers, site planning approvals): As weather becomes more extreme, floods in Lakewood will increase in frequency and size, leading to more wet basements and infrastructure damage. Green infrastructure, such as green roofs, bioswales, permeable pavements, and wetlands, can absorb water and guide runoff to reduce flooding impacts.

29. Shoreline stabilization: Undertake pilot projects for offshore structures to reduce shoreline erosion with nature-based elements that enhance habitat for native species.

30. Protect and expand the forest canopy: A healthy and robust urban forest can reduce the risk of urban heat islands and lower local temperatures. A tree cover of 33.5% will greatly reduce the impacts of urban heat islands on the community.

Efforts to expand the tree canopy must consider how to reduce existing inequities and increase the resilience of Lakewood as a whole. Neighborhoods south of Madison and east of Wascana Avenues have less tree coverage and, consequently, experience higher daily temperatures. Efforts to expand the forest canopy must include initiatives to improve the tree canopy in these areas.

31. Tree planting initiatives: Develop a list of appropriate climate-proof species for tree planting, and lead community workshops to encourage tree planting on public and private property.

5.5 Extreme Weather Emergency Management

Lakewood residents are already feeling the effects of climate change. Their concerns include rising temperatures and temperature extremes, severe storms, and flooding, as well as how these issues may negatively impact public health and worsen inequities. For example, seniors, children, and low-income residents are among those most vulnerable to high temperatures. Seniors and children tend to experience more health problems during heat waves, while low-income residents are less likely to be able to afford air conditioning.

The City can mitigate the risks posed by climate hazards by planning for emergencies and considering the needs of vulnerable populations.

32. Create extreme heat emergency management plans: Lakewood residents are already struggling with heat waves. In order to minimize heat-related health risks, the City can create an extreme heat emergency management plan with special consideration for residents who do not have AC, as well as vulnerable and/or isolated populations, such as children, seniors, people with disabilities, and those reliant on public transit or active transportation. It is essential that this plan be developed with input from vulnerable populations, community groups, and the Westshore Regional Community Emergency Response Team. The City can also draw on recommendations from the 2019 Community Vision developed by the Resiliency Task Force.

33. Create an extreme cold emergency management plan: Ice and other winter storms are also a concern for residents. They have the potential to isolate seniors, as well as those who have limited mobility or do not have a car. An extreme cold emergency management plan that builds upon the City’s Snow and Ice Control Plan, as well as the 2019 Community Vision recommended by the Resiliency Task Force, can minimize the impact of such challenges. This plan should be

developed with input from vulnerable populations, community groups, and the Westshore Regional Community Emergency Response Team.

34. Incorporate climate adaptation measures into energy efficiency retrofits: With many homes in the city being over 100 years old, and due to the widespread flooding risks, Lakewood must consider how to mitigate potential damage from temperature extremes and flooding. Energy efficiency retrofits can be designed to enable buildings to better regulate temperatures during temperature extremes.

Retrofits and Resilience

The number of homes retrofitted is used as a proxy indicator of increased resilience. Retrofits improve building envelopes so that they can better regulate temperature and therefore protect inhabitants in periods of extreme weather, which has been defined as passive survivability or thermal safety. Thermal safety is defined as maintaining thermally safe conditions during a power outage that lasts four days during peak summertime and wintertime conditions.

35. Incorporate climate resilience considerations into asset management: Lakewood residents are worried about the capacity of the community's aging infrastructure to withstand extreme temperatures, and flooding. For example, the grid may be more likely to go down during storms or if the cooling or heating load becomes too much during temperature extremes. It is critical for the City to assess its infrastructure and plan infrastructure investments with a climate resilience lens to ensure resilience and minimize potential damage from climate hazards.

5.6 Water, Waste, and Wastewater

The majority of the emissions from this sector come from organic matter in landfills that decays over time and releases GHGs long after it is deposited in the landfill. The most effective strategy in reducing these emissions is to reduce the amount of waste entering them. This can be achieved through a combination of waste reduction and waste diversion to composting and recycling facilities.

Emissions from waste accounted for 4% of the total GHG emissions in 2019. GHG emissions from waste are not entirely eliminated in the LC Scenario because tackling the remaining emissions from waste and wastewater is technically challenging, and Lakewood is capturing the majority of emissions from these sources already.

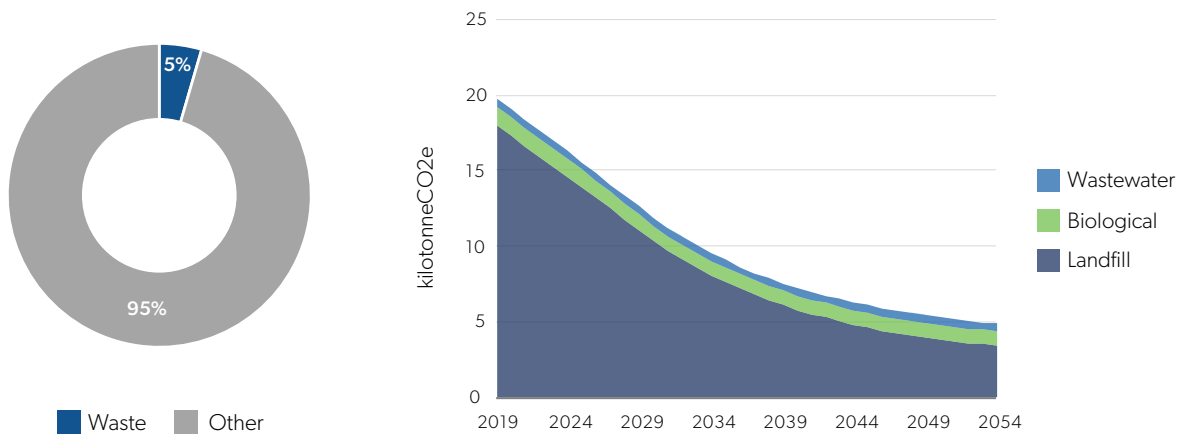


Figure 28. GHG emissions from waste and wastewater in 2019 (left) and by source in the LC Scenario (right).

36. A circular economy strategy: The City will develop a circular economy strategy that focuses on the ideas of zero landfill waste and using waste as a resource. This can include promoting Buy Nothing Groups to encourage the reuse of items and zero-waste stores within the community.

37. Municipal organics collection: The affordability and physical accessibility of the dropoff site can help increase uptake. Centralized curbside collection of organics for composting can be started as a pilot project and rolled out to Lakewood as a whole. Including larger producers of organic waste, like grocery stores and restaurants, can have a meaningful impact on GHG emissions, while also providing compost for municipal landscaping or for community use. The City should consider partnering with existing composting services, such as Rustbelt Riders.

38. Water conservation strategies: Support water conservation through public education and awareness and include water efficiency measures in building retrofits on public buildings. Support the use of landscaping measures with no or low irrigation needs.

5.7 The Role of the City

5.7.1 Leading the Change

39. Develop an annual carbon budget: A carbon budget is a mechanism to align financial budgets with GHG targets in order to operationalize the City's GHG targets. A carbon budget process ensures all departments and expenditures are aligned with GHG reductions.

40. Apply an equity lens for expenditures and policies: An equity lens evaluates the impact of a policy or action on equity-seeking groups and identifies measures or changes that ensure no one is left behind.

41. Apply a climate lens for expenditures and policies: A climate lens is a policy that aligns investments and policies with the climate targets. Staff can ensure that all proposals are "tested" against climate targets and revised accordingly.

42. Addressing the emissions gap: While the LC Scenario guides the decarbonization of the city, it is not enough to reach net-zero emissions by 2050. Therefore, the City must identify and implement opportunities to: (a) accelerate planned action, (b) support carbon removals, and (c) purchase carbon offsets. The City can accelerate action when there is momentum in

certain sectors (e.g. electric vehicle adoption) or when the financial returns are higher than anticipated. The second two options are more uncertain. Carbon removals are currently an unproven and expensive technology. Carbon offsets are a mechanism for purchasing emissions reductions, but this represents a cost that does not generate returns and the integrity of carbon offsets is difficult to validate.

43. Annual GHG and energy use reporting: The City can undertake annual reporting on energy, costs, and emissions. The annual report can also include a review of programs to determine the ones that are successful and the ones that need to be adjusted to be more effective.

44. Make sustainability someone's job: Lakewood will need staff to develop pilot projects, build relationships with working groups, and work within the City to decarbonize municipal operations. With dedicated resources and capacity, the staff can share resources and knowledge and effectively disseminate information throughout the rest of the city government. Each program area will need to be supported by staff with subject matter expertise.

45. A zero-emissions fleet: The City can develop a strategy to decarbonize its fleet by purchasing only zero-emissions light-duty vehicles by 2023 and heavy-duty vehicles by 2026. A key aspect of this effort will be providing appropriate charging and fuelling infrastructure for these vehicles.

46. Zero-emissions buildings: The City can commit to only constructing net-zero buildings beginning in 2023 and can develop a decarbonization strategy to retrofit its existing building stock by 2050.⁴⁹

Making Climate-Safe Investments Now

Every expenditure on infrastructure either locks in new GHG emissions or reduces GHG emissions. The longer the investment life (period over which it pays off) of a type of infrastructure that results in emissions, the more vulnerable it is to transition risk. In other words, if a natural gas boiler is projected to have an operating lifetime of 20 years, it will likely need to be replaced within the decade in order to stay within 1.5° Celsius, forfeiting half of its planned lifetime. A new house that generates emissions will likely need to be retrofitted to be zero emissions within the next decade. As a result, if those decisions are climate safe or climate proofed moving forward, society can avoid significant transition costs. For example, retrofitting a house to zero emissions can cost between \$70,000 and \$100,000, whereas building a new net-zero home can have an incremental cost of less than \$10,000.⁵⁰

⁴⁹ Depth of retrofits are defined in Appendix A, but municipal buildings are retrofitted with 60% thermal efficiency improvement and 30% improvement in electricity consumption.

⁵⁰ These costs are based on analysis completed by SSG for various projects.

5.7.2 Prioritizing Community Involvement

47. Revolving loan fund: A revolving loan fund would be a stable funding program to leverage external funding and offset the cost of a climate change project. It would also provide sustainable funds for climate change retrofits, pilot projects for new climate change efficient technologies, incremental retrofit projects of higher climate change efficiency options, and environmental pilot projects. Initial capital for this fund could come from a carbon fee similar to that developed in Athens, Ohio, where revenues are reinvested into the community to fund the implementation of the LC Scenario.

48. PACE Financing: Develop a city-led Property Assessed Clean Energy (PACE) financing program to provide low-interest loans to property owners to complete energy efficiency retrofits, solar installations, and conversions to heat pumps. Careful program design can ensure that avoided energy costs for households exceed loan payments in the PACE program.

49. Community Climate Advisory Committee: A Community Climate Advisory Committee is a powerful mechanism for selecting and building community support for challenging climate actions.⁵¹ The committee can advise the City on climate actions and serve as a forum for initiating or coordinating community-level programs.

50. Storytelling: A communications roadmap can highlight successes of the implementation, building momentum and enthusiasm. Key strategies include web-based stories, podcasts, learning laboratories, and peer-learning groups.

Climate Action Planning

A key aspect of community energy planning includes prioritizing interventions in terms of a hierarchy based on what lasts longest.⁵² The first priority is land-use planning and infrastructure, including density, mix of land uses, energy supply infrastructure, and transportation infrastructure. The second is major production processes, transportation modes, and buildings, including industrial process, choice of transportation modes, and building and site design. The final priority is energy-using equipment including transit vehicles, motors, appliances, and HVAC systems.

⁵¹ For more information on climate assemblies, see: <https://climateassemblies.org/>

⁵² Jaccard, M., Failing, L., & Berry, T. (1997). From equipment to infrastructure: community energy management and greenhouse gas emission reduction. *Energy Policy*, 25(13), 1065–1074.



**CO-BENEFITS
AND CO-HARMS**

6. Co-Benefits and Co-Harms

Co-benefits and co-harms are effects that result from and are incidental to actions reducing GHG emissions.

The terms co-benefits and co-harms have a variety of synonyms, including ancillary effects and ancillary benefits and costs. The definitions of these terms often vary depending on the context in which they are used.

In the context of completing a monetary analysis, these definitions become particularly important. One distinction, made by the Organisation for Economic Co-operation and Development (OECD), is that co-benefits are effects that are valued in the mitigation costs of a policy or action, whereas ancillary benefits are effects that are incidental and are not accounted for in that analysis.⁵³ For the purposes of this paper, co-benefits are assumed to be any benefits that occur in addition to the action's impact on GHG emissions. Correspondingly, co-harms are any harms that occur in addition to the action's impact on GHG emissions.

Co-benefits and co-harms are not equal. They have different categories of effects.

Not all co-benefits or co-harms are equal. The following set of criteria can be used to consider the co-benefits of initiatives and actions to reduce GHG emissions:⁵⁴

Synergies: Many low-carbon actions have multiple socio-economic benefits. Examples of these types of actions include transit, improving energy efficiency, and fostering a more compact urban design.

Urgency: Some actions are associated with greater urgency in order to avoid loss of inertia on action already taken, lock-in effects,⁵⁵ irreversible outcomes, or elevated costs. This may occur with road infrastructure decisions, major ecosystems displacement and urban form. Some low-carbon actions require time to realize their effects, making immediate implementation paramount.

Costs: Acting early is generally less expensive than acting later. This is because delayed action often involves 'fixing' high-emissions infrastructure rather than making it a low-carbon option from the beginning. Examples include buildings that are initially constructed to low energy efficiency standards and then need to be retrofitted later.

Longevity: Related to urgency, the longevity of planning and development decisions locks cities into their effects for decades and sometimes centuries. For example, widening a roadway allows more vehicles to travel, encouraging more emissions for as many years as the widened roadway remains in use.

⁵³ OECD. (2000). Ancillary Benefits and Costs of Greenhouse Gas Mitigation. OECD Publishing.

⁵⁴ Adapted from (Fay et al., 2015).

⁵⁵ Lock-in effect refers to implementation of a strategy or action that improves performance of an object or activity in the short term but is prohibitive of future change. Lock-in effect can refer to building upgrades or land use. For example, where quick building retrofits are undertaken, no additional improvements in the equipment installed can be expected over the course of its lifetime without considerable additional expense. In this way, lower levels of energy reductions can be locked in for a long period.

Distribution effects: Low-carbon actions have different impacts on different subsets of the population. Those with lower income levels may be unable to afford new heating and cooling systems in their homes; those with limited mobility may not be able to use transit as easily as the able-bodied; and those living in future generations will inherit the impacts of climate change caused by those who came before them.

The following table provides an assessment of the co-benefits and co-harms of taking the low-carbon and adaptation actions over the Business-as-Planned scenario.

Table 6. Summary of impacts.

1. Health		
Co-benefits/ co-harms	Adaptation	Buildings
1.1 Co-benefit: Improved air quality	Dependent on urban design to reduce exposure of pedestrians to air pollution. Locally improved by increasing tree canopy.	Energy-efficient buildings with low-carbon heating/cooling systems have fewer drafts, less condensation, and less temperature variation resulting in greater comfort and better health.
1.2 Co-benefit: Increased physical activity and health	Increased access to natural spaces and trails improves physical and mental health of the community.	
1.3 Co-benefit: Reduction in noise pollution	Vegetation absorbs noise and provides areas in which animals can hear intraspecies communications.	Improved insulation in buildings reduces residents' exposure to exterior noise.
1.4 Co-benefit: Improved accessibility	Mixed urban design results in dwellings being closer to commercial and service destinations.	

1. Health

Transportation	Energy	Waste
<p>Reduced combustion of gasoline and diesel in vehicles reduces NOx and particulate matter in the air. In turn, this reduces respiratory illnesses and flare-ups.</p>	<p>Reduced natural gas combustion in furnaces and industrial processes reduces NOx and particulate matter in the air. In turn, this reduces respiratory illnesses and flare-ups.</p>	<p>Treating waste so as to reduce and capture methane reduces odor issues.</p>
<p>Comprehensive, well-maintained, and safe cycling and walking infrastructure results in increased activity, better mental and physical health, lower obesity rates, and lower rates of absenteeism from work.</p>		
<p>Switching to electric vehicles reduces total vehicle noise as EVs do not produce as much noise as combustion engines.</p>		
<p>Transit-oriented development provides easier access to transit corridors and hubs.</p>		

2. Economic prosperity

Co-benefits/ co-harms	Adaptation	Buildings
2.1 Co-benefit: Increased employment		Retrofitting buildings and building to new, higher standards will create a significant number of direct and indirect jobs annually.
2.2 Co-harm: Decreased employment		
2.3 Co-benefit: Increased long-term affordability		Initial capital costs for more energy- efficient buildings are more than offset with the resulting long-term savings in energy costs.
2.4 Co-benefit: Increased leadership reputation		A requirement for high-performance buildings creates a reputation for the city’s developers and builders as having the skills required for innovative and sustainable building.
2.6 Co-benefit: Increased social capital	Increased mixed-use spaces result in more interactions, increased safety, and larger social networks.	
2.7 Co-benefit: Improved environmental capital	More intentional and denser use of land reduces impervious surfaces, creates opportunities for new public spaces, and preserves greenspace as parks and natural areas that reduce heat island effects. Activating underperforming greenspace provides habitat and infiltration for runoff management.	More efficient buildings require less energy generation, decreasing the need for new energy generation facilities in green spaces outside the city boundary.

2. Economic prosperity

Transportation	Energy	Waste
	<p>Supplying, installing, and maintaining renewable and alternative energy systems, renewable fuels, and energy storage will generate a significant number of new jobs annually.</p>	<p>Waste mining for the circular economy, recycling, and the conversion of waste to fuel will all generate new jobs.</p>
<p>The large-scale shift to EVs will result in a reduction in overall maintenance requirements for vehicles.</p>		
<p>EVs have higher initial capital costs than ICE vehicles; however, in the longer term, they save the owner more in avoided fuel and maintenance. Increased use of transit and active transportation also cost less than personal vehicles.</p>	<p>Initial capital costs to replace high emissions heating and cooling technologies are more than offset with the resulting long-term savings in energy costs.</p>	
<p>Less congestion, shorter commutes, more biking and walking infrastructure draw new, young residents to the city's reputation of being a more liveable community.</p>	<p>Large-scale renewable and alternative energy deployment increase the city's exposure as a climate leader and prepare the local labor force to maintain the energy systems of the future.</p>	<p>The city becomes known not only for managing its own waste, but for converting it from a high-energy consuming enterprise to a profitable energy producer.</p>
<p>Increased active transportation and transit use promotes more interaction among citizens, improving social cohesion.</p>		
	<p>Energy generation within the city boundaries decreases the need to import energy (losing some in the process) and reduces the need for new generation facilities in green spaces beyond the city.</p>	<p>Waste managed as a valued resource results in less pollution of ground and groundwater.</p>

3. Social equity

Co-benefits/ co-harms	Adaptation	Buildings
3.2 Co-benefit: Quality of life for the elderly improves	Access to naturalized spaces improves physical and mental health of all ages, especially when cool outdoor areas provide relief from extreme heat.	Low-carbon buildings are more comfortable and healthier for residents who are more susceptible to illness.
3.3 Co-benefit: Quality of life for children improves	Increased access to outdoor recreation areas and complete green streets makes it easier for children to do more outside, get to know their neighbors, and travel independently.	Low-carbon buildings are healthier, meaning the important development that occurs during childhood years takes place in cleaner spaces.
3.4 Co-benefits: Increased intergenerational equity and resilience	Low-carbon actions that begin early avoid locked-in emissions and increased costs to fix stranded assets in all of these areas. Action now also ensures changes are made before the worsening impacts of climate change begin to damage outdated infrastructure. All of this reduces the burden on future generations.	

3. Social equity

Transportation	Energy	Waste
<p>Sidewalks and cycling infrastructure is developed to be safe for “anyone aged 8-88”, improving seniors’ ability to continue to move in their communities.</p>	<p>Heat exchange systems provide air conditioning to all residents, reducing the impacts of heat waves.</p>	
<p>Safe, connected, well-maintained, and well-used bike paths, sidewalks, and transit infrastructure make these options better for children.</p>		



**THIS IS ONLY
THE BEGINNING**

7. This is Only the Beginning

In the context of climate action, cities are, and must be, leaders. This role takes many forms: custodian, facilitator, implementer, investor, convener, decision-maker, regulator, prompter, and activator. The Climate Action Plan is an ambitious roadmap to achieve net-zero emissions by 2050, and it relies on a whole-city approach in which each staff member and department advances the objectives and targets.

Climate action is about reducing greenhouse gas emissions, building a new economy, and improving quality of life. As is demonstrated by this analysis, the investments required to achieve the City's targets generate both financial returns and health benefits for the people of Lakewood.

By prioritizing actions that will reduce emissions and immediately improve the lives of community members, Lakewood can build momentum to continue the hard work of decarbonization. These actions include:

- Retrofitting buildings, including developing pilot projects and supports for low-income households and rental properties. This can include partnering with local businesses to lead the retrofits, working to identify funding for these retrofits from grants and other sources, and sharing the learnings from these projects.

- Supporting the development of renewable energy, starting with municipal buildings, and those able to participate easily on private properties. By pairing building retrofits with the installation of solar panels, immediate benefits will be felt by homeowners.

- Establishing a network of charging stations for EVs and encouraging new development to include EV charging infrastructure.

- Expanding municipal capacity for managing and delivering these projects.

The scale of the transformation required to meet Lakewood's climate goals can feel overwhelming. Focusing on the first year and then the first 5 years of the transformation will allow for concentrated effort, maximized learning, and appropriate risk-taking and exploration.

There is no time to waste.