CHAPTER 01

CLIMATE CHANGE AND ADAPTATION

GOALS

- Minimize Lakewood's communitywide greenhouse gas emissions and prepare and adapt to ongoing climate change impacts.

TARGETS

- Reduce communitywide greenhouse gas emissions by 20 percent below 2007 levels by 2025.
- Reduce communitywide greenhouse gas emissions by 50 percent below 2007 levels by 2050.
- Reduce municipal greenhouse gas emissions annually through 2025.

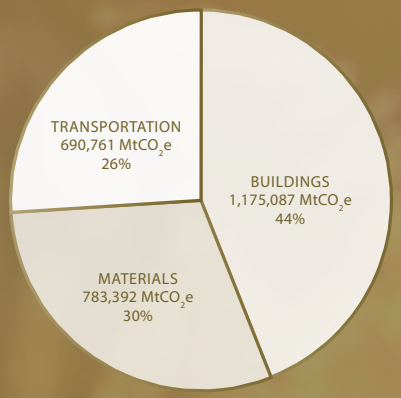
SUSTAINABILITY PLAN STRATEGIES: GREENHOUSE GAS (GHG) EMISSIONS REDUCTION POTENTIAL

BASELINE		
EMISSIONS BY SECTOR – MT CO_2E		
BUILDINGS	1,175,087	44%
MATERIALS	783,392	30%
TRANSPORTATION	690,761	26%
TOTAL GHG	**2,646,240**	**100%**

2025 BUSINESS AS USUAL (BAU)			
EMISSIONS BY SECTOR – MT CO_2E			CHANGE
BUILDINGS	1,053,368	42%	–121,719
MATERIALS	903,600	36%	+120,209
TRANSPORTATION	539,165	22%	–151,596
TOTAL GHG	**2,496,133**	**100%**	**–153,107**

2025 AFTER STRATEGIES ARE IMPLEMENTED			
EMISSIONS BY SECTOR – MT CO_2E			CHANGE
BUILDINGS	792,499	38%	–260,869
MATERIALS	791,443	38%	–112,157
TRANSPORTATION	504,655	24%	–34,510
TOTAL GHG	**2,088,598**	**100%**	**– 407,535**

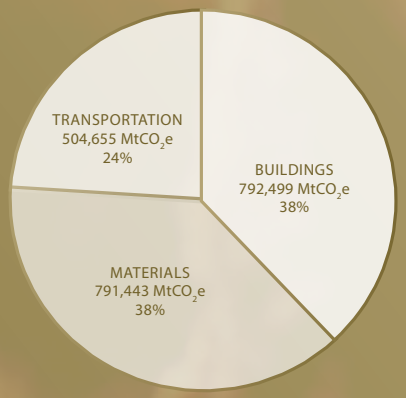
2007 BASELINE EMISSION BREAKDOWN



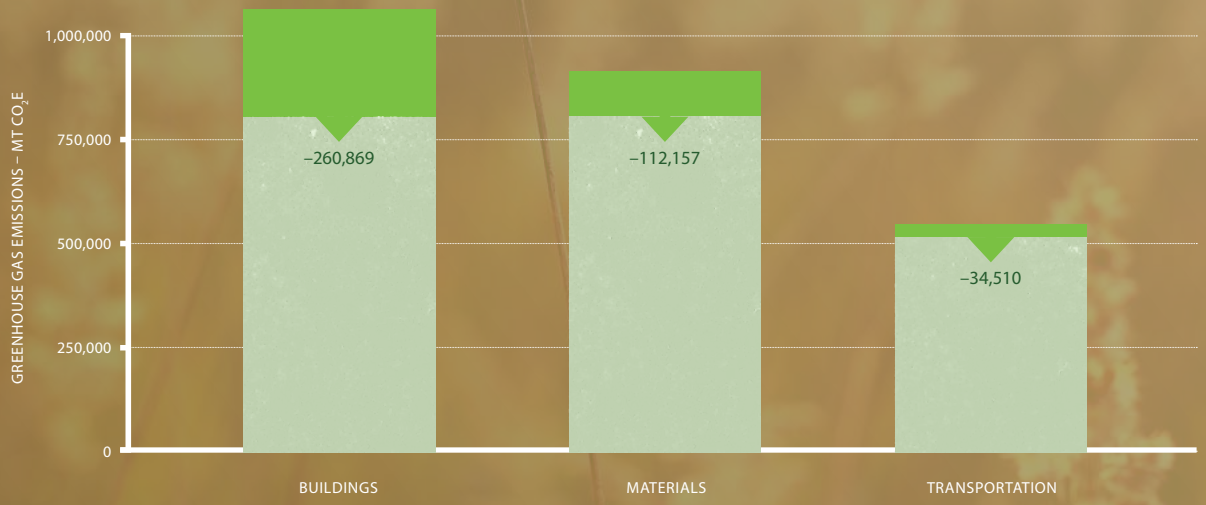
BUSINESS AS USUAL (BAU)

The term "business as usual (BAU)" is an emission value defined in a future year to represent emissions that would occur if an attempt had not been made to reduce emissions. The BAU considers changes to population and changes in emission factors. While the City of Lakewood's population and material sector emission factors are expected to increase annually, the emission factors for electricity and transportation are expected to decrease annually as a result of the state of Colorado's Renewable Portfolio Standard and improvements to vehicle fuel efficiency required by the Federal Corporate Average Fuel Economy (CAFE) emission standards.

2025 – TARGET YEAR EMISSION BREAKDOWN



IMPACT OF GREENHOUSE GAS (GHG) REDUCTION STRATEGIES ON 2025 BUSINESS AS USUAL (BAU)



SCIENTISTS CHARACTERIZE EARTH'S CLIMATE SYSTEM BY MEASURING THE AVERAGE METEOROLOGICAL CONDITIONS—INCLUDING TEMPERATURE, PRECIPITATION, AND WIND.

UNLIKE THE WEATHER WE EXPERIENCE EVERY DAY, Earth's climate changes relatively slowly, varying from year to year and over centuries and millennia. Climate scientists studying past and present climate trends have found that over the past several decades, the dynamics of the Earth's atmosphere have been changing significantly, affecting all parts of our climate system. Some of the most evident and observable changes can be seen in increasing surface and ocean temperatures, rising sea levels, decreasing snow and ice cover, and increasing intensity of storms. While fluctuations in Earth's climate have occurred over the course of the planet's history, scientific evidence overwhelmingly points to human activity as the primary driver of these current rapid and dramatic changes.

One of the most direct lines of evidence linking human activity to climate change is the effect that certain gases, such as carbon dioxide (CO_2), have when released into the atmosphere. Referred to as greenhouse gases (GHG), CO_2, methane, and several other gases, act like a blanket in the lower levels of Earth's atmosphere, causing the greenhouse gas effect, which blocks radiant heat (heat generated by the sun and reflected off of the Earth's surface) from escaping the Earth's atmosphere.

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Beginning with the Industrial Revolution in the in the late 1700s, human civilization has increasingly emitted CO_2 and other greenhouse gases into the atmosphere. Using historic data from tree rings, ice cores, and coral reefs, scientists have determined that preindustrial levels of CO_2 in the atmosphere were around 275 parts per million (ppm). Currently levels of CO_2 in the atmosphere exceed 400 ppm, a 40 percent increase from historic levels. This steady and rapid increase in GHG emissions, unprecedented in Earth's history, has been shown to directly correlate with rising surface and ocean temperatures. Since 1880, the global annual average temperature on Earth has increased 1.5 F. Consensus from the world's leading climate scientists estimate that at current emission rates, temperatures will increase between 6.7 and 8.4 F by the end of the century.[1] In 2014, the average temperature across global land and ocean surfaces was the highest among all 135 years in the 1880–2014 record. Including

[1] IPCC. Summary for Policymakers. "Climate Change 2014: Mitigation of Climate Change." Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2014. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf.

THE RISE OF SEA LEVEL

Global sea level has risen 8 inches since 1880.

2014, nine of the 10 hottest years have occurred in the 21st century.[2]

While there has been past debate over the role of human activity on climate change, there is mounting evidence from studies examining alternative theories that the cause is directly related to human GHG emissions. These studies examine naturally occurring factors that have historically contributed to variation in the planet's climate. For example, climate scientists looking at the impact of increased solar output on climate change have found that temperatures in upper layers of the Earth's atmosphere are cooling, despite the warming of lower atmosphere layers. This reinforces the conclusion of more than 97 percent of the world's climate scientists that GHG emissions and the greenhouse effect are responsible for our current climate trends.[3]

CLIMATE CHANGE IMPACTS

The planet is experiencing unprecedented changes in all parts of the global climate system. These changes have impacts both locally and worldwide. Understanding how these changes are affecting our community and how they might affect us in the future is critical to ensuring our long-term sustainability and prosperity.

OCEANS

Oceans cover more than 70 percent of the Earth's surface. Oceans play a significant role in determining Earth's climate by absorbing CO_2, strongly influencing weather patterns across continents. As heat-trapping gases, primarily CO_2, have increased, ocean surface temperatures and levels of acidity have also increased. Rising ocean temperatures and acidification are having significant impacts on ocean circulation (currents), chemistry, and ecosystems.

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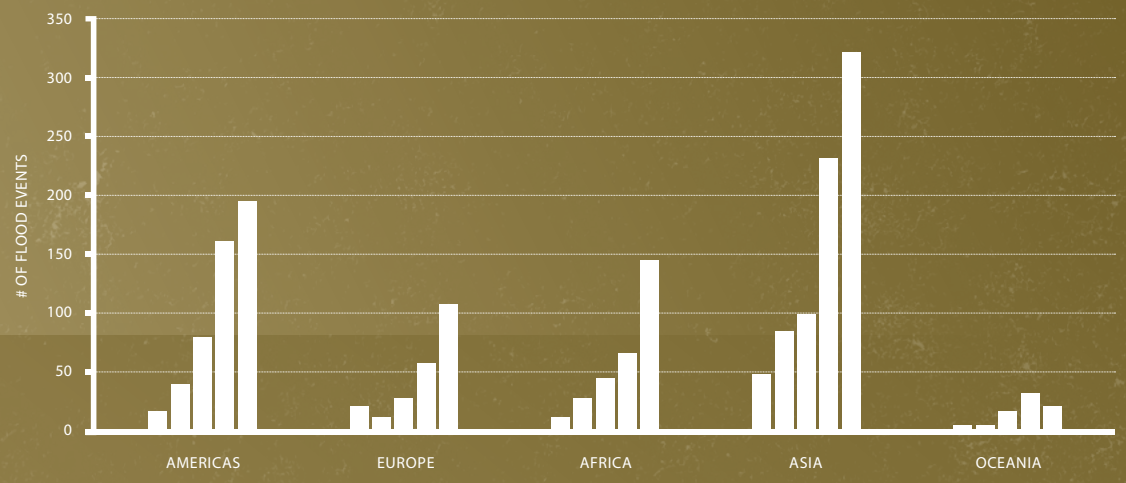
[3] U.S. Global Change Research Program. "2014 National Climate Assessment." GlobalChange.gov http://nca2014.globalchange.gov.

[2] NOAA. "Global Analysis – Annual 2014." National Climatic Data Center. http://www.ncdc.noaa.gov/sotc/global/2014/13.

ARE WE EXPERIENCING MORE FREQUENT EXTREME WEATHER EVENTS?

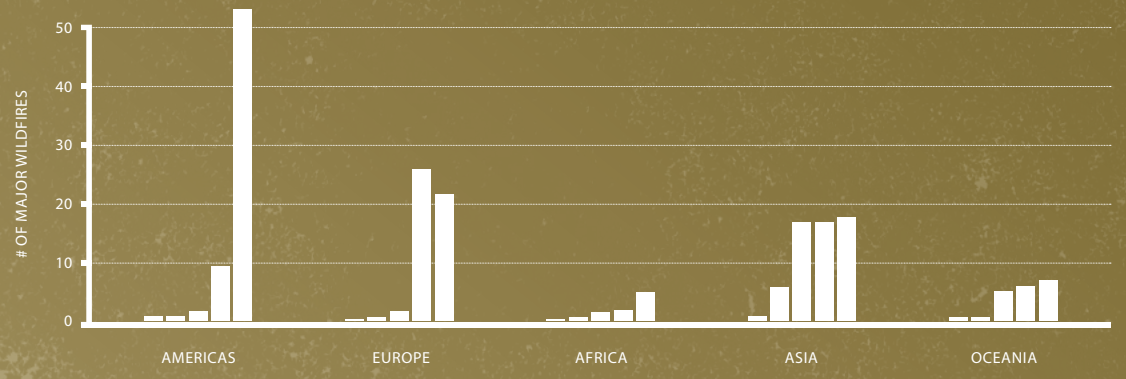
NUMBER OF FLOOD EVENTS 1950-2000

Data plotted by decade



NUMBER OF MAJOR WILDFIRES 1950-2000

Data plotted by decade



Source: Millenium Ecosystem Assessment

SEA LEVEL

Another critical ocean-related impact of climate change is the rise in sea level due to warming ocean temperatures, which causes water to expand, and from melting sea ice. Arctic sea ice has decreased in every decade since 1979. Global sea level has risen 8 inches since 1880 and is projected to rise another 1 to 4 feet by the end of the century. In the United States, more than 5 million people live within four feet of the local high-tide level.[4] The potential impacts of rising sea levels along with rising high tides and storm surges are far reaching and include impacts to infrastructure, local and national economies, personal property loss, and population displacement. A 2009 assessment for the state of California on the impacts of seal level rise estimated that a 4.6 feet sea-level rise would put nearly $100 billion worth of property at risk if no adaptation actions were taken.[5]

EXTREME WEATHER EVENTS

The most common way people experience climate change is through extreme weather events, such as heat waves, droughts, wildfires, hurricanes, heavy downpours, and floods. The intensity, frequency, and duration of heat waves have increased in recent decades, making it the leading weather-related cause of death in the United States.[6] Heat waves also contribute to droughts and wildfires because rising temperatures and evaporation rates increase the drying of vegetation. Since 2000, Arizona, Colorado, Utah, California, and New Mexico have experienced record-breaking wildfires.[7] The frequency and intensity of extreme weather and prolonged drought could also have significant impacts on U.S. crop yields, which supply more than 30 percent of all wheat, corn, and rice on the global market.[8] Projections indicate that the normal state for most of the nation at the end of this century will be what is considered moderate to severe drought conditions today.[9]

Heavy precipitation events and floods are also increasing and are projected to intensify in the coming decades,[10] affecting agriculture

and property. Between 1959 and 2005, floods in the U.S. caused 4,586 deaths,[11] and in September 2013 flooding in Colorado resulted in an estimated 2,000 damaged or destroyed homes.[12]

WATER

Drought and subsequently reduced groundwater, combined with changing precipitation patterns and earlier spring snowmelt, all affect water supply. Climate change impacts are projected to reduce Colorado's water supply, which is already constrained under current climate conditions. Strained water supplies affect our ability to meet consumption demands of cities and agriculture, significantly influencing our economy, water quality, and ecological health.

HUMAN AND ECOSYSTEM HEALTH

The environment also directly affects human health and well-being. Existing health risks, such as respiratory and cardiovascular diseases, infectious diseases, mental health, and stress-related disorders are all amplified by extreme weather, air pollution, and altered infectious disease transmission cycles. Vulnerable populations, such as children, older adults, low-income groups, and those with chronic illnesses, will disproportionately suffer from the added stresses of climate change impacts.

Human health is strongly connected to ecosystem health and biodiversity. The current rate of global species extinction is estimated to be 1,000 to 10,000 times higher than the rate of extinction across our planet's history. Scientists estimate that 25 percent or more of all terrestrial species will be threatened with extinction by 2050.[13] When we lose a gene or species, we lose it forever, and along with the loss of each species we lose the contribution or services that it provided.

Collectively, the impacts of climate change pose serious threats to our physical systems and social well-being. Potential financial impacts are just as devastating, causing disruption and recovery costs to our infrastructure, agricultural productivity, water and energy prices, and human health. In order to capture the costs to our society from increasing concentrations of CO_2, the U.S. government developed the "Social Cost of Carbon" (SCC), which is intended to monetize damages associated with an incremental increase in carbon emissions in a given year. Measuring the costs of climate change allows communities to devote the necessary attention and resources to the greatest challenge of the 21st century.

SOCIAL COST OF CARBON (SCC)

Monetizes damages associated with CO_2 emissions (see p. 28).

Strained water supplies affect our ability to meet consumption demands of cities and agriculture, significantly impacting our economy, water quality, and ecological health.

A PATHWAY FORWARD

As GHG emissions increase and changes to climate systems escalate, so do the risks of severe and sometimes irreversible impacts to our natural and human systems. Collectively, our actions as individual nations and cities contribute to the resilience and vibrancy of our future. Solutions cannot be achieved independently, as GHG emissions accumulate over time in our planet's atmosphere. A coordinated approach is critical to limiting current damages and successfully adapting to future conditions.

MITIGATION

Mitigation means limiting the magnitude and rate of climate change and associated impacts. Mitigation strategies largely consist of preventing or reducing GHG emissions. As communities assess and prioritize potential mitigation strategies, many refer to the "carbon budget" or the

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4 U.S. Global Change Research Program. "2014 National Climate Assessment." GlobalChange.gov http://nca2014.globalchange.gov.

5 California Climate Change Center. "The Impacts of Sea-Level Rise on the California Coast." 2009. http://pacinst.org/wp-content/uploads/sites/21/2014/04/sea-level-rise.pdf.

6 U.S. Global Change Research Program. "2014 National Climate Assessment." GlobalChange.gov http://nca2014.globalchange.gov.

7 J.D. Walsh, et al. "Appendix 3: Climate Science Supplement." Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 2014. doi:10.7930/J0KS6PHH.

8 U.S. EPA. "Agriculture and Food Supply." Climate Change. Last Updated September 9, 2013. http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html.

9 J.D. Walsh, et al. "Appendix 3: Climate Science Supplement." Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 2014. doi:10.7930/J0KS6PHH.

10 U.S. Global Change Research Program. "2014 National Climate Assessment." GlobalChange.gov http://nca2014.globalchange.gov.

11 U.S. Global Change Research Program. "2014 National Climate Assessment." GlobalChange.gov http://nca2014.globalchange.gov.

12 Kevin Duggan. "Recovering after rivers rage." The Coloradoan. http://www.coloradoan.com/story/news/local/2014/09/05/september-flood-anniversary-colorado/15151647.

13 UNEP and UN-HABITAT. "Ecosystems and Biodiversity The Role of Cities." Nairobi, 2005. http://www.unep.org/urban_environment/PDFs/Ecosystems_and_Biodiversity_Role_of_Cities.pdf.

amount of carbon dioxide that can be emitted in order to avert the most dangerous climate change impacts. The carbon budget was identified by the International Panel on Climate Change (IPCC), a scientific body established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). The carbon budget was established to reflect the amount of atmospheric carbon that would hold global temperature increases to 2 C (3.6 F) above pre-industrial temperatures, which was identified by the international community as the upper limit in order to avert the most dangerous climate change impacts.

Maintaining the carbon budget will require 40 percent to 70 percent reductions in GHG emissions by 2050 compared to 2010[14] and require cities, which account for more than half of global GHG emissions and two-thirds of energy production, to lead the way in mitigation efforts. Well-planned, resource-efficient cities can reduce GHG emissions through simple improvements, such as proper insulation and energy efficient technologies. Cities are uniquely positioned to facilitate policy changes and bottom-up initiatives, leading to immediate results.

ADAPTATION

Adaptation means preparing for new conditions, reducing vulnerabilities, and leveraging changes to create new opportunities for growth and sustainability. Even if all GHG emission from human activity ceased, global temperatures are still expected to rise by 0.5 F over the next few decades.[15] In Colorado, moderate to aggressive efforts to mitigate CO_2 emissions would still lead to increased average annual temperatures of 2.5 F by 2025 and 4 F by 2050.[16]

The cumulative effect of the proposed strategies in the plan is projected to decrease Lakewood's emissions by 20 percent by 2025.

With the majority of the world's population living in cities, the impacts of extreme weather call for a proactive plan for responding to future climate variability in order to increase resilience. In order to fully understand these impacts, many local governments and agencies are conducting climate vulnerability assessments to identify their specific climate-related risks and vulnerabilities. These assessments can be used to inform policy decisions, infrastructure investments, and resource allocations based on anticipated climate change impacts.

Preparing for the impacts of changing global and local climate systems necessitates both a comprehensive and local strategy, as well as coordination between neighboring jurisdictions, all levels of government, and partners within the community. Action today will lead to a more resilient tomorrow.

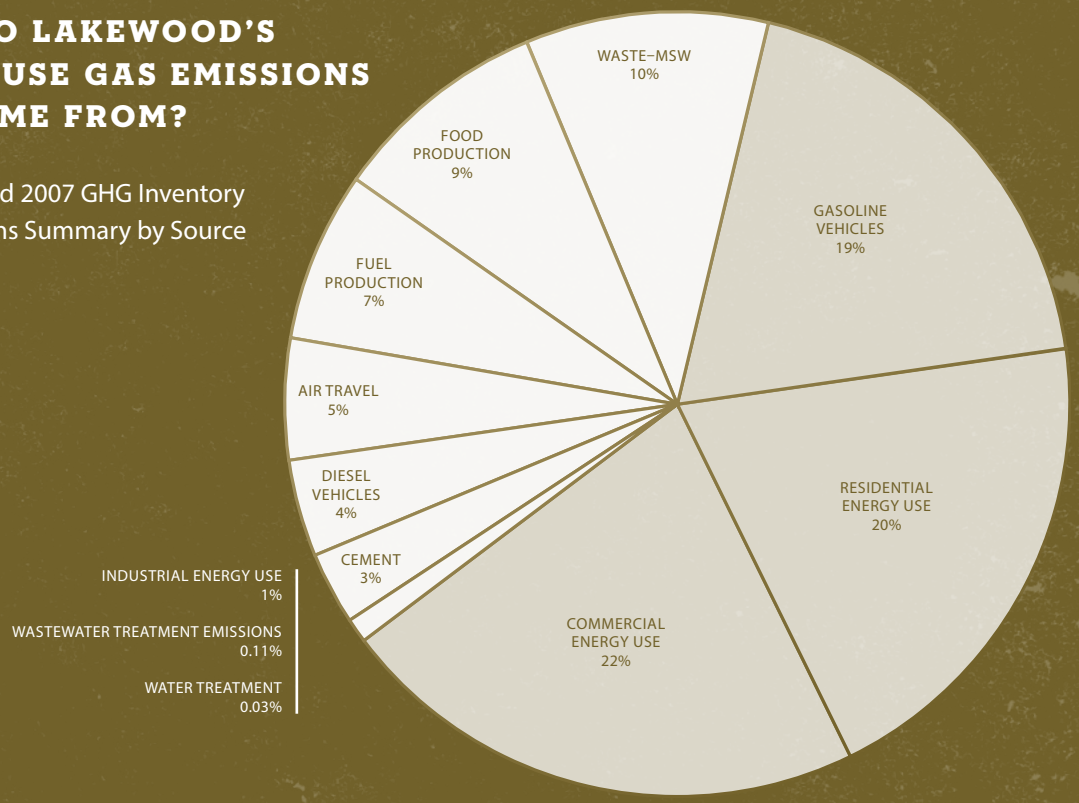
CITY OF LAKEWOOD

In Lakewood, drought, reduced snowpack, strained water supply, disaster recovery costs, and other impacts are already influencing municipal operations and household economies. These impacts will continue to challenge our community in years and decades to come. Our ability to adapt and ensure a resilient future will be largely determined by today's actions.

[14] IPCC. "Climate Change 2014 Synthesis Report." 2014. http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPMcorr1.pdf.
[15] U.S. Global Change Research Program. "2014 National Climate Assessment." GlobalChange.gov http://nca2014.globalchange.gov.
[16] Jeff Lukas, et. al. "Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation." Second Edition. University of Colorado, August 2014. http://cwcb.state.co.us/environment/climate-change/Pages/main.aspx.

WHERE DO LAKEWOOD'S GREENHOUSE GAS EMISSIONS (GHG) COME FROM?

City of Lakewood 2007 GHG Inventory Report: Emissions Summary by Source



In 2007, the City of Lakewood completed a greenhouse gas inventory, which measured our communitywide annual GHG emissions. The inventory reported GHG emissions totaling 2,646,593 metric tons of CO_2 equivalent ($MtCO_2e$). The results are broken down by sector and source, allowing us to measure and track change over time. Residential and commercial energy use are the largest contributors, accounting for 44 percent of total emissions, compared with a national average of 38 percent. Vehicle gasoline use and waste management processes follow behind, contributing 19 percent and 10 percent, respectively. Understanding where our GHG emissions come from and what might be driving their growth is critical in order to mitigate our contribution to global GHG emissions.

This Sustainability Plan uses this GHG data as a baseline from which to measure future emission reductions. The strategies included in this plan aim to reduce the community's overall greenhouse gas emissions and achieve its sustainability goals.

Recommendations from leading organizations urge cities to reduce GHG emission by 80 percent by 2050 through comprehensive strategies, as proposed in the STAR Community Rating System. STAR provides a sustainable community framework, developed by technical experts, sustainability leaders, and local government officials across the country in order to move communities toward sustainable practices, programs, and policies.[17] Tacoma, Washington, a similarly sized city, aims to reduce GHG emissions by 40 percent below 1990 levels by 2020. Evanston, Illinois, a first-ring suburb like Lakewood, set a target of 17 percent below 2007 levels by 2020. Our neighbor, the City and County of Denver, set a 20 percent reduction goal below 1990 levels by 2020. For additional examples see Appendix B: Target Methodology.

The cumulative effect of the proposed strategies in the plan is projected to decrease Lakewood's communitywide emissions by 20 percent by 2025. ■

[17] STAR Communities. http://www.starcommunities.org.

GOAL **CCA1**

MINIMIZE LAKEWOOD'S COMMUNITYWIDE GREENHOUSE GAS EMISSIONS AND PREPARE AND ADAPT TO ONGOING CLIMATE CHANGE IMPACTS.

TARGETS

- Reduce communitywide greenhouse gas emissions by 20 percent below 2007 levels by 2025.
- Reduce communitywide greenhouse gas emissions by 50 percent below 2007 levels by 2050.
- Reduce municipal greenhouse gas emissions annually through 2025.

OBJECTIVES

- **OBJECTIVE:** Contribute to national and global efforts to reduce and report greenhouse gas emissions.
- **OBJECTIVE:** Implement City of Lakewood Sustainability Plan strategies in order to achieve greenhouse gas emission reduction targets.
- **OBJECTIVE:** Ensure long-term community resilience by preparing for future impacts of climate change.

IMPLEMENTATION STRATEGIES

CCA1-A GREENHOUSE GAS DATA COLLECTION, TRACKING, AND REPORTING

Regularly monitor Lakewood's greenhouse gas emissions. Specifically:

- Regularly update the "City of Lakewood Greenhouse Emissions Inventory";
- Conduct and regularly update a municipal operations greenhouse gas inventory;
- Identify appropriate national or international emission tracking entities and regularly report data; and
- Develop tools and standards for tracking Lakewood emissions.

CCA1-B GREENHOUSE GAS REDUCTION STRATEGIES

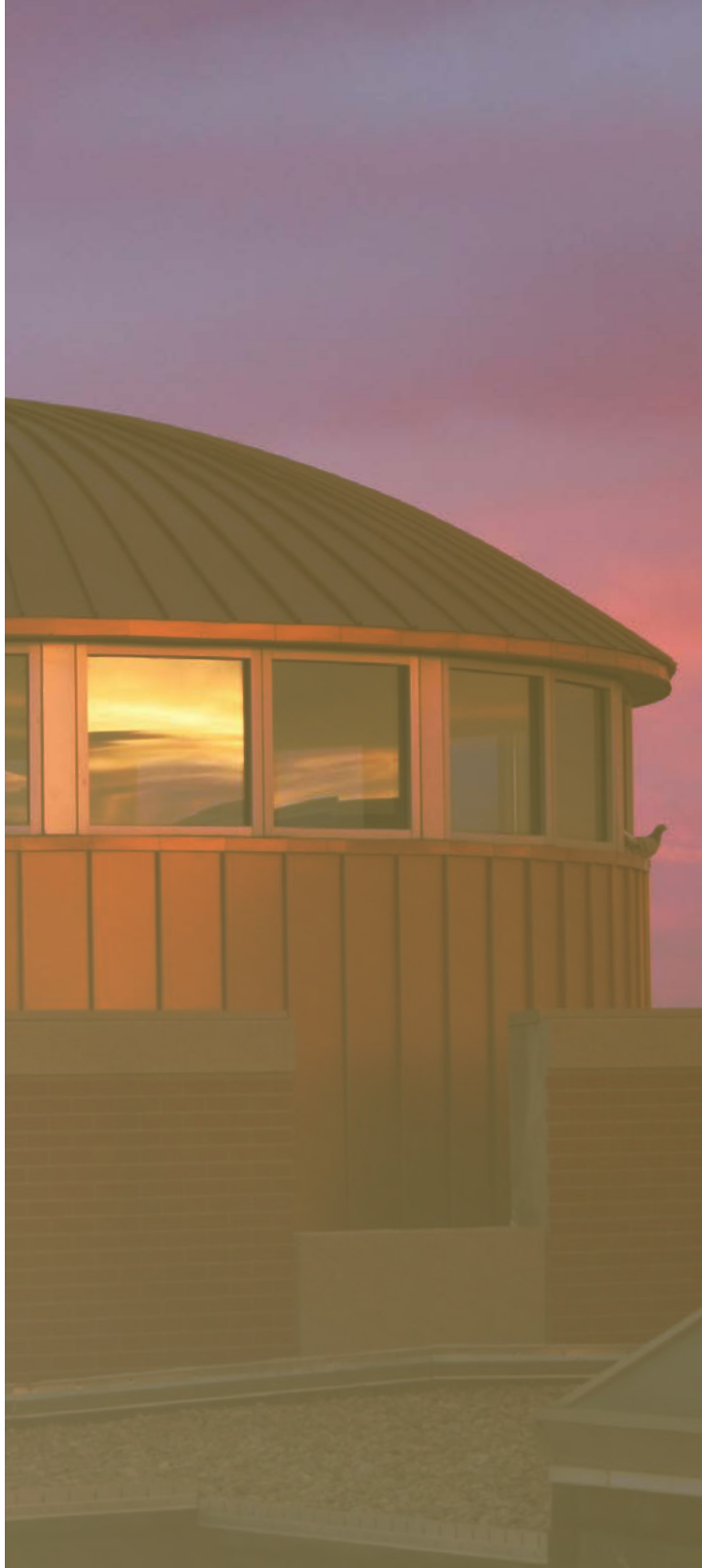
Utilize emission reduction assessments to prioritize and implement greenhouse gas reduction strategies. Specifically:

- Use emission reduction assessments contained in the Sustainability Plan to inform implementation efforts; and
- Consider impacts of all future City actions on emission reduction goals.

CCA1-C CLIMATE CHANGE VULNERABILITY STUDY

Conduct a climate change vulnerability assessment, recognizing that future conditions and threats will be different from current or historical conditions. Specifically:

- Identify potential changes to Lakewood's climate including potential future climate scenarios;
- Identify vulnerabilities and potential impacts of each scenario on Lakewood's infrastructure, natural resources, ecosystems, public safety, economic well-being, population, and overall resiliency.



CONCEPT

SOCIAL COST OF CARBON: $38/TON

THE SOCIAL COST OF CARBON (SCC) is a monetary estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions and can be used to determine the benefit of policies that reduce carbon emissions. The SCC considers the costs to society of a range of climate impacts like agricultural productivity, human health, property, and infrastructure damage from extreme weather events and sea level rise, diminished biodiversity, and loss of ecosystem services. The Social Cost of Carbon is reported in dollars per metric ton of carbon dioxide.

The most recent SCC estimates were calculated in 2013 by a federal interagency working group consisting of representatives from 12 federal agencies. To determine the SCC, the working group used three assessment models that each assume different climate change processes, economic growth scenarios, and variations in the interactions between the economy and climate impacts.

Using the average results of all three of the assessments, the SCC for 2015 is $38 per metric ton of CO_2. The working group also published an additional value that is intended to represent the potential for higher-than-average damages. Rather than using the average of all three assessment models, this number represents the most severe outputs (95th percentile) of the assessment models. This number places the SCC at $109 per metric ton of CO_2.

The City of Lakewood Sustainability Plan sets a target of reducing greenhouse gas emissions by 20 percent by 2025. Based on the SCC estimates, if the city met its reduction target, it would save $26.5 million in the year 2025 alone. ■

LEARN MORE ABOUT THE SOCIAL COST OF CARBON:

www.epa.gov/climatechange/EPAactivities/economics/scc.html
www.epa.gov/climatechange/Downloads/EPAactivities/scc-fact-sheet.pdf
www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

CCA1-D CLIMATE PREPAREDNESS PLAN

Based on the climate change vulnerability study, develop a climate preparedness plan to prepare for multiple climate futures. Specifically:

- Expand existing emergency preparedness plans to encompass the full range of climate-related risks that could lead to emergencies;
- Upgrade existing infrastructure and update standards to minimize vulnerability;
- Develop economic, social, and natural resource management policies that address vulnerabilities and potential impacts;
- Incorporate climate change preparedness into all municipal operations, programs, planning efforts, and policies;
- Monitor impacts of climate change and effectiveness of adaptation strategies in order to adapt strategies and plans as necessary.