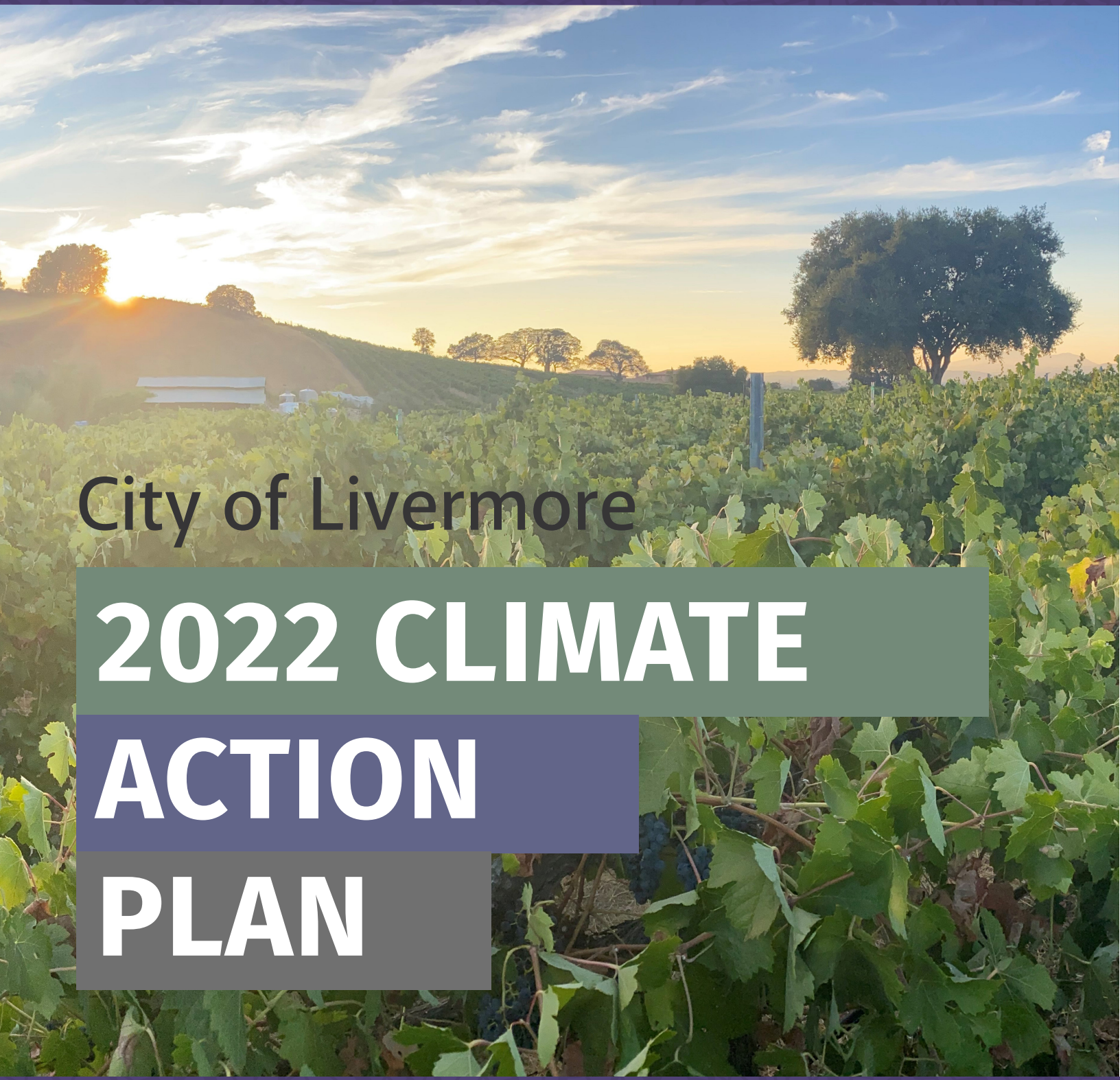
LIVERMORE
CALIFORNIA



City of Livermore

2022 CLIMATE ACTION PLAN

Adopted
November 28, 2022

THERE'S

HERE

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Trish Munro, Council Member

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Quest

Livermore Farmers Market

Letter From The Climate Change Subcommittee

It has been a pleasure working with City of Livermore staff to create this Climate Action Plan (CAP) for you, residents of Livermore.

Climate change poses an existential threat globally, and is already presenting a number of serious risks to Livermore and the Tri-Valley. It is incumbent on all of us to play our part to reduce our carbon footprint and to adapt to near-term and localized risks such as extreme heat events here in Livermore. We hope you find this CAP informative and useful.

The plan summarizes the current state in Livermore and what we are trying to achieve in the future to make Livermore resilient. It articulates what the City is doing, what you can do as an individual, family or business, and what we can do together.

Please take the time to identify how you can participate at this critical time for our community and planet earth. We can all work together to make a difference.

If you have questions or feedback please do not hesitate to contact either one of us. We look forward to hearing from you.

Gina Bonanno (left) and Bob Carling (Right)

Vice Mayor
Gina Bonanno

Council Member
Bob Carling

Acronyms and Abbreviations

Term	Definition
AB	Assembly Bill
Caltrans	California Department of Transportation
CAP	Climate Action Plan
CARB	California Air Resources Board
CDC	Centers for Disease Control and Prevention
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COVID-19	Coronavirus disease 2019
EO	Executive Order
EV	Electric Vehicle
GHG	Greenhouse Gas
GWP	Global Warming Potential
ICLEI	International Council for Local Environmental Initiatives
IPCC	United Nations Intergovernmental Panel on Climate Change
kW	Kilowatt
kWh	Kilowatt hour
MT	Metric ton
MT CO_2e	Metric ons of carbon dioxide equivalent
NASA	National Aeronautics and Space Administration
N_2O	Nitrous oxide
PV	Photovoltaic
RPS	Renewable Portfolio Standard
SB	Senate Bill
U.S. EPA	United States Environmental Protection Agency
VMT	Vehicle Miles Traveled
ZEV	Zero Emission Vehicle

EXECUTIVE SUMMARY

Quest Science Center's Science @ Stockmen's Park event. Photo Credit: Mike Carter

CLIMATE ACTION PLAN GOALS

1 Prepare the community for climate impacts.

The Climate Action Plan outlines actions to build communitywide resilience to climate impacts in Livermore, including drought, extreme heat, and flooding. Preparing for expected climate impacts is known as adaptation.

2 Establish a pathway to carbon neutrality by 2045.

The Climate Action Plan includes updated actions that build off of existing GHG reduction efforts in Livermore. Implementing these actions will set Livermore on a path to carbon neutrality by 2045. Reducing GHG emissions within the community is known as mitigation.

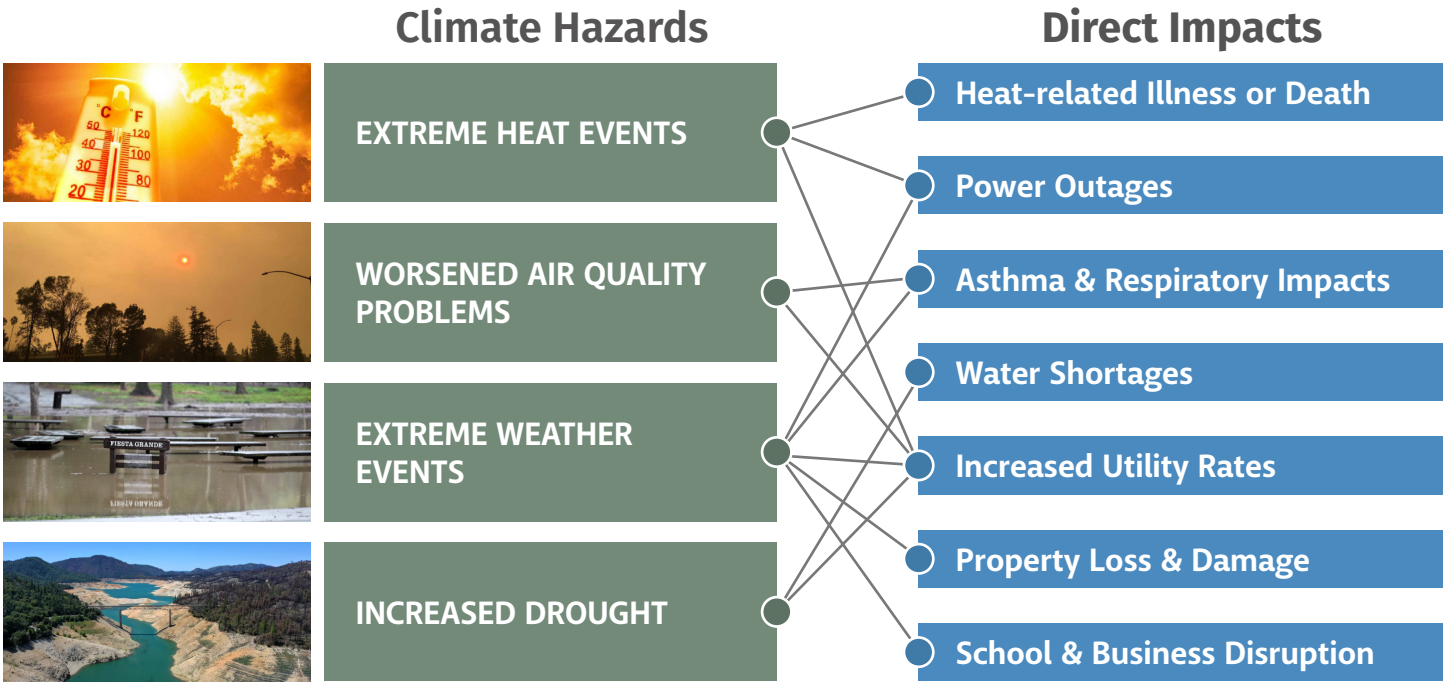
3 Establish the City as a climate leader

The Climate Action Plan outlines specific actions the City will take to address climate change in its own operations. The City will set an example for other cities to follow.

Purpose Statement

The purpose of the 2022 Climate Action Plan (CAP) is to protect public health and the environment, foster a green economy, and improve the quality of life for all Livermore residents. The 2022 CAP is a roadmap to reduce greenhouse gas (GHG) emissions, adapt to extreme weather, deploy reliable and renewable energy, conserve habitat and biodiversity, and ensure equitable access to the benefits of a sustainable city. Livermore will leverage the community's greatest strengths, including cutting edge research facilities, technical and agricultural expertise, and an engaged network of residents, businesses, and institutions, to establish itself as a climate leader and implement the actions outlined in the plan.

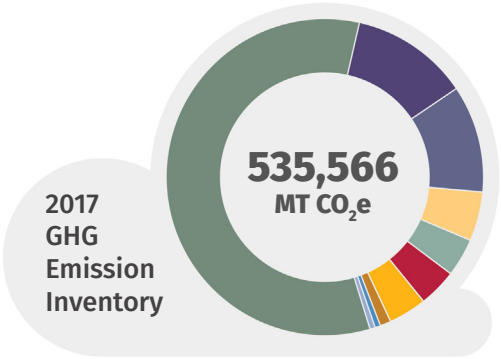
CLIMATE IMPACTS IN LIVERMORE



LIVERMORE'S GHG EMISSIONS

The City completed a community-wide GHG inventory to measure emissions from various sources within Livermore. The GHG inventory helped the City identify strategies to reduce its emissions and will help the City monitor progress reducing GHG emissions and achieving reduction goals.

Livermore's GHG inventory includes emissions from residential and commercial energy use in buildings, on-road passenger and commercial transportation, off-road transportation, landfilled waste, water, and wastewater. The majority of Livermore's emissions come from transportation and building energy.



59%	On-Road Transportation
12%	Residential Gas
11%	Nonresidential Gas
5%	Nonresidential Electricity
4%	Off-Road Transportation*
4%	Waste
4%	Residential Electricity
1%	Direct Access Electricity**
<1%	Water
<1%	Wastewater

* *Offroad includes mobile emissions from construction, recreation, agriculture, lawn and garden, and others.*

** *Direct Access Electricity - Electricity purchased directly by an organization/facility from the wholesale market.*

GHG REDUCTION TARGETS

The City established a goal to reach carbon neutrality by 2045, consistent with State legislation.

2017	2030	2045
5.92 MT CO_2e per person	**3.09 MT CO_2e per Person**	**0 MT CO_2e per Person**

California Climate Legislation

Assembly Bill 32 (2006)
Set a statewide goal to reduce GHG emissions to 1990 levels by 2020.

Senate Bill 32 (2006)
Set a statewide goal to reduce GHG emissions 40 percent below 1990 levels by 2030, extending upon the 2020 goal established by AB 32.

Executive Order B-55-18 (2018)
Set a statewide goal to achieve carbon neutrality by 2045 and maintain net negative emissions afterwards.

LIVERMORE'S CAP STRATEGIES AND OBJECTIVES

	STRATEGY	2030 OBJECTIVES
ADAPTATION	**Extreme Heat**	• Increase resilience to extreme heat events • Cool neighborhoods by expanding the urban canopy • Identify vulnerable areas and populations • Develop cooling centers that are energy-resilient
	Wildfire	• Mitigate wildfire risk • Facilitate building retrofits and operate clean air centers • Stockpile personal protective equipment • Reduce fire risk through fire-safe landscaping standards • Improve emergency alert systems
	Flooding	• Improve stormwater management • Harness Livermore's natural landscapes to improve stormwater management • Reduce the expansion of urban hardscapes
MITIGATION & ADAPTATION	**Drought**	• Improve water conservation • Develop on-site water and water reuse standards • Provide-water efficiency devices • Develop water-efficient demonstration programs
	Energy Resilience	• Enhance community energy resilience • Expand microgrid deployment • Increase local and regional grid reliability • Improve building resiliency
	Buildings and Energy *↓19,379 MT CO_2e*	• Provide 100% renewable electricity by 2024 • Require all-electric new construction by 2023 • Incentivize electric retrofits in 12% of existing buildings • Develop equitable funding and financing • Incentivize local on-site energy generation
	Carbon Sequestration *↓1,950 MT CO_2e*	• Plant 1,000 trees by 2030 • Update City landscaping standards to expand shade trees • Provide free or reduced cost-trees to residents • Preserve open space • Implement carbon farming projects • Explore technology-based carbon capture and storage
MITIGATION	**Transportation and Land Use** *↓49,494 MT CO_2e*	• Add 1,283 publicly available chargers • Reduce VMT by 2% • Achieve a 10% bike mode share • Support sustainable land use practices
	Waste and Materials *↓19,379 MT CO_2e*	• Reduce the amount of organic waste that is landfilled by 75% • Maintain or exceed 75% waste diversion each year • Improve local re-use and repair programs • Expand the use of low-carbon and recycled building materials

EVALUATING THE ACTIONS

The City evaluated the costs, benefits, and readiness of each strategy and action. Additionally, the City assessed the GHG reductions associated with mitigation actions.

Benefits

Resilience + GHG Reduction
Achieving adaptation and mitigation goals concurrently. For example, a building that installs rooftop solar with battery backup can reduce emissions and protect against grid power outages.

Community Connectivity
Promoting a strong sense of community by facilitating complete neighborhoods that are accessible by multiple modes of travel, connecting residents to each other and the City, and connecting historically underserved communities to resources.

Public Health
Creating a cleaner and healthier community by improving air quality and active transportation and protecting against extreme heat and weather events.

Environmental Quality
Improving natural environments within the city to enhance and protect biodiversity and ecosystem services like cleaner air and water.

Green Economy
Diversifying local economic opportunities by attracting high-quality jobs in sustainability industries, such as those developing renewable energy and battery storage technologies.

Readiness

Short-Term
Actions that are ready to be implemented today.

Mid-Term
Actions that require additional study, funding, or partnerships to be completed before implementation.

Long-Term
Actions that require long lead times to fully implement.

Ongoing
Efforts that are currently underway and ongoing.

Costs

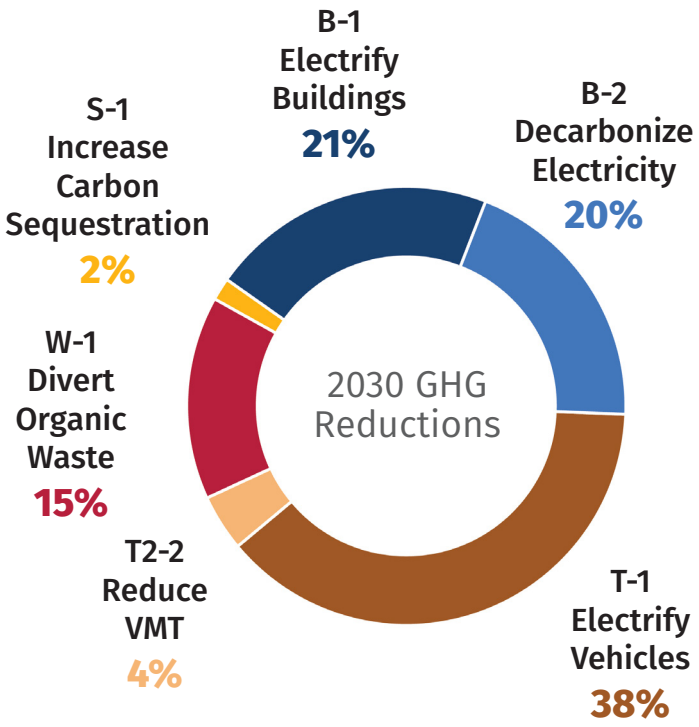
No-Cost
Actions that are expected to have zero costs to the community or City.

Low-Cost
Relatively low upfront costs or City staff time, (e.g., policy ordinances or outreach).

Moderate-Cost
Intermediate level of costs such as consultant work or moderate infrastructure changes, (e.g., feasibility studies, program development, and retrofitting existing infrastructure).

High-Cost
Longer term projects requiring substantial investments into major infrastructure or technology over time, (e.g., energy storage, bike lanes, or other infrastructure changes).

GHG Reductions by Source



IMPLEMENTING THE PLAN

The CAP includes an implementation plan to ensure that the City stays on track to meet its goals. The City identified the following priority efforts for the first five years of CAP implementation. Additionally, the City will monitor its progress and regularly update the CAP to adjust its strategy as needed.

1. **Lay the groundwork**
   Hire a Climate Action Manager, create a brand and identity for the City's climate action program, establish a tracking program for CAP implementation, and create an online resource hub for the community.
2. **Decarbonize electricity & materials**
   Enroll community-wide electricity accounts into East Bay Community Energy's Renewable 100 service option, promote low-carbon building materials.
3. **Electrify buildings & vehicles**
   Require new buildings in Livermore to be all-electric, incentivize electrification retrofits in existing buildings, expand requirements for EV charging.
4. **Partner with the national labs**
   Collaborate with Lawrence Livermore and Sandia National Labs on projects related to microgrids, soil carbon farming, and hydrogen fuel.
5. **Engage with the community regularly**
   Engage regularly with the community through a variety of channels and events.
6. **Support related City efforts**
   Identify synergies with other City plans and efforts, including the General Plan, Tri-Valley Local Hazard Mitigation Plan, and Active Transportation Plan.
7. **Utilize assistance programs & funding**
   Maximize resources to implement the CAP by utilizing funding and technical assistance programs from partners such as East Bay Community Energy and StopWaste.
8. **Study heat & drought strategies**
   Conduct additional studies to identify opportunities to mitigate heat, conserve water resources, and expand the urban forest.
9. **Develop a neighborhood retrofit program.**
   Develop a holistic retrofit program for healthy and resilient building upgrades. Upgrades could include weatherization, air filtration, solar and battery backup systems, and drought tolerant landscaping.

It Takes a Village!

Addressing climate change will require more than just action from the City of Livermore itself. Individuals, businesses, and community groups all have a critical role to play in achieving the City's climate action goals. The quality of life in Livermore for future generations depends on the actions we take today. The City of Livermore looks forward to building a healthier and more resilient Livermore together.

Staying on Track

- Implementation Tracking Tool
- Annual Progress Reports to City Council
- 5-year Plan Updates

You can help create a healthy and resilient Livermore!

VISIT:

LivermoreResilientHub.com

CHAPTER 1.
Introduction

Photo credit: Glen Florey

1-1. Climate Action Plan Overview

The City of Livermore (City) adopted its first Climate Action Plan (CAP) in 2012, which established a greenhouse gas (GHG) emissions reduction goal of reducing emissions by 15% by 2020. The City exceeded the 2020 GHG reduction goal identified in the 2012 CAP by achieving a 17 percent reduction three years early in 2017. The reductions achieved through implementation of the CAP reflect local actions, behavior change, and state initiatives.

This updated CAP establishes new GHG reduction goals consistent with new State legislation. Reducing GHG emissions is known as **climate mitigation**. In addition, the CAP includes strategies and actions to prepare Livermore for the impacts of climate change, which have become increasingly apparent. Preparing for climate impacts is known as **climate adaptation** and is a primary focus of Livermore's overall climate strategy.

2022 CLIMATE ACTION PLAN PURPOSE STATEMENT

The purpose of the 2022 Climate Action Plan (CAP) is to protect public health and the environment, foster a green economy, and improve quality of life for all Livermore residents. The 2022 CAP is a roadmap to reduce greenhouse gas (GHG) emissions, adapt to extreme weather, deploy reliable and renewable energy, conserve habitat and biodiversity, and ensure equitable access to the benefits of a sustainable city. Livermore will leverage the community's greatest strengths, including cutting edge research facilities, technical and agricultural expertise, and an engaged network of residents, businesses, and institutions, to establish itself as a climate leader and implement the actions outlined in the plan.

1-2. Climate Change

The mechanisms that drive climate change have been well understood since the middle of the nineteenth century.[1] The greenhouse effect is the natural process by which gases in the atmosphere trap heat, acting as a blanket and making the temperature habitable for life on earth, shown below in Figure 1-1.

However, since the beginning of the industrial revolution in the eighteenth century, human activities like burning fossil fuels and deforestation have caused large amounts of additional GHGs to be released into the atmosphere.

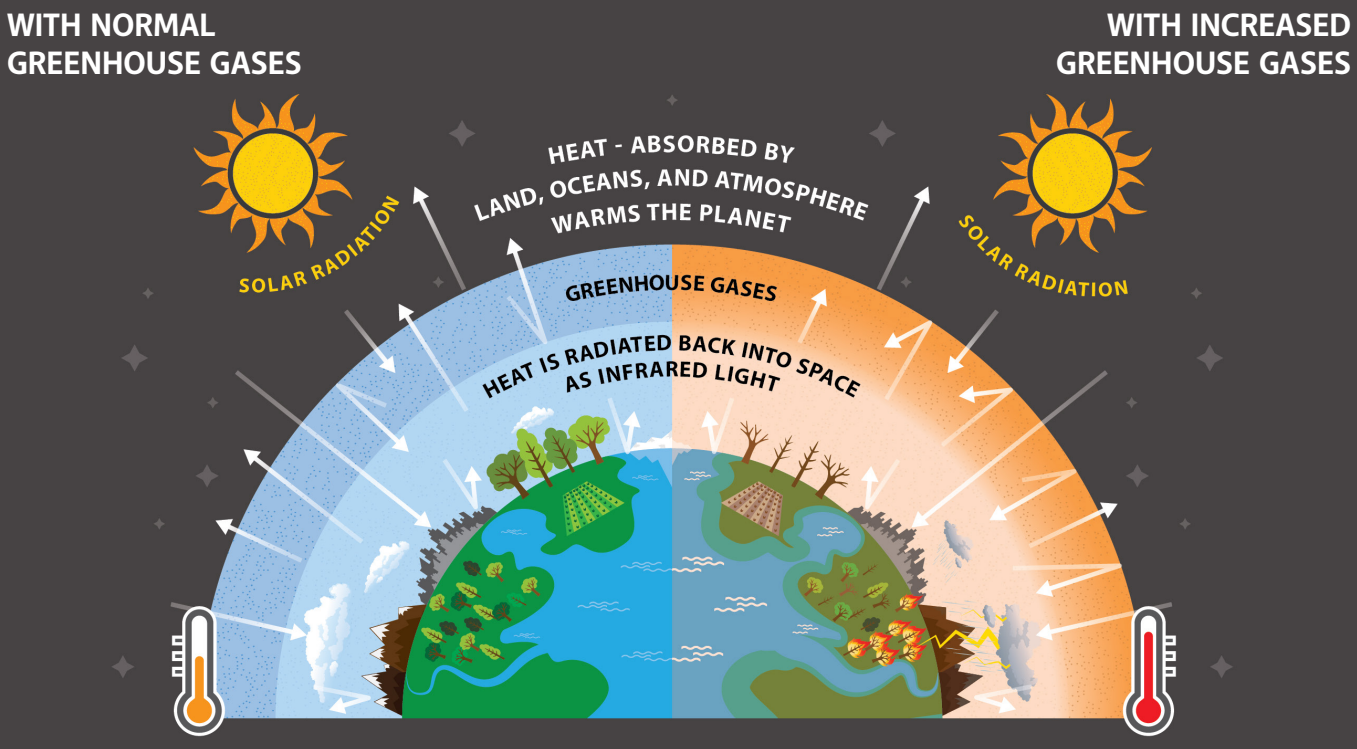
Specifically, atmospheric carbon has increased from a historical range of 200–280 parts per million to over 400 parts per million during the past century. This represents an atmospheric carbon content which is higher than at any point over the past 800,000 years.[2] These additional GHGs cause more heat to be trapped in the atmosphere, and as a result, global temperatures have been rising. Anthropogenic (human-caused) climate change has been the scientific consensus for several decades, with over 97 percent of climate scientists agreeing that the planet is warming due to human activities.[3]

1. *https://climate.nasa.gov/evidence/*
2. Lindsey, Rebecca. September 19, 2019. Climate Change: Atmospheric Carbon Dioxide. *https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide*
3 *https://www.ipcc.ch/report/ar2/wg1/*

Figure 1-1. Greenhouse Gas Effect

In the last century, human activities such as burning fossil fuels and deforestation have caused a jump in the concentration of greenhouse gases in the atmosphere.

THE RESULT: Extra trapped heat and higher global temperatures.



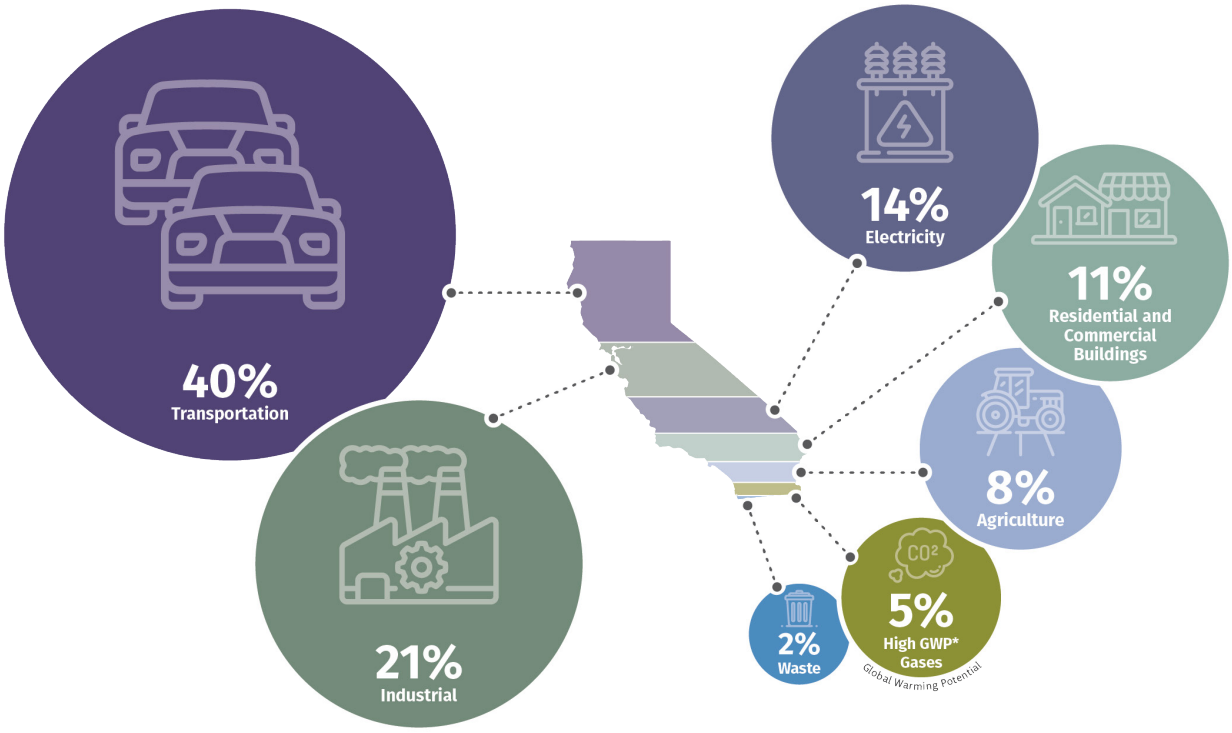
SOURCES OF GHGs

GHGs listed by the United Nations Intergovernmental Panel on Climate Change (IPCC) include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), as well as chloro-fluorocarbons, hydrochlorofluorocarbons, hydro-fluorocarbons, perfluorocarbons, and sulfur hexa-fluoride, which are collectively called fluorinated gases. Fluorinated gases are man-made gases that can stay in the atmosphere for centuries and contribute to the GHG effect. Ninety-seven percent of the annual GHG emissions generated in the United States consists of CO_2, CH_4, and N_2O, while fluorinated gases result in the remaining three percent of emissions.

Each GHG has a differing ability to trap terrestrial radiation, called its global warming potential (GWP).[4] Because of its dominance in terms of total emissions, CO_2 is used as the reference GWP and given a value of 1. CH4 causes 28 times more warming per unit mass than CO_2, so it has a GWP of 28. N2O has a GWP of 265. Fluorinated gases also serve as GHGs and have even larger GWPs, but their occurrence is so small that their impact is negligible. Due to its large rate of emissions, CO_2 is the most important GHG despite its relatively weak GWP.

Anthropogenic GHG emissions stem primarily from the burning of fossil fuels (including gasoline, natural gas, and coal), decomposition of organic waste in landfills, methane emissions from agriculture, and deforestation. California's GHG emission by source are summarized in Figure 1-2.

Figure 1-2. GHG Emission Sources in California



4. *https://www.ipcc.ch/assessment-report/ar5/*

EFFECTS OF CLIMATE CHANGE

Climate change is a global phenomenon that is already linked to a number of changes that will have a dramatic impact on humans, wildlife, and ecosystems. Scientists have measured shrinking ice sheets, warming oceans, increasing global temperatures, less snow cover, higher precipitation variability, sea level rise, and species extinction.[5] As the planet continues to warm, effects like flooding in low-lying areas, drinking water shortages, severe weather, wildfires, and adverse impacts to public health and ecosystems will become more severe.

Globally, a warming trend is exceedingly clear, with all the top seven hottest years on record happening since 2014. The 10 hottest years on record have all occurred since 1998.[6] According to the IPCC, the total increase in global temperature should be limited to below 1.5° Celsius (C) in order to prevent "rapid, far-reaching and unprecedented changes in all aspects of society."[7] If current global trends persist and GHG emissions are not significantly reduced, the World Resources Institute (WRI) projects that the most likely warming scenario is an increase in global temperature by 3.7 °C. This level of warming would produce significant changes by the 2080s.[8]

Reduced water availability for about 32 percent more of the projected global population compared to the 1980s

Approximately seven times more people expected to be exposed annually to a 100-year flood event compared to the 1980s

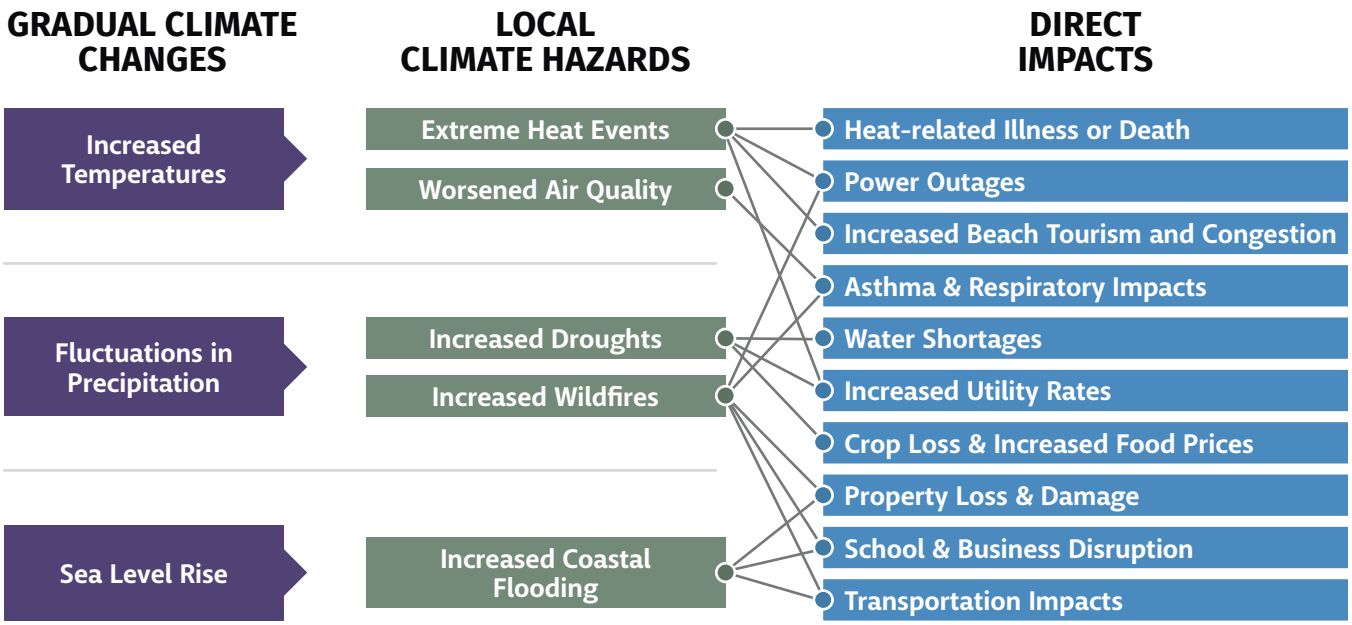
More than a 50 percent decrease in the ranges of the many plant and animal species around the world

Large-scale negative impacts to agricultural production and global food security

5. *https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf*
6. *https://www.scientificamerican.com/article/2020-will-rival-2016-for-hottest-year-on-record/*
7. *https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-specialreport-on-global-warming-of-1-5c-approved-by-governments/*
8. *https://www.wri.org/ipcc-infographics-emissions*

In California, the impacts of climate change are already being felt and will continue to become more severe throughout the twenty-first century. Higher temperatures, more extreme heat events and wildfires, and rising sea levels are all effects of climate change experienced in California. The California Office of Environmental Health Hazard Assessment reported in 2018 that despite annual variations in weather patterns, California has seen a trend of increased average temperatures, more extreme heat days, higher acidity in the Pacific Ocean, earlier snowmelt, and less rainwater runoff.[9] From 1895 to 2011, average temperatures have increased by about 1 °C statewide, and a smaller proportion of annual precipitation is falling as snow instead of rain. During 1972-2018, California experienced a fivefold increase in the annual area burned, very likely due to increased atmospheric temperatures caused by climate change.[10] Over the last century sea levels have risen by more than 5.9 inches along Central and Southern California coast, which has accelerated coastal erosion, disrupted wetlands and natural habitats, and threatened levee systems and other coastal infrastructure.[11] Many of these hazards caused by climate change could have direct effects on Livermore and other communities throughout California, including water shortages, power outages, and property damage. An overview of climate hazards and their impacts is shown below in Figure 1-3 and a detailed vulnerability assessment for the City of Livermore is summarized in Chapter 2 and included in detail in Appendix B.

Figure 1-3. Climate Hazards and Impacts in California



9. *https://oehha.ca.gov/media/downloads/climate-change/report/2018indicatorssummary.pdf*
10. *https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019EF001210*
11. *https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf*

1-3. Legislative Context

CLIMATE LEGISLATION IN CALIFORNIA

California is recognized globally as a leader on climate change, having established a variety of ambitious GHG-reduction targets and associated strategies. The primary legislation that has driven statewide GHG-emissions reductions are Assembly Bill (AB) 32, Senate Bill (SB) 32, and most recently, Executive Order (EO) B-55-18. Aligning with State targets is one of the requirements of the California Environmental Quality Act (CEQA) Guidelines for streamlining. Livermore's CAP meets the requirements of a CEQA Qualified CAP and can be used to streamline new development which is consistent with the CAP's measures and actions. More information on the CEQA requirements can be found in Appendix D.

AB 32 – Global Warming Solutions Act (2006)

AB 32 set a statewide goal for reducing GHG emissions to 1990 levels by 2020 and required the California Air Resources Board (CARB) to prepare a Scoping Plan to outline the main strategies California would take to achieve this goal. The first Scoping Plan was adopted in 2008.[12]

SB 32 (2016)

SB 32 set a new statewide goal for reducing GHG emissions 40 percent below 1990 levels by 2030, extending upon the 2020 goal already established by the Global Warming Solutions Act. In 2017, CARB adopted an update to the Scoping Plan which provided a framework for achieving the 2030 target.

A qualified CAP allows Livermore to streamline new developments that meet our climate goals, decreasing costs and effectively incentivizing climate smart development.

EO B-55-18 (2018)

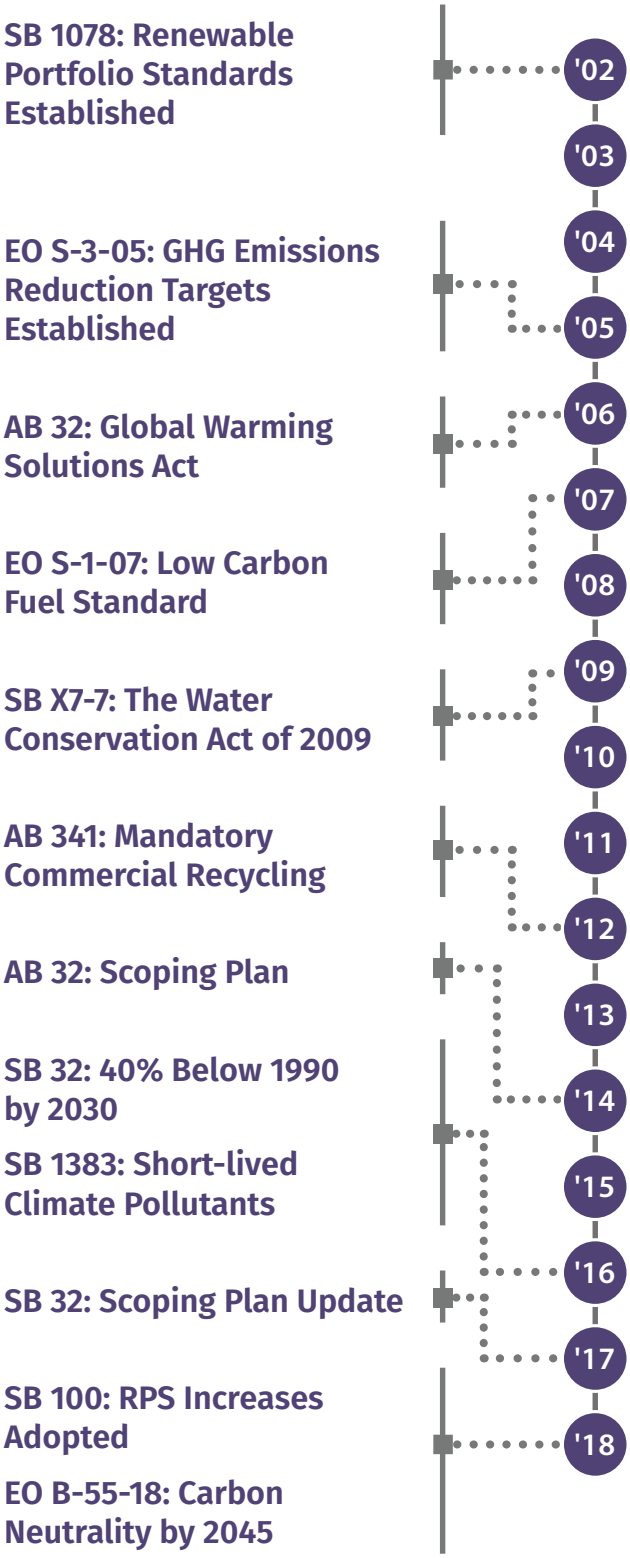
Governor Jerry Brown's Executive Order (EO) B-55-18 (2018) set a new statewide GHG-emission reduction goal to achieve carbon neutrality by 2045 and maintain net negative emissions afterwards. While not yet codified into law, it is generally seen as superseding the previous statewide goal of reducing GHG emissions 80 percent from 1990 levels by 2050.

Other Key Legislation

California's GHG-emissions-reduction strategies that will help achieve these reduction targets are developed through its Scoping Plan and various Sustainable Communities Strategies passed by local Metropolitan Planning Organizations. Other important climate legislation that will help California achieve its GHG-reduction targets include the state's green building code (Title 24), SB 1383, which set targets for reducing organic waste to landfills, and SB 100, which mandated 100 percent carbon-free electricity by 2045. A timeline of major California climate legislation is shown in Figure 1-4. For a complete list of California's climate change regulations please see Appendix E.

12. Both the State of California and the City of Livermore exceeded this goal as of 2017.

Figure 1-4. California Climate Legislation Timeline



1-4. Livermore's Past Climate Action Success

Solar array on the City of Livermore Civic Center Campus.

The City of Livermore (City) is no stranger to taking bold, progressive action on climate change. The City adopted a Climate Change Element into its General Plan in 2009 that established policies for addressing climate change in Livermore. The Climate Change Element called for the City to adopt a CAP to set forth strategies to reduce GHG emissions. The City adopted its first CAP in 2012, which established a target to reduce emissions 15 percent below 2008 levels by 2020. This target was in accordance Assembly Bill (AB) 32. The City conducted a 2017 GHG emissions inventory that revealed Livermore had surpassed the 2020 target by 2017, three years ahead of schedule. More details about the 2017 inventory and the City's emissions reductions are included in Chapter 2.

Since adopting the CAP, the City has adopted additional plans that help implement key components of its overarching sustainability strategy, including an Active Transportation Plan, Green Infrastructure Plan, and Tri-Valley Local Hazard Mitigation Plan. The most relevant plans referenced in the CAP Update are highlighted below in more detail.

Livermore was a founding member of East Bay Community Energy, a Community Choice Energy service which has provided the city with clean electricity options for both residents and businesses since 2018.[13] In 2017, Livermore was awarded the Gold Level Spotlight Award for Sustainability Best Practices by the Institute of Local Governments, as a part of the Beacon Program.[14] Livermore has also been recognized by the Arbor Day Association, which awarded Livermore the Sterling City USA designation in 2018 for achievements in urban forestry education, partnerships, tree planting, and maintenance.

There are currently 96 electric vehicle chargers available to the public in Livermore, and the City has over a dozen electric and hybrid vehicles as a part of its public fleet.[15] Livermore also holds annual electronic waste recycling events, reuses damaged asphalt, and purchases recycled materials for City operations.[16] In 2011, Livermore banned the use of Styrofoam to-go containers for food service businesses, reducing

13. *https://ebce.org/about/*
14. *https://www.ca-ilg.org/award/city-livermore-sustainability-best-practice-activities-0*
15. *https://www.plugshare.com/directory/us/california/livermore*
16. *https://www.livermoreca.gov/departments/community-development/planning/climate-action-plan*

litter and water pollution.[17] The City also utilizes a recycled water system for irrigation, fire protection, and other uses to conserve water.

Since adopting the first CAP, Livermore, like many communities in California, has increasingly felt the impacts of climate change. In recent years wildfires have become more severe, degrading air quality and impacting residents with smoke that can last weeks, such as during the SCU Lightning Complex Fire in 2020. The extended drought of the 2010s was one of the most intense in California's history, straining water supplies and putting the local agriculture and wine industry at risk. Extreme heat events have become more common, worsening public health risks for vulnerable communities and those with existing health conditions. These climate impacts have only reinforced the City of Livermore's commitment to taking meaningful climate action, in order to ensure a prosperous and livable climate for future generations. The City's past efforts provide the foundation for Livermore's CAP Update and will be key to its successful implementation.

Click on the plan name or image below to view the document.

General Plan Climate Change Element
2009

Climate Action Plan
2012

Tri-Valley Local Hazard Mitigation Plan
2018

Bicycle, Pedestrian, & Trails Active Transportation Plan
2018

Stormwater Green Infrastructure Plan 2019

Urban Water Management Plan
2020

Storm Drain Master Plan
2022

FACT: Livermore reached their 2020 GHG reduction goal in 2017, exceeding the goals set by the 2012 Climate Action Plan.

17. *https://www.livermoreca.gov/departments/public-works/environmental-services.*

1-5. CAP Goals and Development Process

Quest Science Center's Science @ Stockmen's Park event. Photo credit: Mike Carter

The Climate Action Plan creates a roadmap to prepare the community for climate impacts and establish a pathway to carbon neutrality by 2045. Implementation and funding strategies are a key consideration of the plan to ensure that strategies are actionable and lead to meaningful improvements in resilience and reductions in GHG emissions. Additionally, implementation of the CAP will be based upon inclusivity, focusing on equity, youth involvement, and open dialogue with local leaders in vulnerable communities.

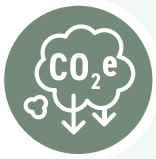
The CAP update leveraged several unique characteristics of the city including its active and engaged community, the technological prowess of Livermore's two National Laboratories, and its strong agricultural heritage. Additionally, Livermore's neighboring communities of Dublin and Pleasanton have both recently updated their own CAPs, setting GHG reduction and climate adaptation goals that are in-line with those of Livermore. This presents an opportunity to work together on regional implementation efforts, whether through the passage of unified codes, joint funding of regional infrastructure projects, or cooperative resilience planning. The risks posed by climate change do not occur in a vacuum and neither should climate mitigation or adaptation planning. Together, Livermore and other Tri-Valley communities can help create a better more sustainable East Bay. The Livermore CAP development process is shown in Figure 1-5.

Figure 1-5. Livermore CAP Update Development Process

1. Complete a Climate Change Vulnerability Analysis. The first step of the CAP Update was to identify the climate change impacts that are expected in Livermore and analyze how those changes would affect the community.

2. Complete a GHG Inventory and Forecast and Establish Reduction Targets. At the same time, the City quantified existing GHG emissions to create a baseline, used growth factors to estimate future emissions, and established targets for reducing GHG emissions that align with established state goals.

3. Conduct Community and Stakeholder Engagement. The City engaged with the community and stakeholders and incorporated feedback and input into the CAP. This engagement included a Climate Action Plan Advisory Committee made up of Livermore residents.



4. Establish a GHG Reduction and Adaptation Strategy. The CAP includes community-specific strategies and actions that will achieve Livermore's GHG emissions reduction targets, build community resilience to climate impacts, and protect vulnerable communities.

5. Complete CAP Document and California Environmental Quality Act (CEQA) Environmental Review. The City combined the data and strategies into an accessible, implementable document and completed CEQA review.

6. Implement the Strategies in the Plan. Following City Council adoption, the City will take action and implement the CAP strategies in the community.

7. Monitor and Track Progress. The City will monitor implementation progress to ensure that it is on-track to meet its goals, and make adjustments to the CAP as needed.

BENEFITS OF CLIMATE ACTION

The City is committed to creating a more sustainable, equitable, and healthy community that balances the needs of a growing population and economy. Through implementing the CAP Livermore expects to see several important benefits. Together, the CAP's measures and actions will contribute to the creation of a stronger community based upon:

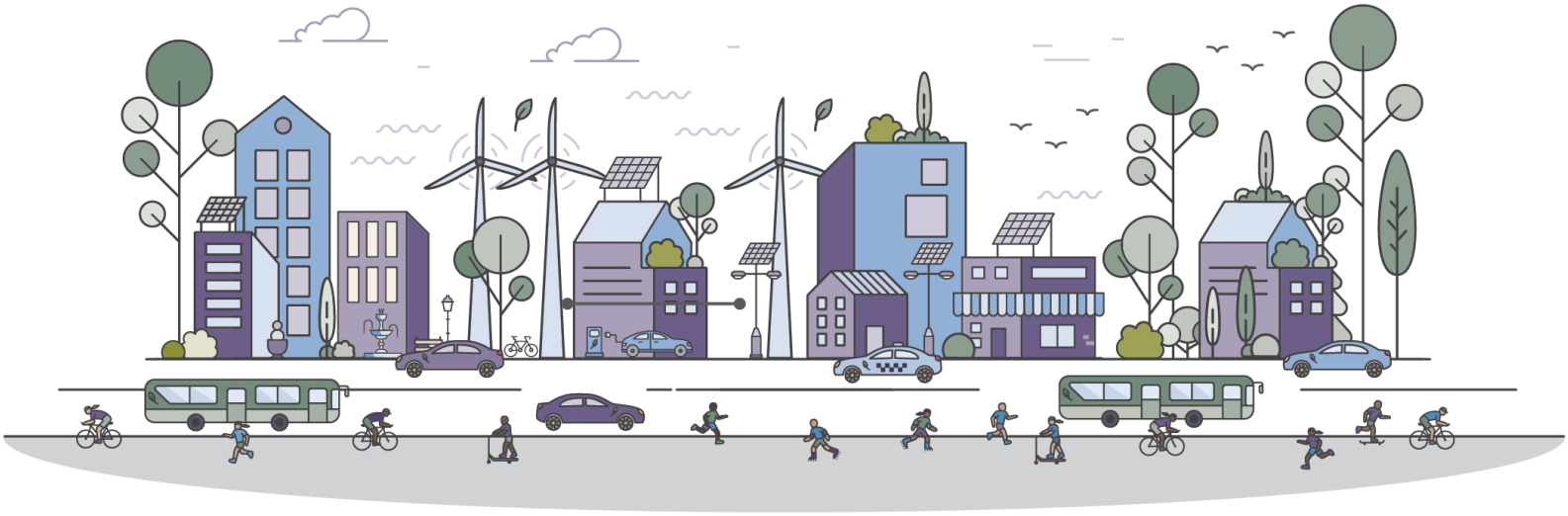
Public Health – Creating a healthier community by improving air quality and active transportation.

Community Connectivity – Promoting a strong sense of community by creating complete, accessible neighborhoods, opportunities to engage, and resources for underserved communities.

Resilience + GHG Reduction – Some GHG reduction strategies can have resilience benefits as well, and vice versa. For example, increasing local energy storage and power generation can increase energy resilience while decarbonizing the grid.

Environmental Quality – Improving natural environments within the city to protect biodiversity and ecosystem services like cleaner air and water.

Green Economy – Diversifying local economic opportunities by attracting high-quality jobs in sustainability industries such as those focused on developing zero emission vehicles or battery storage technologies.



CHAPTER 2.
Climate Change in Livermore

2-1. Climate Change Impacts in Livermore

As a part of Livermore's CAP Update, a Vulnerability Analysis was conducted to evaluate the potential impacts of climate change on community assets and populations. This analysis provides a deeper understanding of Livermore's vulnerabilities to the impacts of climate change that served as a foundation for the climate adaptation strategies and actions included in the CAP to increase resilience. The main findings of Livermore's Vulnerability Analysis are summarized here with additional information provided in Appendix B.

A SUMMARY OF CLIMATE CHANGE IN LIVERMORE

Extreme Heat: Maximum and minimum temperatures are expected to increase by the mid-to-late twenty-first century. The extent of these increases and the associated impacts have a high degree of uncertainty in the near-term.

Wildfires and Air Quality: Wildfire risk will decrease within the city limits, but smoke from increased wildfires statewide will continue to have adverse effects on public health and quality of life in Livermore.

Precipitation Variability: Precipitation variability is expected to increase throughout the twenty-first century with larger flashier storms and less consistent precipitation in between. This is expected to result in both flooding and drought conditions.

Vulnerable Populations and Infrastructure: Vulnerable populations, vital community infrastructure, and the city's transportation system are most sensitive and at-risk to climate impacts. Livermore currently has a low-to-medium adaptive capacity rating due to the high number of existing measures but low overall implementation rates.

INCREASED TEMPERATURES AND EXTREME HEAT EVENTS

By the end of the twenty-first century, average annual temperatures in the Bay Area are projected to increase anywhere from 4.2 °F to 7.2 °F depending on the emissions scenario, when compared to the historic baseline period of 1950 to 2005.[1] Inland areas like Livermore are expected to experience the most significant changes. The Vulnerability Analysis found that temperature projections for Livermore show a consistent increasing trend through the end of the century, with average annual maximum temperatures projected to increase between 4.5 °F to 8.7 °F when compared with 1990. Average annual minimum temperatures are also projected to increase between 3.2 °F and 8 °F by the end of the century, which indicates less cooling off at night.[2] In a medium-to-high emissions scenario, rising temperatures could also cause 75 percent to 85 percent more days with weather conducive to ozone formation when compared to today.[3] Ozone is a compound that when inhaled can cause both short-term and long-term adverse health effects.[4]

The frequency and duration of extreme heat events are also projected to increase in Livermore by the end of the century. Under a high emissions scenario, Livermore is expected to experience 25 extreme heat days annually (defined as days with temperatures over 102.7 °F) by the end of the century, compared to four in 1990. The annual number of heat waves (defined as four or more extreme heat days in a row) is expected to be from 0 to 3 under the same scenario, with the longest duration of consecutive extreme heat days increasing from 2.2 days in 1990 to just over 7 days.[5]

1. *https://barc.ca.gov/sites/default/files/documents/2020-12/20190116-sanfranciscobayarea.pdf*
2. *https://cal-adapt.org/*
3. *https://www.ucsusa.org/resources/california-global-warming-impacts*
4 *https://www.epa.gov/ozone-pollution-and-your-patients-health/health-effects-ozone-general-population*
5. *https://cal-adapt.org/*

Average Annual Minimum Temperature Projected to Increase

3.2°F-8°F

By the End of the Century

INCREASED HUMAN HEALTH IMPACTS FROM LARGE WILDFIRES

Wildfire risk is determined by multiple factors, including climate variability, local topography, land cover, and human activity. Increasing acreage burned by wildfire is being driven by increasing air temperatures and periods of drought.[6] Statewide, the mean area burned is projected to increase by 77 percent by the end of the century under a high-emissions scenario when compared to 1961-1990.[7] Livermore's Vulnerability Analysis, however, found that the annual average of acres burned in Livermore is projected to decrease through the end of the century. This is likely due to wildfires throughout the century reducing the amount of vegetation available to burn, changes in plant communities due to the local warming climate, and the low number of CAL FIRE Very High Fire Hazard Severity Zones within the city. There is a strong connection between human activity and wildfires, with fire activity peaking in wildland-urban interface areas due to increased ignitions. Future land use patterns and development will thus heavily impact wildfire risk throughout the twenty-first century.[8]

While wildfires may not pose a direct threat to life and property within Livermore, smoke from wildfires throughout the state continues to have detrimental effects on quality of life and public health in Livermore. Wildfires have the potential to cause smoky days thousands of miles beyond the areas that they burn, worsening air quality and putting vulnerable populations at risk. The particulates that make up wildfire smoke are pollutants that present a substantial public health risk. This could result in increases in eye and respiratory tract irritation, reduced lung function, pulmonary inflammation, bronchitis, asthma and other lung diseases, cardiovascular disease, and premature death by the end of the century.[9]

6. *https://www.energy.ca.gov/sites/default/files/2019-11/20180827_Summary_Brochure_ADA.pdf*
7. *https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf*
8. *https://barc.ca.gov/sites/default/files/documents/2020-12/20190116-sanfranciscobayarea.pdf*
9. *https://www.cdc.gov/disasters/wildfires/smoke.html*

77%
Increase in Mean Area Burned Statewide
Compared to 1961-1990

Photo credit: Glen Florey

CHANGES IN PRECIPITATION PATTERNS

Average annual precipitation in Livermore will increase slightly by the end of the century.[10] Precipitation will likely be more variable and unpredictable overall, resulting in more whiplash events where extremely dry periods are followed by extremely wet periods.[11] This could pose difficulties for local drinking water supplies and the agricultural industry, both of which rely on the predictability of annual precipitation patterns.

The frequency and intensity of extreme precipitation events (successive days where the total two-day rainfall is above 1 inch) is expected to increase in the Bay Area region through the end of the twenty-first century.

However, this trend is not as clear in Livermore.[12] Projections show the number of extreme precipitation events increasing from three in 1990 to five to seven by mid-century, depending on the emissions scenario. If extreme precipitation events increase, Livermore can expect more flooding in low-lying areas.

Increase of 3-7 Extreme Precipitation Events Annually
From 1990 to Mid-century

▲ *2017 storm damage along the Arroyo Mocho in Livermore.*

REDUCTION IN THE SIERRA NEVADA SNOWPACK

The state's average snow water is anticipated to decline to less than two-thirds of its historical average by 2050,[13] likely to lead to water supply challenges statewide. The snowpack in the Sierra Nevada Mountains is responsible for about 30 percent of the state's annual water supply[14] and provides roughly 75 percent of statewide agricultural water.[15] Wineries and other agricultural businesses in Livermore are highly sensitive to changes in water availability, which could lead to decreased agricultural output from the Tri-Valley region. Reduced water runoff from snowpack may also reduce the amount of electricity that can be produced from hydropower.

Sierra Nevada Mountain Snowpack Provides ~30%
State's Annual Water Supply

10. *https://cal-adapt.org/*
11. *https://barc.ca.gov/sites/default/files/documents/2020-12/20190116-sanfranciscobayarea.pdf*
12. *https://www.energy.ca.gov/sites/default/files/2019-11/20180827_Summary_Brochure_ADA.pdf*
13. *https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf*
14. *https://www.sacbee.com/news/california/water-and-drought/article240394281.html*
15. *https://www.climate.gov/news-features/featured-images/warming-winters-and-dwindling-sierra-nevada-snowpack-will-squeeze#:~:text=Snowmelt%20from%20the%20Sierra%20Nevada,of%20Southern%20California's%20water%20resources.&text=Based%20on%20the%20new%20study,in%20average%20winter%20air%20temperature*.

SENSITIVE STRUCTURES, FUNCTIONS, AND POPULATIONS

Sensitivity describes aspects of Livermore that will be most affected by the identified stressors and hazards that the community will be exposed to as a result of climate change. These can generally be broken down between community structures and functions, and populations. Community structures and functions that were identified include:

- Essential facilities are needed for the health and welfare of the population of Livermore and are especially important following climate-influenced hazard events. Essential Facilities include City of Livermore municipal buildings, healthcare facilities, schools, and senior living facilities
- Sensitive facilities are those places where damage would have large environmental, economic, or public safety consequences, are also considered particularly vulnerable to climate change. These include water collection, storage, and distribution infrastructure, the Livermore Water Reclamation Plant, and Lawrence Livermore and Sandia National Laboratories
- Community functions include the energy delivery system, emergency services such as police and fire, recreation spaces, and agricultural businesses and facilities
- Transportation systems include roads and freeways, bike and trail network, and public transit systems, such as the Altamont Corridor Express and Wheels Bus (also known as the Livermore Amador Valley Transit Authority)

Sensitive populations in Livermore include its senior citizens, chronically ill individuals (e.g., heart and lung disease, diabetes), socially or economically disadvantaged populations, and outdoor workers, such as those in the agriculture industry. Sensitive community structures, functions, and populations may be the most affected by climate impacts, particularly in areas where multiple or compounding vulnerabilities exist.

Adaptive capacity describes Livermore's ability to cope with extreme events and make changes in the community to moderate potential damage. The City has a variety of both reactive and proactive adaptation measures included in its General Plan Climate Change Element, Emergency Operations Plan, Tri-Valley Local Hazard Mitigation Plan, and others. An analysis conducted for the CAP found that while Livermore has over 200 sustainability and adaptation measures, there is a relatively low level of implementation of these measures, resulting in an overall low-to-medium adaptive capacity rating for the community.

The ability of a community to withstand an extreme climate event is called Adaptive Capacity

Livermore Water Reclamation Plant

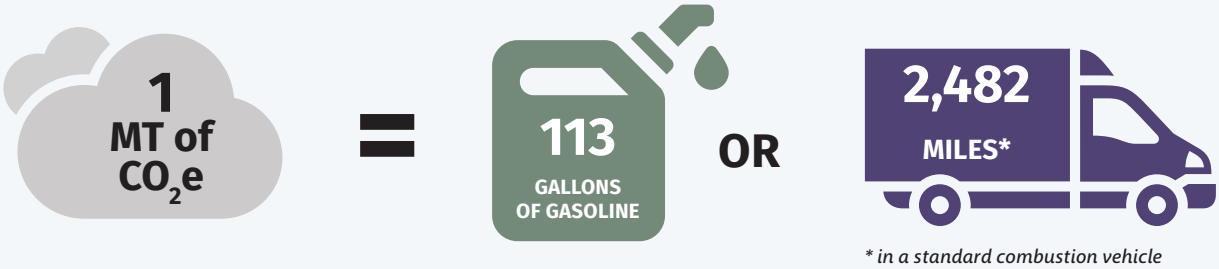
2-2. Livermore's GHG Emissions

An important part of the climate action planning process is the development of a GHG inventory. GHG inventories measure emissions from various sources or sectors within a jurisdiction and allow for monitoring progress, reducing GHG emissions, and achieving established GHG-reduction targets.

Livermore's CAP includes community-wide GHG emissions inventories for 2010, 2015, and 2017, as well as an updated 2005 baseline GHG inventory (originally conducted for the 2012 CAP). Emissions from municipal operations are included as part of the community emissions. They were not calculated separately from community-wide emissions due to their relatively small contribution to Livermore's overall emissions.

Due to CO_2, CH_4, and N_2O comprising the large majority of GHG emissions in Livermore, this CAP focuses on these three gases for its GHG emissions inventory, forecast, and reduction strategy, consistent with the ICLEI – Local Governments for Sustainability's U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. All emissions are converted to the equivalent of one metric ton of carbon dioxide, or MT CO_2e.

One MT CO_2e is the equivalent of using 113 gallons of gasoline or driving 2,492 miles in a standard combustion vehicle.[16]



** in a standard combustion vehicle*

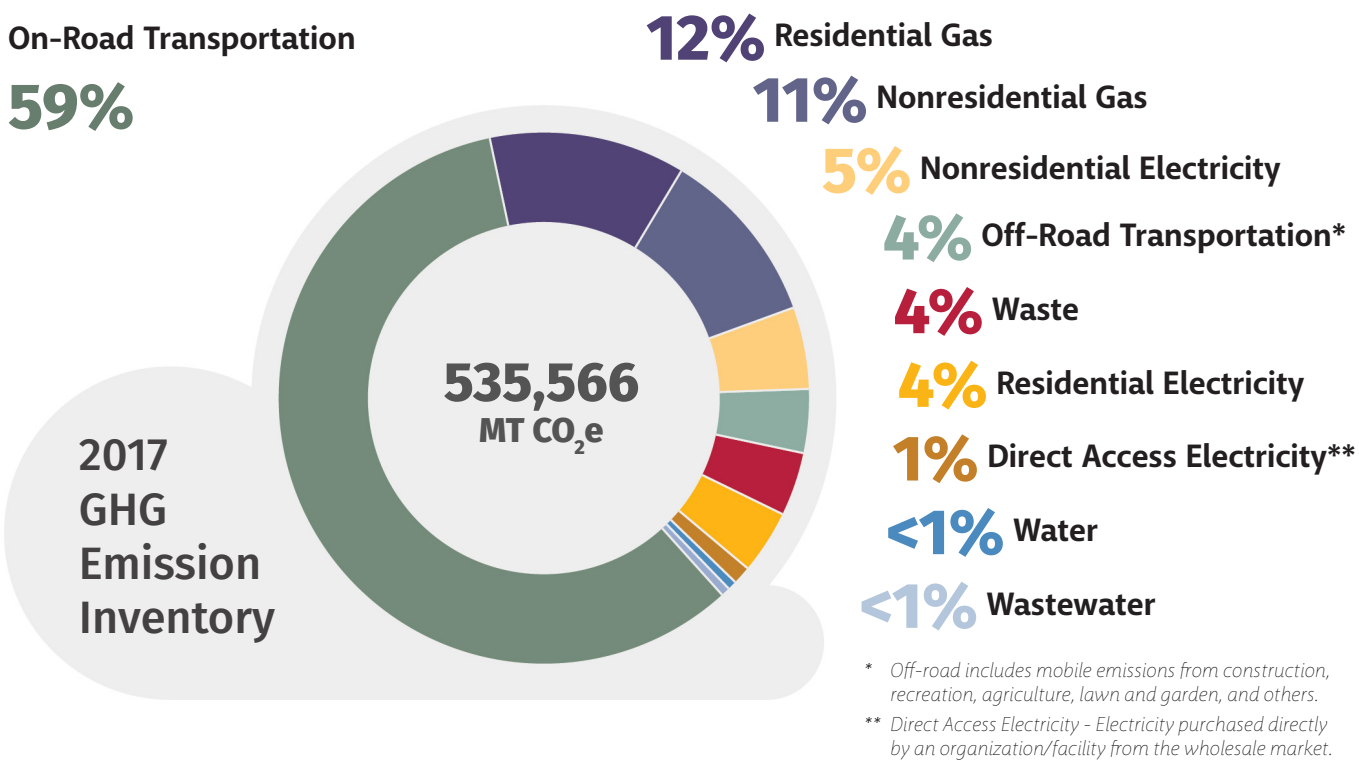
16. *https://developer.epa.gov/greenhouse-gas-equivalencies-calculator-widget/*

2017 GHG INVENTORY

The 2017 GHG inventory was utilized to track progress reducing GHG emissions and to develop updated forecasts and GHG emissions reduction targets for the CAP through 2045. Emissions from residential and commercial energy usage, on-road passenger and commercial transportation, off-road transportation, landfilled waste, water, and wastewater are all included in the inventory. Livermore's total GHG emissions for 2017 were estimated to be 535,566 MT CO_2e, as depicted below in Figure 2-1. More information on the data and methodologies used can be found in Appendix A.

According to the results of the 2017 GHG inventory, the largest source of GHG emissions in Livermore was from on-road passenger and commercial transportation, which accounted for 59 percent of total emissions. This is primarily related to single-passenger automobiles, as well as commercial trucks and delivery vehicles within the city.[17] The second largest amount of GHG emissions was from natural gas usage in both residential and nonresidential buildings, which combined accounted for 23 percent of Livermore's total GHG emissions. Natural gas is used to heat water, homes, and businesses, as well to run natural gas-powered appliances. Electricity usage accounted for the third largest source of emissions, with residential and nonresidential sectors combining for nine percent of total emissions in Livermore.

Figure 2-1. GHG Emissions Summary for Livermore, 2017



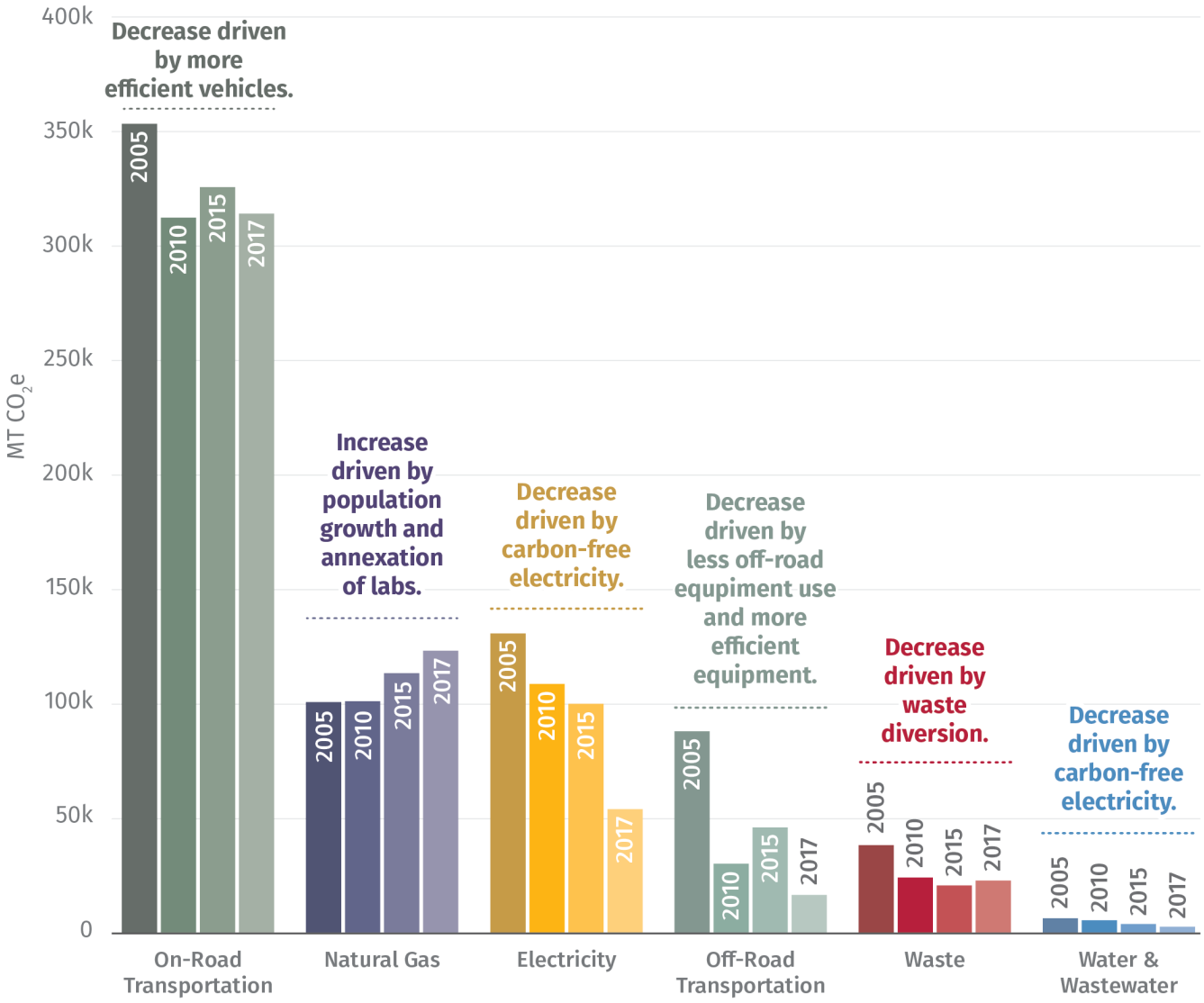
17. On-road vehicle emissions were calculated using vehicle miles travelled (VMT) that was adjusted using recommended methods from the Senate Bill 375 Regional Targets Advisory Committee (RTAC) and converted to GHGs using emissions factors from CARB's Emissions Factor (EMFAC) model.

LIVERMORE'S GHG EMISSIONS OVER TIME

Between 2005 and 2017 Livermore's total GHG emissions have decreased by 17 percent, achieving the 2020 reduction target adopted by the City's previously adopted 2012 CAP. GHG emissions decreased across all sectors from 2005 to 2017, except for nonresidential gas and off-road transportation, which likely increased due to the addition of the Lawrence Livermore National Laboratory and Sandia National Laboratory to the City's boundary in 2012 as well as growth of the commercial sector within the city and offroad vehicles. Additional details including emission factors and activity data for all inventory years can be found in Appendix A.

During the time period that these GHG emission reductions took place, Livermore experienced a population increase of 16 percent. Despite this population growth, Livermore still achieved an overall reduction in GHG emissions (Figure 2-2).

Figure 2-2. Historic Emissions in Livermore, 2005–2017



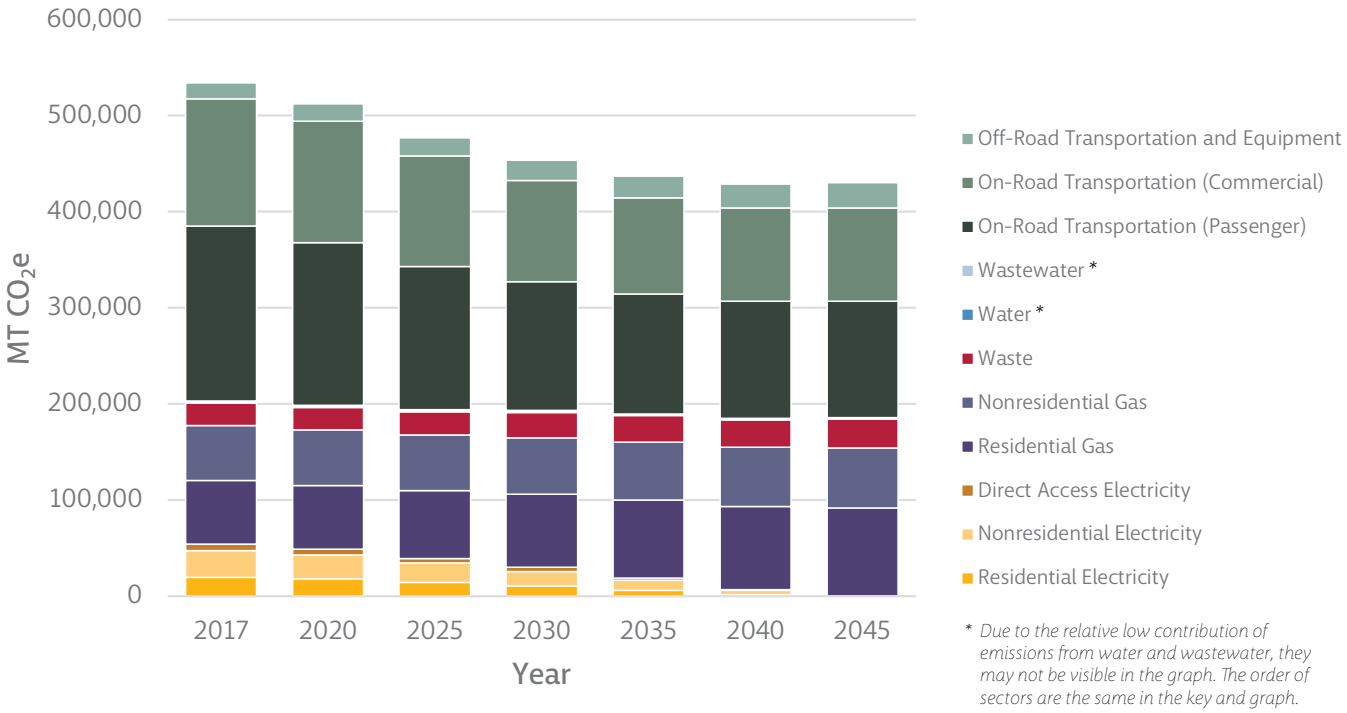
GHG EMISSIONS FORECAST

While GHG inventories provide data on Livermore's current emissions, GHG emissions forecasts estimate the city's projected GHG emissions into the future. Forecasts are developed from the most recent GHG inventory and provide an estimate of how Livermore's emissions might change over time based on demographic projections including population, employment, housing, and transportation activity. Forecasts also include future State legislation that will help lower Livermore's emissions over time.

A GHG emissions forecast was developed to quantify future GHG emissions within the city through 2045. It was developed based off future demographic forecasts from the Association of Bay Area Government's Plan Bay Area 2040 and Livermore's 2003-2025 General Plan. The forecast provides a projection of how GHG emissions are likely to change over time due to the implementation of State regulations described in Chapter 1. The forecast includes several regulations including SB 100 and Advanced Clean Fleets. More information on these regulations and how they were accounted for in the forecast can be found in Appendix A.

Livermore's forecast projects that the City's GHG emissions will decrease through 2030, and continue to decrease, but at a slower rate, through 2045. The slower reduction in GHG emissions after 2030 is due to current State legislation, including Title 24 and California's GHG vehicle emission standards, being fully phased in and then being offset by population and job growth. Potential new State legislation could be adopted in the future to continue driving down emissions statewide. A summary of Livermore's forecast through 2045 is shown below in Figure 2-3.

Figure 2-3. GHG Emissions Forecast for Livermore, 2017–2045



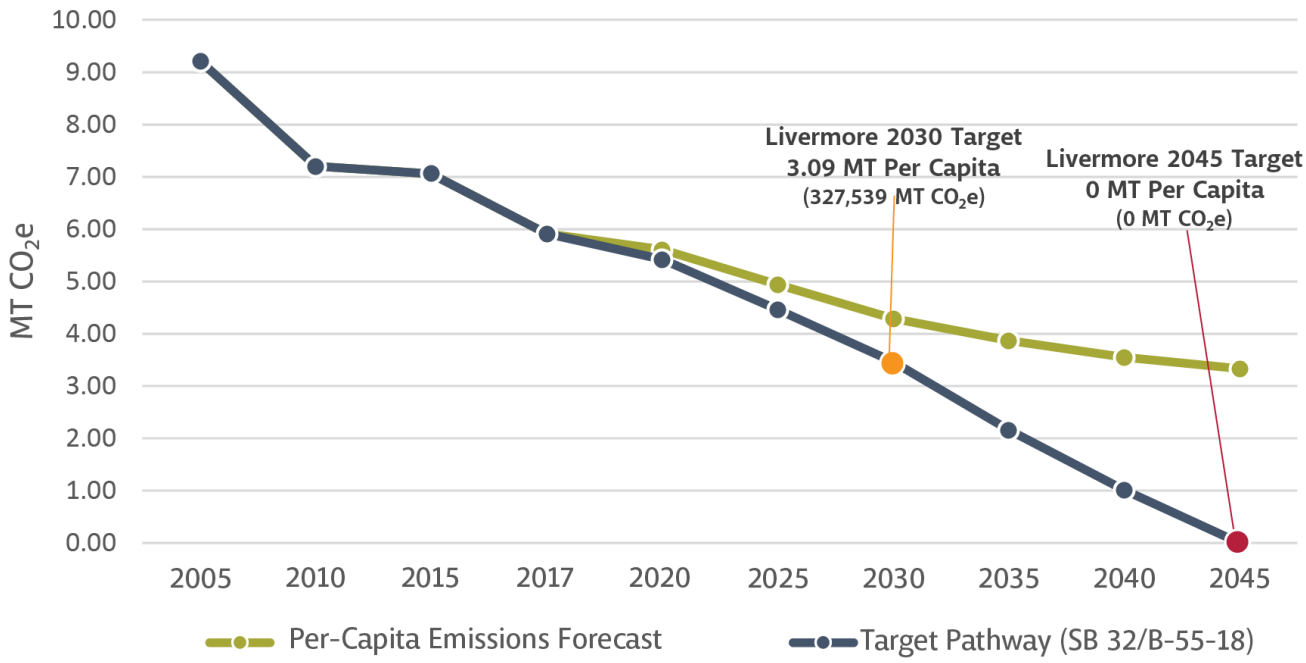
* *Due to the relative low contribution of emissions from water and wastewater, they may not be visible in the graph. The order of sectors are the same in the key and graph.*

LIVERMORE'S GHG EMISSION REDUCTION TARGETS FOR 2030 AND 2045

By defining specific reduction targets, Livermore can track its progress towards meeting its goals and measure the success of its CAP. Livermore's CAP includes GHG reduction targets for 2030 and 2045, calculated based on the GHG emissions forecast and State requirements set forth by SB 32 and EO B-55-18. These GHG reduction targets were established to be consistent with the State's climate goals, which would result in Livermore's "fair share" of emissions reductions in support of California's overall statewide reductions.[18] Additionally, the City established per-capita targets for 2030 and 2045 instead of mass emissions targets, as recommended by CARB in the 2017 Scoping Plan, due to per-capita target's flexibility in the event of greater than expected population growth or decline. The pathway to achieve Livermore targets is shown below in Figure 2-4. The emissions gap between the forecast and the target pathway represents the amount of GHG emissions that Livermore will need to reduce through locally adopted GHG reduction strategies and actions. For 2030, this translates to mass emission reductions of 128,238 MT CO_2e in 2030, and 430,965 MT CO_2e in 2045 based on current population projections.

Livermore will reduce GHG Emissions by 40% below 1990 by 2030 and achieve carbon neutrality by 2045.

Figure 2-4. Per-Capita GHG Emission Reduction Targets Summary for Livermore



18. Association of Environmental Professionals, Final White Paper, Beyond 2020 and Newhall, October 18, 2016. *https://califaep.org/docs/AEP-2016_Final_White_Paper.pdf*

2-3. Community Perspectives on Climate Action

In addition to the Vulnerability Analysis and the GHG inventory and forecast, the City's climate action strategy was informed by extensive community engagement. The City provided an open and inclusive community engagement process with ample opportunities to welcome residents, businesses, and other partners into the CAP process and inspire them to be a part of Livermore's climate-resilient future. The engagement process brought community members into the project early and often, keeping a pulse on their level of support and being responsive to their concerns. The engagement process was driven by three primary goals.

GOAL A

Cultivate a shared understanding of the purpose, motivation, and value of the CAP to the City and individuals and the process of developing the CAP.

GOAL B

Gather community perspectives and feedback on the CAP that are representative of the makeup of the community to inform CAP development.

GOAL C

Build community- wide support for advancing CAP priorities and implementing mitigation and adaptation actions.

ENGAGEMENT ACTIVITIES

Due to the project's timing and the impacts of COVID-19, the initial outreach and engagement scope shifted away from traditional in-person events to more virtually based approaches. The City held a variety of virtual events that provided wide-reaching public engagement.

Climate Action Plan Advisory Committee Meetings (8/20–11/22)

The Climate Action Plan Advisory Committee (CAPAC) was made up of nine Livermore residents selected by the City Council to provide input and feedback to City staff throughout the development of the CAP. Each meeting offered opportunities for members of the public to submit comments in writing.

Online Survey (4–8/20)

The City released a bilingual (English-Spanish) online survey that included questions regarding community perspectives about climate action, priorities for climate action focus areas, and levels of concern about climate impacts.

Online Open House (1/21)

The City developed interactive pages on the project website to mimic an in-person open house. The pages contained information in both English and Spanish about the GHG inventory, vulnerability analysis, and broad strategies the City could take to address climate change in Livermore. They also contained survey questions and comment boxes for members of the public to write their ideas and reactions to the content on each page. The City concluded the online open house engagement with a live Zoom event that gave community members an opportunity to discuss the content directly with representatives from the City and the Climate Action Plan consultant team.

Online Workshop (3/21)

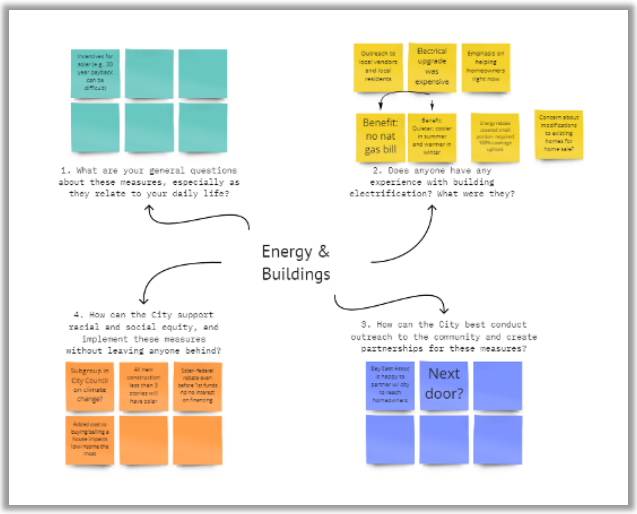
The City hosted an interactive workshop to gather community feedback on the preliminary list of CAP strategies and actions.

Targeted Focus Groups and Presentations (4–8/21)

The City hosted focus groups and presentations to targeted groups that were underrepresented in the engagement activities above. The City met with members of the local business community, stakeholders in the winegrowers and open space community, students from Livermore High School and Junction Avenue School, and service providers such as La Familia and Partners for Change.

Farmers Market (4/21)

As COVID-19 restrictions eased towards the end of the outreach process, City staff were able to host a table at the Livermore Farmers Market.

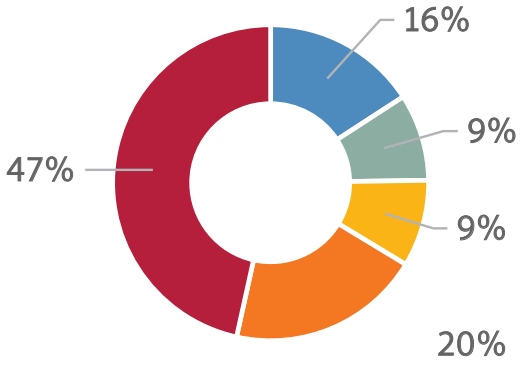


Interactive Mural Board from the Online Workshop

OVERARCHING FEEDBACK FROM ENGAGEMENT

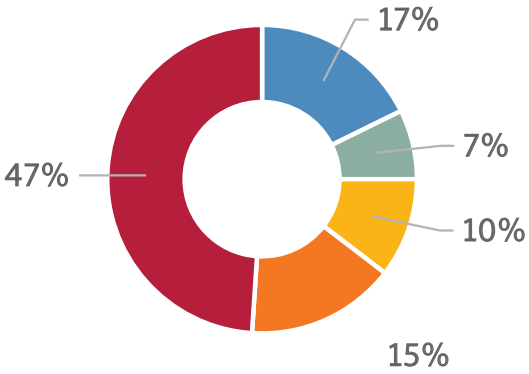
The overall response to Livermore's climate goals and strategies was positive. Over 75 percent of the community has at least some concern over the impacts of climate change. In addition, a strong majority of Livermore's community ranked taking action on climate change as important. The quotes below were received from Livermore community members during outreach events or submitted through surveys.

How worried are you about climate change?



- Not at all Worried (54)
- Not Very Worried (31)
- Slightly Worried (29)
- Quite Worried (68)
- Very Worried (159)

How important is it to you that the City of Livermore community take action on climate change?



- Not Important (57)
- Not Very Important (25)
- Slightly Important (35)
- Quite Important (52)
- Very Important (171)

▼ *Livermore resident responses to online survey.*

> "I believe that the health and safety of all Livermore residents will be impacted."

> "I'm concerned about long periods of drought and blackouts during hot weather months."

> "I'm very concerned that climate change will have the worst impact on the most vulnerable people."

> "We will reap the benefits from important actions taken in 2021 to ensure nobody's livelihood is threatened by climate change."

Throughout the outreach process several key themes developed. Many residents expressed concern over climate change impacts such as water availability, extreme heat, and poor air quality. Residents supported efforts related to expanding renewable energy sources, water conservation, alternative transportation modes, and improving resiliency in public infrastructure. Overall, most residents wanted the City to act on climate, but with cost effective and equitable strategies that preserve Livermore's status as a place where people can live, work, and raise families. These themes and how they were included in the CAP development are summarized in Table 2-5.

Table 2-5. Summarized Community Feedback by Theme

Theme	Community Feedback	Where to Find it in the CAP
Affordability	Participants encouraged the City to provide incentives and financial assistance to property owners and expressed concern that appliance replacements and ongoing electricity costs will be expensive.	Economics and cost effectiveness were made a top priority through the inclusion of the economics guiding principle (Chapter 3). Many actions are no or low cost for the community.
Community Connectivity	Participants value the feeling of community in Livermore and want it to continue to be a place where people want to live, work, raise families, and visit. The ability to move around the City easily through active transportation was also identified.	Community connectivity was made a key benefit in action development. This benefit is reflected throughout Chapter 3.
Outreach and Partnerships	Participants were interested in continued outreach and education to residents and had ideas for partnerships with the local laboratories, homeowners associations, local businesses, transit agencies, and schools.	Partnerships were included as a guiding principle of the CAP and many actions including Priority Area 4 and Strategy I-3 are dedicated to partnerships and outreach.
Awareness and Action	Many participants feel that the City is not acting urgently enough and urge Livermore to be a leader in climate action.	The CAP provides a clear implementation section, funding and financing strategies, and a dedicated implementation action section to spur progress (Chapter 4).
Quality of Life Decline	Participants expressed concern about the decline in quality of life that will be caused by climate change impacts like extreme heat, drought, and wildfire smoke. The impacts on lower income communities was of particular concern.	The CAP focuses heavily on adaptation strategies and actions related to Livermore's most pressing climate issues. A summary of Livermore's adaptation strategy is found on page 33.
Housing and Jobs Balance	Participants are concerned about the availability of housing and jobs in Livermore and want to ensure that there is enough affordable housing to support everyone who works in Livermore.	Through the CAP transportation and land use section (Chapter 3) and the General Plan update, the City is working to increase housing in the city and manage the jobs/housing balance.
Equity	Participants noted that people who are low-income, experiencing homelessness, or have recently secured housing don't have the resources to consider their carbon footprints or the ability to adapt to climate change.	Equity was made a guiding principle and benefit of the CAP. Actions with specific equity benefits are noted throughout Chapter 3.

CHAPTER 3.
Livermore's Climate Action Strategy

3-1. Strategy Overview

Livermore's climate action strategy outlines a plan for how the City can prepare for climate change impacts while reducing GHG emissions to meet its 2030 and 2045 targets. This CAP builds upon Livermore's previous efforts with actions that are equitable, achievable, and implementable. The strategies and actions in the CAP were developed through a collaborative process between City staff, the Climate Action Plan Advisory Committee, Planning Commission, City Council, key stakeholders, and the community (as described in Chapter 2).

HOW TO READ THIS SECTION

The strategies are organized by adaptation and mitigation topic (e.g., Wildfire, Flooding, Buildings and Energy, Transportation and Land Use). Each topic identifies primary objectives the City will use to measure success. The City will aim to complete these objectives before 2030.

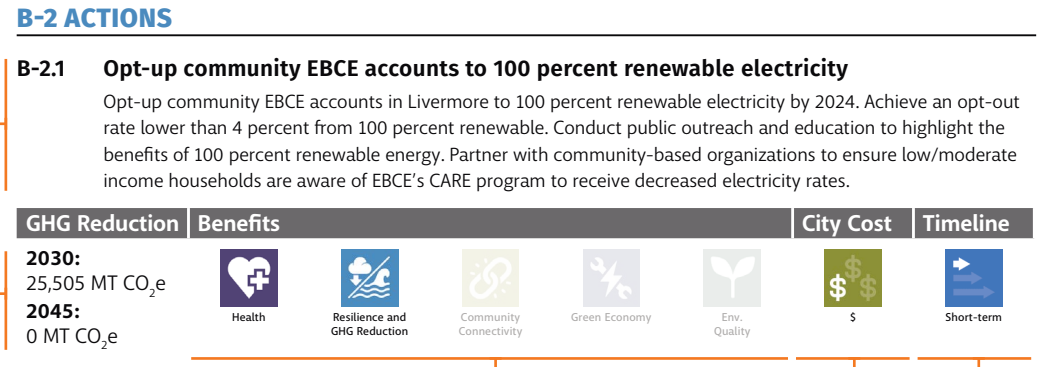
Each strategy includes a summary that details why the strategy was chosen and major considerations for implementation. The mitigation topics include a breakdown of the total GHG emissions reductions expected from each strategy. The strategies identify specific actions the City will take to achieve its objectives. Each action includes a table with the following additional detail:

ACTION NUMBER AND ACTION DESCRIPTION

Identifies and defines what the City will do.

GHG REDUCTIONS

The expected GHG reductions from completing this action in 2030 and 2045. Adaptation actions do not have this data.



BENEFITS

Beyond GHG reductions or increasing resilience, many actions provide additional community benefits. If an icon is highlighted, the action provides that benefit. A definition of each benefit is included under Strategy Benefits.

CITY COST

Identifies the city cost as high, moderate, low, or no cost.

TIMELINE

Identifies the implementation timeline as short-term, mid-term, long-term, or ongoing.

LIVERMORE CAP STRATEGY OVERVIEW

Table 3-1. Working Towards Climate Resilience and Carbon Neutrality

	STRATEGY	2030 OBJECTIVES
ADAPTATION	**Extreme Heat**	• Increase resilience to extreme heat events • Cool neighborhoods by expanding the urban canopy • Identify vulnerable areas and populations • Develop cooling centers that are energy-resilient
	Wildfire	• Mitigate wildfire risk • Facilitate building retrofits and operate clean air centers • Stockpile personal protective equipment • Reduce fire risk through fire-safe landscaping standards • Improve emergency alert systems
	Flooding	• Improve stormwater management • Harness Livermore's natural landscapes to improve stormwater management • Reduce the expansion of urban hardscapes
MITIGATION & ADAPTATION	**Drought**	• Improve water conservation • Develop on-site water and water reuse standards • Provide-water efficiency devices • Develop water-efficient demonstration programs
	Energy Resilience	• Enhance community energy resilience • Expand microgrid deployment • Increase local and regional grid reliability • Improve building resiliency
	Buildings and Energy *↓19,379 MT CO_2e*	• Provide 100% renewable electricity by 2024 • Require all-electric new construction by 2023 • Incentivize electric retrofits in 12% of existing buildings • Develop equitable funding and financing • Incentivize local on-site energy generation
	Carbon Sequestration *↓1,950 MT CO_2e*	• Plant 1,000 trees by 2030 • Update City landscaping standards to expand shade trees • Provide free or reduced cost-trees to residents • Preserve open space • Implement carbon farming projects • Explore technology-based carbon capture and storage
MITIGATION	**Transportation and Land Use** *↓49,494 MT CO_2e*	• Add 1,283 publicly available chargers • Reduce VMT by 2% • Achieve a 10% bike mode share • Support sustainable land use practices
	Waste and Materials *↓19,379 MT CO_2e*	• Reduce the amount of organics that is landfilled by 75% • Maintain or exceed 75% waste diversion each year • Improve local re-use and repair programs • Expand the use of low-carbon and recycled building materials

ADAPTATION STRATEGY SUMMARY

Even if all GHG emissions sources stopped emitting today, the current concentration of GHGs in the atmosphere would continue to change California's climate and directly impact Livermore.[1] Specifically, as described earlier in Chapter 2, Livermore is likely to experience impacts from extreme heat and weather events, drought, and statewide wildfires. These impacts will have cascading effects on Livermore's residents, businesses, infrastructure, environment, and economy. The City developed a suite of adaptation strategies to increase Livermore's resilience to climate change impacts, prioritizing vulnerable communities and vital public facilities.

- **ENERGY RESILIENCE** – Adding distributed energy resources like solar and batteries and working with partners to improve electrical grid reliability and capacity will be key to the City's energy resilience strategy.
- **DROUGHT** – The City's drought strategy uses a range of policy and planning strategies to support water efficiency and on-site water reuse.
- **FLOODING** – The City will implement a suite of natural (green) and engineered (grey) stormwater solutions to capture and infiltrate water while protecting infrastructure.
- **EXTREME HEAT** – Cooling urban areas via expanded shade structures and the urban tree canopy, ensuring energy resilience at cooling centers, and building partnerships with trusted community-facing facilities, as well as incorporating emergency heat response into emergency operations.
- **WILDFIRES** – The City's wildfire adaptation strategy includes updated planning initiatives in the wildland/urban interface to protect infrastructure from potential fires as well as retrofitting existing buildings to protect occupants against poor air quality.

Table 3-2. Adaptation Strategies

Strategy #	Strategy
Energy Resilience	
E-1	Enhance community energy resilience
Drought	
D-1	Improve water conservation and reuse
Flooding	
F-1	Improve stormwater management
Extreme Heat	
H-1	Increase resilience to extreme heat events
Wildfire	
WF-1	Mitigate wildfire risk and improve preparedness

1 *https://earthobservatory.nasa.gov/features/HeatBucket/heatbucket4.php*

MITIGATION STRATEGY SUMMARY

As the City works to protect the community from climate impacts, it will continue its efforts to reduce community-wide emissions. With full implementation of the CAP, Livermore expects to exceed the 2030 reduction target by 692 MT CO_2e and provide substantial progress towards carbon neutrality by 2045 (see Appendix D for more information regarding the calculated emission reductions anticipated from each strategy and action, including substantial evidence). The following four sectors form the core of Livermore's GHG reduction strategy to achieve the 2030 target and establish a pathway to carbon neutrality by 2045:

- **BUILDINGS AND ENERGY** – Building electrification will shift energy use from natural gas to electricity, maximizing GHG reductions from increasingly clean electricity, while also being cost-effective and improving indoor air quality for residents and businesses.
- **TRANSPORTATION AND LAND USE** – Emissions reductions will come from increased adoption of electric vehicles (EVs), as well as increasing alternative transportation usage, such as transit, biking, and walking
- **WASTE AND MATERIALS** – These strategies focus on implementing the requirements of SB 1383, which will decrease the amount of organic waste that is landfilled and in turn reduce methane in landfills.
- **CARBON SEQUESTRATION** – New management practices on natural lands and protecting existing open spaces will help reduce net emissions.

Figure 3-2 details the GHG-reduction trajectory established by the 2022 CAP. Table 3-3 includes a summary of the strategies and their estimated GHG emissions reduction potential.

Figure 3-2. Livermore's GHG Reduction Pathway

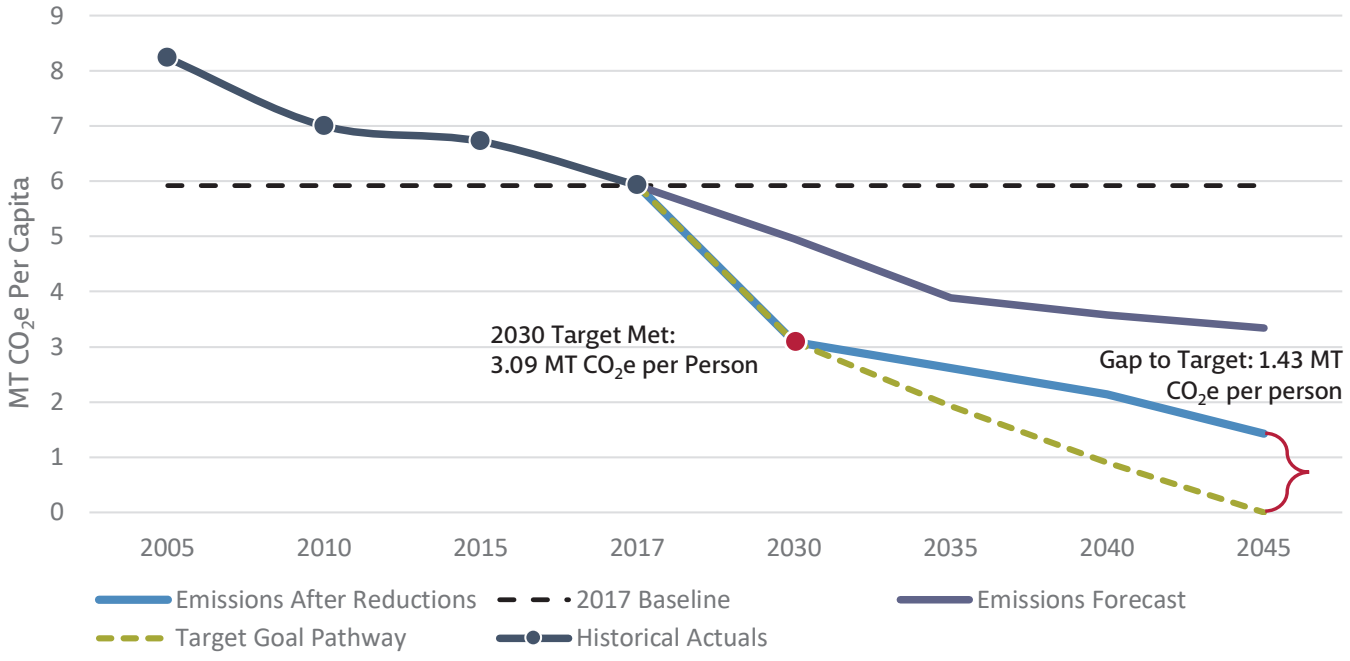


Table 3-3. GHG Mitigation Strategies

Strategy #	Strategy	2030 Emissions Reduction (MT CO_2e)	2045 Emissions Reduction (MT CO_2e)
Buildings and Energy			
B-1	Require new buildings to be all-electric and incentivize electrification retrofits of existing buildings	27,383	121,493
B-2	Decarbonize electricity from the grid and increase local renewable energy generation	25,505	0
Transportation and Land Use - 42% of Total Reductions			
T-1	Facilitate a transition to electric vehicles	49,494	93,458
T-2	Facilitate a transition to transit and shared mobility services	3,033	4,656
T-3	Improve and expand active transportation infrastructure	2,127	2,111
T-4	Support sustainable land use practices	Not Quantified	Not Quantified
Waste and Materials			
W-1	Reduce the amount of waste that is landfilled	19,379	22,646
W-2	Expand use of low-carbon and recycled building materials	Not Quantified	Not Quantified
Carbon Sequestration			
S-1	Maximize local carbon sequestration	2,008	2,434
OVERALL REDUCTIONS			
Emissions Reduction Needed to Achieve State Targets		128,238	430,965
Estimated Reduction Achieved by Full Implementation of Strategies		128,929	246,798
Absolute Emissions Reduction from 1990 (%)[1, 2]		-40%	-66%
Per Capita Emissions Reduction from 1990 (%)		-68%	-85%
Gap to SB 32 Target		(692)[3]	184,167

MT CO_2e = metric ton of carbon dioxide equivalent
1 Emissions reductions go to zero by 2045 due to Senate Bill 100 and the Renewable Portfolio Standard.
2 Absolute emissions reduction values are estimated based on current population projections and are for reference. Actual progress toward the 2030 target will be determined by comparison to the per capita GHG emissions target of 3.08 MT of CO_2e per person pursuant to guidance in the 2017 Scoping Plan.
3 Parentheses denote a negative number or an exceedance of the target.
Note: Quantitative GHG emissions reduction values were rounded to the nearest tenth to reflect the level of estimation involved in calculations.

MUNICIPAL OPERATIONS AND PLAN IMPLEMENTATION STRATEGY SUMMARY

The CAP includes important actions the City will take to lead the community by example to address climate change. The City will reduce emissions and improve resilience in its own operations, dedicate resources to implement the CAP, and develop equitable outreach programs to educate the community on ongoing climate initiatives. Additionally, the City will track and assess CAP implementation progress on a regular basis and adjust its strategies every 5 years (as outlined in Chapter 4) to account for future changes to technology and State law. By taking action, the City can build a meaningful momentum in the community and achieve its goals.

Table 3-4. Municipal Operations and Plan Implementation Strategies

Strategy #	Strategy
Municipal	
M-1	Enhance resilience at public facilities
M-2	Electrify municipal facilities and operations
M-3	Electrify the City's vehicle fleet and encourage employees to utilize alternative transportation and teleworking opportunities
M-4	Conserve water in municipal landscaping and improve on-site stormwater management
M-5	Purchase more sustainable products to reduce waste from City operations
M-6	Utilize public lands to increase local carbon sequestration and reduce urban heat island effect
Implementation	
I-1	Make climate impacts and resilience a standard consideration during planning and development processes
I-2	Dedicate City resource to CAP implementation and consistently monitor progress
I-3	Create a public outreach campaign to educate the community about CAP initiatives
I-4	Foster green innovation in Livermore

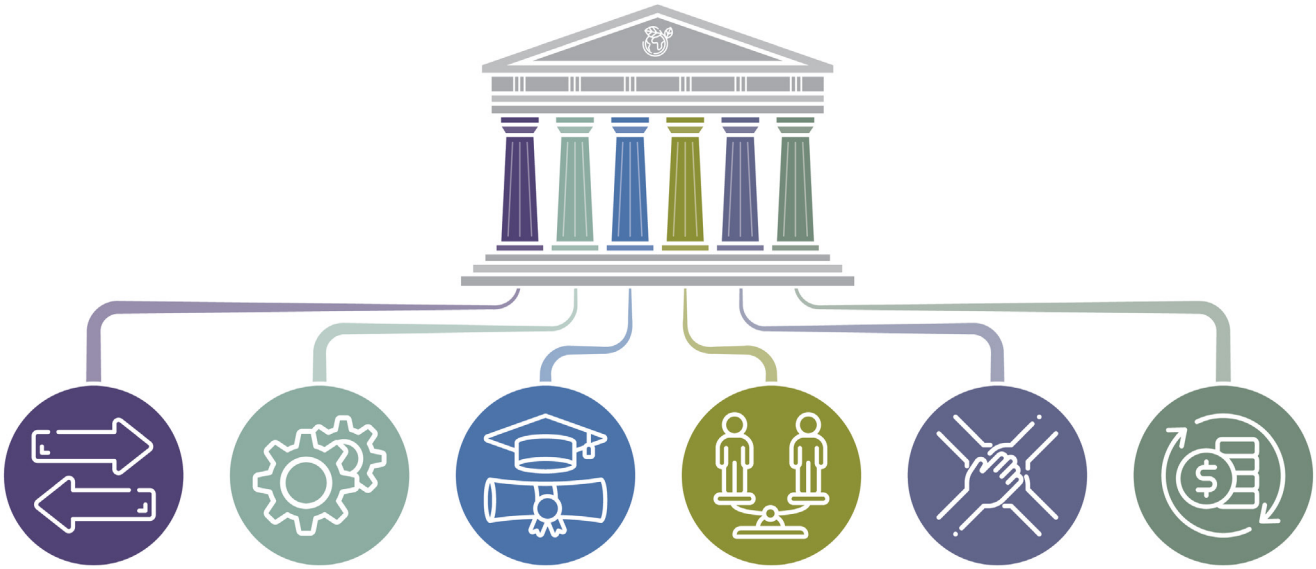
STRATEGY DEVELOPMENT CONSIDERATIONS

To develop the strategies and action in the CAP, the City utilized guiding principles and considered factors such as costs, benefits, and readiness. Each of these elements is described in more detail below.

Guiding Principles

The CAP lays out a comprehensive approach to meeting the City's climate goals through a range of strategies and actions. Each strategy was developed by carefully considering a set of guiding principles. The guiding principles are highlighted below in Figure 3-2. Additional information on how the guiding principles shaped the strategy and action development can be found in Appendix D.

Figure 3-2. Guiding Principles



Mitigation and/or adaptation benefit: Strategies should achieve measurable reductions in GHG and/or improvements in resilience.

Structural change: Strategies should establish institutional and policy framework to facilitate long-term change.

Education: Strategies should include community engagement and empower residents and stakeholders to take action.

Equity: Strategies should promote inclusive participation in decision making and equitable access to benefits.

Partnerships: Strategies should utilize partnerships with outside agencies and community organizations to leverage expertise and resources and maximize the City's capacity.

Economics: Strategies should strive to be cost-effective for the City and the community.

Strategy Costs

Each CAP strategy was categorized as either no-cost, low-cost, moderate-cost, or high-cost based on its costs to both the City and the community. The descriptions for these categories are included in Table 3-5. Implementing CAP strategies and actions can be extremely variable in cost, as strategies range from outreach and education (low-cost) to major investments in new infrastructure such as microgrids and bike lanes (high-cost). While it is tempting to consider just the upfront costs of new policies or actions, there are many other cost considerations that should be part of the decision-making process. For a complete description of the cost considerations for CAP strategies please see Appendix D.

DID YOU KNOW?

1. *A new electric vehicle may cost more upfront than its gas-powered counterpart. However, an electric vehicle can cost less over the lifetime of the vehicle once the costs for gas, oil changes, and other maintenance requirements for gas-powered vehicles are taken into account.*

2. *Investing in climate action pays off. The World Resources Institute found that every dollar invested in resilience and adaptation will result in $2 to $10 dollars' worth of benefit in the future.*

Table 3-5. Cost Framework Summary

Cost Segment	Description
No-Cost	Actions that have zero costs to the community or City. This includes actions that will save money both upfront and over time.
Low-Cost	Actions with relatively low upfront costs or city staff time, (e.g., policy ordinances or outreach). For community members, this represents costs between $1 and $100 per year.
Moderate-Cost	Actions involving consultants or moderate infrastructure changes, (e.g., feasibility studies, program development, and retrofitting existing infrastructure). For community members, this represents costs between $100 per year and $500 per year.
High-Cost	Longer term projects requiring substantial investments into major infrastructure or technology over time, (e.g., energy storage, bike lanes, or other infrastructure changes). For community members, this represents costs between $500 per year and $1,000 per year.

Strategy Readiness

It is important to understand the overall readiness or speed at which a strategy can be deployed. Some policies and actions are ready to be implemented today with existing resources and community support, while others will need additional feasibility studies, community engagement, or funding before implementation can occur. Each CAP strategy was categorized as short-term, mid-term, long-term, or ongoing. The description of each readiness category in included in Table 3-6.

Table 3-6. Readiness Framework Summary

Readiness Timeframe	Description
Short-term	Actions that are ready to be implemented today such as certain ordinances and community outreach efforts. This can also include studies and pilot projects that will set up implementation of longer term actions.
Mid-term	Actions that require additional study, funding, or partnerships to be completed before implementation.
Long-term	Actions that require longer lead times to fully implement.
Ongoing	Actions that are underway and ongoing.

To see a full breakdown of the methods to assess cost, benefit, and readiness, please refer to Appendix D.

STRATEGY BENEFITS

Public Health

Creating a healthier community by improving air quality and active transportation. Reducing fossil fuel use in Livermore will improve public health in the community. Natural gas-powered appliances like gas stoves are a major source of indoor air pollution which worsen health conditions like asthma.[2] Fossil-fuel powered vehicles emit carcinogens and air pollutants that negatively impact public health. All-electric buildings, electric vehicles, and a well-connected active transportation network, residents will provide residents with cleaner air and more opportunities for physical activity.[3]

Community Connectivity

Promoting a strong sense of community by creating complete, accessible neighborhoods, opportunities to engage, and resources for historically underserved communities. Facilitating a city where community members can participate in public life and build deep ties to their neighbors is foundational to building a sustainable Livermore. Research indicates that this type of community cohesion is also important for community mental and physical health outcomes.[4]

Resilience and GHG Reduction

Some GHG reduction strategies can have resilience benefits as well, and vice versa. For example, increasing local energy storage and power generation can increase energy resilience while decarbonizing the grid. Urban greening harnesses the carbon sequestration potential of natural land, while providing shade and urban cooling during extreme heat events.

Environmental Quality

Improving natural environments within the city to protect biodiversity and ecosystem services, like cleaner air and water. Healthy ecosystems can reduce pollutants in the air and local waterways, provide species habitat, and offer natural areas for community recreation. Healthy ecosystems can help alleviate extreme weather impacts as well, passively absorbing rainwater and relieving the burden on Livermore's built infrastructure. Finally, increasing green and natural space within Livermore contributes to increased quality of life for the community.

Green Economy

Diversifying local economic opportunities by attracting high-quality jobs in sustainability industries, such as those focused on developing zero emission vehicles or battery storage technologies. As Livermore decarbonizes, nearly every sector from energy to waste management will experience a green jobs transition, and many will experience green job growth. A recent study by the UCLA Luskin Center for Innovation found that 100,000 full-time equivalent jobs would be created across various sectors of the economy as the result of electrifying all of California's new and existing buildings by 2045. In the waste and materials sector, the process of re-using materials was found to create 200 times as many jobs as sending those materials to landfills and incinerators while recycling increased jobs by a factor of 60.[5]

2 https://www.nationalasthma.org.au/living-with-asthma/resources/patients-carers/factsheets/gas-stoves-and-asthma-in-children

3. Potential of active transport to improve health, reduce healthcare costs, and reduce greenhouse gas emissions: a modeling study, 2019, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6636726/#:~:text=Increasing%20active%20transport%20by%20switching,also%20reduce%20greenhouse%20gas%20emissions*.

4. *https://www.vtpi.org/cohesion.pdf*

5. *https://ilsr.org/new-report-from-global-anti-incineration-alliance-zero-waste-creates-200-times-more-jobs-than-landfills-and-incinerators/*

3-2. Adaptation Strategies and Actions

Energy Resilience

2030 Objectives

- **Enhance community energy resilience**
- **Increase local and regional grid reliability**
- **Expand microgrid deployment**
- **Improve residential and non-residential building resiliency**

Windmill at the Scott Haggerty Wind Energy Center just outside Livermore.

Strategy E-1: Enhance community energy resilience

As natural gas-powered appliances are replaced with electric appliances as part of climate change mitigation, and heating and cooling become increasingly important to adapt to extreme heat and high-smoke days, it is more important than ever to have uninterrupted carbon-free energy generation. Strengthening community energy resilience in Livermore also contributes to Livermore's carbon neutrality goals through increased generation of local renewable energy in addition to implementing a microgrid pilot project. Energy resilience also is foundational for achieving heat and wildfire smoke adaptation actions, which involve cooling and filtering indoor air to increase the health and wellbeing of Livermore residents during these events. Energy resilience also means developing and implementing strategies to reduce the impacts from Public Safety Power Shutoffs which have become more common due to climate change.

Building grid resiliency will rely on a multifaceted approach of assessing existing grid vulnerabilities, building-out local energy generation and storage, and implementing energy efficiency strategies. Improving building resiliency will also emphasize incentives and resources for rental property owners and low-income residents so that energy resilience at the individual-building level is implemented for all. Benefits from this strategy could include the generation of local green jobs as the City promotes on-site power generation and green retrofits. As residential and nonresidential buildings continue to pursue weatherization, both residents and businesses will see long-term savings on energy bills because of more efficient heating and cooling.

Implementing actions for energy resiliency will require strong partnerships and leveraging new sources of funding. Actions that require partnership with other cities, and stakeholders like East Bay Community Energy (EBCE) and Lawrence Livermore National Laboratory will be relatively low-cost to the City, as most costs will stem from staff time spent on partnership development and coordination. Other actions will require new infrastructure investments. Microgrids, which allow a grid to function autonomously even during power outages, have relatively large upfront costs. The best strategy of the cost of microgrids is the cost per unit capacity ($/megawatt [MW]). In California, the average cost per MW of storage added is $3.5 Million.[6] However, these costs can be financed or even completed through public private partnerships and can significantly increase resilience in the City.

6. Asmus, Peter, Adarm Forni, and Laura Vogel. Navigant Consulting, Inc. 2017. Microgrid Analysis and Case Study Report. California Energy Commission. Online at *https://ww2.energy.ca.gov/2018publications/CEC-500-2018-022/CEC-500-2018-022.pdf*. Accessed June 1, 2021.

E-1 ACTIONS

E-1.1 Increase local and regional grid reliability

Work with EBCE, PG&E, other Tri-Valley cities, and the Lawrence Livermore National Laboratory to create a regional grid reliability strategy, with the goal of assessing vulnerabilities to maximize local resilience.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Long-term

E-1.2 Expand microgrid deployment

Based on the results of the municipal pilot (M-1.2) expand microgrid deployment to provide resilience at critical facilities (fire, police, city hall) and in vulnerable communities. Partner with the Lawrence Livermore National Laboratory on microgrid projects and identify and pursue opportunities to obtain state and federal funding.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$$	Mid-term

E-1.3 Improve resilience of residential buildings

Implement a Neighborhood Retrofit Program to improve resilience in residential buildings (i.e., on-site power generation and storage, weatherization, air conditioning, etc.), with an emphasis on connecting incentives and resources with rental property owners and low-income residents. Partner with community organizations to leverage existing resources.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

E-1.4 Improve resilience of non-residential buildings

Develop an equitable incentive program to improve resilience in nonresidential buildings to prevent disruptions in the local economy during power outages.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

Drought

2030 Objectives

- **Improve water conservation and reuse**
- **Study and establish standards for on-site water reuse**
- **Develop a water-efficient demonstration program**
- **Continue to provide water-efficiency devices and encourage residential water capture and reuse**

Winners of the City of Livermore's Beautification Committee Award.

Strategy D-1: Improve water conservation and reuse

Drinking water in Livermore is a combination of local groundwater and imported water from the State Water Project. Water availability in Livermore is variable and is dependent on rainfall and snowpack in the Sierra Mountains, both of which are expected to be negatively impacted by climate change.[7] As the City's water supplies fluctuate and shrink, it is critical to build-up resilience and reserves of water that can be used during droughts that are sourced independently of the State Water Project and leverage on-site water reuse and recycling.

Livermore's water resilience strategy levies multiple actions for on-site water reuse and water conservation. Actions to bolster drought resiliency will transform the way Livermore currently uses water, from implementing water efficient landscaping to updating wastewater treatment methods to increase recycled water availability. A keystone part of Livermore's drought resilience strategy will be to develop on-site water reuse standards. Implementing drought resiliency actions will also depend on showing businesses and residents ways to reduce water demand in landscaping through a water-efficient demonstration program, and the continued provision of free or subsidized water conservation devices to residents in collaboration with Zone 7 and Cal Water.

Costs associated with strategy D-1 include staff and consultant time to develop and implement new plans and standards for water reuse as well as costs for subsidized water-use reduction devices. Community costs include upfront costs for developing on-site water reuse systems for new development and retrofit costs for drought tolerant landscaping and water capture devices. However, these upfront costs will be offset by long-term water savings and the priceless value of a reliable water supply.

7. *www.livermoreca.gov/water*

D-1 ACTIONS

D-1.1 Study on-site water reuse

Partner with Zone 7, Cal Water, large water users, and other stakeholders to study a broad range of strategies for on-site stormwater capture, wastewater treatment, and reuse in commercial and residential settings.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

D-1.2 Establish standards for on-site water reuse

Establish standards to expand on-site water reuse, such as requiring new developments and major renovations to meet certain plumbing and irrigation demands with greywater or stormwater

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Mid-term

D-1.3 Continue implementing the Water Efficient Landscape Ordinance

Continue implementing the Water Efficient Landscape Ordinance during plan check and inspections of new and renovated landscaping.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Short-term

D-1.4 Develop a water-efficient demonstration program

Collaborate with residents, businesses, and agency partners to promote native, drought-tolerant landscaping through demonstration projects. Identify and promote incentives and financing opportunities.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Short-term

D-1.5 Continue to provide water-conservation devices and encourage residential water capture and reuse

Continue working with Zone 7 and Cal Water to provide free or subsidized water-conservation devices to residents with a focus on low-income communities. Encourage the installation of cisterns and other water-storage devices for single-family homes to capture rainwater for irrigation uses.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Ongoing

Flooding

2030 Objectives

- Improve stormwater management
- Harness Livermore's natural landscapes to improve stormwater management through wetland restoration and tree planting
- Update standards to expand permeable hardscapes and passive rain capture

Strategy F-1: Improve stormwater management

Floods are among the deadliest and most common type of natural disaster in the United States.[8] They are caused by an overflow of inland waters (like rivers or streams) or accumulation of water from heavy rains. As an inland city, Livermore is most vulnerable to urban flooding, where heavy rainfall overwhelms the local stormwater drainage capacity due to runoff from roads, parking lots, and other impervious surfaces.[9] As storm events increase in duration and intensity, Livermore will need to increase local capacity to absorb and channel stormwater while not having it overwhelm the local management system.

Actions to reduce flood risk harness existing ecosystems in Livermore to passively absorb rainwater in the urban environment through green spaces like vegetative swales and tree planting. Policies and incentives will also be levered to improve stormwater management through expanded standards for passive rainwater capture in new infrastructure and development projects and new incentives for passive rain capture features in existing landscapes developed in partnership with water and wastewater providers. Hardscapes like impervious parking lots and buildings will be reduced in future developments, ensuring that flood-vulnerable hardscapes do not expand as a result of local economic development. Implementing these actions for resiliency will require staff time and cost and maintenance of permeable surfaces.

On the community side, businesses will need to consider the cost of incorporating pervious materials. However, benefits may also be seen from savings associated with decreased flood damage. Wetland restoration and tree planting as part of this adaptation strategy will deliver benefits in increased environmental quality as the urban canopy expands and urban creeks and floodplains are revitalized with native plant species. The expansion of green spaces, particularly the urban canopy, will also bring down the temperature and help Livermore adjust to rising temperatures. Finally, flood reduction actions can also help to capture rainwater for future reuse, increasing drought resiliency.

8. *https://www.fbiic.gov/public/2010/mar/FloodingHistoryandCausesFS.PDF*
9. *https://www.nrdc.org/stories/flooding-and-climate-change-everything-you-need-know*

F-1 ACTIONS

F-1.1 Prioritize wetland restoration

Implement projects in the Stream Maintenance Plan that will revitalize urban creeks and floodplains, encourage groundwater recharge, and use native plant species to reduce flood risk and restore riparian habitats. Support and promote local programs such as Living Arroyos.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Long-term

F-1.2 Prioritize flood-resiliency projects

Implement stormwater management projects identified in Livermore's Storm Drain Master Plan, Green Infrastructure Plan, and Capital Improvement Program that improve flood resilience from future storms. Ensure new infrastructure and retrofits are adequately sized to handle future flows exacerbated by climate change.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$$	Long-term

F-1.3 Expand passive rain capture standards

Expand the requirements for passive rain capture features, such as vegetative swales and planting trees, in new infrastructure and development projects, particularly in areas of the city that are vulnerable to flooding.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Mid-term

F-1.4 Provide incentives to increase passive rain capture

Work with water and wastewater providers to create and promote incentives for existing landscapes to incorporate passive rain capture features.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Mid-term

F-1.5 Require new hardscape to be permeable

Update standards for new development hardscape to be consistent with CALGreen Tier 1 and/or increase the current fee for installation of new impervious surfaces.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Mid-term

F-1.6 Combine tree planting and stormwater management

Include stormwater management strategies like bioswales when implementing tree planting and other urban greening programs, with a focus on low-income communities.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Long-term

Extreme Heat

2030 Objectives

- **Increase resilience to extreme heat events**
- **Cool neighborhoods by expanding the urban canopy and sources of shade**
- **Identify heat vulnerable areas and populations and enhance equity-focused heat response in emergency planning**
- **Develop cooling centers that are energy-resilient**

Shade structures at May Nissen Park

Strategy H-1: Increase resilience to extreme heat events

Adapting to rising temperatures, extreme heat events, and longer, more frequent heat waves will become a fixture of life in Livermore. Without resiliency strategies, extreme heat can be fatal, and disproportionately affects community members who are elderly, children, have pre-existing physical or mental health conditions, and do not have access to indoor air conditioning. Ensuring that Livermore's vulnerable populations have access and awareness of indoor cooling options and reducing the heat in Livermore's urban areas through expanded shade and urban greening will be critical to ensuring that Livermore's community can stay comfortable and healthy during a hotter future.

Actions to address heat events will rely partially on planning efforts. Specifically, the development of a heat vulnerability index to identify Livermore's most heat-vulnerable areas and populations and developing a heat mitigation plan to reduce urban heat and prepare for higher temperatures. Syncing with actions for carbon sequestration, heat planning also connects with the implementation of an Urban Forest Management Plan, which will expand tree canopy shade, reducing the urban heat island effect. These urban greening efforts will contribute to environmental quality and biodiversity in Livermore, while providing key cooling benefits. The cost to the City of implementing these actions will be moderate, entailing staff time, tree planting costs, shade structure implementation, and retrofit program implementation. The community is not expected to incur any mandatory costs but will certainly experience the benefits of cooler neighborhoods and robust heat emergency strategies. Residents who participate in heat resilience strategy implementation in their homes may see some costs if they decide to participate.

The City will also improve energy resilience in cooling centers, ensuring that they are not vulnerable to power outages and are also using carbon-free electricity to provide indoor cool air to the populations that need them most. Finally, actions to help the Livermore community withstand higher temperatures include integrating heat into Livermore's Emergency Operations Plan and providing well-being checks to vulnerable populations including low-income families, older adults, speakers of non-English languages, and Livermore's unsheltered population. These outreach efforts are both low-cost and have high levels of positive public health impact.

H-1 ACTIONS

H-1.1 Study heat vulnerability

Building off efforts in the 2023 Tri-Valley Local Hazard Mitigation Plan, create a Heat Vulnerability Index to identify and map heat-vulnerable areas and populations in the city. Explore actions to reduce urban heat and prepare for higher temperatures and more frequent extreme heat events.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

H-1.2 Expand tree canopy cover in the city

Utilize the City's new street tree inventory and other available tools to identify areas of the city with low tree canopy cover. Focus tree planting in areas with underserved and vulnerable populations.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

H-1.3 Create a neighborhood cooling program

As part of a Neighborhood Retrofit Program (E-1.3), implement cooling strategies consistent with the Heat Mitigation Plan. Strategies could include planting trees, using heat-resistant materials, and installing heat pump HVAC units. Partner with local nonprofits and organizations to provide resources to low-income residents for retrofits. Partner with manufacturers or installers to make bulk purchases and installations in the community.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

H-1.4 Establish shade standards

Establish and implement shade standards to encourage continuous shade for human movement in areas with high public transit use to protect public transit riders from extreme heat and precipitation events. Standards may encourage shade-providing building features, such as galleries, arcades, and awnings, bus and train shelters, and tree planting.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Mid-term

H-1.5 Install additional shade structures

Build shade structures at public destinations that lack adequate tree cover, major transit stops, and along non-motorized transportation corridors, such as those identified in the City's Active Transportation Plan. Prioritize communities with high-heat vulnerability.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$$	Long-term

H-1.6 Increase resilience at cooling centers

Ensure cooling centers have backup power systems in place to operate during power shutoffs. Explore the use of public libraries and other trusted community-serving facilities as additional cooling centers.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Short-term

H-1.7 Enhance heat response in emergency planning

Integrate an emergency heat plan into the City of Livermore's Emergency Operations Plan that provides an emergency notification and well-being checks to protect the most vulnerable populations, such as Livermore's unsheltered population, low-income families, speakers of non-English languages, and older adults.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

Wildfire

2030 Objectives

- **Mitigate wildfire risk and improve preparedness**
- **Facilitate building retrofits, operate clean air centers, and stockpile personal protective equipment to protect the community during wildfire smoke events**
- **Reduce fire risk through fire-safe landscaping standards and fire fuel-load reduction programs**
- **Improve emergency alert systems through updated hazard planning and outreach**

The City and LARPD use goats for weed abatement to prevent wildfires.

Strategy WF-1: Mitigate wildfire risk and improve preparedness

Although wildfire events are not expected to increase within Livermore's city limits, vulnerable populations will still be affected by wildfire smoke, and experience negative health outcomes due to decreased air quality during smoke events. Livermore is also surrounded by natural and working lands that are vulnerable to wildfire. Livermore's wildfire resilience strategy combines updated hazard planning, fire prevention, and increased supports and infrastructure for maintaining public health and indoor air quality during smoke events.

A major part of the CAP strategy for wildfire resilience is reducing the potential for wildfires to occur. The City will continue to implement the community fire and fuel-load reduction programs while conducting outreach for fire-safe landscape management in multiple languages.

These planning and outreach strategies are relatively low-cost but contribute significantly to Livermore community preparedness, safety, and fire reduction.

Planning for the changing risk profile for wildfire will be updated in the General Plan Safety Element and Tri-Valley Local Hazard Mitigation Plan. This updated planning will be combined with encouraged use of the Alameda County (AC) Alert system to let business owners and residents know about wildfire and smoke events via multilingual and culturally appropriate outreach. Finally, the City will strengthen resiliency for indoor air quality during smoke events by stockpiling personal protective equipment and operating energy-resilient clean air centers. Implementing these strategies across the community may entail a small increase in development cost as new fire standards are adopted. However, the City will bear most of the cost of implementation to adapt to wildfires.

WF-1 ACTIONS

WF-1.1 Update hazard planning for wildfires

Update the General Plan Safety Element and Tri-Valley Local Hazard Mitigation Plan to reflect the changing risk profile for wildfire including emergency response capabilities and evacuation plans.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Short-term

WF-1.2 Create fire-safe landscaping standards

Adopt fire-safe landscaping standards for new construction and major renovations that are based on the risk profile.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Mid-term

WF-1.3 Facilitate building retrofits that maintain indoor air quality

As part of the Neighborhood Retrofit Program, incentivize building retrofits that help maintain indoor air quality during wildfires, including ventilation, filtration, and cooling, with an emphasis on connecting incentives and resources with low-income residents.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Short-term

WF-1.4 Continue to implement community fire fuel-load reduction programs

Continue to update and implement the annual Vegetation Management Program and Weed Abatement Program to remove and thin vegetation.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Ongoing

WF-1.5 Continue to conduct outreach on fire prevention measures

Continue to conduct multilingual public education programs to raise awareness of the new standards and best practices for fire-safe buildings and landscape management. This should include information about maintaining defensible space and implementing low-cost fire prevention measures, such as vegetation management and screening attic vents.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Ongoing

WF-1.6 Operate clean air centers

Ensure cooling centers can also function as clean air centers. Maintain temperature/air quality thresholds that dictate when these facilities become available. Gather input from users to determine how these facilities can continue to be improved and support daily life, such as by offering indoor exercise and recreation activities/spaces.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Short-term

WF-1.7 Stockpile personal protective equipment

Stockpile masks and other personal protective safety equipment for community use during wildfire and/or smoke events and prioritize distribution to vulnerable communities.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Short-term

WF-1.8 Encourage use of the AC Alert system

Promote the AC Alert system to residents and business owners through multilingual, proactive, and culturally relevant outreach methods, with a focus on boosting enrollment in vulnerable communities.

Benefits					City Cost	Timeline
Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Short-term

3-3. Mitigation Strategies & Actions

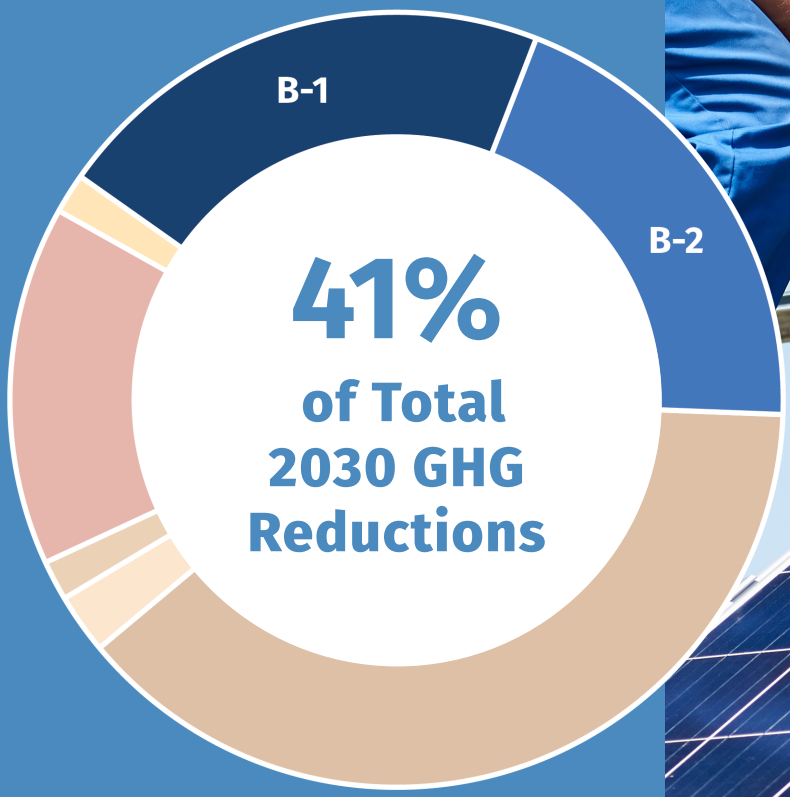
Buildings and Energy

2030 Objectives

- Provide 100 percent renewable electricity by 2024
- Require all-electric new construction by 2023
- Incentivize electric retrofits in 12% of existing buildings by 2030
- Develop equitable funding and financing for building electrification
- Incentivize local on-site energy generation and storage

GHG Reductions

- Strategy B-1 = 27,383 MT CO_2e
- Strategy B-2 = 25,505 MT CO_2e



Strategy B-1: Require new buildings to be all-electric and incentivize electrification retrofits of existing buildings.

Electrification is the most feasible and reliable way that Livermore can meaningfully reduce its GHG emissions to meet its 2030 target.

With the adoption of SB 100 (which requires 100 percent carbon free electricity), all-electric buildings will be carbon neutral by 2045, while buildings with natural gas systems will continue to produce GHG emissions. Buildings generated 33 percent of Livermore's total GHG emissions in 2017. As the grid decarbonizes, electricity used in buildings will become carbon-free, leaving natural gas used for cooking, water, and space heating as the remaining significant sources of emissions. Reducing future natural gas use by preventing it in new construction and making strides towards electric retrofits of natural gas-powered appliances will be essential in achieving Livermore's carbon-neutrality goals.

Building new all-electric buildings in Livermore is more cost-effective than building traditional mixed-fuel buildings, mostly due to cost savings resulting from not needing to install natural gas infrastructure. All-electric homes are also more efficient than those that use natural gas in Livermore's climate zone, reducing lower utility bills for low-income families. Electrification will further relieve the expected future energy burden on low-income families, as natural gas prices are projected to increase significantly due to decreased gas consumption and aging infrastructure.[10] Switching to electric appliances also has the benefit of improving public health, as burning natural gas in poorly ventilated buildings can significantly increase harmful indoor air pollutants that are linked with a higher risk of respiratory illnesses, particularly in vulnerable populations. Peer reviewed studies have documented that residences with gas stoves have a 50 to 400 percent higher average nitrogen dioxide concentrations than homes with electric stoves.[11] Living in a home with a gas stove may increase children's risk of asthma by 42 percent.[12] Given that Californians spend 70 percent of a given day indoors,[13] and potentially more given the context of the COVID pandemic, indoor air quality is an important health consideration for many. Gas usage that occurs within our buildings also causes outdoor air pollution and generates six times more nitrogen oxides emissions than all in-state power plants combined.[14] Outdoor air pollution from buildings has been linked to pre-mature deaths in California.[15]

This strategy, and its resulting actions will be predominantly implemented through City ordinance and partnerships, which tend to be cost-effective to implement while providing long-term climate benefits. Passing an electrification ordinance will include staff time spent by existing personnel, in addition to consultant time. Livermore residents will experience cost savings as well: cost-effectiveness studies show that new building electrification costs less to build than mixed-fuel buildings, particularly when built with heat pumps instead of resistance heating. Though electrifying existing buildings to reduce natural gas consumption can have higher upfront costs, retrofitting existing buildings also provides significant long-term climate benefits. Community costs include retrofitting existing infrastructure, which varies depending on the appliance. Providing financing and incentives from the City could significantly reduce the cost burden on communities to replace non-electric appliances. More information on costs related to building electrification can be found in the Cost Technical Appendix.

10. *https://gridworks.org/initiatives/cagas-system-transition/*
11. U.S. EPA. Integrated Science Assessment (ISA) for Oxides of Nitrogen – Health Criteria (Final Report, Jul 2008). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/071, 2008. *https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=194645*.
12. Weiwei, L., Brunekreef, B., & Gehring, U. (2013). Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children. International Journal of Epidemiology, 42(6), 1724–1737. *https://doi.org/10.1093/ije/dyt150*.
13. Klepeis, N. E., Nelson, W. C., Ott, W. R., Robinson, J. P., Tsang, A. M., Switzer, P., ... & Engelmann, W. H. (2001). The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. Journal of Exposure Science & Environmental Epidemiology, 11(3), 231–252.
14. California Air Resources Board. 2016 SIP Emission Projection Data: 2012 Estimated Annual Average Emissions. *https://www.arb.ca.gov/ei/emissiondata.htm*
15. Dedoussi, I. C., Eastham, S. D., Monier, E., & Barrett, S. R. (2020). Premature mortality related to United States cross-state air pollution. Nature, 578(7794), 261–265.

B-1 ACTIONS

B-1.1 Require new construction to be all-electric

Adopt an electrification ordinance which requires all new construction to be all-electric. Conduct a cost-effectiveness study to develop an ordinance that facilitates both construction and on-bill cost savings. Minimize the number of exemptions associated with the ordinance to limit the number of stranded natural gas lines in the city. Allow case by case allowances for certain site development standards when an applicant can demonstrate infeasibility. Leverage partnerships with the Building Decarbonization Coalition, EBCE, StopWaste, and others, to engage with local building industry stakeholders in development of the ordinance.

GHG Reduction	Benefits	City Cost	Timeline
2030: 10,891 MT CO_2e **2045:** 28,056 MT CO_2e	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Short-term

B-1.2 Incentivize electric retrofits in existing buildings

Incentivize voluntary electrification of existing buildings through incentives, rebates, permit streamlining, and education. Develop a suite of equity strategies to limit displacement and promote equitable distribution of electrification benefits like resilience, improved health and safety, and reduced energy cost burden. Partner with stakeholders such as EBCE and PG&E to establish funding pathways to ease community costs for electrification upgrades.

GHG Reduction	Benefits	City Cost	Timeline
2030: 16,492 MT CO_2e **2045:** 93,437 MT CO_2e	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$	Mid-term

B-1.3 Conduct a cost analysis and feasibility study for existing building electrification requirements

Conduct an existing building electrification feasibility and cost study to understand the potential for, and associated costs of, electrification retrofitting requirements. This would include an analysis for implementing requirements for newly permitted heating and cooling systems, hot water heaters, and other electric appliances.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$	Mid-term

B-1.4 Partner with stakeholders to conduct electrification outreach, promotion, and education

Leverage partnerships with stakeholders to conduct multilingual outreach, promotion, and education around building electrification, including:

- Creating a list of water heater, space heating, and appliance (electric stove/dryers) replacement programs and incentives.
- Hosting an induction/electric stove cooking competition to demonstrate the benefits of electric stoves.
- Organizing events to educate the public on the potential health and cost benefits of replacing gas stoves with electric.
- Offering workforce development trainings for installers and building owners/operators to discuss benefits and technical requirements of electrification.
- Conducting internal trainings with planners and building officials on state decarbonization goals and incentives available for electric homes.
- Conducting targeted outreach to rental property owners to facilitate upgrades that benefit renters.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Mid-term

Strategy B-2: Decarbonize electricity from the grid and increase local renewable energy generation.

In order for Livermore to reach its 2030 reduction target and 2045 carbon-neutrality target, the majority of energy utilized in the City will need to be carbon-free. Renewable electricity procurement is essential for decarbonizing the communities emissions from electricity and will create the foundation for a carbon-free future. The focus of Livermore's energy strategy is procuring 100 percent carbon-free electricity for both residents and businesses as soon as possible. Decarbonizing electricity works hand-in-hand with building electrification and EVs to achieve carbon neutrality in both the building and transportation sectors in Livermore.

One of the primary actions in the energy decarbonization strategy is opting all community accounts into a 100 percent carbon-free or renewable electricity tier through EBCE. As this is a one-time action by City Council, the major costs are staff time (preparing staff reports and conducting community outreach). The community may experience a marginal increase in electricity costs as a result of this action. However, increased electricity cost is dependent on the rate plans used by the household or business: certain plans will experience no increase, and others may experience a marginal on-bill cost. Other actions under B-2 include conducting outreach to low/moderate income households to increase awareness about EBCE's CARE Program, which provides a discounted rate for electricity to qualifying low-income households.

Other actions within Strategy B-2 provide important benefits including increased energy-system resilience through storage and continued analysis of other energy opportunities like hydrogen. Geographic diversification of energy generation reduces the impact of a single event, like a storm or technology failure, on central location. Increasing generation and storage of local renewable energy is considered to be high-cost, as specific financing and funding opportunities have not yet been identified. However, these actions yield long-term substantial climate impacts and can provide long-term savings.

Stakeholder collaboration between the City, PG&E, EBCE, and other community partners will be key to increasing local energy generation and storage incentives. Promoting energy storage at the same time as increased local renewable energy, like community solar, will be an essential strategy for success.

B-2 ACTIONS

B-2.1 Opt-up community EBCE accounts to 100 percent renewable electricity

Opt-up community EBCE accounts in Livermore to 100 percent renewable electricity by 2024. Achieve an opt-out rate lower than 4 percent from 100 percent renewable. Conduct public outreach and education to highlight the benefits of 100 percent renewable energy. Partner with community-based organizations to ensure low/moderate income households are aware of EBCE's CARE program to receive decreased electricity rates.

GHG Reduction	Benefits					City Cost	Timeline
2030: 25,505 MT CO_2e **2045:** 0 MT CO_2e	Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$	Short-term

B-2.2 Coordinate with stakeholders to provide local energy generation and storage incentives

Partner with PG&E, EBCE, and/or other community partners to support and incentivize local on-site energy generation and storage. This could include:

- Connecting home and business owners, particularly those in vulnerable communities, to incentives for renewable energy and storage projects.
- Promoting installation of storage technology in concert with renewable energy infrastructure through multilingual education programs, outreach, and information provided via City platforms.
- Installing a co-located community solar and storage facility to demonstrate the benefits.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Green Economy	$	Mid-term

B-2.3 Establish renewable energy facility standards and permitting requirements

Establish renewable energy facility standards and permit requirements, including solar arrays and battery storage systems, to allow for easier implementation of these technologies in the city.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Green Economy	$	Mid-term

B-2.4 Explore hydrogen and renewable fuel opportunities

Seek assistance from Sandia National Laboratory to identify opportunities to expand hydrogen and renewable fuel projects, particularly in the transportation and industrial sectors.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction	$	Short-term

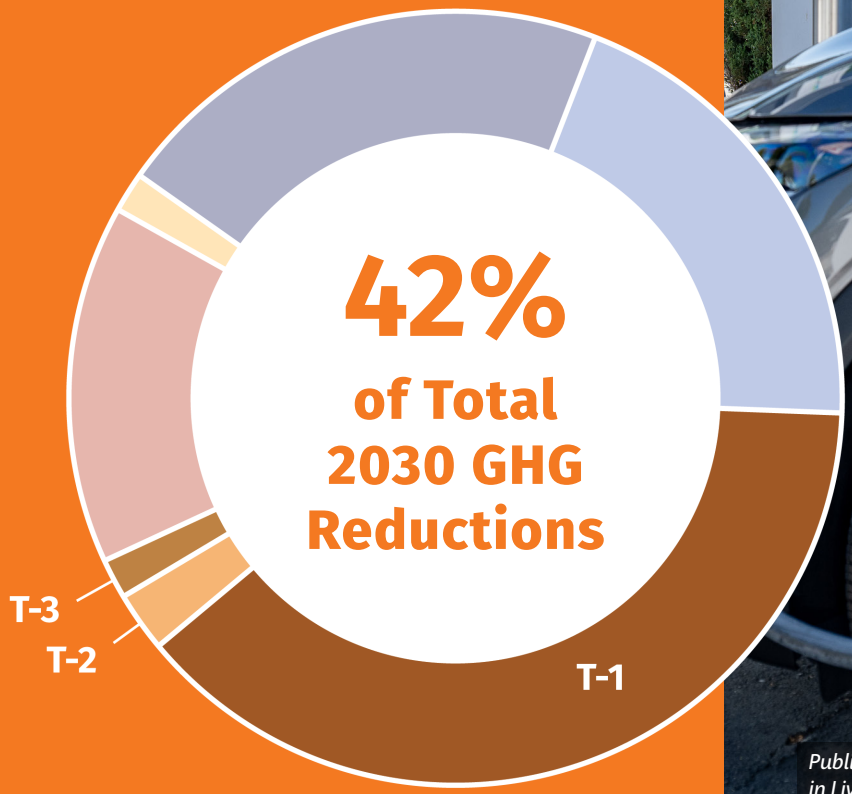
Transportation and Land Use

2030 Objectives

- Add 1,283 publicly accessible electric vehicle chargers
- Reduce Vehicle Miles Traveled (VMT) by 2%
- Achieve 10% bike mode share
- Support sustainable land use practices

GHG Reductions

- Strategy T-1 = 49,494 MT CO_2e
- Strategy T-2 = 3,033 MT CO_2e
- Strategy T-3 = 2,127 MT CO_2e



Public electric vehicle chargers at the San Francisco Premium Outlets in Livermore

Strategy T-1: Facilitate a transition to electric vehicles

Reducing transportation GHG emissions will require reducing the number of miles driven by on-road fossil fuel-powered vehicles, from both passenger and commercial vehicles. On-road transportation accounts for almost 59 percent of total GHG emissions in Livermore, with 58 percent of those emissions coming from passenger vehicles, and 42 percent coming from commercial vehicles (see Appendix A). It is important to electrify the transportation sector so it can benefit from increasingly clean electricity as a result of SB 100. Additionally, reducing tailpipe air pollution through EV adoption provides public health benefits as it reduces a major source of outdoor air pollution.

Actions under Strategy T-1 expand the adoption of EVs across the residential and commercial sectors, primarily through electrification infrastructure installation and ordinances for new construction which will require lifecycle cost saving steps like installation of conduit and panel capacity.

Costs to the City in implementing actions to promote EV adoption include the development of an EV Readiness Plan. A key part of this plan will be identifying funding sources for installing chargers. Implementing these actions rides heavily on effective outreach and education, as well as partnership development with major employers like the Lawrence Livermore National Lab to expand employer adoption of EV use and charging infrastructure. On the community side, developers may see increased costs of conduit and panel capacity for EV capable charging spaces in new development as well as the costs of charger installation. The long-term cost savings of owning an EV could offset the purchase of an internal combustion vehicle.

T-1 ACTIONS

T-1.1 Expand EV infrastructure to support EV adoption

Expand EV infrastructure to support EV adoption in the community by doing the following:

- Establishing standards for EV chargers in new development that expand requirements for EV-Capable, EV-Ready, and/or EV-Installed spaces; Introduce preferential parking for EVs near building entrances at popular destinations; Require all new gas stations and major remodels to install an EV charger; Establish universal, accessible, and multilingual EV signage and marking requirements for EV parking spaces;
- Partnering with stakeholders, like EBCE, BayREN, and affordable housing providers, to coordinate incentives and/or rebates for at-home electric circuits, panel upgrades, and Level 2 chargers, with a focus on supporting EV upgrades for low-income households. Provide multilingual education and outreach to the community on available programs.
- Working with the Livermore Valley Chamber of Commerce, Livermore Downtown Inc, and major employers (e.g., Lawrence Livermore National Lab, Kaiser Permanente, GILLIG, Topcon, LARPD, and LVJUSD) to encourage EV adoption and improvements to EV infrastructure.
- Promoting the availability of public chargers on social media and the City website.

GHG Reduction	Benefits	City Cost	Timeline
2030: 49,494 MT CO_2e **2045:** 93,458 MT CO_2e	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$	Short-term

T-1.2 Identify barriers to electric vehicle adoption

Assess EV infrastructure needs and challenges, strategies to increase EV infrastructure and EV adoption, particularly in underserved communities, and identify funding for charging infrastructure.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$	Short-term

T-1.3 Electrify retail delivery vehicles

Establish licensing fees for vehicles making deliveries, such as online retail deliveries, to provide funding for new active transportation and EV charging infrastructure, and/or provide discount licensing fees for delivery companies which utilize electric vehicles.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Mid-term

T-1.4 Reduce sources of idling emissions

Adopt an ordinance limiting new drive thru businesses and other sources of idling emissions.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Mid-term

T-1.5 Develop an EV car-share pilot program

Work with stakeholders to develop an EV car-share pilot program to provide access to a low-cost and emission-free mobility option in low-income communities.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$	Mid-term

Strategy T-2: Facilitate a transition to transit and shared mobility services

Providing expanded access to mobility programs and transit service will be a vital part of reducing transportation emissions for Livermore, as well as improving transportation equity in the region.

Livermore will support regional transit providers, including the Altamont Corridor Express (ACE), Bay Area Rapid Transit (BART), and the Livermore Amador Valley Transit Authority (LAVTA)[16], to expand service lines and increase the convenience of transit by reducing the time it takes to reach a destination via transit as well as reducing wait times (headways) for transit. Improving shared mobility and transit programs and infrastructure will also help to shift mode share to public transit. Working with the recently created Tri-Valley – San Joaquin Valley Regional Rail Authority will also be key to achieving greater use of public transportation, specifically on the proposed Valley Link project which would connect the existing BART station in Dublin/Pleasanton to the approved ACE North Lathrop Station in San Joaquin County.[17]

Most City costs associated with implementation of this action involve developing partnerships to expand and improve transit systems, as well as outreach and education. If the City chooses to pursue a pilot program for e-bikes or scooters, installation and implementation would entail additional city costs. Members of the Livermore community would experience minimal costs and expanded wallet-friendly options to get between destinations in the city. Improving transportation equity is also a critical part of this strategy and involves identifying and removing barriers for Livermore's vulnerable communities to take public transit, walk, bike, or use rideshare/carshare.

T-2 ACTIONS

T-2.1 Improve transit and shared mobility services.

Improve transit and shared mobility services to reduce single-occupancy vehicle travel by doing the following:

- Supporting efforts by transit providers to offer more frequent and reliable transit service; improve service/communication through multilingual interactive service maps, mobile payments, and real-time arrival info; improve active transportation access to transit stops; and provide enhanced, comfortable stops and stations.
- Consider a pilot program downtown, ideally with e-bikes or scooters.
- Conducting a shared mobility services (e.g., car-share, bike-share, scooter-share) feasibility study, possibly in coordination with neighboring communities Pleasanton and Dublin.
- Based on the feasibility study, establish standards for shared mobility services to operate in Livermore.
- Identify local equity issues and remove barriers for people of color, low-income, people experiencing homelessness, and senior populations to take transit, walk, bike, use rideshare, or carshare.

GHG Reduction	Benefits					City Cost	Timeline
2030: 3,033 MT CO_2e **2045:** 4,656 MT CO_2e	Public Health	Resilience and GHG Reduction	Community Connectivity	Green Economy	Environmental Quality	$$	Mid-term

16 *https://www.wheelsbus.com/wp-content/uploads/2015/08/FINAL-SRTP.pdf*
17. *https://www.valleylinkrail.com/valleylink-project*

T-2.2 Conduct a local transportation survey

Include multilingual National Citizens Survey questions related to transportation to better understand the community's needs and motivation for travelling by car versus other alternatives such as by bike or bus. Use the survey results to inform transportation projects.

GHG Reduction	Benefits	City Cost	Timeline
Not Quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Short-term

T-2.3 Establish ride-share loading/unloading zone requirements

Establish requirements for ride-share parking and loading/unloading zones in new nonresidential development.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Mid-term

Strategy T-3: Improve active transportation infrastructure

Tailpipe emissions are a major source of Livermore's GHG emissions. Reducing the number of miles driven by fossil fuel-powered vehicles, particularly when replaced with public-health boosting active modes of transportation, provides a critical way to reduce GHG reductions while connecting communities and keeping Livermore residents healthy. As part of the CAP strategy, Livermore will prioritize active transportation by expanding access to safe, low-stress, and convenient biking and pedestrian infrastructure. Expanding active transportation infrastructure will increase quality of life and public health through increased exercise and increased community connectivity.

A key part of this strategy, and the largest quantified contribution to GHG reduction comes from Implementing the Livermore Bicycle, Pedestrian, and Trails Active Transportation Plan (ATP). This is projected to add around 77 miles to the active transportation network in Livermore by 2030. An ATP fee study will explore potential funding mechanisms for implementing the ATP.

City costs associated with the expansion of active transportation include staff time devoted towards the implementation of the City's ATP. Developing bike lanes and boulevards will require costs to install (estimated $10,000 per mile), while separated bike lane cost between $1.5 and $3 million per mile. Community costs will be minimal, though may include potential funding mechanisms including sales taxes, or revenues generated through an ATP fee for new development. For more information on City and community cost, please refer to Appendix D.

T-3 ACTIONS

T-3.1 Accelerate implementation of the Livermore ATP

Implement 50 percent of the Livermore Bicycle, Pedestrian, and Trails ATP by 2030 in accordance with its goals, objectives, and policies so that the City adds approximately 77 miles to the active transportation network. Continually improve methods for engaging the community, gathering input, and utilizing it to prioritize projects that implement the ATP. Work with local active transportation organizations like Bike East Bay to identify projects and funding to accelerate implementation of the ATP. Review all ATP projects to ensure ATP projects are deployed equitably across all Livermore neighborhoods with an emphasis on connecting low-income communities to downtown and public transportation.

GHG Reduction	Benefits	City Cost	Timeline
2030: 2,127 MT CO_2e **2045:** 2,111 MT CO_2e	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$$	Long-term

T-3.2 Conduct an ATP fee study

Conduct a fee study and adopt an ordinance requiring development projects to pay fees that will be dedicated to implementing active transportation routes and infrastructure citywide.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Mid-term

T-3.3 Promote active transportation through car-free events

Identify areas of town to periodically close streets to cars, potentially coupled with the Farmer's Market or other large and regular events.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Mid-term

Strategy T-4: Support sustainable land use practices

Livermore's climate strategy includes supporting land use practices that promote sustainable development. Auto-oriented, low-density development increases vehicle miles traveled, destroys natural lands, and increases impervious surfaces that cause polluted stormwater runoff, affecting local waterways. Sustainable land use practices increase density, promote a jobs-housing match, encourage development of vacant and underutilized urban sites, and facilitate walkable and transit-oriented neighborhoods. These strategies will preserve the carbon-sequestration potential of Livermore's surrounding natural lands and reduce total driving and energy consumption. Though these actions do not have quantified GHG reductions, they lay the foundation for sustainable development in Livermore by creating a denser, better-connected, less car-dependent city.

T-4 ACTIONS

T-4.1 Promote a jobs-housing match

Update the General Plan to identify and plan for a housing supply that meets the needs of Livermore's workforce.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; **Resilience and GHG Reduction**; **Community Connectivity**; Green Economy; Environmental Quality	$$	Mid-term

T-4.2 Maximize infill development

Update the Development Code and Specific Plans to maximize opportunities for infill development.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; **Community Connectivity**; Green Economy; Environmental Quality	$	Mid-term

T-4.3 Revise parking standards for developments

Adjust parking minimums and establish parking maximums where appropriate, such as near transit.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; **Community Connectivity**; Green Economy; Environmental Quality	$	Mid-term

T-4.4 Facilitate complete and walkable neighborhoods

Update zoning in neighborhoods lacking amenities like grocery stores and parks. Work with community partners to focus these efforts in low-income communities.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	**Public Health**; Resilience and GHG Reduction; **Community Connectivity**; Green Economy; Environmental Quality	$$	Long-term

Waste and Materials

2030 Objectives

- Reduce the amount of organic waste that is landfilled 75% from 2014 levels by 2025
- Maintain or exceed 75% solid waste diversion each year
- Improve local reuse and repair programs
- Expand the use of low-carbon and recycled building materials

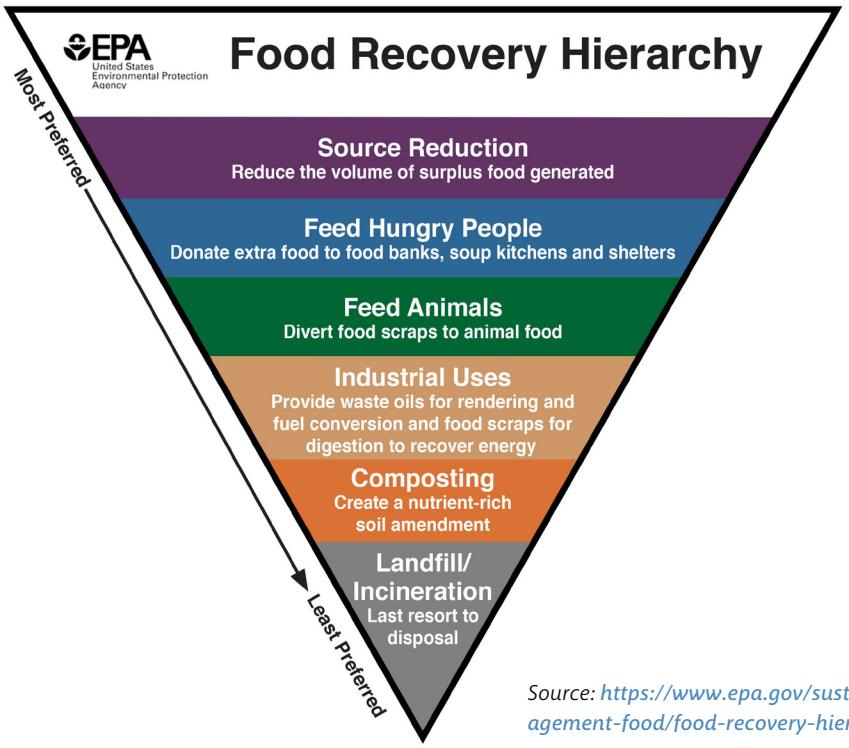
GHG Reductions

☐ Strategy W-1 = 19,379 MT CO_2e

Strategy W-1: Reduce the amount of waste that is landfilled

Emission reductions in the waste sector will be driven through compliance with SB 1383, which requires all jurisdictions in California to reduce organic waste disposal by 75 percent and increase edible food recovery by 20 percent relative to 2014 levels by 2025. SB 1383 also requires Livermore to procure 7,297 tons of compost or organic material per year. When organic materials like food scraps and yard waste get sent to landfills, they emit methane as they decompose. Methane is considered a climate super pollutant and is 28 times more potent than carbon dioxide. Landfills are the third largest source of methane emissions in California and also emit air pollutants, including $PM_{2.5}$ which are detrimental to human health.[18] Furthermore, analysis from the Natural Resources Defense Council argues that when we landfill edible food, we also should consider the lifetime emissions of getting food from farm to fork to landfill, including water inputs, fertilizer, packaging, labor, and GHGs emitted during shipping.[19] Reducing food waste by prioritizing human consumption and increasing options for composting are critical for mitigating methane emissions.

CalRecycle has provided a suite of recommendations and requirements for jurisdictions to comply with SB 1383. Livermore primarily plans to meet the requirements of SB 1383 by a holistic strategy of expanding organics collection, edible food recovery, conducting outreach and education programs, and ensuring that stakeholders comply through an inspection program. Partnership with stakeholders like Tri-Valley Haven will be critical to the success of Livermore's food recovery strategy, which ties into SB 1383 implementation as well. SB 1383 is state law and therefore, must be implemented by the City. The costs to the City are expected to include planning and implementation costs while each household is expected to see an increase of waste costs of approximately $17 per year. More information is available in Appendix C.



Source: https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy

18. *https://calrecycle.ca.gov/organics/slcp/*
19. *https://www.nrdc.org/food-waste*

W-1 ACTIONS

W-1.1 Implement the requirements of SB 1383

Implement SB 1383, which includes expanded organics collection, edible food recovery, municipal compost procurement, outreach and education programs, and an inspection and compliance program.

GHG Reduction	Benefits	City Cost	Timeline
2030: 19,379 MT CO_2e **2045:** 22,646 MT CO_2e	Public Health; Green Economy; Environmental Quality	$$	Short-Term

W-1.2 Maintain or exceed the City's solid waste diversion goal

Maintain or exceed the City Council mandated goal of 75 percent solid waste diversion every year.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Green Economy; Environmental Quality	$$	Short-Term

W-1.3 Reduce landfill waste at public events

Increase reuse, recycling, and composting and encourage reduction/reuse at temporary public events by mandating the use of recycling and organics collection co-located at every garbage can; encourage reusable food ware, when relevant, according to the California State Retail Food Code.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Green Economy; Environmental Quality	$	Mid-term

W-1.4 Improve waste management in commercial industries

Develop policies to reduce waste and increase reuse in the food industry (e.g., restaurants, facilities serving prepared food and prepackaged food, home meal delivery services), hospitality industry, and other commercial industries. Efforts may include adopting ordinances for compostable food ware, a ban on single-use individual toiletry bottles in hotels/motels, grant/discount programs for switching to reusables, and working with home meal delivery services (e.g., Blue Apron), etc. to reduce single-use packaging and encourage reuse. Provide resources for multilingual technical assistance and financial incentives for low-income entrepreneurs.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Green Economy	$$	Mid-Term

W-1.5 Reduce construction waste

Require construction sites to separate waste for proper diversion and reuse or recycling, consistent with CALGreen voluntary requirements.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Green Economy	$	Mid-term

W-1.6 Improve reuse and repair

Partner with state and other public institutions to develop and implement programs that improve reuse and repair, such as Fix-it-Clinics and tool-lending libraries. Work with retailers to develop programming around reuse and repair.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Green Economy	$$	Mid-Term

W-1.7 Work with community partners to recover food

Support community partners such as the Alameda County Community Food Bank and Tri-Valley Haven to divert edible food waste and support food insecure community members.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health, Community Connectivity, Green Economy	$	Short-Term

Strategy W-2: Expand use of low-carbon and recycled building materials

Embodied carbon, which can be defined as the GHGs emitted to construct a building, is a significant source of carbon emissions in the building and materials sector and comprises 11 percent of global GHG emissions.[20] Embodied carbon emissions for buildings in Livermore are not included in the GHG inventory for this CAP, as the manufacturing of building materials takes place outside of Livermore's boundaries. Nonetheless, the CAP includes actions to reduce embodied carbon emissions in construction.

This strategy takes place at the local, regional, and statewide level, as construction practices and norms happen beyond the bounds of a single jurisdiction. As part of Livermore's CAP actions, the City will explore standards for embodied carbon performance in new buildings, while ensuring that housing and rent costs would not be negatively impacted. The costs associated with moving towards low-carbon building materials includes outreach and engagement costs to the City, while new construction could see marginal costs increases of around 1 percent.[21]

W-2 ACTIONS

W-2.1 Raise awareness for low-carbon and recycled building materials

Work with local, regional, and state partners to promote the availability and cost-effectiveness of low-carbon and/or recycled construction materials.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; **Green Economy**; Environmental Quality	$	

W-2.2 Explore standards for new construction that limit embodied carbon emissions

Consider implementing embodied carbon performance standards and material-efficient building practices, with exemptions for cost barriers as needed to prevent these changes from directly increasing housing or rent costs.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; **Green Economy**; Environmental Quality	$	

20. *https://www.buildinggreen.com/feature/urgency-embodied-carbon-and-what-you-can-do-about-it*
21. *https://rmi.org/insight/reducing-embodied-carbon-in-buildings*

Carbon Sequestration

2030 Objectives

- Maximize local carbon sequestration
- Plant 200 trees by 2025 and 1,000 trees by 2030
- Update City landscaping standards to expand shade tree requirements for new development
- Provide free or reduced cost-trees to residents in Livermore
- Preserve open spaces
- Implement carbon-farming projects
- Explore technology-based carbon capture and storage opportunities

GHG Reductions

Strategy S-1 = 2,008 MT CO_2e

Strategy S-1: Maximize local carbon sequestration

Livermore's carbon neutrality strategy includes carbon sequestration or "negative emissions" mechanisms that remove carbon from the atmosphere. Lawrence Livermore National Laboratory (LLNL) is a leader in developing pathways to achieve carbon neutrality and eventually a carbon negative future. LLNL recent report, "Getting to Neutral: Options for Negative Carbon Emissions in California" cites three key ways California can sequester enough carbon to reach carbon neutrality:

- Capture and store carbon through natural and working lands (lowest cost)
- Convert waste biomass to fuels and store carbon dioxide (moderate cost)
- Implement direct air capture and carbon dioxide storage (highest cost)

The CAP prioritizes nature-based actions such as increasing the urban tree canopy, updating landscaping standards, preserving existing open space, and implementing soil carbon farming projects that maximize the carbon sequestration potential of natural lands. Nature-based solutions provide relatively small amounts of sequestration but maximize other benefits and minimize costs. Over time, the City will track opportunities to cost-effectively sequester carbon through biomass conversion and direct air capture.

Nature-based actions for carbon sequestration have numerous benefits, including improving environmental quality, reducing urban heat through increased shade, and improving quality of life through expanded green spaces and access to open spaces and natural landscapes. Costs for these actions include staff time for planning and implementation and the cost of materials for new tree planting and urban greening initiatives. Partnerships will be essential for implementing carbon farming projects and exploring technology-based carbon capture opportunities.

S-1 ACTIONS

S-1.1 Expand tree canopy cover in the city

Consistent with Action H-1.2, utilize the City's new street tree inventory to identify areas of the city with low tree canopy cover. Conduct tree planting efforts in these areas, with a focus on underserved and vulnerable populations. Update the City's Tree Preservation Ordinance to expand canopy coverage and climate-ready tree species. Additionally, identify strategies to repurpose timber waste (rather than incineration or chipping).

GHG Reduction	Benefits	City Cost	Timeline
2030: 58 MT CO_2e **2045:** 58 MT CO_2e	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$	Mid-term

S-1.2 Implement carbon farming projects using SB 1383-compliant organic materials

SB 1383 requires Livermore to procure approximately 7,297 tons of compost or other organic material annually. Partner with agricultural and public agency stakeholders, including the parks district and school district, on carbon farming projects to apply SB 1383-compliant organic material locally.

GHG Reduction	Benefits	City Cost	Timeline
2030: 1,950 MT CO_2e **2045:** 2,376 MT CO_2e	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$$	Mid-term

S-1.3 Update the City's landscaping standards

Update standards to expand requirements for shade trees and plant species that sequester a high amount of carbon. Ensure that the new trees are native and/or low or very low water needs per Water Use Classification of Landscape Species (WUCOLS).

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Mid-term

S-1.4 Preserve open spaces

Continue the City's open space preservation efforts to preserve open space as conservation or working land to maintain carbon sequestration and other benefits.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$$	Ongoing

S-1.5 Explore technology-based carbon capture and storage opportunities

Partner with carbon-restoration leaders, including the national laboratories, to explore opportunities for technology-based carbon capture and storage projects.

GHG Reduction	Benefits	City Cost	Timeline
Not quantified	Public Health; Resilience and GHG Reduction; Community Connectivity; Green Economy; Environmental Quality	$	Long-term

3-4. Municipal Strategies & Actions

The CAP includes several municipal strategies that complement the other mitigation and adaptation strategies within the plan. Municipal operations contribute a relatively small proportion of overall community GHG emissions. However, actions to reduce these emissions are important to show community leadership and promote more sustainable uses of local resources. GHG-emissions reductions from municipal strategies and actions were not quantified to avoid double counting with reductions from other strategies.

The municipal strategies and actions include electrification of municipal buildings, vehicle fleets, and reductions in energy usage, water, and waste. The municipal strategies also include utilization of public lands for local carbon sequestration and improving the resilience at critical municipal facilities. Each of the strategies builds on adaptation and mitigation strategies already outlined in the plan and represent a key part of the City's plan to achieve its climate goals.

Strategy M-1: Enhance resilience at public facilities.

M-1 ACTIONS

M-1.1 Demonstrate the feasibility of community wide energy resilience through a municipal pilot project

Through the development of a municipal microgrid project at a critical facility, the City will demonstrate the feasibility of expanding local electricity generation and storage to improve community resilience.

M-1.2 Expand renewable energy and battery storage projects

Install renewable energy and battery back-up systems at municipal facilities (City Hall, Police Department, Water Reclamation Plant) to increase energy independence and reliability during blackouts, extreme heat events, and other emergency incidents

M-1.3 Retrofit municipal facilities to withstand climate-related hazard conditions

Ensure that City facilities are sufficiently hardened to withstand climate-related hazard conditions, such as weatherization for extreme storm events and better seals to outdoor air during wildfire smoke days.

Strategy M-2: Electrify municipal facilities and operations.

M-2 ACTIONS

M-2.1 Opt-up municipal EBCE accounts to 100 percent renewable electricity

Opt-up municipal accounts to 100 percent renewable electricity by 2023.

M-2.2 Conduct energy audits of City facilities and evaluate life cycle costs of energy upgrades

Complete energy audits for all City facilities and implement feasible recommendations for fuel switching and efficiency upgrades. Develop a policy for the City which would require all new building upgrades to include lifecycle costing over 30 years and tie this directly to energy consumption and building electrification. This would include the building's operational and maintenance costs and ensure that the City has the most cost-effective (and sustainable) buildings possible.

M-2.3 Electrify existing buildings and increase energy efficiency

Adopt a retrofitting policy for City-owned buildings such that electrification and energy efficiency retrofits are incorporated into City buildings as part of building upgrades and repairs identified in the Capital Improvement Program.

M-2.4 Replace gas-powered landscaping equipment

Transition to all-electric landscaping equipment, including leaf blowers, for municipal operations. Use this to promote all-electric equipment in the community, providing information on the City website outlining available incentives for residents and businesses.

Strategy M-3: Electrify the City's vehicle fleet and encourage City employees to utilize alternative transportation and teleworking opportunities.

M-3 ACTIONS

M-3.1 Prepare a Fleet Electrification Plan

Prepare a Fleet Electrification Plan that outlines the transition of the municipal fleet to EVs where possible.

M-3.2 Expand EV charging at public facilities

Install new public and employee EV chargers at City-owned facilities.

M-3.3 Increase bike facilities at public buildings

Establish bike lockers at City facilities that are usable by employees and the public. Add bike locker facilities at off-street parking lots.

M-3.4 Increase teleworking opportunities

Adopt an internal policy to allow City employees to work from home on a regular basis, as specific job positions allow.

Strategy M-4: Conserve water in municipal landscaping and improve on-site stormwater management.

M-4 ACTIONS

M-4.1 Conserve water in City landscaping

Implement water conservation strategies, such as increasing efficiency and use of recycled water, in City landscaping and grounds maintenance procedures.

M-4.2 Convert existing turf areas on municipal sites

Reduce water use by converting existing turf areas to drought tolerant and/or native landscaping.

M-4.3 Convert impermeable surfaces on municipal sites

Identify impermeable surfaces that can be targeted for a transition to increased infiltration.

Strategy M-5: Purchase more sustainable products to reduce waste from City operations.

M-5 ACTION

M-5.1 Adopt a green purchasing policy

Adopt an Environmentally Preferable Purchasing Policy for municipal operations.

Strategy M-6: Utilize public lands to increase local carbon sequestration and reduce urban heat island effect.

M-6 ACTIONS

M-6.1 Expand open space management

Expand management of City-owned public lands and landscaping to improve carbon sequestration; evaluate and ensure that landscaping plans utilize native species where feasible.

M-6.2 Coordinate with other public agencies and stakeholders on carbon sequestration

Coordinate with other public agencies, including the parks district and school district, and other stakeholders on carbon-sequestration efforts including soil-carbon farming and carbon capture and storage.

3-5. Implementation Strategies & Actions

The most important facet of Livermore's CAP is how the strategies and actions are implemented in the community and how success is monitored over time. Dedicating City resources to climate efforts, tracking implementation progress, considering climate change in all City plans and processes, and communicating important initiatives to residents and business will be key to the successful implementation of the CAP. This section includes a framework for ensuring successful implementation of the strategies and actions listed in the CAP. Implementation actions like hiring or designating a climate action manager will be important drivers for the CAP's overall success.

Strategy I-1: Make climate impacts and resilience a standard consideration during planning and development processes.

The City can facilitate consistent implementation of the CAP by building climate mitigation and resilience into its regular decision-making structures. Since climate will touch nearly all of the community in one way or another, it makes sense to make climate a core decision-making variable.

I-1 ACTIONS

I-1.1 Evaluate climate impacts and risk in development review

Implement an internal process to consider climate change impacts and risks during development review. Amend the standard Planning Commission and City Council agenda report template to include a statement on how the project or program supports or addresses CAP goals.

I-1.2 Consider climate impacts and risk in Capital Improvement Program projects

Ensure that new infrastructure will be designed with forecasted changes in climate (precipitation, temperature, wildfire) in mind. Utilize the Livermore Vulnerability Tool, as well as Google Environmental Insights Explorer tools and data, to evaluate the potential climate impacts when assessing new public infrastructure projects. Utilize materials that reduce environmental impact, such as low-carbon concrete and drought tolerant plants.

I-1.3 Conduct a carbon fee study

Conduct a study and explore an ordinance requiring development fees from projects that exceed a determined threshold of carbon emissions. Dedicate revenues to implement CAP programs.

I-1.4 Evaluate the financial risks of climate impacts

Evaluate existing and potential financial risks posed by climate change to both the City and community. Recommend strategies to mitigate these risks as available and appropriate, including options for insurance products, green infrastructure bonds, real estate strategy and other appropriate mechanisms.

I-1.5 Integrate mitigation and adaptation planning in other City plans

Coordinate mitigation and adaptation planning with other City plans, including the Tri-Valley Local Hazard Mitigation Plan, General Plan, ATP, Green Infrastructure Plan, Emergency Operations Plan, Development Code, and Specific Plans.

Strategy I-2: Dedicate City resources to CAP implementation and consistently monitor progress.

While most of the strategies and actions developed for the CAP are cost effective and feasible, it will still take resources to implement. By designating a climate action manager, tracking progress, and prioritizing equitable implementation, the City can better implement the CAP for everyone in the community.

I-2 ACTIONS

I-2.1 Designate a Climate Action Manager

Create a new Climate Action Manager position responsible for implementing CAP strategies and actions by drafting ordinances, managing technical studies, leading outreach efforts, updating the online portal, networking with partners and stakeholders, and pursuing grant opportunities.

I-2.2 Establish local incentives, rebates, and streamlined permitting to facilitate CAP implementation

Establish local incentive and rebate programs to assist residents and businesses in areas such as building electrification, weatherization, water conservation, and EV charging. Streamline permitting processes to further incentivize implementation of CAP efforts.

I-2.3 Create a CAP tracking program

Develop a tracking program for CAP efforts to track annual implementation progress.

I-2.4 Report implementation progress

Report progress on CAP implementation annually to the City Council on strategy progress and establish accountability in achieving CAP goals. Report GHG emissions and CAP information to a Public Disclosure Program, such as the Carbon Disclosure Program and SEEC Clear Path.

I-2.5 Prioritize equitable implementation

Implement CAP strategies and actions through an equity lens. Work to ensure that communities who are most impacted by climate change, including people of color, low-income families, and people experiencing homelessness, benefit the most from adaptation and mitigation efforts.

I-2.6 Utilize Assistance Programs and Pursue Funding Opportunities

Pursue funding opportunities to implement CAP actions. Utilize guidance, resources, and technical expertise from partners like East Bay Community Energy and StopWaste. Expand staff capacity through programs like Civic Spark and Climate Corps.

Strategy I-3: Create a public outreach campaign to educate the community about CAP initiatives.

Many of the strategies and actions in the CAP Update can only be initiated by the City. In the end, it will take the entire community to make behavioral changes, ranging from the appliances the community buys to how the community moves around the City. However, the community cannot make these changes without the right information. The City will take a leadership role in communicating with the public, listening to hurdles, and making corrections along the way.

I-3 ACTIONS

I-3.1 Create a brand and identity

Develop a consistent brand for all climate action campaign activities, which may be used in logos and hashtags.

I-3.2 Promote transparency to the public

Communicate the City's climate action goals and progress to the public regularly, with information displayed prominently on physical and digital outlets citywide.

I-3.3 Engage with the community regularly

Hold regular climate action outreach events, such as workshops, presentations, focus groups targeted at specific community groups, public contests or challenges, and an annual event such as Earth Day or New Year's Green Resolutions. Inform the community on potential climate change impacts, as well as weatherization and other actions that community members can take to increase resilience in their home or business.

I-3.4 Target commercial stakeholders and both public and private institutions

Develop workforce trainings and information that is specifically targeted to large commercial stakeholders in the city. This may include businesses in the agriculture and viticulture sector, parks district, contractors, realtors, restaurants, school district, retail stores, and landscapers. Encourage climate change resilience planning and strategies in private companies, institutions, and systems essential to a functioning Livermore.

I-3.5 Target rental and multifamily property owners

Conduct targeted outreach to rental and multifamily property owners to incentivize upgrades for tenants, including electrification and weatherization.

I-3.6 Expand outreach and education to Livermore's youth

Partner with the school district to expand on current outreach targeted towards students within Livermore to provide opportunities for education and action implementation.

I-3.7 Establish an online resource portal

Develop an online portal that provides climate action information and resources for all stakeholders and community members. Content may include resources on rebates and regulations, guides for reducing individual GHG emissions and preparing for climate emergencies, and a calendar of upcoming climate action events.

I-3.8 Increase social resilience

Increase community resilience/social capacity by supporting Neighbors Helping Neighbors programs. These programs enable neighbors to exchange contact information, acquire supplies, and establish a neighborhood plan to assist each other, particularly vulnerable residents, during climate emergencies.

Strategy I-4: Foster green innovation in Livermore.

The future of the economy is green. Green job growth has accelerated in recent years, regularly outperforming other sectors.[22] Livermore is already at the forefront of these types of jobs and with the Lawrence Livermore National Laboratory and other local institutions, the City is in prime position to be at the forefront of green technology and other industries. These actions will help support this growth into the future.

I-4 ACTIONS

I-4.1 Expand the local green economy

Coordinate economic development efforts identified in the 2021–2025 Economic Development Strategy with CAP actions. Attract companies and organizations to Livermore that will expand the local green economy and are innovators in sectors related to climate action and resilience.

I-4.2 Partner with the national laboratories

Partner with Lawrence Livermore National Laboratory and Sandia to identify new technologies and potential pilot projects.

22. *https://www.epi.org/publication/bp349-assessing-the-green-economy/#:~:text=Greener%20industries%20grow%20faster%20than,was%200.034%20percentage%20points%20higher.*

Livermore Farmers Market

CHAPTER 4.
Implementation Plan

4-1. Implementation Plan Overview

The City of Livermore developed the CAP to be a visionary yet feasible roadmap to both decrease GHG emissions and improve overall resilience to climate change. The timelines, costs, legislative environment, and benefits assumed in this plan will continue to evolve as new information and opportunities become available. Therefore, this CAP should be viewed as a strategic framework that will be reevaluated over time.

This chapter describes the nine priority areas on which the City will focus during the first five years of CAP implementation. While other actions will likely be implemented as opportunities arise, the City will focus its resources on these foundational actions. Together, these actions will significantly reduce GHG emissions, improve resilience, spark innovation and collaboration, and engage the community.

The implementation plan also outlines the City's approach to funding and financing the priority actions, tracking and reporting implementation progress, and updating the CAP to respond to changes in legislation, technologies, and priorities.

TEAM LIVERMORE

Making meaningful progress towards reducing Livermore's GHG emissions and improving resilience starts with City leadership. The City's efforts can act as catalysts for change throughout the wider community, however, successful implementation of the CAP also depends on participation from community partners, residents, and businesses. Figure 4-1 describes the communitywide efforts that will be required transition to a resilient and carbon-free Livermore.

Figure 4-1. Team Livermore

CITY: The City can adopt ordinances, build infrastructure, streamline permitting, and connect the community to resources.

BUSINESS: Businesses can adopt new technologies and behaviors, utilize programs and incentives, and promote the benefits of adopting more sustainable business practices.

PARTNERS: Partners like EBCE, Quest, and the national labs provide education, leadership, financial assistance, and technical expertise.

RESIDENT: Residents can adopt new technologies and behaviors, utilize programs and incentives, and promote the benefits of living more sustainably.

4-2. Five-year Priority Areas

The City identified nine priority areas on which to focus for the first 5 years of CAP implementation. These priority areas were selected, because they are critical to jumpstart and sustain CAP implementation, are cost-effective and feasible steps to significantly reduce emissions, and improve resilience and align with existing efforts and available resources in the city, region, and state. This section includes more detailed costs, responsible departments, implementation timelines, and budget availability for the actions in these priority areas. The nine priority areas for the next five years are summarized in Figure 4-2.

Figure 4-2. Livermore's Five-year Priority Areas

FUNDING AND FINANCING

While some of the City's priority areas are already budgeted for and in some cases already underway, other actions will need additional funding or financing to be implemented. Action costs vary widely throughout the CAP and while many actions are low or no cost, other infrastructure related projects like microgrids and bike lanes can require significant upfront funding. However, many tools exist for cities to cover upfront costs including federal and state grants, low interest financing, bonds, and public/private partnerships. For a complete description of the costs and funding approaches the City can deploy as well as several case studies for specific measures see Appendix C.

PRIORITY AREA 1: Lay the Groundwork

The City's first step is to lay the groundwork required to jumpstart implementation. As part of this focus area, the City will establish a brand and identity for the City's ongoing climate efforts, create an online resource hub for residents to learn about climate actions, build a tool to track and communicate implementation progress, and hire a Climate Action Manager to spearhead CAP implementation and drive change throughout the city. These foundational actions will be completed within the first year.

Action		Responsible Department	Action Start Date	Community Cost	City Costs	Budgeted
I-3.1	Create a brand and identity	CDD - Planning	In progress	$	$	Yes
I-3.7	Establish an online resource portal	CDD - Planning	In progress	$	$	Yes
I-2.3	Create a CAP tracking program	CDD - Planning	Q4 -2022	$	$	Yes
I-2.1	Designate a Climate Action Manager	CDD - Planning	Q1 - 2023	$	$	Yes

CMO - City Manager's Office
CDD - Community Development Department
PWD - Public Works Department

PRIORITY AREA 2: Decarbonize Electricity and Materials

A foundational aspect of Livermore's carbon-neutrality strategy is to use carbon-free electricity. Once Livermore's electricity is carbon-free, not only will emissions from electricity drop significantly, but also will transform fossil fuel uses that are electrified by ultimately making them carbon-free.

Action		Responsible Department	Action Start Date	Community Cost	City Costs	Budgeted
M-2.1	Opt-up municipal EBCE accounts to 100% renewable electricity	CDD - Planning	Complete	$$$	$	Yes
M-5.1	Adopt a green purchasing policy	PWD - Environmental Services	Complete	$$$	$	Yes
B-2.1	Opt-up community EBCE accounts to 100% renewable electricity	CDD - Planning	Q1 -2023	$$$	$	Yes
W-2.1	Expand awareness of low-carbon and recycled building materials	CDD - Planning	Q1-2024	$$$	$	No
W-2.2	Explore standards for new construction that limit embodied carbon emissions	CDD – Planning, Engineering, Building	Q1 - 2024	$$$	$	No

PRIORITY AREA 3: Electrify Buildings and Vehicles

Once Livermore's electricity is carbon-free, the next priority will be to electrify buildings and vehicles to reduce GHG emissions and improve air quality.

Action		Responsible Department	Action Start Date	Community Cost	City Cost	Budgeted
B-1.1	Require new construction to be all-electric	CDD – Planning	In progress	$$$	$	Yes
T-1.4	Establish standards for EV charging	CDD - Planning	In progress	$$$	$	Yes
B-1.3	Conduct a cost analysis and feasibility study for existing building electrification requirements	CDD – Planning, Building	Q1 - 2024	$$$	$$	No
M-3.1	Prepare a Fleet Electrification Plan	PWD – Maintenence	In progress	$$$	$$	Yes
M-3.2	Expand EV charging at public facilities	CDD – Planning, Engineering	In progress	$$$	$$	Yes

PRIORITY AREA 4: Partner with Livermore's National Laboratories

Livermore is home to two national laboratories that conduct cutting edge research and hold a wealth of knowledge and expertise in the fields of energy and climate change. The City will deepen its collaboration with the labs to field pilot projects on cutting edge technologies. Specifically, the City will partner with Lawrence Livermore National Laboratory on carbon farming and other sequestration technologies, microgrids and energy resilience, and opportunities to utilize biogas from the City's wastewater treatment facility. The City will also pursue a partnership with Sandia National Laboratory to identify opportunities to expand the use of hydrogen fuels. The City will pursue these efforts throughout the first 5 years. However, actual projects will largely rely on the ability to secure grant funding.

Action		Responsible Department	Action Start Date	Community Cost	City Cost	Budgeted
I-4.2	Partner with the National Laboratories	CDD - Planning	In progress	$$	$	Yes
E-1.2	Expand microgrid deployment	CDD – Planning, Engineering PWD	Q1 - 2023	$$	$$	No
B-2.5	Explore hydrogen and renewable fuel opportunities	CDD - Planning	Q1 - 2023	$$	$	Yes

PRIORITY AREA 5: Engage with the Community Regularly

While the City can take meaningful action to reduce emissions and improve resilience, partnership and collaboration with the community is imperative to successful CAP implementation. Therefore, the City will prioritize engagement with the community, including Livermore's youth, through a variety of communication channels and community events. The City will also explore opportunities to establish an ongoing community advisory or working group to assist with climate efforts. Additionally, the City will regularly report implementation progress to the community.

Action		Responsible Department	Action Start Date	Community Cost	City Cost	Budgeted
I-3.2	Promote transparency to the public	CDD – Planning, CMO	Q4 -2022	$$	$	Yes
I-3.3	Engage with the community regularly	CDD – Planning, CMO	Q4-2022	$$	$	Yes
I-3.6	Expand outreach and education to Livermore's youth	CDD – Planning	Q1-2023	$$	$	Yes
I-2.4	Report implementation progress	CDD - Planning	Q4-2023	$$	$	Yes

PRIORITY AREA 6: Support Related City Efforts

Many existing City efforts are supported by the CAP and vice versa. Combining these efforts and identifying synergies is a major priority of the City. In the first 5 years, the City will integrate climate mitigation and adaptation into other City plans, such as the General Plan Update and Local Hazard Mitigation Plan Update, implement SB 1383 and the Active Transportation Plan, and replace gas-powered landscaping equipment.

Action		Responsible Department	Action Start Date	Community Cost	City Cost	Budgeted
W-1.1	Implement the requirements of Senate Bill 1383	PWD – Environmental Services	In progress	$	$$	Yes
I-1.5	Integrate mitigation and adaptation planning in other City plans	CDD – Planning; PWD	In progress	$	$	Yes
T-3.1	Accelerate implementation of the Livermore Active Transportation Plan	CDD – Planning, Engineering	Q4-2022	$	$$	Partial
M-2.4	Replace gas-powered landscaping equipment	PWD - Maintenance	Q1-2023	$	$$	No
T-4.1	Promote a jobs housing match	CDD – Planning	In Progress	$	$$	Yes
T-4.4	Facilitate complete and walkable neighborhoods	CDD – Planning	In Progress	$	$$	Yes

PRIORITY AREA 7: Utilize Assistance Programs and Funding

The major limiting factors of Livermore's previous CAP was funding and staff time. For the CAP Update, Livermore will focus on securing additional funding from both the State and other sources (as defined in Appendix C). Additionally, partners like East Bay Community Energy and StopWaste provide both guidance and resources, in areas such as building electrification and energy resilience, that the City will utilize to maximize its capacity. The City is not alone in its efforts to reduce emissions and improve resilience for the community.

Action		Responsible Department	Action Start Date	Community Cost	City Cost	Budgeted
I-2.6	Utilize assistance programs and pursue funding opportunities	CDD – Planning, Engineering PWD	In progress	$	$	Yes
I-3.5	Target rental and multifamily property owners for outreach and education related to incentive programs	CDD	In progress	$	$	Partial

PRIORITY AREA 8: Study Heat and Drought Strategies

Two of Livermore's most pressing climate challenges are extreme heat and drought. Within the first 5 years, the City will begin additional planning efforts to better define strategies that mitigate heat, conserve water resources, and expand the urban forest.

Action		Responsible Department	Action Start Date	Community Cost	City Cost	Budgeted
H-1.1	Study heat vulnerability	CDD – Planning PWD – Maintenance	Q1 - 2025	$	$$	Partial
D-1.1	Study on-site water reuse	CDD – Planning PWD – Water Resources	Q1 - 2025	$	$$	No

PRIORITY AREA 9: Develop a Neighborhood Retrofit Program

The City will coordinate with partners to develop a holistic neighborhood retrofit program that will provide the information and resources needed for Livermore's community members to upgrade their buildings to be more resilient, healthy, and decarbonized. The program will include solutions to weatherize homes and businesses, expand solar and battery systems, convert natural gas to electric equipment, improve air quality, plant trees and drought friendly landscaping, and reuse on-site water.

Action		Responsible Department	Action Start Date	Community Cost	City Cost	Budgeted
B-1.2	Incentivize electric retrofits in existing buildings	CDD PWD	Q1 - 2026	$	$$	No
E-1.3	Improve resilience of residential buildings	CDD PWD	Q1 - 2026	$	$$	No
H-1.3	Create a neighborhood cooling program	CDD PWD	Q1 - 2026	$	$$	No
WF-1.3	Facilitate building retrofits that maintain indoor air quality	CDD PWD	Q1 - 2026	$	$$	No

4-3. Progress Tracking and Reporting

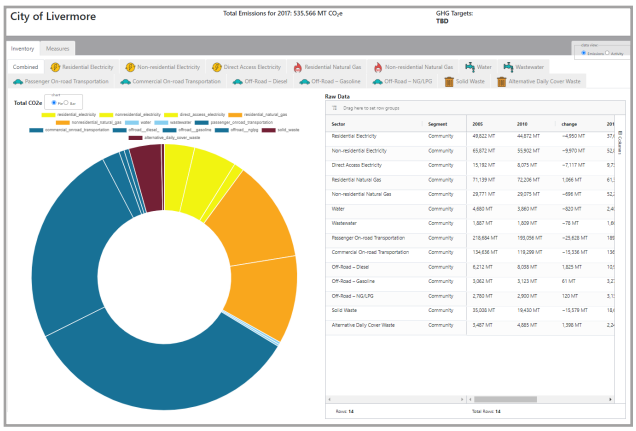
Climate action planning is infinitely iterative, as shown in Figure 4-3. As strategies and actions are implemented, it is imperative to track and evaluate the overall impact of each effort. The City will track CAP implementation in its CAPDash tracking tool, report progress annually to City Council, and update the CAP every 5 years. If the City determines specific actions are not achieving the anticipated emissions reductions or resilience improvement, the City will revise its strategy to stay on track to meet its goals.

Figure 4-3. CAP Implementation and Monitoring Process

CAPDASH

CAP implementation will be tracked in CAPDash, which is a customizable, web-based dashboard developed by Rincon Consultants, Inc. that allows Livermore to track the implementation of each strategy. See Figure 4-4 for an example of the CAPDash dashboard. The City will also conduct GHG-emissions inventories on a bi-annual basis, which will be available for the community to review via CAPDash.

Figure 4-4. CAPDash



ANNUAL REPORTS

City staff will report implementation progress to the City Council every year, beginning in 2024. The annual reports will help hold the City accountable to the commitments in the plan and identify barriers to implementation that may need additional focus.

FIVE-YEAR CAP UPDATES

As technology evolves and the State adopts new mandates, the City may need to revise its existing strategies and actions or develop new ones. The City will update the CAP every 5 years to adjust its approach as necessary. The next CAP update should be completed by the end of 2027.

4-4. Community Activation Guide

YOU CAN HELP CREATE A HEALTHY AND RESILIENT LIVERMORE.

Addressing climate change will require more than just action from the City of Livermore itself. Individuals, businesses, and community groups all have a critical role to play in achieving the City's climate action goals. You can help create a healthy and resilient Livermore by taking individual actions today.

Purchase renewable electricity

East Bay Community Energy (EBCE) provides electricity to customers in Livermore. Enroll your account in the Renewable 100 service option to support locally generated renewable energy.

Install solar panels & batteries

Solar and battery systems reduce your electricity emissions and allow you to store solar energy for use at night or during power outages.

Weatherize your home or business

Weatherize your home or business to save energy, lower your utility bills, stay cool during heat waves, and maintain indoor air quality during smoke events.

Install a heat pump & electric appliances

Install electric, energy-efficient appliances when your old appliance breaks or is no longer working efficiently.

Plant trees in your neighborhood

Plant trees in your neighborhood to reduce heat, sequester carbon, absorb stormwater, and provide habitat.

Install water-wise & fire-safe landscaping

Reduce your water use by replacing your lawn with drought-tolerant landscaping and use water-efficient irrigation. Additionally, adopt fire-safe landscaping practices if you live in an area at risk for wildfires.

Bike, walk, or take transit

Biking, walking, skateboarding, scootering, taking public transit, and carpooling are all good alternative transportation options to reduce your transportation footprint.

Drive an electric vehicle

Purchase or rent an electric vehicle to reduce emissions when you do need to drive.

Compost your yard & food waste

Divert organic waste from the landfill by composting your yard and food waste. Livermore Sanitation provides composting to garbage pickup subscribers for residential use at no charge.

Install a water conservation kit

Taking advantage of water conservation kits from Cal Water and the City that provide free or subsidized water-efficient showerheads, faucet aerators, and toilet leak detection tabs is a great way to start.

Use permeable hardscapes

Install permeable hardscape alternatives like loose gravel, permeable asphalt, grass pavers, and permeable interlocking pavers to prevent flooding.

Looking for more ideas?

The City is building an online resource hub to help the community identify and implement climate actions. The resource hub will be available by the end of 2022 at ***LivermoreResilientHub.com***

Closing Remarks

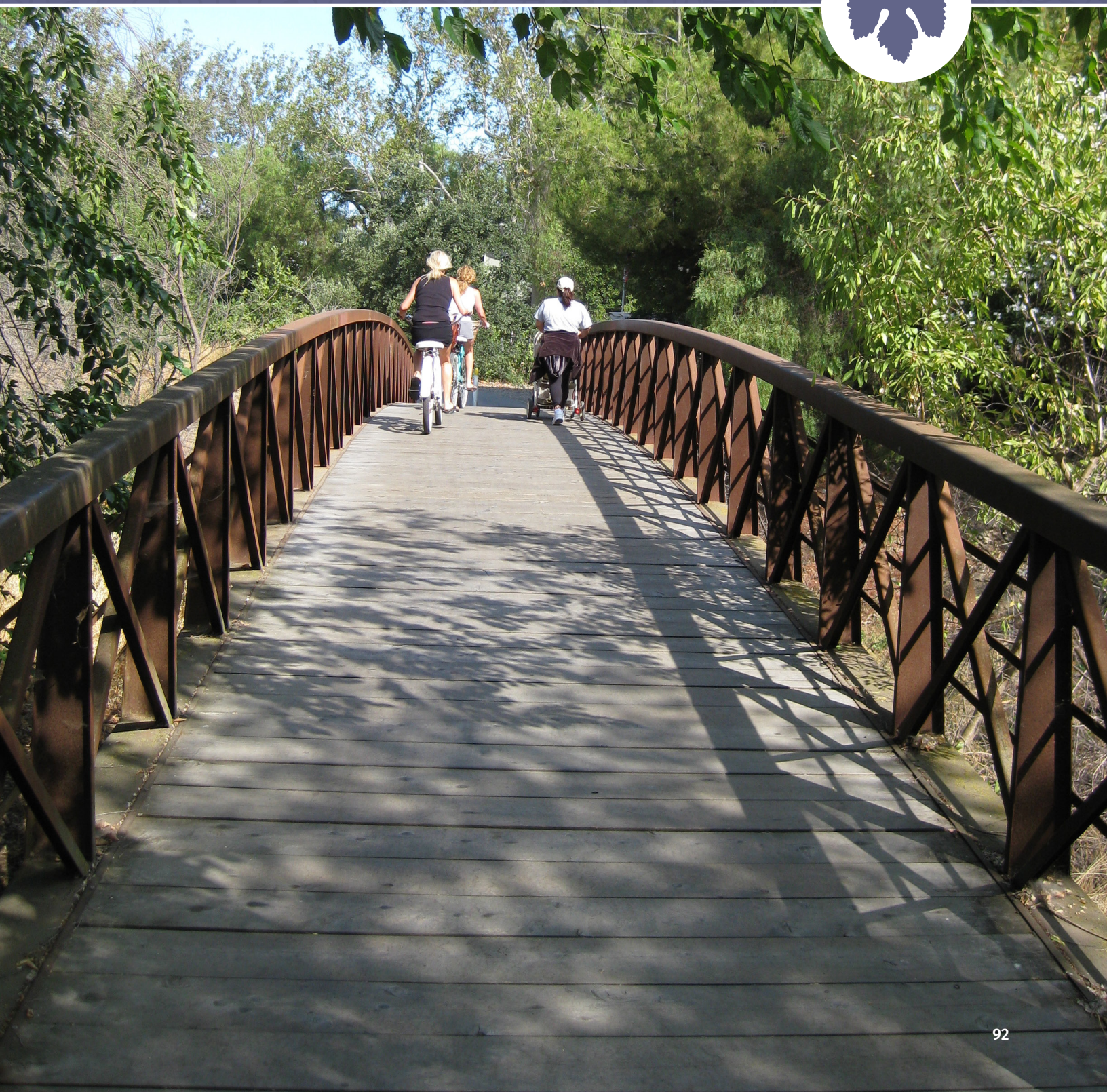
While climate change may seem like an overwhelming challenge and we may not all agree on the solutions, we can all agree that everyone wants a safe and healthy climate for Livermore's future. Thinking about what we can do locally can also be daunting in the context of a global threat. One thing is for certain and that is while one city can't solve the problem alone, without action at the local level the problem won't be solved.

California is a leader in climate action in the U.S. and Livermore can be a leader in California—environmental stewardship is in Livermore's DNA. There is a role for all of us in this climate action plan—the actions we take individually and collectively can make a difference.

The quality of life in Livermore for future generations depends on the actions we take today.

▲ Livermore resident responses to Climate Action Plan survey.

Appendices



Appendix Table of Contents

Appendix A - GHG Inventory and Forecast Methodology and Calculations

Livermore Climate Action Plan Update

prepared for

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1052 South Livermore Avenue
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Updated April 2022

RINCON CONSULTANTS, INC.
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1 Introduction

California considers greenhouse gas emissions (GHG) emissions and the impacts of climate change to be a serious threat to the public health, environment, economic well-being, and natural resources of the state and has taken an aggressive stance to mitigate the impact of climate change at the state-level through the adoption of legislation and policies. Many cities and counties within California have developed local climate action plans and aligned goals to correspond with state emissions reduction targets. The two major state GHG emissions-related goals are established by Assembly Bill (AB) 32 and Senate Bill (SB) 32. AB 32 required state agencies reduce California GHG emissions to 1990 levels by 2020, whereas SB 32 requires a 40 percent reduction below 1990 levels by 2030. The goals set by AB 32 were achieved even earlier by the state in 2016,[1] and many California jurisdictions are completing updated GHG inventories to quantify progress toward their specific 2020 goals as well as develop targets to align with the requirements of SB 32. Additionally, Executive Order (EO) B-55-18, which was passed in 2018 by Governor Jerry Brown, establishes a goal for achieving carbon neutrality statewide by 2045. Executive Orders are only required by law for state agencies, but future climate legislation and goals are anticipated to be passed by the California legislature in the future[2].

This technical appendix to Livermore's Memorandum Detailing GHG Emissions Inventory, Forecast, and Provisional Targets for Livermore Climate Action Plan Update (2020) details the results of the GHG emissions inventories completed for Livermore (2005, 2010, 2015 and 2017) and forecasts of future GHG emissions (2020, 2025, 2030, 2035, 2040 and 2045). This technical appendix also quantifies the reduction impact that state regulations will have on Livermore's *business-as-usual forecast*[3] and presents the results in an *adjusted forecast.*[4]

This technical appendix covers GHG emissions inventories[5] prepared for 2010, 2015 and 2017 and updates made to the original 2005[6] baseline GHG inventory which was completed to fix discrepancies in the calculation methodologies and align the inventory with current standards. This allows for comparisons between all inventory years and provides accurate measurement of the City's progress towards the 2020 GHG reduction goals established in the first Livermore Climate Action Plan (CAP)[7] in 2012. All inventory years now use the most recent population, employment, and emissions factor data allowing for consistent and comparable methodologies across all inventory years and between Bay Area jurisdictions that are also using the GHG emissions inventories completed by East Bay Energy Watch (EBEW). These various inventories will assist in the

[1] California Air Resources Board. California Greenhouse Gas Emissions Inventory. Available: https://ww3.arb.ca.gov/cc/inventory/inventory.htm. Accessed: April 14, 2020

[2] AB 2832 and SB 1362 were both introduced to the California state legislature in February 2020, which would codify the 2045 carbon neutrality target set out by Executive Order B-55-18 in 2018 into law.

[3] Forecasts emissions based on population and job growth, with no reduction measures from federal, state, or local governments.

[4] The adjusted forecast scenario incorporates expected federal, state, and local GHG reduction measures into the emissions forecast to develop a more accurate forecast of emissions through 2045.

[5] Note that all reference to inventories, forecasts, and targets in this memorandum are in reference to communitywide GHG emissions.

[6] The Updated 2005 GHG Emissions Inventory is an update of the previously prepared 2005 inventory that informed the first City CAP. This was done to use the most recent methodology, emissions factors, and data sources available, as well as for consistency between other inventory years. The original updated 2005 inventory was created by East Bay Energy Watch, and then updated by Rincon (for more information on these updates, refer to Section 2.3 of this Technical Appendix).

[7] City of Livermore. 2012. City of Livermore Climate Action Plan. Available*:* http://www.cityoflivermore.net/civicax/filebank/documents/9789/ Accessed: April 12, 2020.

preparation of the Livermore CAP Update by clearly tracking progress in specific GHG emissions sectors and to forecast future GHG emissions and develop a respective GHG target gap analyses that will assist in developing CAP Update policies structured to achieve Livermore's GHG emissions targets.

1.1 Regulatory Background

The state of California has adopted a variety of legislation and policies to mitigate and adapt to the effects of climate change. This includes legislation that sets clear targets for the state reducing GHG emissions which cause climate change, as well as directing state agencies such as the California Air Resources Board (CARB) to develop implementation plans for achieving these targets. The most relevant of the climate legislation passed in California are summarized below.

- **Executive Order S-3-05 (2005),** signed by former Governor Schwarzenegger in 2005, establishes statewide GHG emissions reduction goals to achieve long-term climate stabilization as follows: by 2020, reduce GHG emissions to 1990 levels and by 2050, reduce GHG emissions to 80 percent below 1990 levels. The 2050 goal was accelerated by the 2045 carbon neutral goal established by Executive Order (EO) B-55-18, as discussed below.[8]
- **Assembly Bill 32 (2006),** known as the Global Warming Solutions Act of 2006, requires California's GHG emissions be reduced to 1990 levels by the year 2020 (approximately a 15 percent reduction from 2005 to 2008 levels). The AB 32 Climate Change Scoping Plan, first published in 2008, identifies mandatory and voluntary measures to achieve the statewide 2020 emissions limit, and encourages local governments to reduce municipal and community GHG emissions proportionate with state goals.[9]
- **Climate Change Scoping Plan (2008),** the original California Climate Change Scoping Plan, includes measures to address GHG emissions reduction strategies related to energy efficiency, water use, and recycling and solid waste, among other measures. Many of the GHG reduction measures included in the Scoping Plan (e.g., Low Carbon Fuel Standard, Advanced Clean Car standards, and Cap-and-Trade) have been adopted and implemented since approval of the Scoping Plan.
- **Climate Change Scoping Plan Update (2013),** the first update to the California Climate Change Scoping Plan, defines CARB climate change priorities for the next five years and set the groundwork to reach post-2020 statewide GHG emissions reduction goals. The Scoping Plan Update highlighted California's progress toward meeting the 2020 GHG emissions goals defined in the original Scoping Plan. The Plan Update also evaluated how to align the state's longer-term GHG reduction strategies with other state policy priorities, including those for water, waste, natural resources, clean energy, transportation, and land use.
- **Executive Order B-30-15 (2015)**, establishes statewide GHG emissions reduction goals of reducing GHG emissions to 40 percent below 1990 levels by 2030.
- **Senate Bill 32 (2016),** signed by former Governor Brown in 2016, establishes a statewide mid-term GHG reduction goal of 40 percent below 1990 levels by 2030.

[8] Executive Orders are binding only unto State agencies. Accordingly, EO S-03-05 will guide State agencies' efforts to control and regulate GHG emissions but will have no direct binding effect on local government or private actions.

[9] Specifically, the AB 32 Climate Change Scoping Plan states CARB, "encourages local governments to adopt a reduction goal for municipal operations emissions and move toward establishing similar goals for community emissions that parallel the State commitment to reduce GHG emissions by approximately 15 percent from current levels by 2020" (p. 27). "Current" as it pertains to the AB 32 Climate Change Scoping Plan is commonly understood as between 2005 and 2008.

- **Second Climate Change Scoping Plan (2017),** formally adopted by CARB in December 2017, updated the state Scoping Plan to include the GHG reduction goal of 40 percent below 1990 levels by 2030 set forth by SB 32. The Scoping Plan outlines the roadmap to achieve this goal and gives guidance on how to achieve substantial progress towards 2050 state goals.
- **Executive Order B-55-18 (2018),** signed by former Governor Brown in 2018, expanded upon EO S-3-05 by creating a statewide GHG goal of carbon neutrality by 2045. EO B-55-18 identifies CARB as the lead agency to develop a framework for implementation and progress tracking toward this goal in the next Climate Change Scoping Plan Update, which is expected in 2021 or 2022.

CEQA Guidelines Section 15183.5

The California Environmental Qualified Act (CEQA) has established specific requirements for climate action plans to qualify for project specific CEQA analysis streamlining. According to CEQA Guidelines Section 15183.5, project-specific environmental documents can tier from, or incorporate by reference, the existing programmatic review in a qualified GHG emissions reduction plan, which allows for project-level evaluation of GHG emissions through the comparison of the project's consistency with the GHG emissions reduction strategy included in the qualified GHG emissions reduction plan. To meet the requirements of CEQA Guidelines Section 15183.5, a qualified GHG emissions reduction plan must include the following:

1. Quantify existing and projected GHG emissions within the plan area;
2. Establish a level, based on substantial evidence, below which the contribution to GHG emissions from activities covered by the plan would not be cumulatively considerable;
3. Identify and analyze sector specific GHG emissions within the plan's geographic area;
4. Specify measures or a group of measures, including performance standards, that if implemented, would collectively achieve the specified emissions level;
5. Establish a tool or mechanism to monitor progress and to require amendment if the plan is not achieving specified levels; and
6. Be adopted in a public process following environmental review.

The state of California, via CARB, has issued several guidance documents concerning the establishment of GHG emissions reduction targets for local climate action plans to comply with legislated GHG emissions reductions goals and CEQA Guidelines Section 15183.5(b). In the first California *Climate Change Scoping Plan,*[10] CARB encouraged local governments to adopt a reduction target for community emissions paralleling the state commitment to reduce GHG emissions. In 2016, the state adopted SB 32 mandating a reduction of GHG emissions by 40 percent from 1990 levels by 2030 and in 2017 CARB published *California's 2017 Climate Change Scoping Plan* (hereafter referred to as the Scoping Plan Update) outlining the strategies the state will employ to reach these targets.[11] With the release of the Scoping Plan Update, CARB recognized the need to balance population growth with emissions reductions and in doing so, provided a new methodology for proving consistency with state GHG reduction goals through the use of per capita efficiency targets.

[10] California Air Resources Board. 2008. Climate Change Scoping Plan. Available: https://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf. Accessed: April 16, 2020

[11] California Air Resources Board. California's 2017 Climate Change Scoping Plan. Accessed at: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf. Accessed: April 16, 2020

These targets are generated by dividing a jurisdiction's GHG emissions for each horizon year by the jurisdiction's total population for that target year and are discussed further in Section 5.

1.2 Greenhouse Gas Emissions Inventory Introduction

The Livermore GHG emissions inventories serve to detail progress towards Livermore's GHG emissions reduction targets. Each inventory provides the total community GHG emissions in carbon dioxide equivalents (CO_2e).[12] Data for 2005, 2010, 2015, and 2017 inventories was originally gathered by EBEW and then reviewed and updated by Rincon for consistency with the latest methodology available in the International Council for Local Environmental Initiative (ICLEI) U.S. Community Protocol[13] and California Supplement[14]. In order to maintain consistency across all years, the updated 2005 inventory will replace the existing 2005 baseline inventory used in Livermore's 2012 CAP. Changes to the 2005 inventory methodology include adding emissions from the water and wastewater inventory sectors and removal of the Bay Area Rapid Transit (BART) emissions, because the City of Livermore does not have direct control over BART and is unable to reduce these emissions and because reliable BART data was not available for the subsequent inventories.

Emissions for each inventory year were calculated using the principles and methods from these protocols. Emissions from nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2) are included in this assessment. Each GHG has a different capability of trapping heat in the atmosphere, known as its global warming potential (GWP), which is normalized relative to CO_2 and expressed as carbon dioxide equivalent, or CO_2e. The CO_2e values for these gases are derived from the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change GWP values for consistency with the yearly CARB GHG inventory, as shown in Table 1.[15,16]

Table 1 Global Warming Potentials of Greenhouse Gases

Greenhouse Gas	Molecular Formula	Global Warming Potential (CO_2e)
Carbon Dioxide	CO_2	1
Methane	CH_4	28
Nitrous Oxide	N_2O	265

MT CO_2e: metric tons of carbon dioxide equivalent

[12] Carbon dioxide equivalent is a term for describing GHG emissions in a common unit, signifying for any GHG the amount of CO_2 that would have the equivalent global warming impact. The equivalent amount of CO_2 is calculated based on the GHG global warming potential value.

[13] ICLEI. 2012. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. Available: <https://icleiusa.org/publications/us-community-protocol/>. Accessed: April 23, 2020.

[14] Association of Environmental Professionals. 2013. The California Supplement to the United States Communitywide GHG Protocol. Available: <https://califaep.org/docs/California_Supplement_to_the_National_Protocol.pdf>. Accessed: April 23, 2020.

[15] Intergovernmental Panel on Climate Change. 2014. Fifth Assessment Report: Climate Change. Direct Global Warming Potentials.

[16] All calculations use Intergovernmental Panel on Climate Change Fifth Assessment Report GWP values.

Greenhouse Gas Emissions Sectors

Each of the community inventories for the City of Livermore include estimated emissions for the following sectors:

- Energy (electricity, natural gas, direct access electricity)
- On-road Transportation (passenger, commercial)
- Off-road Transportation
- Waste (solid waste, alternative daily cover)
- Water
- Wastewater (direct, indirect)

Excluded Emissions

The following emissions sectors were excluded from Livermore's 2012 CAP baseline inventory for 2005 and are also excluded from the updated 2005, 2010, 2015, and 2017 inventories. Additional updates were also made to the 2005, 2010, and 2015 inventories in order to maintain consistent sources and emissions factors between all inventory years. These changes are summarized in Sections 2.2 and 2.3.

Consumption-based Emissions

GHG emissions from consumption of goods within the city are excluded from the inventory and forecast of future emissions. Consumptive based inventories for municipal jurisdiction are a relatively new the climate planning practice and standardized factors and methodologies are currently being developed. Without consistent methods, factors and established boundaries, the data provided from these inventories is limited and could negatively impact a jurisdictions ability to detail their progress with future GHG reductions.

Natural and Working Lands Emissions

GHG emissions from carbon sinks and sources in natural and working lands are not included in this inventory and forecast due to the lack the specific data necessary to estimate their contribution to the jurisdictions overall GHG emissions. CARB has included a state-level inventory of natural and working lands in the 2017 Scoping Plan Update[17] GHG inventory; however, at the time of this City of Livermore community-wide inventory, sufficient data was not available to conduct a jurisdiction-specific working lands inventory. CARB has developed the Natural and Working Lands Implementation Plan[18] and the Nature Conservancy and California Department of Conservation[19] have developed an inventory tool (TerraCount) which may be able to perform these inventories for Alameda County.

[17] California Air Resources Board. 2017. California's Climate Change Scoping Plan Update.

[18] California Air Resources Board. 2019. California 2030 Natural and Working Lands Climate Change Implementation Plan. Available: https://ww2.arb.ca.gov/sites/default/files/2019-06/draft-nwl-ip-040419.pdf. Accessed: April 12, 2020.

[19] California Department of Conservation. TerraCount Scenario Planning Tool. Accessed: https://maps.conservation.ca.gov/terracount/. Accessed: April 6, 2020.

Agricultural Emissions

Emissions from agricultural activities are not included in this inventory as the Community Protocol and California Supplement[20] both note agricultural activity is not a required component of Community Protocol inventories and should be included only if relevant to the community conducting the inventory. Agricultural emissions are generally inventoried at a County scale, and data is difficult to allocate to local municipal jurisdictions. Regulations exist to encourage urban agriculture within the City boundaries. Many of the emissions from these activities (e.g. energy) are covered under other sectors included in this inventory and no major commercial-scale livestock activity is noted within the city boundaries.

High GWP Emissions

High GWP emissions, including chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs) used as substitutes for ozone-depleting substances are not included in this inventory as it is not a required component of the Community Protocol and the California Supplement notes these emissions are not generally included in California inventories, including in Livermore. Furthermore, many of these emissions are from industrial manufacturing sources and are already accounted for in the California Cap-and-Trade program.

[20] Association of Environmental Professionals. 2013. The California Supplement to the United States Community-Wide Greenhouse Gas (GHG) Emissions Protocol. Available: https://califaep.org/docs/California_Supplement_to_the_National_Protocol.pdf. Accessed: April 8, 2020.

2 Previous GHG Emissions Inventories

2.1 1990 Reference-Year Inventory

The state of California uses 1990 as a reference year to remain consistent with AB 32 and SB 32, which codified the state's 2020 and 2030 GHG emissions targets by directing CARB to reduce statewide emissions to 1990 levels by 2020 and 40 percent below 1990 levels by 2030. The City of Livermore's initial inventory was conducted for the year 2005. The state indicated in the first Climate Change Scoping Plan in 2008 that local governments wishing to remain consistent with state targets could use a 15 percent reduction from 2005-2009 levels as a proxy for a 1990 baseline.[21] The updated 1990 proxy baseline used for target setting by the City of Livermore is 610,604 MT CO_2e.[22]

2.2 2005 Baseline Inventory

In 2008, Livermore collaborated with ICLEI to develop a 2005 community GHG emissions inventory. The 2005 inventory quantified community emissions and forecast business-as-usual (BAU) conditions to 2020 based on expected population, employment, and growth. It included emissions from the residential energy, commercial/industrial energy, on-road transportation (using data from the Metropolitan Transportation Commission (MTC) for VMT data), and waste sectors. This inventory was used to inform the development of the City's General Plan Climate Change Element, which includes a goal to reduce GHG emissions by 15% below 2008 levels by 2020.

In 2010, ICF International updated this 2005 inventory to include additional sectors (referred to here as the 2012 CAP baseline inventory), developed an estimate of 2008 emissions based on the 2005 inventory, and updated the 2020 forecast using current socioeconomic factors. The 2012 CAP baseline inventory added emissions from water consumption and wastewater treatment and utilized the Alameda County CMA Travel Demand Model (now known as Alameda CTC) for VMT estimates. These changes led to an overall 40% decrease in GHG emissions for the 2005 baseline inventory year compared to the original 2005 inventory completed by ICLEI.

The 2012 CAP baseline inventory was updated again by Rincon as part of this current 2020 inventory and forecast effort for the CAP Update, using the most recent methodology, data, and emissions factors. As part of the CAP Update, GHG inventories for 2010, 2015, and 2017 that were originally developed by East Bay Energy Watch in 2019 were also updated by Rincon (see Section 2.3 below for more details on changes made by Rincon to these inventories).

Table 2 compares changes in emissions by sector between the original 2012 CAP baseline inventory and the updated CAP 2.0 2005 inventory. Overall, emissions in the updated CAP 2005 inventory increased by 5 percent, mainly due to an increase in emissions from the off-road transportation sector.

[21] Due to lack of 1990 inventory data for local governments, page 27 of the 2008 Climate Change Scoping Plan identifies 15 percent below "current" (2005-2008) levels by 2020 as consistent with the State goals of 1990 levels by 2020, allowing local governments to back-cast to develop 1990 baselines for future GHG reduction targets.

[22] Calculated using updated 2005 CAP 2.0 inventory created by EBEW and completed by Rincon.

Table 2 GHG Emissions Comparison Between the 2012 CAP Baseline Inventory and the CAP 2.0 Update 2005 Inventory

Sector	2012 CAP Baseline GHG Emissions ($MT CO_2e$)[23]	CAP 2.0 Updated 2005 GHG Emissions ($MT CO_2e$)	Percent Change
Residential Energy[1]	121,572	120,961	-0.50%
Nonresidential Energy[1]	104,183	95,643	-8.20%
Direct Access Electricity	N/A[2]	15,192	+100%
On-road Transportation	147,327	353,319	+139.82%
Off-road Transportation	N/A[2]	88,179	+100%
Solid Waste Disposal	32,783	38,495	-17.42%
Water and Wastewater	6,072	6,567	-8.15%
Municipal Operations	7.095	N/A[3]	-100%
Total	**411,937**	**718,358**	**+74.39%**

kWh: kilowatt hours; mgy: million gallons per year; N/A: not applicable; MT CO_2e: metric tons of carbon dioxide equivalent; VMT: vehicle miles traveled

[1] The electricity and gas sectors were not separated in the 2005 CAP 1.0 inventory.

[2] Direct access electricity data not separated from nonresidential electricity in inventory. Off-road emissions not included.

[3] Municipal operations are a subset of community emissions in the updated 2005 CAP 2.0 inventory and were not calculated separately.

2.3 Summary of 2005, 2010, 2015, and 2017 East Bay Energy Watch Inventories

In 2019, East Bay Energy Watch (EBEW) developed GHG inventories for jurisdictions across the Bay Area. GHG inventories for 2005, 2010, 2015, and 2017 were established for the City of Livermore as part of this effort (referred to from here as the EBEW inventories). Although the EBEW inventories use slightly different methodologies than the 2005 inventory, due to the availability of data, the consistency of the new methodology between all inventory years and between other local jurisdictions, and the use of the most recent emissions factors and data sources, the City has adopted the EBEW inventories and will incorporate updated versions into the CAP process.

Several updates were performed by Rincon as part of the current effort to adjust the EBEW inventories to create a consistent methodology across the 2005, 2010, 2015, and 2017 inventories. These included adding natural gas emissions from the industrial sector in 2015 and 2017 (due to the data being unavailable from PG&E reporting due to CPUC energy data access rules[24]), adding activity and emissions data for both water and wastewater sectors into the inventories, and updating off-road transportation sector emissions calculations to utilize the most recently available data.

The following section outlines the changes made to the EBEW inventories for consistency with the ICLEI U.S. Community Protocol[25] and inventory years.

23 Original 2005 CAP 1.0 inventory here refers to the 2012 CAP 1.0 inventory, which had previously been updated from ICLEI's 2005 inventory (completed in 2008 for use in Livermore's 2012 CAP 1.0).

24 California Public Utilities Commission Decision (D.14-05-016) establishes the Data Request and Response Process, a protocol for investor owned utilities to follow when providing customer usage data to eligible third-party requesters.

25 ICLEI. 2013. U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version 1.1.

Natural Gas

When examining the available PG&E natural gas data for Livermore (obtained via PG&E's Green Communities portal) it was determined that an unknown, large natural gas facility came online in Livermore between 2011 and 2012 and triggered the CPUC 15-15 rule[26] starting in 2014. This prevented PG&E from reporting industrial natural gas emissions in 2015 and 2017 as a part of the data request for Livermore's energy data, which was listed as 'Fail-Dropped'. In other years, industrial natural gas emissions were included with commercial emissions.

To allow for accurate comparison and better consistency of energy sector emissions between all four EBEW inventory years, however, the calculated activity data from Lawrence Livermore National Lab (LLNL) was added into the nonresidential natural gas sector for 2015 and 2017 to account for industrial natural gas emissions. CARB reports Cap-and-Trade emissions data to the public as a part of California's Regulations for the Mandatory Reporting of Greenhouse Gases[27], which covers all entities that emit over 10,000 MT CO_2e in a given year. Rincon examined this data for large facilities in Livermore to determine the source of the large increase in natural gas usage. By comparing Cap-and-Trade data to the available PG&E data, it was determined that LLNL, which began reporting as a part of the Cap-and-Trade program in 2012, was largely responsible for the new natural gas usage. This was confirmed by calculating the activity data for LLNL's emissions, using the calculated emissions factor for PG&E natural gas[28], which matched the increase in natural gas usage shown in Livermore's PG&E data for 2012 and 2013.

Other industrial emissions were not added into the inventories, as they are under the purview of the CARB Cap-and-Trade Program for emissions reductions and are, therefore, already accounted for in the 2017 Scoping Plan Update. The California Supplement does not recommend including these sources unless they are under the direct jurisdictional control of the reporting agency.[29]

Direct Access Electricity

Direct Access is an option that allows eligible customers to purchase their electricity directly from third party Electric Service Providers. Direct access electricity[30] was not reported by PG&E for the 2017 reporting year due to the CPUC's data access rules, specifically what is known as the 15-15 rule. It was determined by examining the available PG&E data for Livermore (obtained via PG&E's Green Communities portal) that direct access electricity users triggered the 15-15 rule in 2017. This prevented PG&E from reporting 2017 direct access electricity activity data as part of the data request for Livermore's energy data. In all other years, including the 2005, 2010, and 2015 inventory years, this direct access electricity data was reported.

To allow for accurate comparison of energy sector emissions between inventory years, direct access electricity usage and emissions were estimated for 2017. This was done by using the average ratio

[26] The 15/15 rule states no data can be provided if there are less than 15 users in any sector or if one user makes up more than 15 percent of the total usage. This applies to natural gas and electricity consumption.

[27] Cap-and-Trade emissions data obtained from the California Air Resource Board's Mandatory Reporting of Greenhouse Gas (MRR) data portal. Available: https://ww2.arb.ca.gov/mrr-data. Accessed May 7, 2020.

[28] Emissions factor for natural gas = .00531051, as calculated and used in the 2017 baseline inventory and GHG forecast for CAP 2.0. See Section 3.1 for more details on energy emissions factors.

[29] Association of Environmental Professionals. 2013. The California Supplement to the United States Community-Wide Greenhouse Gas (GHG) Protocol. Page 10.

[30] Direct access electricity is retail electric service where customers purchase electricity from a competitive provider called an Electric Service Provider (ESP), instead of from a regulated electric utility. An ESP is a non-utility entity that offers electric service to customers within the service territory of an electric utility. The utility delivers electricity that the customer purchases from the ESP to the customer over its distribution system.

of direct access electricity usage to commercial electricity based off 2015 and 2016, the closest available years with data. Direct access electricity usage was estimated in this way for 2017 also to provide direct access electricity emissions across all four inventory years.

Water and Wastewater

The EBEW inventories did not include data or emissions from water or wastewater, which are standard sectors in the ICLEI U.S. Community Protocol. Activity data for these sectors was obtained from the City in April 2020 for 2005, 2010, 2015, and 2017, and added into the inventories for all years. Water data was provided in millions of gallons supplied by CalWater and Livermore Municipal Water, and emissions were calculated by determining the amount of electricity used as a part of processing and distribution[31], and multiplying by PG&E emissions factors for electricity. Wastewater data was provided in millions of gallons from the Livermore Water Reclamation Plant, and emissions were calculated using the following ICLEI Community Protocol methods (determined based on facility information gathered by Rincon): WW.2, WW.8, and WW.12. For more detail on these calculations, see Section 3.3.

BART

The EBEW inventories originally included emissions from Bay Area Rapid Transit (BART). It was decided by Rincon and City staff to ultimately remove these emissions from the four EBEW inventory years (2005, 2010, 2015, and 2017). This was due to a lack of emissions data available for years after 2013, which prevented emissions from being accurately calculated and forecasted. Additionally, all four inventory years originally used the same emissions factor, calculated based off of 2013 data, leading to inaccurate estimation of emissions. The City of Livermore ultimately does not have control over reducing these emissions, and BART already has its own GHG emissions reduction goals in place over the next decade. These emissions also represented a small percentage of Livermore's overall emissions (0.22% in 2017). For these reasons, these emissions were ultimately removed.

Off-road Transportation

The EBEW inventories originally calculated GHG emissions from off-road equipment using the CARB OFFROAD2007 model. In late 2021, CARB released OFFROAD2021 as a replacement for previous off-road inventory models, which included more up-to-date off-road equipment inventories and activity estimates.[32] Rincon updated the 2005, 2010, 2015, and 2017 inventories to use off-road transportation activity data from the CARB OFFROAD2021 model database.

[31] Electricity usage was determined via methods outlined in the California Energy Commission's Refining Estimates of Water-related Energy Use in California, 2006. https://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF.

[32] CARB. 2021. Mobile Source Emissions Inventory – Modeling Tools. https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-modeling-tools.

Summary of GHG Inventory Data by Year

A summary of emissions for the 2005, 2010, 2015, and 2017 GHG inventories by sector for Livermore can be found below in Table 3, as well as back-casted emissions for 1990.

Table 3 Livermore GHG Inventories Emissions Summary

Sector	1990[1] (MT CO_2e)	2005 (MT CO_2e)	2010 (MT CO_2e)	2015 (MT CO_2e)	2017 (MT CO_2e)
Residential Electricity	42,349	49,822	44,872	37,602	19,775
Residential Gas	60,468	71,139	72,206	61,334	65,896
Nonresidential Electricity	55,991	65,872	55,902	52,865	27,836
Nonresidential Gas	25,305	29,771	29,075	52,236	57,462
Direct Access Electricity	12,913	15,192	8,075	9,734	6,545
On-Road Transportation	300,322	353,320	312,355	325,691	314,154
Off-Road Transportation	10,246	12,055	14,061	17,394	18,002
Waste	32,721	38,495	24,315	20,859	23,052
Wastewater	1,604	1,887	1,809	1,661	1,366
Water	3,978	4,680	3,860	2,400	1,479
Total Emissions	**545,898**	**642,233**	**566,530**	**581,776**	**535,567**
Emissions per capita	9.62	8.23	7.00	6.72	5.92

$MTCO_2e$: metric tons of carbon dioxide equivalent

[1] All 1990 inventory data calculated as a 15 percent reduction from CAP 2.0 2005 inventory levels per California Air Resources Board Scoping Plan. The original 2012 CAP used this same methodology for calculating 1990 emissions, although a 2008 inventory was developed as a baseline.

[2] Includes emissions from direct access electricity.

[3] Nonresidential natural gas emissions adjusted to include estimated emissions from industrial sources, which were not reported by PG&E due to CPUC privacy rules.

The updated activity data, emissions factors, and total emissions for the 2005, 2010, 2015, and 2017 inventories for Livermore are summarized below in Table 4, Table 5, Table 6, and Table 7. All of the inventory years utilize the same methodology, except for changes made to the original EBEW inventories by Rincon to specific inventory years (as identified in this section).

Table 4 Livermore 2005 GHG Inventory Data

	Activity Data	Emissions Factors	Emissions (MT CO_2e)
Residential Electricity (kWh)	223,251,790	0.000223	49,822
Residential Gas (therms)	13,395,923	0.00531	71,139
Nonresidential Electricity (kWh)	295,174,279	0.000223	65,872
Nonresidential Gas (therms)	5,606,070	0.00531	29,771
Direct Access Electricity (kWh)	39,378,526	0.000386	15,192
Passenger On-road Transportation (VMT)	548,153,828	0.000399	218,684
Commercial On-Road Transportation (VMT)	91,610,896	0.00147	134,636
Off-Road – Diesel (Gallons)	600,655	0.0103	6,212
Off-Road – Gasoline (Gallons)	338,135	0.00905	3,062
Off-Road – NG/LPG (Gallons)	477,673	0.00582	2,780
BART (Passenger Miles)	Removed	Removed	Removed
Solid Waste (tons)	119,384	0.293	35,008
Alternative Daily Cover Waste (tons)	14,193	0.246	3,487
Wastewater (mgy)	2,640	0.000223	1,887
Water (mgy)	5,879	0.000223	4,680
Total			**642,233**

kWh: kilowatt hours; mgy: million gallons per year; N/A: not applicable; MT CO_2e: metric tons of carbon dioxide equivalent; VMT: vehicle miles traveled; NG: natural gas; LPG: liquefied petroleum gas

Table 5 Livermore 2010 GHG Inventory Data

	Activity Data	Emissions Factors	Emissions (MT CO_2e)
Residential Electricity (kWh)	221,110,304	0.000203	44,872
Residential Gas (therms)	13,596,747	0.00531	72,206
Nonresidential Electricity (kWh)	275,465,613	0.000203	55,902
Nonresidential Gas (therms)	5,475,062	0.00531	29,075
Direct Access Electricity (kWh)	28,367,259	0.000285	8,075
Passenger On-road Transportation (VMT)	493,823,032	0.000391	193,056
Commercial On-Road Transportation (VMT)	80,288,169	0.00149	119,299
Off-Road – Diesel (Gallons)	777,146	0.0103	8,038
Off-Road – Gasoline (Gallons)	344,849	0.00905	3,123
Off-Road – NG/LPG (Gallons)	498,303	0.00582	2,900
BART (Passenger Miles)	Removed	Removed	Removed
Solid Waste (tons)	65,600	0.296	19,430
Alternative Daily Cover Waste (tons)	19,881	0.246	4,885
Wastewater (mgy)	2,586	0.000203	1,809
Water (mgy)	5,324	0.000203	3,860
Total			**566,528**

kWh: kilowatt hours; mgy: million gallons per year; N/A: not applicable; MT CO_2e: metric tons of carbon dioxide equivalent; VMT: vehicle miles traveled; NG: natural gas; LPG: liquefied petroleum gas

Table 6 Livermore 2015 GHG Inventory Data

	Activity Data	Emissions Factors	Emissions (MT CO_2e)
Residential Electricity (kWh)	203,689,656	0.000185	37,602
Residential Gas (therms)	11,549,521	0.00531	61,334
Nonresidential Electricity (kWh)	286,367,883	0.000185	52,865
Nonresidential Gas (therms)[1]	9,836,396	0.00531	52,236
Direct Access Electricity (kWh)	32,760,434	0.000297	9,734
Passenger On-road Transportation (VMT)	534,438,400	0.000355	189,523
Commercial On-Road Transportation (VMT)	95,769,686	0.00142	136,168
Off-Road – Diesel (Gallons)	1,061,791	0.0103	10,982
Off-Road – Gasoline (Gallons)	362,052	0.00905	3,278
Off-Road – NG/LPG (Gallons)	538,354	0.00582	3,134
BART (Passenger Miles)	Removed	Removed	Removed
Solid Waste (tons)	65,091	0.286	18,619
Alternative Daily Cover Waste (tons)	9,118	0.246	2,240
Wastewater (mgy)	2,179	0.000185	1,661
Water (mgy)	3,708	0.000185	2,400
Total			**581,777**

kWh: kilowatt hours; mgy: million gallons per year; N/A: not applicable; MT CO_2e: metric tons of carbon dioxide equivalent; VMT: vehicle miles traveled; NG: natural gas; LPG: liquefied petroleum gas

[1] Data for 2015 industrial natural gas was unavailable due to the CPUC's 15-15 privacy rule. Emissions from industrial natural gas for 2015 were estimated using reported emissions from the Livermore Lawrence National Laboratory as a part of California's Cap-and-Trade program.

Table 7 Livermore 2017 GHG Inventory Data

	Activity Data	Emissions Factors	Emissions (MT CO_2e)
Residential Electricity (kWh)	205,232,521	0.000096	19,775
Residential Gas (therms)	12,408,537	0.00531	65,896
Nonresidential Electricity (kWh)	288,894,815	0.000096	27,836
Nonresidential Gas (therms) [1]	10,820,445	0.00531	57,462
Adjusted Direct Access Electricity (kWh)[2]	32,283,926	0.000203	6,545
Passenger On-road Transportation (VMT)	538,932,050	0.000338	181,900
Commercial On-Road Transportation (VMT)	96,824,903	0.001422	132,254
Off-Road – Diesel (Gallons)	1,104,596	0.0103	11,425
Off-Road – Gasoline (Gallons)	371,061	0.00905	3,360
Off-Road – NG/LPG (Gallons)	552,683	0.00582	3,217
BART (Passenger Miles)	Removed	Removed	Removed
Solid Waste (tons)	73,437	0.286	21,006
Alternative Daily Cover Waste (tons)	8329	0.246	2046
Wastewater (mgy)	2,132	0.000096	1,366
Water (mgy)	4,378	0.000096	1,479
Total			**535,566**

kWh: kilowatt hours; mgy: million gallons per year; N/A: not applicable; MT CO_2e: metric tons of carbon dioxide equivalent; VMT: vehicle miles traveled

[1] Data for 2017 industrial natural gas was unavailable due to the CPUC's 15-15 privacy rule. Emissions from industrial natural gas for 2017 were estimated using reported emissions from the Livermore Lawrence National Laboratory as a part of California's Cap-and-Trade program.

[2] Data for 2017 direct access electricity was unavailable due to the CPUC's 15-15 privacy rule. Emissions from direct access electricity for 2017 were estimated using the average ratio of direct access electricity to commercial electricity between 2015 and 2016.

3 2017 GHG Emissions Inventory

The methodologies, data sources, calculations, and results associated with the Livermore community-wide 2017 GHG emissions inventory update are included in this section. This section focuses on the 2017 inventory since it is the most recent inventory, but the methodologies used for the 2017 inventory were also utilized for the 2005, 2010, and 2015 inventories. The 2017 Livermore GHG emissions inventory serves as the inventory to inform development of future GHG emissions forecasts that will assist the City in setting GHG emissions targets that are consistent with state-level goals and the Livermore General Plan 2003-2025.

The 2017 GHG inventory is structured based on emissions sectors. The ICLEI Community Protocol recommends local governments examine their emissions in the context of the sector responsible for those emissions. Many local governments will find a sector-based analysis more directly relevant to policy making and project management, as it assists in formulating sector-specific reduction measures for climate action planning. The reporting sectors are made up of multiple subsectors to allow for easier identification of sources and targeting of reduction policies.

The 2017 inventory reports all Basic Emissions Generating Activities[33] required by the Community Protocol[34] by the following main sectors:

- Energy (electricity and natural gas)
- Transportation
- Water and Wastewater
- Solid Waste

The data used to complete this inventory and forecast came from multiple sources, as summarized in Table 8. Data for the 2017 water and wastewater sector calculations were provided by the City via personal communication with Tricia Pontau.

[33] Required emissions generating activities include: use of electricity by the community, use of fuel in residential and commercial stationary combustion equipment, on-road passenger and freight motor vehicle travel, use of energy in potable water and wastewater treatment and distribution, and generation of solid waste by the community.

[34] ICLEI. 2012. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. Section 2.2.

Table 8 Inventory and Forecast Data Sources

Sector	Activity Data	Unit	Source
Inventory			
Energy	Electricity Consumption Natural Gas Consumption	kWh Therms	Pacific Gas and Electric; CARB Mandatory GHG Reporting (Cap-and-Trade)
On-road Transportation	Annual Mileage	VMT	Metropolitan Transportation Commission Vehicle Miles Traveled Data Portal; EMFAC2017 Model
Off-road Transportation	Annual Fuel Consumption	Gallons	OFFROAD2021 Model
Water	Water Pumping Electricity Usage	AF kWh	Tricia Pontau; Livermore Municipal Water; California Water Service
Wastewater	Electricity Consumption, Water Treated	kWh MGD	Tricia Pontau; Community Protocol Estimates; Livermore Water Reclamation Plant
Solid Waste	N/A	N/A	CalRecycle; California Air Resources Board Landfill Emissions Tool Version 1.3
Forecast Growth Indicators			
Population	Residents	Persons	California Department of Finance E4 and E5 demographic datasets; Association of Bay Area Governments Plan Bay Area Projections 2040
Commerce	Jobs	Number of Jobs	California Department of Finance E4 and E5 demographic datasets; U.S. Census OnTheMap tool; Association of Bay Area Governments Plan Bay Area Projections 2040
Transportation	Annual Mileage, Emissions	N/A	EMFAC2017 Model; Metropolitan Transportation Commission Vehicle Miles Traveled Data Portal
Off-road Transportation	Annual Fuel Consumption	Gallons	OFFROAD2021 Model
Building Efficiency	Title 24 Efficiency Increases	Percent	California Energy Commission
Electricity Emissions	Renewable Portfolio Standard	Percent	Renewable Portfolio Standard; Senate Bill 100

kWh; kilowatt hours; VMT: vehicle miles traveled; AF: acre-foot; MGD: million gallons per day; N/A: not applicable;

GHG Inventory data was originally gathered by EBEW and then reviewed and updated by Rincon for consistency with the latest methodology available in the Community Protocol[35] and California Supplement[36]. The updated 2005 GHG Inventory added emissions from the water and wastewater inventory sectors and removed the Bay Area Rapid Transit (BART) emissions, because the City of Livermore does not have direct control over BART and is unable to reduce these emissions and because BART data was not available for the subsequent inventories. Information regarding updates to the original EBEW 2005, 2010, 2015, and 2017 inventories is in Section 2.3 and information relating to the emissions forecast are located in Section 4 of this technical appendix.

[35] ICLEI. 2012. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. Available: <https://icleiusa.org/publications/us-community-protocol/>. Accessed: April 23, 2020.

[36] Association of Environmental Professionals. 2013. The California Supplement to the United States Communitywide GHG Protocol. Available: <https://califaep.org/docs/California_Supplement_to_the_National_Protocol.pdf>. Accessed: April 23, 2020.

3.1 Energy Emissions

The energy sector includes GHG emissions resulting from the consumption of electricity and natural gas. Both energy sources are used in residential and nonresidential (commercial and industrial) buildings and for other power needs throughout the City of Livermore. The following subsections describe the data sources, emissions factors and calculation methodologies associated with electricity and natural gas.

Overall, residential energy emissions were about equal to non-residential (commercial and industrial) in their contribution to energy emissions in 2017, at approximately 50.11 percent and 49.89 percent respectively, as shown in Figure 1. It should be noted that, due to data availability issues in reporting years after 2013, large industrial gas data was not provided by PG&E and was instead estimated for 2015 and 2017 to allow for more accurate comparisons between inventory. Direct access electricity usage was also estimated for 2017 as data from PG&E was not available. Additional information on why this change was made as well as the methodologies used to estimate 2017 commercial gas data are provided in Section 2.3.

Electricity

Emissions resulting from electricity consumption were estimated by multiplying annual electricity consumed by an emissions factor representing the average emissions associated with generation of one megawatt hour (MWh) of electricity. Electricity is supplied to the City by PG&E. In its 2017 report to the verification body, The Climate Registry, PG&E reported an electricity carbon intensity factor of 210 pounds CO_2e per MWh.[37] PG&E also reported to the California Energy Commission, an average of 33 percent renewable energy in its portfolio in 2017.[38] From 2005, residential electricity use decreased by 18,019 MWh while nonresidential electricity decreased by 6,279 MWh for a total net decrease of 24,298 MWh. Therefore, the 83,275 MT CO_2e reduction in GHG emissions from electricity between 2005 and 2017 was due to a decrease in electricity usage and an approximately 57 percent reduction in the PG&E electricity emissions factor.

In 2017, a total 47,611 MTCO_2e was generated within the community due to residential and commercial electricity use. Table 7 show the breakdown of emissions from electricity by both category (residential, nonresidential) and by source.

Direct access electricity was also calculated using the same methodology, but with a calculated emissions factor of 0.203 MT CO_2e/MWh. This is equivalent to the California state grid (CAMX) average carbon intensity of electricity (reported by the California Energy Commission), as direct access electricity is not provided by PG&E.[39] Direct access electricity data was not provided by PG&E due to CPUC privacy regulations, and so was estimated based off the average of 2015 and 2016 direct access activity data. Direct access electricity accounted for 32,284 MWh of electricity use in 2017, which resulted in 6,545 MT CO_2e of emissions.

[37] The Climate Registry. 2019 Default Emissions Factors. Available: https://www.theclimateregistry.org/wp-content/uploads/2019/05/The-Climate-Registry-2019-Default-Emission-Factor-Document.pdf. Accessed: April 15, 2020

[38] California Energy Commission. Sacramento Municipal Utility District 2016 Power Content Label. Available: https://ww2.energy.ca.gov/pcl/labels/2017_labels/PG_and_E_2017_PCL.pdf Accessed April 15, 2020

[39] California Energy Commission. Total System Electric Generation. Available: https://ww2.energy.ca.gov/almanac/electricity_data/system_power/2017_total_system_power.html. Accessed: May 7, 2020.

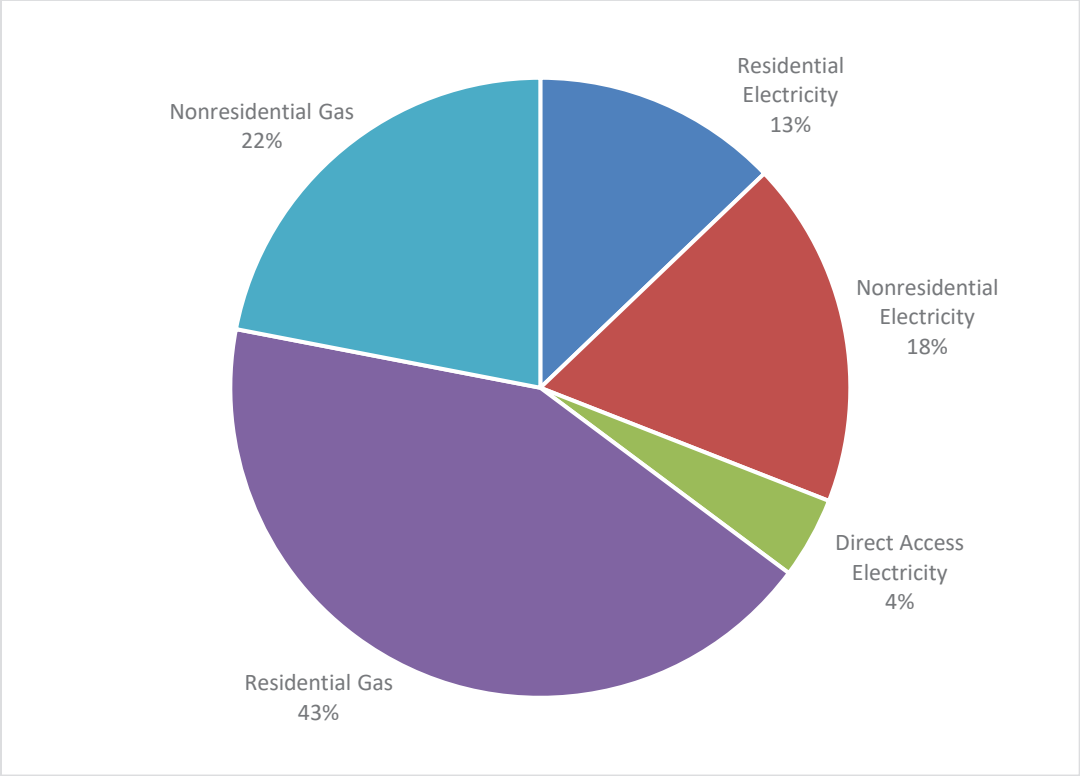
Natural Gas

In order to calculate emissions from natural gas consumption, the total therms consumed is multiplied by the PG&E reported emissions factor of .00531 MT CO_2/therm. Due to CPUC privacy regulations, data regarding the therms of natural gas consumed in 2017 was not provided by PG&E. Emissions were instead estimated based on the most recently available data for this category, which was 2013. [40]

Residential natural gas usage decreased from 13.4 million therms in 2005 to 12.4 million therms in 2017, and nonresidential natural gas usage increased from 5.6 million therms to 10.8 million therms Overall, this resulted in a 5,243 MT CO_2e reduction in emissions from the natural gas sector in 2005 compared to 2017.

In 2017, the residential and nonresidential sectors consumed a total of 23,228,982 therms of natural gas, which, based on the emissions factor of 0.00531 MT CO_2/therms, generated 123,358 $MTCO_2e$. A complete breakdown of natural gas use by category and sector is provided in Table 9.

Figure 1 Energy Emissions by Category for Year 2017



[40] Emissions were added based on reported emissions from the Lawrence Livermore Laboratory to CARB as a part of California's Cap-and-Trade program. For more information on this calculation and adjustment, see Section 2.3.

Table 9 Energy Emissions by Category for Year 2017

Source	Activity Data	Emissions Factor	Total Emissions ($MTCO_2e$)
Residential			**85,671**
Natural Gas	12,408537 therms	0.00531 MT CO_2e/therms	65,896
Electricity	205,233 MWh	0.09635 MT CO_2e/MWh	19,775
Nonresidential			**85,298**
Natural Gas[1]	10,820,445 therms	0.00531 MT CO_2e/therms	57,462
Electricity	288,895 MWh	0.09635 MT CO_2e/MWh	27,836
Direct Access Electricity			**6,545**
Natural Gas	32,284 MWh	0.2027 MT CO_2e/MWh	6,545
Total			**177,514**

MWh: megawatt hours; MT CO_2e: metric tons of carbon dioxide equivalent

[1] Large industrial natural gas has been estimated for 2017 due to CPUC privacy rules.

3.2 Transportation Emissions

On-Road

Transportation modeling for VMT attributed to the City of Livermore was obtained using the Bay Area Metropolitan Transportation Commission (MTC) VMT data model. The emissions associated with on-road transportation were then calculated by multiplying the estimated daily VMT and the average vehicle emissions rate established by CARB EMFAC2017 modeling for vehicles within the region. The MTC model does not directly provide VMT projections for 2017, so VMT was estimated by interpolating for years between 2015 and 2020 (for which VMT data is directly available from the MTC model).

The MTC VMT modeling results allocate the total VMT derived from the activity-based model to the City of Livermore using the Origin-Destination (O-D) method. The O-D VMT method is the preferred method recommended by the U.S Community Protocol in on-road methodology TR.1 and TR.2 to estimate miles traveled based on trip start and end locations. Under these recommendations, all trips that start and end within the City are attributed to the City. Additionally, one half of the trips that start internally and end externally and vice versa are attributed to the City, and no "pass through" trips are accounted for.

Due to the MTC model not being able to provide VMT for unincorporated county areas, data was used from the Highway Performance Monitoring System,[41] which is published annually by Caltrans. This data provides VMT counts on local roads for each jurisdiction, as well as County-level VMT for all other roads (state highways, roads on land under state or federal jurisdiction such as military bases or state parks, etc.). This data includes all vehicle types and is allocated using the geographic boundary method.

[41] Caltrans. 2019. Highway Performance Monitoring System. Available: https://dot.ca.gov/programs/research-innovation-system-information/highway-performance-monitoring-system. Accessed: May 25, 2020

Commercial VMT for heavy-duty vehicles is also provided by MTC, but separately from light-duty vehicles VMT.[42] Commercial VMT includes heavy-duty freight trucks, motor homes, public and private buses, and other commercial vehicles. Commercial VMT was assigned to individual communities by MTC using a method called "Longitudinal Employer-Household Dynamics" (LEHD). Under this method, MTC first models the county-wide VMT of heavy-duty vehicles using an approach called a geographical boundary method. In this method, all the heavy-duty VMT that occurs within a county's geographic limits is assigned to that county, regardless of where the trip begins or ends. MTC next looks at the number of jobs in specific economic sectors that generate heavy-duty vehicle trips (such as agriculture, construction, retail trade, and manufacturing) for the entire county and for each jurisdiction in the county. The US Census provides the number of jobs in these sectors through its online OnTheMap tool.[43] MTC sums the number of jobs in these sectors, and uses the percent of each community's share of jobs in these sectors, relative to the number of Alameda County jobs in the sectors, to allocate heavy-duty VMT. In 2017, Livermore was attributed 7.52 percent of commercial VMT in Alameda County, which was 3,553,565.

In 2017 on-road transportation attributed to the City of Livermore resulted in 314,154 MT CO_2e. This resulted in a 39,165 MT CO_2e reduction compared to 2005. During this time VMT decreased by 0.6 percent or 4 million miles traveled, and the emissions reductions in this sector were driven by an increase in average vehicle efficiency and adoption of electric vehicles. These changes drove the 12 percent decrease in average vehicles emissions per mile.

A summary of the VMT results can be found in Table 10.

Table 10 Estimated On-Road Transportation Emissions for 2017

Source	Activity Data (VMT)[2]	Emissions Factor (MT CO_2e per VMT)	Total Emissions (MTCO_2e)
Internal-Internal Daily VMT	319,968	0.000445	142
½ Internal-External Daily VMT	608,864	0.000445	271
½ External-Internal Daily VMT	615,276	0.000445	274
Total Passenger Daily VMT	1,544,108	0.000338	522
Total Adjusted Passenger Daily VMT[3]	1,553,118	0.000338	525
Total Commercial Daily VMT	267,057	0.001366	365
Total Adjusted Commercial Daily VMT[3]	279,034	0.001366	381
Yearly Passenger VMT[1]	**538,932,050**	**0.000338**	**181,900**
Yearly Commercial VMT[1]	**96,824,903**	**0.001366**	**132,254**
Yearly VMT[1]	**635,756,952**	**0.000852**	**314,154**

MT CO_2e: metric tons of carbon dioxide equivalent; VMT: vehicle miles traveled

[1] Weekday to annual conversion of 347 is used per CARB guidance on VMT modeling

2 The origin-destination methodology for VMT calculation attributes 100 percent of internal to internal daily trips, 50 percent of internal-external and external-internal daily trips and excludes all pass-through trips. This sum is then multiplied by 347 to get an annual VMT number.

[3] Motorcycle, motor homes, and bus VMT not included in original data, and were estimated based on average prevalence of these vehicles in Alameda County, which is approximately 1 percent.

42 East Bay Energy Watch. 2019. Regional Greenhouse Gas Inventory Methodological Summary. Available: https://static1.squarespace.com/static/53fe4fcfe4b070b8a2eb623b/t/5c36664b21c67c309508c0ff/1547069004776/EBEW-RegionalGHGTool-Methodological-Summary.pdf. Accessed: May 25, 2020.

43 United States Census Bureau. 2018. OnTheMap Version 6. Available: https://onthemap.ces.census.gov/. Accessed: April 2020.

Transportation emissions are generated by the community of Livermore through on-road transportation, including passenger, commercial, and heavy machinery. Emissions factors are established using the latest CARB and EPA-approved emissions modeling software, 2017 State EMissions FACtors (EMFAC) Model. Carbon dioxide, nitrous oxide, and methane emissions from engine combustion are multiplied by their GWP to determine CO_2e per VMT. Emissions for both passenger and commercial vehicles were established using the EMFAC2017 GHG module and weighted by VMT to establish an average emissions factor per VMT for the City. Emissions from electricity used by charging of electric vehicles are captured under the electricity sector. In 2017, the average emissions factor for cars on the road in the County of Alameda was 0.000435 $MTCO_2e$ per VMT as calculated using the EMFAC2017 model.[44] Technical details on the EMFAC2017 modeling tool can be found on the EMFAC Mobile Source Emissions Inventory Technical Support Documentation Portal.[45]

Off-Road

Off-road emissions were calculated using the California Air Resources Board's OFFROAD2021 modeling tool.[46] Some categories of off-road equipment are included in the datasets, but were not present in the Alameda County OFFROAD2021 output, and so were not included[47]. These categories are commercial harbor craft, locomotives, and forestry equipment.. OFFROAD2021 output for Alameda County fuel consumption is shown below in Table 11. This data was supplemented by various demographic, land use, and infrastructure data. Population and household data are from the California Department of Finance's E5 dataset and jobs data comes from the U.S. Census. The Metropolitan Transportation Commission supplied land use data, and the California Department of Conservation provided necessary data on oil wells. EBEW also used data on road miles in each community, which was obtained from Caltrans.

Since the off-road emissions data is available at a County level, a portion of emissions had to be allocated to the City of Livermore. These allocation methods were developed by EBEW and modified by Rincon for each category, which look at how much of a certain activity or indicator occurs in each community as a percent of how much of that activity or indicator occurs county-wide. These allocations by equipment category are shown below in Table 12. Total emissions from off-road transportation in 2017 was 58,852 MT CO_2e, shown in Table 13.

[44] California Air Resources Board. 2017. EMFAC2017. Base year 2017, County of Alameda model run. Available: https://www.arb.ca.gov/emfac/ Accessed: April 5, 2020

[45] California Air Resources Board. EMFAC Software and Technical Support Documentation. Available: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-modeling-tools-emfac Accessed: April 5, 2020.

[46] California Air Resources Board. 2021. OFFROAD2021 version 1.0.2 Emissions Inventory. Available: https://arb.ca.gov/emfac/. Accessed: April 1, 2022.

[47] East Bay Energy Watch. January 2019. Regional Greenhouse Gas Inventory Methodological Summary. Available: https://static1.squarespace.com/static/53fe4fcfe4b070b8a2eb623b/t/5c36664b21c67c309508c0ff/1547069004776/EBEW-RegionalGHGTool-Methodological-Summary.pdf. Accessed: June 1, 2020.

Table 11 Estimated Off-Road Activity Data for Alameda County 2017

Source	Diesel	Gasoline	Natural Gas/LPG
Agricultural Equipment	391,247	0	0
Airport Ground Support Equipment	197,062	968,520	113,373
Cargo Handling Equipment	3,867,750	338,177	65,565
Construction and Mining Equipment	6,020,196	239,270	0
Industrial Equipment	985,121	2,803,920	5,052,615
Lawn and Garden Equipment	56	2,936	0
Light Commercial Equipment	446,969	794,877	630,231
Ocean Going Vessels	12,631,094,402	0	0
Oil Drilling	8,108	0	0
Other Portable Equipment	5,690,698	0	0
Pleasure Craft	0	23,333	0
Recreational Equipment	0	404,075	0
Transport Refrigeration Units	4,607,216	0	0
Total	**12,653,308,824**	**5,575,110**	**5,861,784**

Notes: LPG: liquefied petroleum gas
All data is presented in gallons per year.

Since the off-road emissions data is available at a County level, a portion of emissions had to be allocated to the City of Livermore. These allocation methods were developed by EBEW and modified by Rincon for each category, which look at how much of a certain activity or indicator occurs in each community as a percent of how much of that activity or indicator occurs county-wide. These allocations by equipment category are shown below in Table 12.

Table 12 Allocation Method for Off-Road Equipment Categories

Source	Allocation Method
Agricultural Equipment	Percent of agricultural acres
Airport Ground Support Equipment	Excluded – No airport facilities in Livermore
Cargo Handling Equipment	Excluded – No port facilities in Livermore
Construction and Mining Equipment	Percent of service population[2]
Industrial Equipment	Percent of industrial acres
Lawn and Garden Equipment	Percent of service population[2]
Light Commercial Equipment	Percent of jobs
Ocean Going Vessels	Excluded – No port facilities in Livermore
Oil Drilling	Percent of active wells
Other Portable Equipment	Percent of service population[2]
Pleasure Craft	Excluded – No docking facilities in Livermore
Recreational Equipment	Percent of population

Transport Refrigeration Units	Percent of service population[2]

[1] EBEW allocated all airport ground support equipment emissions to Oakland because it is the only included community with commercial airport operations. Although charter service and general aviation is available at airports in Concord, unincorporated Contra Costa, Hayward, and Livermore, activity and emissions at these facilities is considered insignificant.

[2] Service population is the sum of residents plus jobs, or people who live in the community plus people who work in the community. Someone who both lives and works in the community is counted as two people under this method.

After applying the above attribution metrics to the fuel consumption outputs from OFFROAD2021 Alameda County, GHG emission factors were applied to the fuel totals to obtain total GHG emissions. The GHG emission factors used were 0.0103, 0.00905, and 0.00582 MT CO_2e per gallon of fuel; for diesel, gasoline, and natural gas/liquefied petroleum gas, respectively. Total emissions from off-road transportation in 2017 was 58,852 MT CO_2e, shown in Table 13.

Table 13 Estimated Off-Road Transportation Emissions for 2017

Source	Fuel Consumption (Gallons)	GHG Emissions (MT CO_2e)
Diesel	1,104,596	11,425
Gasoline	371,061	3,360
Natural Gas/Liquefied Petroleum Gas	552,683	3,217
Total	**2,028,314**	**18,002**

Notes: MT CO_2e: metrics tons of carbon dioxide equivalent

3.3 Water and Wastewater Emissions

Water

Water is supplied to Livermore by Livermore Municipal Water and the California Water Service (CalWater), primarily sourced from the State Water Project in the Central Valley. The Livermore Municipal Water receives treated water from Zone 7 Water Agency and serves about one-third of the City, while central and southern parts of the City are served by CalWater. Water supplied to the community contributes emissions through the use of energy to extract, convey, treat, and deliver water. The amount of energy required for community water usage was calculated using embodied energy data emissions factors based on the processes used, taken from the California Energy Commission's 2007 Refining Estimates of Water-Related Energy Use in California report. It was determined that in 2017 Livermore Municipal Water provided water at an average of 3,808 kWh per million gallons, while CalWater provides water at an average of 3,305 kWh per million gallons. This resulted in Livermore Municipal Water using 6,608 MWh and CalWater using 8,736 MWh to provide the City water in 2017. A breakdown of all water emissions by source are shown below in Table 14.

PG&E is the electricity provider for the City; therefore, PG&E's energy emissions factor of 210 pounds CO_2e/MWh was applied to the calculated electricity used for water consumption in the city. Energy consumption related to water use in the city of Livermore resulted in the generation of approximately 1,479 MTCO_2e in 2017, or 52 percent of total water and wastewater emissions. In 2005, the City used 5,879 million gallons of water. In 2017, Livermore used 4,378 million gallons of water, or about 26 percent less overall. Emissions overall decreased by 3,200 MT CO_2e, due to this decrease in water usage as well as the reduction in PG&E's electricity emissions factor.

Wastewater

The wastewater generated by community residents and businesses creates GHG emissions during the treatment processes, including process, stationary, and fugitive emissions. The sources and magnitude of emissions depend on the type of wastewater treatment plant and the treatment processes utilized.

Wastewater generated in the City of Livermore is collected in local sewer lines which ultimately discharge into the Livermore Water Reclamation Plant managed by Water Resources Division of the Livermore Public Works Department. The wastewater treatment plant treated 2132 million gallons of sewage from Livermore in 2017, according to data obtained from the City. Emissions were calculated using Community Protocol Methodology WW.2, WW.8, and WW.12 based on processes used at the treatment facility (Figure 2). In 2017, a total of 3.32 MT N_2O and 1.88 MT CH_4 were emitted from the effluent discharge, process and stationary sources at the treatment plant. The wastewater treatment plant also used 3,671,304 kWh of electricity in 2017, which resulted in emissions of 354 MT CO2e. As shown in Table 14 the total process emissions and electricity usage for Livermore wastewater treatment and disposal resulted in emissions of 1,366 MT CO_2e per year, or 48 percent of the water and wastewater emissions.

Table 14 Water and Wastewater Emissions for Year 2017

Source	Activity Data	Kilowatts per Million Gallons[1]	Kilowatt Hours	Emissions Factor (MT CO_2e/ MWh)	Total Emissions (MT CO_2e)
Water Use					
Livermore Municipal Water	1,735 MG	3,808	6,608,374	0.09635	637
California Water Service	2,643 MG	3,305	8,736,088	0.09635	842
Total					**1,479**
Wastewater Generation					
Livermore Water Reclamation Plant[2]	2,132 MG	1,722	3,671,304	0.09635	354
Process Nitrous Oxide Emissions	0.3034 MT N_2O	–	–	1 N_2O to 265 CO_2e	80
Stationary Methane Emissions	1.88 MT CH_4	–	–	1 CH_4 to 28 CO_2e	53
Effluent Discharge	3.32 MT N_2O	–	–	1 N_2O to 265 CO_2e	879
Total					**1,366**

MWh: megawatt hours; MT: metric tons; CO_2e: carbon dioxide equivalent; CH_4: methane; N_2O: nitrous oxide

[1] Calculated based off of the data regarding the processes used for water and wastewater generation. Water factors included: average depth of groundwater wells (160 ft), and sources of water (surface water, groundwater, state water project, recycled water). Wastewater factors included: type of wastewater treatment technology (activated sludge and digesters), use of pumps to dispose of wastewater, wastewater discharge into the San Francisco Bay, and number of septic tanks in Livermore (144 in 2017)

[2] Indirect emissions from electricity use during the wastewater generation process.

Figure 2 Wastewater Methodology

Box WW.2.(alt)	**Example Calculation of N_2OEmissions from Combustion when only Population Served by System is Known**	
A centralized wastewater facility serves a city with a population of 100,000 people. No other data is available. Based on this scenario the N_2O emissions from the combustion of digester biogas can be calculated as follows		
Description		Value
N_2O emissions	= Total N_2O emitted by combustion ($mtCO_2e$)	Result
P	= Population served by anaerobic digester	100,000
Digester gas	= Measured standard cubic feet of digester gas produced per person per day (std ft^3/person/day)	1.0
fCH_4	= Fraction of CH_4 in biogas	0.65
BTU_{CH4}	= Default BTU content of CH_4, higher heating value (BTU/ft^3)	1028
10^{-6}	= Conversion from BTU to 1 MMBTU	10^{-6}
EF_{N2O}	= N_2O emission factor (kg N_2O/MMBTU)	6.3 X 10^{-4} kg N_2O per MMBTU
365.25	= Conversion factor (day/year)	365.25
10^{-3}	= Conversion from kg to mt (mt/kg)	10^{-3}
GWP_{N_2O}	= Global Warming Potential; conversion from mt of N_2O into mt of CO_2 equivalents	GWP^{11}
Sample Calculation:		
Annual N_2O emissions = $(100{,}000 \times 1 \times 0.65 \times 1028 \times 10^{-6} \times (6.3 \times 10^{-4}) \times 365.25 \times 10^{-3}) \times 310$ = *4.8 $mtCO_2e$*		

***Equation WW.8* N_2O Process Emissions from Wastewater Treatment Plants (or aeration basin) without nitrification or denitrification**		
Annual N_2O emissions = $((P \times F_{ind\text{-}com}) \times EF \times 10^{-6}) \times GWP$		
Where:		
Description		Value
Annual N_2O emissions	= Total annual N_2O emitted by WWTP processes ($mtCO_2e$)	Result
P	= Population served by the WWTP	User input
$F_{ind\text{-}com}$	= Factor for high nitrogen loading of industrial or commercial discharge	1.25
$F_{ind\text{-}com}$	= Factor for insignificant industrial or commercial discharge	1
$EF_{w/o\ nit/denit}$	= Emissions factor for a WWTP without nitrification or denitrification(g N_2O/ person / year)	3.2
10^{-6}	= Conversion from g to mt (mt/g)	10^{-6}
GWP_{N_2O}	= Global Warming Potential; conversion from mt of N_2O into mt of CO_2 equivalents	GWP^{25}
Source: *As listed in LGO protocol Equation 10.7 from EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1890-2007, Chapter 8, 8-13 (2009)*		

Equation WW.12.(alt) **N_2O Emission from Effluent Conversion when only Population Served by Wastewater Treatment Plant is Known**		
Annual N_2O emissions = ((P × $F_{ind-com}$) × (Total N load - N uptake x BOD5 load) × EF effluent × 44/28 × (1 – Fplant nit/denite) × 365.25 × 10^{-3}) × GWP		
Where:		
Description		Value
N_2O emissions	= Total annual N_2O emitted by effluent (mtCO2e)	Result
P	= Population	User input
$F_{ind-com}$	= Factor for industrial or commercial discharge	1.25 (if applicable)
Total N-Load	= Average total nitrogen per day (kg N/person/day)	0.026[34]
N uptake	= Nitrogen uptake for cell growth in *aerobic* systems (kg N/kg BOD_5)	0.05
OR		
N uptake	= Nitrogen uptake for cell growth in *anaerobic or lagoon* systems(kg N/kg BOD_5)	0.005
BOD_5	= Amount of BOD_5 produced per person per day (kg BOD_5/person/day)	0.090
EF	= Emission factor (kg N_2O-N/kg sewage-N discharged)	0.005 for river or stream discharge, 0.0025 for direct ocean discharge[35]
44/28	= Molecular weight ratio of N_2O to N_2	1.57
F*plant nit/denit*	= Fraction of nitrogen removed from the WWTP with nitrification/denitrification	0.7
OR		
F*plant*	= Fraction of nitrogen removed from the WWTP without nitrification/denitrification	0.0
365.25	= Conversion factor (day/year)	365.25
10^{-3}	= Conversion from kg to mt (mt/kg)	10^{-3}
GWP	= Global Warming Potential; conversion from mt of N_2O into mt of CO_2 equivalents	GWP[36]
Source: *As listed in LGO protocol Equation 10.10 from EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007, Chapter 8, 8-13 (2009); except Grady, C.P. L., Jr., G. T. Daigger, and H. C. Lim, Biological Wastewater Treatment p. 108-109, 644 2nd Edition (1999)*		

3.4 Solid Waste Emissions

GHG emissions result from management and decay of organic material solid waste. Community waste was calculated by determining lifetime methane emissions from solid waste generated by the community in the year of the inventory, using Community Protocol method SW.4[48]. This

[48] ICLEI. 2012. US Community Protocol. Available: https://icleiusa.org/publications/us-community-protocol/. Accessed: April 24, 2020.

methodology attributes 100 percent of lifetime GHG emissions from the tonnage reported in the inventory year.

Waste from the City of Livermore went to 20 landfills in 2017 according to waste data obtained from CalRecycle. Data for the inventory was split between instate solid waste and alternative daily cover waste, 73,437 tons and 8,329 tons respectively. Small quantities of 'transform' and 'AIC' waste data from two landfill sites were not included in the inventory (Covanta Stanislaus, Inc. and Fink Road Landfill), because only reported in-state waste and alternative daily cover waste were included in the inventory. Activity data for the waste sector of the GHG inventory is shown below in Table 15 by landfill destination.

Table 15 Summary of Solid Waste Activity Data by Landfill for Year 2017

Source	Solid Waste (tons)	ADC Waste (tons)
Landfills	**–**	**–**
Altamont Landfill & Resource Recovery	9,047	699
Azusa Land Reclamation Co. Landfill	13	0
Corinda Los Trancos Landfill (Ox Mtn)	26	0
Fink Road Landfill	362	0
Foothill Sanitary Landfill	93	0
Forward Landfill, Inc.	861	0
Keller Canyon Landfill	383	88
Kirby Canyon Recycl. & Disp. Facility	1	0
L and D Landfill	0	1
Monterey Peninsula Landfill	191	0
Newby Island Sanitary Landfill	113	0
North County Landfill & Recycling Center	3	0
Potrero Hills Landfill	204	0
Recology Hay Road	686	0
Redwood Landfill	3	1
Sacramento County Landfill (Kiefer)	1	0
Vasco Road Sanitary Landfill	61,443	7,535
Yolo County Central Landfill	1	0
Zanker Material Processing Facility	6	4
Total Tons of Waste Disposal	**73,437**	**8,329**

Communities are required to estimate the emissions resulting from waste disposed by the community (SW.4.1)[39], regardless of whether the receiving landfill(s) are located inside or outside of the community boundary. Community Protocol Method SW.4.1[39] is summarized in Figure 3, utilizing mass of waste being disposed, organic content of waste, methane capture ability of the landfill, oxidation rate, and methane GWP. The 2017 emissions factor for generated solid waste and ADC waste in Livermore was derived from the California Air Resources Board California Landfill Emissions Tool Version 1.3, shown in Table 16 and Table 17, respectively.

Figure 3 Waste Generation Methodology

Equation SW.4.1 Methane Emissions

$$CH_4\ Emissions = GWP_{CH4} * (1- CE) * (1-OX) * M * \sum_i P_i * EF_i$$

Where:

Term	Description	Value
CH_4 emissions	= Community generated waste emissions from waste M ($mtCO_2e$)	Result
GWP_{CH4}	= CH_4 global warming potential	
M	= Total mass of waste entering landfill (wet short ton)	User Input
P_i	= Mass fraction of waste component i	User Input
EF_i	= Emission factor for material i ($mtCH_4$/wet short ton)	Table SW.5
CE	= Default LFG Collection Efficiency	No Collection, 0 Collection, 0.75
OX	= Oxidation rate	0.10

Source: As developed by ICLEI staff and Solid Waste Technical Advisory Committee. Emissions factors from U.S. EPA Municipal Solid Waste Publication (2008) available at http://www.epa.gov/epawaste/nonhaz/municipal/pubs/msw2008data.pdf

In 2017, Livermore produced 73,437 tons of solid waste and 8,329 of ADC waste.[49] A CO_2e emissions factor for mixed-waste of 0.286 MT CO_2e/ton was established and multiplied by the total solid waste disposed of from the community to calculate emissions from waste generated in 2017 of 21,006 MT CO_2e. For ADC waste, a CO_2e emissions factor of 0.246 MT CO_2e/ton was established and multiplied by the total ADC waste disposed of from the community to calculate emissions from waste generated in 2017 of 2046 MT CO_2e. These emissions factors include the expected lifetime emissions associated with the specified tonnage of waste sent to landfill. The emissions factors were developed using SW 4.1 as well as the relative waste stream percentages of different organic materials as shown in Table 16 and Table 17 to establish a methane emissions factor. From 2005 to 2017 GHG emissions from community waste decreased by 15,442 MT of CO_2e. This was due to a combination of factors including a reduced solid waste emissions factor as well as an overall reduction in waste generation of 51,812 tons. Total waste emissions for 2017 are summarized in Table 18.

[49] CalRecycle. 2017. Local Government Information Center. Available: https://www.calrecycle.ca.gov/LGCentral/MyLoGIC/. Accessed: April 18, 2020.

Table 16 California Default Solid Waste Characterization[1]

Waste Type	WIPFRAC	TDOC	DANF	ANDOC	Weighted MT CO_2e/ton
Newspaper	1.44%	47.09%	15.05%	0.12%	0.279029616
Office Paper	0.73%	38.54%	87.03%	0.62%	1.320583313
Corrugated Boxes	3.13%	44.84%	44.25%	0.95%	0.781203158
Coated Paper	12.10%	33.03%	24.31%	0.72%	0.316139414
Food	18.12%	14.83%	86.52%	1.99%	0.505176074
Grass	1.84%	13.30%	47.36%	0.12%	0.247998153
Leaves	3.52%	29.13%	7.30%	0.07%	0.083723708
Branches	3.27%	44.24%	23.14%	0.20%	0.403054324
Lumber	11.91%	43.00%	23.26%	1.45%	0.393788725
Textiles	5.85%	24.00%	50.00%	0.66%	0.472461427
Diapers	4.29%	24.00%	50.00%	0.52%	0.472461427
Construction/Demolition	2.31%	4.00%	50.00%	0.11%	0.078743571
Medical Waste	0.11%	15.00%	50.00%	0.00%	0.295288392
Sludge/Manure	0.57%	5.00%	50.00%	0.00%	0.098429464
MSW Total				**7.52%**	**0.28604673**

[1] The static values here are from the California Landfill Emissions Tool Version 1.3

Table 17 Alternative Daily Cover Waste Characterization[1]

Waste Type	WIPFRAC	TDOC	DANF	ANDOC	Weighted MT CO_2e/ton
Newspaper	0.00%	47.09%	15.05%	0.12%	0.003580198
Office Paper	0.00%	38.54%	87.03%	0.62%	0.00861393
Corrugated Boxes	0.00%	44.84%	44.25%	0.95%	0.021806282
Coated Paper	0.00%	33.03%	24.31%	0.72%	0.034152408
Food	0.00%	14.83%	86.52%	1.99%	0.081728001
Grass	50.00%	13.30%	47.36%	0.12%	0.004081975
Leaves	25.00%	29.13%	7.30%	0.07%	0.002627254
Branches	25.00%	44.24%	23.14%	0.20%	0.011770174
Lumber	0.00%	43.00%	23.26%	1.45%	0.041876495
Textiles	0.00%	24.00%	50.00%	0.66%	0.024668962
Diapers	0.00%	24.00%	50.00%	0.52%	0.018088588
Construction/Demolition	0.00%	4.00%	50.00%	0.11%	0.001622068
Medical Waste	0.00%	15.00%	50.00%	0.00%	0.000298201
Sludge/Manure	0.00%	5.00%	50.00%	0.00%	0.000497751
MSW Total				**7.25%**	**0.245693584**

[1] The static values here are from the California Landfill Emissions Tool Version 1.3

Table 18 Summary of Solid Waste Activity Data for Year 2017

Source	Tons	Emissions Factor (MT CO_2e/ton)	Total Emissions (MT CO_2e)
Solid Waste	73,437	0.286	21,006
ADC Waste	8,329	0.246	2,046
Total Waste Emissions	**–**	**–**	**23,052**

MT CO2e: metric tons of carbon dioxide equivalent

3.5 2017 GHG Emissions Inventory Results Summary

Overall the City of Livermore's GHG emissions were estimated to be 535,566 MT CO_2e in 2017. The on-road transportation sector (passenger and commercial vehicles) was the largest emissions sector with 55 percent of total baseline inventory emissions, followed by natural gas use in the energy sector at 18 percent. Off-road transportation emissions were estimated to be 3 percent of emissions, and waste accounted for 4 percent. The smallest emissions sector was water and wastewater, which combine to account for less than 1 percent of total 2017 emissions for the City of Livermore. Emissions are summarized in Table 19 and Figure 4.

Table 19 2017 GHG Inventory

Sector	Activity Data	Emissions Factors	Units	MT CO_2e
Residential Electricity (kWh)	205,232,521	0.00009635	MT CO_2e/kWh	19,775
Nonresidential Electricity (kWh)	288,894,815	0.00009635	MT CO_2e/kWh	27,836
Direct Access Electricity[5] (kWh)	32,283,926	0.0002027	MT CO_2e/kWh	6,545
Residential Gas (therms)	12,408,537	0.00531	MT CO_2e/therms	65,896
Adjusted Nonresidential Gas (therms)	10,820,445[1]	0.00531	MT/CO_2e/therms	57,462[1]
Passenger On-Road Transportation (VMT)	538,932,050	0.000338	MT CO_2e/mile	181,900
Commercial On-Road Transportation (VMT)	96,824,903	0.001366	MT CO_2e/mile	132,254
Off-Road – Diesel (Gallons)	1,104,596	0.0103	MT CO_2e/gallon	11,425
Off-Road – Gasoline (Gallons)	371,061	0.00905	MT CO_2e/gallon	3,360
Off-Road – NG/LPG (Gallons)	552,683	0.00582	MT CO_2e/gallon	3,217
Waste (tons)[6]	81,766	0.2860	MT CO_2e/ton	23,052
Wastewater (kWh)	N/A[4]	N/A[4]	MT CO_2e/kWh	1,366
Water (kWh)	15,344,462	0.00009635	MT CO_2e/kWh	1,479
Total Emissions				**535,566**

MWh: megawatt hours; kWh: kilowatt hours; CO_2e: carbon dioxide equivalent; MT: metric tons; VMT: vehicle miles traveled; ADC: Alternative Daily Cover

[1] No natural gas usage was reported by PG&E for large industrial users after 2013 due to California Public Utilities Commission privacy rules. Natural gas emissions reported by the Lawrence Livermore National Laboratory to the California Air Resources Board as a part of the Cap-and-Trade program were added to allow for accurate comparison of emissions from nonresidential gas in previous inventory years. Data reported as a part of the Cap-and-Trade program can be found here: https://ww2.arb.ca.gov/mrr-data

[2] Off-road emissions calculated as a proportion of total emissions in Alameda County based on changes in population and does not have activity data.

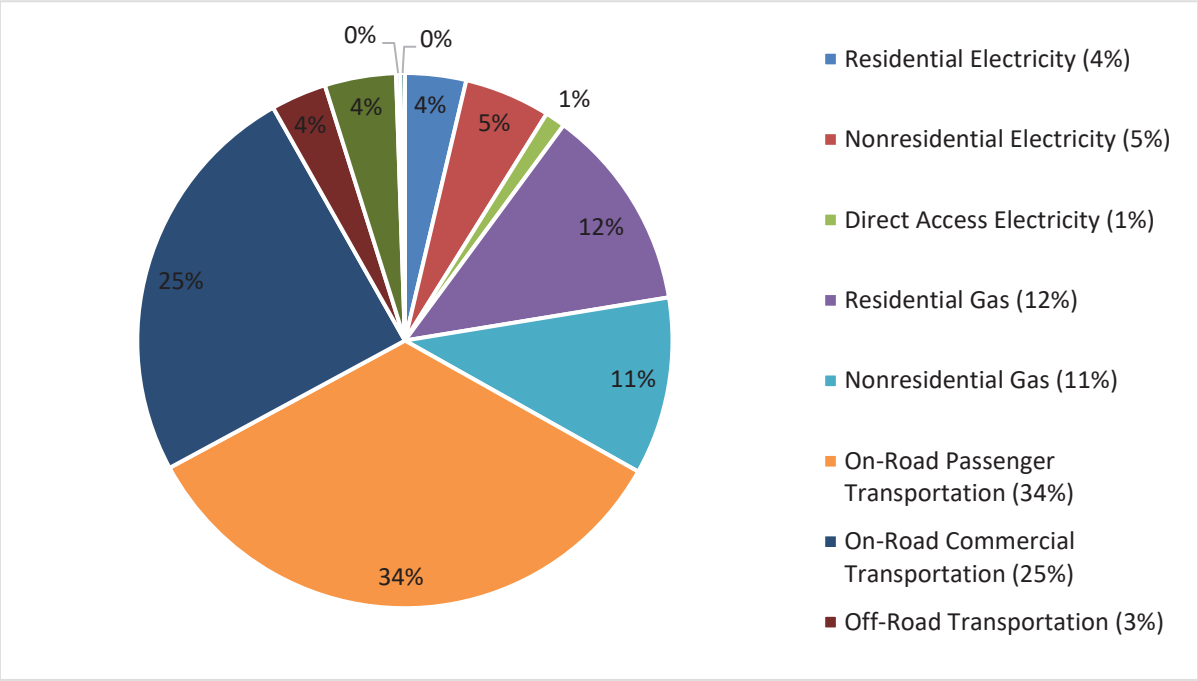
[3] Off-road emissions calculated as a proportion of total emissions in Alameda County based on Livermore's percentage of population and jobs within the County, as well as the effective change in service population, which was defined as on the sum of new population and jobs in Livermore divided by the total sum of new jobs and population in Alameda County for each inventory year.

[4] Wastewater is a combination of stationery and process emissions, further detail is Section 3.3.

[5] Direct access service is retail electric service where customers purchase electricity from a competitive provider called an Electric Service Provider instead of from a regulated electric utility. An Electric Service Provider is a non-utility entity that offers electric service to customers within the service territory of an electric utility.

[6] Includes 8329 tons of Alternative Daily Cover Waste for which a different emissions factor was used (.246 MTCO_2e/ton). This emissions factor was calculated using data from the CARB California Landfill Emissions Tool Version 1.3.

Figure 4 2017 City of Livermore Community Emissions by Sector



Between 2005 and 2017, Livermore was able to reduce total GHG emissions by 17 percent from 2005 to 2017, or 106,667 $MTCO_2e$, and experienced a population increase of approximately 16 percent which led to a per-capita emissions reduction of 38 percent. The 17 percent decrease in total GHG emissions from 2005 levels meets the 2020 AB 32 goal of reducing emissions by 15 percent (1990 levels), as well as the 2020 emissions reduction target set forth by Livermore's 2012 CAP. Table 20 summarizes GHG emissions changes in Livermore from 2005 to 2017, and Table 21 summarizes changes in activity data.

Between 2005 and 2017, Livermore reduced GHG emissions in every sector except for nonresidential gas and off-road transportation, which may have increased due to growth in development of the commercial and industrial sectors within the City. Major GHG emissions reductions were achieved in the waste sector and wastewater sectors, although these sectors make up smaller proportions of Livermore's overall emissions as shown in Figure 4. It is worth noting that large GHG emissions reductions from electricity usage were driven largely by PG&E's electricity fuel mix, which saw a significant decrease in carbon intensity[50] from 2005 to 2017. Although there was an increase in commercial vehicle miles traveled (VMT), GHG emissions associated with the commercial on-road transportation sector declined because of the increased fuel efficiency of vehicles as detailed in Table 20 and Table 21.

[50] Carbon intensity is the amount of carbon by weight emitted per unit of energy consumed. For example, as the percentage of renewable energy sources used to produce electricity increases, the carbon intensity of that electricity decreases.

Table 20 Summary of Livermore GHG Emissions Changes from 2005 to 2017

GHG Emissions Sources	2005 (MT CO_2e)	2017 (MT CO_2e)	Percent Change
Residential Electricity	49,822	19,775	-60%
Nonresidential Electricity	65,872	27,836	-58%
Direct Access Electricity	15,192	6,545[2]	-57%
Residential Gas	71,139	65,896	-7%
Nonresidential Gas	29,771	57,462[1]	+93%
Solid Waste	35,008	21,006	-40%
Alternative Daily Cover Waste	3,487	2,046	-41%
Water	4,680	1,479	-68%
Wastewater	1,839	1,366	-28%
On-Road Passenger Transportation	218,684	181,900	-17%
On-Road Commercial Transportation	134,636	132,254	-2%
Off-Road Transportation	88,179	58,852	+49%
Total Emissions	**642,233**	**535,566**	**-17%**
Emissions Per Capita	**9.62**	**5.92**	**-38%**

MT CO_2e: metric tons of carbon dioxide equivalent

[1] PG&E did not report data for industrial natural gas usage in Livermore for 2015 and 2017 due to the CPUC's 15-15 privacy rule. Industrial natural gas usage was estimated for these years using the reported GHG emissions from the Livermore Lawrence National Laboratory for those years as a part of California's Cap-and-Trade program. (see Section 2.3 for more details on this calculation).

[2] PG&E did not report data for direct access electricity usage in Livermore for 2017 due to the CPUC's 15-15 privacy rule and was estimated using the average of 2015 and 2016 data as they were the closest available years (see Section 2.3 for more details on this calculation).

Table 21 Summary of Livermore Activity Data and Emissions Factor Changes from 2005 to 2017

Raw Activity Data	2005 Activity Data	2017 Activity Data	Percent Change
Population	78,019	90,454	+16%
Residential Electricity (kWh)	223,251,790	205,232,521	-8%
Residential Gas (therms)	13,395,923	12,408,537	-7%
Nonresidential Electricity (kWh)	295,174,279	288,894,815	-2%
Adjusted Nonresidential Gas (therms)	5,606,070	10,820,445[1]	+93%
Direct Access Electricity (kWh)	39,378,526	32,283,926[2]	-18%
Wastewater (kWh)	4,546,080	3,671,304	-19%
Water (kWh)	20,975,856	15,344,462	-27%
Solid Waste (tons)	119,384	73,437	-38%
Alternative Daily Cover Waste (tons)	14,193	8,329	-41%
Passenger VMT	548,153,828	538,438,400	-2%
Commercial VMT	91,610,896	95,769,686	+5%
Passenger VMT Emissions Factor (MT CO_2e/VMT)	0.000399	0.000338	-15%
Commercial VMT Emissions Factor (MT CO_2e/VMT)	0.001470	0.001366	-7%
Off-Road D**iesel (gallons)**	600,655	1,104,596	+84%
Off-Road Gasoline (gallons)	338,135	371,061	+10%
Off-Road NG/LPG (gallons)	477,673	552,683	+16%
PG&E Elec Factor (MT CO_2e/MWh)	0.000223	0.000096	-57%

MT CO_2e: Metric tons of carbon dioxide equivalent; kWh: Thousand watt hours; MWh: Million watt hours; ADC: Alternative Daily Cover; NG: natural gas; LPG: liquefied petroleum gas

[1] Includes activity data from Lawrence Livermore National Laboratory, calculated using reported emissions to CARB as a part of the Cap-and-Trade Mandatory GHG Reporting program and the natural gas emissions factor of 0.00531.

[2] Activity data for 2017 direct access electricity unavailable from PG&E due to CPUC privacy rules and was estimated for consistency with other inventory years based on an average of 2015 and 2016 direct access electricity data.

4 Future GHG Emissions Forecasts

A GHG emissions inventory sets a reference point for a single year. However, annual emissions change over time due to factors such as population and job growth as well as new technologies and policies. A GHG emissions forecast accounts for projected growth and presents an estimate of GHG emissions in future years. Calculating the difference between the GHG emissions forecast and the GHG emissions reduction targets set by a jurisdiction determines the GHG emissions reduction gap that needs to be closed through the jurisdiction's climate action plan policies. This section calculates an emissions forecast for the City of Livermore through a 2045 in a *business-as*-usual (BAU) scenario, and then quantifies the reduction impact that state regulations will have on the City of Livermore GHG emissions forecast and presents the results in an *adjusted scenario* forecast. The *adjusted scenario* incorporates the impact of state regulations which would reduce the City of Livermore's GHG emissions to provide a more accurate picture of future emissions growth and the responsibility of the City and community for GHG reductions once state regulations to reduce GHG emissions have been implemented.

Several indicator growth rates were developed and applied to the various emissions sectors to forecast emissions as shown in Table 22. The growth rates were applied to the most recent inventory year (2017) data to obtain projected activity data (e.g., energy use, waste production). Growth rates were developed from the Association of Bay Area Government's Plan Bay Area Projections 2040, EMFAC Modeling, OFFROAD2021 modeling, Livermore 2025 General Plan demographic projections methodology, and California Department of Finance demographic estimates for the City of Livermore and Alameda County. As the Applicable state and federal regulatory requirements, including Corporate Average Fuel Economy standards, Advanced Clean Car Standards, Renewable Portfolio Standard, and Title 24 efficiencies were then incorporated to accurately reflect expected reductions from state programs.

Plan Bay Area Projections 2040 has demographic projections starting with 2010 and was the primary source for forecast projections.[51] In comparison with demographic data from the California Department of Finance E4 and E5 datasets[52] (which are updated year-to-year based on census data and jurisdictional data on population changes). However, Plan Bay Area Projections 2040 underestimates population and job growth in Livermore for 2015. This was due to the use of "modeled" rather than "observed" data used in the projections.[53] Therefore, subsequent forecast years are lower than those provided by Department of Finance. For this reason, these demographic projections were corrected to better reflect real-world population changes that occurred in Livermore up until 2017, using the calculated percent difference between the Plan Bay Area Projections 2040 and the Department of Finance data in 2015 and 2020. The result is a set of adjusted population and job projections through 2045 that reflect the greater increase in growth experienced by the City of Livermore between 2015 and 2020.

[51] Association of Bay Area Governments; Metropolitan Transportation Commission. 2018. Plan Bay Area Projections 2040. Available: http://projections.planbayarea.org/. Accessed April 22, 2020.

[52] California Department of Finance. 2020. Available: http://www.dof.ca.gov/Forecasting/Demographics/Estimates/. Accessed: April 22, 2020.

[53] http://mtcmedia.s3.amazonaws.com/files/Projections_2040-ABAG-MTC-web.pdf

4.1 Business-as-Usual Forecast Scenario

The City of Livermore business-as-usual scenario forecast provides an estimate of how GHG emissions would change in the forecast years if consumption trends continue as in 2017, absent any new regulations which would reduce local emissions. Several indicator growth rates were developed from 2017 activity levels and applied to the various emissions sectors to project future year emissions. Table 22 contains a list of growth factors used to develop the business-as-usual scenario forecast. The BAU growth factors were then multiplied by the population or service person growth rates to develop the BAU emissions forecast.

Table 22 Business-as-Usual Growth Factors

Sector	Activity Data
Emissions per capita (MT CO2e/capita)	6.4
Residential electricity per capita (kWh/capita)	2,268.9
Commercial electricity use per job (kWh/employment)	6,002.0
Residential gas per capita (therm/capita)	137.2
Commercial gas use per job (therm/job)	224.8
Solid Waste per service person (tons/SP)	0.53
ADC Waste per service person (tons/SP)	0.06
Wastewater Process GHG per service population (MT CO_2e/SP)	0.01
CO_2e per ton solid waste (MT CO_2e/ton)	0.29
CO_2e per ton ADC waste (MT CO_2e/ton)	0.25
Water electricity per service person (kWh/SP)	110.7
Wastewater electricity per service person (kWh/SP)	26.5
Total VMT per service person (VMT/SP)	4,587.4

kWh: kilowatt hour; SP: service person (sum of population and employment) MT CO_2e: metric tons of carbon dioxide equivalent; VMT: vehicle miles traveled

Under the BAU forecast scenario, the City of Livermore's GHG emissions are projected to continue increasing through 2045. This increase is led primarily by a strong commercial and residential development trend. After the current General Plan horizon year of 2025, major increases in in emissions are largely attributed to the increased population and vehicular traffic from the greater Alameda County Area traveling into the city. By 2045, the City is expected to produce 99,286 MT CO_2e more under the business-as-usual projections, an increase of 19 percent over 2017 emissions. Per capita emissions are projected to go down, however, from 5.92 in 2017 to 4.92 in 2045. The BAU forecast is summarized below in Table 23.

Table 23 Business-as-usual Forecast by Sector

	2017 (MT CO_2e)	2020 (MT CO_2e)	2025 (MT CO_2e)	2030 (MT CO_2e)	2035 (MT CO_2e)	2040 (MT CO_2e)	2045 (MT CO_2e)
Population	90,454	91,474	96,699	105,967	113,218	120,925	129,158
Jobs	48,133	48,340	48,686	49,372	50,649	51,499	52,364
Residential Electricity	19,775	19,998	21,140	23,167	24,752	26,437	28,237
Nonresidential Electricity	27,836	27,956	28,156	28,553	29,291	29,783	30,283
Direct Access Electricity	6,545	6,618	6,996	7,667	8,192	8,749	9,345
Residential Gas	65,896	66,639	70,445	77,197	82,479	88,094	94,091
Nonresidential Gas	57,462	57,709	58,123	58,941	60,465	61,481	62,513
Waste	23,052	23,256	24,183	25,839	27,257	28,681	30,194
Water	1,479	1,492	1,551	1,657	1,748	1,840	1,937
Wastewater	1,366	1,378	1,433	1,531	1,615	1,699	1,789
On-Road Passenger Transportation	181,900	184,250	191,175	198,101	201,095	204,090	207,084
On-Road Commercial Transportation	132,254	132,641	134,445	136,248	138,355	140,462	142,568
Off-Road Transportation	18,002	18,951	20,532	22,114	23,680	25,245	26,811
Total Emissions	**535,566**	**540,888**	**558,181**	**581,014**	**598,930**	**616,560**	**634,852**
Emissions Per Capita	**5.92**	**5.91**	**5.77**	**5.48**	**5.29**	**5.10**	**4.92**

MT CO_2e: metric tons of carbon dioxide equivalent

4.2 Adjusted Forecast Scenario

Adjustments Due to State Legislation

The adjusted scenario estimates future City of Livermore emissions including adopted GHG reduction strategies currently being implemented at the state and federal level. The 2017 Scoping Plan Update identified several existing state programs and targets, or known commitments required by statute which can be assumed to achieve GHG reductions without City action, such as increased fuel efficiency standards of mobile vehicles. The following known commitments are factored into the adjusted scenario projection and a summary of the programs can be found in Table 24.

Table 24 Summary of Legislative Reductions

Legislation	2020 (MT CO_2e)	2025 (MT CO_2e)	2030 (MT CO_2e)	2035 (MT CO_2e)	2040 (MT CO_2e)	2045 (MT CO_2e)
Senate Bill 100	6,003	16,514	28,314	41,250	55,159	70,265
Title 24	82	1,157	3,080	4,776	6,448	2,281
Transportation (Pavley, etc.)	21,344	62,120	94,871	114,488	125,512	131,342
Total	**27,429**	**79,790**	**125,265**	**160,514**	**187,119**	**203,887**

MT CO_2e: metric tons of carbon dioxide equivalent

State programs will lead to an estimated reduction of approximately 203,887 MT CO_2e in GHG emissions by 2045 in Livermore. The increasing decarbonization of the electricity supply due to SB 100 and the Renewable Portfolio Standard (RPS) will lead to GHG emissions reductions in Livermore and avoid over 70,265 MT CO_2e by 2045. The transportation sector will experience the largest GHG reductions, with over 131,342 MT CO_2e reduced by 2045 through state and federal fuel efficiency and tailpipe emissions standards. A description of the GHG reduction policies for each sector are included below.

Transportation Legislation

The CARB EMFAC2017 transportation modeling program incorporates legislative requirements and regulations including Advanced Clean Cars program (Low Emissions Vehicles III, Zero Emissions Vehicles program, etc.), and Phase 2 federal GHG Standards. Signed into law in 2002, AB 1493 (Pavley Standards) required vehicle manufactures to reduce GHG emissions from new passenger vehicles and light trucks from 2009 through 2016, with a target of 30 percent reductions by 2016, while simultaneously improving fuel efficiency and reducing motorists' costs.[54]

Prior to 2012, mobile emissions regulations were implemented on a case-by-case basis for GHG and criteria pollutant emissions separately. In January 2012, CARB approved a new emissions-control program (the Advanced Clean Cars program) combining the control of smog, soot causing pollutants, and GHG emissions into a single coordinated package of requirements for passenger cars and light trucks model years 2017 through 2025. The Advanced Clean Cars program coordinates the goals of the Low Emissions Vehicles, Zero Emissions Vehicles, and Clean Fuels Outlet programs. However, in 2019 the federal government issued a final action entitled the One National Program on Federal Preemption of State Fuel Economy Standards Rule, which finalized Part I of the Safer, Affordable, Fuel-Efficient (SAFE) Vehicles Rule and stated that federal law preempts state and local tailpipe GHG emissions standards as well as zero emissions vehicle mandates. While still in flux, under the SAFE Rule discussed above, fuel economy and GHG emissions standards for new vehicles may not improve beyond model year 2020. According to CARB, the federal rollback proposal of the remaining Advanced Clean Cars Program standards would increase global warming emissions by 14 million metric tons per year by 2025.[55]

[54] California Air Resources Board. 2013. Clean Car Standards – Pavley, Assembly Bill 1493.

[55] California Air Resources Board. 2018. California moves to ensure vehicles meet existing state greenhouse gas emissions standards. Available: https://ww2.arb.ca.gov/news/california-moves-ensure-vehicles-meet-existing-state-greenhouse-gas-emissions-standards-0. Accessed: April 17, 2020.

Reductions in GHG emissions from the above referenced standards were calculated using the CARB EMFAC2017 model for Alameda County. The EMFAC2017 model integrates the estimated reductions into the mobile source emissions portion of the model.[56]

Note: As of the time of this writing, the federal Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule Part 2 has been posted in the Federal Register but will not take effect until June 29, 2020. This new rule rolls back California fuel efficiency standards for on-road passenger vehicles, so that cars and trucks will now only achieve a 40.4 mpg industry average by 2026 compared to the 46.7 mpg projected requirement under the previous California Advanced Clean Car Program/federal Corporate Average Fuel Economy (CAFE) standards. No methodology currently exists for extracting or altering the on-road passenger vehicles fuel efficiency standard aspect of the Emissions Factors (EMFAC) model[57] used to calculate forecasted vehicle GHG emissions. In addition, the California Climate Change Scoping Plan does not yet address or provide guidance related to this pending change in fuel efficiency standards with regard to GHG emissions determination. Furthermore, California is currently challenging this new rule in the court system. Therefore, the Livermore adjusted forecasts have not been modified to reflect the new SAFE Rule Part 2.

Title 24

Although it was not originally intended to reduce GHG emissions, California Code of Regulations Title 24, Part 6: California's Energy Efficiency Standards for Residential and Nonresidential Buildings, was adopted in 1978 in response to a legislative mandate to reduce California's energy consumption, which in turn reduces fossil fuel consumption and associated GHG emissions. The standards are updated triennially to allow consideration and possible incorporation of new energy-efficient technologies and methods. Starting in 2020, new residential developments will include on-site solar generation and near-zero net energy use. For projects implemented after January 1, 2020, the California Energy Commission estimates the 2019 standards will reduce consumption by seven percent for residential buildings and 30 percent for commercial buildings, relative to the 2016 standards. These percentage savings relate to heating, cooling, lighting, and water heating only and do not include other appliances, outdoor lighting not attached to buildings, plug loads, or other energy uses. The calculations and GHG emissions forecast assume all growth in the residential and commercial/industrial sectors is from new construction.

The 2017 Scoping Plan Update calls for the continuation of ongoing triennial updates to Title 24 which will yield regular increases in the mandatory energy and water savings for new construction. Future updates to Title 24 standards for residential and non-residential alterations past 2023 are not taken into consideration due to lack of data and certainty about the magnitude of energy savings realized with each subsequent update.

Renewables Portfolio Standard & Senate Bill 100

Established in 2002 under SB 1078, enhanced in 2015 by SB 350, and accelerated in 2018 under SB 100, California's Renewable Portfolio Standard (RPS) is one of the most ambitious renewable energy

[56] Additional details are provided in the EMFAC2017 Technical Documentation, July 2018. Available: https://www.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf. Accessed: April 15, 2020. The Low Carbon Fuel Standard (LCFS) regulation is excluded from EMFAC2017 because most of the emissions benefits due to the LCFS come from the production cycle (upstream emissions) of the fuel rather than the combustion cycle (tailpipe). As a result, LCFS is assumed to not have a significant impact on CO_2 emissions from EMFAC's tailpipe emissions estimates.

[57] The EMFAC model is developed and used by CARB to assess emissions from on-road vehicles including cars, trucks, and buses in California and to support CARB regulatory and planning efforts to meet Federal Highway Administration transportation planning requirements.

standards in the country. The RPS program requires investor-owned utilities, publicly owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 50 percent of total procurement by 2026 and 60 percent of total procurement by 2030. The RPS program further requires these entities to increase procurement from GHG-free sources to 100 percent of total procurement by 2045.

PG&E provides electricity in Livermore and is subject to the RPS requirements. PG&E forecast emissions factors include reductions based on compliance with RPS requirements through 2045. In 2017, PG&E reported an emissions factor of 210 pounds CO_2e per MWh.

Direct access electricity accounted for 6.1 percent of total electricity usage in 2017, which is provided by third party electricity providers instead of traditional energy utilities. Emissions factors for the carbon intensity of direct access electricity was assumed to be equal to the state average, calculated to equal .203 MT CO_2e/MWh in 2017. RPS requirements were used to adjust this emissions factor for forecasted emissions through 2045.

Assembly Bill 939 & Assembly Bill 341

In 2011, AB 341 set the target of 75 percent recycling, composting, or source reduction of solid waste by 2020 calling for the California Department of Resources Recycling and Recovery (also known as CalRecycle) to take a statewide approach to decreasing California's reliance on landfills. This target was an update to the former target of 50 percent waste diversion set by AB 939.

Actions beyond the projected waste diversion target of 5.9 pounds per person per day set under AB 939 for the City of Livermore will be quantified and credited to the City during the Climate Action Plan measure development process. As of 2017, Livermore is meeting both the 5.9 pounds per person per day and 9.5 pounds per job per day diversion targets set by CalRecycle under AB 341.

Senate Bill 1383

SB 1383 established a methane emissions reduction target for short-lived climate pollutants in various sectors of the economy, including waste. Specifically, SB 1383 establishes targets to achieve a 50 percent reduction in the level of the statewide disposal of organic waste from the 2014 level by 2020 and a 75 percent reduction by 2025.[58] Additionally, SB 1383 requires a 20 percent reduction in "current" edible food disposal by 2025. Although SB 1383 has been signed into law, compliance at the jurisdiction-level has proven to be difficult. For example, Santa Clara County suggests the 75 percent reduction in organics is not likely achievable under the current structure; standardized bin colors are impractical; and the general requirement is too prescriptive.[59] As such, SB 1383 is not included as part of the adjusted forecast. Instead measures addressing compliance with SB 1383 will be addressed through newly identified GHG reduction measures included in the Climate Action Plan.

Adjusted Forecast Results

The adjusted scenario is based on the same information as the business-as-usual scenario but also includes the legislative actions and associated emissions reductions occurring at the state and federal levels. These actions include regulatory requirements to increase vehicle fuel efficiency or standards to reduce the carbon intensity of electricity. The difference between the emissions

[58] CalRecycle. April 16, 2019. Short-Lived Climate Pollutants (SLCP): Organic Waste Methane Emissions Reductions (General Information). Available: https://www.calrecycle.ca.gov/climate/slcp. Accessed: April 16, 2020

[59] Santa Clara County. June 20, 2018. SB 1383 Rulemaking Overview. Available: https://www.sccgov.org/sites/rwr/rwrc/Documents/SB%201383%20PowerPoint.pdf. Accessed: April 16, 2020

projected in the adjusted scenario and the GHG reduction targets established for each horizon year is the amount of GHG reductions which are the responsibility of the City. This "gap analysis" provides the City with the total GHG emissions reduction required as well as information on the emissions sectors and sources which have the most GHG reduction opportunities.

The electricity and water/wastewater sectors all experience a strong downward trend, approaching near-zero in 2045 due to extremely stringent RPS from SB 100. Natural gas emissions are expected to continue an upward trajectory until the 2045 due to strong population growth projections in the city. This trend is partially offset due to the increasingly stringent efficiency requirements for new homes in the upcoming Title 24 code cycles. Commercial growth will also lead commercial natural gas emissions on a similar trajectory. Transportation emissions are expected to decrease significantly in the next 10 to 15 years due to existing fuel efficiency requirements and fleet turnover rates. As most current regulations expire in 2025 or 2030, emissions standards will experience diminishing returns while VMT continues to increase, leading to lower rates of emissions reduction in the transportation sector.

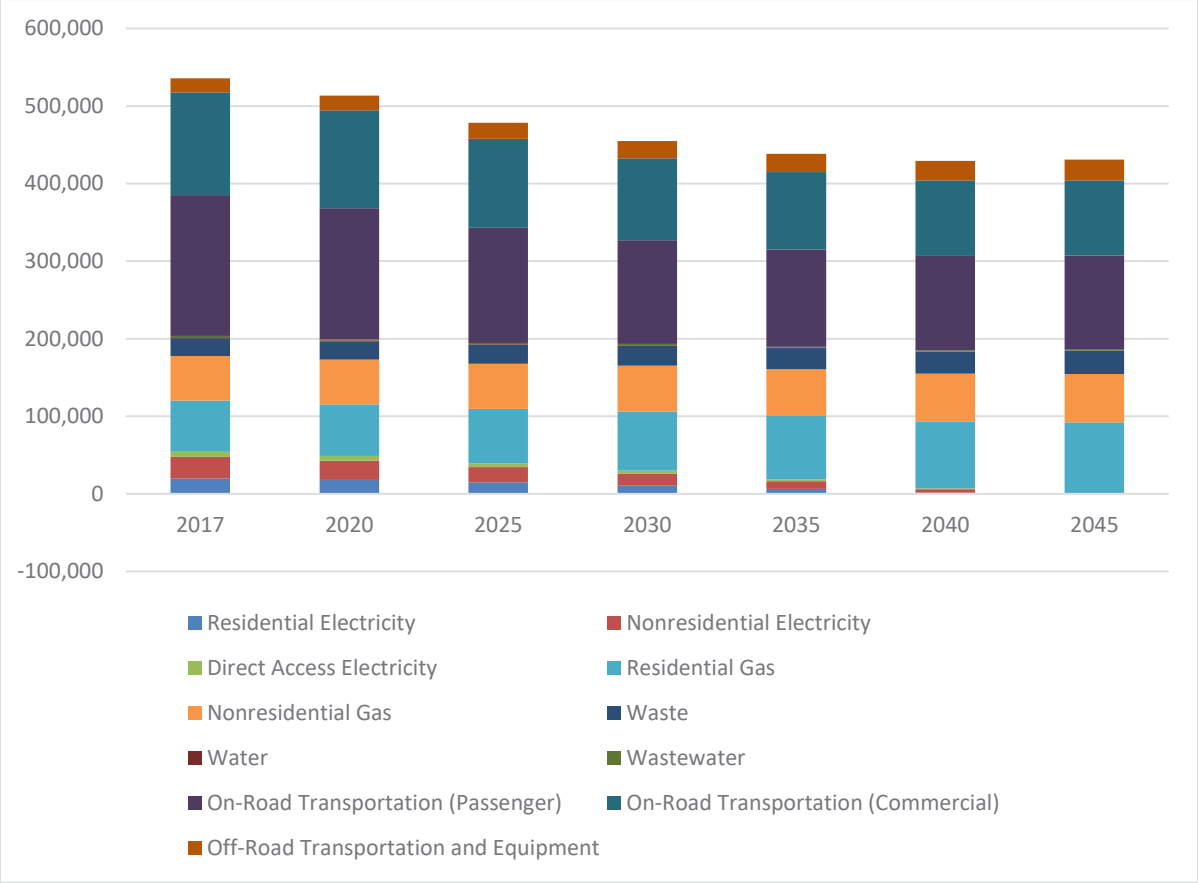
A summary of Livermore's projected emissions by sector and year through 2045 can be found in Figure 5 and Table 25. Further details on the growth rates and emissions for each sector can be found in the corresponding discussion sections.

Table 25 Adjusted Forecast Summary by Sector by Year

	2017 (MT CO_2e)	2020 (MT CO_2e)	2025 (MT CO_2e)	2030 (MT CO_2e)	2035 (MT CO_2e)	2040 (MT CO_2e)	2045 (MT CO_2e)
Population	90,454	91,474	96,699	105,967	113,218	120,925	129,158
Jobs	48,133	48,340	48,686	49,372	50,649	51,499	52,364
Residential Electricity	19,775	17,816	14,455	10,692	6,281	1,269	0
Nonresidential Electricity	27,836	24,949	20,040	15,105	10,049	4,758	0
Direct Access Electricity	6,545	5,944	4,996	3,997	2,597	996	0
Residential Gas	65,896	66,621	70,161	76,440	81,353	86,575	92,152
Nonresidential Gas	57,462	57,703	58,088	58,849	60,267	61,211	62,171
Waste	23,052	23,256	24,183	25,839	27,257	28,681	30,194
Water	1,479	1,332	1,108	888	624	328	0
Wastewater	1,366	1,340	1,327	1,347	1,346	1,338	1,326
On-Road Passenger Transportation	181,900	169,242	148,578	133,987	125,081	121,771	121,487
On-Road Commercial Transportation	132,254	126,305	114,922	105,492	99,881	97,268	96,823
Off-Road Transportation	18,002	18,951	20,532	22,114	23,680	25,245	26,811
Total Emissions	**535,566**	**513,465**	**478,628**	**455,776**	**440,625**	**433,262**	**430,965**
Emissions Per Capita	**5.92**	**5.61**	**4.95**	**4.30**	**3.89**	**3.58**	**3.34**

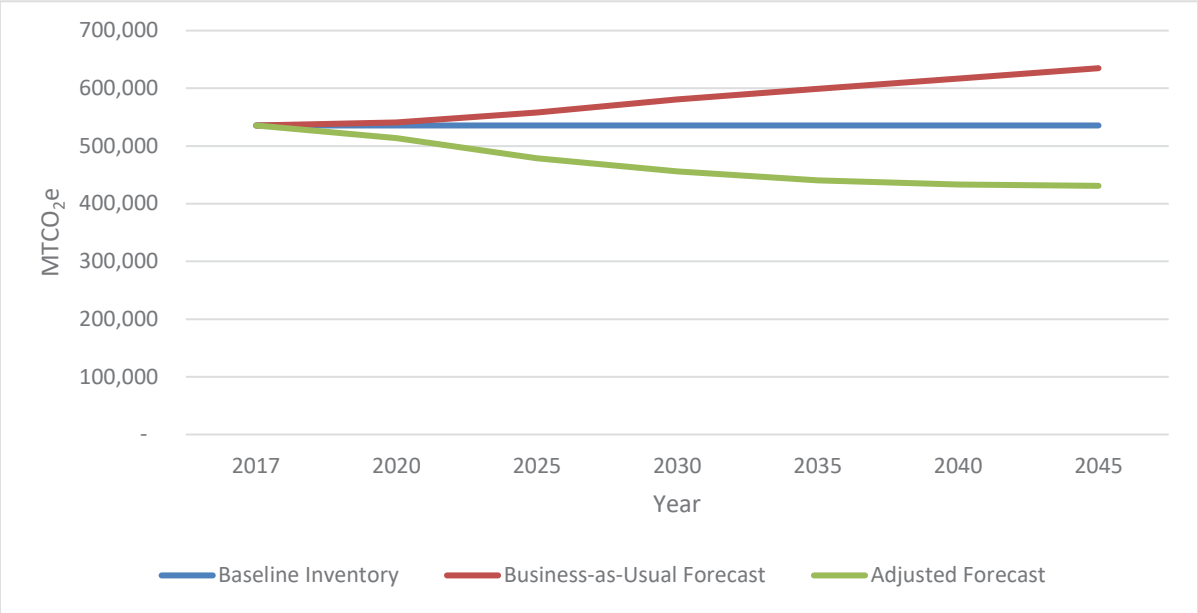
MT CO_2e: metric tons of carbon dioxide equivalent

Figure 5 Adjusted GHG Emissions Forecast Results by Sector and Forecast Year



As shown in Figure 6, without legislative reductions, Livermore's emissions would increase proportionally with population and economic growth. In reality, several existing legislative reductions would limit the Livermore's emissions growth, causing projected emissions to decrease. This scenario is depicted by the Adjusted Forecast. The legislative reductions for each sector and scaling methods used to project emissions are discussed in detail below.

Figure 6 BAU Scenario and Adjusted Scenario Forecast



Electricity Emissions

Between 2017 and 2045, electricity emissions for residential and nonresidential buildings in the City of Livermore are assumed to decrease from 51,735 MT CO_2e to 0 MT CO_2e in 2045 despite steady growth in Livermore's population and employment levels due to the adoption of SB 100 and the renewable portfolio standard

Emissions from future electricity use were forecasted by projecting anticipated growth in residential and commercial sectors and multiplying by expected electricity emissions factors. Anticipated growth in the residential sector was projected as a function of population growth within the city while commercial sector electricity use was projected as a function of employment projections. Legislative adjustments included in the electricity sector forecast include RPS of 60 percent by 2030 and 100 percent GHG-free by 2045. Additionally, Title 24 building code efficiency increases for the 2019 code cycle were applied to all new growth within the city. The methodologies for the electricity sector which were forecasted in the adjusted scenario are summarized in Table 26 and Table 27.

Table 26 Electricity Sector Adjusted Scenario Forecast Methodology

Source Category	Forecasted Activity Data (Scaling Factor)	Emissions Factor	Applied Legislative Reductions
Residential Electricity	Population growth in Livermore	Assumes an electricity mix of 44 percent, 60 percent, and 100 percent GHG-free by 2025, 2030, and 2045, respectively, for PG&E emissions factors per RPS requirements.	Title 24 standards for new construction in 2019 (53 percent residential, 30 percent commercial), RPS requirements
Commercial & Industrial Electricity	Employment growth in Livermore		

RPS: Renewable Portfolio Standard; GHG: greenhouse gas; PG&E: Pacific Gas and Electric

Table 27 Electricity Adjusted Scenario Forecast Results by Forecast Year

Activity Data	2020	2025	2030	2035	2040	2045
Residential Electricity						
Population	91,474	96,699	105,967	113,218	120,925	129,158
BAU total kWh	207,546,359	219,401,455	240,429,720	256,881,190	274,369,398	293,048,186
BAU per capita kWh	2,268.92	2,268.92	2,268.92	2,268.92	2,268.92	2,268.92
Adjusted kWh (Title 24)	207,136,052	212,707,947	222,591,232	230,323,423	238,542,881	247,321,911
Adjusted per capita kWh (Title 24)	2,264.46	2,264.46	2,264.46	2,264.46	2,264.46	2,264.46
Adjusted emissions factor (MT CO_2e/MWH)	0.0860312	0.0688249	0.0516187	0.0344125	0.0172062	0
MT CO_2e	**17,816**	**14,527**	**10,692**	**6,281**	**1,269**	**0**
Nonresidential Electricity						
Employment	48,340	48,686	49,372	50,649	51,499	52,364
BAU total kWh	290,135,098	292,216,547	296,328,536	303,994,718	309,098,544	314,288,060
BAU per job kWh	6,002.01	6,002.01	6,002.01	6,002.01	6,002.01	6,002.01
Adjusted kWh (Title 24)	290,010,745	291,467,760	294,346,152	299,712,479	303,285,158	306,917,819
Adjusted per job kWh	5,999.44	5,999.44	5,999.44	5,999.44	5,999.44	5,999.44
Adjusted emissions factor (MT CO_2e/MWh)	0.08603	0.06882	0.05162	0.03441	0.01721	0
MT CO_2e	**24,949**	**20,040**	**15,105**	**10,049**	**4,758**	**0**
Direct Access Electricity						
Population	91,474	96,699	105,967	113,218	120,925	129,158
BAU total kWh	32,647,902	34,512,758	37,820,591	40,408,476	43,159,443	46,097,694
BAU per capita kWh	357	357	357	357	357	357
Adjusted kWh (Title 24)	32,611,369	33,916,768	36,232,251	38,043,770	39,969,447	42,026,223
Adjusted per capita kWh	357	357	357	357	357	357
Adjusted emissions factor (MT CO_2e/MWh)	0.1823	0.1483	0.1142	0.07614	0.03807	0
MT CO_2e	**5,944**	**4,996**	**3,997**	**2,597**	**996**	**0**

MT CO_2e: metric ton of carbon dioxide equivalent; kWh: kilowatt hour; MWh: megawatt hour; BAU: business-as-usual

Natural Gas Emissions

Emissions from projected natural gas use were forecast using a similar methodology to the electricity sector. Anticipated natural gas use was projected for the residential and commercial sectors separately using population change and employment increase as growth indicators respectively. These results were multiplied by a natural gas emissions factor of 0.00531 MT CO_2e per therms of natural gas.[60] Unlike electricity, the natural gas emissions factor is based on the quality of the gas and remains relatively constant over time. As there are no legislative requirements related to renewable natural gas at this time, this analysis did not consider any shift to renewable gas which may become more common over time and the use of which may affect future natural gas emissions

[60] The Climate Registry. 2019 Default Emissions Factors. Accessed: https://www.theclimateregistry.org/wp-content/uploads/2019/05/The-Climate-Registry-2019-Default-Emission-Factor-Document.pdf. Accessed: April 15, 2020

factors. The methodologies and data used to calculate natural gas emissions over time are summarized in Table 28 and Table 29.

Legislative adjustments applied for the natural gas sector include efficiency increases from Title 24 building code updates for new construction after the 2019 code cycle begins. Specific efficiency increases for new buildings over the previous triennial cycle are discussed in Section 4.3.

Table 28 Natural Gas Adjusted Scenario Forecast Methodology

Source Category	Forecasted Activity Data (Scaling Factor)	Emissions Factor	Applied Legislative Reductions
Residential Natural Gas	Population growth in Livermore	0.00531 MT CO_2e/therms[1]	Title 24 standards for efficiency in new construction in 2019 (7 percent residential, 30 percent commercial over 2016 Title 24)
Commercial & District Natural Gas	Employment growth in Livermore		

MT CO_2e: metric ton of carbon dioxide equivalent

[1] Reported directly by PG&E for 2017 in their data delivery forms and greenhouse gas emissions data to The Climate Registry.

Table 29 Natural Gas Adjusted Scenario Forecast Results by Forecast Year

Activity Data	2020	2025	2030	2035	2040	2045
Residential Gas						
BAU therms	12,548,434	13,265,203	14,536,590	15,531,261	16,588,613	17,717,949
Title 24 adjusted therms	12,545,157	13,211,753	14,394,143	15,319,186	16,302,524	17,352,806
Emissions factor (MT CO_2e/therms)	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531
MT CO_2e	**66,621**	**70,161**	**76,440**	**81,353**	**86,575**	**92,152**
Nonresidential Gas						
BAU therms	10,866,899	10,944,859	11,098,872	11,386,006	11,577,168	11,771,539
Title 24 adjusted therms	10,865,813	10,938,315	11,081,547	11,348,582	11,526,362	11,707,128
Emissions factor (MT CO_2e/therms)	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531
MT CO_2e	**57,703**	**58,088**	**58,849**	**60,267**	**61,211**	**62,171**

MT CO_2e: metric ton of carbon dioxide equivalent; BAU: business-as-usual

Waste Emissions

The forecast used a baseline emissions rate of 0.530 tons of solid waste per service population and 0.0601 tons of ADC waste per service population, calculated using 2017 inventory data for tons of waste divided by the 2017 service population, along with projected growth in Livermore service population from Plan Bay Area Projections 2040 to establish the estimated tonnage of waste being disposed yearly through 2045. A 2017 solid waste emissions factor of 0.286 MT CO_2e and a 2017 ADC waste emissions factor of 0.246 MT CO_2e, calculated using 2017 waste characterization data from CARB's California Landfill Emissions Tool, were used to project emissions consistent with service population growth. Emissions from the waste sector will likely be less than the projected totals due to decreasing rates of organic material in the waste stream and recent legislation such as SB 1383 discussed in previous sections. At this time no mandate exists for individual cities and the

waste reductions from these bills are incorporated into the Climate Action Plan through City reduction measures to avoid double counting. A summary of the methodologies and data used to model waste emissions over time are provided in Table 30 and Table 31.

Table 30 Solid Waste Adjusted Scenario Forecast Methodology

Source Category	Forecasted Activity Data (Scaling Factor)	Emissions Factor[1]	Applied Legislative Reductions
Solid Waste	Service population growth	0.5778 tons solid waste per service person, 0.286 MT CO_2e/ton of solid waste	N/A
ADC Waste	Service population growth	0.0655 tons ADC waste per service person, 0.246 ADC MT CO_2e/ton ADC waste	N/A

MT CO_2e: metric ton of carbon dioxide equivalent; N/A: not applicable

[1] Waste per service person growth factors calculated using 2017 inventory data for tons of waste, divided by total service population in 2017. Emissions factors calculated using 2017 waste characterization data from CARB's California Landfill Emissions Tool.

Table 31 Waste Emissions Adjusted Scenario Forecast Results by Forecast Year

Activity Data	2020	2025	2030	2035	2040	2045
Service Population	139,813	145,385	155,338	163,866	172,424	181,522
Ton Solid Waste per Service Population	0.53	0.53	0.53	0.53	0.53	0.53
Ton ADC Waste per Service Population	0.06	0.06	0.06	0.06	0.06	0.06
Total Tons Solid Waste	74,087	77,039	82,313	86,833	91,367	96,188
Solid Waste Factor (MT CO_2e/ton)	0.286	0.286	0.286	0.286	0.286	0.286
Total Tons ADC Waste	8,402	8,737	9,335	9,848	10,362	10,909
ADC Waste Factor (MT CO_2e/ton)	0.246	0.246	0.246	0.246	0.246	0.246
MT CO_2e	**23,256**	**24,183**	**25,839**	**27,257**	**28,681**	**30,194**

MT CO_2e: metric ton of carbon dioxide equivalent

Transportation Emissions

Transportation emissions forecasts were developed consistent with the inventory methodology, through the determination of on-road annual VMT multiplied by a year-specific weighted emissions factor for emissions per mile travelled. VMT forecasts for the City of Livermore were obtained from the Bay Area MTC VMT data portal.[61] MTC's Traffic Demand Model was utilized to model VMT through 2045. Emissions factors were established for each year through the use of the EMFAC2017 GHG module, which established VMT and total emissions for each vehicle type in the County. These respective emissions factors were applied in each year to establish transportation emissions forecasts as shown in Table 32 and Table 33.

[61] Bay Area Metropolitan Transportation Commission (MTC) VMT Model. 2020. Available: http://capvmt.us-west-2.elasticbeanstalk.com/data. Accessed: April 19, 2020.

Table 32 Transportation Adjusted Scenario Forecast Methodology

Source Category	Forecasted Scaling Factor	Emissions Factor	Applied Legislative Reductions
On-road Transportation	MTC VMT Modeling[1]	EMFAC2017 model analyzing light duty (LDA, LDT1, LDT2, MDV, MCY) and heavy duty (LHD, T6, T7, PTO, MH, SBUS, UBUS, OBUS, Motor Coach, All Other Buses) vehicles.	EMFAC emissions factors account for legislative reductions from Advanced Clean Cars, Pavley Clean Car Standards, Tractor-Trailer Greenhouse Gas Regulation, and adopted fuel efficiency standards for medium- and heavy-duty vehicles.
Off-Road Transportation	OFFROAD2007 Model[2]	OFFROAD2007 Model	N/A

MT CO_2e: metric ton of carbon dioxide equivalent; VMT: vehicle miles traveled

[1] MTC VMT data portal incorporates data from the MTC's large-scale simulation model of daily travel behavior, used for its regional planning efforts and in Plan Bay Area. More information can be found on the MTC VMT Data Portal website at http://capvmt.us-west-2.elasticbeanstalk.com/about. Accessed: May 5, 2020.

[2] California Air Resources Board. OFFROAD2007. Available: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-road-archives. Accessed: April 1, 2020.

Table 33 Transportation Adjusted Scenario Forecast Results by Forecast Year

Activity Data	2020	2025	2030	2035	2040	2045
Population	91,474	96,699	105,967	113,218	120,925	129,158
Passenger VMT	545,893,360	566,412,825	586,932,289	595,803,761	604,675,234	613,546,706
Commercial VMT	97,108,456	98,428,891	99,749,326	101,291,552	102,833,778	104,376,005
Passenger EMFAC Emissions Factor (g CO_2e/mile)	310	262	228	210	201	198
Commercial EMFAC Emissions Factor (g CO_2e/mile)	1,301	1,168	1,058	986	946	928
Passenger MT CO_2e	**169,242**	**148,578**	**133,987**	**125,081**	**121,771**	**121,487**
Commercial MT CO_2e	**126,305**	**114,922**	**105,492**	**99,881**	**97,268**	**96,823**
Off-Road MT CO_2e	**62,867**	**69,559**	**76,252**	**84,025**	**91,799**	**99,572**
Total MT CO_2e	**560,632**	**529,879**	**510,512**	**499,456**	**495,646**	**502,737**

MT CO_2e: metric ton of carbon dioxide equivalent; VMT: vehicle miles traveled

Water and Wastewater Emissions

Due to the increased use of the water system attributed to increases in job and population growth in Livermore, service population was used as a scaling metric to determine water and wastewater service emissions through 2045, as shown in Table 34. Projections for water used a baseline activity factor of 110.7 kWh per service population per year, calculated using 2017 inventory data for electricity used for water processing and distribution divided by the 2017 service population based on Plan Bay Area Projections 2040. This emissions factor was multiplied by service population growth through 2045 to find total kWh usage. The RPS for electricity generation was then applied to water emissions, as described in the Legislative Adjustment Section, to determine final MT CO_2e emissions as shown in Table 35 and Table 36.

As wastewater emissions are calculated from both direct and process emissions sources. Wastewater projections used an emissions factor of 0.00693 MT CO_2e per service population per

year, calculated using wastewater process emissions data from the 2017 inventory divided by the total service population in 2017 based on Plan Bay Area Projections 2040, and a growth indicator of service population to determine future wastewater emissions.

Table 34 Water and Wastewater Adjusted Scenario Forecast Methodology

Forecasted Activity Data (Scaling Factor)	Emissions Factor[1]	Applied Legislative Reductions
Service population (population and employment growth)	PG&E electricity emissions factors, 110.7 kWh per service population per year	Assumes an electricity mix of 44 percent, 60 percent, and 100 percent GHG-free by 2025, 2030, and 2045 respectively for PG&E emissions factors per RPS requirements.
Service population (population and employment growth)	0.00693 MT CO_2e per service person per year for wastewater	N/A

MT CO_2e: metric ton of carbon dioxide equivalent; kWh: kilowatt hour; PG&E: Pacific Gas and Electric; N/A: not applicable

[1] Growth factors based on 2017 inventory data, divided by the total service population in 2017 based on Plan Bay Area Projections 2040 data.

Table 35 Water Adjusted Scenario Forecast Results by Forecast Year

Activity Data	2020	2025	2030	2035	2040	2045
Service Population	139,813	145,385	155,338	163,866	172,424	181,522
kwh/Service Person	110.7	110.7	110.7	110.7	110.7	110.7
Total kWh	15,480,255	16,097,168	17,199,181	18,143,417	19,090,975	20,098,213
RPS Electricity Factor (MT CO_2e/MWh)	0.08603	0.06882	0.05162	0.03441	0.01721	0
MT CO_2e	**1,332**	**1,108**	**888**	**624**	**328**	**0**

MT CO2e: metric ton of carbon dioxide equivalent; kWh: kilowatt hour; RPS: renewable portfolio standard

Table 36 Wastewater Adjusted Scenario Forecast Results by Forecast Year

Activity Data	2020	2025	2030	2035	2040	2045
Service Population	139,813	145,385	155,338	163,866	172,424	181,522
MT CO_2e/Service Population	0.00693	0.00693	0.00693	0.00693	0.00693	0.00693
MT CO_2e	1,340	1,327	1,347	1,346	1,338	1,326

MT CO_2e: metric ton of carbon dioxide equivalent; kWh: kilowatt hour;

Appendix B – Vulnerability Analysis

Livermore Climate Action Plan Update

prepared for

City of Livermore
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prepared with the assistance of

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September 2020

RINCON CONSULTANTS, INC.
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Project No: 19-08435

Tricia Pontau, Associate Planner
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Subject: City of Livermore Climate Action Plan Update, Vulnerability Analysis

Executive Summary

This report provides a climate change vulnerability analysis for the City of Livermore which evaluates the potential impacts of climate change on community assets and populations. The most recent report from the Intergovernmental Panel on Climate Change (IPCC), the Fifth Assessment Report, defines vulnerability as "the propensity or predisposition to be adversely affected." It adds that vulnerability "encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2013). Understanding the vulnerabilities that the City may face due to climate change provides a foundation to prepare the Climate Action Plan Update (CAP) that includes climate adaptation programs and policies to increase Livermore's resilience to climate change.

This analysis includes the following components:

- Objectives of the analysis
- Methodology used
- Vulnerability Components
    1. Exposure to changes in temperature, precipitation, and wildfire
    2. Sensitivity of community structures, community functions, and populations to exposures
    3. Potential Impacts of each exposure on community structures, community function, and populations
    4. Adaptive Capacity – Livermore's ability to cope with climate change impacts
    5. Risk and Onset – the likeliness and expected timing of events

The major findings of this analysis are:

- maximum and minimum temperatures are expected to increase;
- precipitation variability is expected to increase over the century;
- increased temperature and associated impacts have a high certainty of occurring in the near-term;
- intense rainstorms and changes in seasonal patterns are expected to occur in the near-term
- Livermore has a low to medium adaptive capacity rating due to the variety of sustainability and adaptation measures developed yet low implementation rate of these measures.

Objectives

The effects of climate change such as increased wildfire intensity, rising temperatures and reduced water resources are becoming increasingly present therefore Livermore's Climate Action Plan must be updated to reflect these impacts and adapt the City's mitigation practices. This Climate Action Plan will include measures to reduce Greenhouse Gas (GHG) emissions to reduce future climate change impacts while also addressing the existing events Livermore experiences related to climate change. To develop effective adaptation measures we must first understand the local impacts related to climate change. This vulnerability assessment is intended to help develop an understanding of the primary impacts of climate change on the community of Livermore and was completed to begin to evaluate the degree to which physical, socioeconomic, and natural factors are susceptible to, or unable to accommodate, the effects of climate change. Consistent with the California Adaptation Planning Guide (CEMA & CNRA 2020) the assessment is comprised of the following five vulnerability components:

1. **Exposure** – the nature and degree to which the community experiences a stress or hazard;
2. **Sensitivity** – the aspects of the community (i.e., people, structures, and functions) most affected by the identified exposures;
3. **Potential Impacts** – the nature and degree to which the community is affected by a given stressor, change, or disturbance;
4. **Adaptive Capacity** – the ability to cope with extreme events, to make changes, or to transform to a greater extent, including the ability to moderate potential damages and to take advantage of opportunities; and
5. **Risk and Onset** – the likeliness and expected timing of impacts.

Together these components help contribute to an understanding of the overall vulnerability of a community and the specific aspects within that community that are most vulnerable to climate change. Climate change will have the greatest impact on those people, structures, and functions that have the greatest exposure and sensitivity to climate change impacts, as well as the lowest adaptive capacity.

Methodology

For this vulnerability assessment, the years 1990, 2030, 2050, and 2100[1] were examined. The year 1990 provides recorded historic data, while the years 2030, 2050 and 2100 present projections of expected change in the future. The 2030 future year was selected to examine near-term climate impacts, and the years 2050 and 2100 serve as benchmark years to measure rates of change over time.

This report was completed using infrastructure data provided by the City, including the location of trails, public facilities, and streets, and Cal-Adapt climate projection data. Cal-Adapt is an interactive, online platform developed by the University of California Berkeley to synthesize climate change projections and climate impact research for California's scientists and planners. Cal-Adapt is consistent with State guidance to use the "best available science" for assessing climate change vulnerability at the local level. This analysis uses Cal-Adapt to study potential future changes in average and extreme temperatures, precipitation, drought, wildfire, and storms under two greenhouse gas (GHG) emissions scenarios: Representative Concentration Pathway (RCP) 4.5 and RCP 8.5. RCP 4.5 describes a scenario in which emissions peak around 2040, decline over the next 30 years and then stabilize by 2100 while RCP 8.5 is the scenario in which emissions continue to rise through the middle of the century before leveling off around 2100. The climate projections used in this report are from four models selected by California's

[1] When 2100 projections were not available, 2099 projections were used (e.g. Cal-Adapt projections)

Climate Action Team Research Working Group and the California Department of Water Resources as priority models for research in California. These models include:

- A *warm/dry* simulation (HadGEM2-ES)
- A *cooler/wetter* simulation (CNRM-CM5)
- An *average* simulation (CanESM2)
- The model that presents a simulation most unlike these three, for full representation of possible forecasts (MIROC5)[2]

The average of the model projections is used in this report. Technical Appendix 1. Cal-Adapt provides a detailed explanation of the tool and how it was used for this analysis. As previously introduced, the California Adaptation Planning Guide defines five components to be analyzed in a vulnerability assessment. Each vulnerability component is analyzed with respect to Livermore in the proceeding sections of this memo.

Vulnerability Components

Vulnerability Component 1 - **Exposure**

Exposure is the nature and degree to which the community experiences a stress or hazard. Climate change is a global phenomenon that has the potential to impact local health, natural resources, agriculture, infrastructure, emergency response, tourism, and many other facets of society. The direct changes projected for Livermore include increases in temperature, and potential changes in precipitation patterns. Secondary impacts occur as a result of primary impacts, as shown in Table 1. Projected changes to climate are dependent on location. According to climate change projections provided by Cal-Adapt, climate change could lead to increasing temperatures and temperature extremes, and changes in precipitation in Livermore.[3] These conditions could lead to an increased exposure to drought, wildfires, and flooding in the region.

Table 1 Primary and Secondary Climate Change Impacts in Livermore

Primary Impact	Associated Secondary Impacts
Changed temperature and/or precipitation patterns	Changed seasonal patterns
Increased temperature	Heat waves
Increased temperature and/or changed precipitation	Intense rainstorms
Wildfire and/or increased precipitation	Landslides
Increased temperature and/or reduced precipitation	Drought, wildfire

[2] There were 10 California GCM models that were ranked from 1-10 by California's Climate Action Team Research Working Group and the California Department of Water Resources for different temperature and precipitation factors. The models ranged from the "warm/dry" model which had all metrics closest to 1 to the "cool/wet" model which had all metrics closest to 10. The MIROC5 displays a pattern of ranking that is most unlike the other 3 models and therefore, is included to represent the full spread of all 10 model simulations.

[3] Cal-Adapt provides projections for temperature, precipitation, and wildfire, and these projections will be discussed in the Exposure section of the document. Drought, which does not have associated Cal-Adapt projections is addressed under temperature and precipitation exposure, as well as in the Potential Impacts and Risk and Onset sections.

Source: Modified from CEMA & CNRA 2012

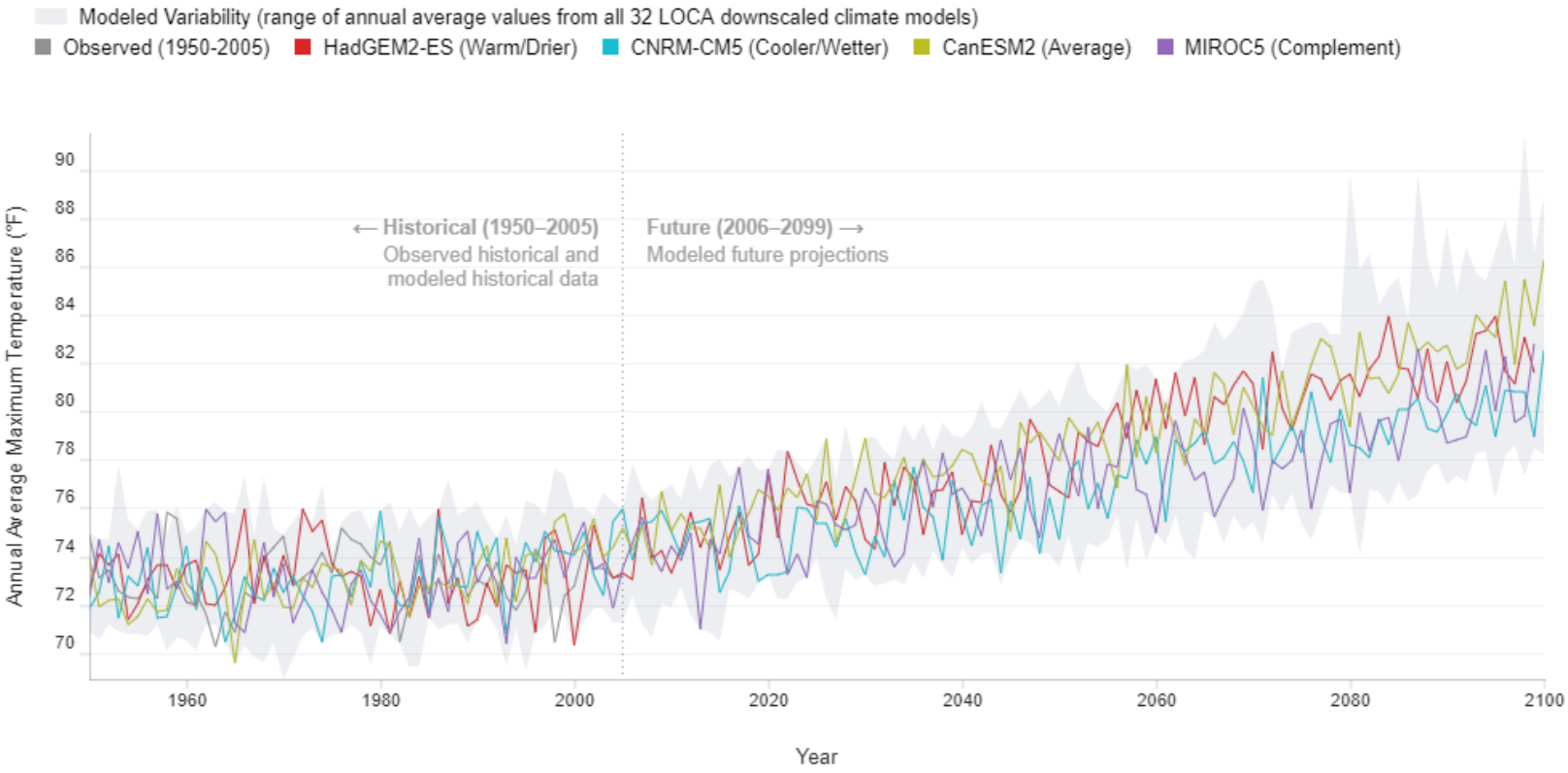
Temperature

Since 1901, average temperatures across the country have increased with eight of the top ten warmest years on record having occurred over the past 30 years (EPA n.d.) Average trends are increasing at both the local scale and the global scale.

Figure 1 below shows observed and projected annual average maximum temperature in Livermore (UC Berkeley & CEC n.d.) Below is a summary of key observations from Figure 1.

- **Projected temperature trends** in Livermore display consistent increases over time. Compared to 1990, annual average maximum temperatures in Livermore are expected to rise between 4.5°F and 8.7°F by the end of the century, depending on the GHG emissions scenario (UC Berkeley & CEC n.d.)
- **Annual average minimum temperatures** are expected to rise between 3.2°F and 8°F by the end of the century. Increasing annual average minimum temperatures trends also indicate less cooling off at night.

Figure 1 Historical and Projected Annual Average Maximum Temperature in Livermore[4]



[4] Chart shows annual average maximum temperature for Livermore (Grid Cell 37.65625 -121.78125) under RCP 8.5 (emissions continue to rise strongly through 2050 and plateau around 2100)

Table 2 depicts observed and projected temperature changes in Livermore for both RCP 4.5, the "stabilizing" scenario[5], and RCP 8.5, the "high emissions" scenario[6]. Below is a summary of key observations from Table 2.

- **Annual number of heat waves,** defined as four or more days over 102.7°F, is projected to increase from 0 to 3 heat waves by the end of the century, based on RCP 8.5 (UC Berkeley & CEC n.d.)
- **Annual number of extreme heat days,** defined as temperatures greater than 102.7°F, is projected to increase from 4 in 1990 to about 25 by the end of the century, based on RCP 8.5 (UC Berkeley & CEC n.d.)
- **Warm nights,** described as nights when daily minimum temperature is above the extreme heat threshold of 62.1°F, are expected to increase substantially from 11 in 1990 to about 101 by 2100 based on RCP 8.5 (UC Berkeley & CEC n.d.)
- **Longer heat waves** could occur due to the combination of temperature changes. Between 1950 and 1990, the longest stretch of consecutive extreme heat days per year in Livermore was 2.2 days, by the end of the century the average heat wave is projected to last just over 7 days under RCP 8.5 (UC Berkeley & CEC n.d.)

Table 2 Temperature Changes

Effect	1990 (Observed)	2030 (RCP 4.5 | RCP 8.5)	2050 (RCP 4.5 | RCP 8.5)	2099 (RCP 4.5 | RCP 8.5)
Annual average maximum temperature	73°F	76.1°F | 75.9°F	77.1°F | 77.1°F	77.5°F | 81.7°F
Annual average minimum temperature	47.1°F	48.1°F | 48.6°F	49.4°F | 50.3°F	50.3°F | 55.1°F
Average extreme heat days per year[1]	4	11 | 11	17 | 13	13 | 25
Average warm nights per year[2]	11	18 | 15	18 | 33	42 | 101
Average heat waves per year[3]	0	0.8 | 1.0	2.8 | 0.8	0.8 | 3.0
Max duration of heat wave (days)[4]	2	4.0 | 5.3	7.5 | 3.8	4.3 | 7.3

[1] Number of days in a year when daily maximum temperature is greater than heat threshold of 102.7° F

[2] Number of nights in a year when daily minimum temperature is above extreme heat threshold of 62.1° F

[3] Number of 4-day heat waves (daily maximum temperatures above extreme heat threshold of 102.7° F) by year

[4] Longest stretch of consecutive extreme heat (> 102.7° F) days by year

Source: UC Berkeley & CEC n.d.

[5] RCP 4.5: Scenario in which emissions peak around 2040 and then decline

[6] RCP 8.5: Scenario in which emissions continue to rise throughout the 21st century before leveling off

Precipitation

Total annual precipitation in the United States and globally has increased since 1901 (EPA n.d.) However, shifts in weather patterns have led to substantial decreases in precipitation in certain locations, such as the Southwest of the United States (EPA n.d.)

The Cal-Adapt projections show little change in total annual precipitation in Livermore with no clear or consistent trend during the next century, as illustrated in Figure 2. However, even small changes in precipitation can lead to significant impacts such as altered water availability throughout the year, decreased agricultural output in the region, and altered seasonal patterns which could cause increased droughts and/or flooding. Below is a summary of key observations from Table 3.

- **Annual average precipitation,** is projected to increase by the end of the century, based on both RCP 4.5 and RCP 8.5 (UC Berkeley & CEC n.d.)
- **Extreme precipitation events,** defined as the number of days in a water year (October-September of the following year) with 2-day rainfall totals above extreme threshold of 1 inch, is projected to increase from 3 in 1990 to about 5 mid-century, before dropping to 0 by the end of the century, based on RCP 8.5 (UC Berkeley & CEC n.d.)
- **Max duration of consecutive extreme precipitation events,** defined as the longest stretch of consecutive days in a water year (October-September) with 2-day rainfall totals above extreme threshold of 1 inch, is projected to increase slightly midcentury from 1 to 1.5 and decrease to 0 at the end of the century, based on RCP 8.5 (UC Berkeley & CEC n.d.)

Figure 2 Historical and Projected Annual Average Precipitation in Livermore[7]

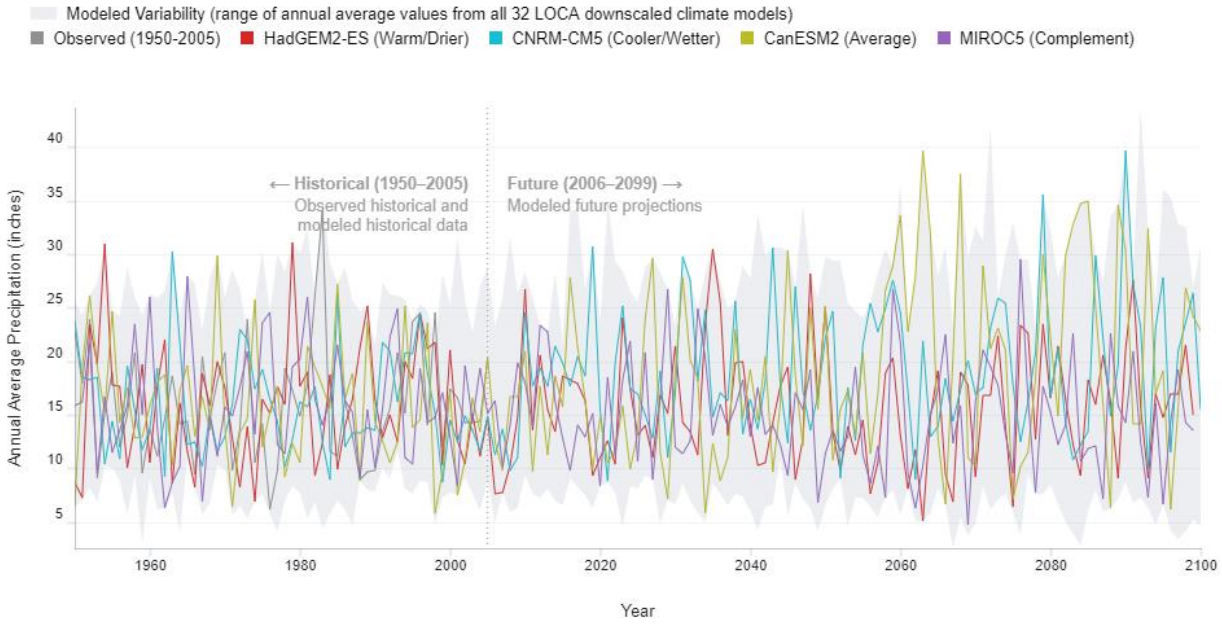


Table 3 Precipitation Changes

Effect	1990 (Observed)	2030 (RCP 4.5 | RCP 8.5)	2050 (RCP 4.5 | RCP 8.5)	2099 (RCP 4.5 | RCP 8.5)
Annual average precipitation (inches)	9.7	15.9 | 17.3	23.2 | 21.0	17.6 | 19.8
Extreme precipitation events by water year[1]	3	5 | 5	7 | 5	0 | 0
Max duration of consecutive extreme precipitation events by year[2]	1	2 | 1.3	2.8 | 1.5	0 | 0

[1] Number of days in a water year (Oct-Sep) with 2-day rainfall totals above extreme threshold of 1 inch

[2] Longest stretch of consecutive days in a water year (Oct-Sep) with 2-day rainfall totals above extreme threshold of 1 inch

Source: UC Berkeley & CEC n.d.

Precipitation Extremes

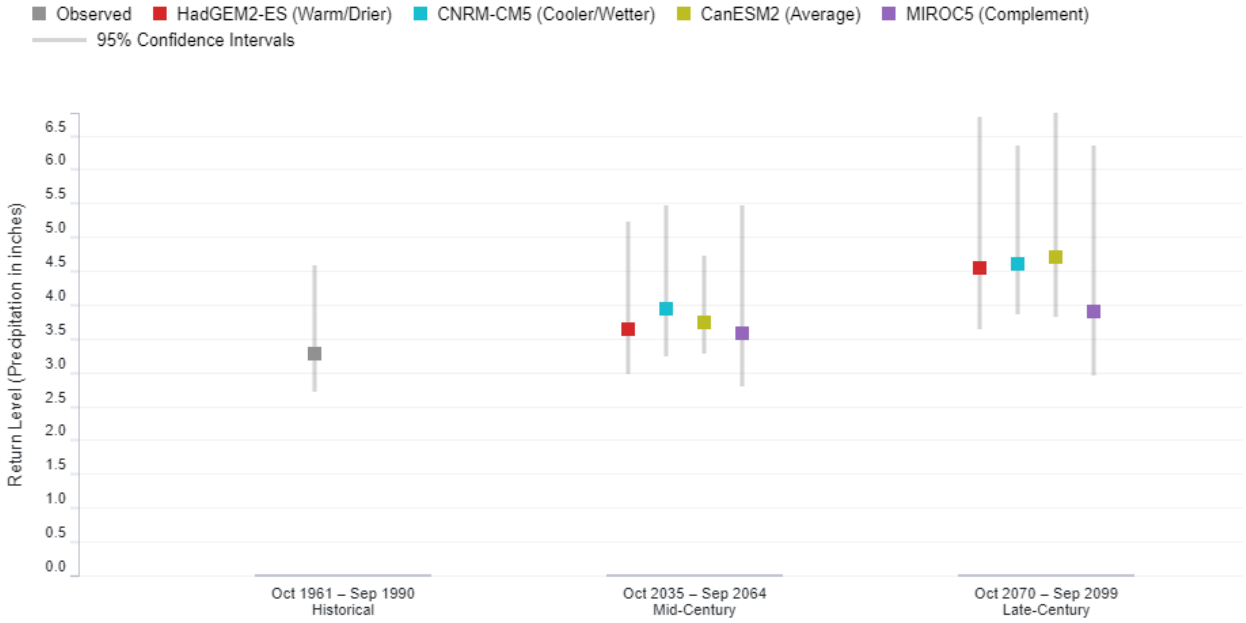
A warming climate is likely to influence the frequency and intensity of precipitation events. Heavy precipitation events have been on the rise in the United States since the 1980s. Across the country, nine of the top ten years for extreme one-day precipitation events have occurred since 1990 with the occurrence of abnormally high annual precipitation totals also increasing (EPA n.d.).

Both increased temperatures and altered precipitation patterns can lead to altered seasons and intense rainstorms in Livermore. As depicted in Figure 3, there is a high degree of variability in these extreme precipitation event projections, with some models projecting little to no change while others project

[7] Chart shows annual average maximum temperature for Livermore (Grid Cell 37.65625 -121.78125) under RCP 8.5 (emissions continue to rise strongly through 2050 and plateau around 2100)

potentially increased intensity (UC Berkeley & CEC n.d.) These projections further vary depending on the return period[8] selected. Based on the 20 year return period select in Figure 3, the estimated intensity of extreme precipitation events (return level) may increase slightly by the end of the century. The Average (CanESM2) model, for example, is projecting an increase to 4.71 inches of precipitation compared to 3.28 historically (1961 – 1990), based on RCP 8.5 (UC Berkeley & CEC n.d.) Despite this projected increase, it is important to consider the confidence intervals provided, which describe 95% confidence that the true mean of precipitation extremes will fall within the given range (grey bars). Given that the confidence intervals for all projections overlap with the confidence interval for the historical data, it is not clear whether the intensity of storms will increase or decrease in Livermore. However, increasing intensity of rainstorms could result in more flooding, which could impact human health and safety in Livermore and should be considered as part of planning efforts.

Figure 3 Changes in Intensity of Extreme Precipitation Events in Livermore[9]



Wildfire

Wildfire is determined by climate variability, local topography, land cover and human activity. Climate change has the potential to affect multiple elements of the wildfire system including fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk and increased temperatures may intensify wildfire danger by warming and drying out vegetation.

The California Department of Forestry and Fire Protection (CAL FIRE) has determined that there are no Very High Fire Hazard Severity Zones in Livermore. Though there are no Very High Fire Hazard Severity

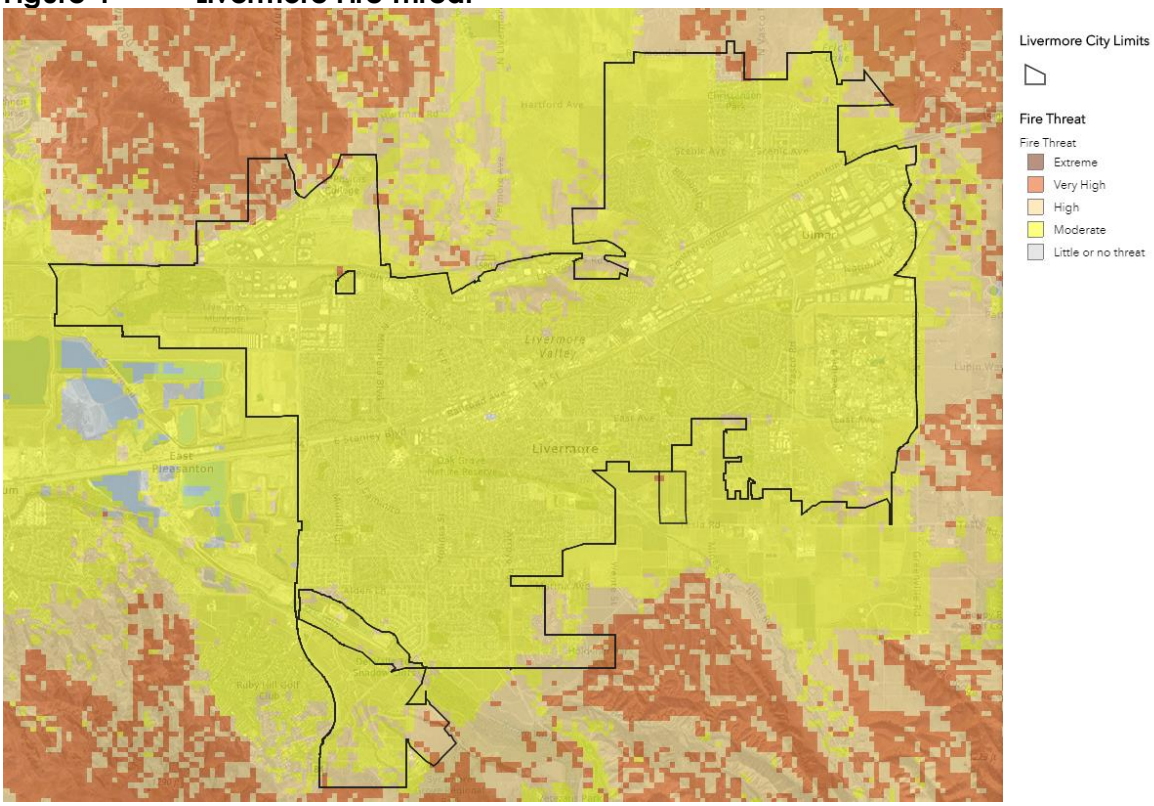
[8] Average time between extreme events (e.g. "1 in 100 year event")

[9] Chart shows estimated intensity (*Return Level*) of Extreme Precipitation events which are exceeded on average once every 20 years (*Return Period*) for Livermore (Grid Cell 37.65625, -121.78125) under RCP 8.5 emissions scenario. Extreme precipitation events are described as days during a water year (Oct-Sept) with 2-day rainfall totals above an extreme threshold of 0.67 inches.

Zones in Livermore, there are Moderate and High Fire Hazard Severity Zones to the north, east, and south of Livermore. Figure 4 shows that there is moderate wildfire threat in the entire city, and some very high fire threats in the north and south of the city. Government Code §51181 requires CAL FIRE to periodically reassess and update the Very High Fire Hazard Severity Zones as needed. Due to amount and extent of the wildfires recently, the fire hazard severity zones are currently being reassessed throughout the State.

Not only do wildfires pose a threat to life and property in the communities in which they burn, their smoke can threaten the health of communities up to thousands of miles beyond the areas in which they burn (TIME 2018). Wildfire smoke is comprised of air pollutants including particulate matter, known to be a public health risk (CDC 2013). The effects of exposure to these pollutants range from eye and respiratory tract irritation to reduced lung function, pulmonary inflammation, bronchitis, exacerbation of asthma, other lung diseases, and cardiovascular disease, and premature death (CDC 2013). The increasing number and extent of wildfires in the Western United States may pose a substantial risk to public health in Livermore.

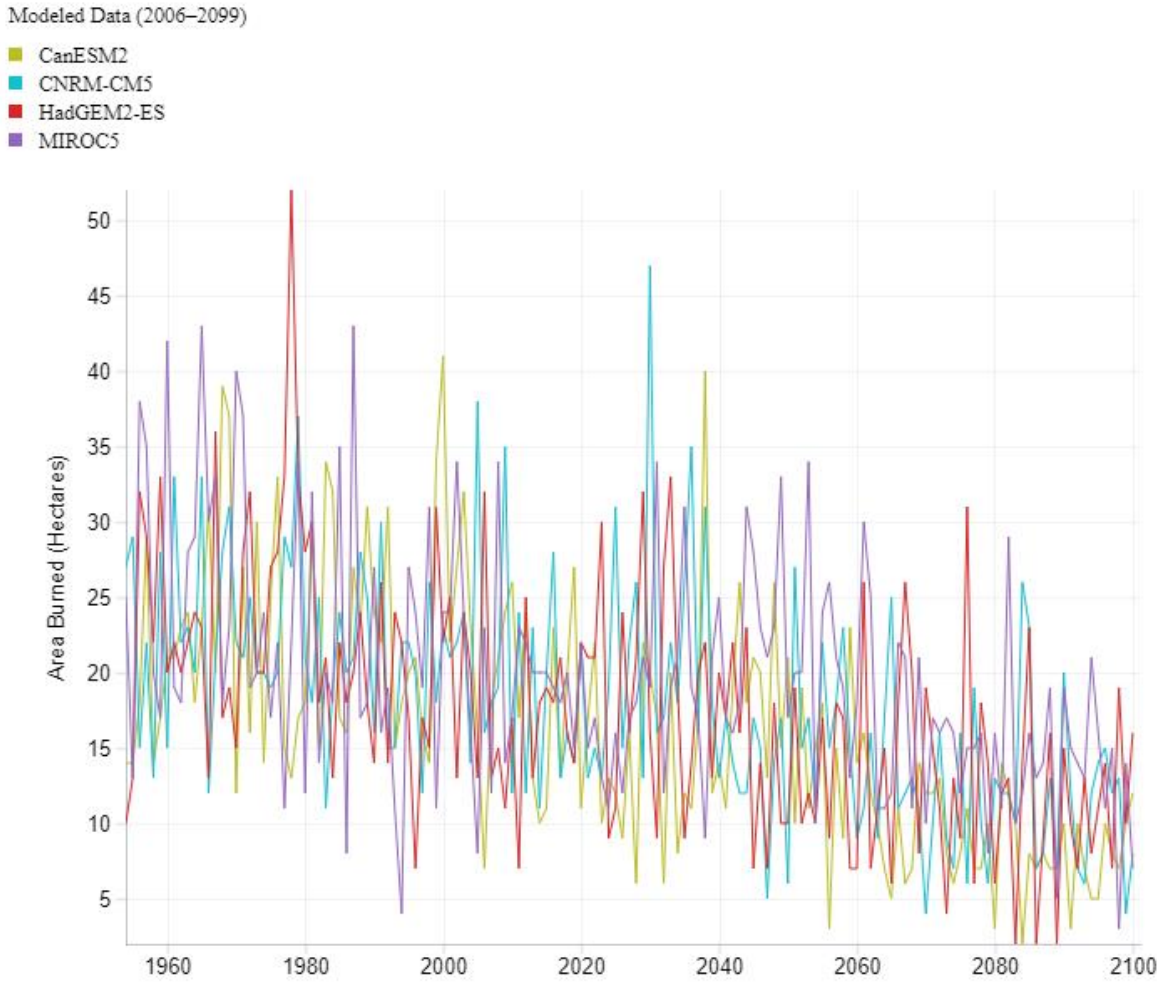
Figure 4 Livermore Fire Threat



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community | Esri, NASA, NGA, USGS, FEMA | Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA | California Department of Forestry and Fire Protection | Alameda County Registrar of Voters, 2011

Cal-Adapt fire hazard maps project a decrease in acres burned by the end of the century (Figure 5). Average annual hectares burned is projected to decrease from 19.3 in 2020 to approximately 9.5 by the end of the century. Research has shown that there is great spatial variability in wildfire risk based on climate variability and trends, and in some regions vegetation may be reduced by drought conditions and thus reduce fuel available to burn (Westerling 2018). It is unclear whether this is the scenario applicable to Livermore, so despite the projected decline in wildfire risk for the Livermore area, it is recognized that wildfire is a serious hazard to public health and safety that may increase with climate change in other parts of the state (UC Berkeley & CEC n.d.)

Figure 5 Annual Average of Area Burned in Livermore[10]



Vulnerability Component 2 - **Sensitivity**

[10] Chart shows annual average area burned for Livermore (Grid Cell 37.65625, -121.78125) under RCP 8.5 emissions scenario.

Sensitivity describes the aspects of the community (i.e., people, structures, and functions) most affected by the identified exposures. As described in the exposure section above, Livermore may experience a variety of impacts from climate change, including rising temperatures and variable precipitation, which could impact community structures, functions, and populations. This section of the Vulnerability Analysis lists potentially affected community resources using the Sensitivity Checklist provided in the California Adaptation Planning Guide (CEMA & CNRA 2020). The Potential Impacts section of the analysis estimates how the impacts will occur and their projected severity. The points of sensitivity, or potentially affected community resources (community structure, community functions, and populations) in Livermore, are described below.

Livermore Community Overview

The City of Livermore is the easternmost city in the San Francisco Bay Area, making it the gateway to the Central Valley. The City encompasses an area of approximately 26.44 square miles and has a population of approximately 91,411 (City of Livermore n.d.). Livermore is home to prominent science and technology centers, Lawrence Livermore National Laboratory and Sandia National Laboratory, making it a science and technology hub. These labs along with the Livermore Valley Joint Unified School District and Valley Care Health System Lifestyle Rx Fitness Center are the economic foundation of the City, providing a large portion of employment opportunities in Livermore (City of Livermore 2019).

Community Structures

The following community structures can be potentially affected by exposure to climate change impacts such as extreme heat and flooding:

- Residential
- Commercial
- Industrial
- Government
- Institutions (schools, churches, hospitals, etc.)
- Parks and open space
- Recreational facilities
- Transportation facilities and infrastructure
- Communication infrastructure
- Water treatment plant and delivery infrastructure
- Wastewater treatment plant and collection infrastructure

Essential facilities such as medical facilities, police and fire stations, emergency operations centers, evacuation shelters, and schools are essential to the health and welfare of the population of Livermore and are especially important following climate-influenced hazard events. The following community structures within Livermore would be particularly sensitive to climate change impacts such as flooding and wildfire:

- Municipal buildings, including the three Livermore Public Library branches
- Hospitals, doctor's offices, and other medical entities, including Kaiser Permanente and the Stanford Health Care ValleyCare
- Educational facilities including the 19 schools in Livermore Valley Joint Unified School District and Las Positas Community College

- Childcare facilities
- Senior living facilities
- Livermore Police Department and Livermore – Pleasanton Fire Stations #5 through #10

Sensitive facilities, such as water and wastewater treatment plants, where damage would have large environmental, economic, or public safety consequences, are also considered particularly vulnerable to climate change. These sensitive facilities include:

- City water system including groundwater wells and distribution pipelines
- Wastewater systems such as the Livermore Water Reclamation Plant, and approximately 286 miles of sanitary sewer lines.
- Lawrence Livermore National Laboratory and Sandia National Laboratories

Community Functions

Community functions that may be disrupted by climate change in Livermore include:

- Government continuity
- Water, sewer, and solid waste
- Energy delivery
- Emergency services
- Public health and safety
- Emotional and mental health
- Business continuity
- Housing access
- Employment and job access
- Food security
- Mobility, transportation, and access
- Quality of life
- Social services
- Ecological function
- Tourism
- Recreation
- Agriculture, including farms and vineyards
- Industrial operations

Transportation systems such as roads, bridges, overpasses, rail, bikeways and trail networks, and the Livermore Transit Center may be particularly threatened by the impacts of climate change such as floods, landslides, severe winds, and wildfires. The City maintains a variety of roadways ranging from a freeway and highway to local streets and special rural routes which travel through City-identified vineyard lands. Roadways play a critical role in how people and goods are transported throughout the city. The major roads running through the city are Interstate 580 (I-580) and State Route 84 (SR-84). Local public transit, provided by Livermore Amador Valley Transit Authority (LAVTA), is an important component of the City's transportation network, providing the community with alternatives to automobile travel. Rail freight through Livermore is served by the Union Pacific Railroad, which is an east-west route originating in

Oakland and tying into two major north-south routes in the San Joaquin Valley. Additionally, the City provides a comprehensive, safe network of bikeways and trails for transportation and recreational purposes for a variety of non-vehicular users. In 2003, the city had a total of 66.5 miles of multi-use trails (Class I) and bike lanes (Class II). Impacts to the regional transportation system could critically impact mobility, transportation, and access in Livermore.

Lifeline utility systems such as potable water, wastewater, fuel, natural gas, electric power, and communication systems in Livermore may also be particularly sensitive to increased climate related events such as flooding, drought, wildfires, and landslides. These lifeline utility systems are essential to the health and safety of the Livermore community.

Populations

Populations that may be sensitive to climate change exposures described above include:

- Seniors
- Children
- Individuals with disabilities
- Individuals with compromised immune systems
- Individuals who are chronically ill
- Individuals without access lifelines (e.g., car or transit, phones)
- Disadvantaged communities
- Low-income, unemployed, or underemployed communities
- Individuals with limited English skills
- Renters
- Students
- Seasonal residents
- Individuals uncertain about available resources because of citizenship status

Vulnerable populations are more susceptible than others to climate related exposures such as people who may require special response assistance or special medical care after a climate-influenced disaster. The disproportionate effects of climate change on vulnerable populations are caused by physical, social, political, and/economic factors which are further exasperated by climate impacts. In the event of a climate-influenced disaster such as wildfire, flood, or landslide, vulnerable populations may have less access to emergency response information and lack the resources needed to cope with and recover from climate impacts. The 2009 California Climate Adaptation Strategy identifies those most at risk and vulnerable to climate-related illness as the elderly; individuals with chronic conditions such as heart and lung disease, diabetes, and mental illnesses; infants; the socially or economically disadvantaged; and those who work outdoors (CNRA 2009). According to the Census, Livermore residents under 65 that reported no insurance was 4.1% and the proportion of people living in poverty is about 4.6%.

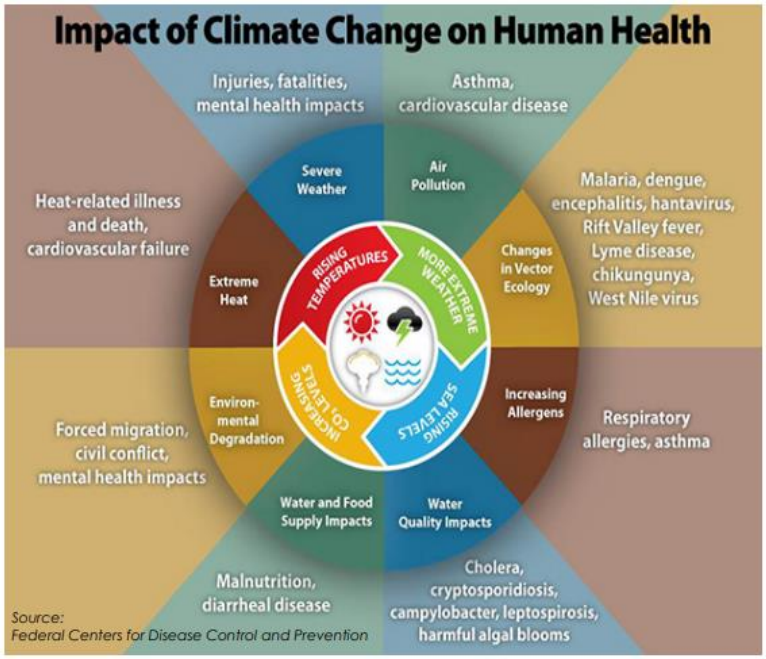
Moreover, the Census estimates that in 2019, 12.9% of the population was 65 years or older and 23.5% of the population was under the age of 18. These individuals may face unique impacts related to climate change. According to the findings from a United Nations Children's Fund (UNICEF) study, children are "physiologically and metabolically less able than adults at adapting to heat." The study recognizes that geography plays a role on the impacts of climate change that may affect specific populations and acknowledges the fact that those with fewer resources have a more difficult time adapting (UNICEF 2011).

Financial wellbeing also impacts climate change sensitivity, as well as preparation, because those with greater access to resources have a greater ability to prepare and adapt. In addition, more than 20% of Livermore residents speak a language other than English at home, which may result in language barriers in dissemination of information related to climate change preparation and emergency response (Census n.d.)

Vulnerability Component 3 - **Potential impacts**

Potential impacts are the nature and degree to which the community is affected by a given stressor, change, or disturbance. As climate change continues to progress, increased stress to vulnerable populations and sectors of society are expected. In the City of Livermore, the most likely primary impacts of climate change include increasing temperatures and altered precipitation patterns. Climate change impacts may damage infrastructure, reduce economic viability, influence water supply, and decrease public health and safety (Figure 6). The potential impacts of increasing temperature extremes, altered precipitation, and increasing wildfire in Livermore and the greater San Francisco Bay Area are discussed below.

Figure 6 Impact of Climate Change on Human Health



Temperature

As describe in the Exposure section above, Livermore may experience a variety of impacts from climate change, which include an increase of average annual maximum temperature between 5.3°F and 9.3°F by the end of the century (UC Berkeley & CEC n.d.) This increase in temperature may result in changes in seasonal patterns, possible heat waves, drought, and potentially increased storm frequency and intensity. The potential impacts to community structures, functions, and populations are described below.

Community Structures – Potential Temperature Impacts

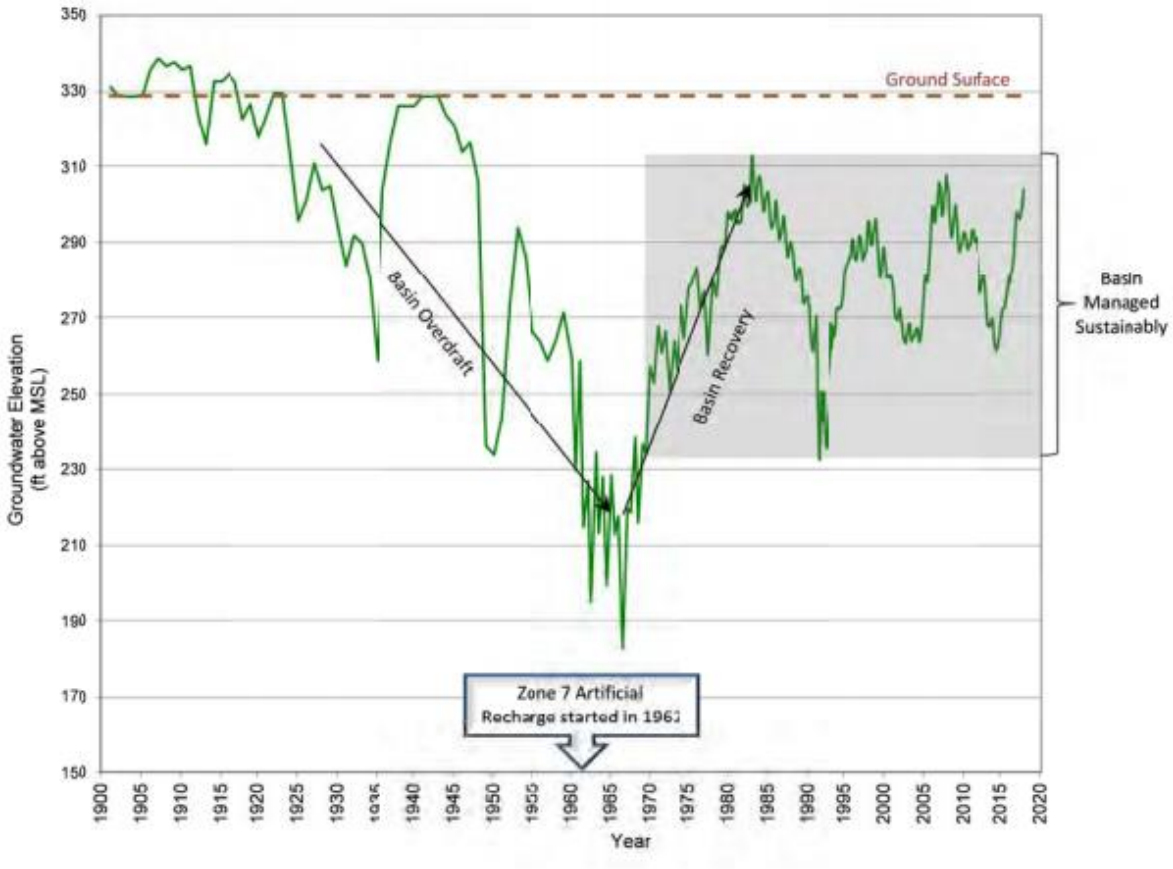
Community infrastructure and the City's transportation system may be impacted by increased temperatures. Long periods of intense heat may result in increased use of electricity for home cooling purposes that could tax the system and result in electricity restrictions or black-outs. In addition, cyclists and active commuters could be impacted by increased temperatures and could suffer from heat related illnesses making them less inclined to ride their bikes for transportation if the temperatures continue to rise. This would increase demand on other aspects of the transportation system including public transit and roadways, which may exacerbate worsening air quality conditions.

Community Functions – Potential Temperature Impacts

As mentioned above in the Sensitivity section, increases in temperature could also have a substantial impact on the City's economy. Vineyards and farms are an essential part of the City's community and economy and could be affected by climate change through crop failure, transportation system issues, and decreased labor from heat exposure.

High temperatures may also contribute to a reduced water supply. For instance, higher temperatures will melt the Sierra snowpack earlier and drive the snowline higher. Higher temperatures in addition to a reduction in precipitation falling as snow, would result in less snowpack to supply water to California users (CNRA 2009). Increased temperatures could therefore result in decreased potable water supply for the City which relies on local groundwater, surface water, and imported water (Cal Water 2016). Zone 7 Water Agency (Zone 7) has managed and imported local surface water and groundwater resources for beneficial uses in the Livermore Valley Groundwater Basin for more than 55 years. According to the Annual Report for the Sustainable Groundwater Management Program and as shown in Figure 7, Zone 7 replenished the groundwater basin in 1962 after decades of basin overdraft. Since then, Zone 7 has been sustainably managing the Livermore Valley Groundwater Basin (Zone 7 2019). With temperatures expected to increase and snowpack expected to decrease, there may be an increase in the reliance on the Livermore Valley Groundwater Basin, putting pressure on local water supply.

Figure 7 Bernal Key Well Hydrograph

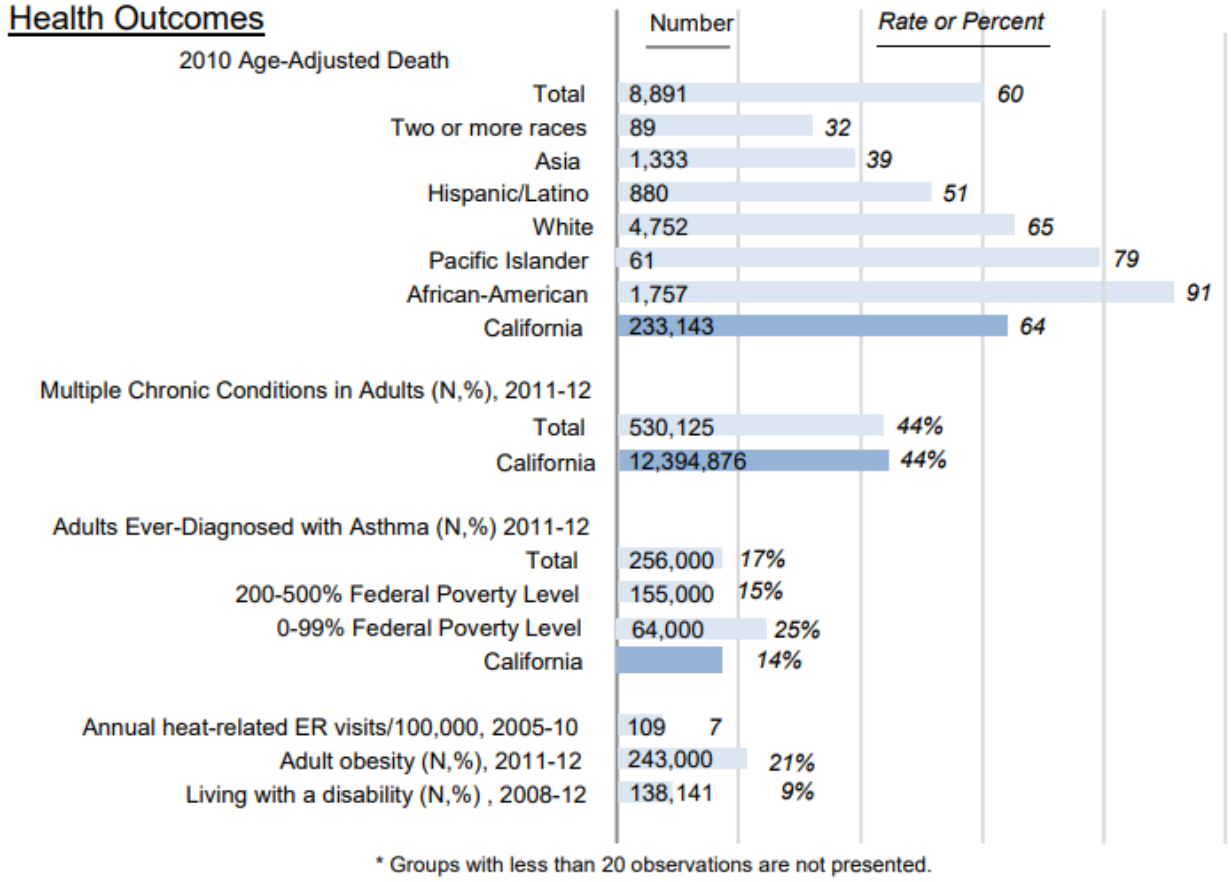


Vulnerable Populations – Potential Temperature Impacts

Public health may be negatively impacted by a changing climate as a result of changing environmental conditions (e.g., extreme weather events; changes in temperature and rainfall that decrease water supply; worsening air quality; and increases in allergens and air pollutants). This could lead to hazardous conditions, such as heat stroke and respiratory ailments for individuals with disabilities or compromised immune systems, children playing outdoors, tourists, farm workers and others working outdoors. Potential impacts to public health include cardiovascular disease; exacerbation of asthma, allergies, and chronic obstructive pulmonary disease; increased risk of skin cancer and cataracts; premature death; cardiovascular stress and failure; and heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones (CEMA & CNRA 2012). Figure 8 shows a profile of health outcomes and inequities specific to Alameda County, the number of people in the County, or state of California, and the relative percentage for the County or State (Maizlish et al. 2017). Disparities among race/ethnicity groups and poverty groups are apparent, as is the heightened vulnerability of obese and disabled individuals to heat effects. Those in Livermore without health insurance (4.1%) and living in poverty (4.6%) are particularly vulnerable. Figure 9 displays the profile of social vulnerabilities and climate risks in Alameda County (Maizlish et al. 2017). There is currently one census tract within Livermore (Census Tract 4514.04,

Figure **10**) that is designated as an Opportunity Zone[11] (CA.gov) or economically distressed community where new investments in Caltrans transportation projects, Air Resources Board low carbon projects, and High-Speed rail investments are a priority (State of California n.d.) Additionally, three block groups have been identified as disadvantaged communities by the State, as shown in Figure 11 (DWR n.d.) With anticipated increases in minimum and maximum temperatures, economically disadvantaged residents may find it more difficult or impossible to afford the additional costs of cooling their homes. Consequently, many low-income households, especially those of seniors and individuals with disabilities will be particularly vulnerable to the effects of extreme heat events.

Figure 8 Profile of Health Outcomes and Inequities in Alameda County



[11] Census tract defined by the Internal Revenue Service (IRS) as "economically-distressed community where new investments, under certain conditions, may be eligible for preferential tax treatment."

Figure 9 Profile of Social Vulnerabilities and Climate Risks in Alameda County

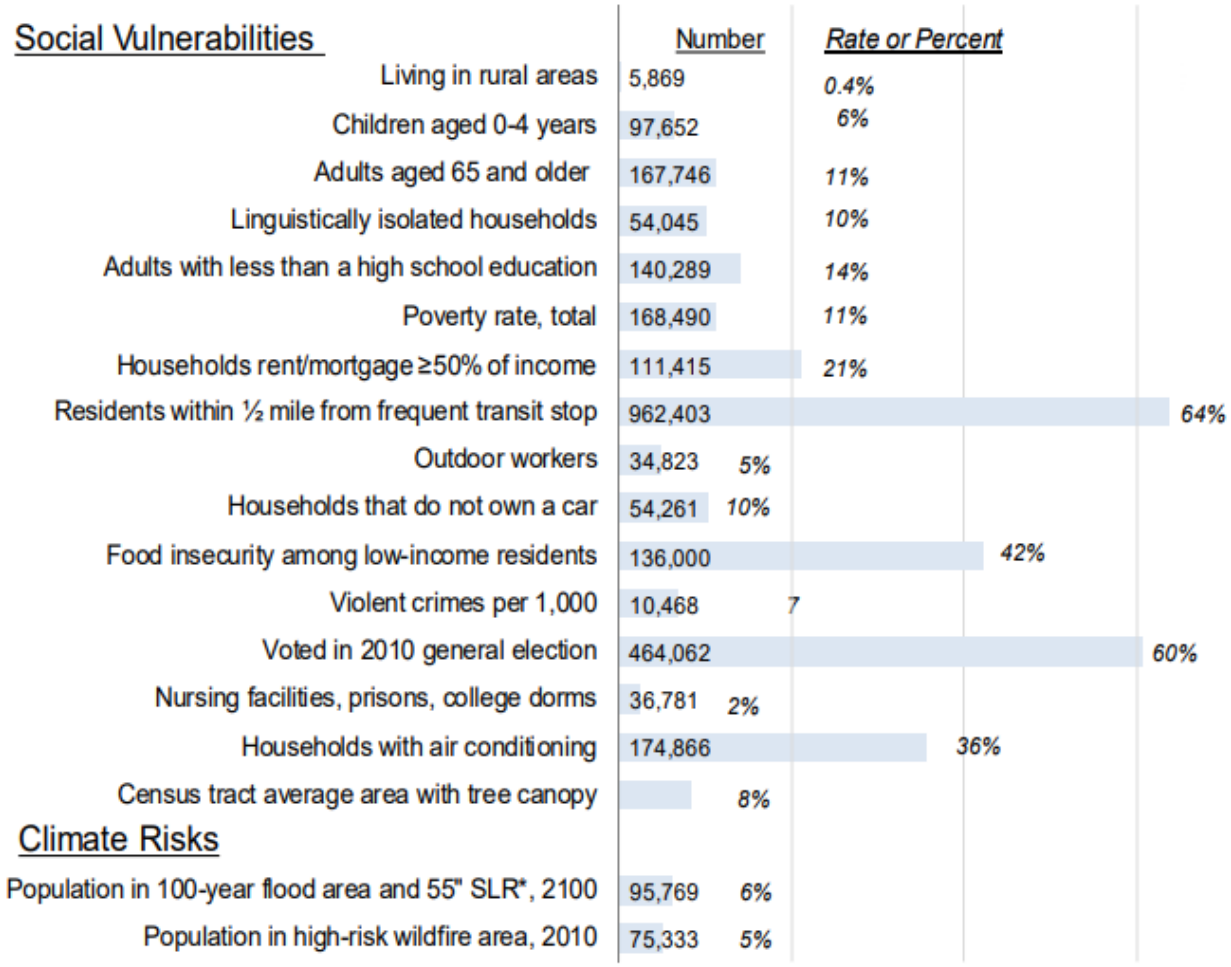


Figure 10 Opportunity Zone

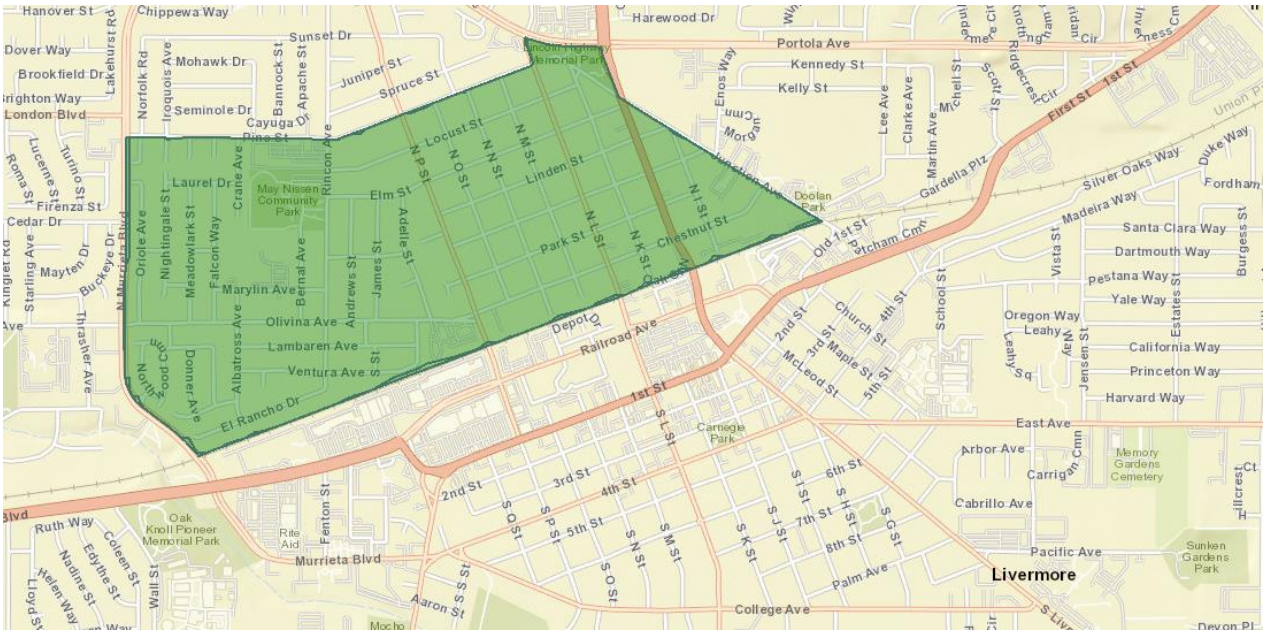
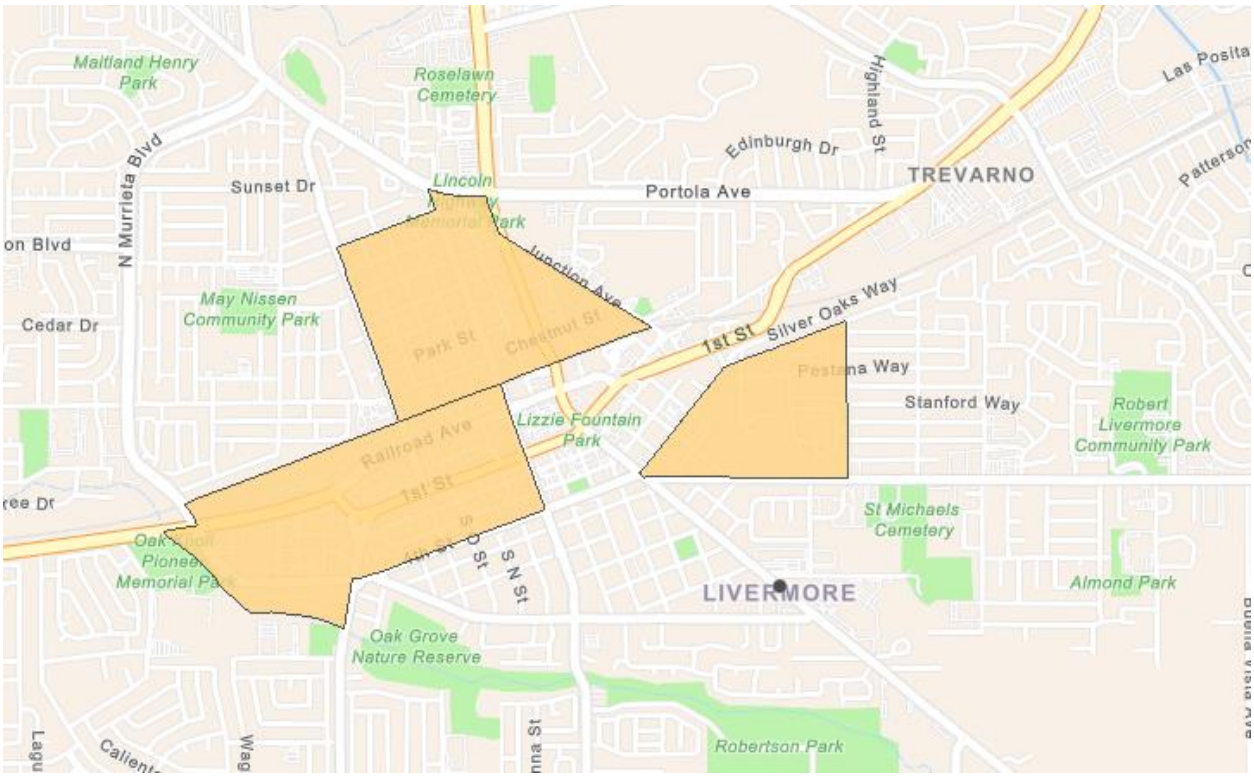


Figure 11 Disadvantaged Communities



Increasing temperatures may also impact vulnerable youth populations. Due to their less-developed physiology and immune system, children are especially vulnerable to air and water quality, temperature, humidity and vector-borne infections. These health concerns are not just physical; children can be

impacted psychologically as well, which could result in a loss of self-confidence, nervousness, and insomnia (UNICEF 2011). This additional stress on children's systems could affect them into adulthood and result in lifelong ailments.

Additionally, rising temperature may also indirectly impact human health through impacts to biological species and natural habitat, such as increases in the incidence of vector borne disease (WHO 2018). Insects have no internal control over their body temperature, and as ambient temperatures rise, the distribution of insects may expand through increased reproductive rate, biting behavior, and survival. Moreover, the incubation period for pathogens within vectors is also temperature-dependent, and the period often becomes shorter as conditions warm (WHO 2018). This will result in pathogens developing and spreading more quickly; susceptibility to disease may increase.

As rising temperature impacts public health, community resources such as hospitals and various doctors' offices and medical entities may be impacted by an increased need for various health care services including heat and respiratory care.

Precipitation

The precipitation projections show variability over time. Periods of decreased precipitation may result in more frequent and persistent droughts, especially in combination with increased temperatures which would result in decreased water supply, water quality and public health; reduced viability of natural landscapes; and increased risk of wildfires in the region. As mentioned in the Exposure section above, the frequency and severity of storm events could increase with climate change. This could result in impacts to community structure, functions and human health and safety, particularly related to flooding.

Community Structures – Potential Precipitation Impacts

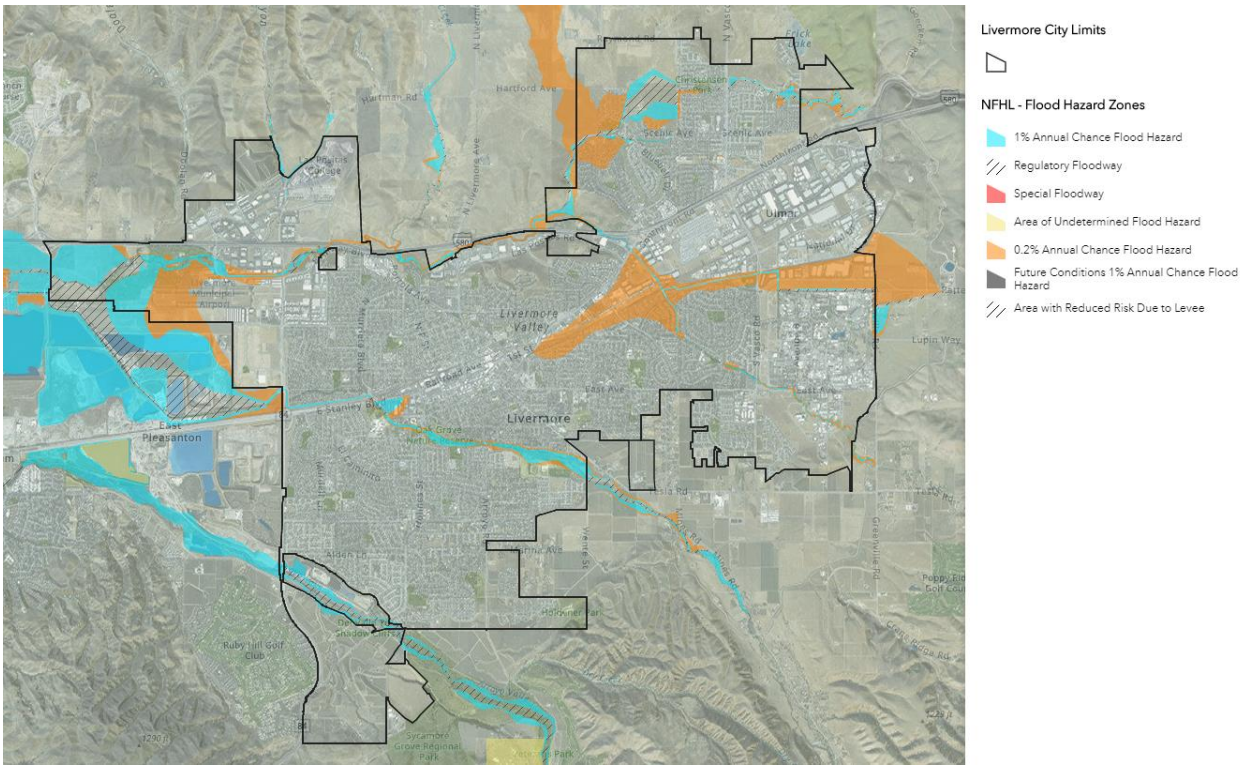
Increased flooding may result in water and wastewater treatment plants being unable to handle increases in intense rainfall events and associated runoff. This could impede the proper functioning of on-site septic systems or overwhelm sewers and centralized sewage treatment plants. As a result, untreated water, with a full load of toxics and organic waste could enter streams and the ocean. Flooding may also impact the City's transportation network inhibiting movement of people and goods. Emergency response systems would similarly be affected by flooding through restricted access to and from emergency response systems, increasing wait times for these crucial services. Communication to these entities may also be impacted if electricity transmission is interrupted or if water and other natural resources are unavailable.

The Tri-Valley Local Hazard Mitigation Plan assessed the flood loss potential to critical facilities exposed to flood risk. Critical facilities include medical and health services, emergency services, educational facilities, government facilities, utilities, transportation facilities, and hazardous materials. Both Lawrence Livermore National Laboratory and Sandia National Laboratory are considered high profile critical facilities because they house hazardous materials. The plan estimated the following flood-related risks:

- **A 10-percent annual chance flood event (i.e. flood of a magnitude historically expected every 10 years on average)** would affect 12 facilities and on average the facilities would receive a 4.12 percent damage to the structure and 27.03 percent damage to the contents.
- **A 1-percent annual chance flood event** (i.e. flood of this magnitude historically expected every 100 years on average) would affect 21 facilities and on average the facilities would receive a 7.33 percent damage to the structure and 27.78 percent damage to the contents.

- **A 0.2-percent annual chance flood event** (i.e. flood of this magnitude historically expected every 500 years on average) would affect 66 facilities and on average the facilities would receive a 15.18 percent damage to the structure and 39.94 percent damage to the contents.

Figure 12 Livermore Flood Hazard Zones



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community | Esri, NASA, NGA, USGS, FEMA | Esri Community Maps Contributors, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA | Alameda County Registrar of Voters, 2011

Community Functions – Potential Precipitation Impacts

During intense storms and precipitation events, the local economy may be impacted through more frequent disruption to community services, such as power outages. Additionally, a flooded structure or agricultural field could result in increased expenses and disruption to work.

Populations – Potential Precipitation Impacts

Public health and safety may be directly impacted by injury and or death of community members resulting from large floods. Public health may also be indirectly impacted by reduced access to emergency response and health centers resulting from infrastructure impacts discussed above.

Wildfire

Community Structures – Potential Wildfire Impacts

The Cal-Adapt projections for wildfire risk in Livermore is projected to decrease over this century. Because of this, the direct impact of wildfire to community structures in the City are expected to remain low.

Community Functions – Potential Wildfire Impacts

Similar to community structures, direct impacts of wildfire to the economy in Livermore are unlikely. However, secondary impacts of decreased air quality could indirectly affect the economy by impacting vulnerable workers, reducing tourism, and directly impacting health of community members as noted below.

Populations – Potential Wildfire Impacts

Despite the low risk of direct wildfire impacts to Livermore, the potential of increasing wildfires in the greater San Francisco Bay Area and Central Valley could impact populations through increasing secondary impacts such as poor air quality, changes in water quality, and erosion. Vulnerable populations such as individuals with compromised immune systems, seniors, children, and outdoor workers are likely to be impacted most by these secondary impacts.

Vulnerability Component 4 - **Adaptive Capacity**

Adaptive capacity is the ability to cope with extreme events, to make changes, or to transform to a greater extent, including the ability to moderate potential damages and to take advantage of opportunities. Adaptive capacity is the current ability to address the potential impacts of climate change and includes adjustments in behavior, resources, and technologies (CEMA & CNRA 2012). The City of Livermore has actively taken steps to increase the City's adaptive capacity, which include promoting hazard mitigation, disaster preparedness, and proactive planning through stream and stormwater management programs. Table 4 lists the City's guiding documents and programs that have an underlying emphasis on adaptive capacity.

Table 4 Livermore Planning Documents and Programs

Document	Year Established
Climate Action Plan	2012
General Plan Climate Change Element	2009
Bicycle, Pedestrian, and Trails Active Transportation Plan	2018
East Alameda County Conservation Strategy	2010
Stream and Stormwater Management Programs	Ongoing
Tri-Valley Local Hazard Mitigation Plan	2018
2005 GHG inventory Report	2007
EBEW GHG Inventory Reports	2005, 2010, 2015, 2017
Green Infrastructure Plan	2018
Livermore Emergency Operations Plan	2018

The City has approximately 200 sustainability and adaptation related measures from the existing planning documents listed above. Most of these measures can be grouped into four major categories: energy, water, transportation, waste, and land use. The two major exposures expected in Livermore are higher temperatures and potentially increasing frequency and intensity of storms, and a variety of measures address these exposures indirectly. Many energy measures have been developed which could increase the City's adaptive capacity related to increased temperatures, however, most of these have been determined to be low quality (due to the lack of a clear objective, strategy to obtain objective, funding,

metrics to measure progress, and/or lead responsible party). Furthermore, few of these measures have been implemented. The same is true for sustainability measures related to water and land use.

The City has developed both reactive and proactive measures to addressing climate change adaptation. The Stream and Stormwater Management Programs is a collaborative effort between the City, Parks District, and Water Agency to provide habitat enhancements around stream and flood channels. This form of stream maintenance and repair increases the City's adaptive capacity related to higher precipitation rates and the potential for flooding.

Though the City has a vast number of sustainability measures developed, few have been successfully implemented, giving the City a low to medium adaptive capacity rating. While the City does have some level of emergency preparedness, such as through the Livermore Emergency Operations Plan, there are few implemented measures in place to address long-term effects of climate change such increased heat and decreased air quality.

Vulnerability Component 5 - **Risk and Onset**

Risk is defined as the likelihood or probability that a certain magnitude, extent, or scale of potential impact will occur (CEMA & CNRA 2012). For each impact, a level of uncertainty, based on the probability of the primary or secondary exposures is assigned (
Table ***5***). According to the Intergovernmental Panel on Climate Change, temperature changes have a greater than 90% probability of occurring, providing a high certainty rating for this impact. Precipitation changes have a greater than 66% probability of occurring, providing a medium certainty rating.

Table *5* Probability of Global Primary Impacts

Driver	% Probability (IPCC)	Certainty Rating
Temperature Change	>90%	High
Precipitation Change	>66%	Medium

Source: Adapted from CEMA & CNRA 2012, IPCC 2007

For each associated secondary impact (e.g., heat waves, intense rainstorms, drought, etc.), a certainty rating and timeline for expected impacts to Livermore were assessed based on the conservative estimates from

Table ***5*** and secondary impacts explored in the Exposure section of this assessment (Table 6). Expected near-term secondary climate impacts to Livermore include changed seasonal patterns, heat waves, and intense rainstorms. These impacts may occur in the near-term (2020 – 2040) because they occur, in part, as a result of increased temperature, which has a high certainty rating globally and high exposure risk in Livermore. Drought and wildfire are expected to occur in the mid-term largely due to the variability of precipitation projections in Livermore.

Table 6 Probability of Secondary Impacts Based on Global Models

Primary Impact	Associated Secondary Impacts	Certainty Rating	Timeline for Expected Impacts to Livermore[1]
Changed temperature and/or precipitation patterns	Changed seasonal patterns	Medium	Near-term
Increased temperature	Heat wave	High	Near-term
Increased temperature and/or changed precipitation	Intense rainstorms	Medium	Near-term
Increased temperature and/or reduced precipitation	Drought and wildfire	Medium	Mid-term

[1] Near-term: 2020 – 2040; Mid-term: 2040-2070; and Long-term: 2070-2100

Source: CEMA & CNRA 2012

Conclusion

Climate change will affect populations throughout the state, nation, and world differently based on their actual and perceived vulnerabilities. This assessment serves as an assessment to better understanding Livermore's vulnerability to climate change impacts and inform the development of additional adaptive measures. The major findings of this analysis are:

- maximum and minimum temperatures are expected to increase
- precipitation variability is expected to increase over the century
- increased temperature and associated impacts have a high certainty of occurring in the near-term
- intense rainstorms and changes in seasonal patterns are expected to occur in the near-term
- Livermore has a low to medium adaptive capacity rating due to the variety of sustainability and adaptation measures developed yet low implementation rate of these measures

The City has a variety of planning documents and programs that provide a low to medium rating in adaptive capacity. There are opportunities to further improve adaptive capacity to climate change exposure described in this analysis. In addition to focusing on the implementation of high priority measures that address effects of increasing temperatures and storms, it will be important to focus these efforts in vulnerable communities such as in the opportunity zone and disadvantaged communities highlighted in Figure 10 and Figure 11. Some examples of measures that could be implemented to improve adaptive capacity include:

- Encouraging green building practices in new and redevelopment with a focus on disadvantaged communities
- Provide infrastructure improvements such as cool pavements, green roofs, and planting trees and vegetation in disadvantaged communities
- Communicate heat warning information and appropriate responses to the public, especially to the most vulnerable members of the community, and provide community cooling centers in areas with low-income, elderly, and young populations
- Incentivize and/or require the installation of heat pump HVAC units which provide energy efficient heating and cooling

- Increase distributed energy resources and therefore electricity security through the implementation of microgrids and battery storage
- Strengthen water supply systems to meet forecasted demands of residents, businesses, and visitors as variability in water resources increases

The Climate Action Plan will provide the framework for Livermore to prepare for and adapt to the impacts of climate change that may affect the city and focus efforts on vulnerable populations, structures, and functions to minimize the residual effects of climate change and prepare Livermore for long term climate resiliency. The CAP will work in unison with the City's planning documents (Table 4) to provide strategies for the City to prepare, adapt, and mitigate the impacts of climate change.

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Appendix C - Cost Technical Appendix

Livermore Climate Action Plan Update

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Introduction

As part of its updated Climate Action Plan, the City of Livermore – in coordination with Rincon Consultants, Inc. (Rincon), the Livermore Climate Action Plan Advisory Committee, and the community of Livermore – has developed a comprehensive strategy to improve resiliency to climate change and for reducing community-wide GHG emissions to net carbon neutrality by 2045. However, achieving carbon neutrality requires significant, strategic investments into many elements of the community including new policies, infrastructure, technology, and behavior change on the part of the community. In order to develop transparency around the prioritization of these investments, Rincon has assembled a technical appendix detailing the estimated cost associated with the implementation of each of the 20 identified strategies based on cost data derived from past projects, case studies, and available research and academia.

Climate Action Plans exhibit high variability in implementation costs depending on the strategies identified, their level of specificity, and the accompanying funding and financing strategies, which may vary depending on the scope of the project. For example, costs may vary from capital-intensive investments like the installation of a microgrid to enhance energy resiliency in the event of climate disasters to setting up bike infrastructure to encourage alternative means of transportation. Furthermore, depending on the type of desired bike infrastructure, costs may vary from $10,000 to $1M per mile.[1] [2] Each reporting entity exhibits their own priorities and funding mechanisms based on the needs of its local community, in addition to having unique backdrops of political climate, land use practices, social equity concerns, and more. Simply put, one size does not fit all. The intent of this appendix is to distill these highly variable cost/benefit considerations into a document that provides a clear understanding of the potential costs and the primary variables that effect cost and provide a replicable pathway towards net carbon neutrality based on the strategies provided.

The strategies listed below have been broken down into 4 cost segments which include:

1. **Low-Cost:** The low-hanging fruit for the community or City, generally delineated as strategies associated with relatively low upfront costs or city staff time, (e.g., policy ordinances or outreach). For community members, this represents costs between $1 and $100 per year.
2. **Moderate-Cost:** Intermediate level of costs associated with consultant and moderate infrastructure changes, (e.g., feasibility studies, program development, and retrofitting existing infrastructure). For community members, this represents costs between $100 per year and $500 per year.
3. **High-Cost:** Longer term projects requiring substantial investments into major infrastructure or technology over time, (e.g., energy storage, bike lanes, or other infrastructure changes). For community members, this represents costs between $500 per year and $1,000 per year.

[1] 2018 Livermore Active Transportation Plan https://www.cityoflivermore.net/civicax/filebank/documents/18254

[2] 2018 Livermore Active Transportation Plan Appendices Table includes estimated cost per project. https://www.cityoflivermore.net/civicax/filebank/documents/18253

Table 1 Strategy Cost Summary

Strategy #	Strategy	Cost Categorization	City Cost Variables	Community Cost Variables	2030 MT CO_2e Reduction or Adaptive Capacity	2045 MT CO_2e Reduction or Adaptive Capacity
Adaptation Strategies						
E-1	Enhance community energy resilience.	High Cost	• Staff time • Microgrid costs Weatherization upgrades	N/A	High Adaptive Capacity	High Adaptive Capacity
D-1	Improve water conservation and reuse.	Low Cost	• Staff time • Ordinance/resolution/plan development • Staff time to develop partnerships	• Cost of water conservation efforts • On-bill water savings	High Adaptive Capacity	High Adaptive Capacity

F-1	Improve stormwater management.	Moderate Cost	• Size of project (acreage) • Staff time • Ordinance development (hardscape)	• Runoff rate • Parcel size • Runoff factor for user type (commercial, industrial, institutional) • Fee increases for new impervious surfaces	Moderate Adaptive Capacity	Moderate Adaptive Capacity
H-1	Increase resilience to extreme heat events.	Moderate Cost	• Staff time • Heat Mitigation Plan cost • Tree planting costs • Shade structure implementation • Backup power at cooling stations	• N/A	High Adaptive Capacity	High Adaptive Capacity
WF-1	Mitigate wildfire risk and improve preparedness.	Low Cost	• Staff time • Cost of personal protective equipment • Creation of fire safe development standards • Creation of community fire fuel load reduction program • Creation and operation of clean air centers • Building retrofits to improve indoor air quality	• Increased development costs	Low	Low

Mitigation Strategies						
B-1	Require new buildings to be all-electric and incentivize electrification retrofits of existing buildings.	Low Cost	• Staff and consultant time required to develop and pass an ordinance • Staff and consultant time required for outreach and education • Staff and consultant time required for conducting a cost analysis and feasibility study	• Cost savings of all electric home compared to fuel mix • Long-term savings on energy bills	27,383	121,559
B-2	Decarbonize electricity from the grid and increase local renewable energy generation.	Moderate Cost	• Staff time • Outreach and education	• Electricity costs per rate plan	25,505	0
T-1	Facilitate a transition to electric vehicles.	Moderate Cost	• Grant or financing availability for EV Readiness Plan • Staff and/or consultant time for ordinance development, outreach, and partnership development • Infrastructure costs for new chargers at municipal locations • Use of public/private partnerships • Electricity and charging rates	• Cost of charging infrastructure • Marginal cost of EV selected (Cost of combustion vehicle compared to EV alternative) • Lifecycle cost of EV ownership • Lifecycle costs of combustion vehicle ownership	49,494	93,458

T-2	Facilitate a transition to transit and shared mobility.	Moderate Cost	• Staff time • Bike share costs (pilot program) • Ordinance development costs	• TDM support actions • Transit Passes	3,033	4,656
T-3	Improve active transportation infrastructure.	High Cost	• Planning and consultant costs • Construction cost • Ongoing maintenance costs	• Costs associated with funding mechanism, e.g., sales tax or parcel tax	2,127	2,111
T-4	Support sustainable land use practices.	Low Cost	• Staff time • Consultant time	None Identified	Supportive	Supportive
W-1	Reduce the amount of waste that is landfilled.	Low Cost	• Staff time to develop an ordinance • Staff time for outreach and education • Development of High Diversion Plan • Staff time for partnership development for food recovery	• Increased cost of food items served in reusable/ compostable food ware • Cost to businesses to implement waste diversion techniques • Cost to residents to implement home composting • Cost to businesses to implement composting	19,379	22,646
W-2	Expand use of low-carbon and recycled building materials	Low Cost	• Staff time for outreach and education • Development of carbon performance standards and material-efficient building practices for new construction	• Increased cost of building material	Supportive	Supportive

S-1	Maximize local carbon sequestration.	High Cost	• Staff time • New trees • Operating and maintenance cost of trees • Carbon farming study and pilot project • Landscaping standards update • Urban Forest Management Plan preparation & implementation	• Cost of trees • Cost of water/maintenance of trees	58	58
Municipal Strategies						
M-1	Enhance resilience at public facilities.	High Cost	• Cost of microgrid/battery storage • Cost of energy efficiency and AQ upgrades selected • Energy Cost Savings	N/A	Supportive	Supportive
M-2	Electrify municipal facilities and operations.	Moderate Cost	• Staff time • Type of units electrified • Number of facilities	N/A	Supportive	Supportive
M-3	Electrify the City's vehicle fleet and encourage City employees to utilize alternative transportation and teleworking opportunities.	Moderate Cost	• Staff time • Number and type of vehicles electrified • EV charging infrastructure • Alternative transportation incentives	N/A	Supportive	Supportive

M-4	Conserve water in municipal landscaping and improve on-site stormwater management.	Low Cost	• Cost of new fixtures • Cost of new landscaping • Water savings offsets	N/A	Supportive	Supportive
M-5	Purchase more sustainable products to reduce waste from City operations.	Moderate Cost	• Staff time • Update Environmentally Preferable Purchasing Policy • Marginal cost of new products	N/A	Supportive	Supportive
M-6	Utilize public lands to increase local carbon sequestration and reduce urban heat island effect.	Moderate Cost	• Staff time • Open space/landscaping maintenance costs	N/A	Supportive	Supportive
Implementation Strategies						

I-1	Make climate impacts and resilience a standard consideration during planning and development processes.	Low Cost	• Staff time • Consultant time for carbon nexus study • Consultant time for financial risk analysis	N/A	Supportive	Supportive
I-2	Dedicate City resources to CAP implementation and consistently monitor progress.	Moderate Cost	• Staff time	N/A	Supportive	Supportive
I-3	Create a public outreach campaign to educate the community about CAP initiatives.	Moderate Cost	• Staff time	N/A	Supportive	Supportive
I-4	Foster green innovation in Livermore.	Low Cost	• Staff time	N/A	Supportive	Supportive

Cost Considerations

For each strategy, the cost description focuses on both internal costs (municipal-focus) and external costs (community-focus) and provides insight into the variability of these costs including the primary variables that may affect cost effectiveness including several primary considerations:

Upfront versus Lifecycle Costs

When discussing how much a strategy or action costs it is important to differentiate between the upfront costs, the cost of an LED light bulb, versus the lifecycle costs of purchasing, operating, maintaining, and ultimately disposing of that lightbulb. While LED lightbulbs may be more expensive up front when compared to an incandescent bulb, the lifecycle costs of owning an LED lightbulb are significantly lower, providing a significant return on investment.

Incremental or Marginal Costs

When discussing costs, it is important to specify the difference between how much a strategy costs overall and what the incremental or marginal cost is. The incremental or marginal cost is the difference in cost between the new action and the old or standard action. For example, purchasing a new electric vehicle could cost $30,000 which should be considered a high cost. However, the marginal cost of purchasing an electric vehicle versus purchasing a new internal combustion vehicle may be zero or near zero because of reduced long-term operating and maintenance costs including no fluids to replace, fewer moving parts like transmissions, and less brake wear. It is important to consider what the incremental/marginal costs are for each strategy by keeping in mind what the alternative costs are. In many cases, the difference is negligible.

Financing

One of the major financial tools available to make large investments into infrastructure, vehicles, or buildings is financing. Financing allows us to leverage the time value of money and put future expected money flows to use today. For example, a solar array may cost $20,000 and result in an energy bill that is $200 less per month. The cost of the solar array could be considered high. However, the loan for the solar array requires a monthly payment of $150 dollars, resulting in a net monthly savings of $50 dollars. Under this scenario the solar array does not carry a high cost, rather it provides an overall savings. The ability to finance can make seemingly high-cost investments low to no cost over time.

Understanding the ranges of cost savings and revenue streams, and how those costs and revenues accrue over time into a payback or ROI calculation, are prudent factors to structuring partnerships, engaging stakeholders, and making optimal financial decisions. For example, energy efficiency retrofits can generate cost savings of more than 30% for 15 to 20 years. If external partners are involved, such as with an energy savings performance contract (ESPC), cities may not need to provide any upfront capital, but the project's cost savings would accrue with a private third party and be lost by the city. An anaerobic digester may need $5M to $10M in upfront capital but could also generate $1 to $2M annually in natural gas delivery revenue. Over 20 years, which can be an attractive financial investment for a city. Cities must consider the estimated return on investment (ROI), how project costs and

revenues balance out over the useful life of the project, and whether they are willing to forego long-term cost savings or revenue generation capacity by partnering with a private third party.

The Cost of Doing Nothing

Finally, it's also important to keep in mind that doing nothing to prepare for and mitigate climate change will also carry a cost. The alternative to implementing these strategies is not zero. One immediate example is the cost to install conduit and panel capacity for electric vehicle chargers for all new construction. While this action increases upfront construction costs by a few hundred dollars, doing that same work after the building is completed can be an order of magnitude higher (~$3,000). Given the move towards electric vehicles, the cost of not installing EV infrastructure today could cost the community significantly more in the future. In a similar vein, adaptation strategies will cost the city and the community today. Planting trees, installing microgrids, and setting up cooling centers all have upfront costs. However, it's imperative that we weight these costs against the costs of a future without these adaptive strategies given what we know about the climate. Research published in the journal Nature predict the cost of not decreasing emissions to carbon neutrality by mid-century could range between $149.78 trillion to $791.98 trillion by the end of the century.[3] That same study found that if we mitigate climate change and achieve carbon neutrality by mid-century the world could see a $127-to-$616 trillion-dollar economic benefit after considering the cost of mitigation. The humanitarian impact is also significant. The Red Cross and Red Crescent Societies estimate that the number of people in need of humanitarian aid each year could double to $200 million annually by 2050 due to climate change costing $20 billion per year.[4] Furthermore, the World Resources Institute has found that investing in adaptation and resilience provides a benefit-cost ratio ranging from 2:1 to 10:1, meaning that for every dollar invested in resilience and adaptation we stand to see $2 to $10 dollars' worth of benefits.

Funding and Financing Considerations

There are three major categories of financial pathways available for climate action: funding, financing, and revenue generation. For the purposes of this project, **funding** refers to repayment-free capital that is available from third-parties, **financing** refers to borrowed capital including loans, bonds, and other cost- sharing mechanisms that ultimately require the borrower to pay back the capital in full (typically with interest), and revenue generation from new charges, fees, or taxes, to citizens, beneficiaries, or customers, which can be placed on specific project users or applied to every resident or business in a given area. In some cases, **revenue generation** includes capturing cost savings that accrue from the project. Funding, financing, and revenue generation are often used together to implement major capital

[3] Wei, Yi-Ming et al. Nature Communications. 2020. Self-preservation strategy for approaching global warming targets in the post-Paris Agreement era. Accessed at https://www.nature.com/articles/s41467-020-15453-z. Accessed June 9, 2021.

[4] International Federation of Red Cross and Red Crescent Societies. 2019. The Cost of Doing Nothing: The Humanitarian Price of Climate Change and How it Can be Avoided. Accessed at https://reliefweb.int/report/world/cost-doing-nothing-humanitarian-price-climate-change-and-how-it-can-be-avoided. Accessed June 9, 2021.

projects. While funding can support a capital project as a stand-alone mechanism, financing usually requires identifying a funding or revenue stream that will be used to repay borrowed capital.

Six Major Types of Funding & Financial Mechanisms
This list is ordered by the increasing amount of debt load that would be incurred by the city (or other project lead): starting with free capital from grants and partnerships, continuing to capital borrowed from loans and bonds, and concluding with city funding from budget, taxes, and fees.

1. **Grants** can provide a substantial source of 'repayment-free' capital if cities have the staff capacity to invest in grant management. Grants make the most sense for cities with the necessary staff capacity (1-2 full-time equivalents, either internal or external experts) to track grant opportunities, craft meaningful proposals that link to the goals and mission of the donors, submit applications, and track results required for ongoing reporting.

    - **Pros:**
        - Grants do not have to be repaid
        - Grants can support purchases that enable cities to be the sole owner and operator of a project, and maintain city control over project details
        - Can attract media and generate credibility and prestige when awarded by national institutions, which helps promote cities' climate leadership and innovative projects

    - **Cons**:
        - Often competitive
        - Effort spent applying not always rewarded
        - Grants from federal, state, and other government sources tend to have strict limitations on what funds can be spent on, as well as burdensome reporting requirements
        - Not sustainable, have to reapply often with uncertain outcomes
        - Can sometimes come with 'match' requirements, where the grantee has to come up with ~10-50% of the project budget and the grant will cover the rest

2. **Partnerships** often tap resources, and secure capital, from non-governmental and corporate actors, which can spread the financial risk of a project across multiple public, private, and/or nonprofit entities. Partnerships are well-suited for cities who cannot or do not want to own their project outright, and who are willing to share possible cost savings and revenue generation with a third-party. Examples of partnerships include Energy Savings Performance Contracts (ESCOs), Sponsorships, Public-Private Partnerships, and Power Purchase Agreements.

    - **Pros**:
        - Private partners can expedite project design, initial implementation, and ongoing management
        - Can leverage private sector expertise to spark innovation, and better design, build, and manage projects

  - Can enable public sector to capture tax incentives and other private-market benefits
  - Private actors may fully fund the initiative

- **Cons**:
  - City may not have ultimate ownership of project, and may lose operational control
  - City may not have access to cost savings or revenue generated from project
  - Negotiations can be complex, lengthy, and difficult, and tensions can arise between parties given their divergent operational speeds, with public parties prioritizing safety and durability, and private partners preferring quick decision making and maximizing efficiency and profits.
  - Partnerships are less transparent than budget, bonds, and other mechanisms

3. **Loans** give cities access to upfront capital, whose principal and interest must be repaid over the duration of the loan. While cities should first consider grants and private partners that can provide repayment-free capital, when those pathways are unavailable loans are a dependable alternative. In many cases, municipal borrowers and impact-driven projects can find financing with low-interest rates. Loans can also include Lease-Purchase Agreements which defer upfront costs but require more total capital over the life of the payment.

    - **Pros**:
      - Provides upfront capital on short notice with predictable terms and contracts
      - Spreads the cost of a project across the useful life of the asset, and thus allocates costs to current and future users

    - **Cons**:
      - Loans add debt to the balance sheet
      - Lenders may have stipulations on what the borrowed capital can be spent on (assets vs. wages, etc.)
      - Private investor and bank loans are usually offered with higher interest rates than municipal bonds
      - Loans are less transparent than budget, bonds, and grants, unless cities pursue extraordinary levels of disclosure

4. **Bonds** provide dependable, predictable financing for cities looking to capitalize large infrastructure projects ranging from the millions to billions of dollars. A city can issue a bond directly or apply for funds from a state bonding program. These bonds can be backed either by general city funds, or specific revenue sources. There are multiple types of bond structures including general obligation, revenue, and conduit bonds, as well as certifications like “green” bonds for climate and sustainability that communicate what types of projects bond proceeds are being used for.

- **Pros**:
    - Bonds enable cities to borrow large amounts of up-front capital with fixed low-interest rates and long repayment periods
    - Bonds spread out costs over useful life of project, which can be decades, and allocates costs to current and future users of the project
    - Tax-exempt municipal bonds can attract capital from high-net-worth investors, especially local wealthy individuals and families who benefit from tax deductions on bond's interest if they live in your city's county or state.

- **Cons**:
    - Issuing general obligation bonds can be a politically charged process if your city requires voter approval
    - Bonds cannot be repaid through cost savings from a project, they must be repaid through additional topline revenues coming from a project or from reallocated funds within the municipal budget.
        - If a third party is generating revenues from the installation or operation of a project, those revenues can be used to support the bond. When combined with an Energy Savings Performance Contract, this is called a Morris Model Bond.
    - City bond ratings affect the interest rates of municipal bonds, with poorly rated cities having to pay higher interest rates on their bonds. This can pose as a challenge to lower income cities, and in cities that face frequent flooding, fires and other climate threats that threaten financial solvency — as all of these factors can depress city bond ratings.

5. **Budget** refers to using money in a city's general fund to capitalize projects. Every year cities collect tax revenue and other fees to populate their general funds, portions of which are appropriated to new capital projects and infrastructure investments. As the inability of city budgets to cover the expansive list of new costly climate projects in CAPs is a primary motivation for this project, financial mechanisms beyond budget must begin covering a larger share of the load, and other financial mechanisms should be fully explored before cities turn to budget funding. Yet, opportunities remain for climate action to take higher priority in cities' budgeting processes and for city budgets to fund appropriate climate-related expenditures. If using city budget is an option, well-suited projects tend to have total costs that are small enough to fit into 1 to 3 years of the city's budget, and/or have costs incurred in a dispersed manner, ideally evenly distributed over several years or decades, like the costs of staffing for a new program.

    - **Pros**:
        - City budget funds are available immediately, and thus can respond to pressing time-sensitive funding needs
        - City budget funds come with few restrictions, and can be tailored to match project needs exactly

  - Funding from the city budget does not increase debt burden, and frees up future budget that would otherwise be spent servicing debt payments with interest
  - Budget funding utilizes existing contractual relationships, and does not require creating new partnerships or entering into new legal arrangements

- **Cons**:
  - The amount of funding available each year is limited, so large projects can exhaust an agency's entire capital budget for the year.
  - Similarly, it can take decades to accumulate enough to pay upfront costs of major infrastructure projects. If cities do save portions of the budget for several years in order to have enough capital to cover the upfront costs of a project, cities can end up paying more for the project due to inflation.

6. **New taxes and fees**, as well as cost savings and other revenues, can create new flows of capital to fund climate action. Most often, however, ongoing revenue generation is not earmarked for a particular project and accumulated in a savings account. Rather, new revenue flows are funneled into cities' general funds, or leveraged through financing, as is the case with revenue bonds. Revenue generation via new taxes and fees makes sense for cities that have not significantly raised taxes or fees on residents in the past year or two, for projects that do not need immediate upfront capital, or for cities pursuing a revenue bond that needs a source of project-based revenues.

   - **Pros**:
     - New or raised taxes and fees provide cities with stable sources of ongoing revenue that can provide consistency and budget flexibility for decades
     - With adequate political support and restrictive legislation, revenues from taxes and fees can be set aside to create funds for very specific purposes, with revenues generated from specific stakeholder groups

   - **Cons**:
     - New or raised taxes and fees require significant political capital and community support to implement
     - There may be state-level regulation affecting which tax and fee structures a city can use
     - Certain tax structures can be regressive, placing a higher burden on low-income communities
     - Revenues generated from specific taxes and fees can fluctuate based on economic conditions and personal behavior, which can create last minute budget shortfalls

Strategy Cost Benefit Analysis

The following section discusses the primary variables impacting costs for each of the strategies as well as information on the potential costs to the City and community based on the cost considerations listed above. Strategies are organized into 4 categories: Adaptation, Mitigation, Municipal, and Implementation.

Adaptation Strategies

The strategies listed in this section aim to increase Livermore's resilience to climate change impacts, prioritizing vulnerable communities and vital public facilities. These strategies cover Energy Resilience, Drought, Flooding, Extreme Heat, and Wildfire.

Energy Resilience

Strategy E-1: Enhance community energy resilience

City Costs

City Cost Variables

- Staff time
- Microgrid costs
- Weatherization upgrades

City Cost Discussion

The climate resiliency of buildings is a primarily a factor of its capacity to withstand intense weather disasters. Municipal costs associated with E-1 include enhancing and promulgating microgrid resiliency, including staff time allocated towards developing partnerships, seeking grants, and conducting weatherization upgrades, the latter of which can reduce the energy consumption of buildings by up to 35%, resulting in long-term savings from reduced operating and maintenance costs.[5] The City costs associated with this strategy range from low costs (for staff time), to moderate costs (for facilitating weatherization upgrades) to high costs (micro grid expansion). The best strategy of the cost of microgrids is the cost per unit capacity ($/MW). In California, the average cost per MW of storage added is $3.5M.[6]However, these costs can be financed or even completed through public private partnerships. Furthermore, a single microgrid would help meet the goals of several strategies.

Community Costs

Community Cost Variables

- N/A

[5] Statewide Energy Efficiency Collaborative. Weatherization Guide for Local Governments. Accessed at https://californiaseec.org/wp-content/uploads/2017/01/Weatherization-Guide-for-Local-Governments.pdf. Accessed June 1, 2021.

[6] Asmus, Peter, Adarm Forni, and Laura Vogel. Navigant Consulting, Inc. 2017. Microgrid Analysis and Case Study Report. California Energy Commission. Accessed at https://ww2.energy.ca.gov/2018publications/CEC-500-2018-022/CEC-500-2018-022.pdf. Accessed June 1, 2021.

Community Cost Discussion

Costs incurred by the community for E-1 are focused largely on weatherization and other building upgrades. Costs will remain highly variable for existing buildings depending on their existing infrastructure and capacity to retrofit or enhance their surrounding environment, such as including fire safe or stormwater best management practices in their outdoor landscaping, reducing energy demand on the grid, converting to electric heating and cooling, construction of rooftop solar, and more. However, single family homes can make significant weatherization progress for <$1000.[7] Several weatherization assistance programs are currently available and more may be developed by the City.[8] Furthermore, weatherization has been found to pay back over $2 for every $1 invested over time.[9]

Drought

Strategy D-1: Improve water conservation and reuse

City Costs

City Cost Variables

- Staff time
- Ordinance/resolution development
- Staff time to develop and maintain partnerships for demonstration program and efficiency devices subsidy

City Cost Discussion

Promoting water efficiency is one of the most cost-effective means to not only conserve water but reduce GHG emissions. As opposed to retrofitting infrastructure or creating new programs to reduce emissions, promoting behavioral change requires little investment for immediate benefits of avoided emissions and costs associated with water treatment and delivery. Municipal costs to promote efficient water use, develop policies, and implement the water efficient landscape ordinance will require additional staff time.

Community Costs

Community Cost Variables

- Cost of water conservation efforts
- On-bill water savings

Community Cost Discussion

Using less water means lower water bills for the community. Community costs may include investment into smarter watering practices, like the City's water efficient lawn conversion rebate, weather-based irrigation controller rebate, or high-efficiency clothes washer rebate. Costs incurred by the community are relatively low compared to other strategies and added incentives provided by the City lead to

[7] https://www.homeyou.com/ca/weatherization-livermore-costs

[8] https://www.benefits.gov/benefit/1844

[9] https://www.energy.gov/eere/wap/about-weatherization-assistance-program

quicker returns on investment, saving money on their bills in the long-term. Depending on the property, more efficient outdoor watering practices may reduce bills by 50%. When considering lifecycle costs, many water conservation actions provide a return on investment especially when considering rebates and incentives. Costs for onsite water reuse systems vary greatly from hundreds to hundreds of thousands of dollars depending on the size and complexity. However, these costs are offset over time based on water and wastewater savings.[10]

Flooding

Strategy F-1: Improve stormwater management

City Costs

City Cost Variables

- Size of project (acreage)
- Type of retrofit
- Staff time
- Staff time
- Cost and maintenance of permeable surfaces

City Cost Discussion

Increasing permeable surfaces effectively reduces urban runoff and returns water to the ecosystem, offsetting marginal costs associated with wastewater treatment. The cost of different permeable retrofit projects is dependent on the scale of the project and the costs associated with design, permitting and construction. The most effective method of assessing cost for permeable projects is notated on a dollar per acre of pervious surface basis. Project costs with a scope of less than ½ acre of pervious cover tend to be two orders of magnitude more expensive than storage retrofit practices. Costs may range depending on the type of pervious surface desired. Porous surfaces like gravel are relatively much cheaper alternatives to more expensive urban solutions like permeable concrete. On the low end, constructed wetlands and basic retention systems may cost as low as $2,200 while urban on-site retrofits may cost as high as $150,000.[11] Lifecycle considerations include cost savings associated with the method of pervious surface selected, such as a simple greenspace, or the avoidance of paving areas that would otherwise be paved and instead covered with porous material, such as gravel.

Municipal costs associated with this strategy involve staff time allocated towards the ongoing programmatic implementation of the City's Stormwater Management Plan, Green Infrastructure Plan, and Capital Improvement Program. Direct costs include expenses for maintaining infrastructure, constructing new devices, or monitoring water quality. Costs vary widely depending on the type of infrastructure installed. However, it's important to understand the savings that can be gained by using low impact development and green infrastructure.

[10] https://living-future.org/wp-content/uploads/2022/05/2019-Water-System-Financial-Case-Studies-1.pdf

By improving flood resiliency from future storms, the City can expect to save money in the long-term by avoiding reconstruction resulting from the damage of these storms under a business-as-usual approach. Urban trees also reduce stormwater runoff and water pollutants, improving ecosystem health, and provide barriers to urban flooding as a pervious surface.[12] A meta-analysis of green infrastructure systems found that green infrastructure can be less expensive than standard infrastructure alone even before taking into account lifecycle benefits.[13] A study of tree planting in five US cities found that "The five cities reported here spent $13– 65 annually per tree, but benefits returned for every dollar invested in management ranged from $1.37 to $3.09."

Community Costs

Community Cost Variables

- Runoff rate
- Parcel size
- Runoff factor for user type (commercial, industrial, institutional)
- Cost of incorporating pervious materials
- Savings associated with decreased flood damage

Community Cost Discussion

With the requirement of passive rain capture features for new infrastructure and development projects, the community may expect costs to rise for new construction projects. However, these costs covered by developers may lead to savings by the community at-large because of reduced damage to nearby communities vulnerable to flood risks. While most of the costs associated with stormwater management are accrued by the City, homeowners would receive monetary benefits through higher property values as a result of an improved quality of life.[14] Currently, under the City's Stormwater System Enterprise Fund, every resident owning property within the incorporated City limits but discharging stormwater to a collection and conveyance system owned and operated by the City shall pay a service charge calculated in accordance with Municipal Code Section 13.46.050. The annual service charge is dependent on the parcel size, runoff factor associated with user type, and the runoff rate per acre.[15]

Similar to the costs incurred by the City, community costs vary depending on pervious material chosen and the marginal cost of the impervious material that would be selected under a business-as-usual approach. These costs would only be applicable to new construction or replacement projects. Some simple solutions like bioswales or simply less hardscapes like concrete or paving can be low to no cost.

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[12] United States Environmental Protection Agency. 2013. Stormwater to Street Trees: Engineering Urban Forests for Stormwater Management. Accessed at https://www.epa.gov/sites/production/files/2015-11/documents/stormwater2streettrees.pdf. Accessed June 1, 2021.

[13] https://www.epa.gov/sites/production/files/2015-10/documents/lid-gi-programs_report_8-6-13_combined.pdf

[14] Sacramento State University, Environmental Finance Center. 2019. Estimating Benefits and Costs of Stormwater Management. Accessed at https://www.efc.csus.edu/reports/efc-cost-project-part-1.pdf. Accessed June 10, 2021.

[15] City of Livermore Stormwater System Enterprise Fund. Municipal Code 13.46.010. Accessed at https://www.codepublishing.com/CA/Livermore/Municipal/Livermore13/Livermore1346.html#13.46.050. Accessed June 1, 2021.

Extreme Heat

Strategy H-1: Increase resilience to extreme heat events

City Costs

City Cost Variables

- Staff time
- Tree planting costs
- Shade structure implementation
- Backup power at cooling stations

City Cost Discussion

This strategy includes several actions that would incur upfront and ongoing City costs. Municipal costs included in this strategy involve staff time allocated towards the development of a heat vulnerability index and mitigation plan which could be completed by existing staff or creating a full-time Climate Action Program Manager for a cost of approximately $150,000. Conducting tree canopy surveys to identify shade deficient areas in the City would be completed by a consultant for a cost between $75,000 and $150,000, which is also included under actions for sequestration. The cost of implementing additional shade structures at bus stops are likely between $10,000 and $15,000 per stop.[16] Backup power at cooling stations could be completed through the development of a microgrid system that would provide backup power to several buildings. Microgrids costs are significant. However, these costs can be financed or even completed through public private partnerships. Tree planting and maintenance costs can average around $1,300 per tree for installation, watering, maintenance, and reporting.[17]

Community Costs

Community Cost Variables

- N/A

Community Cost Discussion

Due to the actions of this strategy in the development of a heat pump retrofit program, community members may opt-in to the financial incentive offered by the City to retrofit their own homes and improve indoor air quality. This cost would be incurred on a voluntary basis for the benefit of the community. Otherwise, there are no more costs to the community associated with this strategy.

Wildfire

Strategy WF-1: Mitigate wildfire risk and improve preparedness

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[16] Wesoff, Eric. 2011. Solar Bus Shelters From GoGreenSolar. Accessed at https://www.greentechmedia.com/articles/read/solar-bus-shelters-from-gogreensolar#:~:text=A%20traditional%20bus%20stop%20costs%20anywhere%20from%20%2410%2C000%20to%20%2412%2C000. Accessed June 9, 2021.

[17] Ainsworth, Greg. 2021. RE: Medea Tree Estimate. Email. Message to Ryan Gardner and Camila Bobroff.

City Costs

City Cost Variables

- Staff time
- Cost of personal protective equipment
- Creation of fire safe development standards
- Creation of community fire fuel load reduction program
- Creation of clean air centers
  Building retrofits to improve indoor air quality

City Cost Discussion

Municipal costs associated with this strategy can be largely covered with the onboarding of a Climate Action Program Manager to manage the supportive actions therein. Additional costs may include the purchase of additional reserves of personal protective equipment, staff time dedicated to outreach and education associated with the use of AC alert systems, the creation of fire safe development and landscaping standards, such as a Fire Safe Garden Program, updating hazard planning for wildfires, establishing a community fire fuel load reduction program, and the creation of clean air centers.

Community Costs

Community Cost Variables

- Additional cost for new construction in fire zones
- Savings associated with reduced fire damage

Community Cost Discussion

Due to the actions of this strategy falling on the responsibility of the City, there are no direct costs incurred by the community for this strategy. However, additional considerations may be made for including fire safe construction practices into new construction projects. Variables within these costs are dependent on the marginal cost of implementing fire safe practices versus a business-as-usual approach. Long-term savings from reduced fire damage are difficult to quantify but could equal the cost of each structure hardened against fire.

Mitigation Strategies

As the City works to protect the community from climate impacts, it will continue its efforts to reduce community-wide emissions across all sectors. These strategies cover Buildings and Energy, Transportation and Land Use, Waste and Materials, and Carbon Sequestration.

Buildings and Energy

Strategy B-1: Require new buildings to be all-electric and incentivize electrification retrofits of existing buildings

City Costs

City Cost Variables

- Staff and consultant time required to develop and pass an ordinance

- Staff and consultant time required for outreach and education
- Staff and consultant time required for conducting a cost analysis and feasibility study

City Cost Discussion

This strategy would predominately be implemented through an ordinance. A benefit to ordinances is that they tend to be relatively cost-effective to implement, while providing effective long-term change for the benefit of the community in accordance with the City's CAP. Passing the electrification ordinance would include staff time to be covered by existing staff as well as consultant time. Variability within these costs are dependent staff or consultant time dedicated to ordinance development and outreach but are estimated below $30,000 total. Therefore, the upfront costs to the City are considered low and the lifecycle costs to the city are also low due to the need for a one-time investment.

Community Costs

Community Cost Variables

- Cost savings of all electric home compared to fuel mix
- Long-term savings on energy bills

Community Cost Discussion

Cost effectiveness studies completed for Livermore's climate zone show that new building electrification costs less to build than mixed fuel buildings.[18] Single family homes are $6,171 dollars less expensive to build all-electric compared to a mixed fuel home. When built with heat pumps instead of resistance heating, homes are both cheaper to construct and cheaper to live in offering up to $177 per year of on bill savings while saving approximately $4,613 in construction costs. Therefore, this strategy is considered low cost, but will be a significant cost savings for community members purchasing new homes.

Strategy B-2: Decarbonize electricity from the grid and increase local renewable energy generation

City Costs

City Cost Variables

- Staff time
- Outreach and education

City Cost Discussion

The primary action in this strategy is opting up the City of Livermore into a 100% carbon free or renewable electricity tier through East Bay Community Choice Energy. This is a one-time action by City Council and therefore, the major costs are staff time to prepare staff reports and conduct community outreach. Other substantial strategies include amending the building code to include major remodels in energy efficiency upgrades and solar requirements. Staff time will also be required to conduct outreach and generate staff reports prior to City Council adoption.

[18] City of Livermore. 2019. Existing Low-Rise Residential Buildings. Accessed at https://explorer.localenergycodes.com/livermore-city/forecast/12-PGE/studies/1,2,3. Accessed June 9, 2021.

Community Costs

Community Cost Variables

- Electricity Costs per Rate Plan

Community Cost Discussion

Externally, B-2 may cost the community a marginal increase in money spent per kWh. However, this increased electricity cost depends on the rate plans used by the household/business. Based on the rate schedule of Strategy B-1 (Require new buildings to be all-electric and incentivize electrification retrofits) and an average monthly usage of 416 kWh, monthly bills would not increase under the East Bay Community Energy (ECBE) Brilliant 100 rate plan and would increase by approximately $4 per month under the ECBE Renewable 100 rate plan for both standard and CARE rates.[19]

Transportation and Land Use

Strategy T-1: Expand electric vehicle infrastructure to support zero emission vehicles

City Costs

City Cost Variables

- Grant or financing availability for EV Readiness Plan
- Staff and/or consultant time for ordinance development, outreach, and partnership development
- Infrastructure costs for new chargers at municipal locations
- Use of public/private partnerships
- Electricity and charging rates

City Cost Discussion

Costs associated with improving electric vehicle (EV) infrastructure include the development of an EV Readiness Plan to promote sustainable, equitable charging infrastructure deployment. EV readiness ordinance costs are wrapped into the electric building ordinance calculated in Strategy B1. Costs to develop an EV Readiness plan are estimated to cost $70,000.[20] Needs of staff managing this project, such as outreach and education, partnership development, and more, may result in additional staff time. The City has several options for installing public chargers. The first option is for the City to own and operate a charger. Under this scenario the City should expect EV chargers to cost between $1200 and $3,000 per charger for level 2 charges.[21] The City would then charge for the rate of electricity and

[19] PG&E – EBCE Joint Rate Comparisons. Accessed at https://www.pge.com/pge_global/common/pdfs/customer-service/other-services/alternative-energy-providers/community-choice-aggregation/ebce_rateclasscomparison.pdf. Accessed June 1, 2021.

[20] City of Berkeley. 2018. RFP for Electric Vehicle Roadmap: Strategies for Transitioning from Fossil Fuel Vehicles. Accessed at https://www.cityofberkeley.info/uploadedFiles/Finance/Level_3_-_General/RFP%2018-11229-C%20EV%20Roadmap%20Strategic%20Plan%207-10-18.pdf. Accessed June 10, 2021.

[21] Nicholas, Michael. 2019. International Council of Clean Transportation. Estimating Electric Vehicle Charging Infrastructure Costs Across Major US Metropolitan Areas. Accessed June 1, 2021. Accessed at https://theicct.org/sites/default/files/publications/ICCT_EV_Charging_Cost_20190813.pdf

maintenance for charging. These costs may be financed through the CalCAP program.[22] Another option is a public/private partnership where the City contracts with a third party to own and operate the infrastructure.[23] This could help the City decrease its upfront costs. Finally, the City may be able to support/encourage local businesses and building owners to install additional chargers by educating them on the benefits such as increased customer satisfaction or by connecting them to funding/financing or third-party vendors.

Community Costs

Community Cost Variables

- Cost of charging infrastructure
- Marginal cost of EV selected (Cost of combustion vehicle compared to EV alternative)
- Lifecycle costs of EV ownership
- Lifecycle costs of combustion vehicle ownership

Community Cost Discussion

Externally, the community may see increased costs of new construction because of new requirements to include EV capable charging spaces in new lots. Community members should expect to pay between $400-$800 per space for added conduit and panel capacity.[24] This is compared to $2,500-$6,000 to install EV capable spaces as a retrofit depending on the type of parking space (surface, structure, etc..).[25] The cost to install a EV charger that is ready to use is approximately $1000 per charger for non-networked Level II chargers.

The cost to purchase an EV is another major consideration on the success of this strategy. The cost of an electric vehicle varies significantly depending on the EV chosen. Since the purchase of an EV will likely offset the purchase of an internal combustion vehicle, the marginal cost should be considered here. EVs also offer considerable opportunities for lifecycle cost savings compared to their internal combustion (ICE) or hybrid vehicle counterparts since they do not need oil changes, transmission fluid changes, spark plugs etc. For example, the electric MINI cooper emits approximately half of the greenhouse gas emissions than that of its ICE and hybrid models while costing considerably less per month in fuel, maintenance, and total vehicle costs per month.[26] In general, new electric vehicles may or may not cost more upfront, but generally cost less over their lifetime compared to combustion vehicles.

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22 https://www.treasurer.ca.gov/cpcfa/calcap/evcs/summary.asp

23 https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-charge-network/program-participants/approved-program-vendors.page

24 California Air Resources Board. 2019. EV Charging Infrastructure: Nonresidential Building Standards. Accessed at https://ww2.arb.ca.gov/sites/default/files/2020-08/CARB_Technical_Analysis_EV_Charging_Nonresidential_CALGreen_2019_2020_Intervening_Code.pdf. Accessed June 10, 2021.

25 Property Manager Insider. 2019. How Much do EV Charing Stations Cost? Accessed at https://www.propertymanagerinsider.com/how-much-do-ev-charging-stations-cost/. Accessed June 10, 2021.

26 MIT Trancik Lab. Carbon Counter. Accessed at https://www.carboncounter.com/#!/explore?cars=35870;35756;36427. Accessed June 1, 2021.

Strategy T-2: Improve shared mobility programs and transit service

City Costs

City Cost Variables

- Staff time
- Bike share costs
- Ordinance development costs

City Cost Discussion

Many of the costs associated with implementation for this strategy involve partnership development to expand and improve City transit systems and outreach and education to promote innovative new programs. While building new transit infrastructure and running more buses and more routes can be expensive, this is largely outside the City's responsibility. The City will need staff time to work with LAVTA, ACE, and others to promote the expansion of transit within the City.

Developing a bike share program is estimated to cost as much as $4,000 per bicycle, which covers the cost of docking stations and kiosks.[27] However, many mobility as service options are available that could provide these options at no cost to the city such as scooters and electric mopeds. Staff time needs may be better managed with the onboarding of a full-time Climate Action Program Manager to manage the implementation of these projects, programs and ordinances, shared ride services ordinance, and more. Variable costs include staff time dedicated to TDM implementation, work with partners, and consultant and/or staff time required for surveys and ordinance development.

Community Costs

Community Cost Variables

- Transit Passes
- TDM Compliance

Community Cost Discussion

Variable costs to the community lie largely in new requirements resulting from future ordinances that consider a shift away from single-occupancy vehicles, such as parking reductions or minimums, bike parking requirements, parking pricing, and more. No specific community costs were identified as part of this strategy and is therefore considered no to low cost.

Strategy T-3: Improve and expand active transportation infrastructure

City Costs

City Cost Variables

- Planning and consultant costs
- Construction costs

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[27] Beitsch, Rebecca. 2016. PEW Trusts. Despite Popularity, Bike Share Programs Often Need Subsidies. Accessed at https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2016/03/24/despite-popularity-bike-share-programs-often-need-subsidies. Accessed June 10, 2021.

- Ongoing maintenance costs

City Cost Discussion

Costs associated with T-3 include staff time dedicated towards the implementation of the City's Active Transportation Plan, which may include the development of bike lanes, bike boulevards, separate and mixed-use paths, and separated bikeways, the latter of which could cost between a range of $1.5M-$3M per mile. On the other hand, designated bike lanes and bike boulevards may cost as low as $10,000 per mile.[28] The Active Transportation Plan identifies capital and maintenance cost per unit and per project. Additionally, the Active Transportation Plan identifies implementation strategies to construct bicycle and pedestrian improvements as part of private development and public capital improvements such as the resurfacing or streets.

In addition, costs may include staff time dedicated towards partnership development, outreach and education, workshops, and community events. Variable costs depend largely on the type of infrastructure the City believes is best suited to address the needs of its local community, while best enabling diversion from passenger vehicles within the greater context of lowering greenhouse gas (GHG) emissions.

Community Cost

Community Cost Variables

- Costs associated with funding mechanism, e.g., sales tax or parcel tax

Community Cost Discussion

Additional community costs may include potential funding mechanisms for this infrastructure, such as a parcel tax, sales tax, and more. However, substantial cost savings opportunities exist within diverting drivers from the road to improve health and quality of life. Furthermore, the institution of car-free days downtown can enable more active transportation, and more pedestrian friendly events, like farmers markets.

Strategy T-4: Support sustainable land use practices

City Costs

City Cost Variables

- Staff and consultant time required to develop and pass an ordinance
- Required outreach and education
- Staff time to update City planning and zoning documents
- Staff time to review and approve infill development applications

City Cost Discussion

The cost of this measure would require additional staff time by expanding opportunities for infill development within City planning and zoning documents. In addition, various CEQA exemptions and

[28] Melanie Curry. Streets Blog 2019. Breaking Down CalTrans' Cost Estimate of the Complete Streets Bill. Accessed at https://cal.streetsblog.org/2019/08/30/breaking-down-caltrans-cost-estimate-of-the-complete-streets-bill/#:~:text=On%2Dstreet%20bike%20lanes%2C%20buffered,use%20paths%3A%20%241M%2Fmile. Accessed June 1, 2021.

streamlining provisions have been provided for infill projects located near transit, including SB 375 and SB 743. These exemptions would reduce staff time required to conduct the necessary operations for this measure. Additional actions would be accomplished through rezoning and the general plan update which is currently underway.

Community Costs

Community Cost Variables

- Infill development costs compared to green field development

Community Cost Discussion

With the costs of this strategy being fully absorbed by the City, no direct costs incurred by the community were identified. However, indirect costs should be considered as infill development to support sustainable land use practices, compared to green field development, could increase development costs and overall building costs.

Waste and Materials

Strategy W-1: Reduce the amount of waste that is landfilled

City Costs

City Cost Variables

- Staff time
- Staff time to develop ordinance
- Staff time for outreach and education
- Development of High Diversion Plan

City Cost Discussion

Implementation and compliance with SB 1383 are required by state law. Municipal costs to implement this strategy are dependent on rate increases, current and future infrastructure requirements, and potential need for the onboarding of new staff to manage and implement programs, including coordination with partners like StopWaste and waste haulers. Variables within the cost of implementation include staff time required to update waste hauler contracts, estimate capacity planning for organic food waste and edible food recovery, conduct outreach and education, and more. In addition, the integration of waste management practices to enable better composting programs for the City may result in savings, while improving the health and resiliency of local soils.

To effectively reduce the amount of waste that is landfilled, it is critical to understand what feasible opportunities exist for waste diversion with more granular waste data. The development of a High Diversion Plan can help inform this strategy, which, including the cost of staff time set aside to draft the RFP and implement the Plan, is estimated to cost approximately $100,000.[29,30] Additional costs include

[29] City of Los Banos. 2020. RFP for Residential and Commercial Garbage, Recyclable Material and Organic Waste Collection Services. Accessed at https://sjc.granicus.com/MetaViewer.php?view_id=3&clip_id=1524&meta_id=87614. Accessed June 10, 2021.

[30] City of San Juan Capistrano. 2017. RFP for Sustainable Waste Diversion Projects. Accessed at http://www.losbanos.org/wp-content/uploads/2020/03/Los-Banos-Solid-Waste-RFP-Package-Final.pdf. Accessed June 10, 2021.

staff time dedicated to outreach and education, as well as $10,000[31] for the development of a compostable food ware ordinance, which would create an upstream, systemic change in how waste is processed in the City. Variables within these costs include staff or consultant time dedicated to developing a High Diversion Plan, staff time dedicated to plan implementation and education, and additional time allocated towards the passing of the food ware ordinance.

Community Costs

Community Cost Variables

- Cost to implement composting at home
- Cost to businesses to implement composting
- Increased cost of food items served in reusable/compostable food ware
- Cost to businesses to implement waste diversion techniques

Community Cost Discussion

To satisfy the requirement of SB 1383, CalRecycle estimates the cost to the community to be $17 per household per year after full implementation, and $662 annually for small businesses.[32] However, the costs for individuals will vary significantly, as the cost is dependent on the amount of waste that is currently disposed and the ability of the business to reduce the amount of organic disposal.

As for the community, costs incurred are relatively low while providing great benefit to the City's emissions reduction. Ordinances are known to be an effective means to influence consumer behavior. For example, after the passing of the 2013 Alameda County Reusable Bag Ordinance, which charged $0.10/bag, bag purchases by affected retail stores declined 85%.[33] For businesses, costs include the marginal cost of providing compostable food ware compared to the cost of food ware already in practice. In Alameda County, the *Rethink Disposable* program, in partnership with StopWaste, demonstrated that several businesses that voluntarily minimized single-use food ware saw net cost savings of $1,000-$22,000 per year.[34] Developers may see additional operating costs associated with the separation of waste for proper reuse and recycling for better rates of waste diversion and consumers may see variable cost increases to food items as a result of these food items being provided in new compostable food ware.

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[31] Estimated cost for staff/consultants to complete ordinance

[32] CalRecycle. 2016. Proposed Regulation for Short-Lived Climate Pollutants: Organic Waste Methane Emissions. Accessed at https://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/Final_Sria_11-16%20.pdf#search=%22SB%201383%20Economic%20Analysis%22. Accessed June 1, 2021.

[33] City of Berkeley Zero Waste Department. 2020. Passing a Single-Use Food ware and Litter Reduction Ordinance in Berkeley, CA. Accessed at https://zwconference.org/wp-content/uploads/presentations/nrc-nzwc_detournay_c.pdf. Accessed June 1, 2021.

[34] City of Berkeley. 2018. Single Use Disposable Food ware and Litter Reduction Ordinance. Accessed at https://ecologycenter.org/wp-content/uploads/2018/11/Disposable-Free-Dining-Ordinance.pdf. Accessed June 10, 2021.

Strategy W-2: Expand use of low-carbon and recycled building materials

City Costs

City Cost Variables

- Staff time for outreach and education
- Staff time for development of carbon performance standards and material-efficient building practices

City Cost Discussion

Costs to expand the use of low-carbon and recycled building materials may include staff time to raise awareness for low-carbon and recycled building materials, and staff time required to develop standards for new construction that limit embodied carbon emissions. Working with local, regional, and state partners to raise awareness around the availability and cost-effectiveness of low-carbon and recycled building materials will ensure that best practices and the most up-to-date information is incorporated in communitywide efforts to reduce embodied carbon emissions in construction.

Community Costs

Community Cost Variables

- Potential for increased cost of building material

Community Cost Discussion

With the expansion of low-carbon and recycled building material, there is potential for increased building costs due to higher material costs. More and more studies are finding, however, that embodied carbon reductions in new construction result in little to no cost premiums. Optimizing concrete mix, using high recycled content rebar, and selecting low- or no-embodied-carbon insulation products are shown to reduce embodied carbon significantly at little to no cost premiums. [35] In instances where embodied carbon performance standards and material-efficient building practices implemented by the City do increase costs, exemptions for cost barriers will be included as needed to prevent these changes from directly increasing housing or rent costs.

[35] https://rmi.org/insight/reducing-embodied-carbon-in-buildings.

Carbon Sequestration

Strategy S-1: Maximize local carbon sequestration

City Costs

City Cost Variables

- Staff time
- New trees
- Operating and maintenance cost of trees
- Carbon farming study and pilot project
- Green scaping ordinance

City Cost Discussion

Costs to maximize local carbon sequestration may include staff and/or consultant time dedicated towards the development and implementation of an Urban Forest Revitalization Program, the preservation of open spaces, the development of a carbon farming study and pilot project, and the adoption of a green scaping ordinance. Unbeknownst to many, trees are one of the few assets of a city than increase in value over time. Investment in a healthy urban forest can provide greater returns on investment for the City and its citizens. Over the lifetime of the project, costs to fully implement an urban canopy program for a large city like San Francisco costs as much as $2.4M towards the purchase of vegetation and $3.2M towards operating and maintenance.[36] However, smaller programs are likely to be significantly less. In addition to the benefits of carbon sequestration, an urban canopy would provide co-benefits in cooling urban areas and providing healthier, more equitable, and higher quality air.

Community Costs

Community Cost Variables

- Cost of trees
- Cost of water/maintenance of trees

Community Cost Description

Community costs associated with local carbon sequestration focus on new construction, which may expect increased development costs associated with including more urban trees, shading, and permeable surfaces in proposed projects for the benefit of the overall community. Community members may also choose to plant their own trees. The cost of a new tree varies by species and size but could be anywhere from $25 to $200. Watering and other maintenance is likely to be minimal (a few dollars a summer) while trimming costs may increase in the future once the tree is larger. Co-benefits of carbon sequestration projects to the community include more open spaces, savings on electricity bills if trees help shade your home, more greenery in the surrounding environment, and enhanced climate resiliency against natural disasters, like flooding, urban wildfires, and drought, improving the overall health and well-being of the community.

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[36] AECOM. 2012. Financing San Francisco's Urban Forest. Accessed at https://healthyplacesindex.org/wp-content/uploads/2018/02/san_francisco_cost_benefits_comprehensive_municipal_street_tree_program.pdf. Accessed June 10, 2021.

Municipal Strategies

Because municipal strategies are intended to reduce emissions that are a subset of larger community emissions, the municipal strategies provided have been grouped into their own category below in this appendix, rather than integrating municipal strategies with community strategies grouped into low, moderate, or high-cost categories. Each strategy is still assigned a cost category, but this accommodation for municipal strategies is intended to centralize all information required to reduce emissions internally and make it easily accessible to the City.

Strategy M-1: Enhance resilience at public facilities

City Costs

City Cost Variables

- Cost of microgrid/battery storage
- Cost of energy efficiency and AQ upgrades selected
- Energy Cost Savings

City Cost Discussion

Municipal costs incurred to enhance energy resiliency at public facilities would include the infrastructure costs associated with new energy generation technologies like solar PV or fuel cells as well as the cost of batteries to store energy. As described in Strategy H-1 and E-4, microgrid costs are significant. The best strategy of the cost of microgrids is the cost per unit capacity ($/MW). In California, the average cost per MW of storage added is $3.5M.[37]However, these costs can be financed or even completed through public private partnerships. Furthermore, a single microgrid would help meet the goals of several strategies including H-1 and E-4.

Strategy M-2: Electrify municipal facilities and operations

City Costs

City Cost Variables

- Staff time
- Types of units electrified
- Number of facilities

City Cost Discussion

Municipal costs incurred to electrify facilities and operations, while increasing energy efficiency and renewable energy, include staff time dedicated towards the installment of a new policy banning natural gas infrastructure, regular energy audits of existing facilities, costs of LED bulbs for streetlight retrofit projects and more. Costs are highly variable depending on the types of units electrified, the number of facilities, and marginal costs between existing infrastructure and appliances selected. However, there exist several opportunities to engage in energy service contracts, which significantly decrease upfront

[37] Asmus, Peter, Adarm Forni, and Laura Vogel. Navigant Consulting, Inc. 2017. Microgrid Analysis and Case Study Report. California Energy Commission. Accessed at https://ww2.energy.ca.gov/2018publications/CEC-500-2018-022/CEC-500-2018-022.pdf. Accessed June 1, 2021.

costs. Overall, the return on investment from this strategy will result in significant long-term savings over the lifecycle of the project as result of lower operating and maintenance costs, while exemplifying leadership in the community. One example are heat pumps, the dominant technology for electric heating and cooling, which are significantly more efficient than their natural gas counterparts, leading to bill savings that typically outweigh any higher upfront costs.[38] The expansion of renewable energy will require additional staff time dedicated towards engagement with PGE and staff and/or consultant time dedicated towards battery storage project development.

Strategy M-3: Electrify the City's vehicle fleet, and encourage City employees to utilize alternative transportation and teleworking opportunities

City Costs

City Cost Variables

- Staff time
- Number and type of vehicles electrified
- EV charging infrastructure
- Alternative transportation incentives

City Cost Discussion

Costs to electrify the City's vehicle fleet include the addition of new EV chargers on municipal grounds and staff time dedicated towards the development of a policy that requires electrification of the City fleet. In addition, costs may include the establishment of bike lockers for public use across the City, such as at City Hall and off-street parking lots for resident use. Cost variability is dependent on the number and type of electrified vehicles selected for deployment, new EV charging infrastructure, and additional savings incurred through the utilization of alternative transportation. The long-term trend of EVs points towards lower upfront costs and higher returns on investment through significantly decreased operating and maintenance costs.[39] As in M-1, there exist several opportunities for low energy service contracts, which would further decrease upfront costs of the project.

Strategy M-4: Conserve water in municipal landscaping and improve on-site stormwater management

City Costs

City Cost Variables

- Staff time
- Low flow water fixtures
- Low water use landscaping

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[38] Energy, Environment, Economics (E3). 2019. Residential Building Electrification in California. Accessed at https://www.ethree.com/e3-quantifies-the-consumer-and-emissions-impacts-of-electrifying-california-homes/. Accessed June 1, 2021.

[39] Heisel, Rebecca. 2020. Consumer Reports Study Finds Electric Vehicle Maintenance Costs are 50% Less than Gas-Powered Cars. Accessed at https://www.betterenergy.org/blog/consumer-reports-study-finds-electric-vehicle-maintenance-costs-are-50-less-than-gas-powered-cars/. Accessed June 10, 2021.

City Cost Discussion

Municipal costs associated with this strategy are embedded in new staff time allocated towards costs associated with reviewing existing water use and identifying low water use alternatives for fixtures and municipal landscaping. Other costs include fixture costs and landscaping costs associated with the chosen upgrades. However, water savings and increased resiliency benefits should also be included in the decision-making process.

Strategy M-5: Purchase more sustainable products to reduce waste from City operations

City Costs

City Cost Variables

- Staff time
- Update Environmentally Preferable Purchasing Policy
- Marginal cost of new products

City Cost Discussion

Municipal costs associated with the reduction of landfilled waste include staff time, such as the work of the City's Green Team, to employ an Environmentally Preferable Purchasing Policy to integrate upstream strategies to reduce waste by the City. By selecting work with vendors who use more environmentally friendly materials, the City maintains a considerable opportunity to lower its operating costs and environmental footprint, decreasing demand for downstream strategies such as waste organization, diversion, and recycling.[40] Variable costs depend on program implementation, education and outreach, and the marginal cost of using more environmentally sustainable materials versus a business-as-usual approach. This strategy expects long-term savings associated with reduced operating costs and more durable and reusable materials.

Strategy M-6: Utilize public lands and open spaces to increase local carbon sequestration and reduce urban heat island effect.

City Costs

City Cost Variables

- Staff time
- Open space/landscaping maintenance costs

City Cost Discussion

Costs to better utilize public lands and open spaces include staff time dedicated towards the development of a map or database identifying public spaces that can be converted to green spaces, including parking spaces and freeways, and walls and rooftops for gardens. The US EPA notes the use of trees, vegetation, and open spaces can considerably lower urban heat island effects, deflecting radiation

[40] Little, Shelley. 2021. 10 Reasons You Should Use Sustainable Building Materials. Accessed at https://www.mymove.com/home-renovation/guides/reasons-you-should-use-sustainable-building-materials/. Accessed June 10, 2021.

from the sun, and releasing moisture into the atmosphere.[41] Where applicable, the City may also consider evaluating landscaping plans to improve the utilization of native species. The USDA encourages use of native species to strengthen wildlife populations, boost conservation benefits, and improve the value of ecosystem services.[42] Variable costs include the number and type of flora selected, planting time, and ongoing operating and maintenance costs of the green spaces.

Implementation Strategies

Important to meeting the objectives of Livermore's CAP is how the strategies and actions will be implemented in the community and how success or hurdles are monitored and discussed over time. Dedicating City resources to climate efforts, tracking implementation progress, considering climate change in all City plans and processes, and communicating important initiatives to residents and business will be key to the successful implementation of the CAP. This section includes strategies for ensuring successful implementation of all the strategies and actions listed in the CAP.

Strategy I-1: Make climate impacts and resilience a standard consideration during planning and development processes

City Costs

City Cost Variables

- Staff time

City Cost Discussion

Municipal costs associated with this strategy are embedded in new staff time allocated towards climate planning considerations for future construction projects as well as the integration of climate considerations into City plans. The opportunity for integration of adaptation planning with other City plans includes the Local Hazard Mitigation Plan, General Plan, Active Transportation Plan, Green Infrastructure Plan, Emergency Response Plan, and zoning land use codes are additional variables to project costs. Additional costs may include outreach and education to the community on local and regional climate impacts.

Community Costs

Community Cost Variables

- N/A

[41] United States Environmental Protection Agency. Reduce Urban Heat Island Effect. Accessed at https://www.epa.gov/green-infrastructure/reduce-urban-heat-island-effect#:~:text=Trees%2C%20green%20roofs%2C%20and%20vegetation,releasing%20moisture%20into%20the%20atmosphere.. Accessed June 10, 2021.

[42] Taylo, Ciji. United States Department of Agriculture. Accessed at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=STELPRDB1166100. Accessed June 10, 2021.

Community Cost Discussion

There are little to no community costs associated with this strategy. Costs may include additional operating expenditures associated with including climate consideration into future construction projects, but the community will largely receive a net benefit in value as a result of being part of a more resilient, socially equitable community.

Strategy I-2: Dedicate City resources to CAP implementation and consistently monitor progress

City Costs

City Cost Variables

- Staff time

City Cost Discussion

The internal cost of implementing this strategy would be optimally accounted for by creating a Climate Action Program Manager position for an estimated annual cost of approximately $150,000. This could be achieved by creating a new position or redesignating an existing staff position. Costs include staff time dedicated to regular progress reports on CAP strategy updates and work with stakeholders to implement the Climate Action Plan actions. Variability within this internal cost depends on staff time allocated to the project, and the cost of onboarding new staff.

Community Costs

Community Cost Variables

- N/A

Community Cost Discussion

Given that the focus of this strategy is to provide transparency on CAP progress to the community, there are relatively few community costs. In fact, the City would benefit from employing a more open and transparent approach to the reporting of their CAP data, enabling better engagement with the community.

Strategy I-3: Create a public outreach campaign to educate the community about CAP initiatives

City Costs

City Cost Variables

- Staff time
- Outreach Platform

City Cost Discussion

Internal costs implementing I-3 are strongly dependent on the outreach platform selected, which range from $100-$10,000 annually depending on the City's needs for basic outreach software or complete software with insights provided.[43] The City should seek to dedicate staff time towards developing a suite

[43] Capterra. 2020. Marketing Automation Software Pricing Guide and Comparison. Accessed at https://www.capterra.com/marketing-automation-software/pricing-guide/. Accessed June 10, 2021.

Climate Action Finance Map

Pathways to Capital for Projects in Livermore's 2021 Climate Action Plan

September 2021

Livermore Climate Action Measures	Capital Types	Top Funding and Finance Pathways	Programs and Partners	Case Examples
BUILDINGS **Measure B-2** Affordable Electrification and Efficiency Retrofits Explore Electrifying existing buildings to reduce natural gas consumption 10% by 2030 and 61% by 2045	GRANT	State Grant via CA Energy Commission	Building Initiative for Low-Emissions Development (BUILD)	N/A: New Program
	GRANT	State Grant via CA Strategic Growth Council	Affordable Housing + Sustainable Communities (AHSC)	2019 Awardees
	GRANT	Federal and State Grants	LIHEAP or Spectrum Community Services	CA WAP
	PARTNER	Utility-Led Incentives	PG&E Rebate Program	CA CPUC
	LOAN	On-Bill Financing (Tariff)	PG&E, East Bay Community Energy	Kansas City, MO - P&L
	LOAN	PACE or C-PACE Financing	PACENation	Greenville, MI - Cambridge Court Apts
	LOAN	Green Bank or Revolving Loan Fund	Coalition For Green Capital	CT Green Bank
	LOAN	Federal or State Loan Program	GoGreen Financing	CAEATFA - REEL
	LOAN	HomeStyle Energy Mortgage	Fannie Mae	Portland, OR
	LOAN	Federal Loan Guarantee	DOE Loan Program	Project Portfolio
BUILDINGS **Measure B-2-3** Tariff On-Bill Financing, Green Bank, and/or Revolving Loan Fund (RLV) Partner with stakeholders to develop funding pathways for electrification upgrades	GRANT	Government and Foundation Grants	Building Decarb Coalition	Baltimore, MD
	PARTNER	Local Economic Development Corporation Partnership	Office of Innovation and Economic Development	NYC RLF (eg. of PPP, but for development)
	LOAN	Program Related Investment or Endowments	Coalition for Green Capital	CT Green Bank + MacArthur
	LOAN	Private Investment or Bank Loan	Coalition for Green Capital	Colorado Clean Energy Fund
	BOND	Green or Revenue Bonds	California iBank	CT Green Bank - Green Liberty Bond
	FEE	Ratepayer Surcharge	PG&E, East Bay Community Energy	CT Green Bank
BUILDINGS **Measure B-4** Residential and/or Commercial Solar and Battery Increase generation and storage of local renewable energy	PARTNER	State-Led Utility Incentive Program	Solar on Multifamily Affordable Housing - SOMAH	Eligible Properties
	PARTNER	Community-Owned Solar Partnership	Solar in Your Community Challenge	Yale University
	PARTNER	Utility Rebates and Incentives	California PUC via PG&E	PG&E Solar Incentives
	LOAN	On-Bill Financing (Tariff)	PG&E, East Bay Community Energy	Fort Collins Utilities
	LOAN	PACE or C-PACE Financing	CaliforniaFIRST	Saratoga, CA
	LOAN	Green Bank or Revolving Loan Fund	Coalition For Green Capital	PosiGen - Solar Lease
	LOAN	CA State Loan Program	GoGreen Financing	CAEATFA - REEL
	LOAN	HomeStyle Energy Mortgage	Fannie Mae	Portland, OR
	LOAN	Federal Loan Guarantee	DOE Loans Program	DOE Project Portfolio
	FEE	Ratepayer Surcharge or Utility Fee	PG&E, East Bay Community Energy	CT Green Bank

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Climate Action Finance Map

Pathways to Capital for Projects in Livermore's 2021 Climate Action Plan

September 2021

Livermore Climate Action Measures	Capital Types	Top Funding and Finance Pathways	Programs and Partners	Case Examples
BUILDINGS **Measure B-4-1** Community Solar and Storage Coordinate with stakeholders to provide local energy generation and storage support and incentives. This could include a co-located community solar and storage facility.	**GRANT**	Federal Grant via FEMA Hazard Mitigation Assistance	Building Resilient Infrastructure and Communities (BRIC)	St. Croix, U.S.
	GRANT	State Grants via CA Public Utilities Commission or CA Energy Commission	CPUC - SGIP, EPIC Grant	Fremont, CA
	PARTNER	Community Choice Aggregation	East Bay Community Energy	Silicon Valley Clean Energy (SVCE)
	PARTNER	Utility Rebates and Incentives	PG&E Community Microgrid Enablement Program	Redwood Coast, CA
	PARTNER	Power Purchasing Agreement	ENGIE, Ameresco	Enovity EE in CA
	PARTNER	Collaborative Community Ownership	Clean Energy Co.	Boardman Hill, VT
	PARTNER	Collaborative Purchasing	R-REP Bay Area	SV-REP
	LOAN	Tax-Exempt Lease Purchase Agreement	GS $mart	DGS Building Retrofits
	LOAN	On-Bill Financing	PG&E, East Bay Community Energy	EESI Case Studies Grand Valley, CO
	LOAN	Green Bank or Revolving Loan Fund	Coalition For Green Capital	San Antonio, TX
	LOAN	Federal or State Loan Program	NREL	Orange County Library
	LOAN	Private Investment Firm Loan	Generate Capital	NYC Hudson, Hillsborough, FL
	BOND	General Obligation Bond (Green)	California iBank	Lakeport, CA
	FEE	Ratepayer Surcharge or Utility Fee	PG&E, East Bay Community Energy	Hawaii Microgrid Tariff
	TAX	Enhanced Infrastructure Financing District	Office of Innovation and Economic Development	New Orleans, LA

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Climate Action Finance Map

Pathways to Capital for Projects in Livermore's 2021 Climate Action Plan

September 2021

Livermore Climate Action Measures	Capital Type	Top Funding and Finance Pathways	Programs and Partners	Case Examples
TRANSPORTATION **Measure T-1** Bike and Pedestrian Improvements Improve active transportation infrastructure to achieve greater than 7% mode shift away from passenger vehicles by 2030 and maintain that through 2045 Active Transportation Funding Resource: https://catc.ca.gov/-/media/ctc-media/documents/programs/atp/2020/funding-programs-that-fund-active-transportation-a11y.pdf	**GRANT**	State Grant via Caltrans	Active Transportation Program	Santa Barbara, CA
	GRANT	State Grant via CA Strategic Growth Council	Transformative Climate Communities (TCC)	Ontario, CA
	GRANT	State Grant via CA Natural Resources Agency	Urban Greening Program	2020 Awardees
	GRANT	Foundation Grants	People for Bikes, Outride	Santa Cruz, CA
	PARTNER	PPP or Sponsorship (ex: Adopt-a-Roadway)	Livermore Chamber of Commerce	Google and Mountain View, CA
	LOAN	State Government Loan Program	ISRF Loan Program	Santa Cruz, CA
	LOAN	Federal Government Loan Program	TIFIA Loan	State of Maryland
	BOND	General Obligation Bond	CA Transportation Finance Authority	San Diego County, CA
	FEE	Transportation Fee	Dept. of Transportation	Chicago, IL
	FEE	Developer Impact Fee	Dept. of Transportation	Santa Monica, CA
	TAX	Enhanced Infrastructure Financing District	Office of Innovation and Economic Development	Santa Rosa, CA
TRANSPORTATION **Measure T-2** Privately-Owned EV Charging Infrastructure Improve electric vehicle infrastructure to achieve passenger vehicle shift to zero emission vehicles greater than 25% by 2030 and 50% by 2045, and commercial vehicle shift greater than 10% by 2030 and 50% by 2045	**GRANT**	Government Grants *see this federal incentives list*	CEC CTP, Federal Transit Administration	Santa Clara, CA
	PARTNER	Public Private Partnership	Blink, ChargePoint	Laguna Beach, CA
	PARTNER	State Infrastructure Incentive Program	CALeVIP	Current Projects
	PARTNER	Utility Incentives or Rebates	PG&E	EV Charge Network
	LOAN	State Loan (with Loan Loss Reserve)	CalCAP (current lender list)	Los Angeles + Noodoe
TRANSPORTATION **Measure T-3** Public Transportation Infrastructure Improve shared mobility programs and transit infrastructure to reduce passenger VMT 2% by 2030, and 4% by 2045	**GRANT**	Federal or State Grants	CalTrans Transit + Intercity Rail Capital Program (TIRCP)	SamTrans + more
	PARTNER	PPP or Sponsorship	Livermore Chamber Of Commerce	San Diego, CA Metro Transit System
	PARTNER	PPP with Transportation Operator	Livermore Amador Valley Transit Authority	Los Angeles Transportation Electrification Partnership
	LOAN	Federal or State Loan Programs	TIFIA Loan	San Luis Obispo, CA
	BOND	Green Bond or Revenue Bond	CAEATFA, CA Transportation Finance Authority	Ventura County, CA
	FEE	Transportation Fee	Livermore Amador Valley Transit Authority	Chicago, IL
	TAX	Enhanced Infrastructure Financing District	Office of Innovation and Economic Development	Los Angeles County

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Climate Action Finance Map

Pathways to Capital for Projects in Livermore's 2021 Climate Action Plan

September 2021

Livermore Climate Action Measures	Capital Types	Top Funding and Finance Pathways	Programs and Partners	Case Examples
FLOODING **Measure F-2** Stormwater Management Improve stormwater management to reduce flood risk	GRANT	Federal Grant via National Fish and Wildlife Foundation (NFWF)	Five Star and Urban Waters Restoration	2020 Awardees
	LOAN	Federal Loan via Environmental Protection Agency (EPA)	Clean Water State Revolving Fund	Brookhaven, GA
	BOND	Environmental Impact Bond (defined here)	Quantified Ventures	Washington DC Water
	FEE	Developer Impact Fee or Stormwater Utility Fee	California Stormwater Quality Association	Los Altos, CA
	TAX	Enhanced Infrastructure Financing District	Office of Innovation and Economic Development	Chicago, IL
SEQUESTRATION + RESTORATION **Measure S-1** Urban Forestry Maximize local carbon sequestration by increasing urban canopy cover by at least 10% by 2030, preserving existing open spaces, and developing carbon farming projects	GRANT	Federal Grant via National Park Service	River, Trails, and Conservation Assistance Program	Los Angeles, CA
	GRANT	Federal Grant via National Fish and Wildlife Foundation (NFWF)	Resilient Communities Program	2020 Awardees
	GRANT	State Grant via California Natural Resources Agency	Urban Greening Program	2020 Awardees
	GRANT	State Grant via CAL FIRE	Urban and Community Forestry Program	2020 Awardees
	GRANT	State Grant via California Strategic Growth Council	Transformative Climate Communities (TCC)	San Fernando, CA
	PARTNER	Federal Partnership with Department of Agriculture Forest Service (USDA)	Urban and Community Forestry Program	2020 Awardees
	LOAN	Federal Loan via Environmental Protection Agency (EPA)	Clean Water State Revolving Fund	Yurok Tribe, CA
	BOND	Environmental Impact Bond (defined here)	Quantified Ventures	SW Colorado
	FEE	Developer Impact Fee or Stormwater Utility Fee	TreePAC	Portland, OR
	TAX	Enhanced Infrastructure Financing District	Office of Innovation and Economic Development	West Carson, LA (consideration)

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Climate Action Finance Map

Pathways to Capital for Projects in Livermore's 2021 Climate Action Plan

September 2021

Livermore Climate Action Measures	Capital Types	Top Funding and Finance Pathways	Programs and Partners	Case Examples
MUNICIPAL **Measure M-1** Municipal Energy Efficiency Electrify municipal facilities and operations, while increasing energy efficiency and renewable energy	GRANT	State and Foundation Grants	EPIC Grant, CPUC-SGIP	Fremont, CA
	PARTNER	Utility Energy Services Contract (UESC)	PG&E Sustainable Solutions Turnkey Program	Cal Poly University
	PARTNER	Energy Savings Performance Contracts	ENGIE, Ameresco	Enovity EE
	PARTNER	Collaborative Purchasing	Sourcewell	MAPC
	LOAN	Tax-Exempt Lease Purchase Agreement	GS $mart	DGS Building Retrofits
	LOAN	On-Bill Financing	PG&E, East Bay Community Energy	Mass Saves
	LOAN	Green Bank or Revolving Loan Fund	Coalition For Green Capital	San Antonio, TX
	LOAN	Government Loan Program	CA CLEEN	Huntington Beach, CA
	LOAN	Investment Firm	Generate Capital	Hillsborough, FL
	BOND	General Obligation Bond (Green)	California iBank	Lakeport, CA
MUNICIPAL **Measure M-2** City-Owned EV Charging Infrastructure Electrify the City's vehicle fleet, and encourage City employees to utilize alternative transportation and teleworking opportunities	PARTNER	Utility Incentive	PG&E EV Fleet Program	Pittsburg Unified School District, CA
	PARTNER	Public Private Partnership	Charge Point	Alameda, CA
	PARTNER	Collaborative Purchasing	Sourcewell	Chula Vista, CA, and Encinitas, CA
	PARTNER	State Infrastructure Incentives Program	CaleVIP - Inland Counties	Current Project List
	LOAN	State Loan Program	CA CLEEN Loans	Fresno, CA Airport
	BOND	General Obligation or Conduit Bond (Green)	California iBank	Westchester, NY

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Appendix D - Measure Quantification and Substantial Evidence

Livermore Climate Action Plan Update

prepared for

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prepared with the assistance of

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1 Introduction

This document presents the technical quantification and evidence supporting the greenhouse gas (GHG) emission reduction potential of the City of Livermore's Climate Action Plan (CAP) Update. Section 15183.5(b)(1) of the California Environmental Quality Act (CEQA) guidelines establishes several criteria which must be met in order to allow for CEQA streamlining and to be considered a "qualified GHG reduction plan". This document provides the information substantiating the GHG reductions identified for the CAP strategies pursuant to Subsection (D) which states, "strategies or a group of strategies, including performance standards, that substantial evidence demonstrates, if implemented on a project-by-project basis, would collectively achieve the specified emissions level."

As part of the CAP Update process, the City of Livermore – in coordination with Rincon Consultants, Inc. (Rincon), the Livermore Climate Action Plan Advisory Committee and the community of Livermore – has developed a comprehensive strategy for reducing community-wide GHG emissions over time. The strategies, actions, and steps in this appendix are consistent with the Climate Action Plan. In addition, steps are also identified in this document. These implementation steps will directly drive GHG emission reductions and direct day to day implementation of the CAP.

The Climate Action Plan's claimed GHG emission reductions are organized around three levels which include:

1. **Sectors.** Sectors define the category in which the GHG reductions will take place and include Energy, Transportation, Waste, Carbon Sequestration, Municipal, Implementation and Outreach, and Carbon Restoration.
2. **Strategies.** Strategies define core strategies within each sector that will result in substantial reductions in GHG emissions
3. **Actions.** Each strategy is driven by sets of actions that together support the GHG emissions reduction necessary to achieve the City's targets
4. **Steps.** This document also identifies steps which are specific policies, ordinances, and other approaches that will directly drive GHG emission reductions.

Strategies and steps can be either quantitative or supportive and are defined as follows:

- **Quantitative.** These strategies and steps are supported by case studies, scientific articles, calculations, or other third-party substantial evidence that demonstrate that the implementation of said strategy/action will achieve the identified measurable GHG reduction. Quantitative strategies/steps can be summed to quantify how the City of Livermore will meets its 2030 target and show substantial progress towards the 2045 emission target. These targets exceed the state goal set by Senate Bill 32 (SB32) of 40% below 1990 by 2030, and carbon neutrality by 2045 as set by Executive Order B-55-18.[1] The GHG reductions were calculated using published evidence provided through adequately controlled investigations, studies, and articles carried out by qualified experts that establish the effectiveness of the reduction

[1] The Association of Environmental Professionals recommends limiting CEQA GHG Analysis to the State GHG Planning Horizon based on a State Legislatively Mandated Target (i.e., SB 32). Therefore, at this time, it is recommended that cities demonstrate quantitatively how they plan to achieve GHG reductions that align with SB 32, but are not required to do the same for the 2045 carbon neutrality goal established by EO-B-55-18, as this goal has not yet been adopted by the State Legislature. Rather, it is recommended that cities demonstrate "substantial progress" towards the 2045 carbon neutrality goal. See *Final White Paper Beyond 2020 and Newhall: A Field Guide to New CEQA Greenhouse Gas Thresholds and Climate Action Plan Targets for California* (Association of Environmental Professionals, 2016).

strategies and steps. Further, the strategies and steps were developed to achieve the 2030 target established by the City of Livermore and make substantial progress towards the 2045 target. The estimates and underlying calculations, provided in this report, include substantial evidence and a transparent approach to achieving the City's shot term GHG emissions reduction target and substantial progress towards achieving the long-term target.

- **Supportive.** These strategies and steps may also be quantifiable and have substantial evidence to support their overall contribution to GHG reduction. However, due to one of several factors – including a low/no direct GHG reduction benefit, indirect GHG reduction benefit, potential for double-counting, or simply a high level of difficulty in quantifying accurate GHG reductions – they have not been quantified and do not contribute directly to the expected GHG reduction target and consistency with the state goals. Despite not being quantified, supportive strategies/steps are nevertheless critical to the implementation of other strategies and action and generally the overall success of the CAP.

Together, the quantitative and supportive strategies and steps listed herein provide Livermore with the GHG emissions reduction necessary to achieve the identified target of reducing per capita emissions by 40% below 1990 levels by 2030 to an estimated 3.17 MT CO_2e per person. Based on current population projections this per capita target translates to a 67% reduction below 1990 GHG emission reduction levels by 2030, exceeding the requirements of SB32.[2] Per capita emission targets were identified by the California Air Resources Board (CARB) and explained in the 2017 Scoping Plan Update provided .[3] The City has also established a target consistent with Executive Order (EO) B-55-18 to achieve carbon neutrality by 2045.[4] The strategies identified in this CAP will lead to a substantial progress in GHG emissions by 2045, providing a foundation for achieving net carbon neutrality. However, the strategies reasonably available to the city and included in this CAP do not provide enough GHG emissions reduction to meet the long term 2045 GHG emissions goal. Achieving carbon neutrality will require significant changes to the technology and systems currently in place. This CAP aims to establish new systems that are resilient and equitable in the face of change that will allow for a transition to carbon neutrality in the future. This includes carbon neutral electricity (which will also lower water and wastewater emissions from local electricity use), electrification of building and transportation systems and increased shift to shared and active mobility, waste reduction and diversion, and carbon sequestration. As the current strategies and steps are implemented, the City will gain more information, new technologies will emerge, and identified pilot projects and programs will scale to the size needed to reach carbon neutrality. Furthermore, the State is expected to continue providing updated regulations and support once the 2030 target is achieved. Future CAP updates will make necessary adjustments and outline new strategies needed to reach Livermore's long-term target of carbon neutrality.[5]

The quantification in this report is intended to illustrate one of several viable paths to pursue as the strategies and steps of the CAP are implemented at full scale. As required in CEQA Guidelines Section 15183.5(b)(e), mechanisms to monitor the CAP's progress toward achieving the GHG emission reductions provided in this report have been established through the CAP development

[2] The percent reduction target is calculated as a reduction in projected absolute emissions from 1990 levels. However, total projected emissions, emission targets, and emission reductions in 2030 and 2045 are dependent on population levels and the targets established in this CAP are efficiency targets. Therefore, while absolute emissions in 2030 and 2045 may differ due to differences between the projected population and actual population, per capita emission targets and per capita emissions reductions will remain stable.

[3] https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf

[4] The goal of carbon neutrality is also consistent with the Paris Agreement and the International Panel on Climate Change's target of carbon neutrality by mid-century.

[5] Association of Environmental Professionals, 2016.

process. If, based on the tracking of community GHG emissions, the City is found to not be on target to reach the GHG reduction levels specified here for meeting SB 32 targets, the CAP as a whole or specific strategies and steps will be required to be amended and a CAP update will be prepared that includes altered or additional strategies and steps and evidence that upon implementation can achieve the City's targets.

Avoiding interference with and making substantial progress toward the state's 2030 and long-term goals is important as these have been set at levels that achieve California's fair share of international emissions reduction targets established by the Paris Agreement and the International Panel on Climate Change that will stabilize global climate change effects and avoid the adverse environmental consequences described under EO B-55-18 Section 3.1.3, Potential Effects of Climate Change.

The strategies and steps laid out in the CAP were driven by a development framework that considered the costs and benefits of each action (Appendix C). In addition, a set of guiding principles were developed that reflected the City's and the community's values. Each strategy and action was developed by carefully considering these guiding principles. The guiding principles are highlighted below in Table 1.

Table 1 Guiding Principles

Principles	Description
Mitigation and/or adaptation benefit	Strategies should achieve measurable reductions in GHG and/or improvements in resilience.
Structural change	Strategies should establish institutional and policy framework to facilitate long-term change.
Education	Strategies should include community engagement and empower residents and stakeholders to take action.
Equity	Strategies should promote inclusive participation in decision making and equitable access to benefits.
Partnerships	Strategies should utilize partnerships with outside agencies and community organizations to leverage expertise and resources and maximize the City's capacity.
Economics	Strategies should strive to be cost-effective for the City and the community.

2 CEQA Qualified CAP

Livermore's CAP aligns with the requirements set forth in CEQA Guidelines Section 15183.5(b) for development of a qualified GHG reduction plan. This includes setting GHG emissions reduction targets which align with those set by the State of California (described above). As a qualified GHG Reduction Plan, development projects that are consistent with the strategies in the CAP can streamline their GHG analysis under CEQA by presuming that the project's GHG emissions are not significant. The requirements set forth in CEQA Guidelines Section 15183.5(b) are as outlined below:

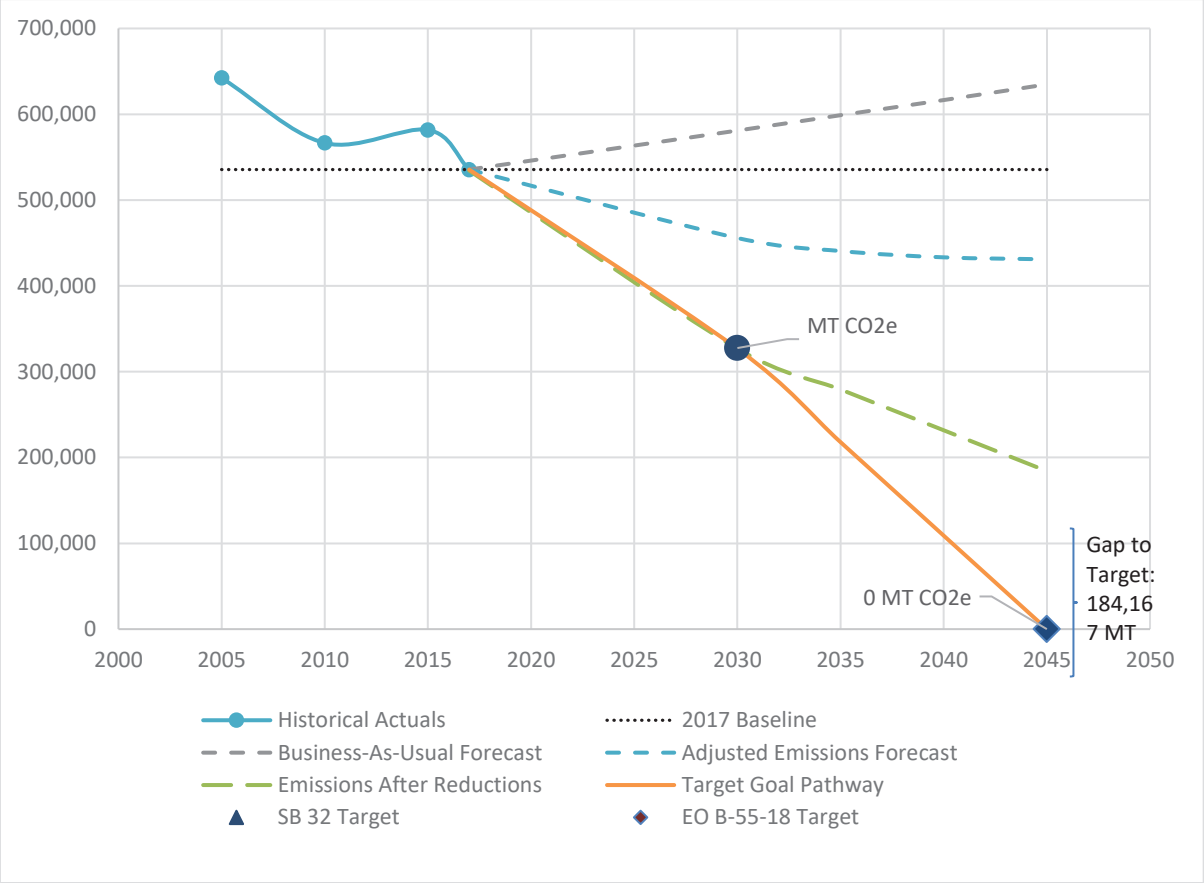
- Quantify GHG emissions, both existing and projected over a specified time period, resulting from activities within a defined geographic area; (Chapter 2)
- Establish a level, based on substantial evidence, below which the contribution to GHG emissions from activities covered by the plan would not be cumulatively considerable; (Chapter 2)
- Identify and analyze the GHG emissions resulting from specific actions or categories of actions anticipated within the geographic area; (Chapter 2)
- Specify measures or a group of measures, including performance standards, that substantial evidence demonstrates, if implemented on a project-by-project basis, would collectively achieve the specified emissions level; (Chapter 3)
- Establish a mechanism to monitor the plan's progress toward achieving the level and to require amendment if the plan is not achieving specified levels; (Chapter 4)
- Be adopted in a public process following environmental review. (Associated CEQA Analysis)
- A qualified CAP allows Livermore to streamline new development that meets our climate goals, decreasing costs, and incentivizing climate smart development.

3 Emission Reduction Summary

The strategies, actions, and steps established by Livermore's CAP Update are expected to reduce per capita emissions below 1990 levels by 68% in 2030 and 85% by 2045. The reductions expected in 2030 exceed the requirements of SB32, but reductions expected in 2045 fall short of the carbon neutrality goal established by EO B-55-18 (

Figure 1). However, as described above, this Climate Action Plan puts Livermore on the pathway to achieve carbon neutrality by 2045.

Figure 1 Estimated GHG Emissions Reduction



A breakdown of the GHG emissions reduction calculated for each strategy is included in Table 2. A complete description of each strategy and its contributing actions and steps is included in the sections that follow.

Table 2 Estimated Emission Reduction Potential of CAP Strategies

Strategy Number	Strategy	2030 Emissions Reduction (MT CO_2e)	2045 Emissions Reduction (MT CO_2e)
Buildings and Energy			
B-1	Require new buildings to be all-electric and incentivize electrification retrofits of existing buildings	27,383	121,493
B-2	Decarbonize electricity from the grid and increase local renewable energy generation	25,505	0
Transportation and Land Use			
T-1	Facilitate a transition to electric vehicles	49,494	93,458
T-2	Facilitate a transition to transit and shared mobility services	3,033	4,656
T-3	Improve and expand active transportation infrastructure	2,127	2,111
T-4	Support sustainable land use practices	Not quantified	Not quantified
Waste and Materials			
W-1	Reduce the amount of waste that is landfilled	19,379	22,646
W-2	Expand use of low-carbon and recycled building materials	Not quantified	Not quantified
Carbon Sequestration			
S-1	Maximize local carbon sequestration	2,008	2,434
Overall Reductions			
Emissions Reduction Needed to Achieve State Targets		128,238	430,965
Estimated Reduction Achieved by Full Implementation of Strategies		128,929	246,798
Absolute Emissions Reduction from 1990 (%)[1, 2]		(40%)	(66%)
Per Capita Emissions Reduction from 1990 (%)		(68%)	(85%)
Gap to SB 32 Target		(692)[3]	184,167

MT CO_2e = metric ton of carbon dioxide equivalent

[1] Emissions reductions go to zero by 2045 due to Senate Bill 100 and the Renewable Portfolio Standard.

[2] Absolute emissions reduction values are estimated based on current population projections and are for reference. Actual progress toward the 2030 target will be determined by comparison to the per capita GHG emissions target of 3.08 MT of CO_2e per person pursuant to guidance in the 2017 Scoping Plan.

[3] Parentheses denote a negative number or an exceedance of the target.

Note: Quantitative GHG emissions reduction values were rounded to the nearest tenth to reflect the level of estimation involved in calculations.

As shown in Table 2, the strategies adopted in Livermore's CAP Update have the ability when fully implemented to reduce GHG emissions below the City of Livermore's 2030 GHG reduction target and make substantial progress towards a 2045 carbon neutrality target. However, a gap still remains to reach the goal of carbon neutrality in 2045. As new technologies develop, and the state consolidates around the 2045 carbon neutrality goal, the City of Livermore will monitor progress and adopt new strategies to achieve this long-term goal. Furthermore, the strategies, actions, and steps in this CAP will create the basis for long-term carbon neutrality when implemented, including electrified buildings and vehicles coupled with decarbonized electricity, improved active transportation, decreased waste generation, and increased carbon sequestration.

The following sections contain the substantial evidence and quantification methodology intended to provide reasonable assurance that the GHG reduction strategies adopted in the City of Livermore's CAP Update will lead to the GHG emissions reduction necessary to achieve the City's ambitious 2030 emission target.

4 Buildings and Energy

4.1 2030 Objectives

- Provide 100 percent renewable electricity by 2024
- Require all-electric new construction by 2023
- Incentivize electric retrofits in 12% of existing buildings by 2030
- Develop equitable funding and financing for building electrification
- Incentivize local on-site energy generation and storage

Strategy B-1 Require New Buildings to be All-electric and Incentivize Electrification Retrofits of Existing Buildings

Livermore's building stock currently relies heavily on natural gas and retrofitting existing buildings to be all-electric will be a substantial task. To ensure new buildings won't need to be retrofitted later, Action B-1.1 will require new buildings and major retrofits be built to utilize only electricity as an energy source through an electrification ordinance. Meanwhile, Action B-1.2 and B-1.3 will provide a framework of updated regulations, incentives, rebates, and outreach to drive the electrification of existing buildings. The details of each action, including their implementation steps and evidence of their GHG reduction potential, are included below.

- **Action B-1.1**: Require new construction to be all-electric
- **Action B-1.2**: Incentivize electric retrofits in existing buildings
- **Action B-1.3**: Conduct a cost analysis and feasibility study for existing building electrification requirements
- **Action B-1.4**: Partner with stakeholders to conduct electrification outreach, promotion, and education

Action B-1.1 Require New Construction to be All-electric by 2023

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
1	GHG Reductions/ Structural Change	**Require new construction to be all-electric:** Adopt an electrification reach code by 2023 which bans the use of natural gas in all new construction where electrification is cost effective. Additionally, require major retrofits to be electric ready (i.e., install a 200-amp electric panel and prewire for electric vehicles and appliances).	2030: 10,891 2045: 28,056
2	Economical	Minimize the number of exemptions associated with the ordinance to limit the number of stranded assets in the City. Allow case by case allowances for certain site development standards when an applicant can demonstrate infeasibility.	
3	Equity	Conduct a cost effectiveness study to ensure no cost increases for low/medium income housing	
4	Education	Conduct outreach and engagement around new building electrification with the community and key stakeholders prior to adopting an electrification ordinance. A strong understanding of the benefits of electrification will be key to avoiding exceptions.	
5	Connectivity	Establish a partnership with the Building Decarbonization Coalition, or a similar organization, to engage with local building industry stakeholders in development of an Electrification Reach Code.	

Continuing to allow natural gas in new buildings would result in an increase in GHG emissions through 2045, due to increases in the population and residential construction in the City projected through 2045 (see adjusted forecast in Appendix A). Conversely, GHG emissions from electricity generation are expected to decrease to almost zero by 2025 due to Action B-2 (emissions from electricity would otherwise decrease to zero in 2045, due to SB 100). Requiring new construction to be all-electric would lead to a mandatory reduction in natural gas consumption compared to adjusted forecast projections by replacing natural gas with electricity.

Emission reductions for Action 1 were calculated separately for residential and commercial construction. It was assumed that with full implementation of the ordinance, no increases in residential and commercial natural gas demand would occur after 2022. Natural gas saved after ordinance implementation was converted to electricity usage (i.e., therms converted to kWh), with the assumption that a modern electric heat pump is on average three time more efficient than natural gas heater.[6] The emission factor for electricity was calculated based on the assumption that Action B-2 would be fully implemented by 2025 (more details on how this emission factor was calculated are included in the section for Strategy E-3). Total emissions saved are equivalent to emissions saved from eliminating natural gas in new construction, minus emissions from increased electricity usage.

Population forecast data based upon MTC projections reflect a steady increase in population between 2017 and 2045 (see Appendix A). The forecast for natural gas usage mirrors this pattern, along with projections for new housing units, which is expected to increase in Livermore through 2045. Residential natural gas from new construction was therefore, calculated based on housing estimates from MTC. Commercial gas usage avoided by electrification was calculated based on the

[6] https://help.leonardo-energy.org/hc/en-us/articles/203047881-How-efficient-is-a-heat-pump-

therms projections from commercial buildings in the adjusted forecast which considers the jobs growth over time. Minimizing the number of exemptions will be a key factor in the success of the ordinance and the reductions claimed as part of the Climate Action Plan. More exemptions, especially for a specific appliance like gas stoves would result in the same amount of natural gas infrastructure being deployed. Under this worst case scenario, the cost of natural gas infrastructure would remain the same, but the amount of natural gas consumed would decrease, significantly increasing the cost of each therm.[7] Therefore, the City will undergo a robust outreach campaign prior to adoption to ensure the community understands the importance of electrification and the long term cost increases expected for natural gas. Emission reduction calculation for Action B-1.1 are shown below in Table 3.

Table 3 Action B-1.1 Calculations

Year	2030	2045
Residential Reductions		
Housing units[1]	37,573	44,026
NG usage (therms)[2]	14,394,143	17,352,806
NG usage per housing unit (therms per house)	383	394
Additional housing units since implementation year[1]	4,853	11,306
NG usage avoided (therms)	1,859,101	4,456,315
Emissions from NG usage avoided (MT CO_2e)[3]	9,873	23,665
Electricity usage from converting to electric (kWh)[4]	18,157,278	43,523,493
Electricity EF (MT CO_2e/kWh)[5]	0.0000026	0
Emissions from converted electricity usage (MT CO_2e)	47	0
Emission reductions (MT CO_2e)	9,826	23,665
Commercial Reductions		
NG usage (therms)[1]	11,081,548	11,707,129
NG usage avoided (therms)	201,276	826,856
Emissions from NG usage avoided (MT CO_2e)[3]	1,069	4,391
Electricity usage from converting to electric (kWh)[4]	1,965,799	8,075,656
Electricity EF (MT CO_2e/kWh)[5]	0.0000021	0
Emissions from converted electricity usage (MT CO_2e)	4	0
Emission reductions (MT CO_2e)	1,065	4,391
Total reductions (MT CO_2e)	**10,891**	**28,056**

[1] MTC Plan Bay Area Projections 2040 long-term growth forecasts (2018), adjusted for population growth in Livermore observed from 2015-2017.

[2] Values from GHG Emissions Forecast. See Appendix A.

[3] Based on an emission factor of 0.00531051 MT CO_2e/therms, as established in Appendix A.

[4] Based on a conversion factor of 29.3001 kWh/therms and the assumption that electric appliances are generally three time more efficient than gas appliances. https://help.leonardo-energy.org/hc/en-us/articles/203047881-How-efficient-is-a-heat-pump-

[5] The residential and commercial electricity emission factors were calculated based on opt-out rates for different CCA customers. See Strategy E-3 for further details on this calculation.

[7] https://gridworks.org/initiatives/cagas-system-transition/

Action B-1.2 Incentivize electric retrofits in existing buildings to Reduce Natural Gas Consumption 12% by 2030 and 61% by 2045

Step Number	Guiding Principles	Implementation Step	Anticipated Reduction (MT CO_2e)
1	Economics	**Perform an electrification feasibility study/existing building analysis** in order to understand the potential for, and associated costs of, electrification retrofitting in the City of Livermore and establish a plan for eliminating natural gas from existing buildings. This would include an analysis for implementing requirements for newly permitted HVAC/hot water heaters and other appliances to be electric. At minimum, the plan would identify a pathway to reduce natural gas use by 12% by 2030.	2030: 16,492 2045: 93,437
2	Partnerships	**Identify and partner with stakeholders to develop resident-level funding pathways for implementing electrification ordinance:** Leverage partnerships with stakeholders and establish funding pathways to ease community members' costs when complying with the electrification ordinance, including: ▪ Partner with East Bay Community Energy and other stakeholders such as PG&E to create or expand electrification/retrofit programs and incentives (e.g., PACE program), especially for low-income residents to support the electrification ordinances. These could include on-bill financing, metered energy efficiency, providing rebates for residential replacement of natural gas-powered air and water heating appliances with electric-powered models, or providing rebates for replacement of antiquated wiring and windows in historic homes and buildings.	
3	Structural Change	**Develop a permit tracking program** for existing building electrification to track annual progress in achieving the targeted electrification goal(s), possibly through the City's existing Accela platform.	
4	Equity	**Develop a suite of Equity Guardrails** with input from the community to ensure existing building electrification improves equity in the community by limiting displacement and promoting equitable distribution of electrification benefits like resiliency, improved health outcomes, and reduced energy burden.	
5	Education	**Identify and partner with stakeholders to conduct electrification outreach, promotion, and education:** Leverage partnerships with stakeholders to conduct outreach, promotion, and education around new and existing building electrification, including: ▪ Induction/electric stove cooking competition to demonstrate the competitiveness of electric stoves for replacing gas stoves. ▪ Information sessions/events that educate the public on safety concerns around gas stoves and health benefits of replacing with electric, as well as potential cost benefits. ▪ Promote water heater, space heating, and appliance (electric stove/dryers) replacement programs and incentives (residential) at time of construction permit. ▪ Work with partners to develop financial and technical resources, including hosting workforce development trainings for installers and building owners/operators to discuss benefits and technical requirements of electrification and move towards all-electric requirements.	

Step Number	Guiding Principles	Implementation Step	Anticipated Reduction (MT CO_2e)
		▪ Conduct internal trainings with planners and building officials on state decarbonization goals and incentives available for electric homes. ▪ Work with partners and stakeholders to establish a comprehensive, coordinated education campaign for property owners and occupants for reducing the use of natural gas in homes and businesses. This could include keeping an updated list of rebates and incentives available for residents who would like to electrify their buildings, and providing multilingual education on the potential savings and benefits of electric heat pumps for water heating and space heating.	

Natural gas usage from existing buildings accounted for about 23% of emissions in Livermore in 2017. The City of Livermore will begin by promoting electrification through education, outreach, and incentives. Performing an electrification feasibility study will support implementation of Action B-1.2 contributing to achieving the GHG reduction benefits of those steps. The feasibility study will help determine which buildings in Livermore can be electrified, how to make electrification cost effective in specific cases, clarify the timeline on which electrification will happen, and investigate more concretely how to implement electrification equitably. The feasibility study will further determine if mandatory actions will need to be take and the cost effectiveness of those actions. While the City will begin implementation of Action B-1.2 through voluntary actions a mandatory requirement may be required in the future based on the results of the electrification study and the community progress. The impacts associated with promotional and educational outreach for electrification have not been well documented due to the cutting-edge nature of the strategy. Electrification as a GHG reduction strategy has only begun to gain traction in California mostly due to the implementation of SB 100 and the expansion of community choice aggregations. While it is not clear how the community will respond to electrification, energy efficiency outreach has been conducted since as early as the 1970's and some research has been conducted on the effects of outreach and education on energy. One study in New York showed that out of the 8,991 people who participated in informational programs, 69% implemented the recommended practices.[8] Another research meta-analysis reviewed dozens of papers covering various energy efficiency, water efficiency, and waste outreach and found that education-only campaigns could produce between 10-12% energy savings.[9]

Electrification is a new idea and not well understood by the community. The education associated with this action as well as the Climate Action Plan itself will facilitate adoption of all-electric technologies. The City will conduct a CAP update after 5 years to check progress and adopt more voluntary or potentially mandatory strategies if necessary.

Approximately 34% of residential natural gas usage is used for water heaters, while 40% is used for space heating.[10] The average life-span for water heaters and HVAC systems is 10 years and 18 years, respectively, and the ordinance would be fully implemented by 2025.[11] As a backstop to voluntary steps and pending the results of the electrification study the City of Livermore could no longer

[8] https://www.joe.org/joe/2009december/pdf/JOE_v47_6a6.pdf

[9] https://aceee.org/files/proceedings/2000/data/papers/SS00_Panel8_Paper10.pdf

[10] https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf

[11] https://www.lowes.com/n/how-to/when-to-replace-a-water-heater, https://www.thisoldhouse.com/ideas/how-long-things-last

accept permits to replace natural gas HVAC and hot water heaters starting in 2025, especially if voluntary efforts have not been successful. These units have been selected due to their large contribution to natural gas use and their cost effectiveness.[12] Based on a 2025 implementation date and the assumed life span of the covered equipment natural gas usage in existing buildings should decrease 12% by 2030, and 61% by 2045. This timeline would be expedited along the way by Action 3, which updates the Green Building Standards Code to encourage electrification at time-of-retrofit or at time-of-sale, including the installation of new 200-amp panels or requiring demonstration of electrification feasibility with an existing panel.

Similar to calculations used for Strategy B-1, avoided natural gas usage was assumed to be replaced by additional electricity usage, and electric appliances were assumed to be three times more efficient than their natural gas counterparts. The emission factor for electricity is assumed to be consistent with Strategy B-3. Emission reduction calculations for Strategy B-2 are shown below in Table 4.

Table 4 Strategy B-2 Calculations

Year	2030	2045
Residential Buildings		
Residential NG usage (therms)[1]	14,394,143	17,352,806
Residential NG usage after new building electrification is implemented (therms)[2]	12,535,042	12,896,491
Percentage of homes with replaced water heaters[3]	18%	100%
NG reduction from water heater replacement (%)[4]	6%	34%
NG saved from water heater replacement (therms)	767,145	4,384,807
Percentage of homes with replaced HVAC[5]	18%	100%
NG reduction from HVAC replacement (%)[6]	7%	40%
NG saved from HVAC replacement (therms)	902,523	5,158,596
Total NG saved (therms)	1,669,668	9,543,403
Emissions from total NG saved (MT CO_2e)[7]	8,867	50,680
Electricity usage from converting to electric (kWh)[8]	16,307,143	93,207,557
Electricity EF (MT CO_2e/kWh)[9]	0.0000026	0
Emissions from converted electricity usage (MT CO_2e)	42	0
Commercial Buildings		
Commercial NG usage (therms)	11,081,548	11,707,129
Commercial NG usage after new building electrification is implemented (therms)	10,880,273	10,880,273
Percentage of commercial with replaced water heaters	18%	100%
NG reduction from water heater replacement (%)	6%	34%
NG saved from water heater replacement (therms)	665,873	3,699,293
Percentage of commercial with replaced HVAC	18%	100%
NG reduction from HVAC replacement (%)	7%	40%
NG saved from HVAC replacement (therms)	783,380	4,352,109
Total NG saved (therms)	1,449,252	8,051,402
Emissions from total NG saved (MT CO_2e)	7,696	42,757

[12] https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

Year	2030	2045
Electricity usage from converting to electric (kWh)	14,154,413	78,635,625
Electricity EF (MT CO_2e/kWh)	0.0000021	0
Emissions from converted electricity usage (MT CO_2e)	29	0
Total reductions (MT CO_2e)	**16,492**	**93,437**

[1] Values from forecast. See Appendix A.

[2] Forecasted natural gas minus natural gas lost to new building electrification

[3] Assumes 100% of homes replace their water heaters incrementally over 10 years after ordinance is first passed. Based on average water heater lifetime of 10 years. https://www.lowes.com/n/how-to/when-to-replace-a-water-heater.

[4] Assume 34% of natural gas usage goes to water heaters. https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf. Multiply by percentage of homes with replaced water heaters to derive total percentage of natural gas reduction from water heater replacement.

[5] Assume 100% of homes replace their HVAC 18 years after ordinance is first passed. Based on average HVAC lifetime of 18 years. https://www.thisoldhouse.com/ideas/how-long-things-last.

[6] Assume 40% of natural gas usage goes to heating/cooling. https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf. Multiply by percentage of homes with replaced water heaters to derive total percentage of natural gas reduction from HVAC replacement.

[7] Based on an emission factor of 0.00531051 MT CO_2e/therm, as established in Appendix A.

[8] Based on a conversion factor of 29.3001 kWh/therm and the assumption that electric appliances are generally three time more efficient than gas appliances. https://help.leonardo-energy.org/hc/en-us/articles/203047881-How-efficient-is-a-heat-pump-

[9] The residential electricity emission factor was calculated based on opt-out rates for different CCA customers. See Strategy E-3 for further details on this calculation.

This action would also focus on building the funding pathway to make existing building electrification possible, particularly for low-income residents of Livermore. The largest barrier to existing building electrification is higher up-front capital costs compared to natural gas. [13] Utility-offered incentives to offset these costs for the end-user are therefore among the most promising opportunities for updating this technology.[14] Once up-front costs are financed, long term savings can be used to achieve cash flow positive retrofits and/or acceptable ROI's. Demonstrating cost effective pathways for existing building electrification will be a key step before mandatory requirements can be set. Examples of funding/financing strategies include:

Low-income Electrification/Retrofit Programs

Electrification programs that target low-income residents are the most cost-effective and potentially successful approach for equitable decarbonization to combat climate change.[15] For example, the Low-Income Weatherization Program (LIWP) is the state's first energy efficiency program that targets low-income Californians and has reduced energy bills in participating multifamily buildings by 30% and overall energy usage by an average of 40%.[16] A case study on a major energy retrofit in a Lancaster 100-unit low income multifamily complex resulted in a one-third reduction in natural gas use (approximately 145 therms per apartment).[17] The study also showed that such retrofits can

[13] California Center for Sustainable Energy. 2009. Solar Water Heating Pilot Program: Interim Evaluation Report. https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

[14] https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf

[15] http://greenlining.org/wp-content/uploads/2019/10/Greenlining_EquitableElectrification_Report_2019_WEB.pdf

[16] California Housing Partnership Corporation and Association for Energy Affordability (2018). California's Cap-and-Trade-Funded Low Income Weatherization Program Multifamily: Impact Report, 3.

[17] https://ww2.energy.ca.gov/2019publications/CEC-500-2019-021/CEC-500-2019-021.pdf

result in increased tenant retention, improved health and comfort, and better ability to afford necessities like food, medicine, health care, and rent.

On-bill Financing

A case study from affordable multi-family residential complexes in Santa Monica showed that electricity savings from the program ranged from 1,811-17,712 kWh and natural gas savings ranged from 914-2,567 therms, with overall energy improvement ranging from 10-35%.[18]

Energy Efficiency Retrofit Programs (e.g., PACE, PG&E's Low-income Weatherization Program, Million Watt Challenge, Metered Energy Efficiency)

While the use of carbon neutral electricity by 2045 due to SB100 ensures all-electric buildings have zero energy emissions, there is still a need to reduce energy consumption within Livermore. Reducing energy consumption will reduce stress on the electricity grid, require less renewable energy generation to meet needs thereby saving resources, and help reduce energy bills within the community.

The best mechanism the City will have for tracking electrification progress – and accurately measuring its GHG reduction benefit as it happens – is through a permit tracking program. Tracking electrification progress on a yearly schedule will allow the City to adjust its electrification approach and respond to potential obstacles as they occur and as new information about electrification becomes available. Utilizing the already existing Accela platform to do this would help to further increase effectiveness and integrate into City efforts.

One of the best ways the City can ensure that electrification has a positive impact on equity in the community is by developing a suite of equity guardrails. These would help to establish what equitable implementation would look like in Livermore, with input from the community. Goals of these guardrails include limiting displacement and promoting the equitable distribution of benefits like resiliency, improved health outcomes, and reduced energy burden.

Strategy B-2 Decarbonize Electricity from the Grid and Increase Local Renewable Energy Generation

In order for Livermore to reach its 2030 reduction target and 2045 carbon-neutrality target, the majority of energy utilized in the City will need to be carbon-free. Renewable electricity procurement is essential for decarbonizing the City's emissions from electricity and will create the foundation for a carbon-free future. The focus of Livermore's energy strategy is procuring 100 percent carbon-free electricity for both residents and businesses as soon as possible. Decarbonizing electricity works hand-in-hand with building electrification and EVs to achieve carbon neutrality in both the building and transportation sectors in Livermore. To reach this objective, the City of Livermore has developed the following actions:

- Action B-2.1: Opt-up community EBCE accounts to 100 percent renewable electricity
- Action B-2.2: Coordinate with stakeholders to provide local energy generation and storage incentives
- Action B-2.3: Establish renewable energy facility standards and permitting requirements
- Action B-2.4: Explore hydrogen and renewable fuel opportunities

[18] https://1p08d91kd0c03rlxhmhtydpr-wpengine.netdna-ssl.com/wp-content/uploads/2017/03/Santa-Monica-Test-Web.pdf

Action B-2.1 Opt-up community EBCE accounts to 100 percent renewable electricity by 2024

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
1	GHG Reductions/ Structural Change/ Economical	**Provide carbon neutral electricity to the community:** Opt-up East Bay Community Energy community accounts in Livermore to 100% carbon-free/renewable electricity by 2024 with an opt-out option	2030: 25,505 2045: 0
2	Education	**Conduct outreach to lower the community opt-out rate:** Maximize the usage of renewable power within the community after all accounts are opted-up, by continuing to achieve an opt-out rate lower than 5% for EBCE 100% renewable power. Monitor progress and perform public outreach and education campaigns highlighting the benefits of 100% renewable energy, including: ▪ Monitoring opt-out rates on an annual basis ▪ Tabling at community events ▪ Establishing a multilingual informational resource page on the City website ▪ Regular social media posts in multiple languages ▪ Energy bill inserts	Supportive
3	Equity/Connectivity	Partner with community organizations to ensure low/medium income households are aware of EBCE's CARE program to receive decreased electricity rates and provide technical assistance as needed.	Supportive

Electricity in Livermore is currently supplied by PG&E, which provides a power mix with 39% renewable resources, and 89% GHG free overall (including nuclear and large hydro).[19] While the portion of renewables in PG&E's grid mix is relatively high compared to other utility providers in the state, the emission factor associated with its electricity is not expected to decrease to zero until the state-mandated year of 2045. In order to reduce GHG emissions in the short-term, the City will provide 100% carbon free electricity to the community through EBCE, Livermore's CCA energy provider by 2024. In general, CCAs use the purchasing power of the community to procure electricity directly from electricity generators. This allows the community to choose its own grid mix, with an option to procure electricity from 100% carbon free renewable generation sources. PG&E will continue to deliver power, maintain lines and infrastructure, and coordinate billing. EBCE currently provides three power mix options[20] for residents to choose from:

- **Bright Choice:** Base option with 60% eligible renewable energy, with prices one percent below PG&E rates
- **Brilliant 100:** 100% carbon-free option that includes hydroelectric power. Same price as PG&E
- **Renewable 100:** 100% renewable option. Price is one cent per kilowatt hour above PG&E rates

To maximize the GHG reduction opportunity this presents, the City will automatically enroll all community accounts in a 100% carbon free option, as many cities in California have already done

[19] https://www.pge.com/en_US/about-pge/environment/what-we-are-doing/clean-energy-solutions/clean-energy-solutions.page?WT.mc_id=Vanity_cleanenergy

[20] https://ebce.org/compare-plans-residential/

today.[21] Customers will have the option to opt-out of the CCA back to PG&E or opt-down to another grid mix option. Currently, about 11% of Livermore residential customers and 4% of commercial customers currently choose to opt-out.[22] Livermore's residential opt-out rate is relatively high compared to other cities, and Action 2 will focus on conducting outreach and educating citizens about the benefits of opting in to EBCE electricity. Based on the added outreach the opt-out rate was assumed to be 5% for residential and 4% for commercial which is more in line with other EBCE communities. The GHG reduction quantification below is based on the forecasted electricity consumption under the adjusted forecast as well as the forecasted electricity emission factor in each year. The increases in electrification and comensurate reduction from a near zero emission factor resulting from other steps are not included in this strategy. It is assumed in all other electrification strategies that the City completes this strategy by 2025.

These actions also have the benefit of making all municipal electricity 100% emission-free, as municipal accounts will have 0% op-out. This includes local electricity usage from the water and wastewater sector from distribution, processing, and transportation. These water/wastewater emission reductions were estimated to be approximately 389 MT CO2e in 2030. However, this reduction is a subset of the community emissions (municipal electricity use is included in the overall community electricity use), and was not added to the community reductions to avoid double counting. The finding of this calculation is included here only for supportive purposes. Calculations for quantified emission reductions from Strategy E-3 are shown below in Table 5.

Purchasing 100% carbon free electricity through EBCE is one of the most cost-effective actions the City can take to meaningfully reduce GHG emissions within the City. The cost of opting up into carbon free electricity with EBCE is approximately the same as the PG&E rate and 100% renewable rates with both PG&E and EBCE are only a few dollars a month extra for most residential rate schedules.[23] However, even a small increase on monthly bills can make a big difference for the most vulnerable populations. Both PG&E and EBCE provides a CARE rate schedule for low-income households. As part of this outreach, the City would partner with community partners to ensure that qualifying community members know about and are able to enroll in CARE to further reduce their energy burden on a monthly basis.

[21] https://innovation.luskin.ucla.edu/2019/09/04/50-cities-are-quietly-leading-the-nations-100-clean-energy-wave/

[22] Opt-out rates based on data received directly via email from Gabrielle Ruxin at EBCE. February 8th, 2021.

[23] https://www.pge.com/pge_global/common/pdfs/customer-service/other-services/alternative-energy-providers/community-choice-aggregation/ebce_rateclasscomparison.pdf

Table 5 Action B-2.1 Calculations

Year	2030	2045
Residential electricity usage (kWh)[1]	222,591,232	247,321,911
Commercial electricity usage (kWh)[1]	294,346,152	306,917,819
PG&E Electricity EF (MT CO_2e/kWh)[3]	0.0000516	0
Emissions from electricity usage before CCA (MT CO_2e)	26,684	0
CCA Electricity EF (MT CO_2e/kWh)[4]	0	0
Weighted residential electricity EF after accounting for opt-out (MT CO_2e/kWh)[5]	0.0000026	0
Weighted commercial electricity EF after accounting for opt-out (MT CO_2e/kWh)[6]	0.0000021	0
Emissions from electricity usage after CCA (MT CO_2e)	1,178	0
Total reductions (MT CO_2e)	**25,505**	**0**

[1] Values from forecast. See Appendix A. Additional electricity load expected from Strategies E-1 and E-2 not included here due to CCA reductions for the added electricity being accounted for in each strategy's respective quantification. Municipal electricity usage subtracted from total commercial electricity usage for independent modelling. See note 2 for details on municipal electricity usage data.

[2] Based on electricity data provided by PG&E. Municipal usage not expected to change substantially between 2020 and 2045.

[3] Values from forecast. See Appendix A.

[4] All community accounts to be automatically enrolled in 100% renewable electricity package with an opt-out option.

[5] Assume 11% residential account opt-out such that 11% of accounts continue to have a PG&E emission factor, while 89% of accounts continue with the CCA-provided emission factor of 0 MT CO_2e/kWh. Opt-out rate provided by Gabrielle Ruxin at EBCE via email on February 8th, 2021.

[6] Assume 4% commercial account opt-out. Opt-out rate provided by Gabrielle Ruxin at EBCE via email on February 8th, 2021.

5 Transportation and Land Use

5.1 2030 Objectives

- Add 1,284 publicly accessible electric vehicle chargers by 2030
- Reduce Vehicle Miles Traveled (VMT) by 2.3%
- Achieve 10% bike mode share
- Support sustainable land use practices

Strategy T-1 Facilitate a Transition to Electric Vehicles

On-road transportation accounts for almost 59% of total GHG emissions in Livermore, with 58% of those emissions coming from passenger vehicles, and 42% coming from commercial vehicles (see Appendix A). It is important to electrify the transportation sector so it can benefit from increasingly clean electricity as a result of SB 100.

While the City cannot require its residents to buy ZEVs and electrify remaining passenger vehicle trips, Strategy T-1 will ensure the infrastructure and support is present in the City to begin to remove present barriers to ZEV adoption. All of the actions and steps in Strategy T-1 support the overall goal and therefore, have been quantified together below.

Action T-1.1 Expand EV Infrastructure to Support 28% Passenger and 16% Commercial EV Adoption by 2030

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
1	Education	**Develop an EV[1] Readiness Plan:** Develop an EV Readiness Plan that is consistent with the Alameda County EV Readiness Guide and Livermore 2003-2025 General Plan transportation policies and actions. This plan should establish a path forward to increase EV infrastructure within the City, promote equitable mode shift to EVs, and identify funding for implementation of public charging infrastructure in key locations. In conjunction with an EV Readiness Plan, conduct a community EV Feasibility Study to assess infrastructure needs and challenges, particularly in frontline communities.	2030: 49,494 2045: 93,458
2	Partnerships	**Increase privately owned EV charging infrastructure:** Work with public and private partners to increase publicly accessible DCFC and Level 2 EV chargers around the City, with a focus on providing access to low-income households and affordable housing by 2030.	
3	Structural Change	**Require EV capable charging spaces:** Amend the Livermore Development and Municipal Code to promote EV chargers in both existing and new development, requiring Cal Green Tier 2 EV Charging levels or equivalent.	
4	Structural Change	**Streamline EV charger permitting:** Streamlining the permitting process for EV infrastructure and alternative fuel stations, including allowing independent charging stations to be erected in the right-of-way or any zoning district or land use type.	

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
5	Partnerships	**Identify and partner with stakeholders to develop EV-related rebates:** Investigate partnerships with public and private partners for rebates on at-home electric circuits, panel upgrades, and Level 2 chargers, with a focus on supporting EV purchases for low-income households in frontline communities.	
6	Equity Education	**Encourage EV adoption amongst residents:** Providing multi-lingual education and outreach to the community on new and existing rebates, incentives, and programs for installation of Level 2 chargers on private property and availability of public charging, through the use of City events, social media, and the City website.	
7	Partnerships	**Increase business EV adoption:** Working with major employers (e.g., Lawrence Livermore National Lab, Kaiser Permanente, GILLIG, Topcon) to encourage EV adoption and improvements to EV infrastructure.	
8	Structural Change	**Establish electrical and technical standards for EVSE[2]:** Establish electrical and technical standards for Electric Vehicle Supply Equipment (EVSE), including construction of equipment, wiring methods, and safety protection consistent with the California Electrical Code and the Underwriter's Laboratories guidance on EVSE. The EVSE inspection process should be streamlined by: ▪ Removing the need for inspection or conducting spot inspections for simpler installations. ▪ Condensing inspections for more complex installations that do not include panel upgrades or underground conduit. ▪ Establish a 24-hour, flexible inspection request program online or with voicemail ▪ Providing shorter inspection windows. ▪ Remolding requirement for electricity to be present during inspection to decrease consumer costs.	
9	Education	**Promote the use of electric construction equipment:** Requiring construction projects to comply with BAAQMD best management practices, including alternative-fueled vehicles and equipment	
10	Education	**Establish universal EV signage:** Establish universal, accessible, and multi-lingual EV signage and marking requirements for EV parking spaces.	
11	Structural Change	**Establish preferential EV parking:** Introduce preferential parking for EVs throughout the City, with a focus on downtown and other busy locations identified around the City.	
12	Structural Change	**Require EV charging infrastructure at new gas stations:** Pass an ordinance to require all new gas stations and major remodels to install electric vehicle charging as space allows.	
13	Economics Structural Change	**Electrify retail delivery vehicles:** Charging licensing fees for UPS, FEDEX, and USPS trucks making online retail deliveries to provide funding for new active transportation and EV charging infrastructure, and/or provide discount licensing fees for delivery companies which utilize electric vehicles.	

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
14	Structural Change	**Adopt an ordinance:** limiting new drive thru businesses and other sources of idling emissions.	

[1] EV = electric vehicle

[2] EVSE = electric vehicle supply equipment

Together the actions and steps within Strategy T-1 will encourage electric vehicle (EV) adoption within the community. The state has established a goal of putting 5 million EVs on the road by 2030.[24] However, the recent passing of executive order N-79-20 calls for 100% of passenger vehicles sold to be all electric by 2035.[25] This new executive order puts the total number of EV's on the road by 2035 at approximately 15 million.[26] Based on the current number of vehicles registered in California and a 2% growth rate per year, 15 million EV's accounts for 35% of total vehicles in 2035. Interpolating between todays EV percentage (5%) gives us an expected EV adoption rate of 25%. As a part of this strategy, the City has established its own goal in line with this and aims to reach 28% passenger EV adoption by 2030 and 50% by 2045. Livermore currently has 1,026 electric vehicles and 766 plug-in hybrid vehicles out of 84,243 vehicles currently registered, together accounting for 2.1% of the vehicles registered within the City.[27]

The City has also adopted commercial EV adoption goals, with 16% by 2030 and 50% by 2045. This is backed by new regulations that CARB adopted in June 2020, requiring truck manufacturers to transition from diesel trucks and vans to electric zero-emission trucks beginning in 2024, and establishing a target for every new truck sold in California to be zero-emission by 2045.[28] Companies in the commercial sector are already moving to electrify their fleets, with Amazon planning to have 100,000 electric delivery vehicles on the road by 2030.[29] If both passenger and commercial EV adoption rates are outpacing EV charging infrastructure, adjustments can be made over time to reflect total EVs as well as charging technologies and consumer behaviors.

While the City cannot require residents or businesses to buy and use EVs rather than gas-powered vehicles, the City will take actions to incentivize this behavior change and support this level of EV adoption. As a part of this strategy, the City's primary target will be to provide one public EV charger for every 20 EV's and ensure as many privately owned chargers are installed in new development as practicable, in line with the leading Cities in California (San Francisco, Los Angeles, and San Jose) and recent charging infrastructure studies. Since the City of Livermore already has 82 existing public charging stations, there is currently one public EV charger for every 22 EVs, and the City will need to have 1,138 new public chargers installed to meet the forecasted demand from passenger vehicles by 2030. The actual number and ideal locations for these EV charging stations would need to be further investigated through an EV Readiness Plan and Feasibility Study, including analysis of greater fast charging infrastructure needed to power the 19 zero-emission commercial truck models set to

[24] https://www.cpuc.ca.gov/zev/

[25] https://ww2.arb.ca.gov/resources/fact-sheets/governor-newsoms-zero-emission-2035-executive-order-n-79-20

[26] https://spectrumnews1.com/ca/la-west/transportation/2020/10/05/what-it-will-take-to-sell-100--evs-in-california

[27] https://www.dmv.ca.gov/portal/uploads/2020/09/MotorVehicleFuelTypes_City_01012020.pdf

[28] https://ww2.arb.ca.gov/news/california-takes-bold-step-reduce-truck-pollution#:~:text=SACRAMENTO%20%E2%80%93%20Today%2C%20the%20California%20Air,California%20will%20be%20zero%2Demission.

[29] https://www.businessinsider.com/amazon-creating-fleet-of-electric-delivery-vehicles-rivian-2020-2

come to the North American market over the next three years (Action 1).[30] Increasing the amount of EV charging infrastructure overall will support these vehicles operating in Livermore. As the need for charging infrastructure changes over time depending on new technologies such as smart chargers, megawatt-scale charging systems tailored specifically to medium- and heavy-duty electric trucks, and trends in personal EV adoption, it will be important for the City to continue updating its long-term goals as necessary.[31]

Steps 2-4 will account for the majority of the targeted number of EV chargers in 2025 and 2030. A 2015 report by Idaho National Laboratory, *Plugged In: How Americans Charge Their Electric Vehicles*, found that nearly 98% of all EV charging events occurred at home or work.[32] In support of these findings, and to address the challenges faced by those who may not be able to install their own home chargers, adoption of an EV Readiness Reach Code would support increased infrastructure at new and existing commercial and multi-family residential developments. EV-ready building codes are one of the most effective and low-cost strategies for states and local governments to encourage consumers to buy or lease electric vehicles and can save consumers thousands of dollars in installation costs.[33]

The City of Livermore currently has EV charging stations installed at City Hall, the Livermore Municipal Airport, and the Maintenance Service Center, both for electric City Trucks and employees with electric cars.[34] Public charging stations in the City are clustered north of I-580 near Las Positas College and Costco Wholesale, as well as high-power chargers (eight 150 kW and two 350 kW charging stations) at San Francisco Premium Outlets. There are also a number of chargers along Discovery Drive to the west of Isabel Avenue, including two stations near the Tesla Warehouse. Other locations in Livermore are scattered throughout central and eastern parts of the City, mainly along Las Positas Road and south of I-580.[35] City-owned EV charging units currently cost a fee to charge per kilowatt hour, which are used to maintain the charging units and to cover electricity costs. While not directly quantifiable, EV charging fees increase turnover at charging stations, helping to promote equitable access to EV charging infrastructure and encourage widespread EV adoption across a greater demographic range.

Title 24, Part 11, Chapter 5 of the California Green Building Standards Code requires all new construction to provide parking spaces and electrical infrastructure sufficient to support future installation of EVSE.[36] Relevant standards can be found in the California Electrical Code and the Underwriter's Laboratories guidance on EVSE, including the construction of equipment, wiring methods, and safety protection. This strategy ensures that Livermore will have clear guidelines and standards in place for installing EVSE infrastructure. It also calls for creating a streamlined permitting and inspection procedure for EVSE ensures reduced wait times and costs for new EV owners. Applying for a permit and waiting for an inspector can be time intensive and costly – as many as three separate visits by the installer may be required to apply for the permit, perform the work, and complete the inspection, and a fourth visit may be needed if the utility requires a separate inspection. To avoid this, the City will streamline the EVSE permitting and inspection process to further ease the burden on new EV owners and support the goals of the strategy.

[30] https://www.greenbiz.com/article/we-should-be-talking-about-charging-infrastructure-heavy-duty-trucks

[31] https://www.nrel.gov/transportation/medium-heavy-duty-vehicle-charging.html

[32] https://www.osti.gov/biblio/1369632-plugged-how-americans-charge-electric-vehicles

[33] https://www.swenergy.org/cracking-the-code-on-ev-ready-building-codes

[34] https://www.cityoflivermore.net/citygov/cdd/planning/cap/default.htm

[35] https://www.plugshare.com/directory/us/california/livermore

[36] https://codes.iccsafe.org/content/CAGBSC2016/chapter-5-nonresidential-mandatory-strategys

Requiring new gas stations in the City to install EV charging stations will help support steps 2-4, and further promote increased EV adoption. Germany announced in 2020 that all of its gas stations would soon be required to provide EV charging, to help remove recharging concerns and boost consumer demand for the vehicles.[37]

The next phase for electric vehicle supply equipment (EVSE) expansion will provide additional publicly accessible charging. Emission reductions from the actions and steps in Strategy T-1 were calculated together as emissions saved by meeting EV adoption goals in 2030 and 2045. Emission reduction calculations are shown below in Table 6.

Promoting the use of electric vehicles for retail deliveries will also help support steps 2-4, and decrease emissions from the commercial transportation sector. This would provide additional funding for the City to install additional EV charging infrastructure. The retail delivery sector is already trending in this direction, with Amazon revealing its first electric vehicle delivery van in 2020, which began making deliveries in 2021. The company has ordered 100,000 electric delivery vehicles already from electric vehicle maker Rivian.[38]

[37] https://www.reuters.com/article/us-health-coronavirus-germany-autos/germany-will-require-all-petrol-stations-to-provide-electric-car-charging-idUSKBN23B1WU

[38] https://www.businessinsider.com/amazon-creating-fleet-of-electric-delivery-vehicles-rivian-2020-2

Table 6 Action T-1.1 Calculations

Year	2030	2045
Passenger Vehicles		
Passenger VMT after mode shift to bikes and transit [1]	577,613,999.81	602,887,641.34
Passenger Vehicle Emission Factor ($MTCO_2e$/mile) (EMFAC)[3]	0.00022828	0.00019801
Emissions from Passenger VMT (MT CO_2e)	131,859.42	119,376.32
EV adoption[2]	28%	50%
Emissions reduced from EV adoption (MT CO_2e)	34,115.75	57,148.81
Additional EV miles from new EV adoption (VMT)	149,445,032.16	288,619,317.11
Additional kWh from new EV miles	53,800,211.58	103,902,954.16
Electricity EF (MT CO_2e/kWh)[4]	0.000002581	0
Emissions from electricity usage for EVs	138.85	0
Commercial Vehicles		
Commercial VMT after mode shift to bikes and transit (VMT)[1]	91,769,379.83	78,282,003.56
Commercial Vehicle Emission Factor ($MTCO_2e$/mile) (EMFAC)[3]	0.00105757	0.00092764
Emissions from Commercial VMT (MT CO_2e)	97,052.48	72,617.62
EV adoption	16%	50%
Emissions reduced from EV adoption (MT CO_2e)	15,528.40	36,308.81
Additional EV miles from new EV adoption (VMT)	14,683,100.77	39,141,001.78
Additional kWh from new EV miles	5,285,916.28	14,090,760.64
Electricity EF (MT CO_2e/kWh)[4]	0.000002052	0
Emissions from electricity usage for EVs	10.85	0
Total reductions (MT CO_2e)	49,494.45	93,457.62

[1] VMT from forecast (see Appendix A) minus VMT avoided from mode shift to bikes in Strategy T-1

[2] Based on executive order N-79-20 100% of passenger vehicle sales will electric by 2035. Assuming 15 million EV's by 2035 due to N-79-20 and a 2% growth rate from current vehicle registrations (32,000,000) and a 5% current share of EV's California would be projected to have 25% EV's by 2030. 25% is in line with State goals. (https://spectrumnews1.com/ca/la-west/transportation/2020/10/05/what-it-will-take-to-sell-100--evs-in-california)

[3] Derived from EMFAC model output for Alameda County 2030 and 2045

[4] The residential electricity emission factor was calculated based on opt-out rates for Livermore as according to EBCE. See Strategy E-3 for further details on this calculation.

The number of new public chargers needed to support Livermore's passenger EV adoption goals were also calculated, shown below in Table 7. This was based on 2020 vehicle registration data from the DMV and the assumption that one public charger should be available for every 20 EVs. The 82 publicly-available EV charging stations already availble in the City were also taken into account. Commercial EVs were not included in this calculation due to the lack of data on current heavy duty trucks registered in the Livermore area. Total registered vehicles were forecasted based on the 2020 ratio of registered vehicles to population.

Table 7 EV Charger Count for Passenger Vehicles Calculations

Year	2030	2045
Population[1]	105,967	129,158
Total registered vehicles[2]	97,590	118,948
Registered EV goal[3]	24,398	59,474
EV's per charger[4]	20	20
New publicly available EV chargers needed[5]	1,138	2,892

[1] Values from forecast. See Appendix A.

[2] Based on a calculated value for cars for capita (0.921) derived by dividing the total number of registered vehicles in Livermore in 2020 (https://www.dmv.ca.gov/portal/uploads/2020/09/MotorVehicleFuelTypes_City_01012020.pdf) by the 2020 population of Livermore as established in Appendix A.

[3] Calculated as total registered vehicles multiplied by EV adoption percentage in above table

[4] https://theicct.org/sites/default/files/publications/US_charging_Gap_20190124.pdf

[5] Based on the assumption that approximately one public EV charger is needed per 20 EVs, taking into account the existing 82 EV chargers already in Livermore. This assumption may change over time due to better technology, changes to consumer behavior, or both. The total number of chargers especially in 2045 will need to be revisited to ensure the numbers reflect the current EV landscape[39]

Strategy T-2 Facilitate a transition to transit and shared mobility services

Improving shared mobility and transit programs and infrastructure through Strategy T-2 will help to shift mode share to public transit. To do this the City must work with regional stakeholders, including the Altamont Corridor Express (ACE), Bay Area Rapid Transit (BART), and the Livermore Amador Valley Transit Authority (LAVTA), to expand service lines and increase the convenience of transit by reducing the time it takes to reach a destination via transit as well as reducing wait times (headways) for transit. Working with the recently created Tri-Valley – San Joaquin Valley Regional Rail Authority will also be key to implement Strategy T-2, specifically on the proposed Valley Link project which would connect the existing BART station in Dublin/Pleasanton to the approved ACE North Lathrop Station in San Joaquin County.[40] By making transit more convenient and making decisions to prioritize transit over single occupancy vehicles, Livermore will begin to shift towards shared transit. Like Strategy T-1 the actions and steps within Strategy T-2 have been quantified together.

[39] https://theicct.org/sites/default/files/publications/US_charging_Gap_20190124.pdf

[40] https://www.valleylinkrail.com/valleylink-project

Action T-2.1 Improve Transit and Shared Mobility Services to Reduce Passenger VMT 2% by 2030, and 4% by 2045

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
1	Partnerships	**Partner with Valley Link, ABAG, LAVTA, BART, and ACE to improve and expand transit within the City.** This could include: ▪ Expanded transit service, especially along transit priority corridors surrounding the downtown core ▪ More frequent and reliable transit service ▪ Improved and/or more efficient technology ▪ Improved service/communication through multi-lingual interactive service maps, app ▪ payments, and real time arrival info ▪ Increase active transportation access to transit stops ▪ Provide enhanced, comfortable stops and stations ▪ Provide multi-lingual education and outreach to the community on new and existing shared transit options ▪ Subsidized transit passes ▪ Provide transit service within ½ mile of all residents in the city where and when the gross density surrounding or adjacent to feasible transit routes meets or exceeds 10-12 units/acre	2030: 3,033 2045: 4,656
2	Mitigation/Adaptation Benefit Partnerships	**Promote Tri-Valley Wheels:** Promote the use of Tri-Valley Wheels, particularly for downtown transit. This could include bus open houses and promoting use of the Transit app	
3	Education	**Prepare for shared bike programs:** Conduct a bike share (e.g., bike-share, scooter-share) feasibility study, in accordance with the Active Transportation Plan and possibly in coordination with Pleasanton and Dublin.	
4	Structural Change	**Adopt a shared-ride services ordinance:** Adopt an ordinance to allow shared-ride services (car/bike/scooter share) to operate in Livermore, possibly in coordination with Pleasanton and Dublin. Seek to establish a pilot bike sharing program downtown, ideally with e-bikes. Ensure access to frontline communities.	
5	Equity	**Improve local transportation equity:** Facilitate transportation equity through multi-lingual programs that identify local equity issues and seek to remove barriers for people of color, low-income, people experiencing homelessness, and senior populations to take transit, walk, bike, use rideshare, or carshare.	
6	Economics	**Conduct a local transportation survey:** Include multi-lingual National Citizens Survey questions related to transportation to better understand the community's needs and motivation for travelling by car versus other alternatives such as by bike, light rail, or bus. Use survey results to inform transit expansion and improvement projects.	
7	Structural Change	**Reduce idling emissions from drive thru restaurants:** Adopt an ordinance banning new drive thru restaurants within in the City to reduce idling emissions.	

In general, increases and improvements to public transportation systems reduce a city's dependence on fossil fuels and reduce VMT. The best ways to improve a transit system and reduce driving is to expand its geographical reach and increase the frequency and reliability of transit service. Approximately 1% increase in transit frequency saves 0.5% in VMT.[41] Bus Rapid Transit can also yield a corridor-level VMT reduction of 1-2%.[42] Mode shift of 2% to transit in Livermore by 2030 and 4% by 2045 was calculated based on new construction being largely transit-oriented development, supported by the two new Valley Link transit stops other actions included in this strategy including lower parking requirements for new developments (see Action 3 below).

In addition, effective communication, especially communication that takes advantage of new and emerging technologies to accurately and easily disseminate trip planning and real-time status information, is a strong factor in helping customers decide to use transit for business or leisure trips.[43] Further, improving transit access has the potential to shift trips from cars to transit, which may reduce vehicle trips, VMT, and GHG emissions, with time spent getting to a transit stop being the key indicator of transit access.[44]

By working with regional stakeholders and partners, Livermore will see significant expansion of transit usage by 2030, which will result in decreases in VMT from passenger vehicles. Most important is the proposed Valley Link rail project, which is a new 42-mile, 7-station passenger rail project that will connect the existing Dublin/Pleasanton BART Station to the approved ACE North Lathrop Station in San Joaquin County. This project will loosely follow I-580, and includes two stations in Livermore, at Isabel and Greenville. The Tri-Valley-San Joaquin Valley Regional Rail Authority, which was established in 2018 through the enactment of Assembly Bill 758, adopted the proposed project plan in October 2019, and is currently undergoing further design and environmental review. The project is scheduled to be finalized by 2025, with the Livermore segment of the project being a part of Phase I construction. Overall VMT reduction from the project is estimated at 99.4 million per year by 2040.[45] As a member agency, along with ACE, BART, and LAVTA (Tri-Valley Wheels), the City of Livermore will continue to work with regional transportation stakeholders to ensure that the new Valley Link rail project is supported by local transit-oriented development through 2030.

A 2019 report from the City of Santa Monica found that 49% of shared rideable trips replaced vehicle trips based on answers to survey questions.[46] A 2014 study from Utrecht University suggests that the car substitution rate of shared rideables is dependent on what proportion of trips are already taken by car in a city. [47] In the study, Minneapolis and Melbourne had between 70% and 76% vehicle mode share in 2014 and showed high rates of car mode substitution (19% to 21%) after shared rideables were introduced. On the other hand, London and Washington DC had between 36% and 46% vehicle mode share in 2014 and showed much lower rates of car mode substitution where shared rideables were introduced (2% to 7%). Sacramento and Santa Monica both had high vehicle mode share (83% and 72% respectively) before shared rideables were introduced, suggesting that the City of Livermore would see a similar if not higher car substitution rate of shared

[41] https://www.smartgrowthamerica.org/app/legacy/documents/smartgrowthclimatepolicies.pdf

[42] https://www.smartgrowthamerica.org/app/legacy/documents/smartgrowthclimatepolicies.pdf

[43] https://transitleadership.org/docs/TLS-WP-Improving-the-Customer-Experience.pdf

[44] https://ww3.arb.ca.gov/cc/sb375/policies/transitaccess/transit_access_brief120313.pdf

[45] https://adobeindd.com/view/publications/434ac81e-84bf-4f0a-868d-a386dce975d2/1/publication-web-resources/pdf/Valley_Link_Project_Over_View_202102.pdf

[46] https://www.smgov.net/uploadedFiles/Departments/PCD/Transportation/SantaMonicaSharedMobilityEvaluation_Final_110419.pdf

[47] http://mobility-workspace.eu/wp-content/uploads/Bike-shares-impact-on-car-use-3.pdf

rideables as Santa Monica and Sacramento. Both studies previously mentioned suggest that average trip duration of shared rideable trips is about 2 miles (this is seen consistently across the six diverse cities mentioned above) and appears to be largely independent of other city metrics. An e-bike ride share program has the potential to see the most successful, as e-bike riders can go longer distances and are more accessible to non-riders. A study in Portland, OR found that a 15% e-bike mode share could result in a 12% reduction in transportation-related emissions.[48]

Performing a bike share feasibility study would assess whether or not Livermore has the density and demand required to support a bike share program, which are an increasingly popular means of transportation in the United States. Bike share programs allow people to rent both traditional and electric bicycles for short periods of time. This study would support Transportation Strategy 3 and implement Livermore's Active Transportation Plan which recommended the City research bike share program options. Conducting this study in collaboration with Dublin and Pleasanton could increase the value of the study overall, and possibly enable the City to enter into a joint bike share program agreement with these two other cities.

Based on the inclusion of shared rideables and the extension of the Valley Link as well as the other coordination and transit improvements listed above, Livermore conservatively assumes a 2% VMT reduction through 2030. The GHG emissions savings associated with this transition is calculated in Table 8.

Table 8 Action T-2.1 Calculations

Year	2030	2045
Passenger miles after mode shift to bikes (VMT)	577,613,999.81	602,887,641.34
Emissions from passenger VMT (MT CO2e)	131,859.42	119,376.32
Decrease in VMT from measure	2%	4%
Adjusted VMT	564,328,878	579,375,023
Emission reductions from VMT avoided (MT CO2e)	**3,033**	**4,656**

[1] VMT from forecast (see Appendix A) minus VMT avoided from mode shift to bikes

Strategy T-3 Improve Active Transportation Infrastructure

Tailpipe emissions are a major source of Livermore's GHG emissions. Reducing the number of miles driven by fossil fuel-powered vehicles, particularly when replaced with public-health boosting active modes of transportation, provides a critical way to reduce GHG reductions while connecting communities and keeping Livermore residents healthy. As part of the CAP strategy, Livermore will prioritize active transportation by expanding access to safe, low-stress, and convenient biking and pedestrian infrastructure. Expanding active transportation infrastructure will increase quality of life and public health through increased exercise and increased community connectivity. Like the other transportation and land use strategies the actions and steps within Strategy T-2 have been quantified together.

[48] https://www.sciencedirect.com/science/article/pii/S1361920920306696

Action T-3.1 Accelerate implementation of the Livermore ATP to Achieve Greater than 10% Mode Shift Away from Passenger Vehicles by 2030, and Maintain that Percentage through 2045

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
1	Structural Change	**Implement Livermore Active Transportation Plan:** Fully implement the Livermore Bicycle, Pedestrian, and Trails Active Transportation Plan adopted in 2018 by 2030 in accordance with the Plan's goals, objectives, and policies so that the City adds approximately 154 miles to the active transportation network. Implementation of the Plan will prioritize frontline communities and: ▪ Improve existing crossings for on-road vehicles, and provide for future crossings of creeks, railroads, and roadways. ▪ Require new facilities be built in conjunction with road reconstruction or re-striping projects, subdivision development, and related off-site improvements, unless a significant cost/feasibility issue is shown. ▪ Construct Class I or Class 4 bikeways in undeveloped areas prior to or concurrent with the development of these areas. ▪ Provide for, and maintain, shaded routes where possible. ▪ Connect neighborhoods, schools, workplaces, transit facilities, and other destinations with on-street facilities and/or separated trails. ▪ Support and participate in Federal, State, Regional, and Local programs, such as countywide Safe Routes to School efforts. ▪ Coordinate with other agencies, adjacent jurisdictions, and regional partners to plan and implement projects that improve Livermore's network and connections to the region. ▪ Continue to provide convenient bicycle parking in the downtown core, either on the street or in public or private parking lots. If demand exists, remove vehicle parking in favor of bicycle parking. Provide adequate bicycle parking facilities at local recreation areas. ▪ Regularly update the City's Bicycle, Pedestrian, and Trails Map and share throughout City and stakeholder partnership platforms, ensuring that the maps are accessible for people with disabilities and speakers of non-English languages.	2030: 2,127 2045: 2,111
2	Economics	**Perform a nexus study:** Conduct a nexus study, and develop an ordinance requiring payment of fees from development projects to implement safe active transportation routes and infrastructure citywide.	Supportive
3	Partnerships	**Identify and partner with stakeholders on active transportation education:** Support and promote local bike community organizations in hosting workshops and classes on bike riding, safety, and maintenance by certified instructors for all ages and skill levels. Also, subsidize safety equipment, such as headlights and helmets, for low-income residents.	Supportive
4	Economics Education Structural Change	**Establish car-free days downtown:** Institute car-free days downtown potentially coupled with the Farmer's Market or other large and regular events.	Supportive
5	Education	**Promote active transportation:** Establish multilingual Citywide events, outreach, educational programs, or platforms to promote active transportation in the community.	Supportive

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
6	Structural Change	**Incorporate outreach into prioritization of active transportation projects:** Continually improve methods for engaging the community, gathering their input, and utilizing it to help prioritize the implementation of projects and actions in the Active Transportation Plan.	Supportive
7	Economics	**Explore new funding opportunities:** Explore new opportunities to generate funding for active transportation projects, such as by implementing a local gas tax used to fund bike and pedestrian improvement projects, prioritizing those in frontline communities.	Supportive

The overall goal of the Livermore Active Transportation Plan is to provide a long-term vision for improving the active transportation network in Livermore and enhance connections to transit facilities, employment, retail and commercial centers, and public facilities. Implementing the Livermore Active Transportation Plan will consist of coordinating City departments with stakeholders (e.g., Bike East Bay, Las Positas College, National Laboratories, other Tri-Valley cities, Alameda County, and frontline communities) to accomplish the following:

- Adding approximately 77 miles to the bikeway network based on a list of prioritized infrastructure and citywide projects developed through a community outreach process with the goal of improving school access, downtown access, I-580 crossings, and other connectivity issues throughout Livermore
- Developing and implementing an effective network-wide wayfinding system that reflects the character of Livermore
- Adding streetscape amenities in the downtown core, along major corridors, and near transit stops, including providing additional waste receptacles near pathways
- Improving safety on bike paths with improved pedestrian-scale lighting, developing e-bike regulations with the Livermore Police Department and Alameda County, and requiring adequate temporary traffic control that considers bicyclists and pedestrians during construction or maintenance activities
- Seek opportunities to include bicycle infrastructure at the time of major road upgrades or major development projects, as this significantly decreases the cost of installation. This action is included as a best practice to decrease the cost burden on the City and further facilitate timely implementation of the Active Transportation Plan
- Improving comfort on bike paths by providing for and maintaining shaded routes where possible
- Improve and increase end-of-trip facilities such as secure, shaded, and well-lit bicycle parking by working with partners/stakeholders and using the permitting process for new development. This includes short term and long-term bicycle parking, including bike racks, bike lockers, and secure parking areas
- Working with ACE, BART, LAVTA, and Tri-Valley – San Joaquin Valley Regional Rail Authority to integrate with transit and other transport modes to address the first/last mile challenge
- Partnering with stakeholders (e.g., Bike East Bay, Las Positas College, National Laboratories) to promote and encourage biking in Livermore.

- Identifying and competing for available funding sources for bicycle projects, including from the California Active Transportation Program, Caltrans Transportation Planning Grants, and Highway Safety Improvement Program

A complete description of the goals, strategy, policy, and implementation framework for expanding and improving Livermore's bikeway network is included in the Livermore Active Transportation Plan as adopted in 2018. The Plan will be updated every five years to identify new projects for implementation, and ensure that improvement projects are correctly prioritized and meet the plan's guiding principles.

Accelerating implementation of the Active Transportation Plan is expected to increase pedestrian and bicycle mode share from 2.3% in 2018 to 10% in 2030. Full implementation of the Active Transportation Plan would increase the length of Livermore's active transportation network by 22.9%. In order to estimate the mode shift potential associated with implementing the Active Transportation Plan, other cities with similar buildouts were compared. Currently the City of Davis has a bike network similar to what Livermore would have at full implementation. Davis currently has a 20% mode share.[49] Similar to Livermore's Active Transportation Plan, the City of Santa Cruz's 2017 Active Transportation Plan establishes a set of projects and programs to increase the mode share of active transportation, from 19.6% in 2014 to 27% in 2030.[50] Therefore, an increase in mode share from 2.3% to 10% is considered conservative. Emission reduction calculations assumed the average bike trip length was 1.5 miles[51] and used model results from EMFAC to characterize VMT in Livermore.

Improving active transportation networks is an important part of building Complete Streets – streets that accommodate bikes, cars, shared transit, and pedestrians in an accessible way. Livermore's Active Transportation Plan implements the City's Complete Streets Policy.[52] Nationally, 48% of all vehicle trips were three mile or less in 2019, a distance easily travelled by foot, bicycle, or other micro mobility platforms.[53] An improved and expanded pedestrian network is the most effective and direct approach for shifting those shorter vehicle trips to walking, and studies show that distance to destinations is one of the strongest predictors of walking as a mode choice. However, not much research has been conducted to determine quantitatively how improving the pedestrian network translates to increased pedestrian mode share. This is further complicated by the fact that while improved pedestrian networks almost always have a positive correlation with increased walking, that does not always translate to decreased VMT. In other words, increased walking does not mean that walking trips are replacing driving trips. Therefore, although Livermore's Active Transportation Plan calls for projects that would increase its active transportation network by 22.9%, the mode shift associated with this was estimated more conservatively. Emission reduction calculations are shown below in Table 9.

[49] https://www.theguardian.com/cities/2015/aug/03/davis-california-the-american-city-which-fell-in-love-with-the-bicycle

[50] https://www.cityofsantacruz.com/home/showpublisheddocument?id=60966

[51] Caltrans California Household Travel Survey (2013)/CARB Bike Path Reductions Technical Documentation (2019)

[52] Livermore Active Transportation Plan (2018), Page 4. https://www.cityoflivermore.net/civicax/filebank/documents/18254

[53] https://inrix.com/blog/2019/09/managing-micromobilty-to-success/

Table 9 Action T-3.1 Calculations

Year	2030	2045
Mode share shift[1]	2%	10%
Passenger Vehicle VMT[3]	586,932,289	613,546,706
Estimated trips/passenger vehicle mile (EMFAC)[2]	0.13746	0.15041
Estimated passenger vehicle trips	80,677,829	92,286,277
New bike trips substituted for vehicle trips[4]	6,212,193	7,106,043
New bike miles substituted for passenger vehicles (miles)	9,318,289	10,659,065
Passenger Vehicle Emission Factor ($MTCO_2e$/mile) (EMFAC)	0.00022828	0.00019801
Total reductions (MT CO_2e)	**2,127**	**2,111**

[1] Livermore Active Transportation Plan Update (2018) proposes projects that will increase total active transportation network length by 22.9% assuming the fully implemented. As Livermore is currently at 2.3% bicycle mode share, the remaining mode share shift in 2030 and 2045 is expected to be 10%.

[2] Derived from EMFAC model output for Alameda County 2030 and 2045

[3] Values from forecast. See Appendix A.

[4] Assume the average bicycle trip is 1.5 miles. Caltrans California Household Travel Survey (2013)/CARB Bike Path Reductions Technical Documentation (2019)

Additional steps such as performing a nexus study will provide the necessary information to develop an active transportation in lieu fee on new development projects to fund additional active transportation infrastructure projects in the future. This study would meet the requirements of the California Mitigation Fee Act for local agencies to charge development impact fees, and could be similar to those conducted by other cities for active transportation purposes, including the City of Oakland and City of San Diego.[54] [55]

Providing education on the benefits of active transportation as well as technical information such as trip planning, safety best practices, incentives and other programs will help generate momentum around active transportation and support the overall strategy. The City has collaborated with Bike East Bay, the National Laboratories, and Wheels bus service to hold Bike to Work Day activities to promote commuting to work by bicycle.[56] The additional promotional activities identified under this action, including establishing car free days downtown and holding bike safety workshops, will continue to build an active transportation community and culture in Livermore.

Finding new funding sources to fund additional active transportation projects are an important part of implementing priority projects identified in Livermore's Active transportation Plan. By exploring new avenues to generate funding, such as by establishing a local gas tax that goes directly to new active transportation efforts, Livermore can increase its ability to implement a wide array of projects.

[54] http://www2.oaklandnet.com/government/o/PBN/OurOrganization/PlanningZoning/s/ImpactFee/index.htm

[55] https://www.sandiego.gov/sites/default/files/6_mobility_choices_nexus_study.pdf

[56] https://www.llnl.gov/news/labs-promote-pedal-power-bike-work-day

6 Waste and Materials

6.1 2030 Objectives

- Reduce the amount of organic waste that is landfilled 75% from 2014 levels by 2025
- Maintain or exceed 75% solid waste diversion each year
- Improve local re-use and repair programs
- Expand the use of low-carbon and recycled building materials

Strategy W-1 Reduce the Amount of Waste that is Landfilled

Emission reductions in the waste sector are driven by compliance with SB 1383, which requires all jurisdictions in California to reduce organic waste disposal 75% and increase edible food recovery 20% relative to 2014 levels by 2025. CalRecycle has provided a suite of recommendations and requirements for complying with SB 1383, including the following:

- Conduct capacity planning and ensure there is adequate capacity and collection services to comply with SB 1383 requirements
- Increase organic waste collection services for all residents and businesses
- Implement an edible food recovery program for commercial edible food generators, with compliance beginning between 2022 and 2024.
- Adopt enforceable ordinances prior to 2022 to ensure that all organics generators and edible food generators are compliant
- Procure organic waste to meet or exceed organic waste product procurement targets for the City, as notified by CalRecycle by 2022
- Conduct education and outreach to all businesses, residents, and commercial edible food generators by 2022
- Monitor compliance beginning in 2022, conduct enforcement beginning in 2024, and maintain records of implementation

The main mechanism through which Livermore will comply with SB 1383 is by updating waste hauler contracts and identifying and partnering with appropriate stakeholders to ensure requirements for organic waste reduction and edible food recovery are met (Strategy W-1). The details of the strategy, including its supporting steps and evidence of its GHG reduction potential, are included below.

Action W-1.1 Implement the Requirements of SB 1383 and Achieve 75% Reduction (from 2014 levels) in Organic Waste by 2025

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
1	Structural Change	**Require residential and commercial organic waste collection through updated waste hauler contracts:** Update waste hauler contracts to include expanded organic waste collection that meets the requirements of SB 1383. Conduct multilingual outreach and education regarding these changes throughout the community.	2030: 19,379 2045: 22,646
2	Equity	**Require edible food recovery:** Adopt an edible food recovery ordinance or similarly enforceable mechanism to ensure edible food generators, food recovery services, and food recovery organizations comply with requirements to increase recovery rates. Work with local food security groups on ordinance design and implementation.	Supportive
3	Structural Change	**Increase the City's recycled product procurement:** Procure and use compost to meet California Model Water Efficient Landscape Ordinance (WELO) requirement for incorporating compost into new and renovated permitted landscapes (at least four cubic yards per 1,000 sq. ft. to a depth of six inches of compost).	Supportive
4	Structural Change	**Conduct capacity planning for organic waste collection:** Engage in organic waste collection capacity planning by executing the following: ▪ Estimate Livermore's disposal of organic waste in tons ▪ Identify and verify amount of available organic waste recycling infrastructure ▪ Estimate the amount of new or expanded capacity needed to process organic waste ▪ Develop and submit an implementation schedule highlighting planning effort to provide enough new or expanded organics capacity, including timelines and relevant milestones by the end of the report period ▪ Identify proposed new or expanded facilities that could be used for additional capacity	Supportive
5	Structural Change Equity	**Conduct capacity planning for edible food recovery:** Engage in edible food recovery capacity planning by executing the following actions: ▪ Estimate the amount of edible food that will be disposed by organics generators in Livermore ▪ Work with commercial food generators to reduce excess edible food generation ▪ Work regionally to establish a full list of food recovery organizations that can receive edible food from Livermore businesses • Identify proposed new or expanded food recovery capacity ▪ Identify the minimum capacity required to recover 20% of edible food that is estimated to be disposed, through a Feasibility Study if necessary ▪ If existing and planned capacity is insufficient based on the above process, the City of Livermore must develop and submit an implementation schedule highlighting the planning effort to provide enough new or expanded capacity for increasing edible food donations and identify proposed new or expanded facilities to be used to for additional capacity	Supportive

Step Number	Guiding Principles	Implementation Steps	Anticipated Reduction (MT CO_2e)
6	Education Partnerships	**Develop and implement a partnered education and outreach program:** Develop and implement a multi-lingual education and outreach program that provides compliance assistance to organics and edible food generators, including: ▪ Identify percentage of organics generators who are "limited English-Speaking households" or "linguistically isolated." If more than five percent (5%) of Livermore's organics generators are defined as "limited English-speaking households" or linguistically isolated," provide education and outreach in a language or languages that will assure the information is understood by that community ▪ Prior to February 2022 and annually thereafter, provide organics generators with information regarding requirements to properly separate materials, organic waste prevention and on-site recycling, and implementing organic waste collection services. ▪ Provide edible food generators with information about methane reduction benefits and information related to edible food donation. ▪ Consider providing in-person technical assistance to generators to set up donation programs and donate appropriate types of edible food	Supportive
7	Education	**Educate the community:** Conduct multi-lingual outreach and education at schools on composting, recycling, waste reduction, nutrition education, and the importance of edible food recovery. Partner with StopWaste on outreach programs if possible.	Supportive
8	Structural Change	**Develop and implement an inspection and compliance program:** Implement an equitable inspection and compliance program for the edible food recovery program and organics procurement program with equitable and clearly defined enforcement mechanisms and penalties, as required by Article 16 in SB 1383.	Supportive
9	Structural Change	**Keep SB 1383 compliance records:** Maintain records, including an initial compliance report, annual report, and implementation record as required by Articles 3, 14, and 16 of SB 1383 for (1) the organic waste collection program, (2) the edible food recovery program, and (3) the organics procurement program.	Supportive
10	Structural Change	**Require organics collection programs:** Pass an ordinance with equitable enforcement mechanisms requiring organics generators to subscribe to organics collection programs or alternatively report organics self-hauling and/or backhauling.	Supportive
11	Structural Change	**Require composting services at businesses:** Pass an ordinance, with equitable enforcement mechanisms and technical assistance for low-income entrepreneurs, that requires composting services at businesses, including front-of-house (FOH) composting collection at most food service businesses.	Supportive

Requiring residential and commercial organic waste generators to subscribe to an organics collection program (provided through updated waste hauler contracts) is expected to provide the level of composting required to reduce Livermore's organic waste disposal 75% below 2014 levels by 2025, one of the primary goals of SB 1383. StopWaste and Livermore Sanitation have been preparing for implementation of SB 1383, and are in the process of assessing local composting

capacity and facilities. This action will capitalize on those efforts and expand them to meet the necessary composting capacity.

Livermore is projected to produce 82,313 tons of waste in 2030, with the majority if not all emissions from this waste coming from organics. Calculations assumed that emission reductions would come from diverting that waste to compost, decreasing the disposal emission factor to zero. In fact, the emission factor for composting those materials is negative, due to the carbon sequestration potential of compost, but these negative emissions were not credited to the City of Livermore as carbon sequestration of the compost would occur at the location of procurement. For the purposes of emission calculations, landfill emissions were assumed to come entirely from organic materials so that a 75% reduction in organics results in a 75% reduction in waste emissions.[57] Emission reduction calculations are shown below in Table 10.

Table 10 Action W-1.1 Calculations

Year	2030	2045
Waste Emissions	25,839	30,194
Organics reduction from SB 1383[1]	75%	75%
Total reductions (MT CO_2e)	**19,379**	**22,646**

[1] SB 1383 requires 75% reduction in organic waste from 2014 levels by 2025.

Other steps like the edible food recovery ordinance will provide an enforceable mechanism through which the City can help organics generators meet the edible food recovery requirements of SB 1383. Jurisdictions are responsible for implementing an edible food recovery program for commercial edible food generators. This means ensuring that there are edible food recovery organizations that have enough capacity and collection services, which will be accomplished through implementation of Action 5. Commercial edible food generators must recover for human consumption the maximum amount of their edible food that they would otherwise dispose of in landfills by making written agreements with food recovery organizations or services to accept this food instead. “Tier One” food generators — supermarkets and large grocery stores, food services providers, food distributors and wholesale food vendors — must comply beginning January 1, 2022. “Tier Two” food generators — large restaurants, hotels with an on-site food facility and 200 or more rooms, health facilities with an on-site food facility and 100 or more beds, large venues and large events, state agencies with large cafeterias and local educations agencies with on-site food facilities — have until January 1, 2024 to comply.

CalRecycle currently does not have an estimate for what percentage of the California waste stream is edible, therefore the effects of this action have not been quantified but characterized as supportive. However, CalRecycle estimates that every 2 ½ tons of edible food recovered is the equivalent of taking one car off the road for a year.[58]

Increasing recycled product procurement will lower the City’s consumption-based emissions – emissions attributed to the production of materials brought into the City – and provide a local market for recycled products, including recycled paper and compost.

[57] Method for Estimating Greenhouse Gas Emission Reductions from Diversion of Organic Waste from Landfills to Compost Facilities (CARB, 2017)

[58] https://www.calrecycle.ca.gov/blogs/in-the-loop/in-the-loop/2020/03/02/yolo-county-edible-food-recovery-kick-off

- **Recycled Paper.** Over 30 years, recycled paper can deliver 1.1 to 1.95 gigatons of carbon dioxide emission reductions.[59] This is because recycled paper produces about 25% fewer total emissions than conventional paper. A particular piece of paper can be reprocessed roughly five to seven times, before fibers are no longer viable, avoiding methane emissions from landfilling each time. Recycling paper has the added benefit of saving trees and reducing water waste.
- **Compost.** Composting avoids methane production in landfills, with the added benefit of carbon sequestration ability, which actively removes carbon from the atmosphere. Additional benefits to using compost are improved soil health, reduced soil loss, increased water filtration and storage, and reduction of other inputs.[60]

SB 1383 requires jurisdictions to conduct capacity planning around SB 1383 to ensure organics recovery and edible food recovery targets can be reasonably met. Conducting capacity planning will help the City develop an implementation plan for SB 1383 and provide information for discussions with waste haulers and other stakeholders, providing support for the GHG reductions expected from overall strategy implementation.

Conducting inspection and compliance activities around the requirements of SB 1383 will help ensure the community is doing its best to achieve the desired organics waste reduction and edible food recovery targets, thereby supporting the GHG emission reductions inherent to Steps 1 and 2.

[59] https://www.drawdown.org/solutions/recycled-paper

[60] https://www.sanjoseca.gov/home/showdocument?id=198

7 Carbon Sequestration

7.1 2030 Objectives

- Maximize local carbon sequestration
- Plant 200 trees by 2025 and 1,000 trees by 2030
- Update City landscaping standards to expand shade tree requirements for new development
- Provide free or reduced cost-trees to residents in Livermore
- Preserve open spaces
- Implement carbon-farming projects
- Explore technology-based carbon capture and storage opportunities

Strategy S-1 Maximize Local Carbon Sequestration

A carbon neutral future includes carbon sequestration mechanisms which take carbon out of the atmosphere. The best technology cities have for achieving higher rates of carbon sequestration is through increasing the urban tree canopy by planting more trees and greenscaping. The CAP strategy supporting this goal will do just that – increase carbon sequestration through greenscaping programs. The primary action under this strategy is implementing an Urban Forest Revitalization Program, which would establish tree planting goals for the future. The details of each action supporting the carbon sequestration strategy, and evidence of their GHG reduction potential, are included below.

Action S-1.1 and S-1.2 Increase Carbon Sequestration by Planting 1,000 New Trees and Meeting the Procurement Requirements of SB 1383

Action Number	Action	Anticipated Reduction (MT CO_2e)
1	**Implement an Urban Forest Revitalization Program:** Implement an Urban Forest Revitalization Program to plant 200 trees by 2025 and 1000 trees by 2030. Focus on areas of City with low tree canopy cover and the highest socioeconomic need based on the development of a canopy map. Identify opportunities for green walls and green roofs in priority locations.	2030: 58 2045: 58
2	**Meet the procurement requirements of SB 1383:** Procure and apply compost to promote carbon sequestration and other benefits.	2030: 1,950 2045: 2,367
3	**Preserve open spaces:** Avoid conversion of open lands to urban areas - achieve carbon and other benefits by keeping the landscape as conservation land or working land.	Supportive
4	**Conduct a carbon farming study and pilot project:** Work with agricultural stakeholders to find a partner for a carbon farming study and pilot project.	Supportive
5	**Improve urban forest management to maximize carbon sequestration:** Prepare and adopt an Urban Forest Management Plan for the City that includes an inventory of existing trees, and the identification of both future tree planting opportunities and a climate-ready tree palette, as well as ongoing operations and maintenance needs.	Supportive
6	**Adopt a Greenscaping Ordinance:** Adopt a Greenscaping Ordinance that has a street tree requirement for all zoning districts, has a shade tree requirement for new development, requires greening of parking lots, and increases permeable surfaces in new development.	Supportive
7	**Establish urban canopy and vegetative barrier best practices:** Adopt a standard policy and set of practices for expanding urban tree canopy and placing vegetative barriers between busy roadways and developments to reduce exposure to air pollutants from traffic.	Supportive

Livermore should develop and implement an Urban Forest Revitalization Program that identifies the goal of planting 200 trees by 2025 and 1000 trees by 2030, prioritizing low-income communities with low tree canopy cover. As of December 2016, the City had approximately 2,500 trees under its management.[61] As a part of the Urban Forest Revitalization Program, the total number of planting locations in the City's Right-of-Way should be identified, to inform a higher tree planting goal that could be set for 2045. Emission reduction calculations associated with this action assume that both the 2025 and 2030 tree planting goals will be met, and that the carbon sequestration potential for seedlings averaged over 40 years is about 0.058 MT CO_2e per tree per year. This number is an average of the 40-year carbon sequestration potential for four common tree species already being planted in Livermore: red oak, black tupelo, valley/white oak, and red maple.[62] Emission reduction calculations are shown below in Table 11.

[61] https://www.eastbaytimes.com/2016/12/16/livermore-assesses-ways-to-keep-tree-stands-alive/

[62] https://planting.itreetools.org/app/report/

Table 11 Action S- 1.1 Tree Planting Calculations

Year	2030	2045
Trees Planted[1]	1,000	1,000
Total reductions (MT CO_2e)[2]	**58**	**58**

[1] Per goals to be set in Livermore's Urban Forest Revitalization Program

[2] Assuming a carbon sequestration potential of 0.057979 MT CO_2e/tree/year; an average of four common municipal tree types (red oak – 0.05268 MT CO_2e/tree/year, black tupelo – 0.03816 MT CO_2e/tree/year, valley/white oak – 0.08466 MT CO_2e/tree/year, and red maple – 0.05641 MT CO_2e/tree/year). https://planting.itreetools.org/app/report/

In addition to the concrete tree planting goals the City has established under Step 1, other steps will help create additional carbon sequestration potential for the City. However, emission reductions from these steps are not quantified, due to the difficulty in determining the exact impact these steps will have on GHG emissions in Livermore. Seeking partnerships with local agriculture stakeholders and the National Laboratories can help the city to pilot innovative carbon farming studies and pilot projects which will help further the City's vision for carbon restoration in the future. Livermore can look to the Marin Carbon Project as a model for carbon farming projects, which has assisted in the development and implementation of over a dozen carbon farm plans in Marin County.[63] A Greenscaping Ordinance which includes increased street tree requirements will help to support these steps and improve the local tree canopy. As the City moves forward in implementing these steps, an updated inventory will be developed to help quantify their impacts.

SB 1383 requires Livermore to procure approximately 7,297 tons of compost or other organic material annually. Livermore's responsibility based on the 2022 population is 7,297 tons based on a 2022 population of 91,216 people and the reported CalRecycle procurement targets.[64] Based on CARB methodologies applying one ton of compost results in carbon sequestration of 0.23 MT CO_2e.[65] The overall GHG emissions savings are calculated in Table 12.

Table 12 Action S-1.2 Compost Application Calculations

Year	2030	2045
Population	105,967	129,158
Estimated procurement requirement[2]	8,477	10,332
MT CO_2e/Ton Compost[1]	0.23	0.23
Total Sequestration (MT CO2e)	1,950	2,376

[1] METHOD FOR ESTIMATING GREENHOUSE GAS EMISSION REDUCTIONS FROM DIVERSION OF ORGANIC WASTE FROM LANDFILLS TO COMPOST FACILITIES DRAFT (ca.gov)

[2] Estimated based on current per capita procurement requirements and projected population data. https://calrecycle.ca.gov/organics/slcp/procurement/recoveredorganicwasteproducts/

63 https://www.marincarbonproject.org/carbon-farming

64 https://calrecycle.ca.gov/organics/slcp/procurement/recoveredorganicwasteproducts/

65 METHOD FOR ESTIMATING GREENHOUSE GAS EMISSION REDUCTIONS FROM DIVERSION OF ORGANIC WASTE FROM LANDFILLS TO COMPOST FACILITIES DRAFT (ca.gov)

Appendix E - CAP Regulatory Context

Livermore Climate Action Plan Update

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Regulatory Context

As the impacts of climate change are becoming clearer, strategies to address climate change are emerging at all levels of government. This section provides an overview of the regulatory context at the international, state, and local levels relative to Sacramento's actions toward reducing greenhouse gas (GHG) emissions.

International Climate Action Guidance

1992 United Nations Framework Convention on Climate Change

The primary international regulatory framework for GHG reduction is the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is an international treaty adopted in 1992 with the objective of stabilizing atmospheric GHG concentrations to prevent disruptive anthropogenic climate change. The framework established non-binding limits on global GHG emissions and specified a process for negotiating future international climate-related agreements.[1]

1997 Kyoto Protocol

The Kyoto Protocol is an international treaty that was adopted in 1997 to extend and operationalize the UNFCCC. The protocol commits industrialized nations to reduce GHG emissions per country-specific targets, recognizing that they hold responsibility for existing atmospheric GHG levels. The Kyoto Protocol involves two commitment periods during which emissions reductions are to occur, the first of which took place between 2008-2012. The second commitment period set new targets and other changes but has not been entered into force (meaning it has not gone into effect).[2]

2015 The Paris Agreement

The Paris Agreement is the first universal, legally binding global climate agreement that was adopted in 2015 and has been ratified by 191 countries worldwide.[3] The Paris Agreement establishes a roadmap to keep the world under 2 degrees Celsius (°C) of warming with a goal of limiting an increase of temperature to 1.5°C. The Paris Agreement does not dictate one specific reduction target, instead relying on individual countries to set nationally determined contributions (NDCs) or reductions based on gross domestic product and other factors. According to the International Panel on Climate Change (IPCC), limiting global warming to 1.5°C will require global emissions to reduce through 2030 and hit carbon neutrality by mid-century.[4]

[1] United Nations Framework Convention on Climate Change (UNFCCC). United Nations Framework Convention on Climate Change. https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf
[2] UNFCCC. What is the Kyoto Protocol? https://unfccc.int/kyoto_protocol
[3] UNFCCC. Paris Agreement - Status of Ratification. https://unfccc.int/process/the-paris-agreement/status-of-ratification
[4] IPCC. Global Warming of 1.5 C. https://www.ipcc.ch/sr15/

California Regulations and State GHG Targets

California remains a global leader in the effort to reduce GHG emissions and combat climate change through its mitigation and adaptation strategies. By the early 2000's, California was passing climate change bills including Senate Bill (SB) 1078 and Executive Order (EO) S-3-05 which began to require state agencies and utilities to address climate change. With the passage of Assembly Bill (AB) 32 in 2006, California became the first state in the nation to mandate GHG emission reductions across its entire economy. To support AB 32, California has enacted legislation, regulations, and executive orders (EO) that put it on course to achieve robust emission reductions and address the impacts of a changing climate. The following is a summary of executive and legislative actions most relevant to the Climate Action Plan.

2002 Senate Bill 1078

In 2002, Senate Bill (SB) 1078 established the California Renewables Portfolio Standards (RPS) Program which requires that 20 percent of retail electricity sales be composed of renewable energy sources by 2017 and was accelerated in 2006 by SB 107,[5] which requires that 20 percent of retail electricity sales be composed of renewable energy sources by 2010, instead of 2017. EO S-14-08 was signed in 2008 to further streamline California's renewable energy project approval process and increase the state's RPS to the most aggressive in the nation requiring 33 percent renewable power by 2020.[6] SB 350, discussed further below, further accelerated the program which mandated a 50% RPS by 2030.

2002 Assembly Bill 1493

In 2002, AB 1493, also known as the Pavley Regulations, directed the California Air Resources Board (CARB) to establish regulations to reduce GHG emissions from passenger vehicles to the maximum and most cost-effective extent feasible. CARB approved the first set of regulations to reduce GHG emissions from passenger vehicles in 2004, with the regulations initially taking effect with the 2009 model year.

2005 Executive Order S-3-05

EO S-3-05 was signed in 2005, establishing statewide GHG emissions reduction targets for the years 2020 and 2050. The EO calls for the reduction of GHG emissions in California to 2000 levels by 2010, 1990 levels by 2020, and 80 percent below 1990 levels by 2050. The 2050 emission reductions target would put the state's emissions in line with the worldwide reductions needed to reach long-term climate stabilization as concluded by the IPCC *2007 Fourth Assessment Report*.

2006 Assembly Bill 32

California's major initiative for reducing GHG emissions is outlined in AB 32, the "California Global Warming Solutions Act of 2006," which was signed into law in 2006. AB 32 codifies the statewide goal of reducing GHG emissions to 1990 levels by 2020 and requires CARB to prepare a Scoping Plan

[5] California Public Utilities Commission.2021. Renewables Portfolio Standard (RPS) Program. https://www.cpuc.ca.gov/General.aspx?id=6442463710
[6] Executive Order S-14-08. http://www.climatestrategies.us/library/library/view/292

that outlines the main state strategies for reducing GHG emissions to meet the 2020 deadline. In addition, AB 32 requires CARB to adopt regulations to require reporting and verification of statewide GHG emissions.

Based on this guidance, CARB approved a 1990 statewide GHG baseline and 2020 emissions limit of 427 million metric tons of CO_2 equivalent (MMT CO_2e). The Scoping Plan was approved by CARB on December 11, 2008 and included measures to address GHG emission reduction strategies related to energy efficiency, water use, and recycling and solid waste, among other measures. Many of the GHG reduction measures included in the Scoping Plan (e.g., Low Carbon Fuel Standard, Advanced Clean Car standards,[7] and Cap-and-Trade) have been adopted since approval of the Scoping Plan.

In May 2014, CARB approved the first update to the AB 32 Scoping Plan. The 2014 Scoping Plan update defined CARB's climate change priorities for the next five years and set the groundwork to reach post-2020 statewide goals. The update highlighted California's progress toward meeting the "near-term" 2020 GHG emission reduction goals defined in the original Scoping Plan. It also evaluated how to align the state's longer-term GHG reduction strategies with other state policy priorities, including those for water, waste, natural resources, clean energy, transportation, and land use (CARB 2014).

2007 Executive Order S-1-07

Also known as the Low Carbon Fuel Standard, EO S-1-07, issued in 2007, established a statewide goal that requires transportation fuel providers to reduce the carbon intensity of California's transportation fuels by at least 10 percent by 2020. EO S-1-07 was readopted and amended in 2015 to require a 20 percent reduction in carbon intensity by 2030, the most stringent requirement in the nation. The new requirement aligns with California's overall 2030 target of reducing climate changing emissions 40 percent below 1990 levels by 2030, which was set by SB 32 and signed by the governor in 2016.

2007 Senate Bill 97

Signed in August 2007, SB 97 acknowledges that climate change is an environmental issue that requires analysis in California Environmental Quality Act (CEQA) documents. In March 2010, the California Natural Resources Agency adopted amendments to the State CEQA Guidelines for the feasible mitigation of GHG emissions or the effects of GHG emissions. The adopted guidelines give lead agencies the discretion to set quantitative or qualitative thresholds for the assessment and mitigation of GHG and climate change impacts.

2008 Senate Bill 375

SB 375, signed in August 2008, enhances the state's ability to reach AB 32 goals by directing CARB to develop regional GHG emission reduction targets to be achieved from passenger vehicles by 2020 and 2035. In addition, SB 375 directs each of the state's 18 major Metropolitan Planning

[7] On September 19, 2019, the National Highway Traffic Safety Agency and the U.S. Environmental Protection Agency issued a final action entitled the One National Program on Federal Preemption of State Fuel Economy Standards Rule. This action finalizes Part I of the Safer, Affordable, Fuel-Efficient (SAFE) Vehicles Rule. This rule states that federal law preempts State and local tailpipe GHG emissions standards as well as zero emission vehicle (ZEV) mandates. The SAFE Rule withdraws the Clean Air Act waiver it granted to California in January 2013 as it relates to California's GHG and zero emission vehicle programs.

Organizations (MPOs), to prepare a Sustainable Communities Strategy" that contains a growth strategy to meet these emission targets for inclusion in the MPO's Regional Transportation Plan.

In March 2018, CARB adopted updated regional targets for reducing GHG emissions from 2005 levels by 2020 and 2035. Each region was assigned a target for 2020 and 2035.8

2009 California Green Building Code

The California Green Building Standards Code (CALGreen) is Part 11 of the California Building Standards Code or Title 24 and is the first statewide "green" building code in the nation. The purpose of CALGreen is to improve public health, safety, and general welfare by enhancing the design and construction of buildings. Enhancements include higher energy efficiency, better air quality, and improved daylighting. The first CALGreen Code was adopted in 2009 and has been updated in 2013, 2016, and 2019. The CALGreen Code will have subsequent, and continually more stringent, updates every three years.

2009 Senate Bill X7-7

In 2009, SB X7-7, also known as the Water Conservation Act, was signed, requiring all water suppliers to increase water use efficiency. This legislation sets an overall goal of reducing per capita urban water use by 20 percent by2020.

2011 Senate Bill 2X

In 2011, SB 2X was signed, requiring California energy providers to buy (or generate) 33 percent of their electricity from renewable energy sources by 2020.

2012 Assembly Bill 341

AB 341 directed the California Department of Resources Recycling and Recovery (CalRecycle) to develop and adopt regulations for mandatory commercial recycling. As of July 2012, businesses are required to recycle, and jurisdictions must implement a program that includes education, outreach, and monitoring. AB 341 also set a statewide goal of 75 percent waste diversion from landfill by the year 2020.

2014 Assembly Bill 32 Scoping Plan Update

In 2014, CARB approved the first update to the Scoping Plan. This update defines CARB's climate change priorities and sets the groundwork to reach the post-2020 targets set forth in EO S-3-05. The update highlights California's progress toward meeting the near-term 2020 GHG emissions reduction target, defined in the original Scoping Plan. It also evaluates how to align California's longer-term GHG reduction strategies with other statewide policy priorities, such as water, waste, natural resources, clean energy, transportation, and land use.

8 https://ww2.arb.ca.gov/sites/default/files/2020-06/SB375_Final_Targets_2018.pdf

2014 Assembly Bill 1826

AB 1826 was signed in 2014 to increase the recycling of organic material. GHG emissions produced by the decomposition of these materials in landfills were identified as a significant source of emissions contributing to climate change. Therefore, reducing organic waste and increasing composting and mulching are goals set out by the AB 32 Scoping Plan. AB 1826 specifically requires jurisdictions to establish organic waste recycling programs by 2016, and phases in mandatory commercial organic waste recycling over time.

2015 Senate Bill 350

SB 350, the Clean Energy and Pollution Reduction Act of 2015, has two objectives: to increase the procurement of electricity from renewable sources from 33 percent to 50 percent by 2030 and to double the energy efficiency of electricity and natural gas end users through energy efficiency and conservation.

2015 Executive Order B-30-15

EO B-30-15 was signed in 2015, establishing an interim GHG emissions reduction target to reduce emissions to 40 percent below 1990 levels by 2030. The EO also calls for another update to the CARB Scoping Plan to provide a pathway to achieve this goal.

2016 Senate Bill 32

In September 2016, the governor signed SB 32 into law, extending AB 32 by requiring the state to further reduce GHGs to 40 percent below 1990 levels by 2030 (the other provisions of AB 32 remain unchanged).

2016 Senate Bill 1383

Adopted in September 2016, SB 1383 requires CARB to approve and begin implementing a comprehensive strategy to reduce emissions of short-lived climate pollutants. SB 1383 requires achievement of the following reduction targets by 2030:

- Methane – 40 percent below 2013 levels
- Hydrofluorocarbons – 40 percent below 2013 levels
- Anthropogenic black carbon – 50 percent below 2013 levels

SB 1383 also requires CalRecycle, in consultation with CARB, to adopt regulations that achieve specified targets for reducing organic waste in landfills. SB 1383 further requires 20% of edible food disposed of at the time to be recovered by 2025.

2017 Scoping Plan Update

In December 2017, CARB adopted the 2017 Scoping Plan, which provides a framework for achieving the 2030 goal set by SB 32. The 2017 Scoping Plan relies on the continuation and expansion of existing policies and regulations, such as the Cap-and-Trade Program, as well as implementation of recently approved legislation, such as SB 350 and SB 1383.

The 2017 Scoping Plan also puts an increased emphasis on innovation, adoption of existing technology, and strategic investment to support its strategies. As with the 2014 Scoping Plan Update, the 2017 Scoping Plan does not provide project-level thresholds for land use development. Instead, it recommends that local governments adopt policies and locally appropriate quantitative thresholds consistent with statewide per capita goals of six metric tons (MT) CO_2e by 2030 and two MT CO_2e by 2050 (CARB 2017). As stated in the 2017 Scoping Plan, these goals may be appropriate for plan-level analyses (i.e., city, county, subregional, or regional level), but not for specific individual projects because they include all emissions sectors in the state (CARB 2017).

CARB is currently developing the 2022 Scoping Plan Update, which will focus on continuing to work towards the SB 32 target and lay out a path for achieving carbon neutrality by 2045.

2018 Senate Bill 100

Adopted in September 2018, SB 100 supports the reduction of GHG emissions from the electricity sector by accelerating the state's RPS Program, which was last updated by SB 350 in 2015. SB 100 requires electricity providers to increase procurement from eligible renewable energy resources to 33 percent of total retail sales by 2020, 60 percent by 2030, and 100 percent by 2045.

2018 Executive Order B-55-18

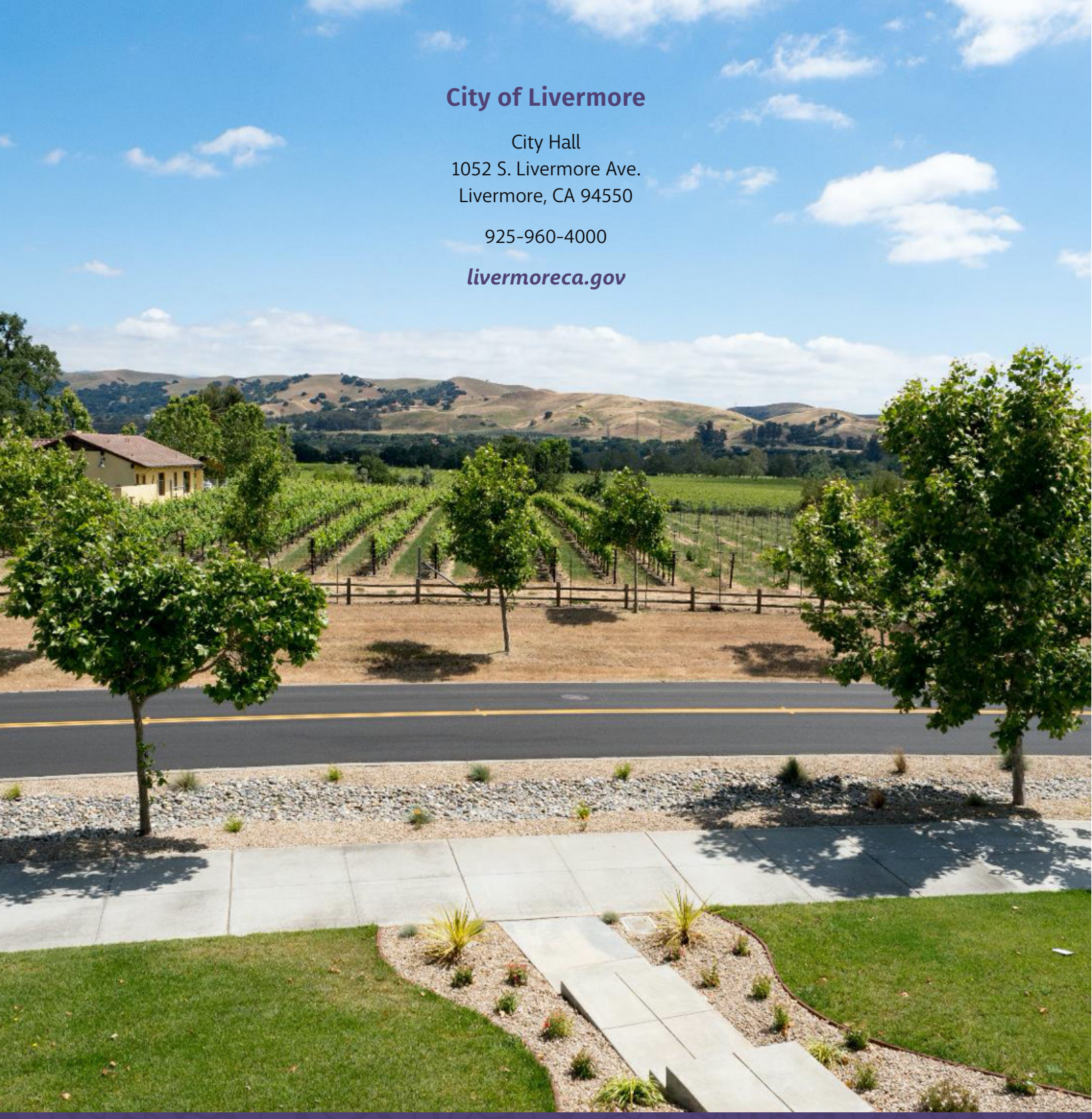
In September 2018, the governor issued Executive Order B-55-18, which established a new statewide goal of achieving carbon neutrality by 2045 and maintaining net negative emissions thereafter. This goal is in addition to the existing statewide GHG reduction targets established by SB 375, SB 32, SB 1383, and SB 100.

2022 Scoping Plan Draft

Though still in draft form the CARB's 2022 Scoping Plan Update assesses progress toward the statutory 2030 target, while laying out a path to achieving carbon neutrality no later than 2045. The 2022 Scoping Plan Update focuses on outcomes needed to achieve carbon neutrality by assessing paths for clean technology, energy deployment, natural and working lands, and others, and is designed to meet the State's long-term climate objectives and support a range of economic, environmental, energy security, environmental justice, and public health priorities.

2022 California Climate Crisis Act

This bill, the California Climate Crisis Act, declared that the policy of the state is to achieve net zero greenhouse gas emissions as soon as possible, but no later than 2045, and achieve and maintain net negative greenhouse gas emissions thereafter, and to ensure that by 2045, statewide anthropogenic greenhouse gas emissions are reduced to at least 85% below the 1990 levels.



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