Focus 2030: A Pathway to Net Zero Emissions

July 2019

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A Department of the City and County of San Francisco

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Message from Mayor London N. Breed

Last year, the Intergovernmental Panel on Climate Change issued its most dire report yet on the global climate crisis. The evidence could not have been clearer: we are facing a climate emergency. Cities like San Francisco have a moral and civic imperative to uphold the ambition of the Paris Climate Agreement and limit global temperature rise to 1.5°C. Cities have enormous power—and a responsibility—to reduce harmful greenhouse gas emissions in order to stabilize the planet. That is why I committed San Francisco to achieving net zero emissions by 2050.

I am pleased to present this technical report demonstrating the pathway for San Francisco to achieve these deep emissions reductions. We must act now. By working closely with local businesses, building owners, environmental groups, labor unions, and community-based organizations, we can address this climate crisis while improving lives, creating jobs, and ensuring a high quality of life for all San Franciscans.

London N. Breed, Mayor
City and County of San Francisco

Mayor Breed at the Global Climate Action Summit Clean Energy Kick-Off Event, Moscone Center, September 2018.

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Acknowledgements

San Francisco's *Focus 2030: A Pathway to Net Zero Emissions* was developed for the Mayor's Office by the San Francisco Department of the Environment, with critical assistance from partner agencies dedicated to the fight against climate change. Published July 2019.

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Key Findings

This report demonstrates that achieving deep emissions reductions will require an ongoing commitment that builds upon and surpasses San Francisco's past successes. Without further progress on emission-reducing policies and programs, greenhouse gases citywide will trend upward due to population and economic growth. A steadfast commitment to continued and increased action will be necessary to ensure San Francisco does its part to keep global warming to 1.5°C.

If San Francisco maintains and deepens its commitment to supplying 100% renewable electricity; prioritizes low-carbon forms of mobility such as transit, walking and biking; reduces our consumption of energy; and transitions away from fossil fuels, the city could realize a 68% reduction in emissions below 1990 levels by 2030 and a 90% reduction by 2050.

Even assuming a steadfast commitment, the city is unlikely to reach net zero emissions without new innovations, partnerships and collaborations as the findings of this report estimates there will be some emissions that cannot be eliminated by San Francisco alone. This report therefore also advises that beyond reducing local emissions, San Francisco should take bolder action now to achieve more rapid gains in the fight against climate change by sequestering carbon and encouraging the sustainable consumption of goods and services.

Emissions reductions must come from three primary sectors – buildings, transportation and waste – within which seven Strategic Priorities were identified and evaluated. In the buildings sector, reductions must be realized by increasing energy efficiency, electrifying new and existing buildings, and ensuring that San Francisco is served by 100% renewable electricity from 2030 onward. In the transportation sector, between today and 2050, emissions reductions must be derived equally from transportation mode shift and the electrification of all cars and trucks. In the waste sector, continuing to reduce the amount of material sent to landfill, while increasing the recovery of recyclable and compostable materials, will be essential to reducing local emissions. Yet to realize the greatest global emissions reductions, San Francisco must significantly decrease the consumption of goods and services and the amount of refuse[1] the city generates.

TABLE 1- STRATEGIC PRIORITIES EVALUATED

Transportation	Buildings	Zero Waste
Shift 80% of all trips taken to walking, biking and transit by 2030	Electrify space and water heating with high-efficiency products such as heat pumps	Reduce generation 15% by 2030
Electrify 25% of private cars and trucks by 2030 and 100% by 2040	Increase building energy efficiency	Reduce disposal to landfill or incineration 50% by 2030
	Power buildings with 100% renewable electricity	

[1] Refuse refers to recyclables, compostables and trash bound for landfills.

Introduction

The science is clear. Climate change is impacting communities around the globe[2], causing more extreme heat waves, heavy precipitation, flooding, droughts, sea level rise, wildfires, and air pollution. Considered one of the greatest public health threats of the 21st century, climate change is already impacting San Francisco, as recently evidenced by the 2017 Labor Day Heat Event[3]; the fire seasons of 2017 and 2018 which created extended periods of very poor air quality; and a 2019 flood caused by heavy rainfall during high tide. Climate change is a crisis that is impacting residents and infrastructure, placing a disproportionate burden on our most vulnerable populations: low-income communities, communities of color, seniors, and people with disabilities.

San Francisco's response to the climate crisis must be swift and acknowledge the imperative of accelerating emissions reductions, adapting to the impacts already upon us, and preparing for the changes ahead. *Focus 2030: A Pathway to Net Zero Emissions* is a foundational step in San Francisco's progress toward addressing the climate crisis. This technical report quantifies the potential emissions reductions of seven Strategic Priorities based on our ambitious climate and sustainability goals. It focuses on accelerating action over the next decade, driven by the urgent need to limit the increase in global temperature to 1.5°C, the highest that Earth's natural systems can tolerate without severe and irreversible changes.

The analysis completed for this report demonstrates a potential path to net zero emissions[4] by 2050 through the transformation of our energy supply, buildings, transportation, and waste systems. The findings also serve as a starting point for San Francisco's 2020 Climate Action Strategy update. Collaboration and participation of key city departments, local businesses, building owners, environmental groups, labor unions, and community-based organizations will be critical to developing an effective, inclusive and equitable Climate Action Strategy. San Francisco is committed to addressing the unequal burdens of climate change, and fulfilling this commitment will require active community engagement, particularly of those most burdened by the impacts of climate change such as people of color, low-income and frontline communities, to ensure that San Francisco's efforts evaluate and eliminate longstanding systems and practices that unintentionally perpetuate inequities.

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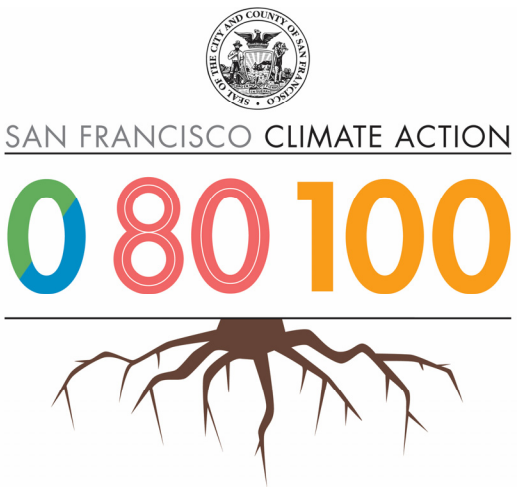
[2] https://nca2018.globalchange.gov/chapter/front-matter-about/

[3] https://sfgov.maps.arcgis.com/apps/MapJournal/index.html?appid=093e26ddb26a4e3180fa1e35158858bf

[4] Net zero emissions refers to reducing to the greatest extent possible production of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and offsetting any residual emissions that cannot be eliminated through methods such as carbon sequestration.

Achievements

From the city's first Sustainability Plan in 1996, to the release of an updated Climate Action Strategy in 2013, to the historic commitment to net zero emissions in 2018, San Francisco has been a climate action pioneer, setting ambitious goals and taking bold steps toward reducing emissions and protecting the environment. San Francisco's 0-80-100-Roots Climate Action Framework defines ambitious climate and sustainability goals. By achieving these goals, the city will enjoy the benefits of cleaner air, fewer vehicles on the road, a more reliable transit system, more bike lanes and pedestrian-friendly networks, highly efficient homes and businesses powered by 100% clean electricity, and a healthy, well-developed urban canopy and green spaces.



The 0-80-100-Roots Climate Action Framework outlines four goals:

- Zero Waste: By 2030, reduce refuse generated[5] 15% and disposal to landfill and incineration 50% below 2015 levels
- Mode Shift: By 2030, increase sustainable trips to 80%
- Energy: By 2030, supply 100% renewable electricity and 100% renewable energy by 2050
- Roots: Sequester carbon through ecosystems restoration, increased urban tree canopy, and compost application

The effectiveness of our efforts to achieve these goals has been clear: in 2017, San Francisco achieved a 36% reduction in greenhouse gas emissions below 1990 levels, greatly surpassing the target of 25% established by the San Francisco Board of Supervisors[6]. A steady decline in emissions over the last two decades, even as the population and economy has grown, is primarily due to the continued replacement of fossil fuel power generation with renewable sources. In addition, a clean

[5] Refuse generation refers to the total amount of material discarded to recycling, composting and landfill.
[6] https://www.sfbos.org/ftp/uploadedfiles/bdsupvrs/ordinances08/o0081-08.pdf

electric grid, increased building energy efficiency, a transition to low-carbon transportation fuels, and a state-of-the-art zero waste program have also spurred emissions reductions over time.

While these achievements are remarkable, if the Paris Climate Agreement is to be met, San Francisco and other cities around the world must accelerate local action. Additionally, because emissions from the consumption of goods and services produced outside the city can be up to three times greater than emissions generated within San Francisco's boundaries, we must focus on shifting behavior toward sustainable consumption, using low-carbon products, and supporting a circular economy.

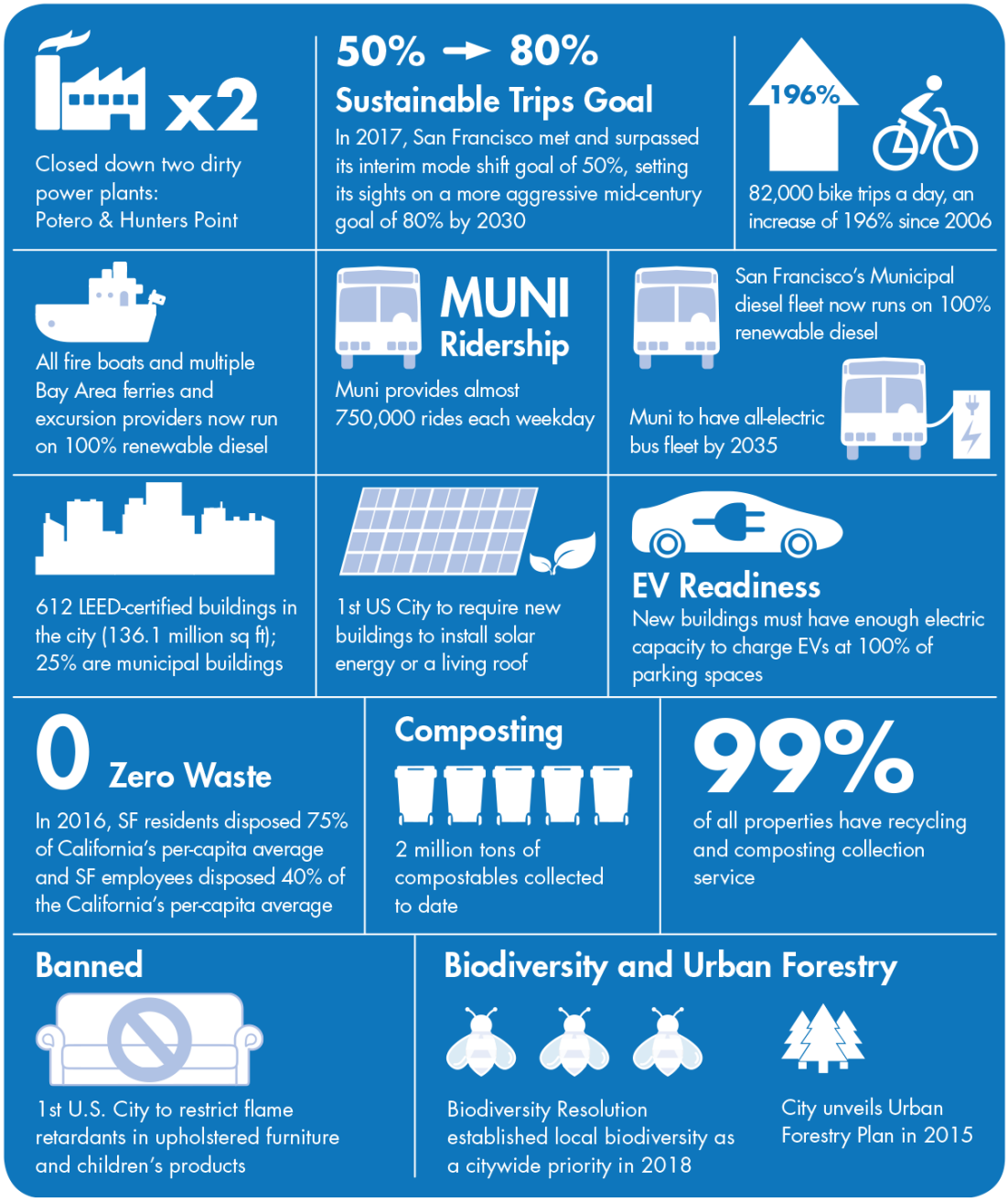


FIGURE 1- ACHIEVEMENTS TO DATE

A Scenario-based Approach

San Francisco has been tracking and reporting emissions using globally accepted protocols since 2008 and has a deep understanding of the emissions produced from different sectors. Based on this understanding, the city has developed two scenarios, each of which uses San Francisco's 2017 emissions inventory as a baseline: A business-as-usual (BAU) scenario and a Goals scenario. The BAU scenario assumes the city does not advance or accelerate its climate efforts further and consequently, does not reach its goals. The Goals scenario examines the potential emissions reductions that can be achieved if the city meets its 0-80-100-Roots commitments.

This analysis also examines how emissions reductions in the transportation and buildings sectors might be impacted by the timing of meeting the 0-80-100-Roots commitments. Specifically, for the transportation sector we evaluated the impact of slowing down the time to achieve 80% sustainable trips, while for the building sector we evaluated the impact of speeding up the timing to achieve zero emissions new buildings.

TABLE 2 - ANALYSIS ASSUMPTIONS[7] [8] [9]

	BAU Scenario Assumptions	Goals Scenario Assumptions
Energy 	The electricity mix remains the same as in 2017, with renewables remaining at only 64% of the mix between now and 2050.	Future energy demands from the transportation and building sectors are met by a continued increase in renewables, with 100% renewable electricity by 2030 maintained through 2050.
Buildings 	Energy efficiency savings in new and retrofitted buildings do not increase more than current standards. The ratio of natural gas and electricity used in buildings remains the same as 2017.	New buildings are net zero emissions by 2030 and approximately 3% of existing buildings are retrofitted each year, resulting in a nearly 100% efficient existing-building stock and all-electric no later than 2050.
Transportation 	Trips taken by walking, biking and transit remain at 54% with no further increase between 2017 and 2050. Electric vehicles continue to be less than 2% of total vehicles registered in the City.	By 2030, 80% of all trips are taken by walking, biking, or transit, and 25% of private vehicles registered in San Francisco are electric.
Zero Waste 	Levels of refuse generated and disposed per capita remain the same as in 2017, however due to population growth the total amount generated and disposed increases.	Refuse generation is reduced 15%, and disposal is reduced 50% by 2030 despite population growth.

[7] The main assumptions of the BAU and Goals scenarios are summarized in Table 2 and described in detail in Appendix A.
[8] Renewable energy in San Francisco is defined as solar (PV), wind, small hydro and existing large hydroelectric, geothermal, and biomass.
[9] The World Green Building Council defines net zero carbon buildings as a building that is highly energy efficient and fully powered from on-site and/or off-site renewable energy sources (non-CO_2 emitting).

PHOTO COURTESY LUMINALT 1

Energy

Eliminating fossil fuels as a source of power generation, known as decarbonizing the electric grid, is central to achieving our ambitious emissions-reductions goals. Today, the electric grid continues to become cleaner; in 2017, electricity supplied to San Franciscans was 82% emissions-free[10], with 64% of electricity generated from renewable sources that include wind, solar and existing large hydropower. City-owned buildings are powered by 100% GHG-free electricity[11] and CleanPowerSF, San Francisco's Community Choice Aggregation program, is increasing its renewables portfolio and expanding its customer base.

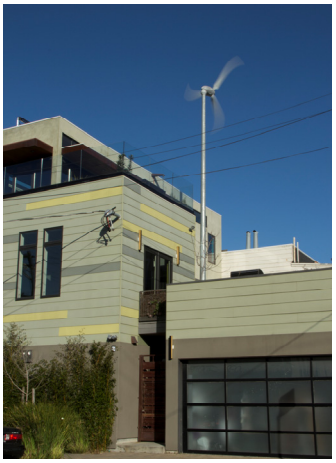


PHOTO BY LAURA SASSO

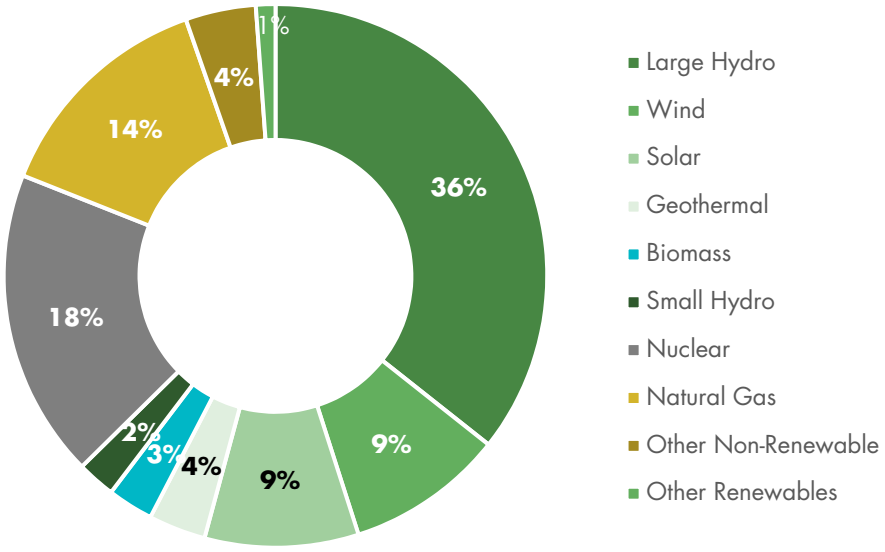


FIGURE 2 - SAN FRANCISCO 2017 ELECTRICITY GRID MIX

To achieve net zero emissions by 2050, San Francisco must continue to focus on supplying energy from emissions-free, renewable sources. In the buildings and transportation sectors, the city must ensure the use of efficient electric technologies powered by renewable electricity. To support grid optimization, it will also be important that these efficient, electric technologies be combined with smart time-of-use devices and energy storage solutions.

[10] In 2017, only natural gas and other non-renewable electricity sources generated emissions.
[11] In 2010 the city fully sourced GHG-free electricity from the San Francisco Public Utilities Commission's (SFPUC) Hetch-Hetchy system.

The analysis conducted for this report estimated that by 2050 demand for electricity could increase as much as 94%. Even with improvements in energy efficiency, electricity demand will increase due to local population growth (and a commensurate increase in housing units and commercial spaces), a switch to electric heating and cooling systems, and an exponential uptick in electric vehicle usage. If San Francisco is to meet this demand in the coming decades while simultaneously reducing emissions, it will thus be crucial to accelerate the development of cost-effective, renewable energy resources that can be reliably dispatched when needed.

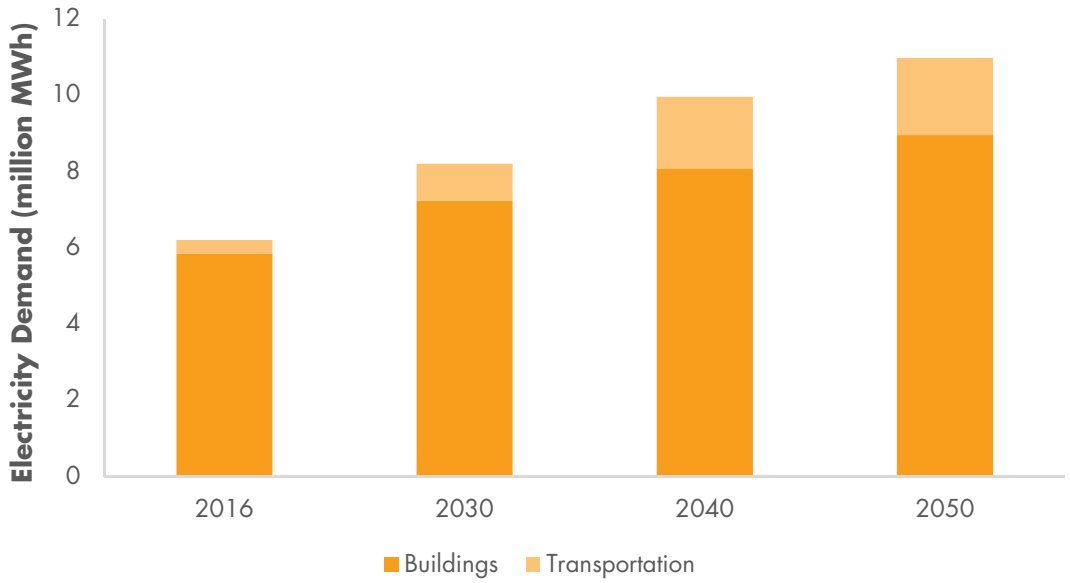


FIGURE 3 – ESTIMATED ELECTRICITY DEMAND INCREASE FROM BUILDINGS AND TRANSPORTATION

Path Forward

The transition to a city powered by 100% renewable electricity will depend on a diversity of offsite (CleanPowerSF) and onsite renewable power sources (rooftop solar photovoltaic systems); energy storage; and the mass deployment of electric appliances and vehicles. A smart, clean grid can benefit San Francisco residents by providing reliable power during times of need, for example after a disaster or an extreme weather event[12]. The importance of reliably providing 100% renewable electricity for our buildings and transportation systems cannot be understated. Should the city fail to meet its renewable electricity goal by 2030, and continues to use natural gas and other fossil fuels, San Francisco could see up to five times more cumulative emissions by 2050. Achieving 100% renewable electricity faces financial and environmental hurdles, highlighting the imperative to continue reducing energy usage through both efficiency measures and consumer behavior change.

[12] https://sfgov.org/orr/sites/default/files/documents/Lifelines%20Council%20Interdependency%20Study.pdf

Buildings

Between 2004 and 2016, progressive green building codes resulted in more than 133 million square feet of LEED-certified buildings in San Francisco, including 52 city-owned properties. Additionally, since 2013, the San Francisco Energy Watch and Bay Area Regional Energy Network (BayREN) energy efficiency programs collectively reduced electricity use 200 GWh, resulting in more than $3.7 million in estimated energy savings.

In part due to these efforts, in 2017 buildings were responsible for only 44% of citywide emissions[13], with commercial and residential buildings contributing almost equally. Most building emissions stem from the use of natural gas for water heating and space conditioning (heating and cooling). Electricity use for lighting, mechanical equipment, and "plug loads" (e.g. computers, televisions, microwaves, etc.) generated less than one-fifth of building emissions in 2017. Despite a significant increase in the number of buildings in San Francisco and the widespread proliferation of personal electronic devices requiring constant charging, emissions from buildings have declined 51% relative to 1990 levels.

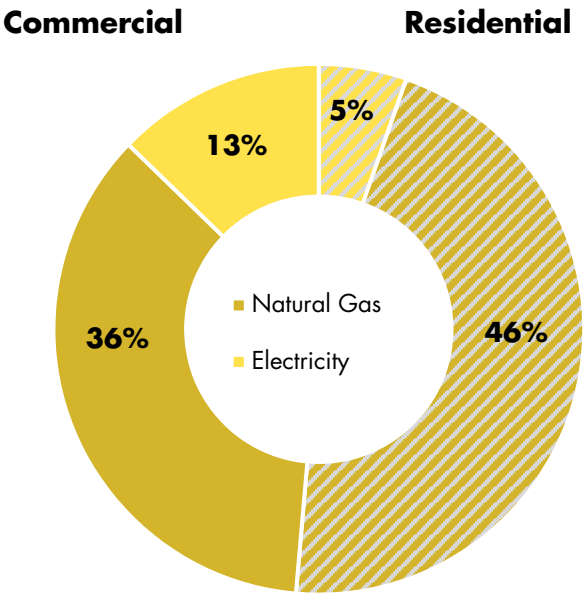
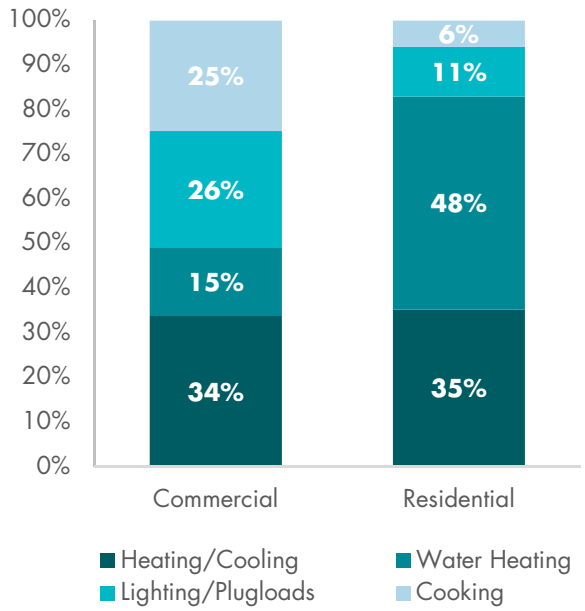


FIGURE 4– BUILDING EMISSIONS BY SUB-SECTOR, 2017

[13] https://sfenvironment.org/carbonfootprint



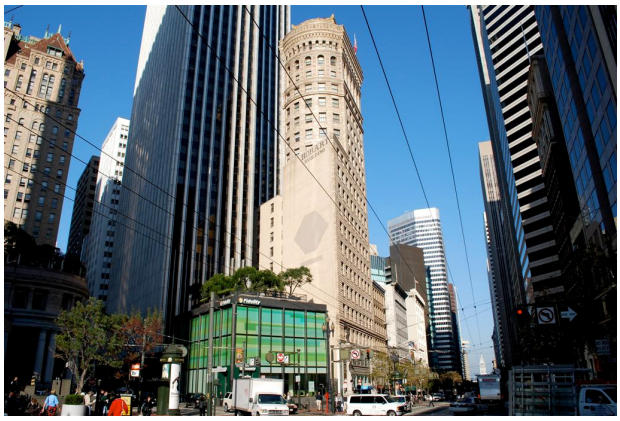


FIGURE 5 - BUILDING EMISSIONS BY END-USE[14]

Strategic Priorities

Transitioning away from fossil fuels is key to driving down building sector emissions. A large majority of buildings in San Francisco rely on natural gas for space- and water-heating which, combined, account for 49% of commercial building emissions and more than 80% of residential building emissions. Eliminating natural gas is possible and cost-effective with current technologies, such as high-efficiency electric heat pumps, which can be powered by renewable electricity. The benefits of transitioning to electric end-uses can be maximized through a continued focus on energy efficiency efforts like increasing insulation and sealing leaky walls and windows, which reduce demand for heating and cooling while bringing other health and comfort benefits.

2030 Emission-Reduction Potential

Aggressively increasing electrification in new and existing buildings could reduce sector emissions 22%. Increasing energy efficiency could likewise reduce sector emissions 10% by 2030, compared to business-as-usual. A complete transition to 100% renewable electricity by 2030 will contribute an additional 24% to building sector emissions reductions compared to business-as-usual.

Buildings Strategic Priorities

Electrify space- and water-heating with high-efficiency products such as heat pumps

Increase building energy efficiency

Power buildings with 100% renewable electricity

[14] 2006 California Commercial End Use Survey (CEUS)

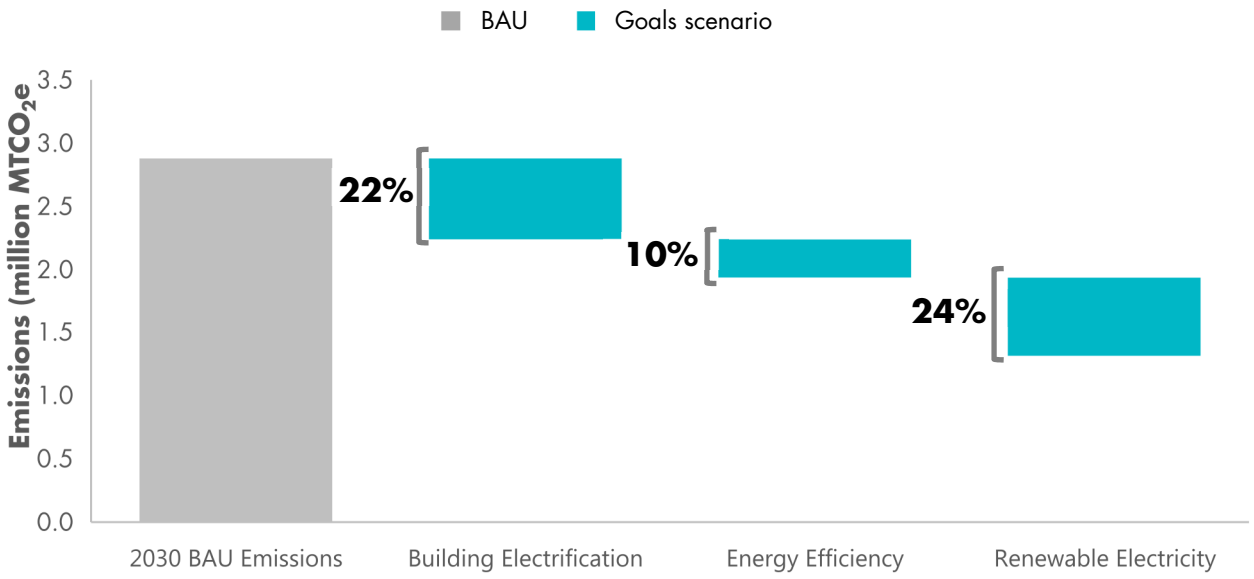


FIGURE 6 - POTENTIAL EMISSIONS REDUCTIONS IN THE BUILDING SECTOR BY 2030

New Construction

San Francisco adds an average of 4.5 million square feet of new buildings per year.[15] Ensuring new buildings are all-electric and energy efficient from the start will reduce emissions and provide immediate co-benefits, while avoiding the costs of expensive electrification retrofits in the future. San Francisco has committed to zero emissions new construction by no later than 2030. Accelerating this to 2023 could result in 44% lower emissions from new buildings over the next decade, while accelerating to 2020 would reduce emissions by 80%.

[15] Estimate based on projected population growth rates for San Francisco and the 2016 land use total square footage by use type.

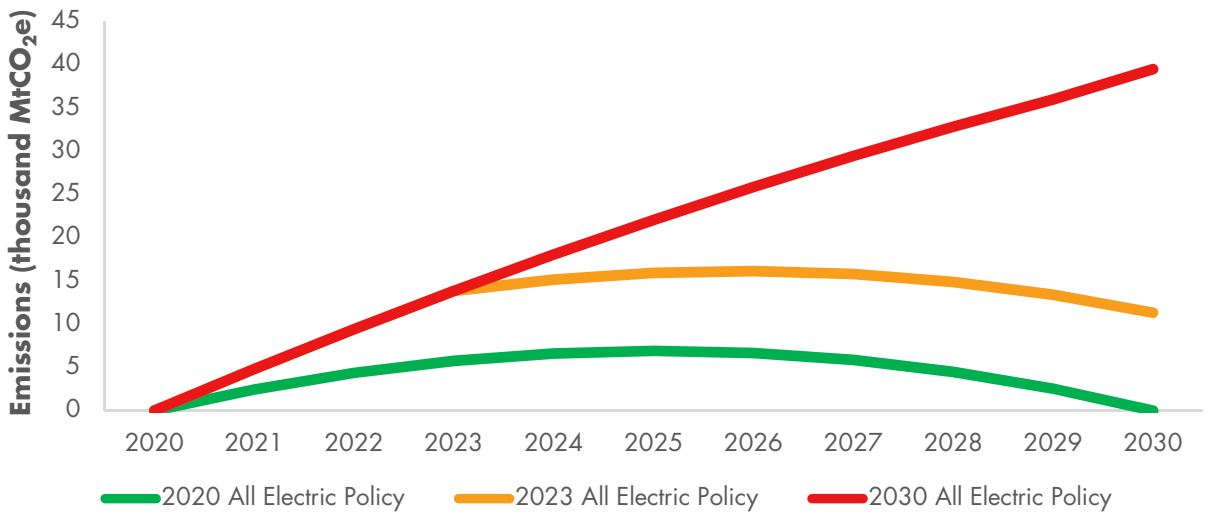


FIGURE 7 - IMPACT OF ACHIEVING ALL-ELECTRIC NEW CONSTRUCTION IN 2020 VERSUS 2023 AND 2030

Existing Buildings

It is currently estimated that about 5% of all energy-consuming equipment used in buildings "turns over" each year (i.e. is replaced because it is broken or has reached the end of its useful life). Today, gas equipment is typically replaced with a similar gas-burning system. To achieve net zero emissions by 2050, at least 3% of all existing gas-based equipment in buildings must be replaced annually with electric systems, starting today. Any delays in initiating steady and systematic electrification of existing buildings will result in a much higher volume of future electrification retrofits needed to meet San Francisco's goals.

Electrifying existing buildings is inherently more challenging than electrifying newly constructed buildings. Efforts currently underway to speed up electrification retrofits in the near- and long-term include, but are not limited to: updating state rules to make ratepayer funds available to support electrification retrofits; adjusting utility rates to ensure equity and maximize bill savings; engaging with product manufacturers and contractors to reduce costs and meet increasing demand; and educating consumers about the many benefits of these technologies.

Path to Zero Emissions

The Goals scenario makes several assumptions with respect to the building sector Strategic Priorities, namely that starting in 2030, all new buildings will be all-electric and efficient; that starting today, existing buildings must be retrofitted with efficient, all-electric systems at an average annual rate of 3% per year; and that electricity will be emissions-free by 2030. Collectively, the Strategic Priorities have the potential to reduce emissions by 95%, leaving about 5% of residual emissions in 2050.

Achieving these levels of efficiency and electrification in new and existing buildings is critical given the fact that once electricity is emissions-free in 2030, further reductions can only be derived from eliminating natural gas. Given the current rate of existing building electrification, the assumptions in the Goals scenario will not be realized without considerable effort. Ensuring that all, or nearly all retrofits, renovations, and equipment replacements are electric is essential to achieving our net zero emissions goal.

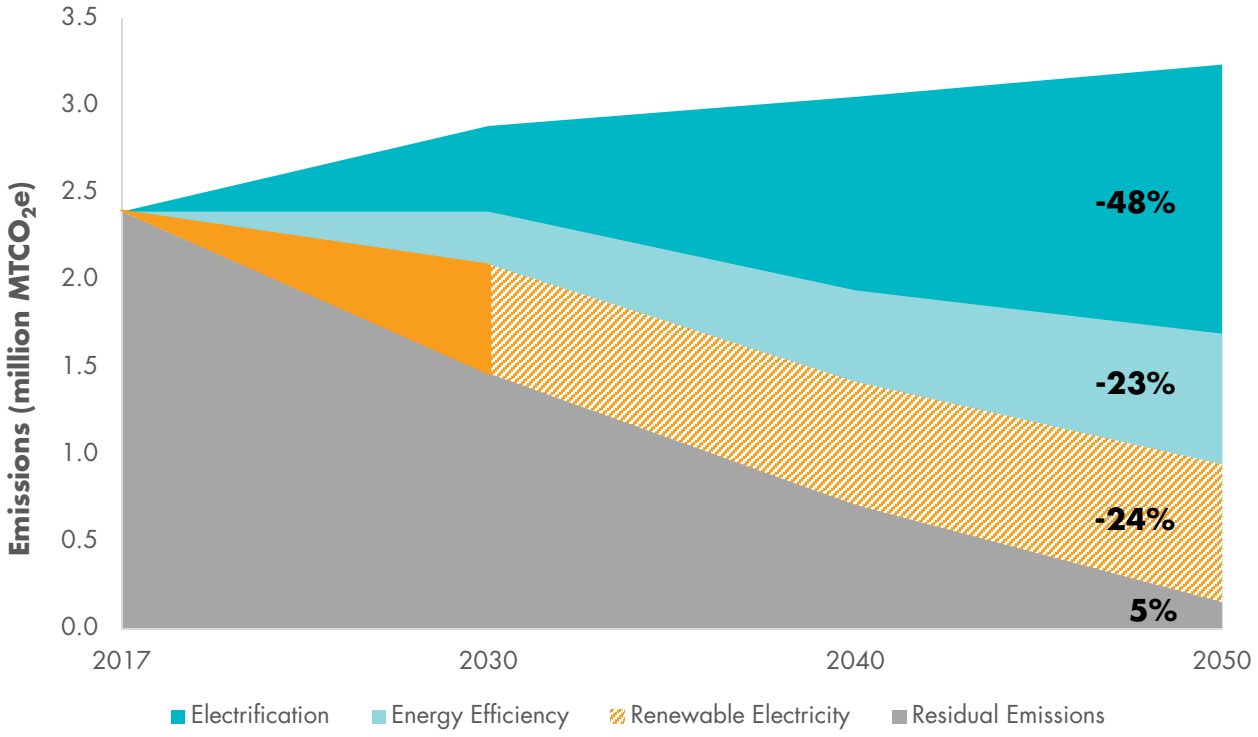


FIGURE 8 - PATH TO ZERO EMISSIONS IN BUILDINGS

Summary of Actions to Help Achieve the Strategic Priorities

Ensuring San Francisco's electricity is emissions-free, and progress is made towards a just transition to highly efficient electric buildings would result in many advantages for developers, owners, and tenants, including lower construction and operating costs, improved indoor air quality, and increased safety. This transition could also lead to buildings that are more resilient to the impacts of climate change. Zero emission new buildings are possible today and are necessary to avoid expensive retrofits in the future. Retrofitting existing buildings will require greater effort, engagement, and careful evaluation to ensure energy affordability for all. To support this, San Francisco will continue to engage with local, regional and state stakeholders and policymakers to unlock new financial tools and resources; bring product manufacturers, contractors, and labor into the electrification marketplace; and educate building owners and the public on the multiple benefits of low-carbon building technologies.

Building Co-benefits

Taking action to reduce emissions in the building sector could result in numerous benefits for equity, health, environment, economy, and resilience.

Equity
In San Francisco, low income and communities of color disproportionately live in buildings without proper weatherization and adjacent to industrial activities or freeways and high-density arterials. Energy efficiency measures like insulation help maintain comfortable interior temperatures and keep heating and cooling costs low, which will benefit low-income residents who spend a higher percentage of their money on utilities. Enhanced ventilation in more efficient systems also closes the gap in exposure to air pollution.

Health
Today nearly all residential buildings in San Francisco are heated by natural gas and do not have cooling. Switching to high-efficiency electric heat pumps can provide emissions-free heating and provide cooling, which is especially important for vulnerable populations such as the elderly and young children during heat waves. Burning natural gas in household appliances including gas cooking produces indoor air pollution that can cause immediate and long-term respiratory problems, especially for young children and people with asthma. Air-sealing and supplying mechanically filtered fresh air limits exposure to outdoor contaminants and can greatly improve indoor air quality, while also keeping energy costs low.

Environment
Eliminating natural gas reduces leaks of methane – a super greenhouse gas that traps more heat in the atmosphere over a shorter period than carbon dioxide. Transitioning to high-efficiency electric heat pumps would eliminate the use of methane as a fuel and reduce risk of leaks both within homes and from distribution pipes.

Economy
Zero emissions buildings support economic development and create new local jobs for workers who construct and retrofit buildings. As residents save money on energy bills and employment grows, more capital is available to go back into the local economy.

Resilience
Natural gas infrastructure poses safety risks, notably from fire hazards associated with leaks that can be exacerbated after earthquakes. It is estimated that after a major earthquake, it could take just one week to restore electric service, but up to six months to restore gas. All-electric buildings can also be integrated with solar panels and battery storage to power critical loads and services needed in an emergency.

Transportation

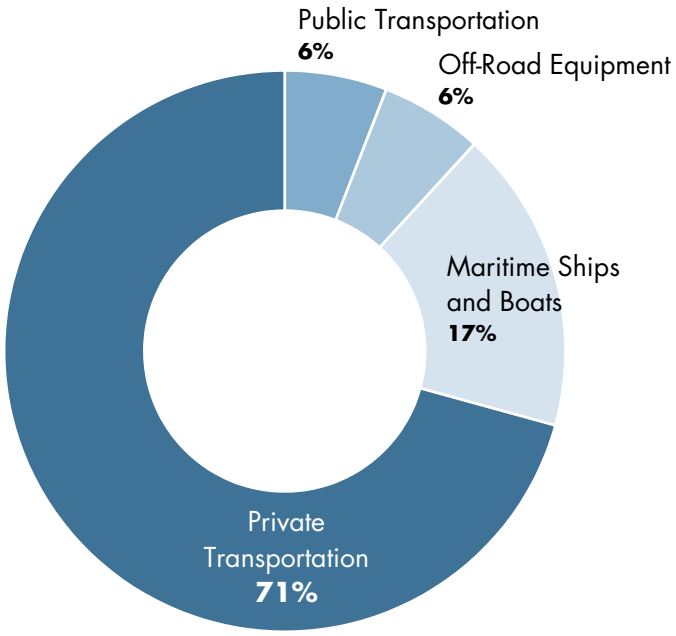
San Francisco is fully committed to implementing its Transit First policy, which focuses on getting people out of cars by increasing the share of trips made by sustainable modes such as biking, walking and transit. Sustainable modes are the cornerstone of San Francisco's strategy to achieve a zero emission transportation sector. In addition to being low- to zero emissions, biking, walking and transit reduce congestion, improve public health and safety, and are often more equitable, sustainable, and affordable. Efforts to coordinate transportation and land use planning also help ensure that job and housing growth support Transit First and also reduce emissions in the long term.

Progress to-date toward this policy, established in 1973, is clear: in 2017 San Francisco surpassed its former mode-shift goal of 50%, with residents using sustainable modes for 54% of their trips. This is promising given over half of San Francisco's public transit fleet, including light rail, cable cars, historic streetcars and electric trolley buses, are powered by emissions-free electricity, with the remaining bus fleet to be converted to all-electric by 2035.

Despite this progress, success in reducing transportation-related emissions has been slower. Since 1990, emissions from the transportation sector have decreased by only 10%. In 2017 San Francisco's rapidly evolving transportation sector was responsible for 46% of citywide emissions, with most of these (71%) coming from private cars and trucks that also cause severe traffic congestion, safety hazards, and negative impacts on quality of life. Public transportation and off-road equipment[16] each contributed a small portion to transportation-sector emissions (6% respectively), while maritime ships and boats made up the remainder (17%).

[16] Off-road vehicles and equipment refers to non-transport uses such as generators, construction machinery, etc.

San Francisco's public transportation system contributes less than 6% of the sector's emissions. As part of its transition to zero emissions, it runs on 100% renewable diesel since 2015. Renewable diesel hybrid electric buses will be fully electric by 2035. Given this transition, the city is now focusing on how to promote the transition of private cars and trucks to zero emission vehicles while upholding key policies, including the Transit First policy.



Transportation Strategic Priorities

80% of all trips in 2030 are taken by walking, biking and transit

25% of private cars and trucks are electric by 2030 and 100% by 2040

FIGURE 9 - TRANSPORTATION EMISSIONS BY SUB-SECTOR, 2017

Strategic Priorities

Achieving deep emissions reductions in the transportation sector will require the public to continue to increase biking, walking and transit trips as well as a transition to zero emission (electric) cars and trucks. There is substantial work ahead if San Francisco is to accelerate these changes and realize deep emissions reductions in this sector. Travel behavior—including mode choice, total vehicle miles travelled, type of fuel used, and vehicle efficiency—is a key factor influencing transportation emissions. Trip distance is a major influence on travel behavior, informing the cost and perceived ease of the mode taken. San Francisco is working to shift travel behavior through approaches that include transit-oriented development, transportation demand management, complete streets infrastructure, and more.

2030 Emissions Reduction Potential

A combination of mode shift and fuel switch is required to reduce emissions in the transportation sector. By 2030, if San Francisco achieves its ambitious Sustainable Trips[17] goal of 80%, sector emissions could be reduced 39% compared to business-as-usual (current mode share: 54% of all trips by bike, walk or transit).

In addition, if 25%[18] of private cars, trucks and other private-mobility modes[19] that remain on the road transition to electric, a further 18% reduction could be achieved. Moving beyond the current 2% of electric vehicles in the city to 25% (or more) will require an increase in electric vehicle charging stations available to the public across the city.

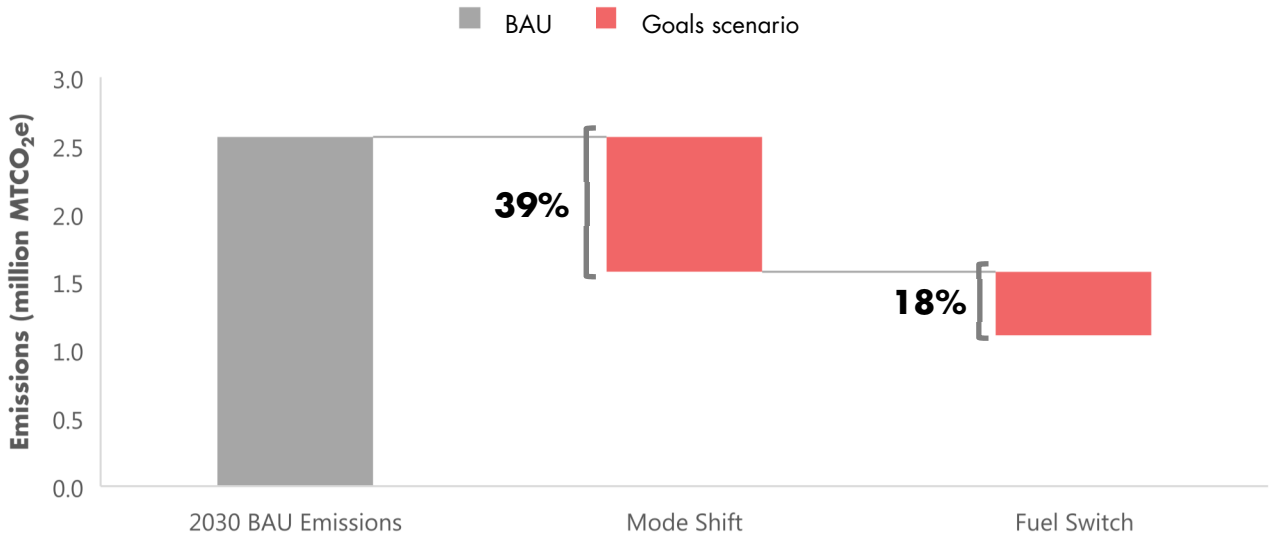


FIGURE 10 – POTENTIAL EMISSIONS REDUCTIONS IN THE TRANSPORTATION SECTOR BY 2030

Impact of Mode Shift

If San Francisco achieves its 80% Sustainable Trip goal while concurrently electrifying 25% of the cars and trucks that remain on the road, transportation-sector emissions could decline 57% by 2030 compared to business-as-usual. However, if only 60% of trips in 2030 are taken by bike, walk or

[17] For this report, a Sustainable Trip is defined as any trip taken by biking, walking or using transit. SFMTA's Strategic Plan defines a sustainable travel mode as one that supports the city's climate action goals and one that also meets the long-term economic, social, and physical needs of the city. Because they directly support these goals, the SFMTA will promote walking, bicycling, and public transit, as well as those modes that complement their use, like taxis and vehicle sharing. Determination of the sustainability of other transportation modes and methods used to travel to, from, and within San Francisco will be made in later SFMTA planning and strategy work as data becomes available.

[18] This percent was estimated based on California's state goal of 5 million electric vehicles on the road by 2030. San Francisco's Electric Vehicle Roadmap has set a vision for all trips originating in, ending in or passing through San Francisco to be emissions-free by 2040. While these goals are more stringent, they are consistent and complement regional goals as defined in the 2017 Clean Air Plan and Plan Bay Area 2040.

[19] Private mobility includes cars, vans and medium-or heavy-duty trucks, taxis, paratransit, emerging mobility fleets, and commuter shuttles, as well as motorbikes and scooters scooters.

transit, the pace of emissions reduction will be slower—a 33% decline–even with the same 25% electric vehicle adoption rate. Beyond slower emissions reductions, this outcome would result in an increase in private cars and trucks, private-vehicle trips taken, and vehicle miles traveled within the city. This could have significant impacts on our already congested streets, making the transition to electric cars and trucks much more difficult, and negatively affect the quality of life of all San Franciscans.

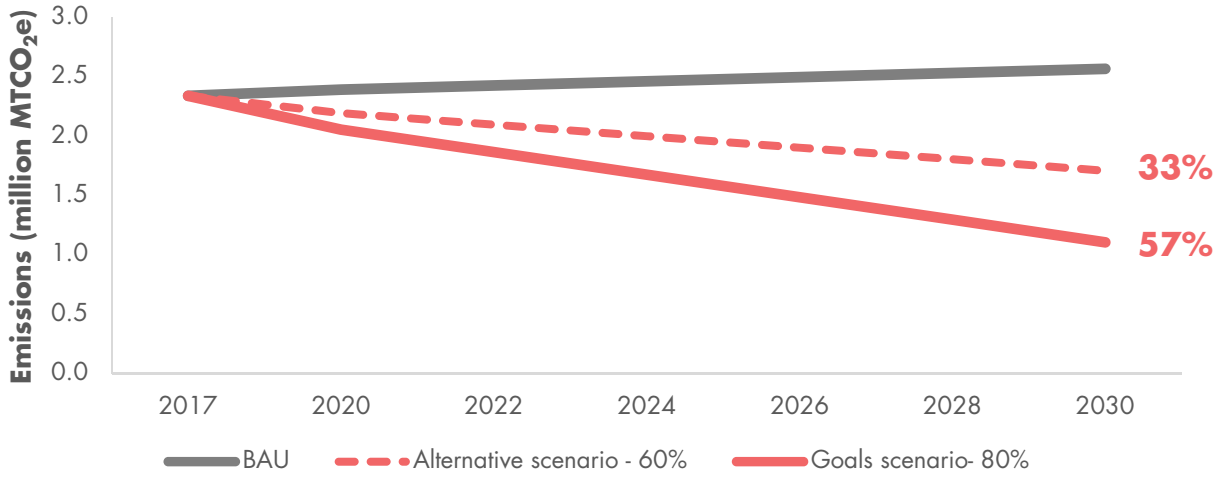


FIGURE 11 - IMPACT OF ACHIEVING 80% SUSTAINABLE TRIPS IN 2030 ON EMISSIONS REDUCTION

Path to Zero Emissions

By 2050, emissions in the transportation sector could decline 81% under the Goals scenario compared to business-as-usual. Zero emissions in the on-road portion of the sector (public and private transportation) is within reach. However, getting to zero is challenging because emissions from large maritime ships, boats, and off-road equipment are currently beyond the control of the city. San Francisco will need to work with other cities in the region, as well as the state government to address residual emissions[20] from the sector. Partnerships and collaboration will be essential to promote zero emission policies and technologies for the maritime sector. As for electric off-road equipment, there have been recent advances in low emissions alternatives, however, transitioning to zero emissions will require innovation and market transformation extending beyond the city's sphere of direct influence.

[20] Residual emissions are those where the city has limited options to eliminate or reduce further.

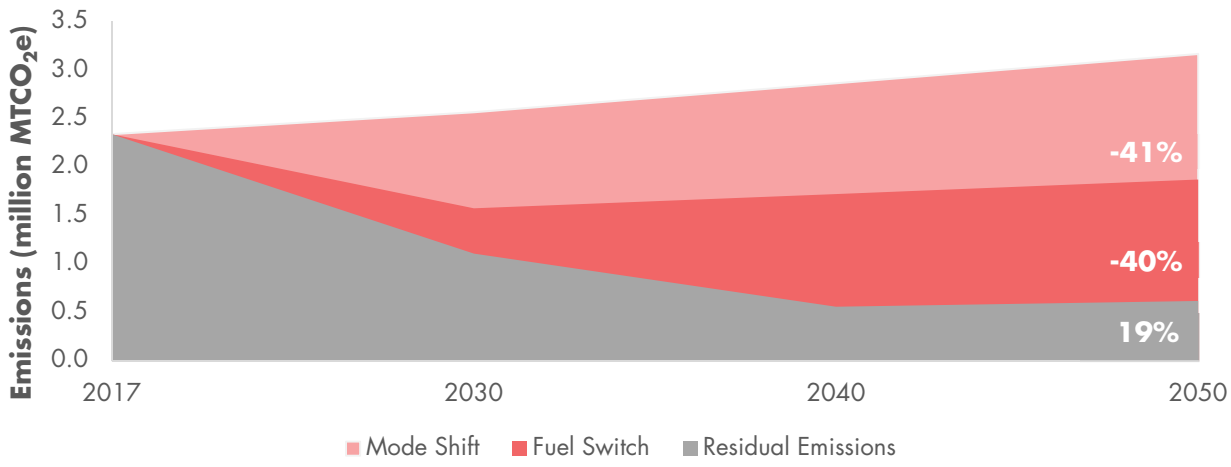


FIGURE 12 - PATH TO ZERO EMISSIONS IN THE TRANSPORTATION SECTOR

Summary of Actions to Help Achieve the Strategic Priorities

San Francisco has already reduced emissions from some portions of the transportation sector. Accelerating and expanding these reductions will require improving and expanding our transit system, including additional bus rapid transit (BRT) corridors, rapid networks, system upgrades and facility investments. Expediting reductions will also require implementing new policies and programs, such as congestion pricing, while expanding existing infrastructure, such as improving the extent and safety of the bicycle and pedestrian networks. Continued efforts to influence travel behavior will also be necessary and might include creating jobs and housing near transit, focusing on transformative transit investments, and promoting sustainable transportation for all, education and incentives. Lastly, San Francisco must accelerate its efforts to develop a publicly available electric vehicle charging network, for example in off-street parking facilities.

Transportation Co-benefits

Taking action to reduce emissions in the transportation sector could result in numerous benefits for equity, health, environment, economy, and resilience.

Equity
People of color, low-income communities, and people with disabilities are often disproportionately burdened by mobility and accessibility challenges. Enhancing biking, walking, and transit systems is part of a larger strategy to make transportation more accessible and affordable for all. These modes also encourage denser and more affordable development, while improving community cohesion.

Health
Walking and biking improve physical health outcomes. Greater investment in safer streets could reduce pedestrian and bicycle injuries and fatalities. Reduced congestion and zero emission vehicles decrease tailpipe emissions and can improve local air quality for low-income communities, who often suffer from greater pollution exposure, and for those who suffer from asthma and chronic respiratory illnesses. Biking, walking and transit also help reduce stress and travel time while encouraging clean, safe, and lively streets.

Environment
More affordable, active transit and public mobility options for all can result in fewer private vehicles and less congestion. Biking, walking, transit and zero emission vehicles reduce air pollution, the extraction and processing of oil and gas, and greenhouse gas emissions. Non-motorized modes reduce noise and eliminate the risk of water pollution derived from fluid leaks.

Economy
Biking, walking, and transit connect people to jobs in San Francisco and have the potential to provide better access to goods and services. Residents, workers and visitors can save money by using these alternatives rather than paying for fuel, vehicle parking and maintenance. Switching from fossil-fuel powered vehicles to electric vehicles could lower lifetime operational costs. In addition, the low-carbon transportation sector promotes job growth around electric-vehicle maintenance, bicycle repairs and sales, and software development for bike sharing. Research shows that bicycle and pedestrian infrastructure can also help improve local businesses by making them more visible to people using these modes.

Resilience
More diverse and extensive active transportation and transit options, as well as zero emission vehicles that operate using local electricity, could help support San Francisco's ability to remain operational in the face of extreme weather events, congestion, or unexpected fuel shortages. Solar-powered charging stations could fuel electric vehicles when the grid is down, and these stations would have a supplemental benefit of helping to stabilize the electric grid.

Zero Waste

San Francisco is a global leader in waste reduction and one of the first large U.S. cities to collect and compost food scraps and ban single-use plastic bags. In 2003, the city set a goal to achieve zero waste. Zero waste means reducing, reusing, recycling or composting discarded materials—in that order—with the goal of nothing disposed to landfill or incineration.

PHOTO BY LARRY STRONG, COURTESY RECOLOGY 1

Infrastructure investments, mandatory recycling and composting, and convenient access to the three-stream collection system (recyclables, compostables, and landfill) have resulted in a dramatic increase in recovery and a reduction in disposal. In the twelve years between 2000 and 2012, material sent to landfill was cut in half, resulting in a 62% reduction in emissions. However, between 2012 and 2016 rapid economic growth and a construction boom resulted in a 36% increase in disposal.

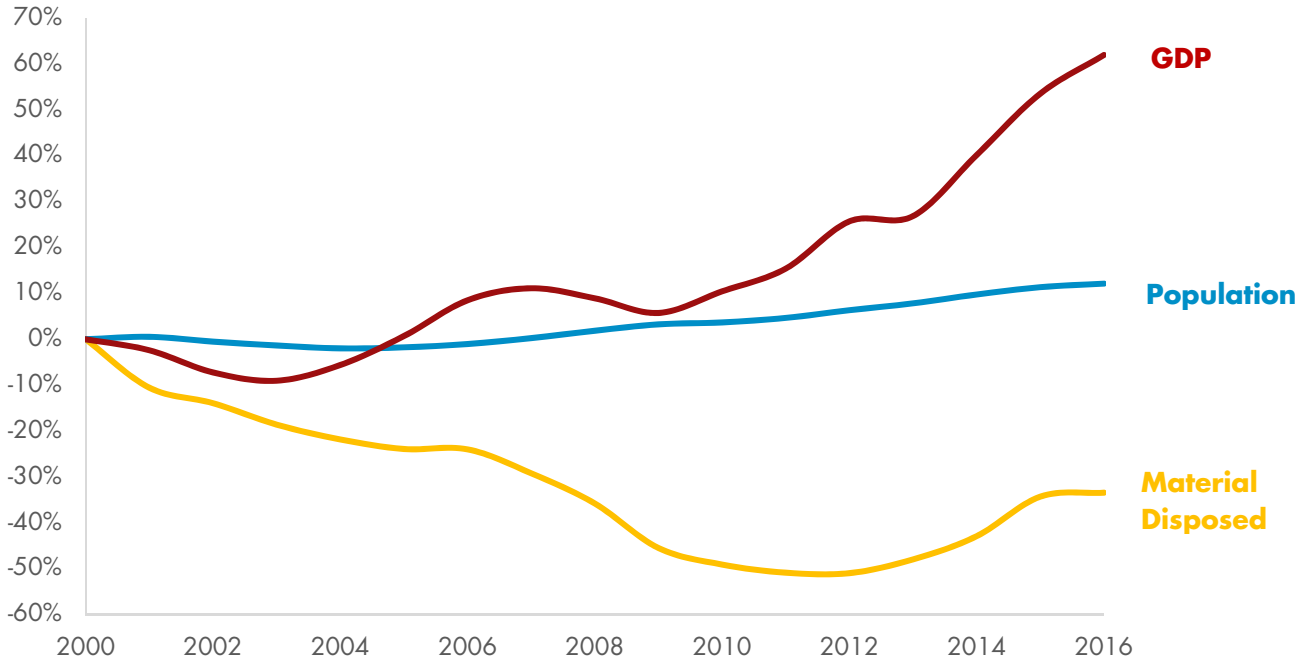


FIGURE 13 – SAN FRANCISCO POPULATION, GDP AND MATERIAL-DISPOSAL TRENDS FROM 2000 TO 2016

In 2016, almost half of the materials disposed to landfill from San Francisco were organics and paper, with organic materials responsible for 6% of citywide sector-based[21] emissions. The other half of disposed material was from construction and demolition (C&D) and other inert materials. Construction and demolition discards include materials that do not decompose and therefore do not

[21] A sector-based inventory accounts for emissions happening within a defined geographic area and time period in the following sectors: stationary energy (buildings), transportation, waste, industrial processes and product use (IPPU), and agriculture, forestry and other land use (AFOLU).

generate direct greenhouse gas emissions. However, organic materials such as wood that do generate emissions still make up about 5% of C&D debris disposed, hence why it is important to prioritize approaches that ensure material is recovered rather than landfilled.

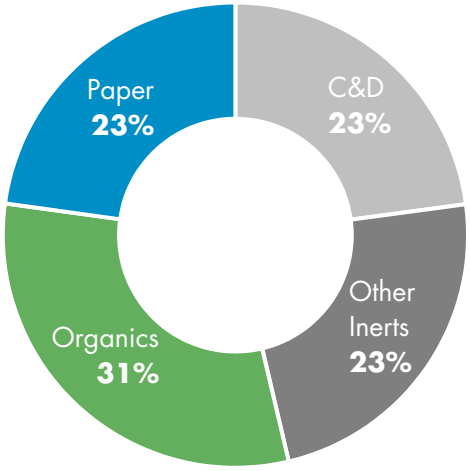


FIGURE 14 – 2013 MATERIAL DISPOSAL CHARACTERIZATION STUDY

Strategic Priorities

While San Francisco is a global leader in waste reduction, achieving net zero emissions will require bolder action. Recognizing this, San Francisco recently furthered its commitment to zero waste by pledging to aggressively reduce the amount of waste generated and disposed. This commitment is critical because a growing population and a culture of consumption have led to a near doubling of refuse[22] generated since 2000. While not accounted for in the citywide sector-based emissions inventory, the consumption and discard of products, even those that are inorganic or inert, have an outsized global emissions impact (see next section on Sustainable Consumption).

Zero Waste Strategic Priorities

Reduce refuse generation 15% by 2030

Reduce disposal to landfill and incineration 50% by 2030

[22] Reducing refuse generation refers to reducing the total amount of material discarded to recycling, composting and landfill.

2030 Emission Reduction Potential

Reducing refuse generation 15% by 2030 could reduce sector emissions 25% compared to business-as-usual, while decreasing disposal by 50% could result in an additional 31% reduction.

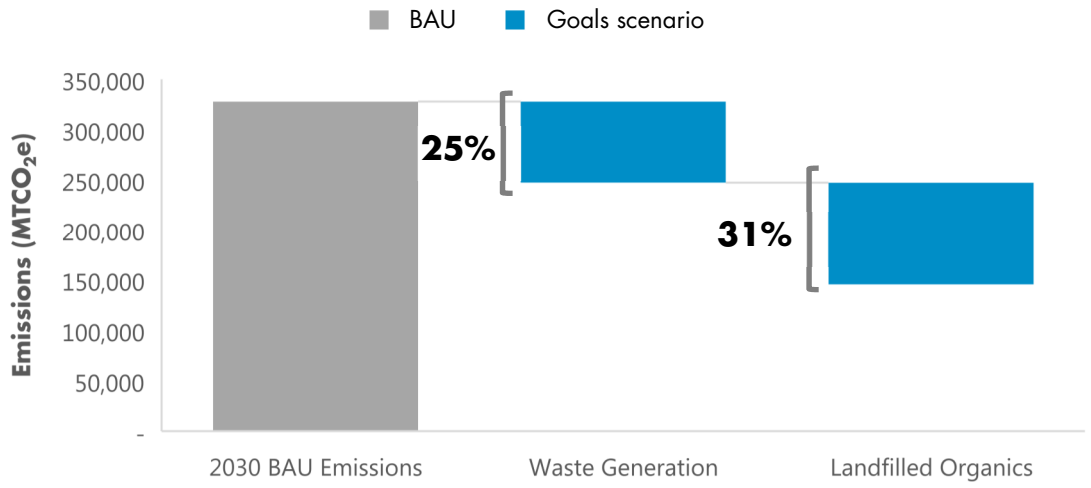


FIGURE 15 – POTENTIAL EMISSIONS REDUCTIONS FROM ZERO WASTE BY 2030

Path to Zero Emissions

Near zero emissions is possible in the waste sector. By achieving the 2030 zero waste commitments and continuing to advance similar ambitious goals until 2050, reducing emissions by 91% is possible, leaving only a small amount of residual emissions from organic material that ends up in landfills. San Francisco is already working to address these emissions by exploring new technologies that can recover all organics before disposal, with a goal to bring these online before 2030.

PHOTO BY LARRY STRONG, COURTESY RECOLOGY 2

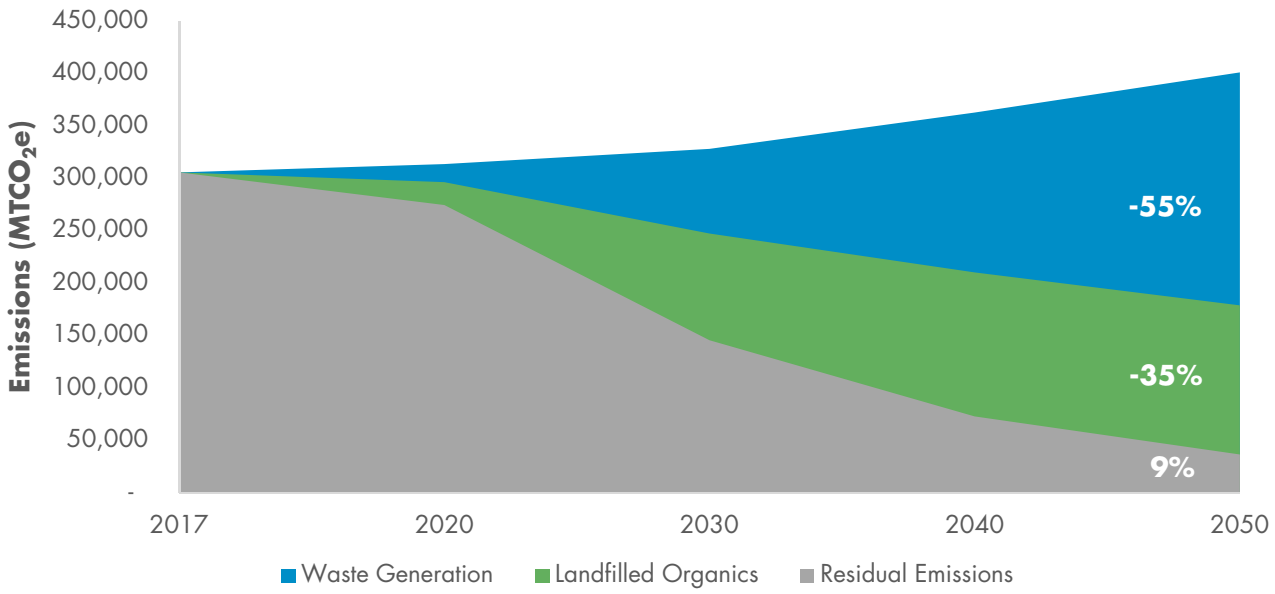


FIGURE 16 – PATH TO ZERO EMISSIONS FOR ZERO WASTE

Summary of Actions to Help Achieve the Strategic Priorities

To accelerate progress toward zero waste, San Francisco will continue to pursue groundbreaking behavior-change policies, infrastructure investments, and new technologies that maximize resource recovery and eliminate waste at its source. Actions and policies that can help the city achieve its zero waste goals include focusing on construction and demolition material; preventing food waste; increasing the recovery of organics, paper and other materials; reducing single-use products; and ensuring accessibility and inclusivity of zero waste programs.

PHOTO BY LARRY STRONG, COURTESY RECOLOGY 3

Zero Waste Co-benefits

Taking action to reduce emissions from refuse generation and disposal could result in numerous benefits for equity, health, environment, economy, and resilience.

Equity

The pursuit of zero waste is a community effort that helps build capacity around material recovery. It allows for the recovery and redistribution of useful goods such as food, furniture, clothing and office supplies to those in need. For communities that live near material sorting and storage facilities, reducing waste generation reduces traffic, air and noise pollution.

Health

Material reuse and recycling reduces air and water pollution from the mining and transportation of raw materials. Resource recovery minimizes landfill toxins that pose a serious threat to neighboring communities. Compost that is applied to land can reduce chemical fertilizer and pesticide use, improving soil health and fertility, and naturally mitigate air and water pollution. Reducing the use of single-use plastics also reduces the exposure to toxic emissions that are released when heating or burning plastic. Plastic bags can block drains and the sewage system which can become a breeding ground for mosquitoes and other pests.

Environment

Zero waste efforts help preserve valuable and scarce natural resources by permitting the reduction, reuse and recovery of materials. These efforts prevent plastics, glass and metals from ending up in our oceans and threatening marine life. They also reduce virgin material use and decrease energy used in the extraction, processing and transportation of raw materials. Recovered organics can be used to produce compost that sequesters carbon and improves soil health, crop production, and water retention.

Economy

Reducing, reusing, recycling and composting operations can more create local jobs than disposal operations, supporting the local economy. Sharing, reusing and fixing items costs less money than buying new items. Farmers and property owners who apply compost can save money by reducing the use of chemical fertilizers.

Resilience

By reducing the amount of discarded materials and increasing reuse, recycling, and composting, the risk of reaching landfill capacity is reduced. Limited and valuable landfill capacity can then be reserved for the disposal of non-recoverable debris generated during an emergency or disaster.


12 DRY PINTS
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CALIFORNIA GROWN
Strawberries
CALIFORN
STRAWBERR

Sustainable Production and Consumption

San Francisco's commitment to producing and consuming sustainably is not new. The city has longstanding programs and policies seeking to change consumption; requiring building energy and water efficiency, for example, reduces energy use. Reduction, reuse and recycling programs serve to minimize the use of new products and virgin resources. Further reducing the consumption of goods and services will help San Francisco to reduce refuse generation and presents a new opportunity to deepen the city's commitment to lowering global emissions.

The Focus 2030 analysis within this report is built on data from a conventional inventory that is sector-based and accounts for emissions generated from three main sources within the city: buildings, transportation, and waste (even when the landfill is outside the city). Yet to capture the impact that production and consumption patterns have on global emissions, a different approach that allocates emissions to producers or consumers of goods and services, regardless of where emissions occur, is needed. For example, a Consumption-Based Emissions Inventory (CBEI) measures emissions from a consumer lens, accounting for both "upstream" emissions (from production and manufacturing, pre-purchase transport, wholesale and retail sales), as well as "downstream" emissions (from use and disposal), accounting for all phases of the global goods and services supply chain.

Since most of the goods and services consumed in San Francisco are produced outside of the city's boundaries, the CBEI is considerably larger (up to three times larger) than the conventional inventory. Additionally, most of San Francisco's consumption-based emissions (63%) are from the production phase of the global supply chain, highlighting the need to explore ways to reduce consumption and measure and account for the city's progress in reducing these emissions.

Emissions from a Consumer Lens

A consumption-based emissions inventory (CBEI) is a different approach to understanding a city's emissions footprint. As opposed to a conventional, or sector-based inventory, the CBEI measures emissions that occur throughout the supply chain of goods and services consumed in an economy. For example:

Conventional Emissions Inventory: Captures emissions from food that decomposes in a landfill and releases methane into the atmosphere

Consumption-Based Emissions Inventory: Captures emissions from the farming, packaging, and shipping of food to San Francisco, including its eventual disposal

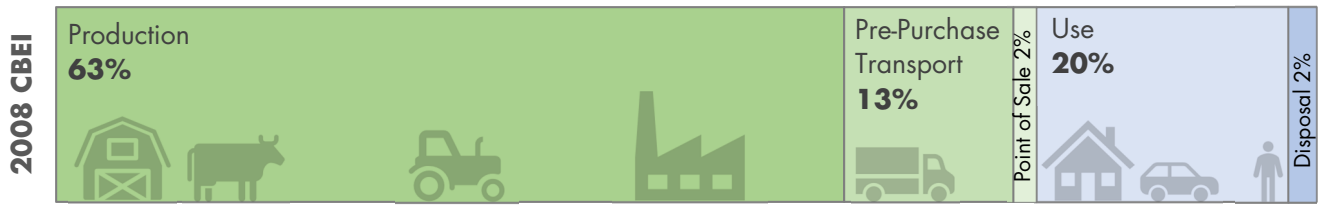

FIGURE 17 - SAN FRANCISCO'S CONSUMPTION-BASED EMISSIONS, 2008

Path Forward

Building on San Francisco's success in addressing sector-based, conventional emissions, the city will begin tackling emissions derived from the production and consumption of goods and services. Expanding the scope of emissions that the city takes responsibility for is a more comprehensive approach that better reflects San Francisco's impact on the planet. To help prioritize and drive new policies and programs, the city will focus on product and service categories that generate the highest emissions, including food and beverages; construction materials (e.g. wood, concrete); goods (e.g. electronics, clothing); and services (e.g. healthcare, education). Through behavior change initiatives, including innovative communication campaigns, policies, and programs, San Francisco will seek to reduce production and consumption-related emissions, accelerating deep reductions from global supply chains that operate beyond our geographic boundary.

Residual Emissions

Analysis of the emissions reductions that can be achieved in the building, transportation and waste sectors suggest that even after meeting the ambitious climate and sustainability targets described in the Goals scenario, San Francisco may still have to contend with 12% of business-as-usual emissions that cannot be eliminated. These residual emissions are those that remain due to limited existing options to eliminate or reduce them further.

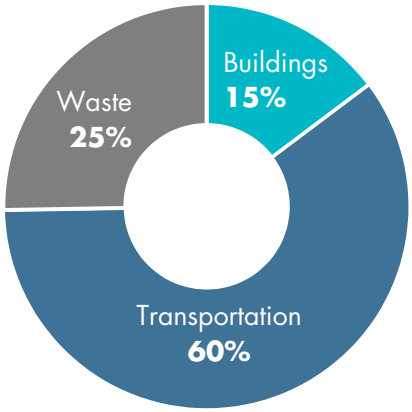

FIGURE 18 - RESIDUAL EMISSIONS IN 2050 BY SECTOR

About 15% of the residual emissions in 2050 are expected to originate from buildings that reduce but cannot not eliminate natural gas due to physical constraints, historic preservation issues, or similar intractable barriers. An additional 60% of estimated residual emissions in 2050 are expected to originate from the transportation sector, specifically maritime ships and boats and off-road equipment. Emissions from large maritime ships that visit the Bay Area are included in the transportation sector; however, San Francisco does not have direct influence over the types of fuels these ships use. Lastly, a quarter of residual emissions could come from organic materials that continue to be sent to landfill. As previously mentioned, San Francisco is already exploring new technologies to recover organics before they are disposed.

Over time, innovative technologies and new approaches may be developed to enable fuel switching in complex situations, and actions may be taken by other actors (such as the state or federal governments) that reduce or eliminate some sources of residual emissions. In the interim, rather than waiting, San Francisco has the opportunity to begin to address residual emissions both locally and in partnership with neighboring jurisdictions.

How Cities Might Address Residual Emissions

While there is limited guidance for cities on how to address residual emissions[23], options include:

- Developing, investing in or purchasing verified and traceable carbon offsets from a trustworthy provider.
- Avoiding emissions through the prevention, reduction, or destruction of sources such as ozone-depleting substances and industrial pollutants.
- Sequestering greenhouse gases from the atmosphere through land restoration, soil carbon sequestration[24], afforestation[25] and reforestation[26], mass timber in construction, bioenergy with carbon capture and sequestration, direct air carbon capture and storage, enhanced weathering[27] and ocean alkalinization.[28]

San Francisco's Residual Emissions Approach: Carbon Sequestration

San Francisco's 0-80-100-Roots framework addresses residual emissions in part through its focus on pulling carbon out of the atmosphere. Guided by its Roots goal, San Francisco can focus on sequestering carbon through ecosystem restoration and urban greening, urban forestry, and the land application of compost produced from locally collected organic materials. These practices remove greenhouse gases from the atmosphere through natural processes and contribute significantly to keeping our air clean and local temperatures stable.

Ecosystem Restoration And Urban Greening

The Intergovernmental Science and Policy Platform on Biodiversity and Ecosystem Services (IPBES) released a ground-breaking report on May 6, 2019 with a first-of-its-kind, comprehensive assessment of the critical state of the planet's species and ecosystems, including their significant potential contribution to addressing global climate change. San Francisco harbors a diverse mosaic of parks, natural areas, community gardens, green schoolyards and other open spaces. These areas are managed for beauty, recreation, biodiversity, wildlife habitat, and increasingly, for climate mitigation and adaptation. Among the city's thousands of acres of land, opportunities exist for further ecological restoration and enhancement, as well as the installation of perennial woody, plant-based pollinator gardens and landscapes that can sequester carbon and improve quality of life for all species.

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[23] C40, Defining Carbon Neutrality for Cities & Managing Residual Emissions, April 2019.
[24] Refers to agricultural and land management that help raise the soil organic carbon content.
[25] Afforestation refers to planting new forests on lands that historically have not contained forests or restoring tree cover in minimally covered areas.
[26] Reforestation refers to planting of forests on lands that have previously contained forests but that have been converted to some other use.
[27] Enhanced weathering refers to the process of dissolving natural or artificial minerals to remove CO2 from the atmosphere.
[28] https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf

Urban Forestry

San Francisco has an estimated 700,000 trees planted along streets, in parks and on private property. This urban canopy not only sequesters carbon, but also makes the city more walkable, helps clean the air, provides habitat for wildlife and pollinators, and reduces the urban heat island effect. The Urban Forest Plan has a goal to plant 50,000 street trees over the next 20 years. In 2017 the Street Tree Inventory identified 124,795 street trees by species, location, health, and size, and estimated that San Francisco's street trees store 79,000 metric tons of carbon and annually sequester 8,400 metric tons of carbon.

Land Application of Compost

San Francisco has collected over two million tons of compostable material[29] since 1997. This material has been transformed into 750,000 tons of finished compost, avoiding the emissions that would otherwise have occurred if disposed. One ton of San Francisco organic material that contains food scraps can produce 0.37 tons of finished compost. Vineyards, fruit and nut orchards and farms throughout the Bay Area[30] use compost to boost soil carbon sequestration, enrich the soil, and improve water and nutrient retention. Regional research shows that for rangeland soil, one ton of compost can sequester up to 0.18 metric tons of carbon per year, equivalent to 0.66 tons of CO_2 per year[31]. Currently, the amount of finished compost San Francisco produces has the potential to sequester10,000 metric tons of carbon cumulatively per year, and scientists have demonstrated that a one-time compost application continues to sequester carbon year after year, providing significant and cumulative benefits over time.

Photo by Larry Strong, courtesy Recology 4

[29] Organic material used for compost includes: food waste and yard trimming.
[30] Recology produces and sells the city's compost to nearly 800 separate agriculture users in the surrounding 100 miles. They have been doing this for the last 20 years.
[31] One ton of carbon equals 3.67 tons of carbon dioxide.

Conclusion

A business-as-usual approach is not an option if San Francisco is serious about meeting its climate commitments and avoiding the worst consequences of the global climate crisis. Given projected increases in population and economic activity, without further progress on climate policy and programs, San Francisco could see an emissions increase of 21% above 2017 levels – a move in the wrong direction.

Significant emissions reductions are within reach if the city remains committed to its 0-80-100-Roots goals. By 2030, achieving these goals is projected to result in a 68% reduction in emissions below 1990 levels. By 2050, with an ongoing commitment to action, it will be possible to reduce emissions 90% below 1990 levels.

These successes would still leave a small gap to reaching zero, so continued innovation and collaboration will be necessary to identify novel clean energy solutions, transform travel modes and choices, find better ways to move goods, and accelerate activities that sequester carbon.

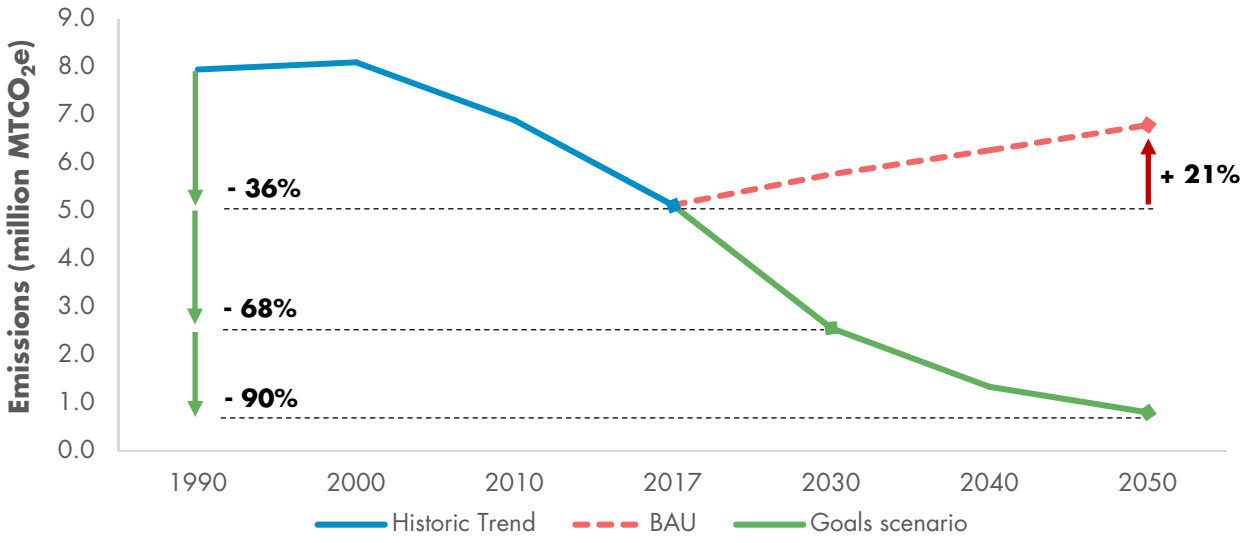

FIGURE 19- POTENTIAL EMISSIONS REDUCTIONS COMPARED TO 1990 LEVELS

Emissions reductions must come from three primary sectors – buildings, transportation and waste – within which seven Strategic Priorities were identified and evaluated. In the buildings sector, reductions must be realized by increasing energy efficiency, electrifying new and existing buildings, and ensuring that San Francisco is served by 100% renewable electricity from 2030 onward. In the transportation sector, between today and 2050, emissions reductions must be derived equally from

transportation mode shift and the electrification of all cars and trucks. In the waste sector, continuing to reduce the amount of material sent to landfill, while increasing the recovery of recyclable and compostable materials, will also be essential to reducing local and global emissions.

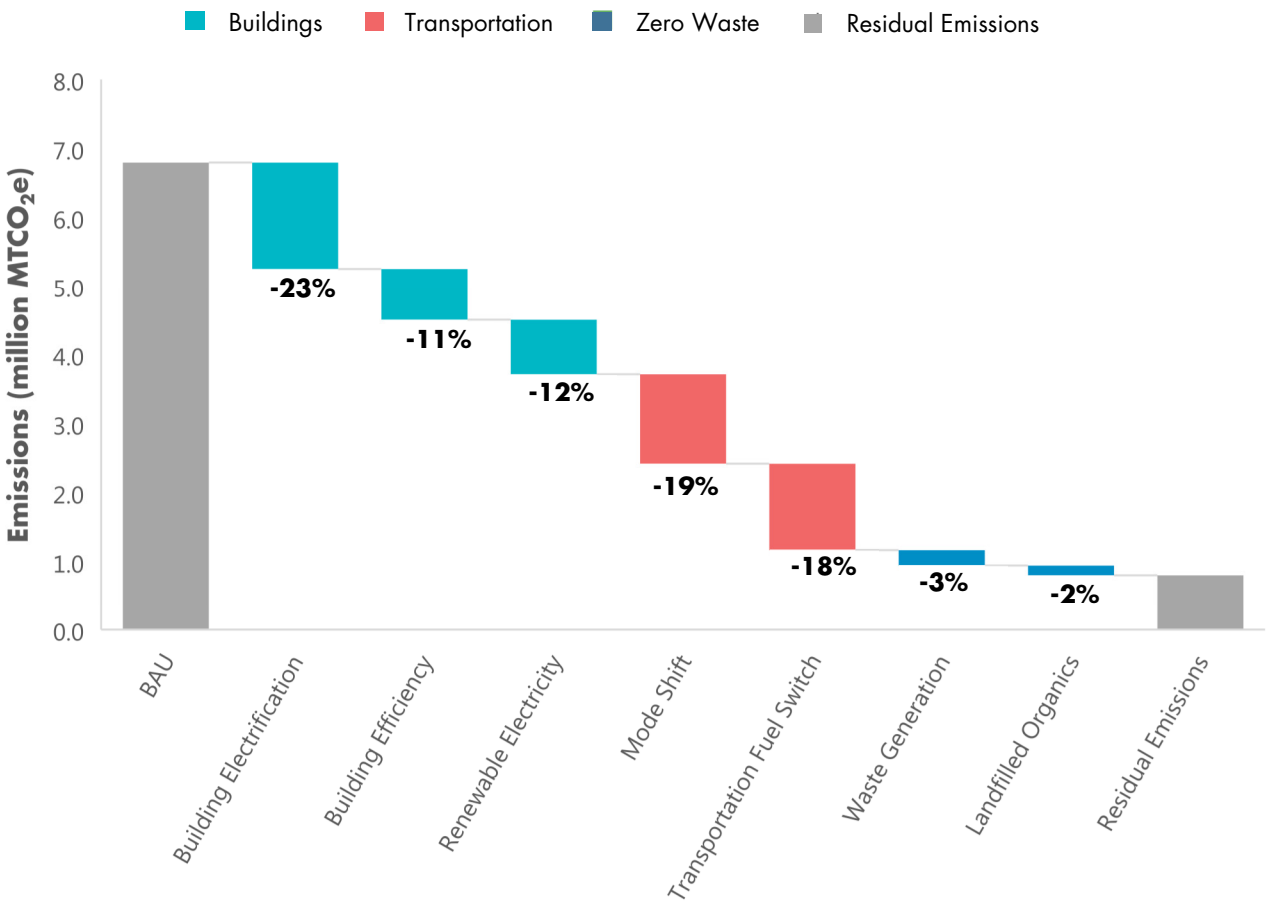

FIGURE 20 - POTENTIAL EMISSIONS REDUCTIONS BY STRATEGIC PRIORITY BY 2050

Final Thoughts

As we look ahead, the path is clear: San Francisco must accelerate action through 2030 to help stabilize the climate by 2050. The actions the city takes to reduce emissions have the potential to offer residents a broad array of benefits, from improved health and equity outcomes, to cleaner air, water and soil, to a stronger and more resilient society and economy. San Francisco is a global climate action leader with a long history of environmental achievement. Tackling the climate crisis is within the city's reach, and with support from all of our innovative, creative, and passionate community, we can meet our goals to make life better today and for generations to come.

Appendix A: Model Assumptions

Parameter	Unit	Assumption	Source
General			
Population	# of people	2016: 870,887 2030: 981,800	Resilient SF
Gross Domestic Product (GDP)	$/capita	2016: $139,000,000,000 2030: $185,941,011,638.77	San Francisco Office of the Controller
Historical GHG Emission Trends	$MTCO_2e$	1990: 7,957,691 2010: 6,897,645 2012: 6,360,506 2016: 5,547,488 2017: 5,127,810	San Francisco's Communitywide Greenhouse Gas Inventory
Energy			
Electricity grid mix	%		San Francisco Public Utilities Commission
Wind		2016: 7.64%; 2030: 73.1%	
Large Hydro		2016: 31.72%; 2030: 24.80%	
Photovoltaic		2016: 9.72%; 2030: 2.2%	
Small Hydro		2016: 2.24%; 2030: 0%	
Geothermal		2016: 3.74%; 2030: 0%	
Biomass		2016: 2.99%; 2030: 0%	
Nuclear		2016: 17.95%; 2030: 0%	
Natural Gas		2016: 13.52%; 2030: 0%	
Import/ others		2016: 10.47%; 2030: 0%	
Waste		2016: 0%; 2030: 0%	
Buildings			
Annual Growth New Buildings	% building growth per year		
Commercial		2018-2030: 0.8%; 2030-2050: 0.5%	Assumption based on employment projections by sector from Plan Bay Area 2040
Multifamily		2018-2030: 0.9%; 2030-2050: 1.5%	SF Planning
Single Family		2018-2030: 0%; 2030-2050: -0.1%	SF Planning
Redevelopment Rate Assuming retrofits started in 2016	% redeveloped existing buildings per year	3%	Assumption based on target to have 100% existing buildings by 2050. Rate is annual rate needed between 2016 and 2050. Percent was estimated by the San Francisco Department of the Environment.

Square Footage	sqft		
Commercial		235,613,069 sqft	OpenDataSF - Land Use, 2017
Residential		522,763,520 sqft	SF Planning Housing Stock Inventory (2016). Assumed MF units 1,000sqft and Single Family 1,875 sqft.
Energy Use Intensities (EUI)			
Baseline EUIs	kWh/sqft	Cultural & Educational: 17.27 Medical: 45.38 Office & Municipal: 22.34 Retail/Entertainment: 68.30 Industrial: 10.07 Hotel: 20.97 Single Family: 10.20 Multi Family: 10.42	Commercial: California End Use Survey (CEUS) pg. 187-189 Residential: San Francisco's 2016 GHG Inventory, Residential Appliance Saturation Survey (RASS)
New Construction/Redevelopment EUIs	kWh/sqft	Cultural & Educational: 10.18 Medical: 21.77 Office & Municipal: 14.72 Retail/Entertainment: 41.13 Industrial: 8.78 Hotel: 11.33 Single Family: 3.89 Multi Family: 3.93	Commercial: California End Use Survey (CEUS) pg. 187-189 Residential: San Francisco's 2016 GHG Inventory, Residential Appliance Saturation Survey (RASS)
Building Fuel Ratios		*Please refer to source*	Commercial: California End Use Survey (CEUS) pg. 187-189 Residential: San Francisco's 2016 GHG Inventory, Residential Appliance Saturation Survey (RASS)
Electricity Emissions Factor (BAU)		0.0000962 ($MTCO_2e$ /kWh)	PG&E 2017 Electricity Emissions Factor
% of Buildings Unaffected by FS and EE		23%	
Transportation			
CA Vehicle Registrations in 2030		2030: 35,795,180 [2% per year growth in overall light-duty vehicle sales and assume that new vehicles after 4 years are retired from the fleet at 5% per year (median vehicle life 16-17 years)]	ICCT report "California's continued electric vehicle market development"
SF Vehicle Registrations in 2030		2030: 541,215 [2% per year growth in overall light-duty vehicle sales and assume that new vehicles after 4 years are retired from the fleet at 5% per year (median vehicle life 16-17 years)]	ICCT report "California's continued electric vehicle market development"

CA EV Registrations in 2030		2030: 5,000,000	Zero Emission Vehicle Executive Order
SF EV Registrations in 2030		2030: 125,115 (2.5% of CA's EVs)	CA DMV Registration Data
Fuel Share	%		
Private Single Occupancy Vehicles (SOV)		2016: Gasoline: 98%; Diesel: 1%; Electricity: 1% 2030: Gasoline: 75%; Electricity: 25%	2016: EMFAC, 2016 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Private Carpool Vehicles		2016: Gasoline: 98%; Diesel: 1%; Electricity: 1% 2030: Gasoline: 75%; Electricity: 25%	2016: EMFAC, 2016 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Other (Taxi & Carshare)		2016: Gasoline: 100% 2030: Gasoline: Gasoline: 75%; Electricity: 25%	2016: San Francisco Municipal Transportation Agency 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
TNC		2016: Gasoline: 98%; Diesel: 1%; Electricity: 1% 2030: Gasoline: 75%; Electricity: 25%	2016: EMFAC, 2016 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Motor Bus		2016: Gasoline: 3%; Diesel: 39%: Landfill CNG: 7%; Biodiesel: 6%; RD 100: 45% 2030: RD 100: 30%; Electricity: 70%	2016: Federal Transit Administration; San Francisco Unified School District; San Francisco Municipal Transportation Agency; San Francisco Airport 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Trolley Bus		2016: Electricity: 100% 2030: Electricity: 100%	2016: San Francisco Municipal Transportation Agency 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Light Rail		2016: Electricity: 100% 2030: Electricity: 100%	2016: San Francisco Municipal Transportation Agency 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Street Car		2016: Electricity: 100% 2030: Electricity: 100%	2016: San Francisco Municipal Transportation Agency 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Cable Car		2016: Electricity: 100% 2030: Electricity: 100%	2016: San Francisco Municipal Transportation Agency 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
BART Rail		2016: Electricity: 100% 2030: Electricity: 100%	2016: BART 2030: Scenario assumptions based on 80% sustainable trips goal by 2030

Caltrain Rail		2016: Diesel: 100% 2030: Electricity: 100%	2016: Federal Transit Administration 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Ferry Boat		2016: Diesel: 100% 2030: RD 100: 100%	2016: Golden Gate Transit; Water Emergency Transportation Authority; Red & White Fleet 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Mode Share	%		
Private Single Occupancy Vehicles (SOV)		Baseline: 28% 2030: 11.7%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Private Carpool Vehicles		Baseline: 15% 2030: 6.3%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Other (Taxi & Carshare)		Baseline: 1% 2030: 0.4%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
TNC		Baseline: 4% 2030: 1.6%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Motor Bus		Baseline: 10% 2030: 15.1%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Trolley Bus		Baseline: 4% 2030: 5.5%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Light Rail		Baseline: 3% 2030: 5.2%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Street Car		Baseline: 1% 2030: 0.8%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
MUNI Cable Car		Baseline: 0% 2030: 0.6%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
BART Rail		Baseline: 7% 2030: 11.2%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Caltrain Rail		Baseline: 0% 2030: 0.6%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Ferry Boat		Baseline: 0% 2030: 0.3%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Bicycle		Baseline: 2% 2030: 10%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030
Walk		Baseline: 25% 2030: 31%	2016: San Francisco Municipal Transportation Agency, Travel Decision Survey 2017 2030: Scenario assumptions based on 80% sustainable trips goal by 2030

Fossil Fuels Emissions Factors	$MTCO_2e$ /gal		
Private Single Occupancy Vehicles (SOV)		Gasoline: 0.01097; Diesel: 0.01049; CNG: 7.3776E-06	ICLEI 2010 LGOP v1.1 Table G.11 and BAAQMD Scaling Factor
Private Carpool Vehicles		Gasoline: 0.01097; Diesel: 0.01049; CNG: 7.3776E-06	ICLEI 2010 LGOP v1.1 Table G.11 and BAAQMD Scaling Factor
Other (Taxi & Carshare)		Gasoline: 0.01751; Diesel: 0.01674; CNG: 7.3776E-06	ICLEI 2010 LGOP v1.1 Table G.11 and BAAQMD Scaling Factor
TNC		Gasoline: 0.01097; Diesel: 0.01049; CNG: 7.3776E-06	ICLEI 2010 LGOP v1.1 Table G.11 and BAAQMD Scaling Factor
Motor Bus		Gasoline: 0.00879; Diesel: 0.01021; CNG/Landfill CNG: 0.00307; Biodiesel: 9.7096E-05; RD 100: 4.244E-06	Gasoline, Diesel, RD100, Landfilled CNG, and CNG: ICLEI 2010 LGOP v1.1 Table G.11 and BAAQMD Scaling Factor; Biodiesel: TCR Table 13.1 for biodiesel
Caltrain Rail		Diesel: 0.0103; RD 100: 0.00009	ICLEI 2012 U.S. Community Protocol v1.0, Diesel Fuel Table TR.1.6 CO_2 emissions; TCR locomotives Diesel Table 13.7 CH4 and N2O emissions
Ferry Boat		Diesel: 0.01035; RD 100: 0.00014	ICLEI 2012 U.S. Community Protocol v1.0, Diesel Fuel Table TR.1.6 CO_2 emissions; TCR Ships and Boats Diesel Fuel Table 13.7 CH4 and N2O emissions
Electricity Emissions Factors	$MTCO_2e$ /kWh		
Private Single Occupancy Vehicles (SOV)		Electricity: *0.000133*	PG&E CO_2 factor; EPA eGRID 2016 CAMX subregion
Private Carpool Vehicles		Electricity: *0.000133*	PG&E CO_2 factor; EPA eGRID 2016 CAMX subregion
Other (Taxi & Carshare)		Electricity: *0.000133*	PG&E CO_2 factor; EPA eGRID 2016 CAMX subregion
TNC		Electricity: *0.000133*	PG&E CO_2 factor; EPA eGRID 2016 CAMX subregion
Motor Bus		Electricity: 0	100% renewable electricity generation
MUNI Trolley Bus		Electricity: 0	San Francisco Public Utilities Commission, 100% renewable electricity generation
MUNI Light Rail		Electricity: 0	San Francisco Public Utilities Commission, 100% renewable electricity generation
MUNI Street Car		Electricity: 0	San Francisco Public Utilities Commission, 100% renewable electricity generation
MUNI Cable Car		Electricity: 0	San Francisco Public Utilities Commission, 100% renewable electricity generation
BART Rail		Electricity: 0.0003096	BART
Caltrain Rail		Electricity: 0.0003096	Assumed same as BART
Zero Waste			
Population (1)	# of people	2000 - 2010 population: 723,959 - 805,235	US Census Bureau 2000-2010 Intercensal Population
Population (2)	# of people	2011 - 2016 population: 812,826 - 870,887	US Census Bureau 2011-2016 Intercensal Population Estimates
GDP (1)	$	2000 - 2016 GDP: $104,363,828,369 - $169,001,677,125	US Bureau of Economic Analysis nominal county GDP

GDP (2)	%	2000 - 2016 Personal Income: 60% of GDP	US Bureau of Economic Analysis nominal SF County Personal income
GDP (3)	$	2000 - 2016 CPI inflation adjustment: 172.2 - 240.0	Bureau of Labor Statistics CPI
Refuse Disposed	tons	2000 - 2016: 872,731 - 580,992	San Francisco Department of Environment, Zero Waste
Construction/C&D, Other Inerts, Organics, Paper	tons	2016 Tonnage allocations: Construction/C&D= 132,909 Other inerts= 136,181 Organics= 179,310 Paper= 132,592	San Francisco Department of Environment, Zero Waste and 2013 Waste Characterization Study
Sustainable Consumption			
SF CBEI lifecycle phases: production, pre-purchase transport, wholesale/retail, use, disposal	$MTCO_2e$	2008 SF Consumption Based Emissions: 21.7 million $MTCO_2e$	Stanton, E.A., Bueno, R. and Munitz, C. (2011). Consumption-Based Emissions Inventory (CBEI). Version 2.0 (March 2011). Somerville, MA: Stockholm Environment Institute-U.S. Center. http://sei-us.org/projects/id/199.