The Mayor's Electric Vehicle Working Group (EVWG)

Electric Mobility Subcommittee

Electric Vehicle Roadmap for San Francisco

June, 2019


METRO STATION
BUS STOP
PUBLIC PARKING
METRO STATION
ONLY BUS
BUS STOP
OUTBOUND
6 MIN
6 MIN
INBOUND
AIRPORT
5 MIN
5 MIN
EAST BAY
LOS ANGELES
10 MIN
10 MIN
SACRAMENTO

Contents

Electric Mobility Subcommittee

The Electric Vehicle Roadmap was created by the Electric Mobility Subcommittee of the San Francisco Electric Vehicle Working Group (EVWG). The views and opinions expressed in this document are not necessarily representative of the views of individual participants and/or the organizations they represent.

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Terms and Abbreviations

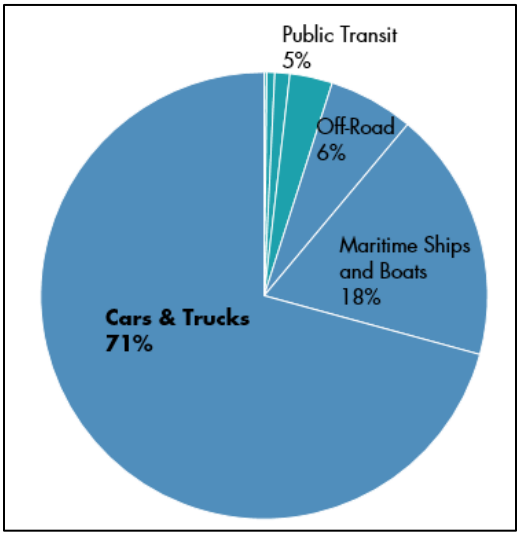
ADM	San Francisco Office of the City Administrator
AV	Autonomous Vehicle
BEV	Battery Electric Vehicle
CCA	Community Choice Aggregation
City	City and County of San Francisco
CO2e	Carbon dioxide equivalent
COPD	Chronic Obstructive Pulmonary Disease
CPUC	California Public Utilities Commission
CVRP	Clean Vehicle Rebate Project
DBI	San Francisco Department of Building Inspection
DCFC	Direct Current Fast Charger
DMV	California Department of Motor Vehicles
DPW	San Francisco Department of Public Works
Emerging Mobility	Innovations in transportation including ride-hailing services (Lyft and Uber), ride-pooling services (Chariot), bike share, autonomous vehicle technologies, and more.
ENV	San Francisco Department of the Environment
ERP	Electricity Resource Plan
EV	Electric Vehicle, including BEV, FCEV and PHEV
EV Roadmap	San Francisco Electric Vehicle Roadmap
EVSE	Electric Vehicle Supply Equipment
EVWG	Electric Vehicle Working Group
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
HACTO	Healthy Air and Clean Transportation Ordinance
HOV	High Occupancy Vehicle
MPGe	Miles per gallon gasoline equivalent
SFMTA	San Francisco Municipal Transportation Agency
MUD	Multi-Unit Dwelling
NREL	National Renewable Energy Laboratory
OEWD	Office of Economic and Workforce Development
PG&E	Pacific Gas & Electric

PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter
PM2.5	PM of less than 2.5 micrometers in diameter
PRT	Port of San Francisco
SFPUC	San Francisco Public Utilities Commission
RMI	Rocky Mountain Institute
SFCTA	San Francisco County Transportation Authority
SF Environment/SFE	San Francisco Department of the Environment
SFO	San Francisco International Airport
SF Planning	San Francisco Planning Department
SFTP	San Francisco Transportation Plan
Sustainable modes	Walking, bicycling, and public transit, as well as those modes that complement their use, like taxis and vehicle sharing
Sustainable trips	Trips using sustainable modes
TDM	Transportation Demand Management
TNC	Transportation Network Company
VMT	Vehicle Miles Traveled

1 Introduction and Summary

The City and County of San Francisco's ("City") rapidly evolving transportation sector is the primary emitter of heat trapping greenhouse gases (GHG) and the key cause of local air pollution and associated health problems. As of 2017, transportation emissions decreased by 10% since 1990,[2] making transportation responsible for 46% of the City's total GHG emissions today. The vast majority of these emissions is caused by private cars and trucks.

GHG Emissions from Transportation in San Francisco in 2017



Public Transportation: Transit First

Increasing the share of sustainable trips

In line with its Transit First policy, the City is focused on getting people out of cars by increasing the share of trips made by transit, bicycling, and walking ("Sustainable trips"). San Francisco implemented the Muni Rapid Network of core bus routes providing nearly 70% of all riders with more frequent and reliable service, supported by dedicated "red" transit lanes. The City also built over 125 miles of bike lanes and established a citywide Transportation Demand Management (TDM) Program.[3] For 2030, the City set a goal to further grow the share of sustainable trips from 57% today to 80%.

Better vehicle technology in City vehicles

In addition to reducing car dependency through prioritizing sustainable trips, the City is leading by example in reducing emissions from its own vehicles. San Francisco has made great strides in using clean vehicle technology and low carbon fuel for its public transit vehicles, taxis, and the municipal fleet:

San Francisco is a Transit First City

To create a more livable city, the City and County of San Francisco envisions[1] a city where:

- Numerous transportation and mobility options are available and affordable for all. There is less need for individually owned cars.
- The City's air is free from toxic vehicle exhaust, and people and goods are moved using renewable energy.
- There are seamless transit connections to local and regional destinations.
- Public right-of-way prioritizes sustainable transportation modes, improving safety and efficiency.
- Neighborhoods are safe, clean, and vibrant with many people walking and biking.

[1] The long-term vision for transportation is described in more detail in *Connect SF,* an ongoing citywide effort to develop a 50-year vision for an effective, equitable, and sustainable transportation system that represents the City's long-term priorities, goals, and aspirations. https://connectsf.org/

[2] 2016 Emission Inventory SF Environment. "Carbon dioxide equivalent" or "CO2e" is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO2e signifies the amount of CO2 which would have the equivalent global warming impact. MMT CO2e is Million Metric Ton CO2 equivalent.

[3] San Francisco's TDM program requires development projects to incorporate design features, incentives, and tools that support walking, biking and transit.

- San Francisco operates the largest electric trolley bus fleet in the U.S., powered by 100% renewable energy from its own municipal utility hydro-electric system.
- Taxis and bus fleets were modernized with fuel efficient hybrid electric vehicles.
- The diesel fuel supply of transit buses, municipal trucks, and ferries was switched to 100% Renewable Diesel.

Going forward, the City committed to electrify its non-emergency fleet sedans by 2022 and its remaining diesel transit buses by 2035.[4] And, with the electrification of Caltrain and BART's transition to renewable energy the City is now close to achieving an emission free public transit system.

Private Transportation: Cars and Trucks

While public transportation is well on its way to becoming emission free, private transportation poses unique challenges as the City is undergoing a transformation into a denser urban environment. Since 1990, San Francisco's economy grew by 166% and the City added 22% more people. Growth is expected to continue with 260,000 more jobs and 104,000 new units of housing being added in the coming decades.[5]

At the same time, the proliferation of smartphones and connected vehicle technologies is enabling the explosive growth of privately-owned ride-hailing vehicles and other forms of emerging mobility, such as shared bikes and electric scooters. These new services add new demands on streets and curbs, competing with the need to prioritize access for pedestrians, bicyclists, and transit vehicles. Soon autonomous vehicle technology may further and more drastically alter the transportation system.

Rapid growth in population and jobs combined with the explosive growth of ride hailing is increasing the number of cars on the road in San Francisco. Over 600,000 vehicles that are registered in or commute into the City are leading to increased congestion, road safety concerns, and traffic incidents[6] and slowing down the City's progress in reducing emissions.

Electric Vehicles: An Opportunity

The City recognizes that the best way to reduce emissions and congestion is to prioritize sustainable modes of transportation. While implementing this strategy, two technical breakthroughs offer an opportunity to more rapidly reduce and eventually eliminate emissions. First, electric vehicle (EV) technology is approaching a tipping point as new models are better performing and more affordable. [7] Second, generation of electricity for EVs is getting cleaner through the transition to renewable energy sources on the grid.[8] San Francisco aims to complete the transition to 100% renewable electrical power

[4] SFMTA Board Resolution to all electric bus fleet by 2035: https://www.sfmta.com/press-releases/san-francisco-committs-all-electric -bus-fleet-2035

[5] Plan Bay Area 2040 projections. http://2040.planbayarea.org/what-is-plan-bay-area-2040

[6] More information: http://sfgov.org/scorecards/traffic-fatalities

[7] Electric drive trains include Plug-in Hybrid Electric Vehicles (PHEV) as well as Battery Electric Vehicles (BEV). Fuel Cell Electric Vehicles powered by hydrogen are included in the definition of EVs. This does not include other technology such as hybrid electric vehicles without a plug, or those running on CNG/LPG and renewable biofuels.

[8] Currently the power mix is 44% renewable (2016) - San Francisco Electric System Power Content and Greenhouse Gas Emissions Forecast.

by 2030, in line with the objectives of the City's 0-80-100 Climate Action framework.[9] When EVs, including Fuel Cell EVs (FCEV) powered by hydrogen, and renewable power are combined, these technologies provide a pathway to eliminate local air pollution as well as GHG emissions from transportation altogether.

EV Vision: 100% Emission-Free Transportation by 2040

In April 2018, San Francisco committed to accelerate GHG emission reductions and pledged to achieve net-zero GHG emissions by 2050. The pledge aligns with the goals adopted in the 2016 Paris Climate Agreement to take urgent action to limit global warming to under 1.5 Celsius/2.7 degrees F.[10]

It is in the context of this pledge, the changing transportation landscape, and the breakthroughs in EV and renewable energy technologies, that the City presents the San Francisco Electric Vehicle Roadmap ("EV Roadmap"). The EV Roadmap puts forward an accelerated path toward electrification of all forms of private transportation[11] and proposes a bold vision for the future: Make all transportation in San Francisco emission-free by 2040.

Interim Targets and Strategies

To inspire near term action and reduce emissions quickly, the EV Roadmap sets interim targets for 2025 and 2030. These targets aim to rapidly electrify vehicle miles traveled (VMT) while reducing total VMT by increasing the share of sustainable trips. The targets also aim to reduce the sale of new gasoline and diesel vehicles with all remaining new car sales being electric by 2030.[12]

To achieve these targets the EV Roadmap proposes six strategies, each addressing a key barrier to adoption of EV technology. The strategies and associated near term actions are described in detail further in this document. They were developed by City departments and agencies in collaboration with a diverse set of external stakeholders, including state and regional agencies, industry, and advocacy organizations. The City will work with these stakeholders, other local governments, and the community to implement the strategies and make the vision of emission-free transportation by 2040 a reality.

[9] 0-80-100 refers to 0 Waste, 80% sustainable trips, 100% renewable energy.
[10] Members to The Paris Agreement agreed to pursue efforts to limit global warming to under 2.7 degrees Fahrenheit/1.5 degrees Celsius https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
[11] Private mobility, including cars, vans and medium- or heavy-duty trucks, taxis, paratransit, emerging mobility fleets, and commuter shuttles, as well as motorbikes and scooters, and by providing supporting infrastructure for electric bikes. The scope of the EV Roadmap encompasses all trips made by vehicles starting from, ending, or passing through San Francisco's boundaries.
[12] As defined by the Zero Emission Vehicle Mandate of the California Air Resources Board:
zero-emission or transitional zero-emission passenger cars and light-duty trucks..

The strategies are:

A. **Public Awareness**: Achieve broad public awareness, understanding and consideration of the options and benefits of electric mobility.
B. **Incentives:** Create a preference for electric mobility over gasoline and diesel vehicles.
C. **Charging Infrastructure:** Ensure that charging infrastructure for EVs is available and convenient for all residents, businesses, and visitors.
D. **Grid:** Integrate EV charging with the electrical grid to maximize the benefits of charging infrastructure and support the transition to a renewable energy future.
E. **Medium- and Heavy-Duty:** Lead the way in medium- and heavy-duty vehicle electrification.
F. **Emerging Mobility:** Advocate for and require emerging mobility options to be emission-free.

Alignment with City Plans and Goals

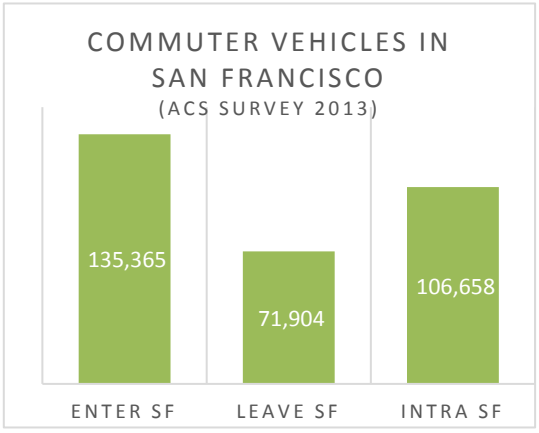
Through these six strategies and the supporting actions that are developed in this document, the EV Roadmap complements the City's Climate Action Plan, its Transit First policy, and its commitment to transition to renewable energy resources. The EV Roadmap also makes important contributions to equity, health, and economic vitality, in support of the overarching goal to create a more livable city. Clean, electric transportation provides cleaner air to all communities, especially benefiting vulnerable groups that are experiencing increased rates of asthma and other illnesses caused or worsened by air pollution. Investments in charging infrastructure and electric mobility provide new opportunities to build the sustainable economy of the future and a livable city for all.

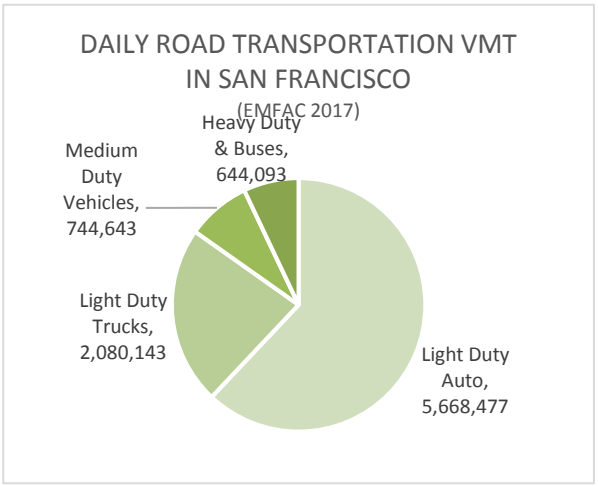
2 Private Transportation Emissions Today and a Vision for the Future

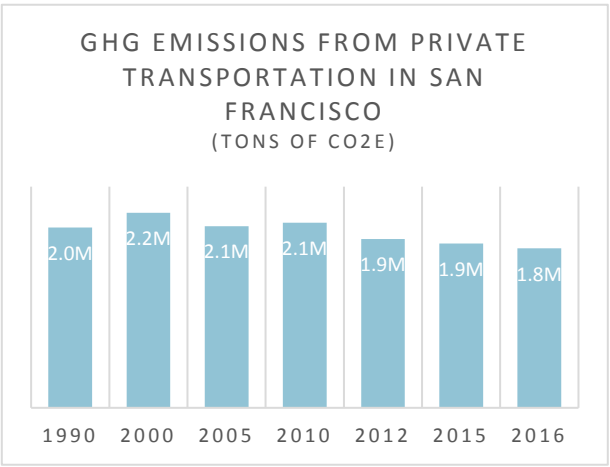
2.1 Private Transportation Emissions

Driven by rapid economic and population growth the San Francisco Bay Area now has the second-most traffic congestion in the U.S., after Los Angeles.[13] 430,000 light-duty cars and trucks and 33,000 medium- and heavy-duty trucks and buses are registered in San Francisco. In addition, 135,000 commuter cars drive into the City daily. Together these 600,000 vehicles drive over 9 million miles per day causing 1.8 million tons of GHG gases to be emitted over the year, or 32% of the City's GHG footprint in 2016.[14] Emissions in transportation have decreased by 10% compared to 1990, but the decrease has been slow and transportation has fallen behind when compared to reductions in other sectors.

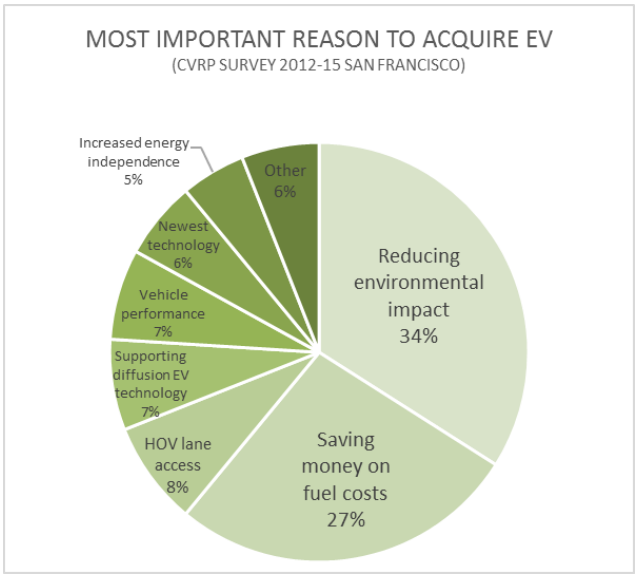
San Francisco is among the leading cities nationally, and the Bay Area is among the leading regions globally in EV adoption, but EVs still only make up a fraction of total vehicle registrations. In October 2018, 10,648 (2.3%) of the approximately 460,000 registered vehicles in San Francisco were EVs, varying widely by neighborhood.[15] Of new sales in San Francisco, EVs made up 6% in 2016, the last year for which the number is available. Early adoption of EV technology has been driven by environmental benefits and fuel cost savings as primary reasons for adoption.[16]

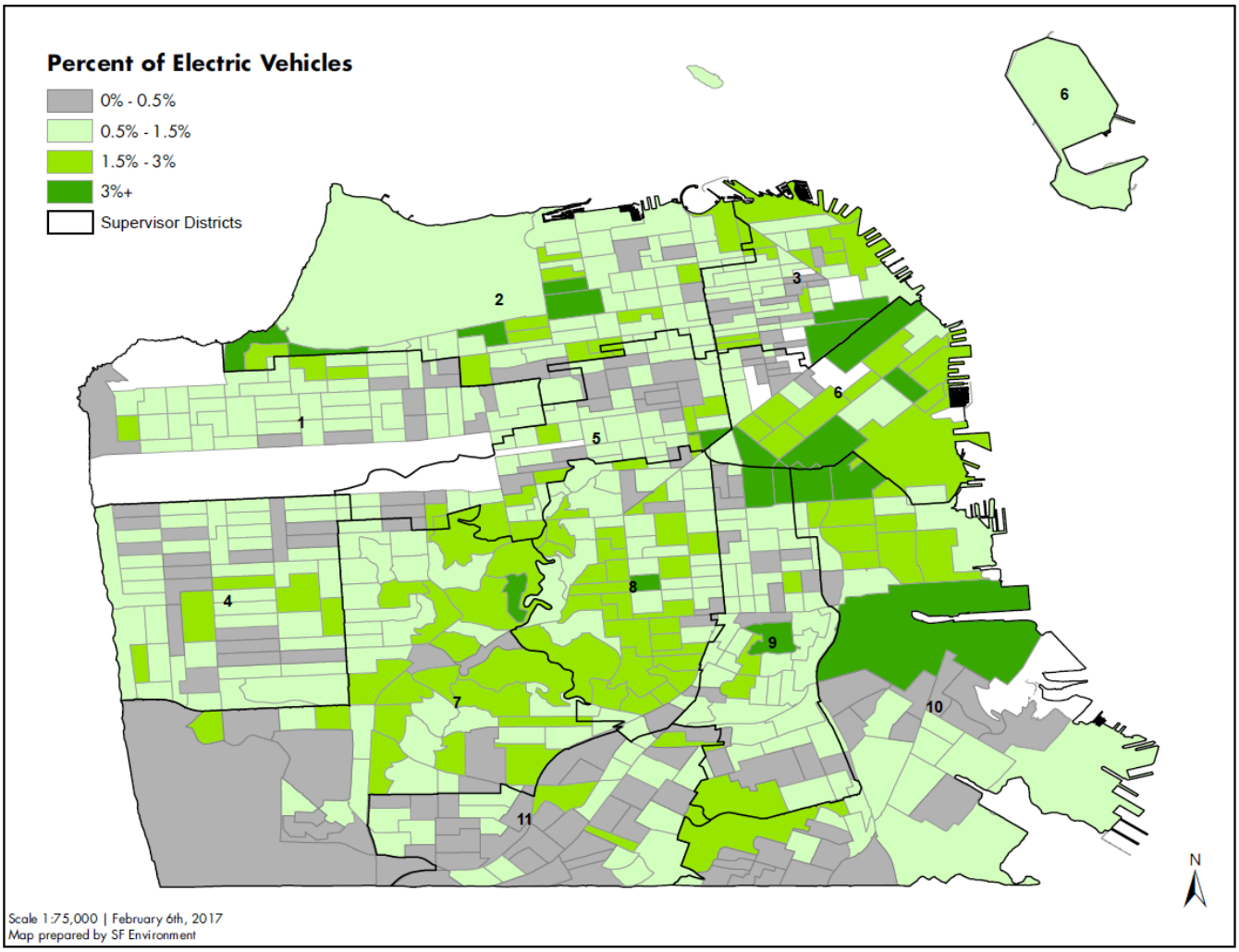






[13] https://www.tomtom.com/en_gb/trafficindex/list?citySize=LARGE&continent=ALL&country=ALL
[14] Source: 2016 GHG emission inventory SF Environment.
[15] DMV registrations October 2018.
[16] Clean Vehicle Rebate Project Survey 2012-2015 for San Francisco.


MOST IMPORTANT REASON TO ACQUIRE EV
(CVRP SURVEY 2012-15 SAN FRANCISCO)
Increased energy independence 5%
Other 6%
Newest technology 6%
Vehicle performance 7%
Supporting diffusion EV technology 7%
HOV lane access 8%
Saving money on fuel costs 27%
Reducing environmental impact 34%


Percent of Electric Vehicles
0% - 0.5%
0.5% - 1.5%
1.5% - 3%
3%+
Supervisor Districts
1
2
3
4
5
6
7
8
9
10
11
N
Scale 1:75,000 | February 6th, 2017
Map prepared by SF Environment

2.2 Background on Electric Vehicle Technology

EVs use electric drivetrains to power the wheels of the vehicle, eliminating tailpipe emissions. The electricity is stored in onboard batteries or in the case of FCEVs as hydrogen. Rather than refueling at gas stations, plug-in EV batteries recharge at electrical outlets and through electric vehicle charging equipment, typically installed in public and private parking garages or lots.

Benefits of Electric over Gasoline or Diesel-Powered Vehicles
● Environmental benefits: EVs eliminate harmful exhaust emissions at the tailpipe and over 75% of GHG emissions from operations today based on the City's current electrical grid. [17] The GHG reduction increases to 100% with a fully renewable energy supply by 2030. ● Lower fuel costs: Fuel costs for EVs can be as low as $0.03 per mile for passenger cars charging on an EV rate plan, 50% or more below the cost of gasoline per mile. ● Lower maintenance costs: EVs have fewer moving parts, no engine oil, and no transmission, reducing maintenance frequency and costs. ● Convenience: As long as daily driving ranges are within the battery capacity (100-300 miles for most Battery Electric Vehicles [BEVs]), EVs can be charged at home, at work, or at destination chargers, rather than visiting a gas station. On-the-road refueling at Direct Current Fast Chargers (DCFCs) is getting faster and more available as well. Higher-powered DCFC stations are being deployed that are capable of adding over 200 miles of range in 30 minutes of charging. ● Comfort: EVs offer quiet, quick and smooth accelerating power without shifting gears.

Vehicle types
Battery Electric Vehicles (BEVs) – 70% of EVs in San Francisco ● Powered by electric batteries only, between 60 and 315 miles of range before recharging is needed. ● All BEVs accept level 1 and 2 charging. Many modern BEVs also come with standard or optional fast charging (DCFC). ● Very efficient in conversion of electric power: 100-136 miles per gallon gasoline equivalent (MPGe reported by EPA). Local ("tailpipe") emissions are zero.
Plug-in Hybrid Electric Vehicles (PHEVs) – 30% of EVs in San Francisco ● Powered by electric charging and gasoline or diesel fueling. Most have an all-electric driving range of 10 - 50 miles. ● All electric driving speeds limited in some models requiring gasoline engine to be engaged at highway speeds. ● Since they have smaller batteries, PHEVs can often be fully charged overnight from a standard household socket (Level 1), but most also accept Level 2.
Hydrogen Fuel Cell Electric Vehicles (FCEVs) – Relatively new: 30-60 vehicles in San Francisco by 2017 ● FCEVs use a fuel cell to convert hydrogen into electric power within the vehicle. Driving range of 265 to 366 miles based on current models (three available today). ● Refueling takes only marginally longer than with gasoline: typically, 5 minutes for a passenger car. In San Francisco, three hydrogen fueling stations are being developed and will open in 2019. ● Efficient in power conversion, but not as efficient as BEVs: 49-67 MPGe (EPA). GHG emissions depend on how hydrogen was produced: Using renewable power creates a low footprint, natural gas a much higher one. Local 'tailpipe' emissions are only water vapor.

[17] PG&E grid mix

Charging types
Level 1: Standard household socket (110v) ● PHEV and low-mileage drivers often find a standard household socket sufficient for their daily charging needs. The charging cable often comes with the car to allow the driver to plug in anywhere.
Level 2: Most common for home and workplace charging (208-240v) ● For BEVs, especially with larger batteries, a full charge requires 6-12 hours. ● Typically, a charging station is mounted to a wall or on a pedestal. The station is hardwired or plugged in to an outlet and provides a charging cable. There are over 600 publicly available level 2 chargers in San Francisco. ● "Smart" Level 2 chargers provide control and monitoring features and allow charging speeds to be modulated, enabling power sharing and demand response to limit grid impact. ● New buildings in San Francisco need to be fully wired to support at least level 2 charging in 10% of parking spaces and have sufficient capacity on the electrical panel to supply shared charging to 100% of parking spaces.
Level 3: Direct Current Fast Charger (DCFC) for short duration of stay ● High-powered commercial charging stations along highway corridors to support road trips, and in urban areas to support high mileage use (Taxi/Transportation Network Company [TNC]), backup/emergency charging, and drivers without home charging access. ● Most BEVs on the market today ship with standard or optional DCFC capabilities. ● A full charge requires between 30-60 minutes depending on the charging speed of the station and the vehicle battery. ● DCFC requires significant investments and ample power, limiting its availability today. Currently there are 20 DCFCs in San Francisco.

2.3 A Vision for the Future: 100% Emission-Free Transportation by 2040

The end goal of the EV Roadmap is to achieve the vision of emission-free transportation by 2040 by electrifying all forms of private mobility, including cars, vans and medium- or heavy-duty trucks, taxis, paratransit, emerging mobility fleets, and commuter shuttles, as well as motorbikes, and scooters as well as by providing supporting infrastructure for electric bikes.[18]

To put San Francisco on the path towards full electrification, the EV Roadmap proposes six strategies detailed in this document to eliminate barriers to adoption and bring about transformative change. Together they put the City on track to meet interim adoption and GHG reduction targets[19] for 2025 and 2030 specifically focused on new passenger vehicles, emerging mobility, medium- and heavy-duty fleets, and incoming commuters.

By 2040, electrification of all private transportation would result in a 29%[20] reduction of the City's overall emissions compared to the 1990 baseline, on top of the reductions that have already been achieved across all sectors – including transportation – to date. Such an achievement would be a major step toward the City's pledge of net-zero GHG emissions by 2050.

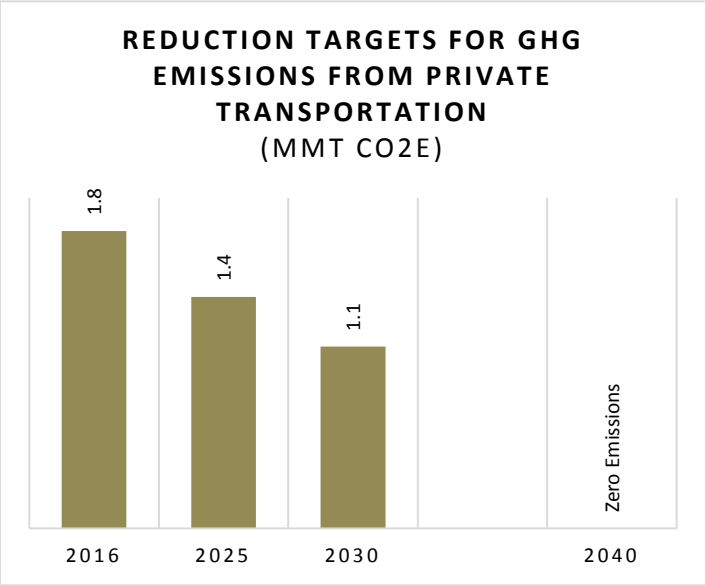
Strategy	Target Outcome 2020-2025
A: Public Awareness	• By 2020, drivers and the general public will be fully informed on key EV benefits so that electric options are always considered.
B: Incentives	• By 2020, clear price signals and other incentives will be in place to encourage electric mobility over gasoline and diesel.
C: Charging Infrastructure	• By 2022, there will be an effective and scalable range of charging options for all residents, fleets, and visitors across the City supporting full electrification.
D: Grid	• By 2025, most EVs will be powered by GHG-free electricity, and all will have access to electricity rates that make EVs an economical alternative to gasoline and diesel-powered transportation.
E: Medium- and Heavy-Duty	• From 2020 to 2025, the City will establish lighthouse projects of early adoption of EV technology for all major categories of medium- and heavy-duty transportation.
F: Emerging Mobility	• By 2020, shared and emerging mobility fleets will commit to a clear path to full electrification before 2025, and any new forms of mobility will be fully electric from the start.

[18] The scope of the EV Roadmap encompasses all trips made by vehicles starting from, ending, or passing through San Francisco's boundaries except for public transit, marine transport, and off-road vehicles such as drayage, forklifts, and airport logistical vehicles.

[19] Metric Ton CO2 equivalent. "Carbon dioxide equivalent" or "CO2e" is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO2e signifies the amount of CO2 which would have the equivalent global warming impact.

[20] Private transportation emissions in 2016 as a % of 1990 baseline. Source: SF Environment Carbon Inventory.

Targets		
By 2025 EVs will be[21]	**By 2030 EVs will be**	**2040 Vision**
50% of new passenger vehicle registrations with no increase in total vehicle registrations per household	100% of new passenger vehicle registrations with no increase in total vehicle registrations per household[22]	All trips originating in, ending in or passing through San Francisco will be emission-free[23]
50% of emerging mobility vehicle miles traveled (VMT)	100% of emerging mobility vehicle miles traveled (VMT)	
2,000 medium/heavy-duty commercial vehicles registered in the City	10,000 medium/heavy-duty commercial vehicles registered in the City	
1/3 of incoming commuter vehicles	2/3 of incoming commuter vehicles	



[21] For reference but outside of the scope of this document: 100% of City-owned light duty passenger sedan portfolio to be electrified by 2022 per the Municipal Zero Emission Vehicle (ZEV) Fleet Ordinance (2017).
[22] Examples of nationwide end of sales of internal combustion engine vehicles: China (no date), Netherlands new cars (2030) and Norway new cars (2025), France and UK new cars (2040).
[23] While San Francisco's goals are more stringent, they are consistent with and complement regional goals as defined in the 2017 Clean Air Plan and Plan Bay Area 2040.

3 Context and Purpose of the Electric Vehicle Roadmap

3.1 Mayor's EV Working Group and Electric Mobility Subcommittee

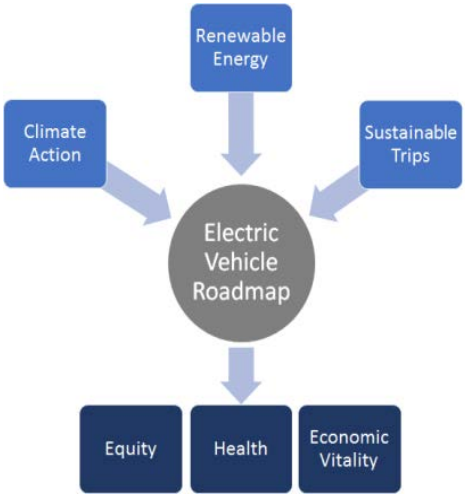
To achieve its policy goals such as cleaner air and reduction of GHG emissions, San Francisco has taken an active role in the promotion of EV technology for decades. The City installed dozens of first generation charging stations in the 1990s and in 2002 bought its first electric fleet vehicles. Since 2009, the City installed over 200 EV charging stations in municipal garages and lots and at San Francisco International Airport (SFO).

With EV technology becoming mainstream, the role of the City and the way it collaborates with the private sector on electrification is evolving. In January 2015, Mayor Ed Lee established the Electric Vehicle Working Group (EVWG) to identify actions and policies to accelerate EV adoption in San Francisco. The EVWG's objective is to ensure that EVs are available, affordable, and easy to use for all. Led by the Office of the City Administrator (ADM) and the San Francisco Department of the Environment (SF Environment), the EVWG was asked to develop recommendations and solutions to electrify the municipal fleet and transform the marketplace for EVs in private transportation.

Throughout 2016 and 2017, ADM and SF Environment staff worked to respond to the Mayor's initial requests, with City leaders unanimously passing the Municipal Zero Emission Vehicle Fleet Ordinance and the EV Readiness Ordinance for new construction and major renovations. The Mayor's Office also funded a study on worldwide best practices and recommendations to inform the City's next steps. On October 30, 2017 a summary of this work was presented that included high level opportunities for action. The EVWG agreed to establish a Subcommittee to lead the development of an EV Roadmap to accelerate electrification of private transportation.

The Subcommittee was formed in December 2017. Chaired by SF Environment, and co-chaired by the San Francisco Municipal Transportation Agency (SFMTA) and the San Francisco Public Utilities Commission (SFPUC), the Subcommittee includes broad representation from City departments and agencies, as well as key stakeholders from the private and non-profit sectors, and regional and state governmental agencies.

This EV Roadmap is the outcome of eight workshops in which the Subcommittee identified the most critical strategies and actions to electrify private transportation. In April and May 2018, the public was engaged for an initial consultation through Community Listening Sessions, in which City representatives gave brief presentations about electric mobility in San Francisco and collected feedback from the public on the best ways to increase awareness and to provide charging infrastructure for EVs.



The following sections describe how the EV Roadmap complements existing policy frameworks, programs, and initiatives, and how it contributes to equity, health, and economic vitality, in support of the overarching goal to create a more livable city.

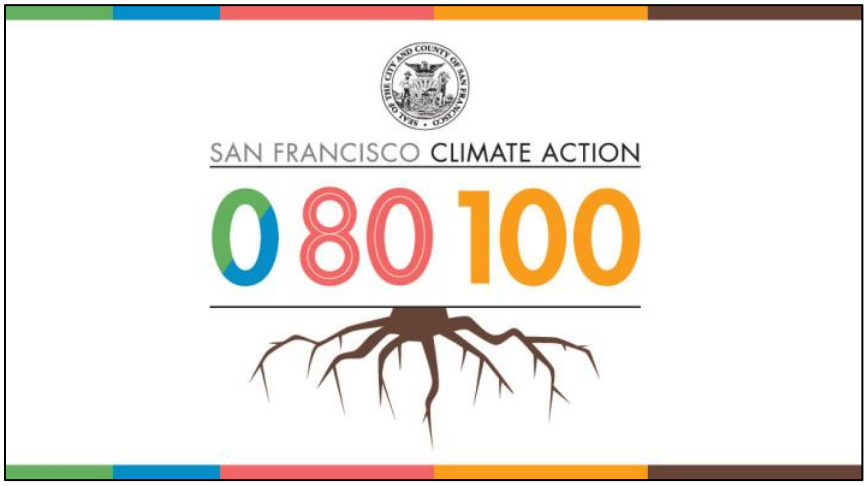
3.2 Existing Plans and Policies

Climate Action

San Francisco has long been a pioneer of innovative and responsible environmental policies and programs. The City has reduced annual GHG emissions 36% below 1990 by enforcing new green building standards, investing in renewable energy systems, pursuing rigorous energy efficiency improvements, increasing the share of sustainable trips and moving closer to zero waste being sent to landfill.

With the effects of climate change being felt sooner and stronger than expected, in 2013 San Francisco updated its *2004 Climate Action Plan* (to be updated again in 2020). The Plan provides a summary of progress, and outlines actions to be taken to meet the City's GHG reduction goals:

- 0: zero waste to landfill
- 80: a transportation system where 80% of all trips are sustainable trips
- 100: a built environment powered by 100% renewable electricity
- Roots: increased biodiversity, urban greening, and other carbon sequestration initiatives



To support the Climate Action Plan, in 2010 San Francisco updated its Environmental Code with the *Healthy Air and Clean Transportation Ordinance* (HACTO),[24] which calls for achieving GHG and air pollution reduction goals by transforming the market for energy efficient vehicles that produce zero or ultra-low emissions, and expanding alternative fueling infrastructure (including EV charging and hydrogen fuel pumps) community wide and at City facilities.

On April 19, 2018, San Francisco pledged net-zero GHG emissions by 2050, replacing the prior goal in the Climate Action Plan of an 80% reduction. With that pledge, the City joined 25 other cities from around the globe that have made the commitment to accelerate emission reduction plans. The pledge aligns with the 2016 Paris Climate Agreement and builds on San Francisco's track record of successfully reducing emissions while simultaneously growing its economy.

[24] HACTO is outlined in Chapter 4 of San Francisco's Environmental Code.

The Paris Climate Agreement, adopted on December 12, 2015, is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) that addresses GHG mitigation, adaptation, and finance starting in the year 2020. Representatives of 195 countries adopted this first-ever universal, and legally binding global climate treaty.

The Paris Agreement intends to hold the increase in the global average temperature to well below 3.6° Fahrenheit/2° C above pre-industrial levels and to pursue efforts to limit the temperature increase to 2.7° Fahrenheit/1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.

San Francisco's pledge to achieve carbon neutrality[25] by 2050 supports and goes beyond landmark legislation of the California State legislature: The California Global Warming Solutions Act of 2006 (AB 32) and Senate Bill 350 (S.B. 350), passed in 2015.

Renewable Energy

As a municipal utility with considerable power generation resources, the PUC has been a leader in the transition to a sustainable power grid, providing renewable power to municipal buildings, the airport, and Port, as well as the City's electric transit fleet for over 100 years.

In 2001, City leaders passed the *Human Health and Environmental Protections for New Electric Generation Ordinance* to consider all practical alternatives to fossil fuel electricity generation in San Francisco.

In 2002, the City released its first *Electricity Resource Plan* (ERP), which outlined actions to improve air quality in San Francisco and move the City toward reliance on renewable sources of electricity by closing the City's two remaining power plants and establishing the long-term goal of a GHG-free electricity sector for all of San Francisco.

With the release of its first *Strategic Sustainability Plan in* 2008, San Francisco set a course of action to ensure that the City's future electricity needs were met through maximizing energy efficiency, supplying the City's energy needs with renewable resources, eliminating GHG emissions associated with energy production and use, and basing energy decisions on the goal of creating a sustainable community.

In 2011 and 2012, the City took further steps to achieve the long-term goal of meeting its electricity needs through 100% renewable resources with City leaders adopting the *Updated Electricity Resource Plan.* The updated ERP identified three broad strategies and fourteen recommendations that San Francisco could take in order to have a GHG-free electric sector by 2030, generating all of its energy needs from the City's Hetch Hetchy hydro-electric project and other renewable energy resources.

In 2012, the Mayor's Office released the *Renewable Energy Task Force Recommendations Report*, which outlined how to maximize on-site distributed renewable generation, expand community-scale

[25] Carbon neutrality is a term used to describe the action of organizations, businesses, and individuals to remove as much carbon dioxide from the atmosphere as each added. The overall goal of carbon neutrality is to achieve a zero-carbon footprint.

renewable projects, explore renewable power purchasing options, and encourage the private sector to invest in renewable energy projects.

In addition to the municipal utility, the City launched *CleanPowerSF*, the City's Community Choice Aggregation (CCA) program, to significantly increase the proportion of electrical energy supplied to the San Francisco electrical grid from local renewable sources, decrease San Francisco's GHG emissions, and help combat global climate change. CleanPowerSF began automatically delivering cleaner energy to San Francisco residents and businesses in phases in May 2016 and will enroll all eligible San Francisco electricity customers by the end of 2019. CleanPowerSF is a not-for-profit entity that works in partnership with the local investor-owned utility, Pacific Gas & Electric (PG&E).

Sustainable Transportation

Since the 1970s, the City has been a national leader in the creation of a sustainable transportation system. The City's public transit, bike and pedestrian networks are vital elements of its strategy to build a more equitable, safe, sustainable, and affordable multimodal transportation system. Mode shift, from single occupancy vehicle trips to sustainable modes, is the City's primary strategy to reduce congestion, improve public health and safety, and reduce GHG emissions.

In 1973, City leaders enacted San Francisco's Transit First policy, which prioritizes the safe and efficient movement of people and goods to ensure quality of life and economic health in San Francisco. A key tenet of Transit First is the prioritization of the use of finite public street and sidewalk space by pedestrians, bicyclists, and public transit over private automobiles. The policy can be found in Appendix a). Implementation of the Transit First policy is a long-term strategic effort, requiring considerable and sustained investments in multimodal transportation infrastructure. In addition, the following key plans, strategies, and principles guide the City's transportation investments:

The *San Francisco Transportation Plan (SFTP)* is the countywide, long-range blueprint for San Francisco's multimodal transportation system. The SFTP outlines a diverse investment strategy and recommends policy actions to optimize investments.

The *SFMTA Strategic Plan* defines the purpose of the Agency and establishes goals and objectives to guide SFMTA's work for the next two years. It also outlines performance metrics and targets by which SFMTA's success will be measured and refines/updates strategic goals and objectives to better address the changing needs of the SFMTA and the City.

In 2017, the San Francisco County Transportation Authority (SFCTA) and the SFMTA adopted ten *Emerging Mobility Services and Technology Guiding Principles* to serve as a framework for evaluating emerging mobility services and technologies. Examples of emerging mobility services and technologies include ride-hail services, autonomous vehicles, bike share, and ride-pooling services. The Guiding Principles reflect adopted City policies, plans, and strategies, and are synthesized to relate to emerging mobility.

Vision Zero SF is the City's policy for building safety and livability into the City's streets, protecting the one million people who move about the City every day. Through implementation of Vision Zero, the City is committing to working together to prioritize street safety and eliminate traffic related injuries and deaths by 2024 in San Francisco.

The *2017 Transportation Sector Climate Action Strategy* provides a framework for the accelerated reduction of emissions from the transportation sector, and for building a more resilient transportation sector to mitigate climate impacts such as sea level rise.

Implementing the Transit First policy is a long-term strategic effort, requiring considerable and sustained investments in neighborhoods and transportation infrastructure. To that end, the City recently launched a citywide effort, *ConnectSF*, to develop a 50-year vision for an effective, equitable, and sustainable transportation system that represents the City's long-term priorities, goals, and aspirations.

3.3 Equity, Health, and Economic Vitality

Eliminating emissions from transportation through electrification contributes to equity, health, and economic vitality in support of the overarching goal to create a more livable City.

Equity

To ensure that the EV Roadmap helps build a more equitable San Francisco, it must:

- address inequities in the broader transportation system/access to electric mobility
- reduce pollution coming from congested corridors and medium- and heavy-duty traffic
- include a robust community outreach and engagement process

Equitable Access

Over the past century, transportation investments have prioritized automobiles over other modes. In many communities, the resulting transportation system created disparities in mobility choices and services along with health, safety, and environmental impacts on low-income and underserved communities[26] who have often been left out of decision-making and transportation planning processes.

San Francisco has been working on a number of initiatives to build a more equitable multimodal transportation system that reflects community priorities. Examples include the Muni Service Equity Strategy which benefits neighborhoods by implementing transit service improvements and improving connectivity to key destinations, reliability and frequency while reducing crowding. The City also coordinates with regional partners such as the Metropolitan Transportation Commission (MTC) to advance the Lifeline Transportation Program, which improves transportation choices for low income populations and addresses transportation gaps or barriers in low income and underserved communities within San Francisco and the region.

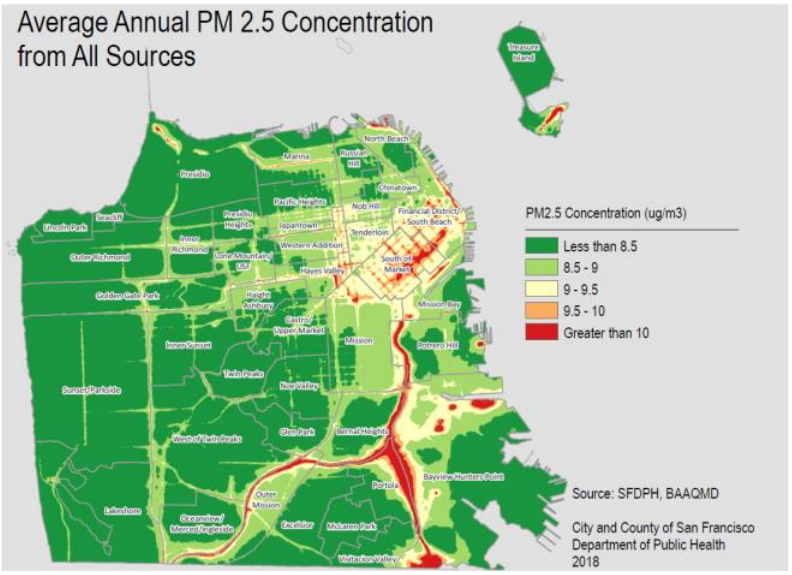
For San Francisco to be able to implement the EV Roadmap in an equitable way, the City needs to address the disparities in access to electric mobility that already exist. If access is unequal, the electric mobility revolution could lead to a growing rift in the already stratified mobility landscape between those who have personal, social, and economic opportunities and those who do not. California's current policy measures to accelerate transportation electrification include incentives such as EV access to

[26] "Underserved communities" will be defined in the context of specific actions and policies, leveraging MTC's Communities of Concern as being vulnerable and/or Department of Public Health's Community Resiliency Index (available at: https://sfclimatehealth.org/neighborhoods/).

carpool lanes, rebates, and special lease terms and electricity rates. Access to the benefits of electric mobility becomes increasingly important as the technology matures and policy makers propose new initiatives.

Clean Air

Creating equitable access to electric mobility options helps ensure that reductions in emissions directly benefit local communities, especially low-income and underserved communities disproportionately impacted by vehicle emissions. Notably, in areas with the worst air quality, emissions come predominantly from commuter traffic and medium- and heavy-duty vehicles on nearby arteries. Access to electric mobility options for local residents and businesses is therefore not enough. To improve air quality in the most affected communities, it is critical to reduce the emissions from incoming and outgoing commuter traffic as well as the diesel emissions from medium- and heavy-duty vehicles.



Community Engagement

For the EV Roadmap to succeed in creating more equitable outcomes, a robust plan for community engagement is essential to the implementation of the proposed actions. As an example of such engagement, the City is currently collaborating with residents and community groups through the Bayview community-based transportation planning process to identify multimodal transportation projects that meet specific needs identified by residents and businesses. These projects will emphasize sustainable modes and improve access and connectivity for transit-dependent groups.

The City also has partnered with the nonprofit GRID Alternatives for more than a decade to provide low income single family homeowners low to no cost roof replacements and rooftop solar installations. To date 255 photovoltaic systems have been installed which will result in $6M in long-term cost saving for low income homeowners. Additionally, San Francisco's energy efficiency programs have prioritized completion of upgrades in both affordable and market rate multi-family properties across the city resulting in more than 6 megawatts of energy savings for residents.

Health

Besides being the primary source of GHG emissions in San Francisco, private transportation is also a key source of local criteria air pollutants, including ozone and particulate matter (PM).[27] While representing a small percentage of all vehicles, medium- and heavy-duty vehicles are responsible for about half of transportation PM of less than 2.5 micrometers in diameter (PM2.5) emissions in the City.[28] Accordingly, air quality issues are concentrated in neighborhoods along the major traffic arteries, the central business district, areas zoned for commercial/industrial activities, and along highway corridors. These areas of lower air quality often overlap with low-income and underserved communities, placing a disproportionate public health burden on residents there.

Health problems associated with exposure to air pollution include:

- Aggravated Asthma: asthma is the leading chronic condition for children
- Chronic Obstructive Pulmonary Disease (COPD): COPD is the third leading cause of death in the United States
- Cancer: exposure to diesel exhaust is an established cause of lung cancer

Recent studies also indicate that exposure well below legal limits still causes increases in mortality,[29] suggesting there is no truly "safe level" for PM pollution.

The San Francisco Department of Public Health is tracking leading indicators such as asthma in vulnerable populations. In 2014, 21% of high school students in San Francisco were diagnosed with asthma, well above the national average of 10%.[30] Rates are even higher, 37.6%, among Black/African American high school students.[31]

Electrification is a key tool to reduce the negative impacts from transportation emissions on vulnerable communities. To achieve optimal air quality benefits, electrification needs to span all duty types, including medium- and heavy-duty fleets which are responsible for a large share of harmful criteria air pollutants.

Economic Vitality

San Francisco is proof that reductions in GHG emissions can go together with strong economic growth. The City's emissions have been reduced by 36% from 1990 levels, while the local economy grew by

[27] Vehicle emissions are responsible for over 50% of CO and over 30% of NOx emissions in the City (BAAQMD 2011) http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Emission%20Inventory/BY2011_CAPSummary.ashx?la=en. In contrast with national trends, air quality in the San Francisco Bay Area is worsening rather than improving.. The Bay Area now ranks worse than LA in both short term and year-round particle pollution: http://www.lung.org/local-content/california/documents/state-of-the-air/2017/sota-2017-statewide-press-english.pd.

[28] 2017 EMFAC model - CARB; The San Francisco Indicator Project – SF Department of Public Health. PM2.5 is highlighted here for brevity and its strong adverse health impacts.

[29] Air Pollution and Mortality in the Medicare Population - 2017 - http://www.nejm.org/doi/full/10.1056/NEJMoa1702747#t=abstract.

[30] https://www.cdc.gov/asthma/most_recent_data.htm.

[31] San Francisco Community Health Needs Assessment – San Francisco Health Improvement Project.

166%,[32] and the population increased by 22%.[33] With the strategies and actions described in this EV Roadmap, the City will further accelerate the transition to a sustainable economy, create new jobs in the clean technology sector, and continue to foster a culture of innovation.

Electrification opens up new employment opportunities for car mechanics, electricians, contractors, and other workers needed to build out charging infrastructure and to service EVs. Many of these job types – specifically electricians and EV-service technicians – have been identified as important occupations for producing employment opportunities in underserved communities.[34]

San Francisco's Office of Economic and Workforce Development (OEWD) will lead the City in working with employers and workforce training partners to identify hiring needs associated with electric mobility. City College of San Francisco has begun EV labor pool development through the establishment of an EV technician training program. The program is free for all San Francisco residents, and trains students to maintain and repair EVs and EV charging stations. OEWD will work with City College and other workforce development programs to prepare a labor pool in support of the strategies put forward in this EV Roadmap.

In addition to the employment opportunities for individuals, the transition to electric mobility creates opportunities for businesses to accelerate their sustainability initiatives and for new initiatives to begin. The Bay Area is already home to globally leading companies in clean technology and emerging mobility. Expanding the City's status as a world leader in electric mobility will cement this leadership role and foster an environment for innovation to tackle the key global challenges in addressing climate change.

3.4 Implementation and Public Engagement

The EV Roadmap proposes six strategies and 33 actions across City departments to be initiated and/or completed in the 2018-2020 timeframe. To coordinate and detail the actions, City staff will create a detailed implementation plan, providing more detail on each action, specifying deliverables, timelines, and stakeholder involvement.

The implementation plan will also put forward a robust community outreach plan to guide implementation of the strategies and actions. It is vitally important to understand the needs of different communities throughout San Francisco so that the actions in the EV Roadmap are equitable and effective for all residents.

[32] Increase in GDP from 1990 to 2017
[33] 2017 – SF Environment
[34] https://www.ucsusa.org/clean-vehicles/electric-vehicles/freight-electrification#.WvI3qn9lCUk

Strategies

The next six sections describe each strategy in more detail, including relevant City context and challenges, and propose actions for 2018-2020 that provide City departments with concrete, near-term next steps.

Strategy		Proposed Actions
A	**Public Awareness**: Achieve broad public awareness, understanding and consideration of the options and benefits of electric mobility.	1. Awareness campaign 2. EV help desk 3. Extended test rides 4. TDM 5. Wayfinding and signage
B	**Incentives:** Create a preference for electric mobility over gasoline and diesel vehicles.	1. EV purchase/lease incentive 2. Regional highway system 3. SFO access and pricing 4. Garage parking policy and pricing 5. Street parking policy and pricing 6. Special zones 7. Transportation pricing
C	**Charging Infrastructure:** Ensure that charging infrastructure for EVs is available and convenient for all residents, businesses, and visitors.	1. Multi-Unit Dwellings (MUD) 2. Smart charging 3. DCFC masterplan 4. City garages 5. Private commercial garages 6. Curbside charging study 7. Workforce training 8. Charging experience
D	**Grid:** Integrate EV charging with the electrical grid to maximize the benefits of charging infrastructure and support the transition to a renewable energy future.	1. Infrastructure limitations solutions 2. Pricing evaluation 3. Stationary battery storage 4. Renewable power
E	**Medium- and Heavy-Duty:** Lead the way in medium- and heavy-duty electrification.	1. Fleet pilots 2. School transportation 3. Recology fleet 4. Port charging for heavy-duty applications 5. Incentives and regulations
F	**Emerging Mobility:** Advocate for and encourage emerging mobility options to be emission-free.	1. TNCs 2. Car share 3. Taxis 4. Car rentals 5. Autonomous Vehicles

Strategy A: Public Awareness

Achieve broad public awareness, understanding and consideration of the options and benefits of electric mobility.

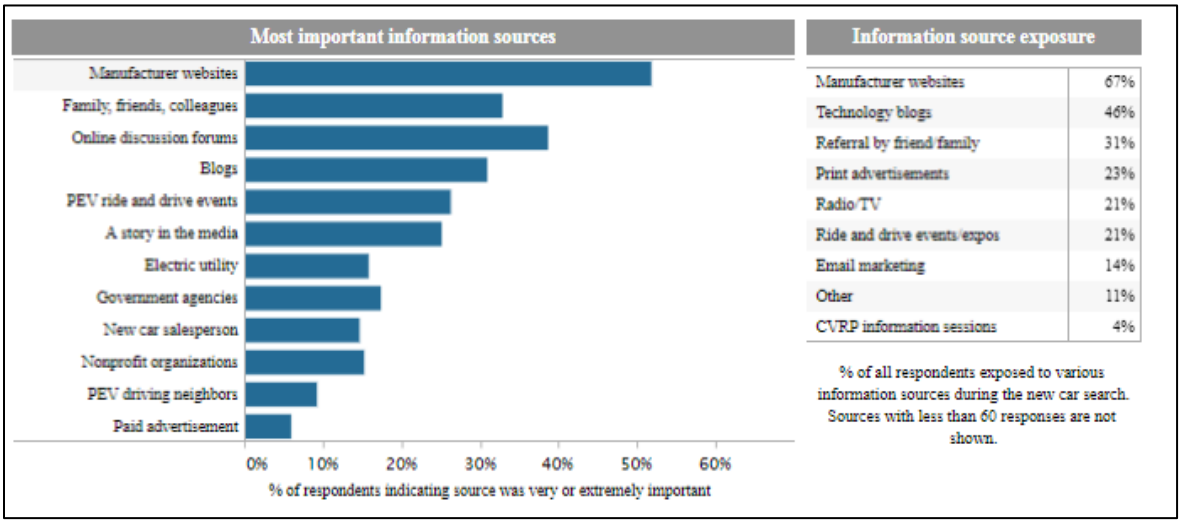
Context

Electric cars and trucks are being propelled into the mainstream by falling sticker prices on increasing model options, extended battery range and incentives. The electric mobility revolution is here, but perceptions that EVs are expensive or inconvenient persist.[35]

Often these concerns result from a lack of easily accessible information and technical assistance. The industry and dealerships were initially slow to catch up to the selling points and fueling requirements for EVs.[36] Early EV adopters therefore based their decisions almost entirely on online research and advice from family, friends, and colleagues.

Drivers and fleet owners may not be aware of incentives that reduce the upfront cost of EVs; the benefits electric mobility offers, such as reduced operation and maintenance expenses; or how to charge at home, work, and at other destinations. Citing concerns about affordability and charging availability, 79% of new car buyers do not yet consider an EV for their next car.[37]

California Clean Vehicle Rebate Project (CVRP) Survey Data for San Francisco 2012-2015



[35] The perception that "EVs are too expensive" is inaccurate for most drivers in California when incentives are considered. While the market price of EVs can be more expensive than traditional internal combustion engine vehicles, after incentives EVs are comparable if not more affordable than traditional vehicles. Furthermore, experiments show that marketing EVs at a price that reflects available tax credits and dealership incentives results in significantly higher sales.

[36] CVRP 2012-2015 for San Francisco: 33% of the time, dealerships offered to facilitate Electric Vehicle Supply Equipment (EVSE) installation; 37% offered assistance with tax/rebate applications; and 33% offered High Occupancy Vehicle (HOV) lane stickers at point of purchase.

[37] National Renewable Energy Laboratory (NREL) 2017 Barriers to acceptance of ZEVs: 79% applies to BEVs, adding PHEVs only slightly increases the pool that would consider an EV. FCEV was not tested as commercial availability was very limited at the time of the study.

Target Outcome and Actions

The following actions ensure that by 2020, drivers and the general public will be fully informed on key EV benefits, and that electric options are always considered when mobility investments and choices are made.

Proposed Actions for Strategy A: Public Awareness		Lead	Support
A1	Develop and fund a city **public awareness campaign** to increase awareness: • Develop and maintain a single online "one-stop-shop" landing page. • Partner with the retail car industry to display educational and promotional materials, such as posters and handouts aligned with state/regional messaging. • Fold in educational/promotional material at any point (online or offline) that an agency interacts with drivers or fleet owners.	ENV	SFMTA, SFPUC
A2	Develop and fund a city EV **Help Desk** providing information and technical assistance for residents and organizations with electric mobility questions.	ENV	
A3	Evaluate options to offer community groups/neighborhoods **extended test rides** in EVs.	ENV	
A4	Explore opportunities to align the City's **Transportation Demand Management** Program and policies with electrification goals.	SF PLANNING, SFCTA, ENV, SFMTA	
A5	Develop wayfinding/branding and **signage** standards for EV charging infrastructure.	TBD City Staff	

Strategy B: Incentives

Create a preference for electric mobility over gasoline and diesel vehicles.

Affordability of EVs

Prices for EVs, especially long-range passenger car models, are rapidly decreasing and are expected to be comparable to gasoline-powered cars as soon as 2025.[38] Currently purchase and lease incentives bridge the price gap and have been effective in driving demand for EVs in the U.S. and globally. After incentives, some EVs are among the most affordable new car options on the market and used EVs, a rapidly growing market, are cheaper still. State and other programs targeting low-income consumers bring down costs even further.[39]

Vehicle Pricing Examples

Illustrative Pricing July 2017 (TMV/CarMax)	Nissan Leaf 2017	Chevrolet Bolt 2017	Used Nissan Leaf 2011-2015 (< 40,000 miles)
MSRP	$30,680	$36,620	
Dealer rebate	-$3,450	-$3,000	
MFG rebate	-$4,000		
Federal tax credit	-$7,500	-$7,500	
State rebate (CVRP)	-$2,500	-$2,500	
Qualifying low income CVRP	-$2,000	-$2,000	
Effective price (excluding tax)	$11,230	$21,620	$6,000 – $11,000

In addition to purchase incentives, lower operating costs are a key driver of EV adoption, saving many drivers $1,000 per year or more. These savings stem from a large difference in fueling and maintenance costs. To fuel an efficient car with gasoline costs between $0.07-0.14 per mile, but charging an EV at home can costs as little as $0.03-0.04 per mile.[40]

While the economics of owning and driving an EV can be favorable, as in the examples above, this is not the case for all residents or communities: affordable charging is not available to everyone, an issue that is addressed in detail the next chapter on Charging Infrastructure.

[38] BNEF 2018 forecast BEV prices

[39] In addition, programs help provide indirect access to incentives through providing financing options for drivers with low credit ratings. For instance: Driving Clean https://drivingclean.chdcnr.com/.

[40] Assumptions: Fuel cost for a 35 MPG car based on local gasoline prices, which fluctuated between $2.46 and $4.74 per gallon over the last 5 years. EV drivers with access to home charging can take advantage of EV rate plans that offer electricity at a constant low price of $0.12 per kWh (off-peak). Electricity prices are more stable and predictable than prices of gasoline. In addition, EVs, especially BEVs, have lower ongoing maintenance costs. For example, BEVs do not have transmissions or require oil changes. Additionally, strong regenerative braking reduces wear and tear on brake pads reducing maintenance costs further. Individual cost savings vary by type of car and use, but can approach 50% or about $0.02-0.03 per mile, saving drivers several hundred dollars per year. For gasoline cars, the fueling cost makes up a significant share of total vehicle costs of $0.59 per mile for an average sedan. https://newsroom.aaa.com/tag/driving-cost-per-mile/.

And, while incentives are key to ensuring affordability, their future is uncertain. Many incentive programs change annually and the Federal Electric Vehicle Tax Credit of up to $7,500 per EV purchased began phasing out for top selling brands in 2018. In the transitional period leading up to price parity, incentives are critical to keeping EVs priced competitively when compared to gasoline or diesel vehicles.

Financial and Other Incentives

To make EVs an attractive alternative to gasoline and diesel vehicles, many cities successfully use transportation and parking pricing policies as well as non-financial incentives, such as access for EVs to preferred parking. The effectiveness of financial and non-financial incentives varies across individuals and groups and the level of EV adoption. Strong, non-financial incentives have been especially important to foster early adoption of EVs, potentially evolving over time as the technology matures.[41]

In evaluating these policy options for San Francisco, the City will look at effectiveness as well as safeguarding that outcomes are equitable, and policies maintain the preference for sustainable modes of transportation throughout the City.

[41]A key example of a non-financial incentive is the ability for EVs to access HOV (or carpool) lanes. HOV lane benefits for EVs are currently available throughout the state until 2022-2025. Zero emission zones are another example. In 2017 a group of 12 cities, including Los Angeles and Seattle, signed a declaration to ensure a major area of these cities is zero emission by 2030. According to CVRP 2012-2015 Survey, HOV lane access was the #1 reason for buying electric cars from 2012-2015 in Santa Clara County.

Target Outcome and Actions

The following actions put in place clear price signals and other incentives to encourage electric mobility over gasoline and diesel by 2020.

Proposed Actions for Strategy B: Incentives		Lead	Support
B1	Evaluate options for a city **EV purchase/lease incentive** for qualified vehicles and individuals.	ENV	
B2	Collaborate regionally to evaluate **EV lane access** policies on managed lanes[42]	SFCTA	SFMTA, ENV
B3	Evaluate incentives (pricing and priority access) for EVs on **SFO** roadways, in queues and in parking facilities.	SFO	ENV
B4	Evaluate options and develop recommendations to use **garage parking policy** (taxes, rates, space allocation) to create incentives to switch from gasoline or diesel vehicles to EVs.	SFMTA	ENV
B5	Evaluate opportunities and develop recommendations for EV **street parking policies and pricing** (including permit and metered spots) to create incentives to switch from gasoline or diesel vehicles to EVs.	SFMTA	ENV
B6	Evaluate opportunities and develop recommendations for low-emission or EV-only parking and/or driving **zones**.	SFMTA	SFCTA, ENV, SF PLANNING
B7	Evaluate **transportation pricing** strategies (congestion charges/VMT pricing/fuel pricing/tolling) that base fee structure on the emission factors of vehicles.	SFMTA, SFCTA	ENV

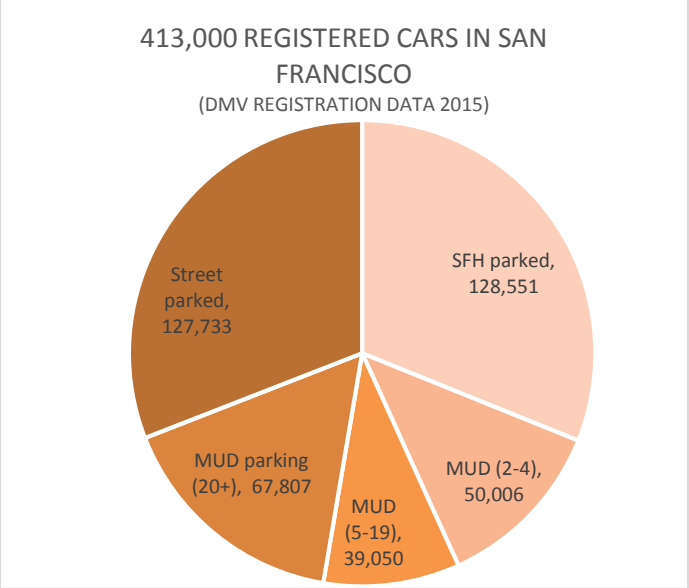
[42] Lane access regulations can include HOV lanes, transit lanes, and/or express lanes. http://2040.planbayarea.org/strategies-and-performance.

Strategy C: Charging Infrastructure

Ensure that charging and fueling infrastructure for EVs is available and convenient for all residents, businesses, and visitors.

Context

Access to convenient and affordable charging infrastructure is critical to supporting electrification. While charging needs vary, most charging for passenger cars is done at private charging stations at home, or secondly at work, with a more limited role for chargers that are accessible by the general public.[43]



Home charging is popular for its convenience, affordability, and guaranteed availability. Extended parking durations at home allow a full charge of large batteries with standard charging equipment at attractive electricity rates, especially when combined with an EV rate plan from the utility.

However, access to home charging depends on the housing type. Single family homes with on-site parking have the most flexibility and require the lowest investment,[44] but in San Francisco about one third of cars are parked in shared MUD garages, where charging station installation is much more complex. Another one third are parked on the street and if electric would rely exclusively on public or workplace charging.

Challenges in Multi-Unit Dwellings

The MUD sector is a large and diverse part of San Francisco's housing stock. There are approximately 179,000 units with 114,000 built-in parking spaces in buildings with 5 or more units.[45]

- Smaller scale (< 100 units) buildings built pre-1940 are the largest sub-segment with 86,000 units. These buildings often have just a few parking spaces, if any.
- At the other end of the scale are more than 120 newer MUDs with over 100 units per building and 24,000 units total in the City. These buildings typically have larger parking garages in line with the parking minimum policies at the time of construction.

[43] https://www.inl.gov/article/charging-behavior-revealed-large-national-studies-analyze-ev-infrastructure-needs/
[44] Many homes have some excess capacity on the panel, electrical wiring distances are short and there is no need to restrict or manage access to the charger.
[45] Initial analysis focused on 5+ MUDs as challenges are more pronounced, but many of the findings may apply to smaller MUDs as well. Duplexes tend to be more similar to single family homes in that charging infrastructure installation is relatively more straightforward in most cases.

While specifics vary from building to building, residents and landlords face significant obstacles in almost all existing MUD developments with off-street parking[46]:

- MUDs have a shared and often fully utilized electrical capacity.[47]
- Many MUDs feature distributed ownership and control over common spaces and investments. Parking space is often deeded to individual units.
- In rent-controlled buildings there are limitations on the owner's ability to recoup capital improvements directly.
- Cost effectiveness requires a coordinated approach across many residents in a single building. It's often cost prohibitive to pay for charging station installation individually, versus electrifying multiple spaces at once to achieve economies of scale.

Map of MUDs with Five or More Units with Supervisor District Boundaries

Challenges for Street-Parked Vehicles

An estimated 128,000 vehicles are parked on the street overnight. Most of these vehicles are personal passenger cars, trucks or vans, but street parking is also used by permitted car share fleets and peer-to-peer car sharing companies.

On Street Parking Spaces in San Francisco (Estimates from SFMTA Parking Study)	
Metered street parking	24,000
Permit zones	78,000
Other street parking spaces	218,000
Total street parking	**320,000**

Today, street-parked vehicles can be charged at work or at publicly available Level 2 and DCFC networks, although availability and time required to charge are limiting factors. Alternatively, charging stations could be located on the curb where vehicles are parked throughout the day, overnight, or for 30-60 minutes in the case of DCFC. In some European cities with limited garage/lot parking, curbside charging is common,[48] while several U.S. cities have started to pilot curbside charging options (Level 2 and DCFC).[49]

[46] San Francisco MUD challenges and opportunities – CEC financed study - April 2018.
[47] Where electrical capacity is limited technologies such as load sharing (common) or dynamic load balancing against the building load (novel) can serve as alternatives to expensive upgrades to the electrical supply.
[48] Amsterdam, a city with a similar number of residents but much lower level of car ownership, had over 2,000 curbside charging stations in 2016 and is planning to get to a total of 4,000 by 2018.
[49] In Los Angeles, over 200 Level 2 stations are planned to support the roll out of electric car share Blue LA https://www.bluela.com/.

The City will review the effectiveness of various charging options, as well as safeguarding that outcomes are equitable and policies maintain access to sustainable modes of transportation. Specifically, the City will consider the following:

- The role of the curb is evolving and needs to provide space for a range of uses such as biking, walking, transit, deliveries, passenger loading, and accessible services.
- Technology of charging infrastructure and battery capacities is rapidly improving with faster charging speeds coming to market in the near future.
- Preferences for when and how to charge vehicles may change as the mobility mix shifts to more sustainable and shared modes of transportation.
- Curbside charging would require the City to form public-private partnerships, and take on a role that is very different from the limited role the City has in permitting private fueling infrastructure for gasoline and diesel today.

Public Charging Infrastructure

San Francisco is among leading cities nationally in providing publicly available charging infrastructure, which is essential to supporting residents, businesses, and visitors. Approximately 750 publicly available Level 2 charging stations are in paid garages in the City center and at SFO.[50] Level 2 chargers need 5-10 hours to fully charge an EV. Additionally, 20 DCFCs are available for use by the public, many in retail parking lots.[51] These stations are highly utilized and take 30-60 minutes to fully charge a car.[52]

Public DCFC Supports Multiple Use Cases

- Range extension
- Charging for residents (e.g., renters who depend on street parking or cannot install charging at a rental property), commuters who do not have access to charging at home or in the workplace, and visitors
- Charging for high mileage vehicles that need to charge frequently (e.g., taxis and ride-hailing fleets)
- A backup solution if regular charging is not yet installed, temporarily unavailable, travel plans change, or an EV missed a charging session
- Charging options for medium- and heavy-duty trucks, vans, and buses that will be electrified in the near future

[50] DOE national AFDC database June 2019

[51] EVGo operates a total of 15 chargers at six Whole Foods/Walgreens parking lots, a Nissan dealership, and UC Hastings Law School. There are three Blink chargers and one ChargePoint charger. Currently many chargers are not available 24 hours per day/7 days per week, have time of stay restrictions (typically 30 minutes) or are retail customer parking access only. Charging speeds range from 24 kW to 50 kW. In addition, hydrogen fueling stations are needed to support FCEVs, refueling in approximately 5 minutes. There are 3 stations scheduled to be opened in San Francisco in 2019.

[52] Higher power DCFC stations, which are beginning to enter the market, will provide even faster recharging (<20 minutes).

While San Francisco's public EV charging network is ahead of most other cities, so is EV adoption. Significant investments are needed to keep up, but building and operating public charging infrastructure has low or even negative financial returns, discouraging private investment. The business model challenges are caused by a number of factors:

- High initial investments in electrical infrastructure upgrades and accessibility compliance
- Limited availability of parking space with often high monthly lease prices for premium locations
- Higher unit cost of electricity as compared to attractive residential EV-rate plans; compounded by peak demand charges for DCFC
- Low (initial) utilization

Public and Privately Owned Commercial Garages and Lots in San Francisco

- 113,000 spaces in private garages and lots
- 56,000 parking spaces managed by local, state, and federal agencies
- 20,000 spaces at SFO

Because of these challenges, much of the investment in public charging infrastructure in the City to date has come from grants and court settlements. With more EVs on the road, the utilization of charging stations is increasing, and car makers, fleet owners, and charging network companies are starting to invest. A key question facing policy makers is how the business model for public Level 2 and DCFC can be further improved to attract private investment, while keeping charging available to the general public and prices competitive.[53]

[53] Public charging, if not subsidized by an employer, municipality or OEM, is often significantly more expensive than home charging, making driving electric in some cases more expensive than driving on gas.

Target Outcome and Actions

The following actions ensure that by 2022 there will be an effective and scalable range of charging options for all residents, fleets, and visitors across the City supporting full electrification.

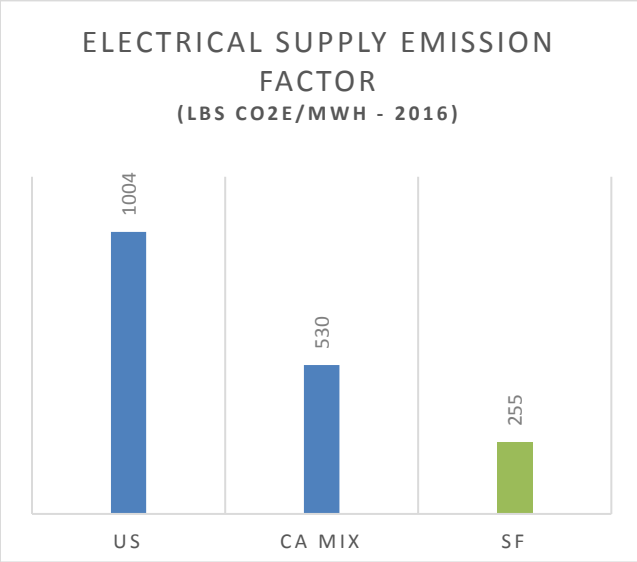
Proposed Actions for Strategy C: Charging Infrastructure		Lead	Support
PRIVATE CHARGING			
C1	Evaluate options for broad deployment of charging infrastructure in **multi-unit dwellings** through an incentive program and code and policy development.	ENV	DBI, SFPUC, SF PLANNING
C2	Develop a home/workplace **smart charging program** that optimizes grid-responsive charging through remote demand response and price incentives.	ENV	SFPUC
PUBLIC CHARGING			
C3	Develop a **DCFC Masterplan** to establish a citywide network to meet current and future demand.	ENV, SFMTA, SFPUC	Relevant City departments
C4	Evaluate options to install/expand publicly accessible charging infrastructure at **City owned parking** facilities and lots.	ENV, SFMTA, SFPUC	Relevant City departments
C5	Evaluate options to accelerate deployment of charging stations in **privately owned**, publicly accessible **garages** and lots.	ENV	
C6	Study **curbside** charging options (including support for micro-transit & e-bikeshare).	ENV, SFMTA, SFPUC, DPW	DBI
GENERAL			
C7	Develop a **workforce** training program to support charging infrastructure installation at scale. Ensure underserved community members have access to jobs by working with San Francisco City College and community-based organizations.	ECN	City College, ENV, DBI
C8	Evaluate options to make the **charging experience** across various vendors/owners and operators more seamless and investments future proof, reinforcing state-level initiatives on the use of standards.	ENV	

Strategy D: Grid

Integrate EV charging with the electrical grid to maximize the benefits of charging infrastructure and support the transition to a renewable energy future.

Context

Relying on renewable electricity to power the transportation system eliminates GHG, and criteria air pollutants. In San Francisco, electrification of the transportation sector is especially attractive because the power supplied to the City is almost 75% cleaner than the U.S. average.[54] Furthermore, the City has adopted a goal to use 100% renewable energy by 2030.[55]



Electrifying transportation will increase demand on the grid (see Appendix m). However, through planning when, where, and how to charge, EVs can help optimize the grid and thereby reduce the unit cost of electricity.[56] By using EVs to absorb excess solar and wind, utilities can avoid curtailment and increase the share of renewables in the electricity supply. [57]

While the potential of EVs to enhance grid reliability and optimize the use of renewables is promising, there are key hurdles slowing down the transition. It is critical that utilities and regulators ensure rates for EV charging reflect grid conditions, thereby guiding charging habits of drivers to the right time of day.

As discussed in the previous chapter on charging infrastructure, the profitability of public charging infrastructure is challenged by current rate structures that limit the availability of advantageous EV-rate plans to residential customers. In addition, peak demand charges pose significant challenges to the ability to profitably operate DCFC stations where demand charges can make up 70%+ of the electricity costs. To accelerate private sector investments, special rate plans may need to be considered that are more conductive to profitable DCFC business models but still allow appropriate cost recovery.

Increased electricity demand and consumption resulting from EV charging may also require costly upgrades to the electrical distribution system, including, but not limited to, new transformers. To unlock the full grid potential of EVs it is critical that:

[54] SF Environment analysis.
[55] The State of California has established a renewable energy mandate of 50% by 2030 and the State Legislature is currently proposing to raise that to 60% and adopt a new target of 100% by 2045.
[56] https://rmi.org/insights/reports/electric-vehicles-distributed-energy-resources/.
[57] Curtailment is a reduction in the output of a generator from what it could otherwise produce given available resources, typically on an involuntary basis.

- Wholesale price signals reach the end user through rates that accurately reflect the cost on the electric system and that are available to all customers.[58]
- Vehicles are plugged in when at rest through charging infrastructure connected and responsive to real time price signals.
- There is an efficient permitting pathway for onsite 'behind-the-meter' stationary battery storage.
- Hurdles in the distribution grid are addressed.

Target Outcome and Actions

The following actions ensure that by 2025, most EVs will be powered by GHG-free electricity, and all have access to electricity rates that make EVs an economical alternative to gasoline and diesel-powered transportation.

Proposed Actions Strategy D: Grid		**Lead**	**Support**
D1	Convene City agencies and PG&E to identify solutions to overcome neighborhood electrical **infrastructure limitations** to supplying EV charging infrastructure (for instance transformer placement).	ENV	DBI, DPW, SF PLANNING, PUC
D2	Evaluate **pricing** to customers for public and residential Level 2 and DCFC chargers, and identify options to make charging more affordable, including alternative rate structures for residential and commercial customers and DCFC.	ENV	PUC
D3	Study options to incentivize DCFC station providers to invest in onsite "**stationary battery storage"** to minimize impact on the grid and increase resiliency.	ENV	
D4	Require charging network providers operating on public land, in the public right-of-way (if and where permitted), or in public facilities to use **100% renewable or GHG-free power** where feasible.	ENV	SFPUC, SFMTA

[58] For home charging, a non-tiered EV rate plan exists, rewarding charging in the off-peak night hours with rates as low as $0.12 /kWh (equivalent to approx. $1.20/gallon gasoline). However, existing EV rate plans typically don't support commercial customers, MUD dwellers, and energy efficient households.

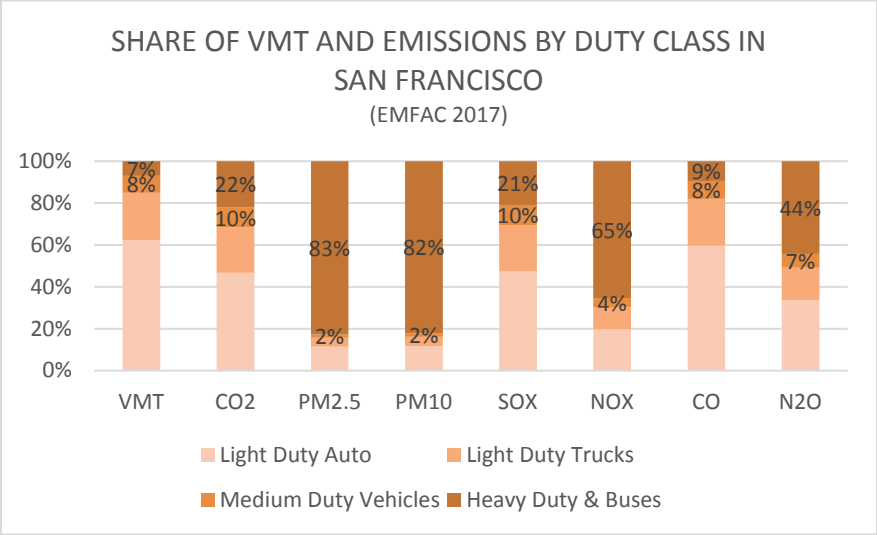
Strategy E: Medium- and Heavy-Duty Vehicles

Lead the way in medium- and heavy-duty electrification.

Context

Electrification provides an opportunity for medium- and heavy-duty fleets to significantly reduce the transportation expenses of their businesses through reduced fuel and maintenance costs. In addition, incentive programs help offset investments in vehicle conversion and support charging infrastructure installation. [59]

The emission reduction opportunity is very significant as well. Medium- and heavy-duty fleets active in San Francisco consist of 33,000 locally registered vehicles, as well as many vans, shuttles, trucks, and buses that drive into or through the City. While only responsible for 15% of VMT, this segment is responsible for 32% of GHG emissions, reflecting the higher fuel use of heavier vehicles. Since most medium- and heavy-duty vehicles are powered by diesel engines, they are responsible for a large share of local particulate emissions as well.



When compared to passenger cars, the availability of electric options for a wider range of duty types is still relatively new. Transit fleets are widely seen as the first adopters of both battery electric and fuel cell electric vehicle technology. Applications for medium-duty delivery vans, shuttles, and heavy-duty niches, such as drayage, are next. The general heavy-duty segment is following closely behind, leveraging many of the same vehicle technologies for electrification. For mainstream adoption, each new application needs to be extensively proven in order to create demonstration projects for these new applications that foster further adoption.

[59] For example https://www.californiahvip.org/

Target Outcome and Actions

The following actions ensure that from 2020 to 2025, the City establishes demonstration projects for early adoption of EV technology for all major categories of medium- and heavy-duty transportation.

Proposed Actions for Strategy E: Medium- and Heavy-Duty		**Lead**	**Support**
E1	Identify, catalog, and support **pilots** in medium- and heavy-duty fleets (e.g., delivery vans and trucks, commuter buses and shuttles, courtesy shuttles, and paratransit.	ENV	SFO, SFMTA
E2	Work with **SFUSD** to support electric transportation for students.	ENV	
E3	Work with **Recology** to expand pilots for electric trucks for waste operations.	ENV	
E4	Evaluate options to install charging infrastructure for trucks parked at **Port** property.	PRT	ENV
E5	Evaluate opportunities and develop recommendations for **incentives/regulations** for electrification of medium- and heavy- duty fleets.	SFMTA, ENV	

Strategy F: Emerging Mobility

Advocate for and encourage emerging mobility options to be emission-free.

Context

Emerging mobility services and technologies are changing how people get around in cities. Ride-hailing, shared vehicles, and rapid innovations in autonomous vehicle technology are just a few examples of how the transportation system continues to evolve. When shared, emerging mobility services and technologies could help reduce single occupancy vehicle trips and the need to own cars. At the same time, emerging mobility services may interfere with the City's goals for a sustainable transportation system by increasing overall VMT. As discussed in Section 3.2, the SFMTA and SFCTA recently developed a set of Guiding Principles to ensure that emerging mobility complements—not competes with—transit, bicycling, and walking options and that goals for emerging modes include sustainability.

In San Francisco, emerging mobility services currently include (not exhaustive):

- Autonomous Vehicles – GM Cruise, Zoox, Waymo
- Microtransit/private transit – Chariot
- Ridesharing/carpool – Waze/Scoop
- Bikeshare – Motivate/FordGoBike
- Courier Network Services – Postmates, Caviar, Eat 24, Uber Eats
- Scooter share – Scoot
- Stationless bikeshare – Social Bicycles/JUMP, Limebike
- Ride-hailing – Transportation Network Companies (TNCs) – Uber, Lyft
- Car share – Zipcar, Getaround, Maven, Turo
- One-way car share – GIG
- Shared use vehicle fleet – Fair, Hertz, Maven Gig
- Electric scooter boards – Bird, Lime, Spin

In addition, for the scope of the EV Roadmap:

- Car rentals
- Taxis

The ability of the City to implement these principles varies with the degree to which emerging mobility services are subject to local regulatory authority. Regardless of its role as regulator, the City always has authority to establish and enforce traffic laws on San Francisco streets and regulate access to the curb and off-street city-owned parking garages and lots.

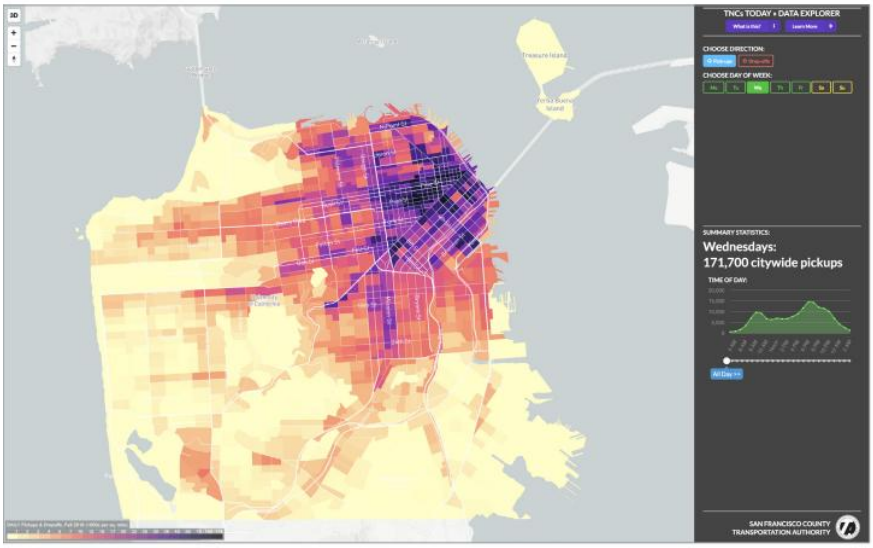
Agency	Authority
SFMTA permitted	• Electric moped parking (Scoot) • On-street car share • Stationed (Bay Wheels) and stationless (Jump) bike-share • Private transit vehicles (Chariot) and commuter shuttles
California Public Utilities Commission (CPUC) regulated	• Transportation network companies (TNCs), such as Uber and Lyft
Local regulation preempted by State or Federal Government	• Courier network services (Caviar, Postmates, Uber Eats) • Autonomous vehicles (potential pending legislation)

Electrification Challenges for Fleets

Today there are a number of emerging mobility services that operate on electricity such as mopeds, scooter boards, bicycles, car share, and most pilots with autonomous vehicles. The operators of these services manage their fleets to ensure their vehicles are available throughout the city and remain charged throughout the day. Maintaining a charge can be a challenge due to high usage and limited availability of charging facilities. Some operators have one or more private charging facilities and may offer incentives for users to bring vehicles to these hubs by offering free trips. Privately owned and operated car fleets also depend, in part, on public charging networks or home charging to operate in the City.

The limitations of charging infrastructure are a key constraint on the ability to expand fleet size and service coverage for all electric emerging mobility services. Operators are looking for opportunities to collaborate with the City and property owners to establish charging sites throughout the City, with a focus on the downtown core.

Growth of Ride-Hailing (TNCs)



Trips made by TNCs (Uber and Lyft) doubled from 2016 to 2017. By the end of 2016, TNC vehicles were making over 170,000 trips within San Francisco per day, which is 15% of all intra San Francisco trips, and about 20% of VMT.[60] TNC activity is particularly concentrated in the most congested and polluted areas of the City, making electrification of this sector even more urgent.

However, currently only approximately 1% of all TNC vehicles in California are electric.[61] Accelerated electrification of TNC vehicles could make a significant contribution to cleaner air and reduced GHG emissions in some of the most polluted areas of the City. In addition, a study from the Rocky Mountain Institute estimates that EVs could boost income for full-time drivers by $2,500-$5,200 per year due to reduced fuel expenses, and $2,700 per year in maintenance and repair cost savings compared to gasoline-powered vehicles. [62]

[60] TNCs today - June 2017 SFCTA.
[61] Electrifying the Ride-Sourcing Sector in California, April 2018 CPUC. The CPUC's definition includes both fully electric and plug-in hybrid electric vehicles. Similarly, approximately 1% of TNC total vehicle miles travelled in California, including deadheading, are made in electric vehicles.
[62] Rocky Mountain Institute study March 29, 2018 "Ride-Hailing Drivers are ideal candidates for Electric Vehicles." Fuel savings are based and dependent on access to residential EV charging rates.

Table 6: Overall Auto Mode Share over Time

Mode	2013	2014	2015	2016	2017
Drive Alone	26%	30%	27%	29%	28%
Carpool	22%	16%	21%	16%	15%
Total (Private Vehicles)	**48%**	**45%**	**48%**	**45%**	**43%**
Carshare	<1%	<1%	<1%	<1%	<1%
TNC	<1%	1%	1%	2%	4%
Taxi	2%	1%	1%	<1%	<1%
Total (All Vehicles)	**50%**	**48%**	**50%**	**48%**	**47%**

Source: Corey, Canapary & Galanis Research, 2017; Fehr & Peers, 2017

There are several challenges associated with the electrification of TNCs:

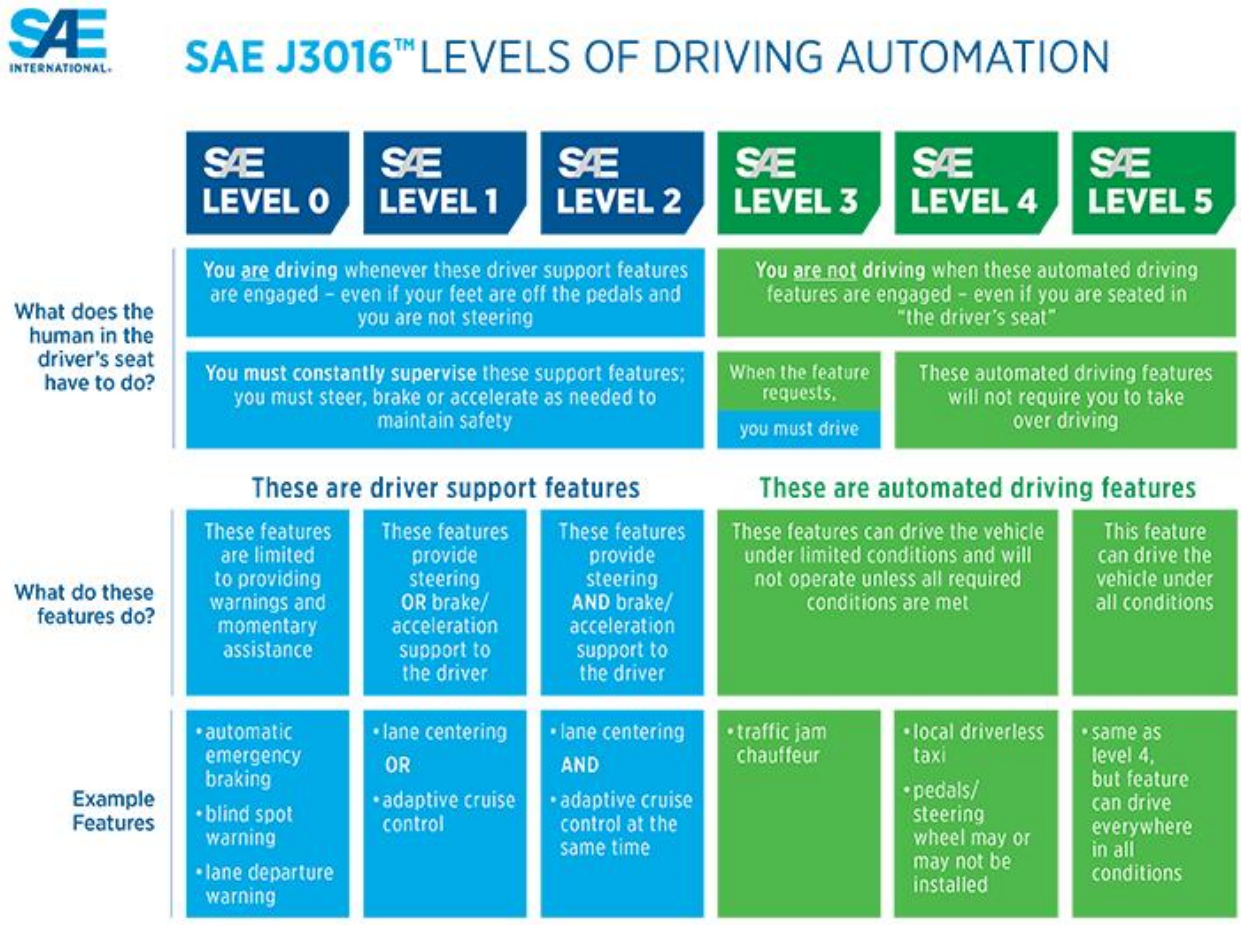
- To qualify as a TNC, the organization can't own or operate their own vehicle fleets. The vehicles are therefore owned by individual drivers or leased/rented from professional fleet management companies.
- TNC drivers' driving patterns and needs are different from the average EV driver. Pilot studies suggest[63] that a range of 200 miles or more is typically considered the minimal practical range for full time TNC use.[64]
- So-called "range anxiety" is exacerbated since TNC platforms currently do not tell drivers the trip length or destination until a trip has been accepted, and the ride matching software is not aware of the state of charge and/or range of the EV.
- Many TNC drivers may work part time or for a limited time period, making an investment in charging infrastructure and a fuel-efficient vehicle less certain to pay off.[65]
- Drivers often park on the street or in MUD garages where, even if they wish to install charging stations, the challenges discussed under Strategy C make it very difficult or impossible to install EV charging at home.
- Relying solely on public charging infrastructure is challenging today. As discussed in Strategy C, there are too few DCFC stations, the stations are not always accessible, and charging speeds are limited, requiring an hour or more for a full charge. Public DCFCs' higher kWh price may also reduce fuel cost savings that would be provided through home charging, negatively impacting the net hourly pay of the driver.

[63] Uber study in London: http://www.energysavingtrust.org.uk/sites/default/files/reports/Uber%20EV%20Trial%20-%20Electric%20Private%20Hire%20Vehicles%20in%20London_1.pdf.
[64] Studies suggest that optimal range may go down for autonomous TNCs restricted to intra-city trips with plentiful charging infrastructure: https://pubs.acs.org/doi/full/10.1021/acs.est.7b04732.
[65] https://www.theinformation.com/articles/how-uber-will -combat-rising-driver-churn 4/20/2017.

Autonomous Vehicle Technology

A large majority of companies developing self-driving cars are either currently testing or working towards fully electric vehicles. However, some companies prefer hybrid technology in order to maximize vehicle mileage. To shift the industry towards electrification, charging infrastructure must be provided and regulatory frameworks must favor electrification. The charging needs for autonomous fleet vehicles will likely be very different from regular passenger EVs as autonomous vehicle (AV) fleets will need to recharge more frequently and will not be subject to factors affecting individual owners such as a desirable charging location or time of day

AVs are advancing rapidly and are being tested in such varied categories as luxury sedans, long haul trucking fleets that drive along open highways, and small shuttle buses that can navigate fixed routes inside low risk environments. As technology develops, AVs should be able to safely navigate more complex traffic scenarios and numerous variables such as road closures. While there is no certain date for when AVs will be deployed on public roads without a safety driver – as some companies are already beginning to test such vehicles without a safety driver today – it is speculated that deployment may begin in select cities between 2020 and 2030.



Mainstream availability of level 4 and 5 AV technology is widely anticipated to have a revolutionary impact on the transportation system overall and on private mobility in particular, potentially upending the private car ownership model. While it is hard to predict when the transition might take place and what form it will take, pilot initiatives are already underway today. The California Department of Motor Vehicles (DMV) recently passed regulations that allow for driverless testing and deployment of AVs, and the CPUC has proposed a pilot to allow AVs to be used for passenger service, both with and without safety operators.

Target Outcome and Actions

The following actions ensure that by 2020, emerging mobility fleets commit to a clear path to full electrification before 2025, and any new forms of mobility are fully electric from the start.

Proposed Strategic Actions for Strategy F: Emerging Mobility		**Lead**	**Support**
F1	Evaluate options and develop recommendations to electrify **TNCs** and similar light duty passenger fleets.	ENV, SFMTA, SFO, SFCTA	
F2	Evaluate options to electrify **vehicle sharing**. Evaluate opportunity to make associated charging infrastructure publicly accessible.	SFMTA, ENV	
F3	Evaluate options to electrify **taxi** fleets.	SFMTA	ENV
F4	Pilot electric **car rentals** at SFO. Evaluate options to expand to other car rental locations.	SFO, ENV	
F5	Set expectation and encourage AV test vehicles and level 4 and 5 commercially available **AV** fleets and private vehicles to be electric.	SFMTA, SFCTA	ENV

Appendices

a) Transit First Policy Directives

1. To ensure quality of life and economic health in San Francisco, the primary objective of the transportation system must be the safe and efficient movement of people and goods.
2. Public transit, including taxis and vanpools, is an economically and environmentally sound alternative to transportation by individual automobiles. Within San Francisco, travel by public transit, by bicycle and on foot must be an attractive alternative to travel by private automobile.
3. Decisions regarding the use of limited public street and sidewalk space shall encourage the use of public rights of way by pedestrians, bicyclists, and public transit, and shall strive to reduce traffic and improve public health and safety.
4. Transit priority improvements, such as designated transit lanes and streets and improved signalization, shall be made to expedite the movement of public transit vehicles (including taxis and vanpools) and to improve pedestrian safety.
5. Pedestrian areas shall be enhanced wherever possible to improve the safety and comfort of pedestrians and to encourage travel by foot.
6. Bicycling shall be promoted by encouraging safe streets for riding, convenient access to transit, bicycle lanes, and secure bicycle parking.
7. Parking policies for areas well served by public transit shall be designed to encourage travel by public transit and alternative transportation.
8. New transportation investment should be allocated to meet the demand for public transit generated by new public and private commercial and residential developments.
9. The ability of the City and County to reduce traffic congestion depends on the adequacy of regional public transportation. The City and County shall promote the use of regional mass transit and the continued development of an integrated, reliable, regional public transportation system.
10. The City and County shall encourage innovative solutions to meet public transportation needs wherever possible and where the provision of such service will not adversely affect the service provided by the Municipal Railway.

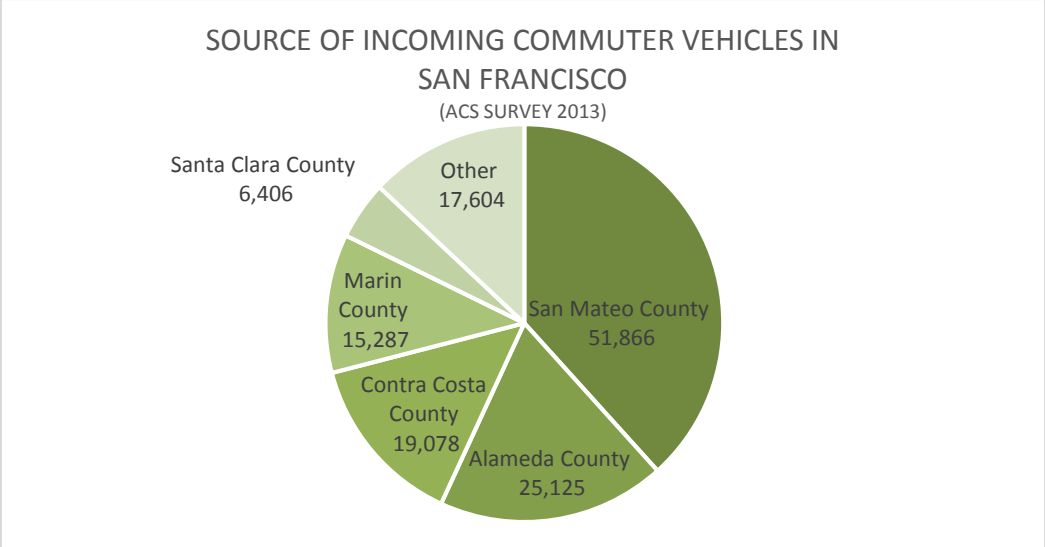
b) Charging Technology

Charger Type	Panel Breaker (Typical)	Kilowatts (Accepted by the Car)	Range added per Hour Typical (RPH)	Connector to the Car
Level 1: Standard household socket PHEV and low-mileage drivers often find a standard household socket sufficient for their daily charging needs. A charging cable often comes with the car, which allows the driver to plug in anywhere.	110-120 VAC 15-20 amp	1.3-1.9 kW	4-5 miles	J1772
Level 2: Common for home and workplace charging For BEVs, especially with larger batteries, a full charge requires 6-12 hours. Typically, a charging station is mounted to the wall or on a pedestal. The station is hardwired or plugged in to an outlet and provides a charging cable. Level 2 "smart chargers" provide control and monitoring features and allow charging speeds to be modulated, enabling power sharing and demand response to limit grid impact. New buildings in San Francisco need to be equipped to support at least level 2 charging in 10% of spaces.	208-240 VAC 40-100 amp (comparable to an electrical dryer outlet)	6.6 – 7.2 kW (PHEV limited to 3.3/3.6) 17 kW (Tesla 100D only)	20 miles 50+ miles	J1772 (or Tesla) J1772 (or Tesla)
Level 3: DC Fast Charger (DCFC) for short duration of stay High powered commercial charging stations along highway corridors to support road trips and in urban areas to support high mileage use (Taxi/TNC), backup/emergency charging, and drivers without home charging access. Most BEVs on the market today ship with standard or optional DCFC capabilities. Currently there are 20 DCFCs in San Francisco.	480 VAC, 3- phase >100 Amp breaker	50 kW (most common) 150+ kW 72 (Urban Supercharger) -120 (Supercharger) kW	75 miles per 30 minutes 225 + miles per 30 minutes 120 – 180 miles per 30 minutes	SAE Combo, ChaDeMo SAE Combo Tesla

c) Vehicle Registrations

CalEnviroscreen[66] 3.0 (Based on statewide percentiles)	Population (CalEnviroscreen)	Car Registrations in ZIP codes (Jan 2017)	EV Ownership
Overall SF	805,235	427,333	1.5%
ZIP codes containing at least one census tract with a 5% healthiest score	212,196 86,009 in census tracts	119,119	1.9%
ZIP codes containing at least one census tract with a 25% unhealthiest score[67]	122,118 40,455 in census tracts	68,872	1.4% (includes city and PG&E fleet registrations)
Zip code 94124 (Bayview-Hunters Point)	32,284	29,126	0.7%

d) Commuters to San Francisco



[66] CalEnviroScreen uses environmental, health, and socioeconomic information to produce scores for every census tract in the state. An area with a high score is one that experiences a much higher pollution burden than areas with low scores.

[67] ZIP codes in which at least one CalEnviroscreen 3.0 designated disadvantaged community is located: 94102 (Tenderloin), 94103 (SOMA), 94107 (Dogpatch/Potrero), 94124 (Bayview -Hunters Point), 94130 (Treasure Island).

e) Dealerships in San Francisco

EV Dealerships in San Francisco		
Dealership	**Address**	**BEV/FCEV 100+ Mile Range**
BMW of San Francisco	1675 Howard St.	I3
Mercedes-Benz of San Francisco	500 8th St.	B-Class
Nissan Infiniti of San Francisco	1395 Van Ness Ave.	Leaf
Royal Automotive Group (Volkswagen, Audi)	165 14th St.	e-Golf
Tesla	999 Van Ness Ave.	Model 3/S/X
Honda	10 S. Van Ness Ave	Clarity (FCEV)
Toyota	1701 Van Ness Ave.,	Mirai (FCEV)
Brands Not in San Francisco		
Ford		Focus
General Motors (Chevrolet)		Bolt
Hyundai/Kia		Ioniq

f) Multiple-Unit Dwelling Building Stock

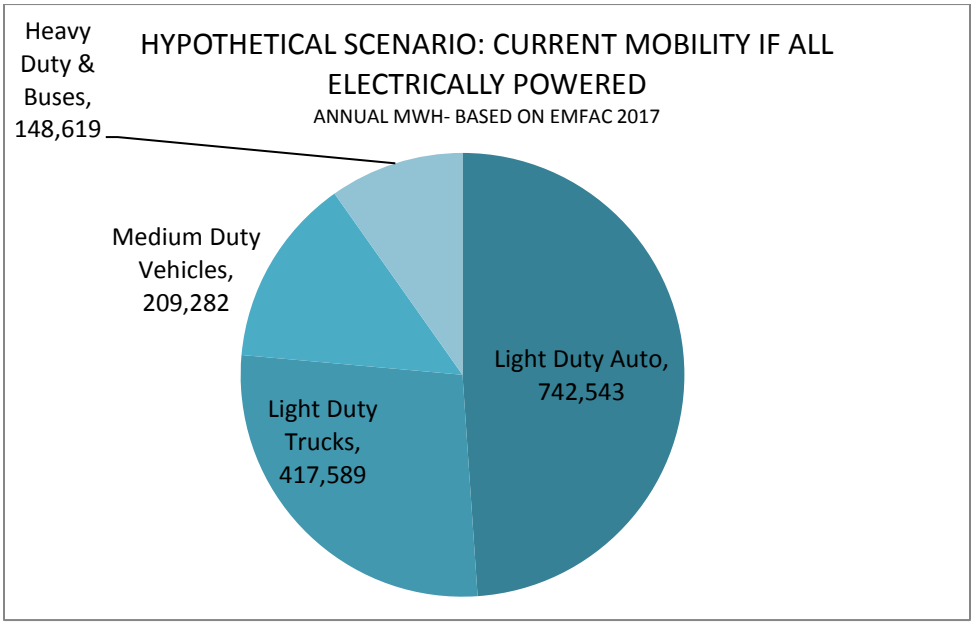
San Francisco MUD Parcels, Housing Units and Parking Spaces by Building Size and Construction Year

Construction Year	Units per Parcel	Number of Parcels	Number of Units	% of City-Wide Housing Units	Estimated Number of Parking Spaces	Average Parking Lot Size
Pre-1940	5-9	3,781	23,989	6%	16,792	4
	10-19	1,822	24,434	6%	6,353	3
	20-99	1,046	38,076	10%	9,900	9
	100+	55	8,005	2%	2,081	38
	Subtotal	**6,704**	**94,504**	**25%**	**35,126**	**5**
1940-1954	5-9	168	1,019	0%	713	4
	10-19	52	631	0%	164	3
	20-99	48	2,322	1%	604	13
	100+	12	3,179	1%	827	69
	Subtotal	**280**	**7,151**	**2%**	**2,308**	**8**
1955-1978	5-9	1,205	8,045	2%	9,574	8
	10-19	546	7,157	2%	5,153	9
	20-99	255	9,545	2%	9,545	37
	100+	50	10,340	3%	10,340	207
	Subtotal	**2,056**	**35,087**	**9%**	**34,612**	**17**
Post-1978	5-9	366	2,439	1%	2,902	8
	10-19	281	3,846	1%	2,769	10
	20-99	287	12,037	3%	12,037	42
	100+	122	24,123	6%	24,123	198
	Subtotal	**1,056**	**42,445**	**11%**	**41,832**	**40**
All construction years	5-9	5,520	35,492	9%	29,982	5
	10-19	2,701	36,068	9%	14,439	5
	20-99	1,636	61,980	16%	32,085	20
	100+	239	45,647	12%	37,371	156
Total		**10,096**	**179,187**	**47%**	**113,877**	**11**

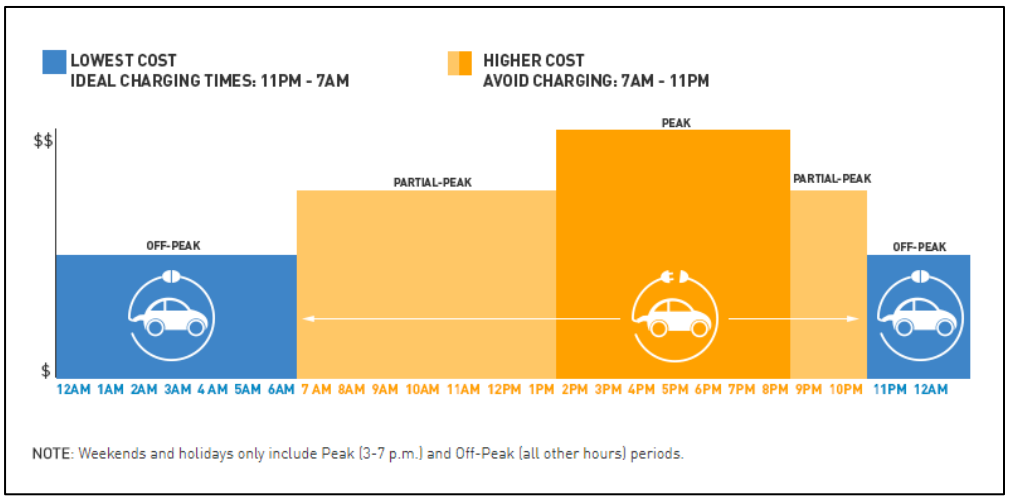
g) Commercial Garages/Municipal Properties

Non-Residential Off-Street Parking Spaces in San Francisco – 2011 (OpenDataSF)	
Owner	**Parking spaces**
SFO	20,000
SFMTA	16,600
Recreation & Parks Department	12,789
Port of San Francisco	3,887
City College of San Francisco	2,663
Department of Public Works	648
Police Department	494
San Francisco General Hospital	348
SFPUC	289
Redevelopment Agency	470
San Francisco Unified School District	233
Other	73
City and County of San Francisco	**58,494**
Presidio	5,061
University of California, San Francisco	4,210
San Francisco State University	3,172
Golden Gate National Recreation Area	1,305
Veterans Administration	1,214
United States Postal Service	703
Laguna Honda Hospital	532
UC	400
State of California	269
Golden Gate Bridge Authority	245
Caltrans	200
DMV	142
BART	53
Other	38
Regional, State and Federal	**17,544**
Private	**113,327**
Grand total	**189,365**

h) Full Electrification Hypothetical by Duty Class



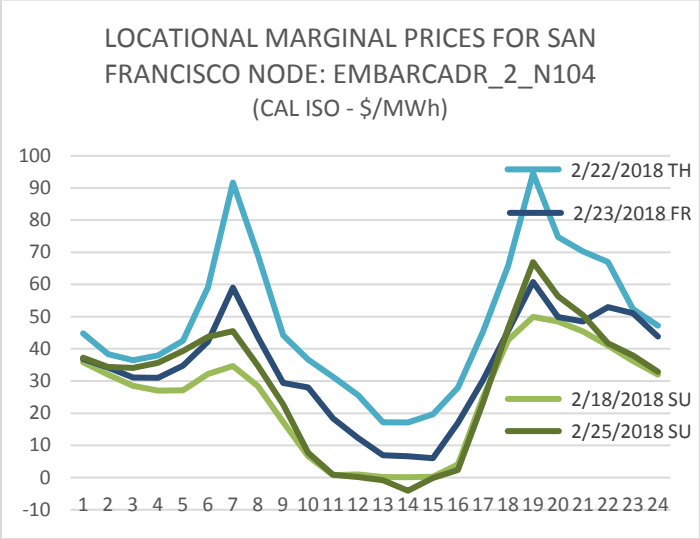
i) Current EV Rate Plan Challenges



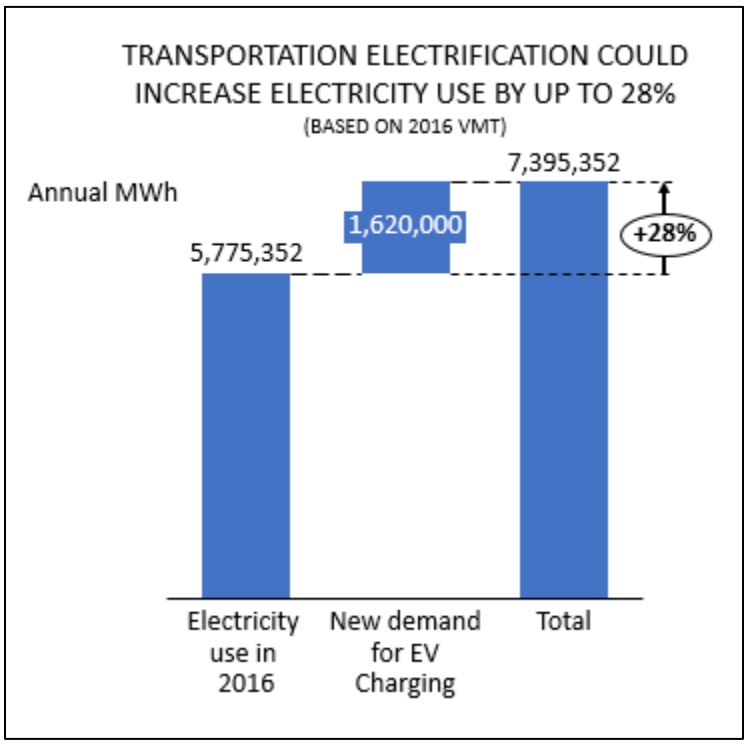
For home charging, a time-of-use EV rate plan rewards charging in the off-peak night hours with rates as low as $0.12/kWh (equivalent to $1.20/gallon gasoline). Uptake of EV specific rate plans is currently estimated at 30% among EV drivers today regionally. EV Rate plans do not reach all because:

- Lack of awareness of impact of EV charging on electricity use and importance of rate plans
- Energy efficient households with limited private mobility needs may prefer a tiered rate plan
- Lack of access to an independent meter – typical in MUD garages
- EV rate plans are not available for larger installations/commercial plans
- Current EV rate plans do not reward charging during peak availability of renewables in the day time

j) Wholesale Generation Prices for Electricity Supply - The Duck Curve



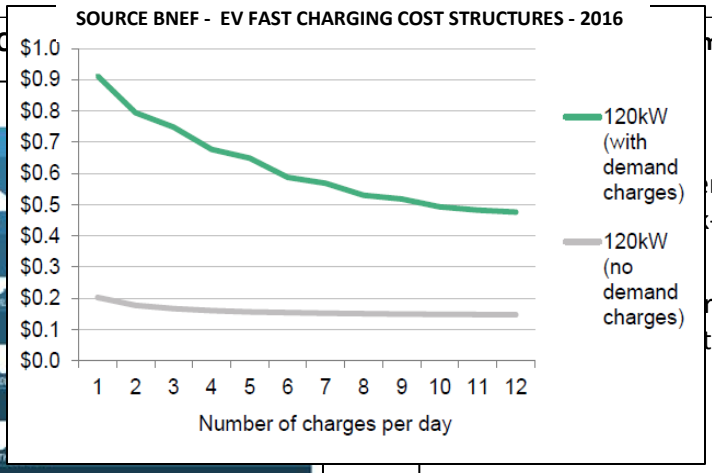
k) Electricity Demand Increase



l) **Cost of Peak Demand Charges for DCFC**

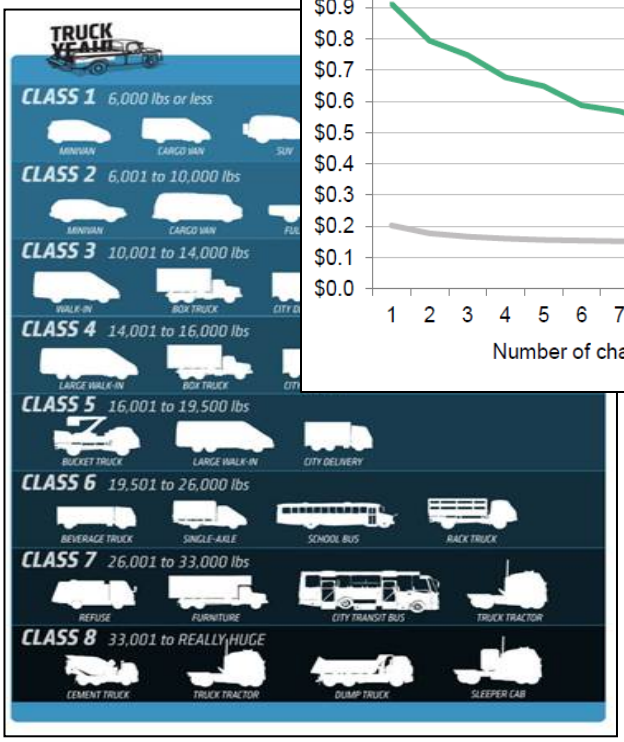
m) Medium- and Heavy-Duty Classes

Cost Curve for DCFC



EMISSIONS BY VEHICLE C

mples of Electric Options



r 20 models

-up: Workhorse

rkHorse, Chanje,

tiv, Zenith

104,433

Buses: Blue Bird, Greenpower, Motiv, Navistar, Lion
Trucks: BYD

138,083

Buses: over 10 mfg: Proterra, BYD
Trucks: BYD, Cummins, Tesla, Volvo

n) Mode Share

Mode Share by Zone

Table 11: Mode Share by Residential Location, Five Year Averages (2013 - 2017)

Place of Residence	Private Auto	TNC/ Taxi/ Carshare	Transit	Walk	Bike	Other
San Francisco	**44%**	**3%**	**23%**	**26%**	**3%**	**1%**
Zone 1	31%	5%	26%	33%	4%	1%
Zone 2	30%	5%	23%	38%	4%	1%
Zone 3	54%	2%	21%	21%	2%	1%
Zone 4	59%	1%	19%	19%	2%	<1%
Zone 5	54%	1%	27%	15%	4%	<1%
Outside of San Francisco	**52%**	**1%**	**30%**	**17%**	**<1%**	**<1%**
East Bay	37%	1%	40%	21%	<1%	<1%
North Bay	64%	1%	17%	17%	1%	<1%
South Bay	64%	2%	24%	11%	<1%	<1%

Shaded cells indicate mode share above 50% goal
Source: Corey, Canapary & Galanis Research, 2017; Fehr & Peers, 2017

Zone Map