The City of Santa Monica: Reducing Greenhouse Gas Emissions

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ACKNOWLEDGEMENT

We'd like to take this opportunity to acknowledge and express gratitude to those who have made this report possible. This report would not have been made possible without the continual support and expertise of all of the following individuals and organizations. Thank you to our advisor, Juan Matute, for gracing us with his wisdom and guidance these past few months, they have been enriching!

Special thanks to Noah Garrison, The City of Santa Monica, Santa Monica's Office of Sustainability and the Environment, and UCLA's Institute of the Environment and Sustainability.

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ACRONYMS

AB	Assembly Bill
ADA	Americans with Disability Act
ARRA	American Recovery and Reinvestment Act
AR5	IPCC's Fifth Assessment Report
AVR	Average Vehicle Ridership
BAU	Business-As-Usual
BBB	Big Blue Bus
BTU	British Thermal Unit
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CHP	Combined Heat and Power
CLUES	Challenging Lock-in Through Urban Energy Systems
CNG	Compressed Natural Gas
CO_2-e	Carbon Dioxide Equivalent
CPH	Copenhagen
EBO&M	Existing Buildings Operations and Maintenance
EEI	Education and Environment Initiative
EIA	Energy Information Administration
EPA	Environmental Protection Agency
ETF	Environmental Task Force
ETRP	Employee Trip Reduction Plan
EV	Electric Vehicle
Expo LRT	Exposition Light Rail Project
GBC	Green Business Certification

GHG	Greenhouse Gas
GWP	Global Warming Potential
HHW	Household Hazardous Waste
HSGP	Human Services Grants Program
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt Hour
LEED	Leadership in Energy & Environmental Design
LNG	Liquid Natural Gas
LUCE	Land Use Circulation Element
LFG	Landfill Gas
MG	Million Gallons
MGD	Million Gallons A Day
MMBTU	One Million British Thermal Unit
MSW	Municipal Solid Waste
MSERC	Mobile Source Emission Reduction Credit
MWD	Metropolitan Water District
NEPA	National Environmental Policy Act
PS	Parking Structure
SAT	Sustainability Advisory Team
SCAQMD	South Coast Air Quality Management District
SCD	Southern California Disposal
SCP	Sustainable City Plan
SERRF	Southeast Resource Recovery Facility
SMMUSD	Santa Monica-Malibu Unified School District
SMURRF	Santa Monica Urban Runoff & Recycling Facility

SSLE	Strategy for a Sustainable Local Economy
SWMP	Sustainable Water Master Plan
TOD	Transit Oriented Development
UWMP	Urban Water Management Plan
WTE	Waste-to-energy

UNITS

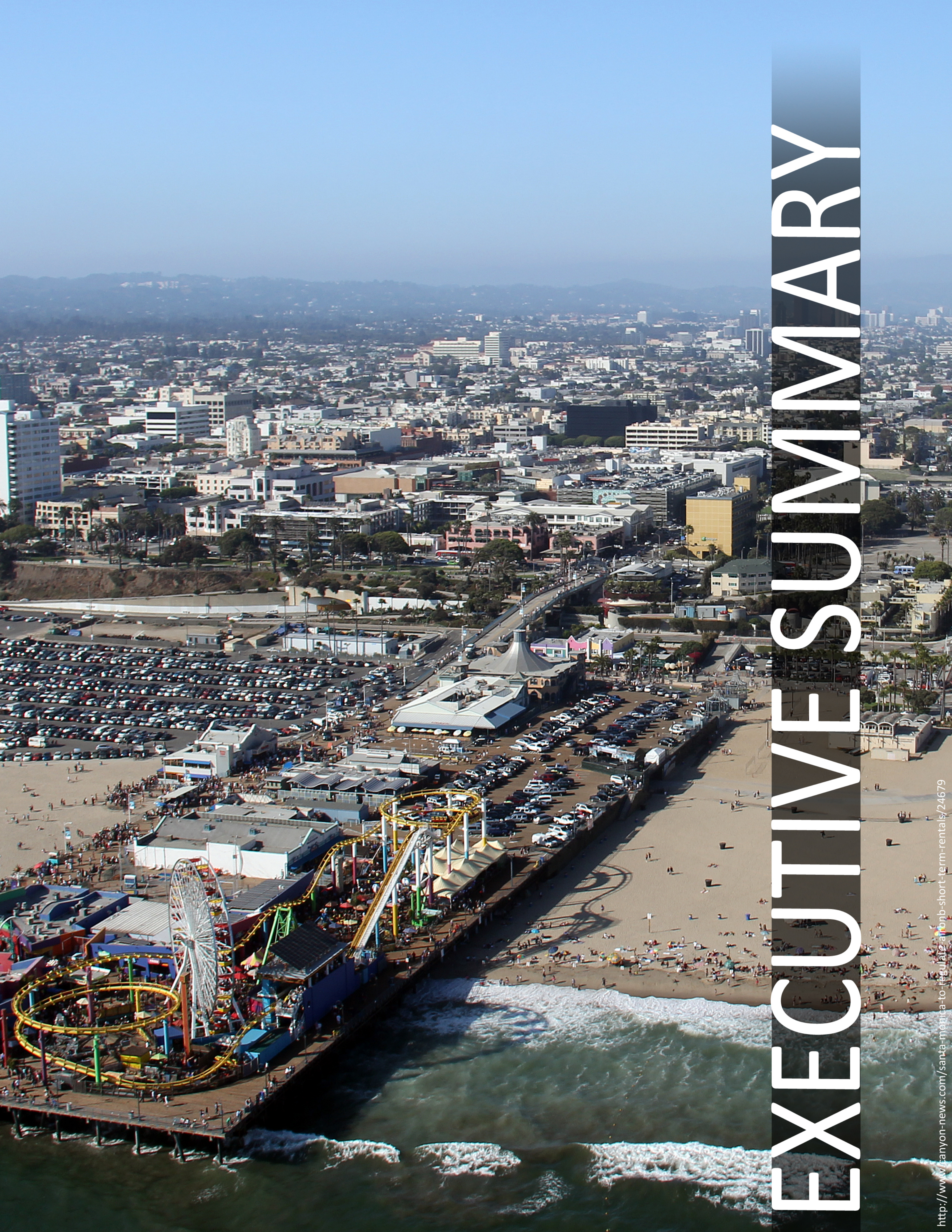
af	Acre feet
GWh	Gigawatt-hour
kWh	Kilowatt-hour
MGY	Million gallons per year
MMBTU	Million British Thermal Units

ENERGY CONVERSIONS

British terminal units (Btu)	1 MMBtu = 1 million Btu = 10 therms = 293.3 kWh
Joules (J)	1 MJ = 1 million J = 947.1 Btu = 0.2778 kWh = 0.009471 therms
Kilowatt hour (kWh)	1 kWh = 3,411 Btu = 0.03413 therms
Therms	1 therm = 100,000 Btu = 29.30 kWh

Water Units	Water Conversion
Acre Feet (AF)	1 AF= 0.32585 MG
Million Gallons (MG)	1 MG = 3.0689 AF

EXECUTIVE SUMMARY



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EXECUTIVE SUMMARY

RESEARCH QUESTIONS

Based on guidance from the City of Santa Monica and an initial review of academic literature and City climate action plans, we prioritized five research questions for this project.

- What goal for greenhouse gas emissions (GHG) should the City of Santa Monica establish for community emissions?
- Which GHG emissions should Santa Monica seek to address?
- How can Santa Monica reduce GHG emissions caused by energy use in buildings, especially existing building?
- How can Santa Monica reduce GHG emissions from transportation? How can the city address trips that cross the jurisdictional boundaries?
- How can the City meet its water needs with local sources of water while reducing GHG emissions?

APPROACH

This report represents seven months' work by a team of UCLA students in the Environmental Science program. Our work was conducted under the supervision of a faculty advisor as a capstone project for the B.S. degree in Environmental Science.

We first divided the project into five areas of expertise: transportation, energy, infrastructure, water, and waste. Each sector was assigned to a member of the team, who researched climate action opportunities for the sector and acted as a subject matter expert in providing recommendations to Santa Monica. After assigned a sector, each member assessed current emission reduction potentials by researching and evaluating current plans and proposals already implemented or planned for implementation in the near future. We also reviewed carbon neutrality and GHG reduction plans from other leading cities, such as Stockholm, Copenhagen, and Seattle, to propose emission-reduction actions.

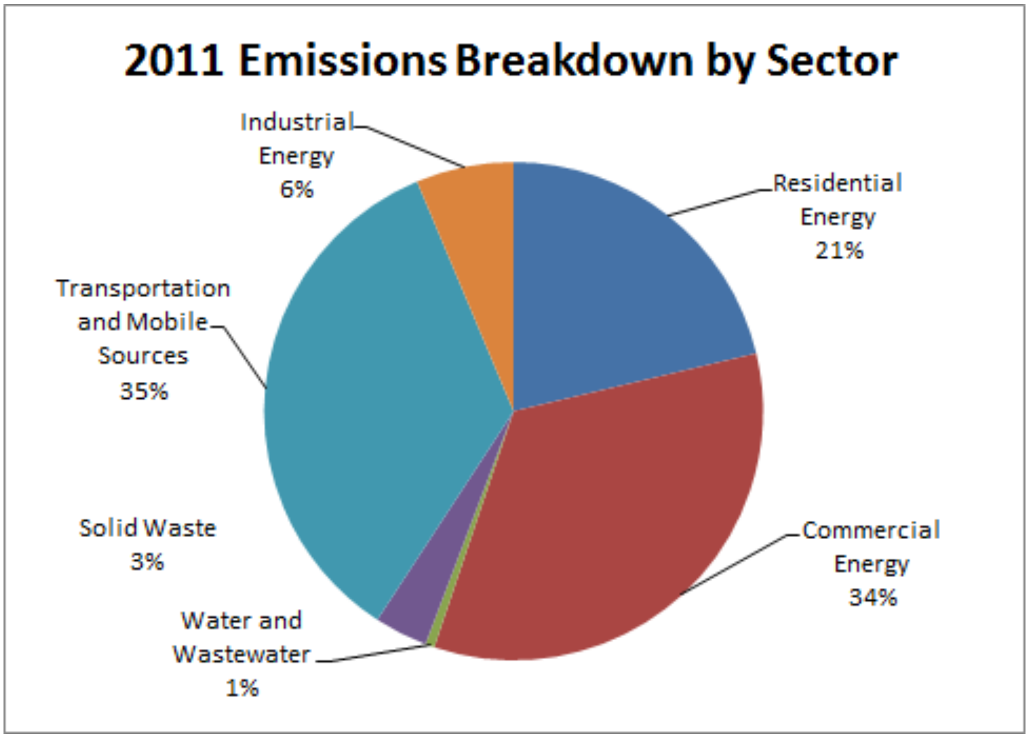


Figure 1: Breakdown of Santa Monica's 2011 emissions by sector**.**

To define the set of emissions Santa Monica should seek to address, we considered academic literature on community GHG accounting boundaries. The types of emission boundaries were defined to clarify whether the accounting framework of Santa Monica's emissions would be measured at basic community emissions (production-based), expanded community emissions-generating activities (geographic-plus), or consumption level (indirect emissions). Santa Monica's current emission goals are centered on the reduction percentages in the annual flow of emissions in a future year. Climate impacts are more a function of the accumulation of emissions (stock) in the atmosphere rather than the annual flow rate.

Therefore, the team recommends a cumulative goal for emissions rather than a percentage reduction from 1990 levels. The team determined that the City had a cumulative emissions budget of 4,772,459 MTCO2e from January 1, 2015. This number was determined by using the IPCC's global cumulative carbon budget of 1 trillion MTCO2e, calculating the remaining balance (410 billion MTCO2e), creating a global per-capita budget based on the projected 2030 global population, and scaling this per-capita budget to Santa Monica's projected 2030 population (103,363).

Once the emission boundary was determined, SEEC-Clearpath California, a climate action planning tool, was used to quantify Santa Monica's GHG inventory. We evaluated the City's current GHG emissions, business as usual projections into the future, and emission reductions resulting from each recommended reduction strategy.

RECOMMENDATIONS

TRANSPORTATION

- Santa Monica should continue to develop its EV charging infrastructure to support an EV carshare program in the City. EV carshare programs reduce the vehicle miles traveled by conventionally fueled vehicles and the car's accessibility can replace multiple privately owned vehicles. A fleet of 250 EV cars could reduce carbon dioxide emissions by up to 2,500 metric tons in Santa Monica. Autolib' and Car2go are two privately owned EV carshare services that are considering operating in the Greater Los Angeles area. Santa Monica should contact these services about expanding their home area to incorporate the City.

- Currently, the Big Blue Bus operates on renewable natural gas. While this is a remarkable accomplishment for a municipal fleet, the BBB should continue to push for use of less carbon intensive fuels. Both electricity and hydrogen are emerging fuel sources for bus fleets. The city should evaluate whether or not these fuel sources are infrastructurally and financially feasible for the Big Blue Bus. The adoption of a cleaner fuel source would help significantly in reducing the emissions associated with an already relatively low GHG intensive mode of transit.

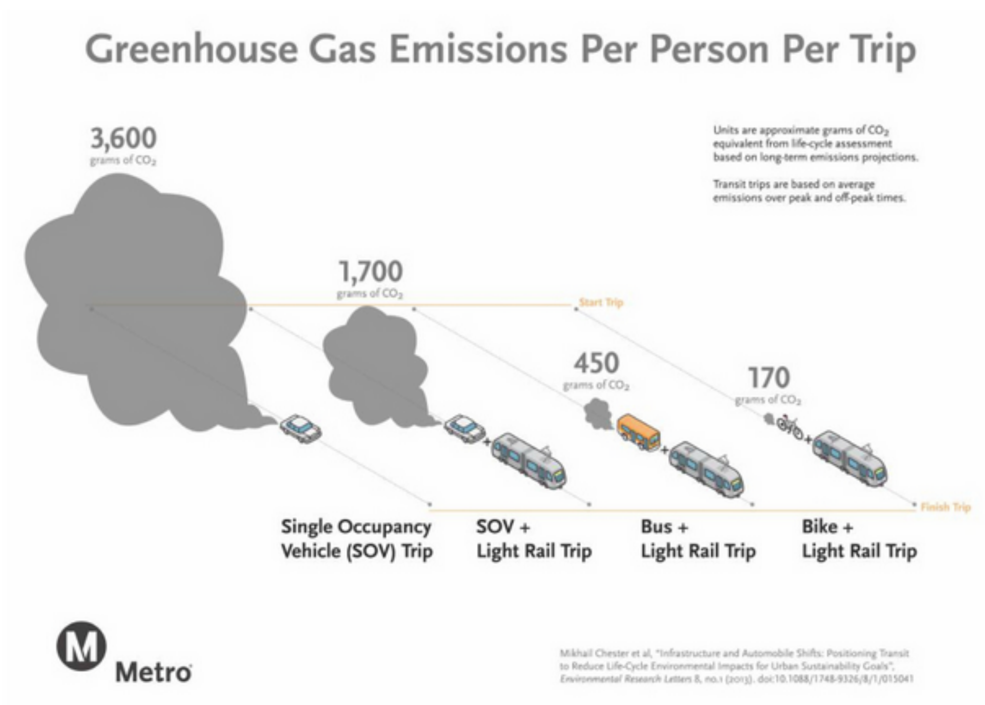


Figure 2: GHG emissions associated with varying modes of transit.

- Above all, Santa Monica will have to make long-term investments in shaping the way its citizens live and transport themselves. The City currently faces a deficit of housing, relative to the number of jobs available in the city. As a result, many of its workers must commute in and out of the city on a regular basis. Transit Oriented Development (TOD) will play a crucial role in the way Santa Monica evaluates its current land use patterns. This entails the integration of residential and commercial growth along transit hubs. Santa Monica should consider the development of more housing units, especially with the arrival of the Expo Light Rail Line. There will be greater use and ability to maximize the environmental benefit of the impending light rail line if more workers live closer to the line. To further maximize the benefits of the transit line, Santa Monica should invest in TOD early so that they can realize more of the benefits sooner.

ENERGY

- Southern California Edison (SCE) serves the City of Santa Monica as its public electric utility, with a plurality of its energy mix being natural gas (Southern California Edison, 2014). Although SCE has made commitments to utilize more sources of renewable energy (solar, wind, biomass) in the future, Santa Monica itself still has the power to claim agency over its residential, commercial, and municipal electricity needs. This can be done by implementing a community choice aggregation (CCA) framework and providing a feed-in-tariff to encourage the growth of solar distributed generation (DG). Both methods would help Santa Monica reduce its GHG emissions by introducing much greater usage of local and renewable energy.

  Under a CCA, the summed demand of consumers is used to negotiate and advocate for more renewable energy sources. New solar, wind, and biomass sources for electricity are secured for procurement, while still using a public utility's transmission and distribution systems. For Santa Monica, this would be done through participation in the plans set forth by South Bay Clean Power: a leading working group focused on creating the first CCA in California' South Bay region. By joining South Bay Clean Power, Santa Monica would receive less of the financial burdens of setting up and maintaining a non-governmental CCA, since multiple cities would be involved in the process. Similar case studies for South Bay cities including Torrance and Hermosa Beach have shown the benefits of these cities partnering to join this historic CCA-in-the-making (Armour, et al., 2014). For example, the Hermosa Beach report projected an abatement of 5,978 megatons (MT) of carbon dioxide (CO_2) (Hampton et al., 2014).

- Distributed generation (DG) refers to an electric power source connected directly to the distribution network or on the customer site of the meter. The City has little potential for wind DG within its boundaries, but significant potential for solar energy generation via rooftop solar PV panels. As of 2014, the Santa Monica has a total of 4.53 MW of solar capacity installed, versus a theoretical potential solar capacity of 257.25 MW (DeShazo, Matulka & Wong, 2011). A feed-in-tariff offers renewable energy generators long-term price guarantees for the energy that they export into the grid, and has been very successful in helping Germany become the world's leader in solar PV generation. Assuming the FiT is implemented in 2020, we may expect PV generation to grow to supply about 28.5% of the City's 2013 electricity consumption by 2050.

WATER

- Santa Monica plans to meet its water needs with local sources of water, including recycled water from Santa Monica's Urban Runoff Recycling Facility (SMURRF), rain harvesting, stormwater capture, and groundwater. Conservation programs and increased water rates limit the water used by residents. Aside from the recommendations given in the Sustainable Water Master Plan, this report recommends expanding SMURRF as well as the different non-potable uses of recycled water. However, after calculating the different GHG emissions associated with Santa Monica's water supply, it was found that SMURRF water has the highest energy intensity per unit of water. The numbers from the calculations can be found below in Table 1. To offset the high energy intensity required at SMURFF, a primary recommendation for the water sector is the generation of renewable energy, including solar are biogas. This will help Santa Monica reach water self-sufficiency while considering the resulting GHG emissions of treating more water at SMURRF.

- Table 1 also shows another top finding of the report, the drastic difference of energy intensities between imported water with and without long distance supply, conveyance, and treatment. By including the supply, conveyance, and treatment of imported water, it further encourages Santa Monica to reduce imported water since it also helps the City achieve its GHG reduction goal.

Table 1: Santa Monica's water supply energy intensity.

Santa Monica Data	kWh/MG
SMURFF 2014	33,346.44
Groundwater 2012	4,142.67
Imported 2012 (without supply/ conveyance/MWD treatment)	215.63
Imported 2012 (with long distance supply/ conveyance/MWD treatment)	9,050.52

INFRASTRUCTURE

- Santa Monica's main focus when it comes to existing buildings and infrastructure should be in performing retrofits to upgrade buildings to higher efficiencies. Presently, over 70% of California's buildings and infrastructure are assumed to have been built prior to 1978 when building efficiency standards were first developed (CEC, 2015). Since there are currently no legal policies requiring the energy-efficiency improvements of existing buildings, the challenge for Santa Monica will be convincing homeowners to retrofit their homes. One method would be to encourage homeowners to perform energy audits themselves so they are cognizant of where the majority of energy is being consumed in their house. Another option would be for Santa Monica to increase energy costs to make the energy that would be saved from the retrofits more appealing to residents. The profits gained from the increased costs could also be used to generate a fund that would go toward subsidizing the retrofits. Finding ways to move away from appliances that use natural gas such as through water heaters and HVAC systems for space heating can also significantly cut down on Santa Monica's emissions. For new construction, California's efficiency standards are increasing such that by 2030 all new buildings are expected to be Zero Net Energy (Fogel, 2013). Therefore, Santa Monica needs to comply with California's standards for all new construction.

WASTE

- Santa Monica should enhance its current waste management strategies with advanced WTE technologies to achieve zero waste goals and reduce emissions in the City. As outlined in its waste management plan, Santa Monica should focus on its behavioral change marketing schemes, because waste prevention - or source reduction, will be the most effective way to reduce overall consumption in the City. Other key strategies to focus on include programs that facilitate recycling and composting efforts and extended producer responsibility. Based on other leading waste management cities, these primary strategies appear to be the most important and provide the greatest reduction in GHG emissions from the waste sector. The City should consider siting gasification and anaerobic digestion facilities to conduct recycling and composting efforts, as well as reduce emissions associated with landfilling and incineration. This will also allow Santa Monica to take advantage of the energy potential from the production of heat and natural gas to reduce its emissions further.

FINDINGS

Clearpath California, a tool developed by ICLEI USA and provided to local governments under the California Statewide Energy Efficiency Collaborative (SEEC) Program, was utilized to analyze the impacts of the report's recommended reduction strategies on Santa Monica's carbon emissions. This was compared against a BAU projection that takes into account state and federal, but not local, actions towards cutting carbon emissions.

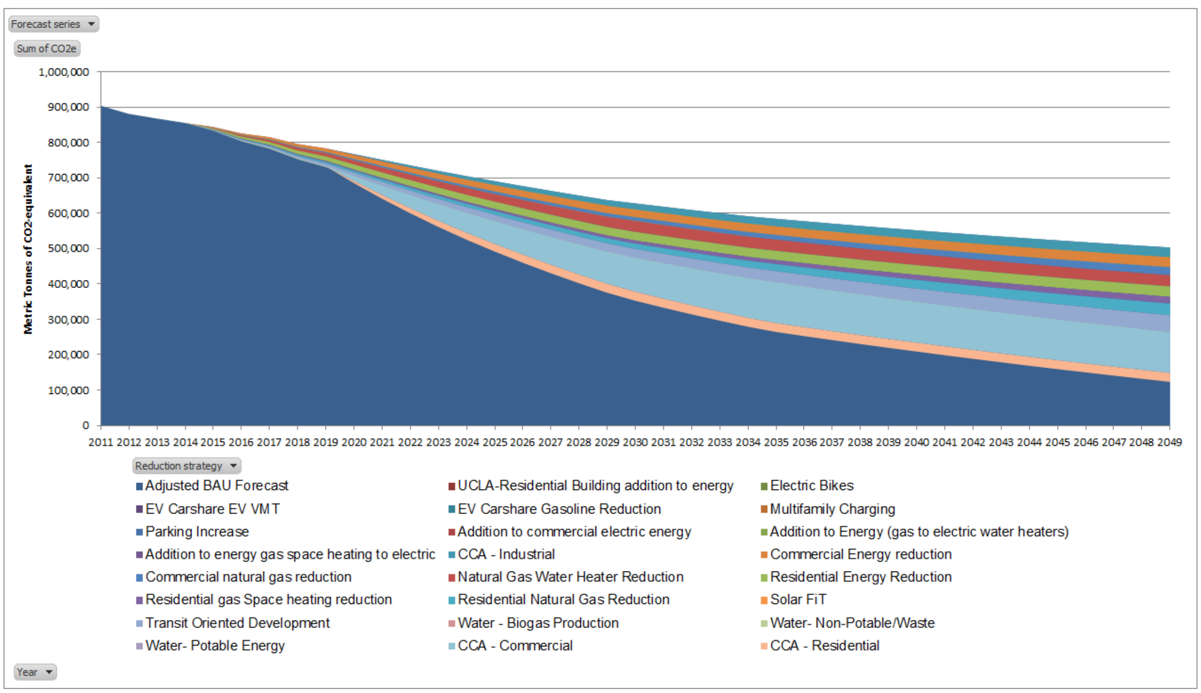


Figure 3: Wedge diagram of total emissions reductions (MTCO2e) and contributing reduction strategies from 2011-2050.

The City will achieve an 81.84% reduction in emissions below 1990 levels by 2050 assuming the recommended scenarios are implemented. This meets the City's previously publicized goal of an 80% emissions reduction below 1990 levels by 2050. The wedge diagram above details the breakdown of reductions by strategy, Figure 3.

The top 9 recommendations detailed in this report provide a cumulative emissions reduction of 10.38 million MTCO2e below a 2011 emissions baseline, Table 2. Implementation of a CCA accounts for 39% of this reduction, followed by residential natural gas reductions at 19% (Figure 4). It is important to note that the recommendation of a solar FiT is not included in this analysis, because the generated solar power would not result in further emissions reductions when the grid electricity provided under the CCA is already emissions-free. Nonetheless, the solar FiT will be crucial in helping Santa Monica become self-sufficient in its water and energy needs, and the team recommends that the City implement it.

Table 2: Cumulative CO2e reduction (in MTCO2e) achieved by each of our top recommendations for the City, below 2011 levels.

Rank	Strategy Name	Cumulative CO2e reduction (MTCO2e)
1	Community Choice Aggregation (All Sectors)	-4,064,008
2	Residential Natural Gas Reductions	-1,980,823
3	Electric Vehicle Measures	-1,187,349
4	Transit Oriented Development	-1,005,530
5	Residential Electricity Efficiency	-781,863
6	Commercial Electricity Efficiency	-705,883
7	Commercial Natural Gas Reductions	-416,430
8	Parking Rate Increase	-242,522
Total		**-10,384,408**

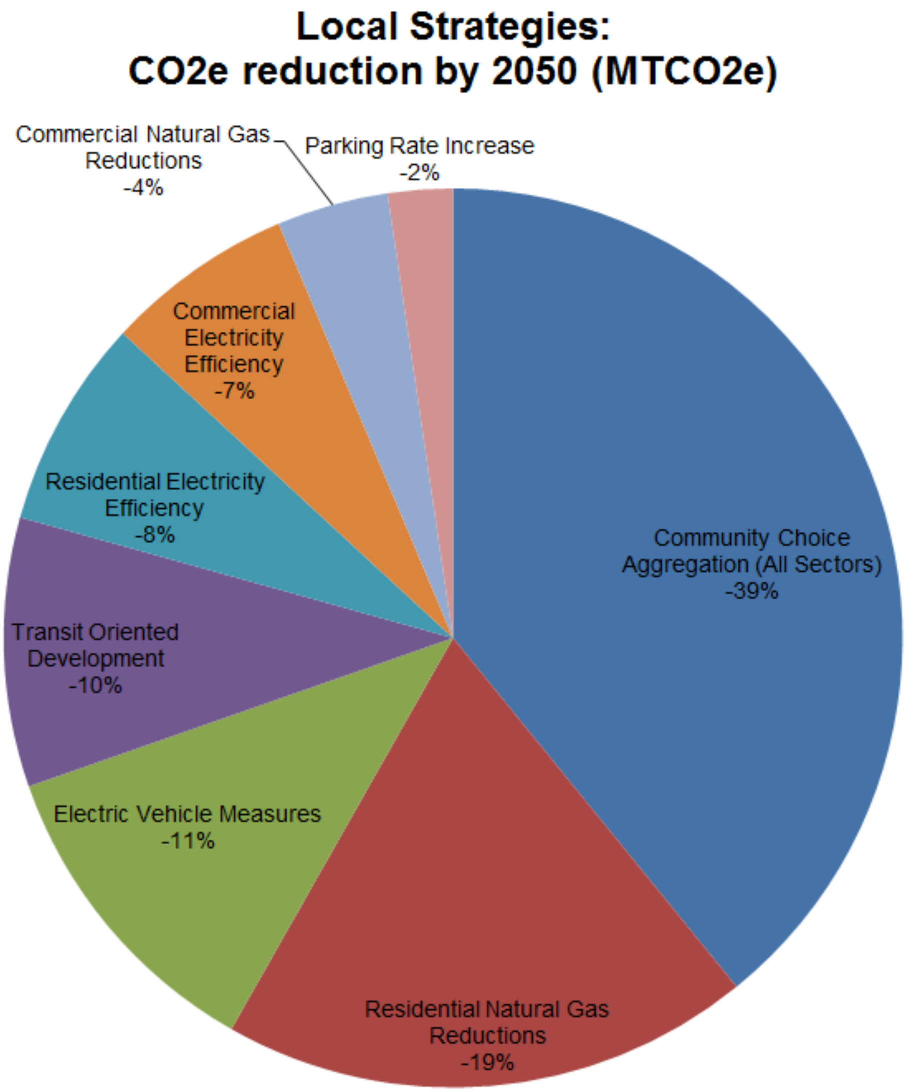


Figure 4: Pie chart showing proportion of CO2e reductions achieved by each strategy, as a percentage of the sum total of emissions reductions achieved by the top recommendations.

Under the recommendation that the City adopts a cumulative approach to emissions reduction, the team calculated that Santa Monica has a recommended cumulative budget of 4,772,459 MTCO2e emissions into the future, based upon the IPCC global budget of 1 trillion MTCO2e. Unfortunately, findings suggest that even with aggressive reduction strategies in place, Santa Monica will exceed that budget within the next five years. There is nonetheless a significant reduction of about 7.71 million MTCO2e in cumulative emissions with the recommended aggressive action to cut emissions, versus BAU projections, Table 3.

Table 3: Cumulative emissions (in MTCO2e) in our recommended stock-based goal based upon IPCC global budget, our BAU scenario and recommended scenario with reduction strategies implemented.

Cumulative Emissions (MTCO2e)	
IPCC-based goal 2015 and beyond	4,772,459
Without Recommended Strategies (BAU) 2015 - 2050	24,649,288
With Recommended Strategies 2015 - 2050	16,938,660

INTRODUCTION

http://www.loewshotelsblog.com/run-beach/

INTRODUCTION

RESEARCH QUESTIONS

In order for a plan allowing Santa Monica to achieve Carbon Neutrality by 2050, or an 80% reduction in GHG emissions at minimum, to be developed, certain research questions had to be answered first.

How do we define carbon neutrality? The general principle behind carbon neutrality is to either stop the release of carbon emissions an entity emits or invest in carbon offsets to remove the equivalent amount of emissions released. While the elimination of emissions is preferred, it is difficult to achieve as cities have become reliant on carbon emitting technologies. For Santa Monica, investments in carbon offsets are most likely going to be required and will be more cost effective for the City rather than attempting to eliminate emissions entirely.

How do we define emissions boundaries for Santa Monica? The boundaries have been divided into five sectors: transportation, energy, water, infrastructure, and waste. Emissions and energy consumption factors were evaluated for each sector separately and these decisions for Santa Monica's scope are outlined in the boundary section of the introduction.
How can Santa Monica address GHG emissions caused by energy use in buildings, especially existing buildings? Santa Monica's main concern for addressing GHG emissions in buildings resides in existing buildings. Santa Monica will need to find ways to incentivize and convince residents that retrofitting would be in their best interest. Methods for accomplishing this could be performing energy audits, increasing energy costs, or subsidizing retrofit costs.

How can Santa Monica reduce GHG emissions from transportation? How can the city address trips that cross the jurisdictional boundaries? The City should work to address traffic and transportation by encouraging use of less GHG intensive fuels and discourage single occupancy vehicle use, which could be done by: providing EV charging infrastructure and carshare and changes in parking pricing. Santa Monica should also encourage shifts in modes of transit with public transportation, biking, and walking. Measures the City can take include: utilizing alternative fuel sources for the BBB, transit-only lanes, electric bike fleet, and movement to TOD. For trips that cross jurisdictional boundaries, Santa Monica is responsible for half of the trip distance and the GHG emissions resulting from the trip.

How can the City meet its water needs with local sources of water? The City's water needs can be met with local sources of water, including recycled water from Santa Monica's Urban Runoff Recycling Facility (SMURRF), rain harvesting, stormwater capture, and groundwater. In addition, conservation programs and increased water rates will limit consumption.

What new infrastructure might be required for Santa Monica to pursue carbon neutrality? How much would it cost? Existing buildings and structures need to be upgraded to higher efficiency standards. The costs to perform some of these retrofits can be extremely expensive, however, and the City may need to find ways to subsidize some of the cost. Santa Monica also needs to further develop its EV charging infrastructure throughout the City to allow for the implementation of an EV carshare service.

Would behavioral changes be required for Santa Monica to achieve >80% reduction in GHG emissions? How would the City affect citizens' behavior? Behavioral change is essential for Santa Monica to achieve its goal and can be done through social media, public relations campaigns, and surveys. The City can affect citizens' behavior by increasing energy and water costs, placing water restrictions, and improving bike lanes and public transportation.

What are global climate change leaders doing? What actions or ideas might be transferable to Santa Monica? Seattle, Stockholm, and Copenhagen have highly developed climate action plans, and thus provide Santa Monica with ideas on how to reduce GHG emissions. Leading cities' transferrable ideas include: programs and building codes increasing retrofits and upgrades, solar panels and windmills generating renewable energy, and improving alternative transportation methods.

APPROACH

We first divided project into areas of expertise. Each sector (energy, transportation, infrastructure, water, and waste) was assigned to a member of the team and each member acted as an "expert" in researching and providing feedback to Santa Monica in their sector. After assigned a sector, we assessed current emission reduction potentials by researching and evaluating current plans and proposals already implemented, or planned for implementation in the near future. We also reviewed carbon neutrality and GHG reduction plans from other leading cities, such as Stockholm, Copenhagen, and Seattle to propose emission-reduction actions.

The types of emission boundaries were defined to clarify whether the accounting framework of Santa Monica's emissions would be measured at basic community emissions (production-based), expanded community emissions-generating activities (geographic-plus), or consumption level (indirect emissions). Santa Monica's current emission goals are centered on the reduction percentages in the flow of emissions by a set year. Climate science is more concerned with the stock of emissions in the atmosphere rather than the annual flow rate. Therefore, the team looked into setting a cumulative stock goal for emissions rather than a percentage reduction from 1990 levels. Once the emission boundary was determined, Santa Monica's current GHG emissions were quantified using ClearPath and existing data. Using current plans and available data, projections of total possible emission reductions were calculated, which helped determine whether additional reduction strategies, such as offsets, are needed in order for Santa Monica to meet its emissions reductions goals.

Who Are We? We are a group comprised of seniors in the Environmental Science practicum program at the University of California, Los Angeles. The practicum program is a capstone project that seniors undertake in the final year of their studies. Groups of 6 or 7 work with a variety of organizations, businesses, and agencies to conduct environmental research projects that are of interest to their clients. Each group is assigned a faculty advisor who provides professional expertise relevant to the project. The groups closely work over a span of two quarters with their clients in a variety of capacities, ranging from independent research to field work, to ensure that their project goals are being met. Through this, our team has been fortunate to have been paired with The Office of Sustainability and the Environment within the City of Santa Monica.

Why Did Santa Monica Approach Us? The Office of Sustainability and the Environment works within the context of the City of Santa Monica developing and implementing local policy initiatives targeting environmental practices and regulatory activities. The Office approached the practicum program last year to provide insight and help develop long term climate action planning for the City. More specifically, the City wanted our team to evaluate the feasibility of obtaining certain carbon reductions goals and help them chart a course for their implementation. Since then, our team has collaborated with the office to conduct research and assess the City's progress in reaching these goals. The first quarter, we spent much of time defining our research questions and doing research within our respective areas of expertise. This past quarter, we have committed to developing recommendations the city can undertake to reach their GHG reductions goals. We hope the City will find the work that we have done has provided value and insight to their vision of a more sustainable city.

SANTA MONICA'S CURRENT SUSTAINABILITY PRACTICES AND FUTURE SUSTAINABILITY GOALS

With increasing population and consumption pressures, the City of Santa Monica has taken the initiative to lessen the community's demands on environmental resources. Santa Monica's Sustainable City Plan (SCP) seeks to ensure social and economic security for both current and future generations, while enhancing residents' quality of life and protecting the environment. Enacted in 1994, the SCP – formerly known as the Santa Monica Sustainable City Program – focuses on evaluating the long-term environmental impacts of community choices and providing sustainable solutions for those choices. While the Plan includes a goal for GHG emissions, its reach is far more comprehensive than emissions and global climate change. The SCP operates under nine goal areas that will help Santa Monica attain Sustainable City status by 2020 (City of Santa Monica, 2014).

Figure 5: The nine goal areas that the CP operates under to help Santa Monica attain Sustainable City status by 2020 (City of Santa Monica, 2014).

The City Task Force on the Environment (ETF) is primarily responsible for developing and overseeing the Plan. The City created the Sustainability Advisory Team (SAT) was created to facilitate communications between the City and concerned departments to ensure the Sustainable City goals are upheld and targets are met. The ETF has developed two reporting tools, the Sustainable City Progress Report and the Sustainable City Report Card, in order to inform relevant parties on the progress of the Plan's goals and adjust policies accordingly. The progress report provides up-to-date, detailed analysis on each specific indicator outlined in the Plan, while the report card offers summaries of the goal areas and grades them based on their effectiveness (City of Santa Monica, 2014).

Each of the nine goals outlined in the Plan contain sub-goals, indicators, and targets. These have been developed to measure the progress of each goal and to assist with policy decisions. The SCP tracks two types of indicators: (1) system level indicators and (2) program level indicators. System level indicators assess the effects of each program goal on the community, and program level indicators measure the success of specific programs or city policies. Additionally, targets have been set for several of the indicators and provide quantitative milestones for the city to achieve by 2020. The Plan has also adopted eleven guiding principles to help the city in its sustainability efforts (City of Santa Monica, 2014).

1	The Concept of Sustainability Guides City Policy
2	Protection, Preservation, and Restoration of the Natural Environment
3	Environmental Quality, Economic Health and Social Equity are Mutually Dependent
4	All Decisions have Implications to the Long-term Sustainability of Santa Monica
5	Community Awareness, Responsibility, Participation and Education are Key Elements of a Sustainable Community
6	Santa Monica Recognizes its Linkage with the Regional, national, and Global Community
7	Those Sustainability Issues Most important to the Community will be Addressed First, and the Most Cost-Effective Programs and Policies will be Selected
8	The City is Committed to Procurement Decisions which Minimize Negative Environmental and Social Impacts
9	Cross-sector Partnerships are Necessary to Achieve Sustainable Goals
10	The Precautionary Principle Provides a Complementary Framework to Help Guide City Decision-Makers in the Pursuit of Sustainability
11	Santa Monica is Committed to Sustainable Rights for its Residents, Natural Communities, and Ecosystems

Santa Monica's existing sustainability practices and future sustainability goals are organized by the nine goal categories. Future goals are based on targets for 2020:

Resource Conservation

The conservation of resources both locally and globally is central to the SCP. Currently, 100% of the power purchased by the city is renewable, which owes to programs such as Solar Santa Monica. The Santa Monica Civic Center Parking Structure – the first sustainable parking lot to be built in the U.S. – has LEED certification and a solar photovoltaic roof that generates 181 kilowatts of electricity for the city. Additionally, 70% of the city's vehicle fleet and equipment are powered by natural gas, an alternative energy source. Further, Santa Monica's commitment to recycling and composting through initiatives such as the Community Waste Diversion Program cut GHG emissions by 36% (City of Santa Monica, 2015; California Air Resources Board). Future targets require further reductions in the waste, water, and energy sectors by 2020. The Plan calls for solid waste generation reductions to 2.4 pounds per person per day with an 85% diversion rate through innovative waste management strategies. Targets for water use require a citywide reduction in both demand and per capita consumption with 100% of water coming from local sources. And lastly, energy use is expected to drop by 10% citywide through reductions in energy use intensity and increasing efficiency in existing buildings. By 2020, the City plans for all new and existing municipal buildings to achieve LEED GOLD certification (City of Santa Monica, 2014).

Environmental and Public Health

Santa Monica has taken big steps to improve environmental and public health in the city. The Watershed Management Plan, passed in 2006, seeks to improve the quality of and divert polluted urban runoff through various methods, including capture and storage and treatment at the Santa Monica Urban Runoff and Recycling Facility (SMURRF). Further measures to protect the quality of the ocean water and sensitive marine ecosystems that live there include the ban on single-use plastic bags and all non-recyclable take-out food containers. Since 1996, the Toxics Use Reduction Program has been in effect to reduce the amount of toxic chemical products used in city operations. As of 2010, 8 of the 20 product categories have been replaced by more sustainable alternatives. Some of the toxic chemicals that have been removed range from triclosan in hand soap to toluene in graffiti removers to petroleum diesel operated fleet vehicles. Moreover, as of 2009 60% of Santa Monica households properly dispose of hazardous waste at the Household Hazardous Waste Center, compared to 2% at the beginning of the decade. Another indicator of public health is access to fresh, local, and organic produce. There are currently four farmers' markets, one of which promotes zero-waste, and three community gardens throughout the city (City of Santa Monica, 2015).

Although Santa Monica has made valiant efforts to create a healthy community for its residents, it seeks to make considerable improvements in air, water, and food quality. Specific goals include eliminating the use of toxic materials and the level of pollutants in the water and air, as well as increasing the consumption of locally and organically grown foods. In terms of water quality, beach closures are still well above the 2020 zero days target for dry weather, with warnings and closures standing at 41 days in 2008. Thus, Santa Monica has established several targets to address wastewater problems, calling for an upward trend of permeable surfaces, city purchases of sustainable products, and the elimination of marine debris. Other relevant targets include a 15% increase in the total amount of organic produce served at city facilities and community institutions, a 15% reduction in residential meat and dairy consumption, and no days in which the ambient air quality standards are exceeded (City of Santa Monica, 2014).

Transportation

Transportation goals seek to minimize pollution and congestion while maintaining equal access for all city residents. This requires the provision of sustainable and affordable modes of transportation throughout Santa Monica (City of Santa Monica, 2014). According to the Office of Sustainability and the Environment, "Santa Monica has been a leading advocate for regional transportation planning, including the Exposition Line Light Rail which is an important part of the overall regional strategy to enhance mobility and relieve congestion" (City of Santa Monica, 2015). The City also encourages ridesharing among Santa Monica businesses, with an average vehicle ridership (AVR) of 1.61 as of 2008. AVR is calculated as the number of employees divided by the number of vehicles on-site, so the higher the AVR the better. This is on track with the Sustainable City Plan target of an AVR of 2 by 2020. Moreover, ridership on the Big Blue Bus continues to increase, with almost 100% of its fleet running on liquid natural gas (LNG). The launch of the Mini Blue Bus in 2007 was in response to increasing public transit demands (City of Santa Monica, 2015). The GHG implications associated with the transportation sector are further outlined in Santa Monica's 15X15 Climate Action Plan, which addresses the City's larger climate goals. The Plan serves to reduce GHG emissions by 15% from 1990 levels by 2015. Based on the 2011 emissions inventory, transportation accounts for 38% of community sources of emissions – the largest of all sectors. Other programs in place to encourage more sustainable forms of transportation include the installation of electrical vehicle (EV) charging stations and the adoption of the Bike Action Plan. The goal of the Bike Action Plan is to establish a bikeshare program and expand the bike network to increase cyclists' safety while reducing vehicle emissions and congestion. The free bike valet service is one method that serves to accomplish these goals. Implementation of the bike infrastructure by 2015 alone will contribute 13% to the total emissions reduction target (City of Santa Monica, 2013). Despite efforts to switch to more sustainable modes of transportation, vehicle traffic still remains a large issue in the city. The SCP does not specify specific quantitative targets, but suggests annual increase in ridership on city transit services such as the Big Blue Bus and EXPO light rail. It also urges annual increases in total bikeshare usage, the number of bikes parked by bike valet, and the total miles of bike lanes (City of Santa Monica, 2014).

Sustainable Local Economy

Santa Monica fosters, and continues to foster, a diverse and sustainable economy. The Strategy for a Sustainable Local Economy (SSLE), developed by the city and its community members in 2008, seeks to "attract and retain businesses that support economic development,

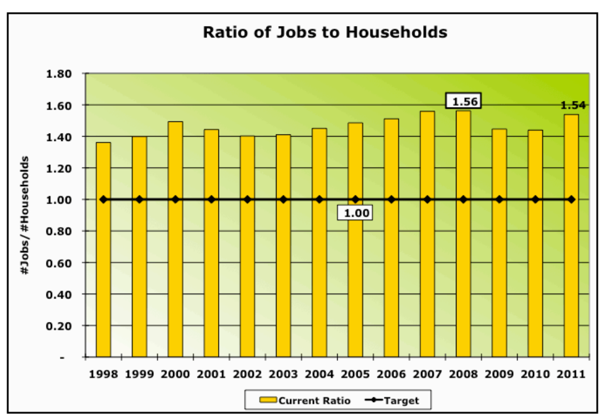


Figure 5: Ratio of jobs to households in Santa Monica.

social responsibility and environmental stewardship" (City of Santa Monica, 2015a). The Green Business Certification Program (GBC), which began in 2005, has recognized over 80 Santa Monica businesses for their commitment to sustainable practices (Sustainable Works, 2015). In conjunction with this, the Sustainable Works Business Greening Program provides businesses with free environmental assessments and employee training to help them reach Green Business status and reduce their environmental impact (City of Santa Monica, 2015). Based on environmental programs such as these, it should not be difficult for the city to attain the SCP target of 200 participants by 2020 considering the upward trend of sustainable business practice (City of Santa Monica, 2014). Moreover, efforts to stabilize the economy by diversifying the business sector have proven successful, with the top three sectors – Information, Professional, Science & Technology, and Financial Services & Insurance – meeting the SCP target of representing 50% or less of the total economic activity of the city. Further, no one sector constitutes more than 25% of the total economic output as outlined by the SCP. Diversification of the local economy protects the community from sudden economic downturns by not relying on any one sector too heavily (City of Santa Monica, 2015; City of Santa Monica, 2014).

Despite Santa Monica's achievements in sustainable development, the rising cost of living in the city and the jobs/housing imbalance present challenges for this goal area. These effects, as stated by the City of Santa Monica (2015), "make it difficult for people to live near their workplace, exacerbating local and regional traffic and parking problems." As of 2011, the jobs/housing balance, which is the ratio of jobs to households, was at 1.54, still well above the SCP target of 1.0. Moreover, housing data from the U.S. Census Bureau (2011) confirmed that only 18% of Santa Monicans actually work in Santa Monica. In order to achieve SCP targets and reduce traffic and pollution in Santa Monica, the City is working to create affordable and appropriate housing types that reflect the job surplus in the community. This will require limiting larger development projects to allow for more housing units to be built (City of Santa Monica, 2015).

Open Space and Land Use

Land use policies in Santa Monica stress open space and transit accessibility to support the natural function of ecosystems, provide recreational space for the community, and encourage sustainable forms of transportation such as biking and walking. Open space in Santa Monica, as of 2008, represents 8.6% of the total land area with 90% of its residents living within a half mile radius of a park (City of Santa Monica, 2015). The City plans to increase the number of acres of public open space by adding parks, gardens, green streets, and other public gathering places as well raising park accessibility to 95% (City of Santa Monica, 2014). Additionally, the Open Space Management Division commissioned the Give Santa Monica Program whereby donations from residents help fund the planting of trees, building of playgrounds, and other open space amenities (City of Santa Monica, 2015). The City projects that 2,000 total trees will be planted with an 80% increase in regionally appropriate vegetation for all new or replaced public landscaped areas by 2020 (City of Santa Monica, 2014). Other projects include the Parks Improvement Project and the 2008 Beach Greening Project – funded by Proposition 13 Coastal Nonpoint Source Pollution Control Grant Program – which reduced storm-water runoff from beach parking lots by replacing asphalt with permeable turf (City of Santa Monica, 2015).

The City also wishes to enhance land use and transportation policies to reduce vehicle dependency and encourage other, more sustainable forms of transportation. Several approved and pending mixed-use development projects are underway that combine residential and commercial space in close proximity to transportation nodes. For example, the pending 1560 Lincoln Boulevard mixed-use project will incorporate five stories of 100 residential units and ground floor commercial space. Promoting this type of development will favor walking, biking, and public transportation over personal vehicles and reduce traffic and parking congestion in the city (City of Santa Monica, 2015). The SCP expects an upward trend of residential and mixed-use projects that are within one fourth of transit nodes (City of Santa Monica, 2014).

Housing

The City seeks to achieve a mixed distribution of affordable and green housing types to accommodate people from all socioeconomic backgrounds, especially disadvantaged groups such as seniors and the disabled. The Rent Control Law passed in 2010, which provides just-cause eviction protections in rent controlled units, has kept apartments affordable to very-low and low income residents in Santa Monica. “In addition to preserving the existing stock of affordable rental units, the city is investing in the development of new affordable housing." The Housing and Redevelopment Division financed three development projects to provide 60 affordable housing units and the new mixed-use, mixed-income Civic Center Village offers 160 of such units (City of Santa Monica, 2015). In addition, the SCP outlines specific targets for the number of new housing units that are produced in the city affordable to very low, low, moderate, and upper income households. The Plan also encourages an upward trend of the production of affordable housing for special needs groups and of "liveable" housing, which includes the percent of residential buildings within a fourth mile of transit stops, open space, and grocery stores (City of Santa Monica, 2014).

The City has created multiple programs and implemented policies to make residential buildings more sustainable. In 2000, the city council adopted an ordinance requiring all new city projects to achieve LEED silver certification. Then, in 2004, the Santa Monica Green Building LEED Grant Program was created to encourage private developers, through financial incentives, to acquire LEED certification. In 2005, an ordinance passed that expedites the permitting process for LEED certified projects. And, in 2008, the City green building codes were amended such that all new residential and commercial buildings are required to submit a LEED for Homes and a LEED for New Construction checklist, respectively (City of Santa Monica, 2015). The SCP has no definitive targets for the production of green housing other than requesting an increase in the percent of housing that is certified LEED silver or higher (City of Santa Monica, 2014).

Community Education and Civic Participation

The City strives to encourage its residents to play an active role in the community by participating in civic affairs and having a basic understanding of sustainability. Santa Monica accomplishes this through community programs and hosting events as well as encouraging community collaboration. There are currently seven active neighborhood organizations, such as Friends of Sunset Park, Ocean Park Association, and Santa Monica Mid City Neighbors to name a few, that work to promote the interests of their respective neighborhoods. In addition, there are eight business improvement districts in the downtown area, as well as on Main, Pico, and Montana Boulevard that work to provide a more viable business environment by improving parking, enhancing advertising efforts, and funding promotional events. Furthermore, the 2010 Land Use and Circulation Element (LUCE) provides residents with the city's 20 year vision for its land use, urban design, and transportation framework with the flexibility of adjusting policy based on community input (City of Santa Monica, 2015). Community involvement can also be measured by the city's voter participation in off year elections, with a 65% voter turnout in 2010 which was more than both the county and the state (City of Santa Monica, 2015). However, the city hopes to augment this by 3%, calling for an increase to 68% in off year elections according to the SCP target (City of Santa Monica, 2014). This year the Santa Monica Cultural Arts Division will celebrate its twenty-fourth year of hosting the city-wide Santa Monica Festival, "connecting art, culture, food, sustainability, wellbeing, and transportation to daily living through an electrifying array of programs, activities, and vendors" (City of Santa Monica, 2015). Additionally, the Community Greening Program hosts sustainable events in Santa Monica to educate residents on how to be more environmentally conscious. It is these kinds of events and programs that make Santa Monica residents so active in their community and put the city at the forefront of sustainability (City of Santa Monica, 2015).

Overall, the SCP aims to have an upward trend in resident participation in civic affairs and community organizations, as well as individual empowerment. It is the City's hope that through extensive outreach programs Santa Monica residents will feel comfortable voicing their concerns and play an active role in making their city a better place to live. This also takes into consideration the extent of sustainable community involvement. The SCP outlines resident participation in the Residential and Community Greening Programs and student participation in the Student Greening Program as indicators for the amount of sustainability community involvement in Santa Monica with specific numerical targets for each (City of Santa Monica, 2014)

Human Dignity

Santa Monica strives to enhance the quality of life for its residents by providing access to housing, education, healthcare, economic opportunity, and other basic needs. By creating an environment that positively impacts human dignity, residents are able to focus more on important sustainability issues. The Human Services Grants Program (HSGP) provided approximately $7.6 million in fiscal year 2014-2015 alone to support community organizations and public institutions such as the Ocean Park Community Center and Santa Monica College (City of Santa Monica, 2014a). Further, the Action Plan to Address Homelessness in Santa Monica, adopted in 2008, decreased homelessness by 8% between 2007 and 2009 (City of Santa Monica, 2015a). The Plan has since created four programs to assist with homelessness efforts; these include the

Chronic Homeless Program, Serial Inebriate Outreach Program, Project Homecoming, and Homeless Community Court (City of Santa Monica, 2015). By 2020, the SCP hopes for an upward trend in the number of homeless individuals receiving assistance by the programs and served by city shelters (City of Santa Monica, 2014). Moreover, in 2011, the Santa Monica-Malibu Unified School District (SMMUSD) implemented the State's first environmental curriculum as part of the Education and the Environment Initiative (EEI). According to the California Environmental Protection Agency (2011), "the curriculum includes 85-units of environment-based education in the traditional subjects of Science and History/Social Science for grades K-12." The SCP outlines specific targets for SMMUSD student graduation rate, school attendance, school safety, and those who receive environmental education consistent with the EEI (City of Santa Monica, 2014).

Arts and Culture

The City Council added the Arts and Culture goal area to the SCP in May 2012 to enhance Santa Monica's sustainability efforts and to create a more vibrant community. The city already took initiative in 2006 by drafting the Santa Monica Creative Capital Plan in order to foster arts and culture in the community. According to the City (2006), "community awareness, responsibility, participation and education are regarded as key elements of a sustainable community…[and] these principles are widely shared by the field of the arts and culture." In order to achieve Creative Capital goals, three strategies have been identified: (1) Celebrating Innovation, (2) Increasing Cultural Participation, and (3) Enhancing Sustainability. Furthermore, the planning process found that 43% of Santa Monica Residents are employed in a creative field (City of Santa Monica, 2006). The SCP plans for an increase in creative sector activity, the presence of opportunities for cultural participation, support for the arts, and attendance and participation (City of Santa Monica, 2014). Kubani (2012) from the Santa Monica Office of the Environment and Sustainability articulated in the City Council Report "in recent years arts and culture integration into sustainable community planning efforts has become a best practice that reflects the vital role these facilities and programs play in developing and sustaining vibrant local communities."

ABOUT GLOBAL CLIMATE CHANGE

THE INTERNATIONAL PANEL ON CLIMATE CHANGE (IPCC) AND THE GLOBAL CARBON BUDGET

The Intergovernmental Panel on Climate Change (IPCC) is the leading international authority on the assessment of climate change. Established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), it is an intergovernmental body with 195 member countries currently. The IPCC reviews the most up-to-date research and provides Assessment Reports (ARs) at regular intervals, on the state of knowledge on climate change. The latest AR is the IPCC Fifth Assessment Report (IPCC AR5), finalized in November 2014.

The IPCC AR5 reports that human activities, such as fossil fuel burning for energy generation, agriculture and deforestation, have been the main driving force for large increases in atmospheric concentrations of greenhouse gases (GHG) including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Between 1750 and 2011, anthropogenic CO_2 emissions amounting to 2040 ± 310 $GtCO_2$ was released into the atmosphere, about 40% of which have remained. (Fig. 1) Natural carbon sinks such as the ocean, plants and soils have absorbed the remaining 60%. Of these anthropogenic CO_2 emissions, about 40% have occurred within the last 40 years. (IPCC AR5)

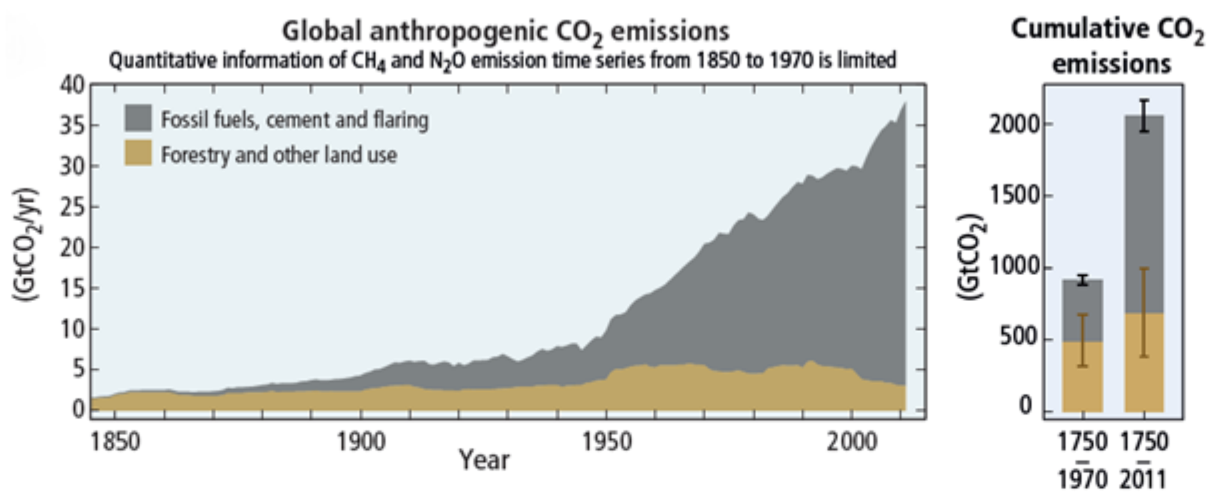


Figure 6: Global anthropogenic CO_2 emissions from 1850 to 2010. Cumulative emissions of CO_2 and their uncertainties are shown as bars and whiskers, respectively, on the right hand side. (IPCC AR5)

In 2010, anthropogenic GHG emissions amounted to 49 ± 4.5 $GtCO_2$-eq/yr [3]. (IPCC AR5) Globally, total anthropogenic GHG emissions have been continuously increasing from 1970 to 2010, the most important drivers being rising CO2 emissions from fossil fuel combustion due to increasing economic and population growth. While contributions from population growth between 2000 and 2010 remained roughly identical as compared to the previous three decades, the contribution of economic growth has sharply risen. IPCC AR5 reports that it is "extremely likely" that anthropogenic forcings are responsible for more than half of the observed increase in global average surface temperature. (Fig. 2) The report also states that anthropogenic influences have "likely" affected the global water cycle, contributed to glacial retreat, and melting of the Greenland ice sheet, while Arctic sea-ice loss, global mean sea level rise and increases in global upper ocean heat content were "very likely" to have anthropogenic contributions.

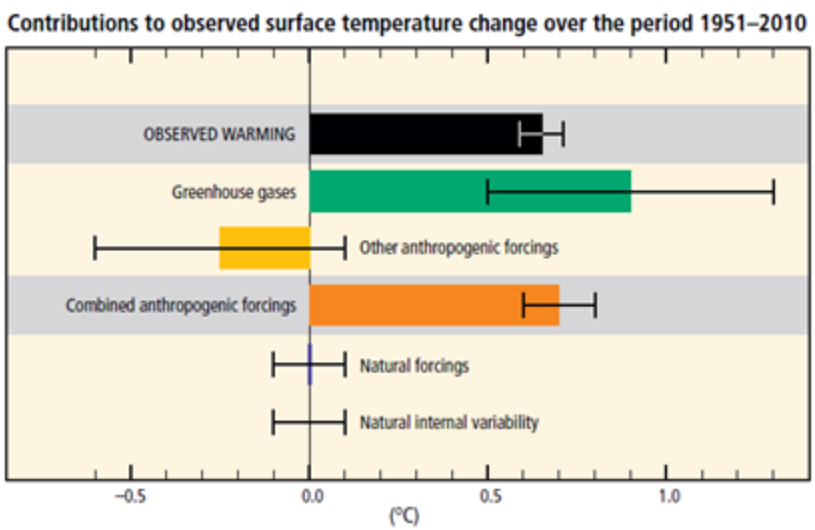


Figure 7: Assessed likely ranges (whiskers) and their mid-points (bars) for warming trends over the 1951–2010 period from various influences. (IPCC AR5)

FUTURE IMPACTS OF CLIMATE CHANGE

Climate change is one of the most highly contested issues of our century and is so for a valid reason. It will only continue to be so as unfavorable environmental conditions, such as warming, are exacerbated. This new standard of production and living for many contemporary societies has forever altered the role humans play in the condition of the planet and climate change. Over the course of the 20th century, the average global surface temperature has increased by .6 C and is projected to increase. Relative to the past nine centuries, the degree of warming in the 20th century has far outpaced its predecessors (Houghton, 2001). Given the context and an increasing and an increasing body of science to support it, human activity plays a very clear role in modifying the earth's climatic conditions and the implications of climate change have far ranging consequences. The impact of climate change is measured through a series of indicators, which can be measured in a variety of methods and information. It is important to note that the impact of global warming is unevenly distributed geographically and demographically, generalizations are difficult to state.

Average Temperature Increase

Without doubt, the earth is warming and is greatly likely due to the growing volume of greenhouse gases that have been released into the atmosphere the past few centuries. This has played a considerable role in the weather variances and climatic extremes that are observed on earth. Key indicators of weather and climate include temperature, precipitation, and drought. Average temperatures of the earth's surface have risen considerably. In the 20th century, average temperatures of the earth's surface rose 6 °C. Over the 21st century, average global temperatures are projected to increase between 2-6 °C. While these may appear to be negligible values, consider that the historic difference between ice age and a warm period is approximately 5-6 °C. Note the transition between an ice age and warm period occurs over a time frame of about 10,000 years (Houghton, 2001). Whereas, these projected temperature changes are currently slated to occur in a timeframe of less than a century. Increased temperatures and drier conditions put certain areas at greater risk for heat waves as well as wildfires, which has negative implications for both the landscape but the people that reside in these areas as well.

Climatic Variations

Global warming is also been tied to the intensity of environmental events that the earth experiences. For example, the intensity and behavior of hurricanes are linked to the warming of ocean waters (Emanuel, 2006). With increased temperatures, there is increased evaporation, which increases the incidence of rain. Given a warming climate, it is expected that rates of precipitation will increase accordingly. Since 1901, the degree of precipitation has grown an average of .2% each decade (U.S. Environmental Protection Agency, 2014). Heavy precipitation occurrences, when precipitation is above normal values for a given area, are anticipated to increase with greater evaporation. Increased and heavy precipitation instances are damaging in that they increase flood risk, may destroy crops, increase soil erosion, and subsequently damage soil structure. As the earth experiences greater rates of precipitation with larger amounts of water being evaporated, less water is being left to reside in soils. This contributes to drying and eventually drought for many areas. Subsequently, there are critical ramifications for the health of agricultural crops, soil, and water resources amongst many other things.

Ocean Temperature

In response to changing climates and weather, the physical landscape has adapted to some of these changes. Some of the most significantly altered landscapes are the oceans of the world, which encompass 70% of the earth's surface (U.S. Environmental Protection Agency, 2014). As more heat is retained in the atmosphere and global temperatures rise, the ocean serves as a sizeable sink for heat. Oceans are ideal reservoirs for heat because they have high specific heats which allows them store large amounts of heat with minor fluctuations in average temperature. In total, global ocean temperatures have risen about .1 °C the past century (U.S. Environmental Protection Agency, 2014). This increase in temperature has sweeping consequences for the function and livelihood of oceans. Increased temperatures may adversely affect wildlife or flora that are unable to adapt or have low tolerance for temperature shifts. This may kill of certain species or displace certain species.

Ocean Acidification

A large concern of warming ocean waters is ocean acidification. As previously mentioned, oceans serve as a reservoir for CO2, with about 26% of anthropogenic CO2 being uptake by the ocean (Gattuso, 2011). With greater levels of CO2 in the atmosphere, there is greater uptake by the ocean of CO2. In the seawater, CO2 turns into a weak acid and is converted into bicarbonate (HCO3-), which makes ocean waters acidic. Surface water level pH levels have decreased from 8.21 to 8.1 (Feely, 2008). Acidic waters make it difficult for calcifying organisms (i.e. organisms with a shell) to maintain a shell as acid dissolves calcium carbonate, an integral mineral of these organisms' shells. Many metabolic and intracellular processes are also pH dependent, which may effectively decrease the vitality of species that are pH sensitive. In addition, acidification inhibits primary productivity by preventing uptake of certain metals or nutrients essential for photosynthesis (Amos, 1999).

Sea Level Rise

Another relevant concern of rising ocean temperatures is sea level rise. As a byproduct of scientific principles, water expands when heated. Therefore, ocean waters expand in volume when surface level temperatures and heat is increased. The melting of glaciers and ice sheets exacerbates this problem, which increases the supply of water being added. Generally, sea level rise is considered more of a problem of the future, as there haven't been critical incidents stemming from the issue quite yet. However, the rate at which it is occurring is fairly alarming. Since 1993 sea level has raised an average of .11 to .12 inches each year, which is double the rate of historic sea level rise (U.S. Environmental Protection Agency, 2014). Sea level rise is of special concern to those living along coastal regions and ecosystems lined along the coast as well. Over 100 million people live within a one-meter distance away from sea level (Bradley, 2011). For areas undergoing sea level rise stress, this could mean lost property and environmental refugees as habitable land becomes scarce. This will also disrupt the operations of businesses that operate on coastal land. Damage to valuable coastal properties and businesses will be costly, as much repair and infrastructure will be needed to rebuild.

The manner in which countries and societies work together to cope with adapting to climate change will be crucial. The concept of adaptation is certainly not a novel one. Populations have proven capable to resist extreme climate transitions, migrate and adapt. However, the rate at which this change is occurring is truly unprecedented from any historical occurrence. It will take a combination of both adaptation and active mitigation to minimize the repercussions of climate change. In a developing and fast-paced world, it is important to recognize, collaborate, and actively work towards this

CLIMATE ACTION IN CALIFORNIA

The California state government has actualized the risks of increased greenhouse gas emissions to the state's coastline, agriculture, snowmelt fresh water supply, and overall well-being. Thus, it has taken steps to become a leader in making targeted efforts towards mitigating the effects of climate change. In 2009, California adopted a statewide Climate Adaptation Strategy (CAS) to summarize climate change impacts and recommend strategies in seven areas: public health, biodiversity and habitat, oceans and coastal resources, water, agriculture, forestry, and transportation and energy. Additionally, the state government has organized "Climate Action Teams" as part of the initiative order to coordinate California-wide efforts to implement emission reduction programs (1).

The most well-known initiative within California's push for fighting climate change is the historic Global Warming Solutions Act of 2006 (Assembly Bill 32). It set an ambitious goal to reduce the state's greenhouse gas emissions to 1990 levels by the year 2020, and furthermore, to 80% below 1990 levels by 2050. Through the bill, California set the stage for its transition into a sustainable future, and showcased itself as an exemplary state focused on climate change mitigation. Assembly 32 was the first program in the United States to take a comprehensive, long-term approach to addressing climate change with both promoting the environment and a sustainable economy at the same time (2). The California Air Resources Board (ARB) is primarily responsible for the implementation of the bill, and publishes an annual statewide greenhouse gas emission inventory.

AB 32 targets activities that contribute to seven major greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, nitrogen trifluoride (2). The quantitative reductions in greenhouse gas emissions are made primarily from cars and trucks, electricity production, and fuels from all parts of the California economy. The reduction strategies are outlined to be accomplished via general policies and planning, direct regulations, market approaches, incentives, and voluntary efforts; these are all outlined in the "Scoping Plan" of AB 32, which is updated every five years (2). The methods are wide-ranging, from better regulating power plants to limit carbon emissions, establishing a 33% renewable energy usage target for 2020 and low carbon fuel standards, encouraging distributed generation of solar energy, institutionalizing a cap-and-trade program, and more.

Apart from AB 32, California has set other legislation in place to ensure that it is addressing climate change. Governor Jerry Brown's Executive Order B-18-12 mandated that new buildings that met specific requirements be constructed with significant energy efficiency guidelines in mind (3). Executive Order B-16-2012 also orders state entities to support and better facilitate the utilization of zero-emission electric vehicles, by supporting research in the field and infrastructure development (4). Measures like these have proven California to be a leader in fighting against climate change, and this culture of environmental advocacy has definitely trickled down into specific counties and cities, including Santa Monica.

CLIMATE ACTION IN SANTA MONICA

Santa Monica updated its 1994 Sustainability Plan in 2006, with a new goal of reducing community greenhouse gas emissions by 15 percent below 1990 levels by 2015. Santa Monica was able to achieve a 14 percent reduction by 2012, but hit a major hurdle as an increase in greenhouse gas emissions was projected from 2012 to 2015, Table 4. The City realized that it was going to need to reduce emission levels by an additional 3 percent by 2015 to meet its 15 percent reduction goal. The City published its short-term 15X15 Climate Action plan in 2012 to outline the 15 measures needed to meet its reduction goal. The plan grouped the 15 measures into eight categories. These categories include Energy Use and Generation Waste Reduction and Recycling, Transportation and Mobility, Open Space and Land Use, Water Conservation and Efficiency, Local Food and Agriculture, Municipal Operations, and Climate Mitigation and Adaption. The 15 measures are summarized in Figure 9.

Table 4: Past and future emissions projections for the City of Santa Monica.

	1990	2000	2007	2011 Estimate	2015 Projection
Population	86,905	85,084	90,379	90,850	93,700
Residential	188,687	202,453	169,425	168,232	168,759
Commercial	329,295	326,164	273,377	241,806	245,506
Industrial	32,227	25,907	53,157	43,412	42,131
Transportation	299,538	300,824	327,923	306,160	319,541
Waste	74,546	47,534	38,779	38,143	38,524
Total	**924,293**	**902,882**	**862,660**	**797,753**	**814,461**
% Below 1990 Levels		2.30%	6.70%	13.70%	11.90%

Santa Monica released an Implementation Update in November of 2014, which documented the City's progress towards the necessary three percent reduction. Santa Monica had reduced 32%, 9,189 MTCO2e, of the roughly 29,000 MT CO2e that are needed to reach the three percent reduction from 2012 to 2015 (Wong, 2014). The same year Santa Monica received the Cool Planet Award for its carbon management, which recognizes Southern California Edison customers that demonstrate leadership in greenhouse gas reductions.

Santa Monica has long been an innovator in adopting policies to reduce greenhouse gas emissions. One example is their selection as one of the five pilot programs for the adaption of a small hydrogen-powered Prius fleet. The City opened the region's fifth municipal fueling station in June of 2006 to maintain this fleet. The program was sponsored by SCAQMD, the City of Santa Monica, and the US Department of Energy and consisted of a fleet of five modified, hydrogen powered Prius hybrids. The fueling station that maintained these vehicles was located in the City's fleet yard on Michigan Ave. This station was able to convert 12 kilograms of hydrogen per day through the electrolysis of water, the equivalent of 4.5 gallons of gasoline (South Coast AQMD, 2006). This program is one of many that have distinguished Santa Monica as a leading example for greenhouse gas reductions.

1. Increase energy efficiency of new buildings to perform 10% better than 2013 Title 24 Standards
2. Reduce energy use citywide in existing buildings by 1 million kWh annually
3. Increase total citywide solar capacity by 500 kW annually
4. Divert 80% of waste from landfills
5. Reduce daily vehicle miles traveled within the city by 13,000
6. Increase biking and mode share to 15 percent
7. Expand public and private infrastructure to support electic vehicle technology
8. Create vibrant mixed use villages that enhance neighborhoods
9. Expand the age, diverstiy and number of trees in the urban forest
10. Reduce water demand by 200,000 gallons per day
11. Reduce consumption of carbon intensive foods
12. Increase the production and consumption of local food
13. Reduce municipal greenhouse gas emissions
14. Monitor greenhouse gas emissions
15. Adapt to teh effects of climate change

Figure 8: The 15 measures proposed by Santa Monica's 15X15 Climate Action Plan (City of Santa Monica, 2013).

DEFINING A COMMUNITY-LEVEL GHG COMMITMENT

OTHER CITIES WITH AGGRESSIVE REDUCTIONS

The Intergovernmental Panel on Climate Change (IPCC) estimates that a reduction of greenhouse gas (GHG) emissions by 80 percent below 2000 levels by 2050 would be required to avoid potentially catastrophic climate change (City of Santa Monica: 15x15). In aligning herself with the international goals established by the IPCC, Santa Monica is charting a path to 80% reductions in emissions below 1990 levels, and is also considering carbon neutrality in the framework. Since such a target is ambitious and has not yet been achieved by any major city, to maximize our success it would be wise to study closely and learn from the GHG emissions reduction plans of international leaders in climate action. Specifically, this report examines three cities in detail – Copenhagen, Stockholm, and Seattle, all three of which have put forth ambitious goals in reducing their GHG emissions.

Copenhagen has announced its intention to become the world's first carbon neutral capital city, achieving carbon neutrality as early as 2025. Stockholm has a long history of being at the forefront of environmental action. The city adopted its first climate plan in 1998, and in 2010 was awarded the title of the first ever European Green Capital for its work on sustainable urban development and for its ambitious targets for the future (City of Santa Monica: 15x15). Stockholm has put forth the goal of reducing emissions by 43% by 2015, and becoming fossil fuel-independent by the year 2050. Seattle has been a national and world leader in climate action for many years. In 2000, Seattle was the first city in the US to adopt a green building goal for all new municipal facilities, and in 2005, Seattle City Light became the nation's first carbon-neutral large electric utility (City of Santa Monica: 15x15). Now Seattle aims to achieve zero net GHG emissions by 2050.

APPROACHES TO ACCOUNTING FOR COMMUNITY GHG EMISSIONS

In addition to examining leading cities' reduction plans, their use of emission boundaries will also be studied. Without a reliable and accurate measurement method, any improvements in GHG emissions may go unaccounted for, which could result in wasted funds and efforts towards addressing climate change. To inventory its emissions, a city must first define the system boundaries of what GHG emissions are attributable to the city. There are several established options for setting these boundaries for communities and local governments (ICLEI, 2013). The first option is "production based" emissions; it is purely geographic and includes direct GHG emissions within the city. Another option is known as "geographic plus," and is a popular method that includes emissions from imported energy and use of air travel by the community. Santa Monica currently uses a variant of the emission "geographic plus" approach to measure its own emissions which excludes air travel Another approach is known as "consumption-based," which for cities without a large export sector is the largest of the three boundary approaches. "Consumption-based" inventories includes the life-cycle emissions, including production, pre-purchase transportation, retail or wholesale, and use phases, of goods and services imported for consumption in the community (Donegan et al., 2012). Figure 10 shows a visual representation of the different GHG emissions with the three scopes. The section that follows examines each of the three leading cities' approach to setting community boundaries.

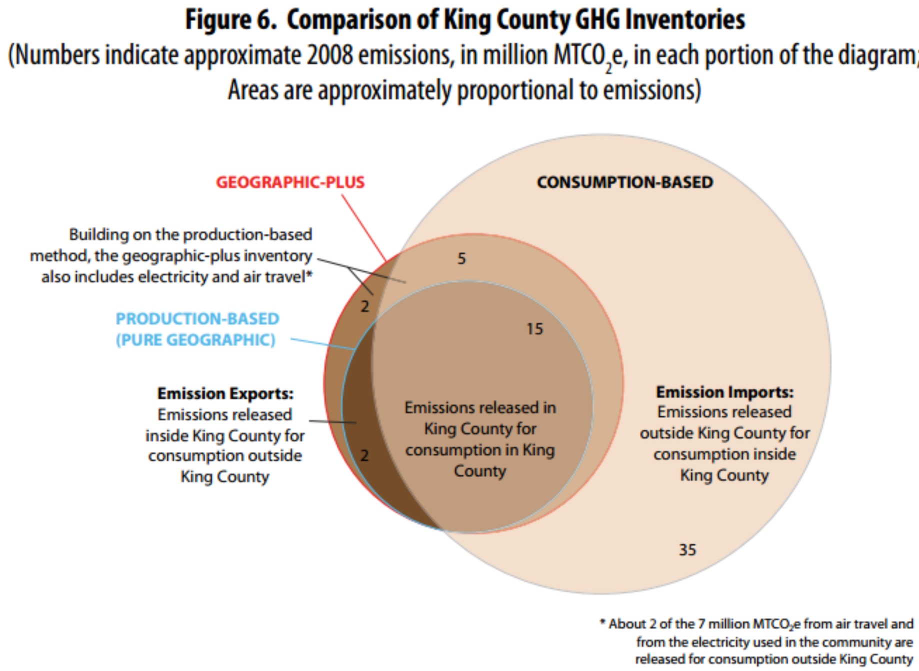


Figure 9: Comparison of King County GHG Inventories: Production Based (Pure Geographic), Geographic-Plus, and Consumption-Based (Donegan, 2012).

Copenhagen, Denmark

Copenhagen, Denmark has made a bold statement in terms of GHG emission reduction goals: in 2012, the city government approved the "Copenhagen (CPH) 2025 Climate Plan", with the ambition of reaching carbon neutrality by 2025, effectively establishing it as the first carbon-neutral capital city in the world (Normander, 2012). Like the Santa Monica 15x15 Climate Action Plan and 2013 Seattle Climate Action Plan, Copenhagen's plan outlines four major areas of targeting

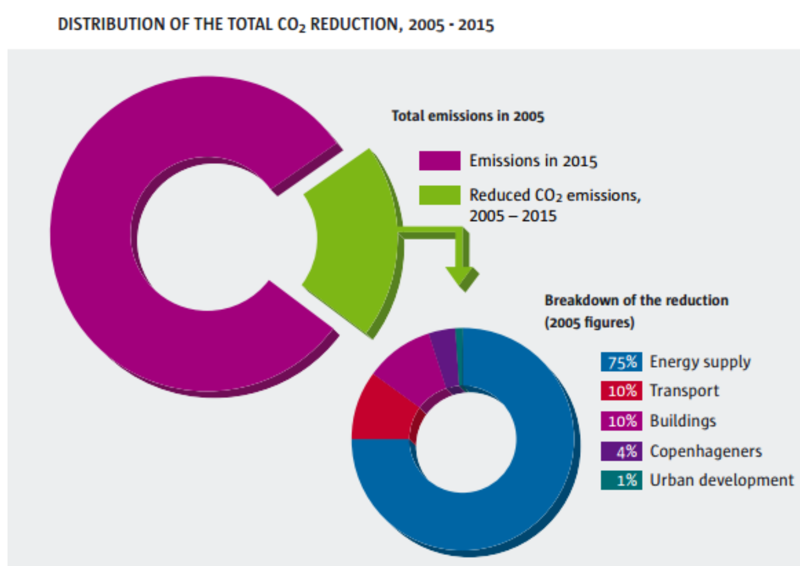


Figure 11: Distribution of The Total CO2 Reduction, 2005-2015 (City of Coppenhagen, 2012).

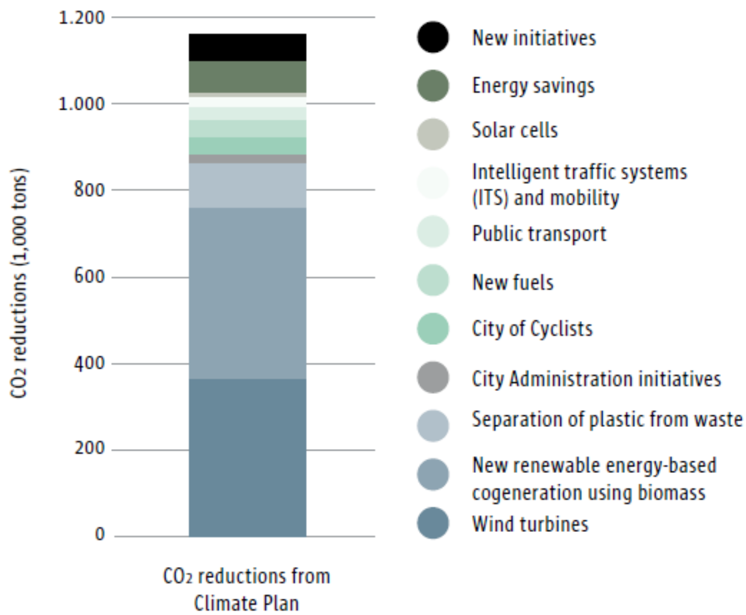


Figure 12: Allocation of CO_2 emission reductions in Copenhagen (City of Coppenhagen, 2012).

GHG reductions (energy production, mobility, energy consumption, and municipal activity), each with its own specific initiatives and goals (City of Copenhagen 5). Figure 10 shows the estimated emissions reductions to be achieved by each initiative by 2025.

The objective of the plan is to reduce carbon emissions by 20% of current levels by 2015 (about 1 million CO_2 tons), and become carbon neutral by 2025. The initiative has planned for 74% of the reduction to come from targeting energy production (855,000 CO_2 tons), 11% from mobility (135,000 CO_2 tons) 7% from energy consumption (80,000 CO_2 tons), and the remaining percentage from municipal administration changes (20,000 CO_2 tons) (City of Copenhagen, 2012).

The energy production changes include a dramatic shift towards primarily “wind, biomass, geothermal energy, and waste” as energy sources (Gerdes, 2012). For energy consumption changes, the city has included goals such as retrofitting older buildings that use energy inefficiently, educating the public on energy efficiency within buildings, and creating design plans for more sustainable lighthouses on the coast (DAC, 2014). This would help with reaching the goal of carbon-neutral district heating and cooling by 2025; in 2010, the municipal utility named Copenhagen Energy opened a new central air conditioning plant powered by nearby seawater, which prevents the release of 14,000 tons of CO_2 annually when compared to conventional cooling methods (Gerdes, 2012). Fourthly, the plan outlines specific measures for energy consumption to be curbed within municipal buildings, including an ambitious switch to electric and hydrogen-powered municipal fleet vehicles, and installation of solar panels on government buildings (City of Copenhagen, 2012).

Information regarding Copenhagen’s impressive reduction goals and climate action plan are easily accessible, but the city does not define the community boundaries for which it plans to neutralize emissions. Therefore, following Copenhagen’s emissions reduction poses a challenge without a properly labeled boundary, making it difficult for other cities to follow its example.

Seattle, WA

Seattle, like Copenhagen, also identified a few areas/sectors that produced a majority of the city's GHG emissions: transportation, building infrastructure and energy, and waste. After realizing, however, that climate change is a broad, far-reaching societal phenomenon that must be addressed with holistic solutions, the Mayor and City Council directed the city's Office of Sustainability & Environment to update and expand their approach, with the 2013 Seattle Climate Action Plan (City of Seattle, 2013). This expansion resulted in the creation of transportation & land use plans, building energy plans, waste plans, and general climate change preparation plans (City of Seattle, 2013). These plans also included several smaller-scope plans designed at targeting very specific sectors and components of the city. For example, within "transportation plans" there are eight smaller-scope plans, including the "bicycle master plan", "pedestrian master plan", and "transit master plan", each with their own quantitative provisions.

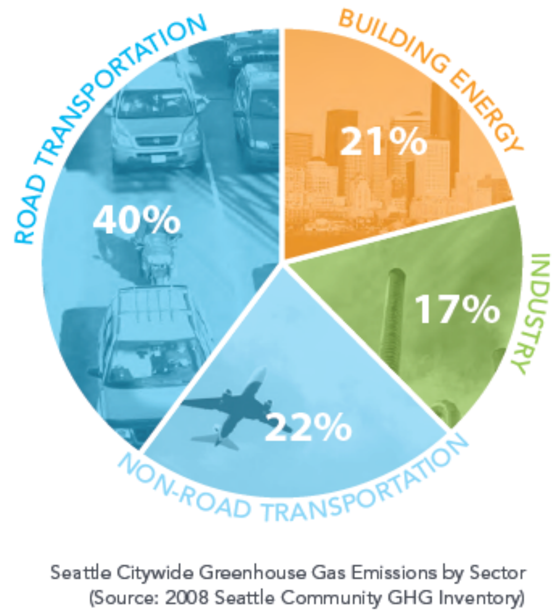


Figure 10: Greenhouse gas emissions by sector in Seattle.

What separates Seattle's plans from other cities is how each of them includes goals, from short-term 2015 "actions," to long-term 2030 "visions." The purpose of these goals is to allow the city to reach zero net GHG emissions by the year 2050, or carbon neutrality, a state of balance in which a measured amount of carbon output equals the amount of carbon emission offsets (Seattle Office of the City Clerk, n.d). The emphasis on offsets and carbon neutrality, stemming from motivations by the Seattle government and building on top of the city's conventional reduction methods, has greatly helped to establish the city as a global leader in GHG reductions. To obtain carbon neutrality, however, careful measurements and

Destination / *Origin*	Seattle	Outside Seattle
Seattle	4,633,466	8,033,767
Outside Seattle	8,696,623	

Figure 14: Transportation emissions within and outside Seattle that the City accounts for.

considerations into what carbon emissions Seattle should be responsible for were included into an emissions inventory.

The 2012 *Seattle Community Greenhouse Gas Emissions Inventory* follows the ICLEI-USA U.S Community Protocol for Accounting and Reporting Greenhouse Gas Emissions and is considered from two perspectives: Core and Expanded emissions. "'Core' emissions are those which the City has the greatest opportunity to influence and are the focus of Seattle's 2013 Climate Action Plan: building energy use, road transportation, and waste management." "Expanded" emissions are sources that serve regional or national demands, while not as directly within the City's to influence (City of Seattle, 2014). These source include "industry, marine, rail, and air travel, yard equipment, and wastewater treatment." Like Santa Monica, Seattle follows ICLEI's recommended estimation for road transportation by including "100% of trips contained within Seattle, 50% of trips with an origin or destination in Seattle, and 0% of trips that both start and end outside Seattle" (City of Seattle, 2014).

The *Seattle Community Greenhouse Gas Emissions Inventory* includes the ICLEI Community emissions summary, which lists the emissions sources and activities included or not. Based on Seattle's inventory, the city is accounting for its emissions using a "geographic-plus" boundary with the inclusion of air travel and electricity.

Stockholm

The first inventory of GHG emissions in Stockholm was initiated in 1995, and established the 1990 emission level to be 3.7 million tons of GHG. Since then, Stockholm has managed to decrease its emissions by 23% to about 2.8 million tons in 2009 (City of Stockholm, 2012). These reductions have been achieved largely through the conversion from oil heating to district heating and switching to biofuels for district heating, which contributed a reduction of 500,000 tons of GHG emissions, heating and switching to biofuels for district heating, which contributed a reduction of 500,000 tons of GHG emissions, the goal of reducing emissions by 43% by 2015, and becoming fossil-fuel free by the year 2050, in the *Stockholm Action Plan for Climate and*

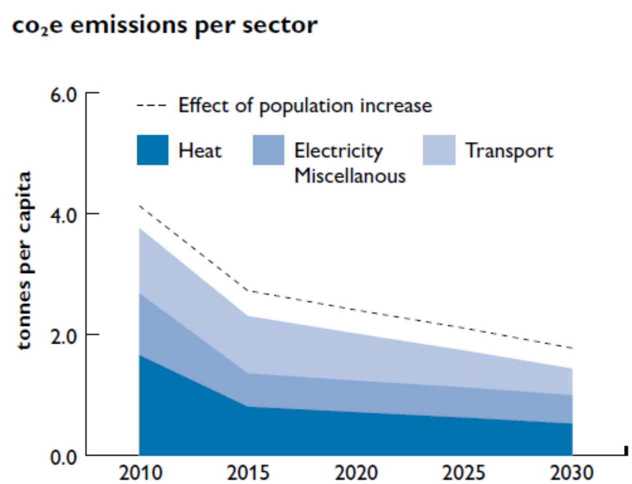


Figure 15: Expected decline in CO_2 emissions by sector between 2010 and 2030, if measures are carried out (Stockholm Plan for Climate and Energy).

Energy 2012-2015 With an Outlook to 2030 (City of Stockholm, 2013) which details the city's plan for achieving this aim.

The report focuses on three main areas targeted for aggressive GHG emissions reductions, namely transport, energy use in buildings and energy production. Figure 15 shows the expected decline in CO_2 emissions between 2010 and 2030.

Stockholm Action Plan for Climate and Energy 2012-2015 With an Outlook to 2030 has a "Greenhouse gas emissions included in the Stockholm City climate targets" section, which explicitly states what is and is not accounted. The action plan states, "production of goods and services", "heating and cooling of all buildings, all traffic work", and "all gas and electricity use" within geographical boundaries of the City of Stockholm" (City of Stockholm, 2013). However, Stockholm does not include "travels by car, train, airplane and ferry outside city limits" and the production of goods and foodstuff from outside the city for consumption within the city. Unlike Seattle and Santa Monica, Stockholm does not estimate emissions using the "geographic plus" approach and only accounts for activities and sources within city boundaries, the "production based" approach.

Copenhagen is internationally-recognized for its "carbon neutrality" goal; however, the city is not setting a precedent in defining which emissions are being neutralized. Stockholm, Sweden and Seattle, Washington are two cities that have defined their boundaries in a comprehensive greenhouse gas emission inventory, further enhancing each city's climate action plan. Without knowing how a city accounts for its emissions, it is challenging to follow the city's actual greenhouse gas reduction progress and even more challenging to compare to other cities.

RECOMMENDING A GHG GOAL FOR SANTA MONICA

GHG EMISSIONS AS A CUMULATIVE STOCK VS. AN ANNUAL FLOW

Greenhouse gases naturally reside in the lower atmosphere and capture the reflected infrared radiation, which aids in warming the earth. As the atmosphere becomes more saturated with greenhouse gases, more infrared radiation is captured and more heat is retained. Climate change is a function of the stock of GHG in the atmosphere rather than the annual flow of GHG. Once GHGs are emitted they "remain in the atmosphere for varying amounts of time" (EPA, 2007). There are short-lived compounds such as particulate matter (PM) that are only airborne for hours to days while the half- life of CO2 ranges between 5 to 200 years (IPCC, 2001). A quarter of the GHG in the atmosphere will remain there "after hundreds of years and about one-tenth for hundreds of thousands of years" (Archer and Ganopolski, 2005; Archer et al., 1998) which explains why climate change is, for the most part without considering short lived gases, a function of the GHG stock.

There are two approaches for developing a carbon budget and goals, “stock” or “flow.” With both types of goal, a city may reach its designated target, but have different paths to reach that goal, thereby, releasing different cumulative amounts of greenhouse gases before the deadline year. Cities can choose to front-load, back-load, or linearly reduce GHG emissions. By front-loading, drastic reductions are made in the beginning, rather than a “business as usual” and waiting until later in the timeline to reach the emissions rate target. The “business as usual” followed by reduction approach is back-loading, which accumulates the greatest greenhouse gas concentrations. The linear approach gradually reduces emissions rate, which is better than back-loading, but should not be preferred over front-loading.

“Flow” based goals focus on the rate of emissions release, rather than the actual concentration. This is illustrated below in “Annual Emissions Inventory (Flow).” The “flow” based model does not set the urgency to reduce the most emissions from the start, front loading. By front -loading emissions, cities emit less greenhouse gases cumulatively since steps are taken to reduce the most emissions in the beginning rather than the end of the timeline. Once carbon dioxide is emitted into the atmosphere, it remains there for years. The “flow” approach does not address the concentration of GHG in the atmosphere that accumulates year after year. “Stock” based goals are cumulative, rather than focusing on rate of emissions, and stress the great accumulation of greenhouse gas in the atmosphere.

Comparing the “Annual emissions Inventory (Flow)” and the “Cumulative Greenhouse Gas Emissions” graphs below show the different urgencies and reactions associated with each process. The flow graph shows a hopeful outlook, where cities feel accomplished with their greenhouse gas reduction while the cumulative graph shows that there is always room for improvement and further reductions. It is important for cities to communicate the need for front-loading and this can be accomplished by following a “stock” based goal and setting a carbon budget. Cities should be reacting to climate change with a “stock” based and front-loading state of mind, emissions need to be cut and these cuts need to be done now rather than later. Specific for Santa Monica, Figure 16 and 17 depict the vastly different amounts of emissions based on a stock-based, carbon neutral, and flow-based GHG goals calculated. The flow-based is the “80% reduction by 2050” and allows the greatest release of emissions, 18,362,578 metric tons compared to the stock-based allowance of 4,772,549 metric tons.

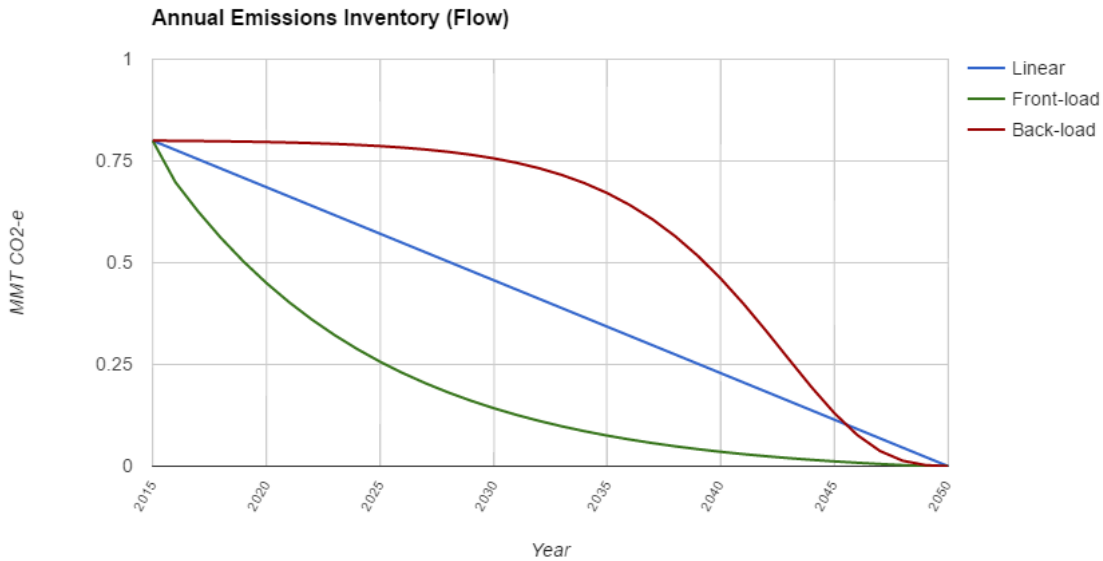


Figure 11: Annual Emissions Inventory (Flow Based) following linear, front-load, and back-load paths.

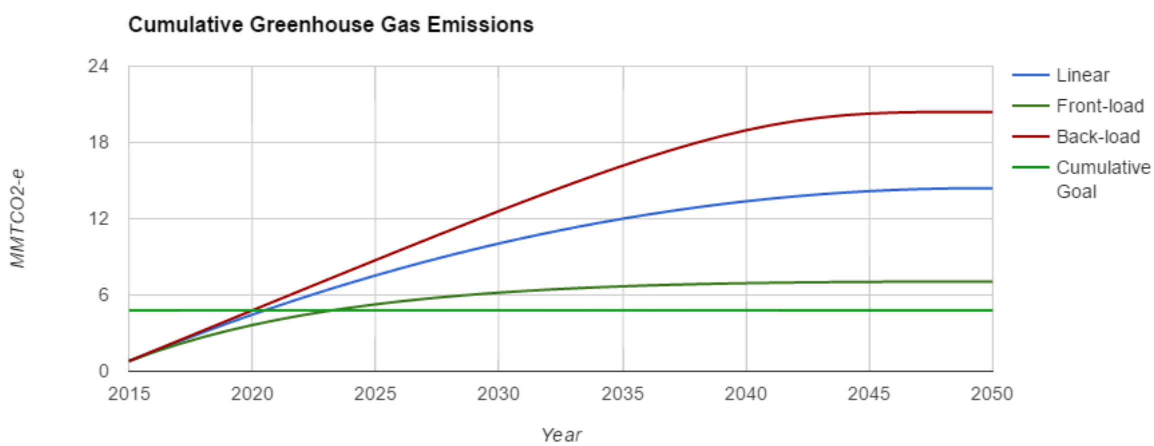


Figure 12: Cumulative Greenhouse Gas Emissions (Stock Based) following linear, front-load, and back-load towards cumulative goal.

The Intergovernmental Panel on Climate Change, IPCC, released its Fifth Assessment Report, AR5, in 2014. The IPCC, established in 1988 by the World Meteorological Organization and the United Nations Environment Program, has a goal to prepare scientific assessments on the impacts of climate change and reasonable response strategies. In the most recent report, the IPCC found that no more than one trillion tonnes of carbon can be released into the atmosphere after

1860 to have a 66% chance of limiting global warming to two degrees Celsius (Intergovernmental Panel on Climate Change, 2015). The IPCC report suggests limiting warming to two degrees Celsius because this is the level that the Copenhagen Accord recognizes as the maximum level of warming that should be allowed. The IPCC's trillion tonnes of carbon should be used when deciding on Santa Monica's cumulative stock goal. This budget assumes that the world population will be 9,478,189,000 in the year 2050 (The World Bank Group, 2015). The projection also assumes that Santa Monica's population to be 103,663, which is the last population projection in Santa Monica's LUCE (Atkins, 2013). Lastly, this model is assuming that 409,740,080,000 tonnes of carbon can still be emitted to remain under the IPCC's cap of a trillion tonnes (Oxford e-Research Centre, 2015). Santa Monica should strive to reach a cumulative budget of 4,772,459 tonnes of carbon dioxide emissions. Though this goal is likely unachievable and Santa Monica is expected to reach this amount in 6 years, following a stock-based goal for GHG reductions creates more urgency to reduce emissions now.

Table 5: Cumulative emissions under different GHG goals.

GHG Goal	**Rationale**	**Cumulative Emissions 2015 to 2050 (metric tonnes)**
Stock-based	Population-weighted proportion of remaining global carbon budget	4,772,549
Carbon Neutral by 20505	Neutralize effect on climate beginning in 2050	14,660,298 (Assuming straight-line reduction)
80% reduction by 2050	Previously-stated needed reduction in global GHGs between 1990 and 2050 to stabilize climate	18,362,578 (Assuming straight-line reduction)

RECOMMENDED BOUNDARIES

Sector	Included	Excluded
Energy	Combustion from coal, natural gas for SM's electricity use, leakages of methane from piping natural gas to power stations	Processing/mining of fossil fuels, emissions from production of solar panels and other materials for energy generation
Infrastructure	Land usage, cementing, Building energy usage/water usage - lighting, solar on roof/on site, heating systems including water heating, appliances, cooling systems, commercial/industrial equipment	Raw materials for construction
Transportation	Direct tailpipe emissions from mobile vehicles (passenger vehicles, freight vehicles, and transit rail), emissions from energy used to charge electric vehicles	Raw materials
Waste	Disposal in landfill, recycling, consumption and use of goods, reuse of goods, composting	Raw materials, extraction and transportation, manufacturing or processing, distribution of goods
Water and Wastewater	Water treatment, extraction and transport, local groundwater, water recycling, local water conveyance, locally delivered potable water, wastewater treatment, wastewater, potable uses, non-potable uses, on site capture/processing/ reuse, local rainwater capture, imported water from State Water Project and Colorado River, and long distance conveyance (California Aqueduct and Colorado River Aqueduct), and biomass	Effluent, runoff(blue)

Emissions Type		Source or Activity?	Included, Required Acitivities	Included, under reporting frameworks: SI	CA	Excluded (IE, NA, NO, or NE)
Built Environment						
Use of fuel in residential and commercial stationary combustion equipment		Source AND Activity	X	X	X	
Industrial stationary combustion sources		Source				NO
Electricity	Power generation in the community	Source		X		
	Use of electricity by the community	Activity	X			
District Cooling/Heating	District heating/cooling facilities by the community	Source				NE
	Use of district heating/cooling by the community	Activity				NE
Industrial process emissions in the community		Activity				NO
Refigerant leakage in the community		Source				NE
Transportation and Other Mobile Sources						
On-Road Passenger Vehicle	On Road Passenger Vehicles operating within community boundary	Source				IE
	On Road Passenger Vehicles operating with community land uses	Activity	X	X	X	
On-Road Freight Vehicles	On-Road freight and service vehicles operating within the community boundary	Source				NE
	On-Road freight and service vehicles associated with community land uses	Activity	X		X	
On-road transit vehicles operating within the community boundary		Source	X		X	
Transit Rail	Transit rail vehicles operating within the city boundary	Source				NE
	Use of transit rail by the community	Activity				NE
Inter-city passenger rail vehicles operating within the community boundary		Source				NA
Freight rail vehicles operating within the community boundary		Source				NA
Solid Waste						
Solid Waste	Operation of solid waste disposal facilities in the community	Source	X	X		
	Generation and disposal of solid waste by the community	Activity	X			
Water and Wastewater						
Potable Water- Energy Use	Operation of water delivery facilities in the community	Source	X	X		
	Use of energy associated with use of potable water by the community	Activity	X			
	Extraction, Treatment, and Transport of Local Groundwater	Activity	X	X	X	
	Supply, Conveyance, and Treatment of Imported Water	Activity	X		X	
Use of energy associated with generation of wastwater by the community		Acitivty			X	NE
Centralized Wastewater System- Process emissions	Process emissions from operation of wastewater treatment facilities located in the community (SMURRF)	Source	X	X		
	Process of emissions associated with generation of wastewater by the community	Activity				
	Biomass (Green Waste and Wastewater- Sources of Methane Emissions and Energy)	Acitivty	X	X		
Use of septic systems in the community		Source and Activity				NA

As mentioned, there are three main ways to account for GHG emissions- production-based, geographic-plus, and consumer-based. Production-based only considers emissions released within the city's geographic boundary, geographic-plus builds on production-based by including electricity and travel that may not be released within city boundaries, and consumer-based accounts for all GHG emitted outside the city for consumption within the city.

Even though cities do not have direct influence over the "expanded" and indirect emissions, this type of assessment stresses the importance of purchasing and holds consumers, in this case, municipalities, responsible for purchasing products that release less GHG in production, transportation, consumption, and eventual disposal. The consumption-based assessment also encourages industries and individual companies to strive to produce less environmentally harmful products from start to finish. Unfortunately, the consumption-based focus is very thorough and requires large amounts of observational data including products' history, which may not be as easily accessible as the information required for the less cumbersome geographic plus and production-based approaches.

The boundaries set up for Santa Monica are in congruence with "geographic-plus" and even account for a few indirect emissions (supply and conveyance of imported water) normally included in "consumption-based." The boundary chosen is similar to Seattle's Community Greenhouse Gas Emissions Inventory, which include "core" and "expanded" emissions. "Core" emissions are described as being under the city's influence while "expanded" emissions are not so easily influenced by the city. An explanation for why the UCLA Practicum Team recommended including or excluding an emissions set follows below.

Waste

From a city perspective, it is difficult to account for the entire life-cycle of materials because the emissions data associated with the extraction, manufacturing, and transportation of products are not currently tracked. This is why Santa Monica must focus on the effects of waste management practices such as landfilling, recycling, composting, and the use and reuse of goods when determining its GHG implications for this sector.

Water

The water supply Santa Monica receives locally, groundwater wells inside and outside of the city plus water recycling from SMURRF, as well as the energy needed to pump, treat distribute water and wastewater, are included in the report for Santa Monica's greenhouse gas emission. On the smaller scale, local rainwater capture is also included in GHG emissions. The conveyance of water from the State Water Project and the Colorado River is included in emissions due to the

GHG implications of Metropolitan Water District's water supply in Santa Monica's move towards water self-sufficiency. Inclusion of the State Water Project and Colorado River Aqueduct within City boundaries is considered indirect emissions, which is the ideal goal for comprehensive GHG accounting. Effluent and runoff are also excluded from this report because they will not result in significant GHG emissions.

Infrastructure

The electricity, natural gas, and other energy that is consumed within single family, multifamily, commercial, industrial, and institutional buildings as well as infrastructure for purposes such as heating, cooling, and lighting are included within this report. Efficiencies and energy uses for residential, industrial, and commercial appliances and equipment will also be considered. All water and land usage that results in energy usage will be incorporated with the exclusion of any imported raw materials used for construction purposes.

Transportation

In the transportation sector, all direct tailpipe emissions from mobile vehicles will be considered. This includes passenger vehicles, freight vehicles, and transit rail. All vehicle emissions are considered when entire trips occur within the city boundaries. However, when trips occur between Santa Monica and another destination, generally commuting trips, only half of the emissions from the total trip are considered. The emissions are split between the departure city and final destination, not the cities among the trip, because travelers receive no service or utility from the cities in between.

TRANSPORTATION

http://en.wikipedia.org/wiki/Santa_Monica,_California

TRANSPORTATION

INTRODUCTION

Transportation encompasses a wide spectrum of modes and forms. Southern California is notorious for its car culture, facilitated by its extensive network of highways and road (Bottles, 1987). In Santa Monica, carbon emissions can be attributed to four primary factors: population, travel demand, vehicle fuel consumption and vehicle type (Yang, 2010). Greenhouse gas emissions are expected to escalate as population, travel demand, and vehicle fuel consumption increase. Modifications to these respective factors play a significant role in manipulating emissions generated from transportation. Fuel efficiency and vehicle type also play a role in the quantity of emissions.

California has committed to short and long term GHG reduction goals. California committed to reduce their emissions down to 1990 levels by 2020 through the monumental Global Warming Solutions Act of 2006 (AB 32). California has also established longer-term goals via Executive Order S-3-05, which commits to reducing GHG emissions 80% below 1990 levels by 2050. Santa Monica is looking to exceed the standards set by California through their aggressive emissions regulations.

Table 6: Comparison of transportation mode use in 07/08 and 09/10.

	07/08 Mode Split	09/10 Mode Split	Change
Total Trips	100%	100%	
Drive alone	67.80%	65.76%	-3.0%
Carpool	12.96%	13.37%	+3.2%
Transit	9.10%	8.95%	-1.6%
Walk	3.40%	3.42%	+0.6%
Bike	2.59%	3.33%	+28.7%
Non-commute*	4.16%	5.16%	+24.0%

** Includes telecommute, compressed work week day off, and non-commute.*

Bicycle mode share increased dramatically in the past two years. Source: Santa Monica Employer Annual Transportation Fee Filing Form/Invoice, FY07/08 - FY09/10

Transportation accounted for the largest proportion of the City's greenhouse gas emissions in 2011 (City of Santa Monica, 2013). Recognizing this, it is urgent to reduce conventional fuel use and explore both alternative fuel sources and modes of transit. Despite the City's current efforts in improving public transit and non-vehicle transportation, a large proportion of Santa Monica's emissions stem from this sector. In 2011, transportation accounted for 38% of Santa Monica's GHG emissions. About 70% of transportation emissions stemmed from private vehicle consumption, while the remaining emissions were attributed to public transportation (City of Santa Monica, 2013). There needs to be a push for less GHG intensive modes of transportation to reach the GHG emissions reduction goals. Public transportation and non-mobile modes of transportation, including walking and biking, will play a crucial role in moving towards this goal. Approximately 56% of those working in Santa Monica live more than 10 miles away from their workplace, requiring workers to regularly commute large distances (US Census Bureau OntheMap). In Santa Monica, approximately 65% of commuters report driving alone to work, Table 6. This figure towers over the 9% of commuters who utilize public transit and the other 3% that report biking to work (City of Santa Monica, 2011).

Increased public transit use allows for a significant reduction in gross emissions, as its per capita carbon footprint is found to be significantly smaller than automobile use (Chester, 2013). For public transit vehicles, popular alternative fuel sources include natural gas, electricity and hydrogen from renewable sources. These fuel sources emit less carbon than conventional diesel fuel. Public transit preserves personal mobility, while reducing carbon emissions. Transitioning these trips to biking or walking, rather than public transit, allows for a carbon neutral or zero-emission transportation experience. Other benefits associated with biking or walking include reduced vehicle expenses, traffic congestion, public health benefits, and lower pollution associated with vehicle transportation. Despite the benefits, there are limitations and additional considerations that discourage the use of these modes of transport. These limitations include the distance traveled, route safety, and weather conditions (Environmental Protection Agency, 1998). Biking and walking are ideal for people who are relatively young and live in areas where residential and commercial sites are close together and have compatible infrastructure.

ZERO EMISSIONS VEHICLES

Zero Emissions Vehicles, or ZEVs, are vehicles that have no associated tailpipe pollutants. This category includes muscle-powered, battery electric, and fuel cell vehicles. This study will focus on battery electric and fuel cell vehicles since they are currently the most viable large scale ZEVs.

Battery electric vehicles require charging infrastructure to recharge the battery between uses. There are three types of electric vehicle charging stations that can be used to charge ZEVs, Table 7. The chargers vary in their charging time, voltage, and price.

Table 6: The different types of EV chargers.

Type of Charger	Charging Time	Voltage
Level 1	11 - 20 hours	120V alternating current
Level 2	3 - 8 hours	240V alternating current
Level 3	30 minutes	480V direct current

There are many benefits for the adoption of zero emissions vehicles. The most obvious of these is that less greenhouse gasses and other pollutants are released with the use of electric and other ZEVs. The estimated emission of greenhouse gases for different vehicle types is shown in Table 8. Another benefit is the energy independence that accompanies the adoption of alternative fuels. California has access to natural gas and renewable energy sources that can generate the electricity needed to power electric vehicles. California can have greater energy independence by switching to these energy types from conventional fuels. The use of EVs also has the potential to benefit the electric grid. The grid can utilize the batteries of charging EVs during peak hours to function more reliably. The adoption of EVs will also help bolster the clean technology sector, allowing for newer and cheaper technologies in the future.

Table 7: The greenhouse gas emissions and cost of different vehicle types (US Department of Energy).

Emissions and Fuel Cost for a 100-Mile Trip		
Vehicle (compact sedans)	**Greenhouse Gas Emissions (pounds of CO2 equivalent)**	**Total Fuel Cost (U.S. Dollars)**
Conventional	87 lbs. CO_2	$8.33
Hybrid Electric	57 lbs. CO_2	$5.48
Plug-in Hybrid Electric	62 lbs. CO_2	$5.43
All-Electric	*54 lbs. CO_2	$3.74

* This is the national average. California has far lower GHG emissions per MWh.

The other ZEV option is fuel cell technology, which uses compressed hydrogen as fuel for the car. Similar to internal-combustion vehicles, fuel cell cars have tanks to store fuel. A conventional engine burns petroleum-based fuels, generating heat and pushing pistons up and down to drive the transmission, which in turn powers the wheels. Hydrogen fuel, on the other hand, is not burned like a petroleum fuels. It fuses chemically with oxygen from the air, creating water. This process releases energy that is used by the motor to drive the car. The largest benefit of fuel cell technology is that the only byproduct leaving the car is water. Other benefits include a driving range similar to gasoline fueled vehicles, refueling time of three to five minutes, and the ability to accommodate large vehicle sizes. In comparison to electric vehicles, hydrogen fuel cell vehicles are more similar to conventional vehicles.

There are multiple constraints to the implementation of ZEVs. Currently, the largest constraint to ZEVs is their high initial cost. However, prices are continuously dropping as battery and fuel cell technology advance. Another limitation to the adoption of ZEVs is the need for new and limitations of existing infrastructure. These concerns apply to both hydrogen and electric vehicles, but pose a larger restraint to hydrogen infrastructure because it would need to replace the current oil-based infrastructure. Other constraints to hydrogen fuel cells are the energy needed to extract pure hydrogen from its natural forms and concerns about the flammability of the high pressure gas. There is also limited consumer awareness of ZEVs and their competitiveness in price to their conventionally fueled counterparts, Figure 18 and 19. The figures show the cost of EVs compared to conventional vehicles over their lifetime. The initial cost of these vehicles is higher; however, electricity costs are substantially less than gasoline to power these vehicles over the lifetime of a car. Despite similar costs over the lifetime of the vehicle, the EV’s high initial cost deters consumers from purchasing.

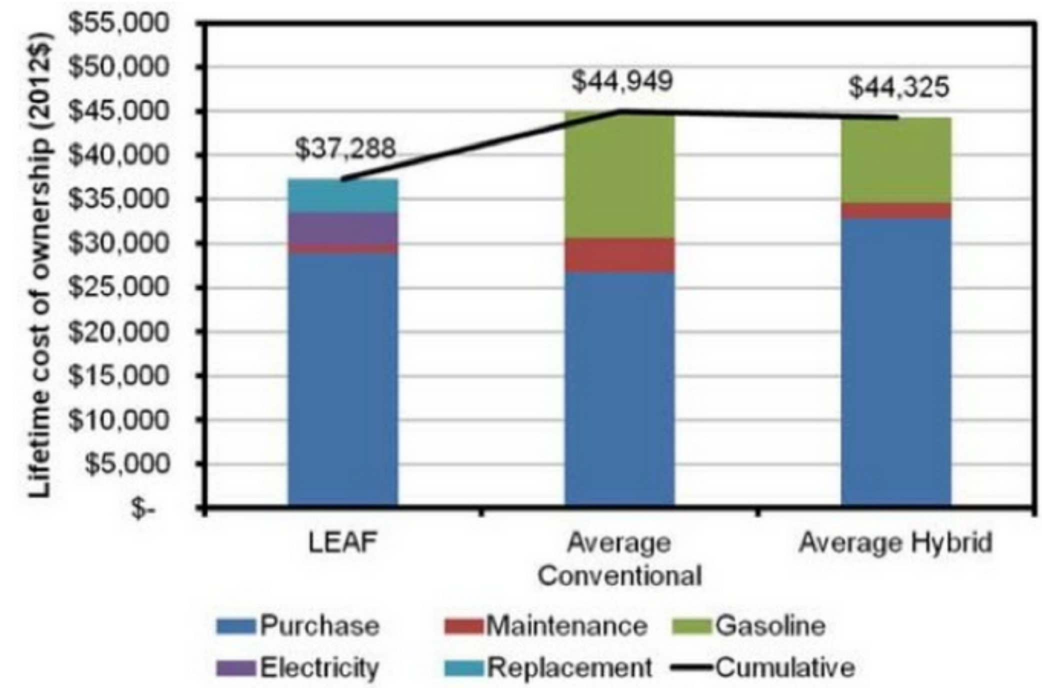


Figure 13: Comparison of the lifetime cost of an electric, conventional, and hybrid car model (Shahan, 2013).

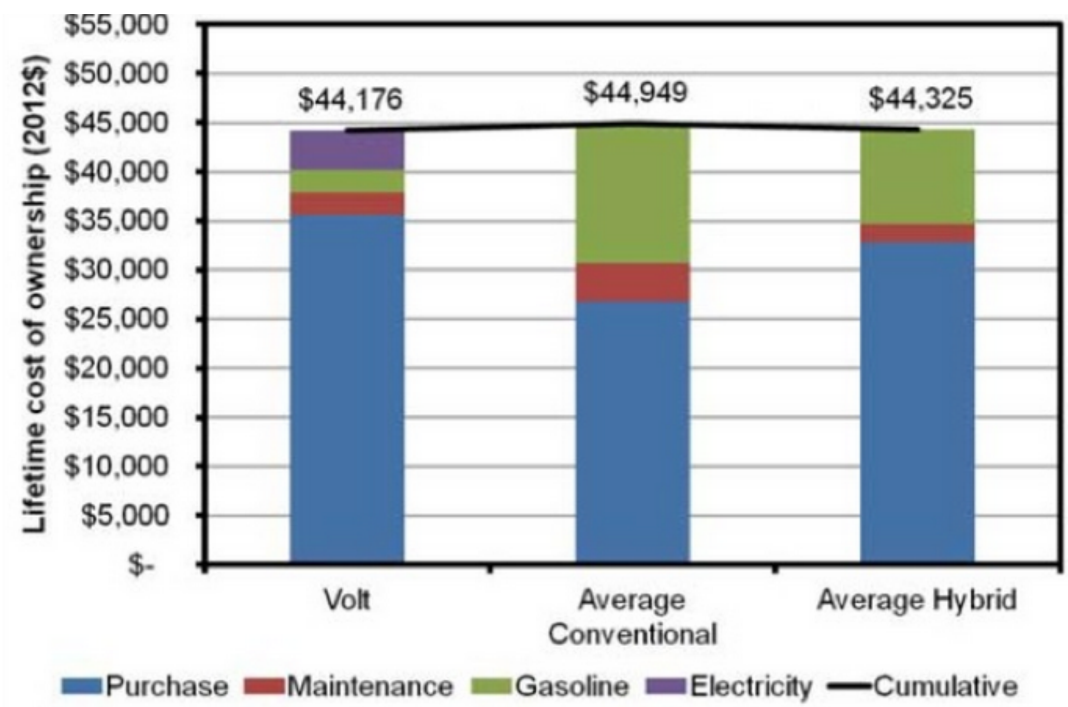


Figure 14: Comparison of the lifetime cost of a plug-in hybrid, conventional, and hybrid car model (Shahan, 2013).

SANTA MONICA'S CURRENT STRATEGIES

MULTIFAMILY CHARGING

One of the main challenges facing Santa Monica in its greenhouse gas reduction goal is access to multifamily charging. This is an issue considering around 70% of the citizens of Santa Monica are renters. Emissions associated with private care use need to be minimized in order to reduce GHG emissions to the desired levels, which is especially difficult for renters who do not own their parking spaces.

AB 2565

The reduction of GHG emission from private care use is particularly difficult for renters because they have an additional challenge to EV use. These renters do not own their property and therefore cannot install EV charging infrastructure without the approval of the owner of the unit or building. Assembly Bill 2565, or AB 2565, is one solution to this problem. This bill will allow renters to buy, install, and operate a charging station for a parking spot they are leasing. The bill was unanimously supported by the Santa Monica City Council on May 13, 2014 and was later approved by the Governor on September 21, 2014. AB 2565 will apply to any lease that is executed, renewed, or extended beginning July 1, 2015.

The bill will require lessors to approve any written requests for the installation of an EV charging station. The bill does not apply to units where more than ten percent of parking spots have EV charging stations, where parking is not provided as part of the lease, where there are less than five parking spots, or if the unit is rent controlled.

CALGREEN

A portion of the California Green Building Standards pertains to the construction of EV ready parking spaces.

> Pursuant to the CALGreen Code, voluntary standards are established for the installation of electric vehicle charging infrastructure in multifamily dwellings for at least 3% of the total parking spaces be capable of supporting future electric vehicle supply equipment. Further, for non-residential development, the CALGreen Code establishes voluntary standards for at least 10% of total spaces to be designated for parking for low-emitting, fuel-efficient, and carpool/vanpool vehicles, including electric vehicles. It is also important to note that each local jurisdiction retains the administrative authority to exceed the CALGreen Code standards.

The CALGreen portion listed above is completely voluntary. These are currently suggestions for the appropriate ratio of EV ready parking spaces to the total number of parking spaces, but there is no enforcement of this ratio.

MUNICIPAL FLEET

Fleet Management manages the majority of Santa Monica's municipal fleet, with the exceptions of the Big Blue Bus and Fire Department vehicles. The Sustainable City Plan calls for 80% of the city fleet vehicles to run on alternative fueled vehicles by 2020. Santa Monica has made major strides towards this goal with 52% of the city's vehicles currently running on alternative fuel. These alternative fuels include compressed natural gas, electricity, hydrogen, and propane. The conventional fuel types used by the city are unleaded, diesel, and flex fuel. The current makeup of the city fleet is shown in Figure 20.

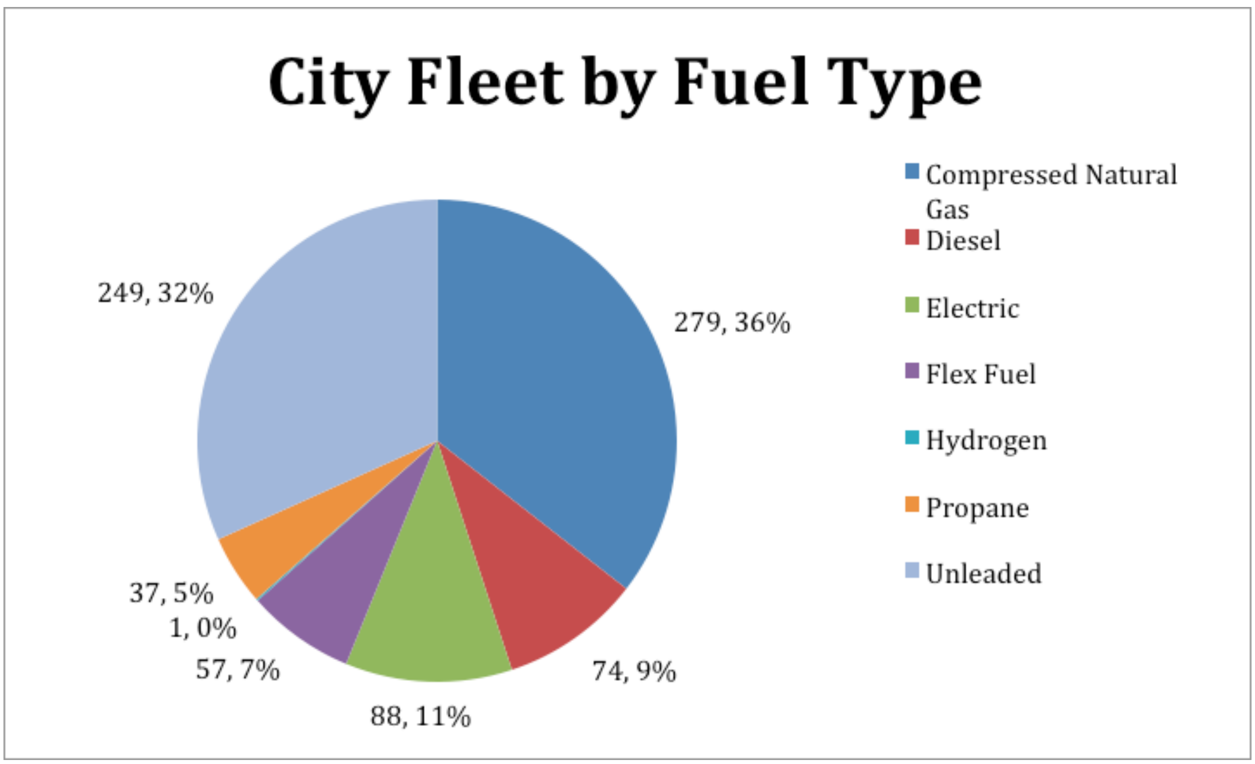


Figure 15: The percentage of different fuel types in the city's fleet as of March 3rd, 2015.

Santa Monica hired the Walker Parking Consultants to complete a parking rate study for all of their parking facilities. The study's purpose was to ensure that parking is available in all parking lots by discouraging use in highly used lots and encouraging parking in underused lots. They did this by identifying the relationship between parking rates and demand in Santa Monica. The output of their model was based on the price of parking in comparable locations and the average peak occupancy rates of their lots.

The study proposed three parking options for the Downtown parking Structures 1-9, which are summarized in Table 9. The first option, Option A, is the hourly rates that were determined by the study's model. These rates fluctuate by hour and would be confusing for consumers if implemented. Option B has the same daily 6 hour maximum as the first option but uses a linear rate for price per hour. Option C is structured with an 8 hour maximum and has a lower rate for the first three hours to encourage short-term parking. Table 10 shows the cumulative pricing that consumers would have to pay and compare these values to the cost at the time of the study and the current cost

Table 8: Recommended parking rates for Downtown Parking Structures 1-9.

Time	Option A	Option B	Option C
1st Hour	$1.64	$2.35	$0.78
2nd Hour	$1.83	$2.35	$0.78
3rd Hour	$1.16	$2.35	$0.78
4th Hour	$3.34	$2.35	$2.35
5th Hour	$2.56	$2.35	$2.35
6th Hour	$1.74	$0.51	$2.35
7th Hour	Free	Free	$2.35
8th Hour	Free	Free	$2.35
Daily Maximum	$12.26	$12.26	12.26

Table 9: Past, current, and potential cumulative pricing per hour for cars parked in Downtown Parking Structures 1-9.

Length of Stay	Rate at Time of Study	Equal Hourly Rate Option	Reduced Rate Hours 1-3 Option	Current Rate
1 hour	Free	$2.35	$0.78	Free
2 hours	Free	$4.70	$1.57	$1.00
3 hours	$2.00	$7.05	$2.35	$2.50
4 hours	$4.00	$9.40	$4.70	$5.50
5 hours	$6.00	$11.75	$7.05	$8.50
6 hours	$8.00	$12.26	$9.40	$11.50
7 hours	$9.00	$12.26	$11.75	$14.00

The study addressed monthly parking permits in structures 1-9. The prices were chosen to encourage long-term permitted parking in the less crowded structures, PS 8 and 9. The recommended parking permits would allow current permit holders to continue their 24/7 access at a new price or to remove overnight parking for a reduced price. They also recommended parking permits for non-current permit holders with cheaper access to PS 8 and 9 to encourage use in these underused structures.

Table 10: Recommended parking permits for Downtown Parking Structures 1-9.

Price	Access
$159.60	24/7 monthly permit parking for current permit holders in structures 1-9
$140.00	Monday-Friday, 6:00AM -7:00PM, access to current permit holders in structures 1-6 and 9
$128.00	Monday-Friday, all day, access in structures 8 and 9
$96.00	Monday - Sunday, 5:00PM - 8:00AM in structures 1-9.

The proposed hourly rate for on-street Downtown meters in is based on the rate in PS 1-9. Their model states that on-street spots should be twice as much as the structures because there is a premium associated with street parking. The model also applies an occupancy rate factor, which in this case is 1.15 because occupancy rates are approximately at 94% capacity during peak hours in Downtown. Since on-street parking is considered short term parking the study used the structure-parking rate from Option C. The resulting hourly meter price they obtained was $1.80.

An issue that was addressed in this study was the pricing of ADA parking spaces. At the time of the study, individuals with ADA placards were able to park for free in PS 1-9. They found that 100% of the ADA parking spaces were occupied during peak times of the day and that 87% of the vehicles in these spaces were parked there for six hours or more (Walker Parking Consultants, 2012). The purpose of these parking spaces is to provide easier access to people with disabilities. Free parking incentivizes people to use these spots and for long periods of time, which reduces the access for people who need to use them. Free ADA parking also encourages people who would otherwise not obtain a placard to do so, further increasing the competition for these parking spaces. Overall, the study recommended that the city eliminate free parking for individuals with ADA placards in hopes of increasing access for the people who rely on them.

Table 11: Recommended pricing for Santa Monica districts outside of Downtown.

Site	Price Using Current Downtown Meter Rates	Price Using Recommended Downtown Meter Rates
Main Street On-street	$1.01	$1.24
Main Street Lots	$0.75	$0.93
Mid City On-street	$1.13	$1.53
Mid City Lot	$0.84	$1.14
Montana Ave	$1.40	$1.60
Pico Boulevard	$0.85	$1.17

AVERAGE VEHICLE RIDERSHIP

Santa Monica enacted Transportation Management Plan Ordinance 1604 in 1990. This ordinance was an effort by the city to reduce traffic congestion and improve air quality. As part of this ordinance, employers with over 50 employees have to maintain an Average Vehicle Ridership, AVR, of over 1.5. AVR is the ratio of employees to cars and is measured by dividing the number of employees leaving or coming to work by the number of vehicles used to commute. Employers are required to submit one of two Emission Reduction Plans to the City. The first, an Employee Trip Reduction Plan, ETRP, requires that the employee survey at least 75% of their employees to determine the AVR for both morning and evening commuters. The employer have to submit a plan that they believe will increase their AVR to over 1.5 if their AVR is lower than 1.5. The second option, for employers who cannot pass an AVR of 1.5, is to purchase Mobile Source Emission Reduction Credits, MSERCs, from a certified broker in place of an ETRP. The effectiveness of this Ordinance can be seen in Figure 21, which shows the average AVR for Santa Monica from 1993 to 2008. In 1993, the City's average AVR was 1.13. By 2006, the City had met its goals of over 1.5 with an AVR of 1.59. Santa Monica set a 2020 target for an AVR of 2.0 for business with over 50 employees in the 2014 update to their Sustainable City Plan.

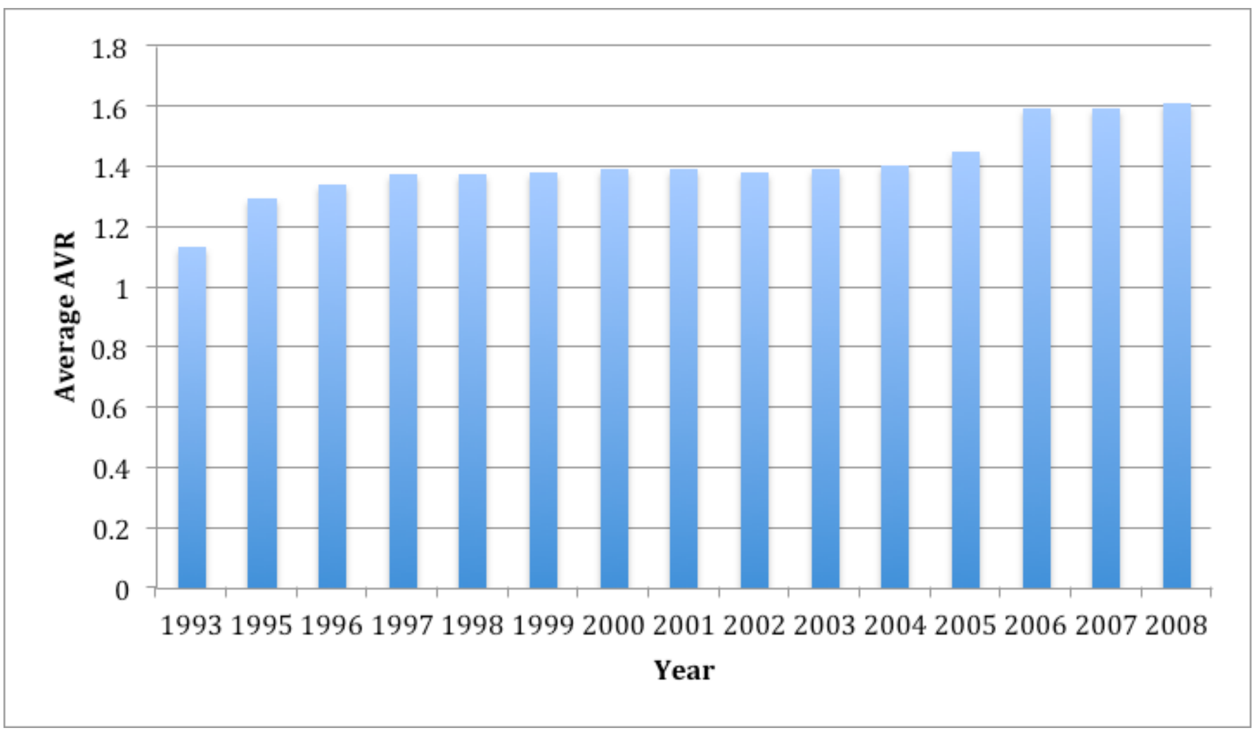


Figure 16: The average AVR for the City of Santa Monica from 1993 to 2008 (Office of Sustainability and the Environment, 2010).

The first violation of businesses not meeting their AVR requirement will result in a warning notice. After the warning notice, each violation will result in a violation notice. A violation notice requires the business to pay a fine of $5.00 per employee per day and can result in the revocation of their business license.

HYDROGEN FUEL INFRASTRUCTURE

The California Energy Commission, CEC, is in the process of installing six new hydrogen fueling stations with a grant of 17 million dollars. Santa Monica secured one of these sites and will begin operating at 1819 Cloverfield Boulevard, Santa Monica, CA, 90404 by the end of 2015. The Santa Monica station will use the same certified equipment that was installed at the South Coast Air Quality Management District, SCAQMD, site. This equipment, which began operations on March 25, 2015, was the first certified site to provide a three-minute fill with five percent accuracy (South Coast AQMD, 2015). The SCAQMD also has a capacity of 100 kilogram per day, which can fuel between 20 and 25 cars (South Coast AQMD, 2015). All station proposals had to verify that at least 33% of the energy used on site was going to be coming from renewable sources. Renewable sources are important because they help reduce the carbon intensity of the creation of hydrogen fuel. There will be five hydrogen fueling stations clustered in the West Los Angeles and Santa Monica areas at the end of 2015, which will provide multiple fueling options for residents of Santa Monica. The Santa Monica facility will be open for public use sometime during this year.

PUBLIC TRANSIT

Santa Monica's primary public transit operator is The Big Blue Bus (BBB), the City's bus operator. The bus currently operates 20 service lines, which serve Santa Monica and several neighboring communities. The neighboring communities include Pacific Palisades, West Los Angeles, Brentwood, Westwood, Cheviot Hills, South Robertson, Mid-City, Westchester, Marina Del Rey, Venice, and Playa Vista. The service lines also provide connections to other regional transit services including LAX, the Metro, Metrolink and Amtrak. In total, the Big Blue Bus serves an area of approximately 51 miles, an area far larger than the 8.6 mile area of the city of Santa Monica.

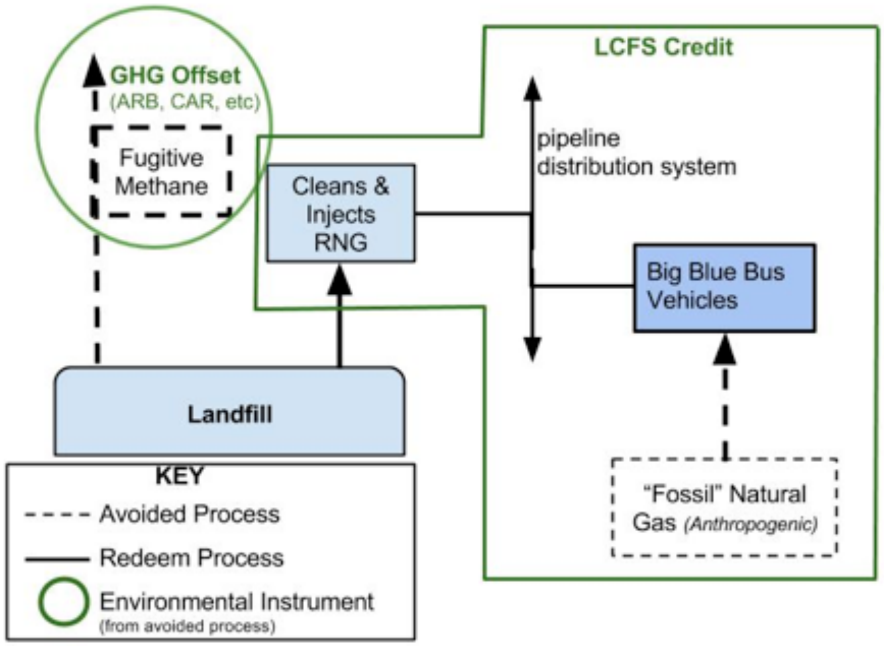


Figure 17: Cycle of Renewable Natural Gas generation (Redeem product) and its distribution to BBB vehicles.

The BBB fleet currently consists of over 200 vehicles. Previously, these vehicles operated on a variety of alternative fuels including liquid natural gas (LNG), compressed natural gas (CNG) and a hybrid of electric/gas. BBB has taken further steps to ensure the sustainability of their fuel sources. As of January 2015, BBB is operating completely on renewable natural gas. The City has recently signed onto a year contract with Clean Energy, a provider of renewable natural gas, to fuel their vehicles with Redeem, a renewable natural gas product. Redeem captures methane from landfills and converts this source of energy into a renewable natural gas fuel source for the BBB. The renewable natural gas is then distributed via existing pipelines, where it is blended with other sources of natural gas. Clean Energy registers each source of renewable natural gas with the California Air Resources Board, which also ensures that Redeem consumers only receive credit for renewable natural gas produced at landfills. The natural gas is injected into pipelines with a clear connection to the consumer. The biogenic methane averts carbon emissions that would have resulted from the release of this methane from the landfills and the excess carbon that would have been emitted from utilizing non-biogenic natural gas. This fuel source averts up to 90% of carbon emissions relative to conventional diesel fuel (Redeem, 2013). Between January and March of 2015, Santa Monica reduced GHG emissions by 2,327 metric tons (Clean Energy, 2015). The City can now claim that the Big Blue Bus is using natural gas that is not obtained using hydraulic fracturing, fracking. The City of Santa Monica is working with The Climate Registry to take formal credit for these reductions in GHG emissions.

Table 12: Redeem LNG usage by the City of Santa Monica between Jan - Mar 2015.

Redeem Delivered	
Redeem LNG (Gallons)	512,280
ALL LNG, including Redeem (Gallons)	512,280
Percentage Redeem LNG Gallons	100%

The Exposition Light Rail Project (Expo) is a highly-anticipated rail line that is expected to begin service in Santa Monica by 2015. The first phase of the project connected service from downtown Los Angeles to Culver City. The second phase of this long-term investment in public transit is expanding service from Culver City to Downtown Santa Monica. The opening of the Expo line will allow commuters to travel from downtown Los Angeles to Santa Monica in less than 50 minutes. Santa Monica has made great efforts to integrate the upcoming Expo line with their existing systems and city infrastructure.

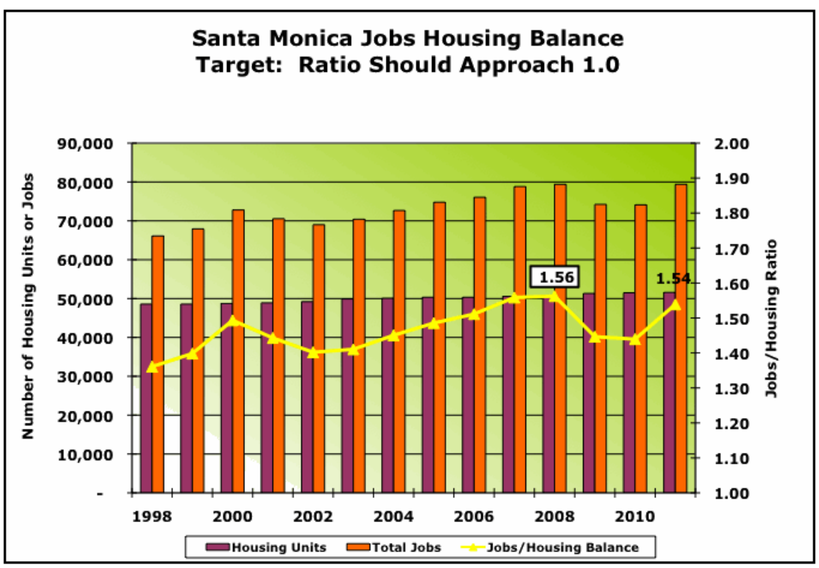


Figure 23: Ratio of housing to jobs in Santa Monica between 1998 and 2010.

Santa Monica has outlined plans for the City's adaption to the arrival of the Expo line in the LUCE. The plan calls for the creation of housing and development around transit hubs, particularly the Expo line. Residents are incentivized to take advantage of public transit and other non-vehicular modes of transportation by moving development closer to transit, reducing dependence on automobiles. The reduction of automobile dependence helps reduce the carbon intensity of the City's transportation needs. This type of urban planning is called Transit Oriented Development (TOD), the integration of residential and commercial growth near high capacity transit. Plans for neighborhoods surrounding the Expo line include more affordable housing units for residents and the burgeoning workforce. Santa Monica currently has a deficit of housing relative to the number of jobs in the city, a phenomenon which leads to increased commute, congestion, and pollution. There are approximately 1.54 jobs for every household, far above the goal ratio of 1.0 (Office of Sustainability and the Environment, 2014). This job and housing imbalance increases the city's GHG emissions inventory because Santa Monica is responsible for half of the greenhouse gas emissions from vehicle trips into the city. The City can reduce its GHG emissions inventory by adding new housing units within the city, assuming it helps to reduce commute distance.

Santa Monica has also developed an Expo Integration Plan, to better align the BBB's service with the new mobility patterns that are anticipated upon the arrival of the Expo. This plan provides recommendations for how BBB routes will enhance connectivity and reduce redundancies in response to the new east-west light rail line. General recommendations of the plan include a need for greater connectivity between the northern and southern sides of the city, a denser service network, concentration of service around transit corridors, and removal of duplicate service areas. These changes are expected to increase revenue service hours by 11%, which is anticipated to induce a 14% increase in ridership (City of Santa Monica, 2015).

BIKING

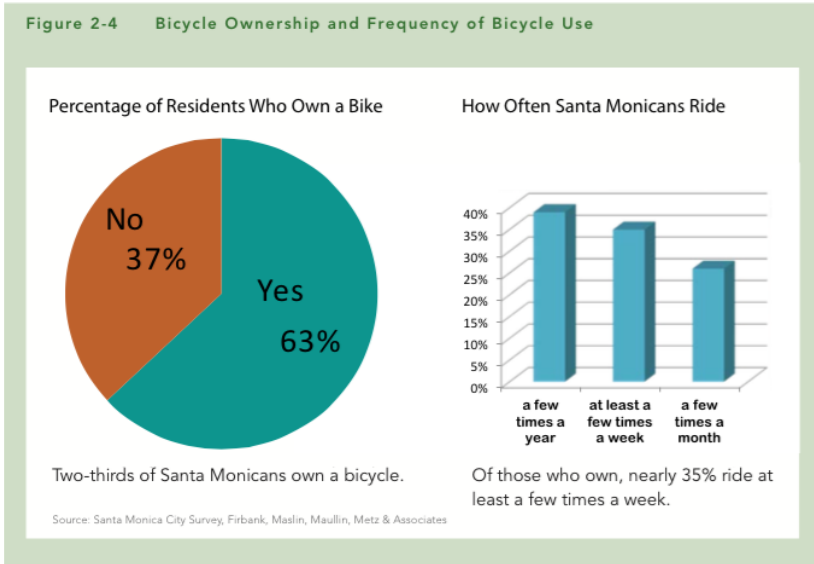


Figure 18: Santa Monica resident bike ownership and bike usage.

Biking is a predominant part of the vibrant beach culture in Santa Monica. Approximately 80% of trips made in Santa Monica are less than 2 miles and approximately 62% of Santa Monica residents own a bike. All points of Santa Monica are less than 10 minutes away from downtown by bicycle (Santa Monica Land Use & Circulation Element, 2010). Santa Monica's sunny weather provides an ideal venue for bicycling year round. Approximately 3.4% of Santa Monicans commute via bike (Santa Monica Land Use & Circulation Element, 2010). Relative to other vehicular modes of transportation, it is also arguably the most efficient with regards to both time and greenhouse gas emissions (Environmental Protection Agency, 1998). Raw materials are needed to construct the bike, which requires energy, but once created the only upstream emissions are from the additional food consumed by the rider.

Santa Monica published its Bike Action Plan in 2011, as a follow up to the LUCE. The plan provides a comprehensive assessment of biking and a specific course of action for the City. The Bike Action Plan is the City's plan for further development of its bicycle network and for programming to encourage and incentivize biking within the City. A key function of the plan is an assessment of the current needs and conditions of bicycling in the city. Currently, Santa Monica's bicycle network is 37 miles, 18 miles of bikeways and 19 miles of bicycle routes. The City

hopes to further expand their existing network, enhance their current network, and bolster connections to schools and transit hubs within the city. The plan includes a list of recommended projects, a framework of specific streets and corridors they would like to prioritize for bicycle development with specific facilities they would like to install.

Santa Monica is also planning on implementing a bike share program in 2015. A fleet of 500 bicycles will be dispersed within the City at hub locations. Locations include the downtown area and major boulevards, such as Main Street and Montana Avenue. The bikes feature a "smart bike" system, consisting of 8-speed functionality and GPS. Users can pick up and drop off a bike at any hub location.

WALKING

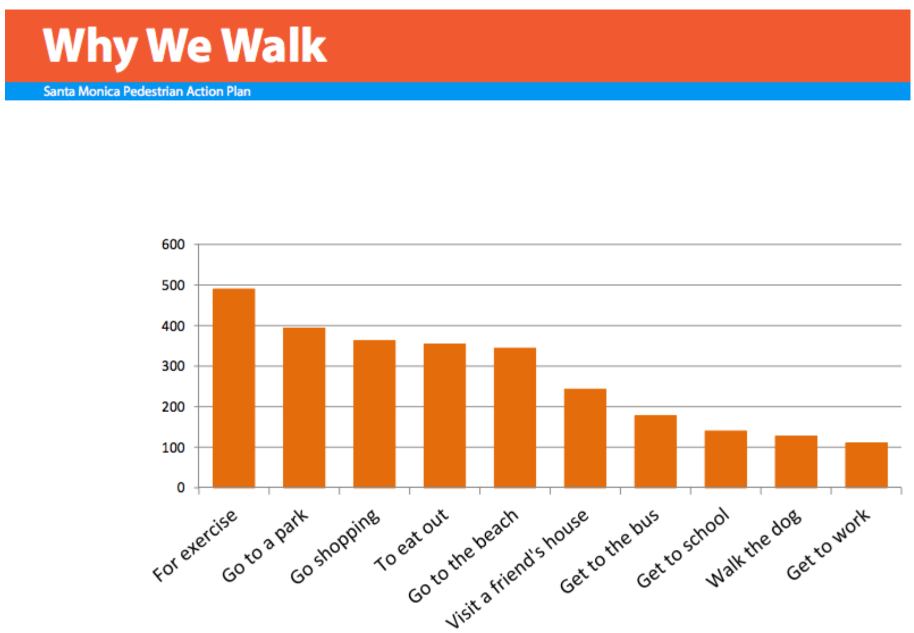


Figure 19: Prominent uses for walking in Santa Monica.

Walking is a pervasive mode of transportation in Santa Monica. It has been cited as the most popular recreational activity within the city (City of Santa Monica, 1997). The most prevalent reasons why residents walk are cited as exercise, going to the park and going shopping. It often provides the foundation for other modes of transit and is vital to the city.

Development goals for improving pedestrian circulation are established in the LUCE. Santa Monica is currently in the process of releasing a Pedestrian Action Plan, expected to be published sometime in 2015. The plan has outlined six primary goals: to promote walking, promote safety, create connectivity, steward sustainability, educate the public, and cultivate community passion.

LEADING GLOBAL CITIES

COPENHAGEN

One program that has been implemented in Copenhagen is Car2go. Car2go is a car sharing service in Europe and North America that is a subsidiary of Daimler. The company is currently operating or has plans to operate in 33 cities. One distinguishing factor of Car2go, unlike many other car-sharing services, is that it is a free-floating car-sharing program. This allows users to get in any available car and drive it for as long as they need. They are not required to return the vehicles to the pickup location, but can park it in any unrestricted parking space in their home area. Users can locate available cars on the Car2go app or the vehicle finder online and do not need to make a reservation for the car.

Car2go reduces the average length of trips by 48% since users utilize other modes of transportation in conjunction with Car2go (Car2go, 2014). It also reduces the length and frequency of inner-city trips; 25.7% of users report to use their private car less for inner-city trips after joining Car2go (Car2go, 2014). In addition, 5.1% of users have sold their primary or secondary vehicle since they joined Car2go (Car2go, 2014). The cars are also 50% smaller than traditional cars and their gasoline cars emit 60% less carbon dioxide than the average private car (Car2go, 2014).

Car2go is currently running in three cities, Amsterdam, Stuttgart, and San Diego, with an EV fleet. It has plans of becoming 100% EV in Copenhagen in the future once EV infrastructure has been completed. In the cities where Car2go runs EVs the Municipality has provided the infrastructure. They "have gathered vast experience in the existing car2go EV cities and learned that the charging infrastructure shall consist of fast charging poles (22kW) to prevent parking congestion and release the charging poles to further user groups after a short time of charging" (Car2go, 2014). The fast chargers allow for greater turnover of car use and provide quicker charging stations for residents.

Copenhagen is widely seen as one of the world's most bike friendliest cities (The Copenhagenize Index 2013, 2013). Approximately 36% of city dwellers commute by bike to work or school (Suzuki, 2013). This is facilitated by the Copenhagen's extensive segregated bicycle track system, which separates bicycle use from motorized vehicle use and provides exclusivity to bicyclists. These tracks are unidirectional, follow the direction of traffic, and accompany about 42% of their roads. Prioritization of cycle tracks has often been cited as the backbone of the City's success in bicycle use. The city also uses greenwaves, which coordinate traffic lights to turn green consecutively for bikers to improve the flow of bicycle traffic. This system allows bicyclists to ride without having to stop, cutting down the length of their commutes.

LOS ANGELES

In 2010, Los Angeles installed meters that accepted credit and debit card in its Downtown area. These meters are connected to a wireless payment sensor, which has given the ability to see which meters are currently in use to City officials. Two years later, on May 21, 2012, LA Express Park came to fruition, which is a program that combined demand-based parking and emerging parking meter sensors. Los Angeles started implementing dynamic priced parking in a 4.5 square-mile area in the downtown area. The purpose of this type of pricing on parking is to discourage vehicle miles travelled in congested areas. Every few weeks the pricing on these meters is subject to change to adapt to changes in traffic patterns. The meters cost the most when there is the highest demand for them. The installation of smart meters has allowed for a more accurate understanding of parking space availability. This has led to the development of parking mobile apps that show users where parking is available and its current price.

Two surveys, an on-street intercept and an online study, were conducted by the Department of Transportation, Los Angeles, and other entities in February and March of 2013. They surveyed people using the dynamic priced meters to gauge the factors that influenced their use and the public knowledge about the project; their findings are summarized in Figures 26 and 27. As shown in figure 26, only 7.2% of people consider the time and 18.8% consider cost when deciding on parking options (Glasnapp, et al., 2014). When these numbers are compared to the more influential factors, proximity and availability, a trend for more expensive but convenient parking options is shown. This could be the reason that dynamic pricing has been effective in the downtown area.

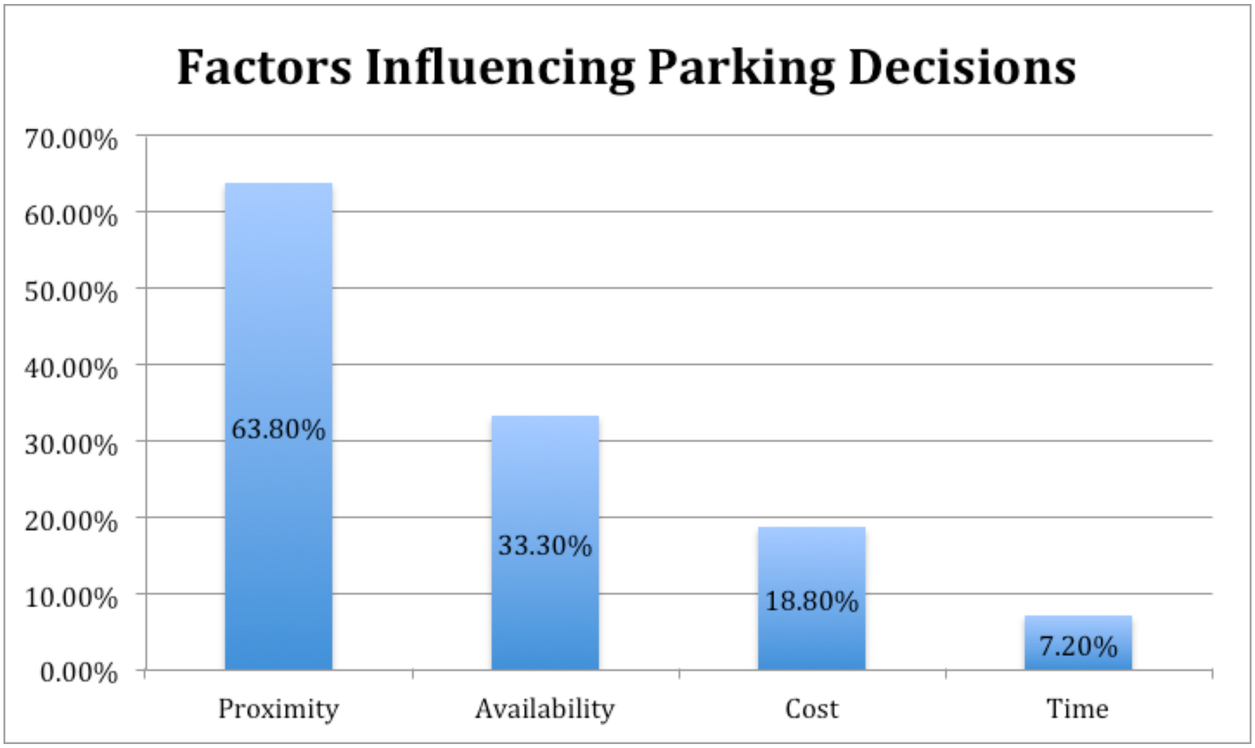


Figure 20: The percentage of people who take proximity, availability, cost, and time into account when facing parking decisions (Glasnapp, et al., 2014).

Figure 27 shows parking users' awareness to the change in price, time of day pricing, and the available mobile apps. These surveys were conducted between nine and ten months after the implementation of LA Express Park. At this time only 30% of users surveyed after parking in these metered spots were aware of an increase in pricing and less than 25% knew about the time of day pricing. These findings show that residents are not as receptive to increases in parking prices as might be expected. Overall, there was a lack of understanding of the LA Express Park in its first year of operations.

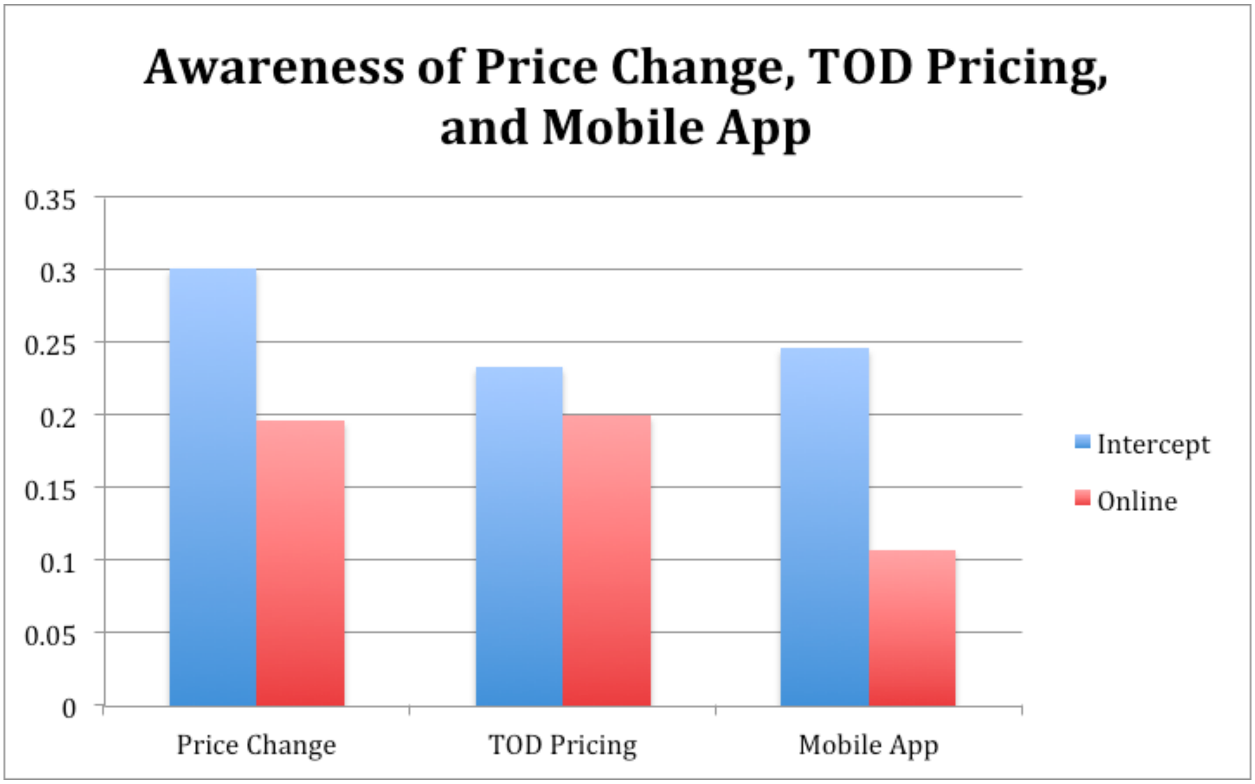


Figure 21: The percent of people surveyed who were aware of price changes, time of day pricing, and mobile parking apps in the LA Express Park area (Glasnapp, et al., 2014).

SEATTLE

Seattle encourages its citizens to carpool through their carpool parking permits. Carpoolers can receive discounted parking rates in designated areas throughout the city if certain criteria are met. The rates vary between $300 and $600 per quarter. In order to qualify at least two adults must commute to and from work together at least four days a week. They must also share 50% of their commute together, live more than two miles from their parking location, cannot possess a parking permit for another area, or pass through the parking area to pick up their other passenger. These parking permits are required to be renewed quarterly. The parking spots are only reserved from 7:00 to 10:00am when the carpool parking spaces are on-street. This does not allow for parking spaces to be wasted since non-permit holders can park in these spots after 10:00 am. Citizens apply for carpool parking permits by submitting applications to Seattle's Commuter Services. The number of permits will never exceed the available places, since a waiting list if established when there are more applications than spots.

BERKELEY

In 2009, the City of Berkeley released its Climate Action Plan, which calls for a 33% reduction below 2000 levels by 2020 and an 80% reduction below 2000 levels by 2050. The city released a 2014 update to the Climate Action Plan, which claims that the City had reduced emissions by 8% since 2000 in 2012 (Office of Energy & Sustainable Development, 2014). Emissions have been decreased in all sectors except transportation; the 2012 levels are the same as the 2000 levels. This is a major concern as transportation accounted for 53% of greenhouse gas emissions in 2012 (Office of Energy & Sustainable Development, 2014). The city released transportation strategies in order to reach their 2020 goal that include electric vehicle infrastructure, transit oriented development, bike and pedestrian infrastructure, and parking and transportation demand management.

Berkeley had started a curbside-charging pilot In order to increase electric vehicle infrastructure in the city. The cost of these installations falls entirely on the homeowner. The costs include permitting, infrastructure, installation, electricity, and maintenance costs. The City allows for the creation of curbside electrical vehicle charging stations when properties do not have adequate space to create vehicle-related paving slabs. In these cases the city requires the resident to file minor encroachment, engineering, and electrical permits. The creation of a curbside charging station does not reserve the space for the resident; therefore, the city recommends residents to place the charging units in an area that is accessible for multiple curbside parking spots. The minor encroachment permit is revocable and will be if there are safety concerns or on-going parking issues. In these cases the residents are required to pay for the removal of the charging station and any associated wiring.

The City estimates the permitting fees associated with this pilot to cost residents approximately $2,000. There is a grant for Berkeley residents installing these charging units from the 11th Hour Project that will cover up to $2,000 in application permit fees, covering the permitting costs. The resident is still expected to pay the infrastructure, installation, electricity, and maintenance costs.

PARIS

The City of Paris released their Climate Action Plan in 2007, which served as their strategy to reduce greenhouse gas emissions. In order to achieve their goal they focused a lot of their attention on the transportation sector. The same year Paris launched their bicycle share system, Velib'. In December of 2011, Paris inaugurated its electric car sharing service, Autolib', which started as a follow-up to Velib'. Bollore, a French investment and industrial holding group, operates this car share service. The service consists of a fleet of Bluecars, all EV cars manufactured by Bollore. The service is provided on a subscription basis that lasts for a year, a month, a week, or a day. The subscription fee varies depending on the length of desired use. Users have to pay for usage fees in addition to the cost of the subscription. These fees vary depending on the length of car use and the subscription type the user has, the usage cost is less when users have a longer subscription. A summary of the subscription and usage fees can be found in Table 14. The subscription and usage costs vary in dollars since the currency exchange between the euro and dollar is constantly fluctuating. Table 14 assumes a conversion rate of 1 euro to 1.10 US dollars.

Table 13: Subscription and usage costs for the different Autolib' subscription lengths.

Subscription Length	Subscription Cost	Usage Rate (30 min)
1 Day	$0.00	$9.90
1 Week	$11.00	$7.70
1 Month	$27.50	$7.15
1 Year	$132.00	$6.05

Autolib' also provides charging to owners of EVs at their charging stations. If residents wish to use the service to charge their private vehicles then they can subscribe to a charging package that has a fee for the first year that the service is used. The fee is 15 euros or the equivalent of around 17 dollars. Once the residents have subscribed to this service they can go to any Autolib' charging station and pay to charge their car there. This system allows for additional accessible charging infrastructure for residents, especially those that live in multi-family housing.

INDIANAPOLIS

Autolib' is in the process of expanding its service to Indianapolis under the name of BlueIndy. The car sharing service planned to launch with 1,000 EVs and 250 charging stations. The project hit a major setback in February of 2015 when Indiana Utility Regulatory Commission denied a proposed increase in the city's electricity rates. The proposed hikes would have cost each customer an additional 28 cents per month in order to fund the installation of the charging stations. In late April of 2015 an agreement was reached that the City would contribute 6 million from parking meter revenues and that Bollore would pay an additional 6 million (Tuohy, 2015). BlueIndy's President claims that the service could be ready as soon as the summer of 2015. In addition to the Indianapolis service, Bloomberg reported in January that Bollore is targeting Los Angeles in his next expansion for Autolib' (Rosemain & Mawad, 2015).

MOUNTLAKE TERRACE

Mountlake Terrace, Washington enacted a law in Municipal code 19.126 that requires a set number of EV parking spots with construction on different land types starting July 1, 2011. EV charging stations must be provided if a new building or off-street parking facility is developed, an addition or improvement to an existing building is made, or if the parking capacity for an existing site is increased by more than 50%. In addition, the development must be larger than 10,000 square feet. The required percentages of parking spaces with EV charging access are outlined in Table 15. This municipal code also requires that beginning January 1, 2011, all projects fitting the aforementioned qualifications must be designed to support double the amount of EV spaces as shown in Table 15. In order for these projects to be designed for expansion of future EV use, "site design must provide electrical, associated ventilation, accessible parking, and wiring connections to transformer to support the additional potential future electric vehicle charging stations" (Mountlake Terrace, 2010).

This code also contains a minimum number of accessible EV charging stations according to the number of available charging stations. Accessible EV charging stations are not required when a development has less than 5 charging stations. A minimum of 1 accessible charging station is required when there are between 5 and 50 charging stations at a site. Each addition of 50EV spaces requires another accessible charging station. These spaces do not need to be limited for ADA placard use, but must have a 44-inch or more barrier free area adjacent to the parking space.

Table 14: Required number of EV charging stations by land use type in Mountlake Terrace.

Land Use Type	Percentage of EV Parking Spaces
Multi-household residential	10%
Lodging	3%
Retail, eating and drinking establishment	1%
Office, medical	3%
Industrial	1%
Institutional, municipal	3%
Recreational/entertainment/culture	1%
Other	1%

ICELAND

Iceland is the first nation to declare its commitment to becoming an exclusive hydrogen economy by 2050. The country made this bold statement and began working with Shell and Daimler-Chrysler in 2000 to develop the fueling stations and infrastructure necessary for this fuel source. Shell has worked to build a hydrogen fueling station in the country that utilizes hydroelectricity to generate clean hydrogen. In 2003, one of the first hydrogen fueling stations was established in Iceland. Daimler Chrysler then converted a fleet of 80 buses to hydrogen fuel cell vehicles to service the capital, Reykjavik. This is part of a more comprehensive plan to eventually convert lighter duty vehicles and their extensive fishing fleet (Brown, 2006).

MADRID

Madrid is the first European city to provide an exclusive electric bicycle fleet, starting in June 2014, called Bicimad. A fleet of 1580 bikes are distributed amongst 123 stations within the city borders. Madrid is a city with hilly terrain, which is conducive to the use of an electric bike. This bicycle share scheme operates on an annual subscription fee that users pay along with a half-hourly rate during their use. One of Bicimad's main criticisms is the absence of a free use window. Most European cities that provide bike shares often provide the first half hour of bike use for free. Bicimad counters that this is offset by the lower annual fee that users pay, relative to other European cities (Carballo, 2014).

RECOMMENDATIONS

PARKING OPTIONS

COST

Santa Monica must pursue significant increases in the cost of parking in order to induce a reduction in emissions from personal vehicles. One study found that a 75% increase in parking fees result in an overall reduction of 3% in vehicle emissions (Shefer, Bekhor, & Mishory-Rosenberg, 2014). The same study documented that small increases in parking costs will actually lead to increases in car emissions. The increase is because there is an associated increase in search time for parking spaces, despite the decrease in demand for parking. This is the reason that Santa Monica should consider a significant increase in parking costs. The increase in parking costs can be implemented dynamically or as a percentage increase on current prices. There would be an expected decrease in overall greenhouse gas emissions of 0.49% with a 3% decrease in passenger vehicle emissions. An increase in parking costs should be done in conjunction with other local cities in order to prevent a decrease in Santa Monica's economy by incentivizing drivers to travel elsewhere because of cheaper parking costs.

DISABLED PLACARDS

One major challenges to the implementation of dynamic pricing on parking or any increase in parking costs is the response of drivers possessing handicap placards. California has issued 2.1 million disabled placards for its 24 million licensed drivers, about 9 percent of all drivers have placards (Groves, 2011). An increase is parking pricing serves as an economic incentive for drivers to use more public modes of transportation; however, it only applies as an economic incentive to users that are required to pay a higher price for parking. Handicap drivers are allowed to park for as long as they want and are not required to pay for parking under California code. One study observed streets that had as high as 75% handicap placards in parked cars (Glasnapp, et al., 2014). They also observed that many of the drivers possessing handicap placards walked to their destinations without any physical signs of handicapping conditions.

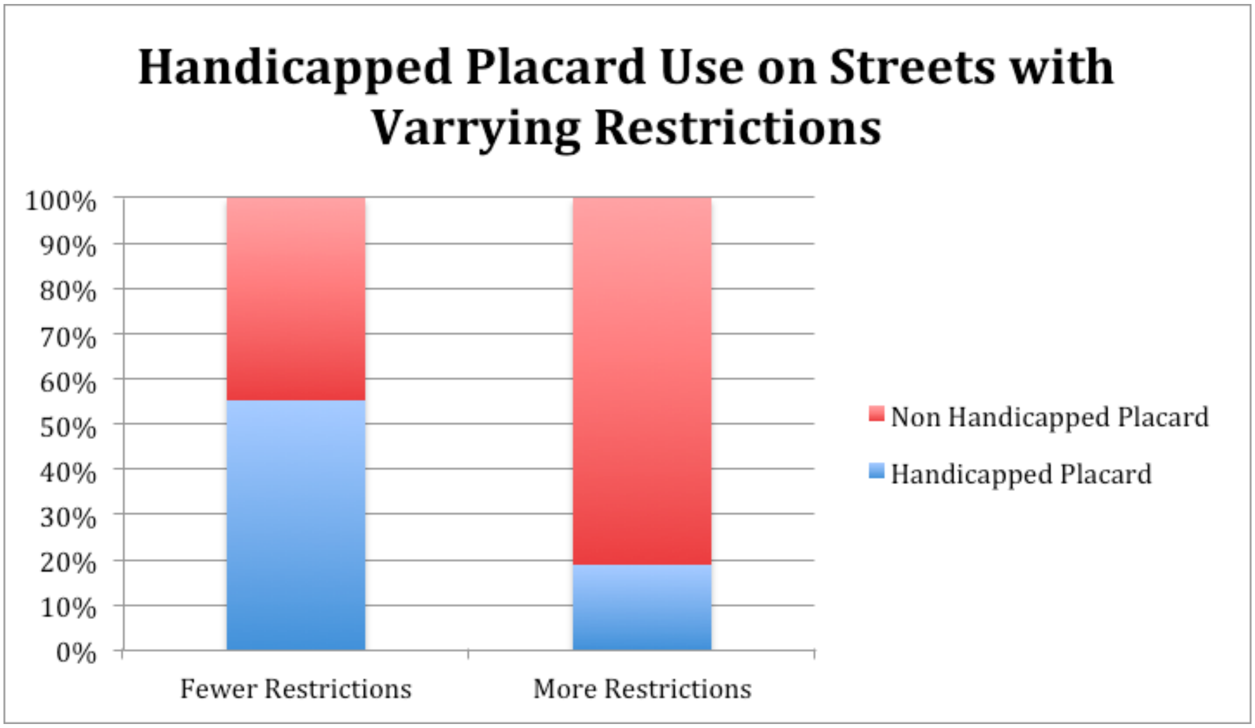


Figure 22: The percent of cars with and without handicap placards on streets with few or many parking restrictions (Glasnapp, et al., 2014).

Policy makers can avoid this problem in the short term by increasing parking restrictions. This study found that there was less handicap placard use on streets with more parking restrictions, shown in Figure 28. This is because the restrictions force the cars possessing handicap placards to move their car when the parking spots are restricted. When parking restrictions are not present these driver have incentives to leave their cars in these high trafficked spots because they do not have to pay the parking costs.

This problem also needs a long-term solution, which can come with Santa Monica urging for a change in California's regulation on handicap placards. One solution that has been explored in Michigan and Illinois is a two-tier system that takes into account varying levels of disabilities. The system is enforced so drivers with less serious disabilities have to pay for parking. The first tier of disabilities is for those that cannot physically approach the parking meter because of their disability or are unable to walk more than 20 feet due to their condition. The individuals falling under this tier can continue to receive free parking. The people in the second tier, all those possessing placards that do not fall under the first tier, are required to pay for their parking costs. There will be a significant increase in revenue from meter payments since nearly 10% of drivers are currently using handicapped placards. The study suggests cities should invest this money in disabled mobility services because some of the revenue will come from legitimate placard holders. Santa Monica should invest 10% of this additional revenue in disabled mobility services and the remainder of the new revenue in expansion of EV infrastructure. Ten percent of the revenue should be invested in these services because the City of Alexandria found that 90% of placards and license plates were being used illegally (Shoup, 2012).

PREFERENTIAL PERMITS FOR CARPOOLS

Santa Monica could also pursue a preferential parking system for commuters, similar to the program implemented in Seattle. This program would allow discounted parking prices to carpoolers who commute to work. Santa Monica would have to develop commuting criteria for this system to work. These criteria could be based off of Seattle, which sets the minimum amount of shared commute, days commuting per week, and their proximity to each other and the parking location. This program would also help Santa Monica reach its goal of an AVR of over 2 for businesses as it economically encourages carpooling. Santa Monica would need to publicize this program extensively if they choose to implement a similar strategy because there would a limited number of residents who meet the criteria.

EV CARSHARE

Santa Monica should develop its EV charging infrastructure and negotiate with EV carsharing services for their implementation in the City. There is significant traffic that occurs across the boundaries of Santa Monica and the greater Los Angeles area. Car2go and Autolib' are two potential carsharing services that Santa Monica can approach. The two services function within a home area that drivers are restricted to when dropping off their cars. The car service's use would be minimized if drivers were limited to the boundaries of Santa Monica for the car use, so the City should negotiate to be included in the same home area as Greater Los Angeles.

Car2go is an obvious choice for Santa Monica to approach because it was implemented in the South Bay of Los Angeles in June of 2014. The service will suspend its service in the South Bay on May 31st due to a lack usage; however, the company is looking at expanding its service throughout the greater Los Angeles area now (Polakoff, 2015). Santa Monica would have to negotiate with Car2go and the City of Los Angeles to expand the service to incorporate Santa Monica if the program is implemented throughout Los Angeles. If Santa Monica chooses to pursue this option then they should push for a gradual transformation of the Car2go fleet to an EV fleet, similar to San Diego. The other option for the City is to get in contact with Autolib', which is looking to expand to Los Angeles, as reported by Bloomberg (Rosemain & Mawad, 2015). Autolib's fleet is entirely electric and would be more effective in reducing Santa

Monica's emissions than Car2go's fleet. Santa Monica should explore the feasibility of expanding the service to Santa Monica if the Autolib' is instated in Los Angeles.

Autolib' estimates that its 3,000 Bluecars in Paris represent a reduction of 22,5000 private vehicles, the equivalent of about 102,000,000 miles per year by combustion engine vehicles (Autolib', 2011). This study assumes that an Autolib' service in Santa Monica would consist of 250 EV vehicles. If the numbers proposed by Autolib' are applied to the 250 proposed cars in Santa Monica there would be an expected reduction in private vehicles of 8,517,961 miles driven per year. Therefore, there would be a reduction of around 2,561.8 metric tons of carbon dioxide in 2015, assuming 8.91 kilograms of carbon dioxide are produced per gallon. The on-road average miles per gallon for passenger vehicles were estimated at 29.6 for 2015. The projected reduction in carbon dioxide by the year of implementation is shown in Table 16. The reduction in greenhouse gas emissions will decrease over time with the implementation of an EV car share program because the fuel efficiency of the replaced cars continues to improve over time. However, the overall greenhouse gas emission will be decreased because of this increase in average mpg of the vehicle fleet.

Table 15: Projected reductions in carbon dioxide with the implementation of an EV car-sharing program.

Year	Carbon Dioxide Reduction (metric tons) per 250 cars
2015	2,561.8
2016	2,502.0
2017	2,428.6
2018	2,353.3
2019	2,273.9
2020	2,191.8
2021	2,105.7
2022	2,017.0
2023	1,936.4
2024	1,861.2
2025	1,787.2

MULTIFAMILY CHARGING

Multifamily charging is a huge obstacle for Santa Monica to reduce private vehicle emissions since 70% of Santa Monica residents are renters. The first recommendation of this report is a modification to the CALGreen code to remove the voluntary aspect of installing EV chargers in 3% of parking spaces in multifamily units. The CALGreen code should be modeled after Mountlake Terrace's Municipal code 19.126, which serves as a requirement rather than a recommendation. Santa Monica should also consider adding the requirement for properties to be EV ready for double the minimum amount required. Santa Monica should also consider increasing the minimum percentages for this portion of the CALGreen code in order to encourage EV purchases and allow for the growth in this sector in the future.

Santa Monica should also consider implementing a curbside-charging pilot similar to Berkeley. The main benefit of this type of pilot is that the resident fronts the cost of the permitting, installation, maintenance, and operating costs. Implementing a program such as this allows for an expansion in public awareness of the EV market and for multifamily residents to have additional access to charging.

The combination of these two programs and the enforcement of AB 2565 starting July 1, 2015 will allow for greater access to charging for residents in multifamily housing. This study predicts that these measures will result in a 3% increase in EV purchases among Santa Monica residents.

ALTERNATIVE FUEL SOURCES, PUBLIC TRANSIT

Finding alternative sources of fuel will be one of the most effective ways to reduce GHG emissions associated with transportation. Currently the BBB operates exclusively on renewable natural gas, which is a notable feat. The City of Santa Monica reports its municipal GHG in accordance with standards set forth by The Climate Registry. Under the current conditions, Santa Monica cannot take credit for the emissions reductions from using renewable natural gas in their inventory. The carbon credits that are being generated are being sold to petroleum product distributors under the State's Low Carbon Fuel Standard. There currently is no accounting guideline to account for GHG reductions from renewable natural gas used under the Low Carbon Fuel Standard. The city should pursue the development of such GHG accounting guidelines so that it can take credit for verified GHG reductions from renewable gas use.

While committing to renewable natural gas is a remarkable accomplishment, the City can continue to do more to reduce the carbon intensity of their fuels and further the sustainability of the City's fuel inventory. Electricity and hydrogen fuel are both emerging fuel sources for public transit (Lowe, 2009). Santa Monica may consider pursuing these fuel sources as possibilities for future use. There are obstacles in implementation and developing the appropriate infrastructure for both electricity and hydrogen fuel cell sources. Electricity, for example, has several obstacles in terms of battery life and availability of charging infrastructure. However, introducing alternative fuel sources that require novel infrastructure can be more easily introduced in a fleet with a centralized depot, rather than private vehicle users where more dispersed infrastructure is needed (Cohen, 2011). The adoption of a completely zero-emission fuel source would be a transformative step the City could take to reduce emissions in public transit.

BUS-ONLY LANES

Currently, the City has designated short transit-only lanes on Santa Monica Blvd and Broadway in Downtown Santa Monica. There were previous considerations to implement a bus-only lane on 1.2 miles of Lincoln Blvd, extending from the Santa Monica Freeway to Grant Street. This proposal was ultimately rejected as it was determined that this alteration would not make a considerable difference in commute time or reduced congestion (King, 2013). Lincoln Blvd is a popular transit corridor and is congested during peak hours. Therefore, Santa Monica should reconsider implementing a bus lane on the entire boulevard or at least a longer stretch, since BBB Line 3 and Rapid 3 both run on Lincoln Blvd. A longer bus-only lane would be more effective in reducing commute times.

Bus-only lanes have been installed along Wilshire Blvd. The first installment opened in 2013 and ran between South Park View Street and Western Avenue. The most recent installment opened in April 2015 and extended the lane from Western Avenue to Federal Avenue. The final installment, anticipated to open in September 2015, will end its run at Centinela Avenue, the border of Santa Monica. Santa Monica should consider extending the bus-only lane in the City as this is a major transit corridor. BBB Line 2 currently runs predominantly on Wilshire Blvd. along with other Metro lines. These bus lanes are in operation during main peak hours, from 7 AM-9 AM and 4 PM-7PM. The adoption of transit only lanes, if placed strategically and planned appropriately has the capacity to save transit users a significant amount of time. With the Wilshire bus-only lane, travel times are anticipated to improve by 24% (Wilshire Bus Rapid Transit Project). Ridership on the Wilshire Boulevard is also expected to increase between 10-15% as a result of the introduction of the bus-only lane (Wilshire Bus Rapid Transit Project). The Introduction of more bus-only lanes will make utilizing public transit a more attractive option and will incentivize residents to use it more frequently.

ELECTRIC BIKES

A bike share program is already underway in the city. Santa Monica should consider enhancing their range of services by extending the bike share service to include electric bikes. Electric bikes have many associated benefits including greater range, ability to withstand terrain, and zero GHG emissions. There is also the added benefit of reduced travel time and energy exertion for the rider. In a study of Gothenburg, Sweden, non-cyclists' most prevalent reasons for not cycling were: environmental factors (i.e. weather, terrain), not owning a bike, and convenience or laziness. The study found, once an electric bike was introduced 53% of the barriers to biking were removed. Even more surprisingly, 76% of the barriers to biking were removed when an electric bike pool was introduced to the city (Brebbia, 2014). An electric bike pool has the ability to alter use and access to bikes. In Santa Monica, Electric bikes would give enhanced range and mobility for areas with varied topography, like the area south of the I-10 freeway and west of Downtown.

TRANSIT ORIENTED DEVELOPMENT

There is a need to adopt long term urban development plans to align with TOD to effect sustainable change on a longitudinal scale and at a meaningful level within the City. A significant portion of a city's GHG emissions are derived from transportation-related activities. Accordingly, TOD entails incorporating mixed-use spaces, including housing, office, and retail, with neighboring public transit systems. This access to transit systems decreases dependence on private motor use with mode shifts to public transit, walking, and biking.

This type of urban development has implications within the City that extend beyond the benefits for transportation emissions. Areas that undergo TOD experience lower levels of energy use. In Los Angeles, households living near high capacity transit are 29% smaller than those that are not and consumer 35% less energy (Nahlik, 2014). These households also tend to drive less and utilize less of non-carbon emitting modes of transit. On average, TOD households drive 11,000 miles annually, which is 48% less than those who don't live near high capacity transit (Nahlik, 2014). In addition, approximately 25% of those who live in TOD will shift 25% of their trips to public transit, biking, or walking (Nahlik, 2014). It's important to recognize that there are several factors that affect the effectiveness of this transition, which include the carbon intensity of electricity generation and fuel economy efficiency. These factors affect the amount of GHGs emitted from energy and transportation use, respectively.

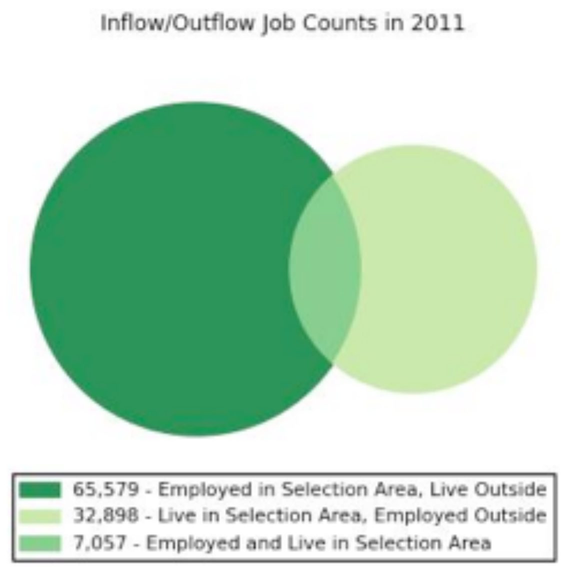


Figure 23: Venn diagram illustrating residences of those who are employed in Santa Monica and those who are employed elsewhere.

Almost 73,000 workers commute into Santa Monica regularly for work, with an average commute time of about 26.2 minutes (US Census Bureau State & County QuickFacts, 2015). This is partly due to the imbalance of job and housing availability in the city. Santa Monica's ratio of jobs to households is currently 1.54, well above the target ratio of 1.0 (Office of Sustainability and the Environment, 2014). There is a stark disparity between the volume of workers in Santa Monica and those who live in Santa Monica. Approximately 7,057 live and work in Santa Monica, which is 18% of the 39,955 total employed people who live in Santa Monica. On the other hand, 65,579 of those who work in Santa Monica live outside of the city. The City is currently accountable for half of the GHG emissions from transportation of commuters. An effective solution to maximize GHG reductions would be to target efforts at encouraging those who work in Santa Monica to live in the City. Santa Monica should consider the development of more housing units to reach a housing to job ratio of 1.0. These housing units will need to reflect the size, location, and affordability of the jobs available in the city (Office of Sustainability and the Environment, 2014). The City will be able to either reduce or eliminate the GHG emissions associated with their commutes with a lowered ratio.

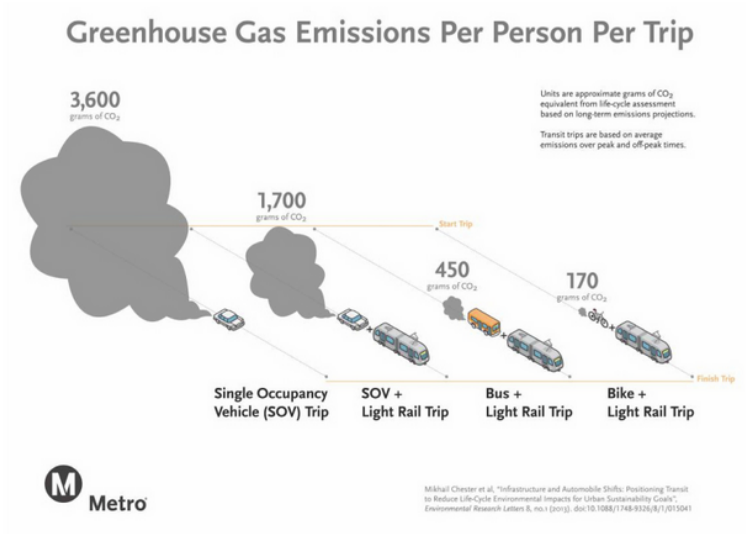


Figure 24: GHG emissions associated with varying modes of transit.

The arrival of the Expo line will aid in significantly reducing the GHG output of commuters who come into and live in Santa Monica, especially those who commute in single passenger vehicles. A commute in a single occupancy vehicle (SOV) averages around 3600 grams of CO2, a significantly greater carbon intensity than if there utilize the light rail along with another mode of transit for transfer (Hymon, 2014). There should be a greater effort from the City to encourage and incentivize use of the Expo Line for those still commuting into Santa Monica. This can be enforced by stricter AVR requirements from city employers or employer provided discounts or incentives for use of the line.

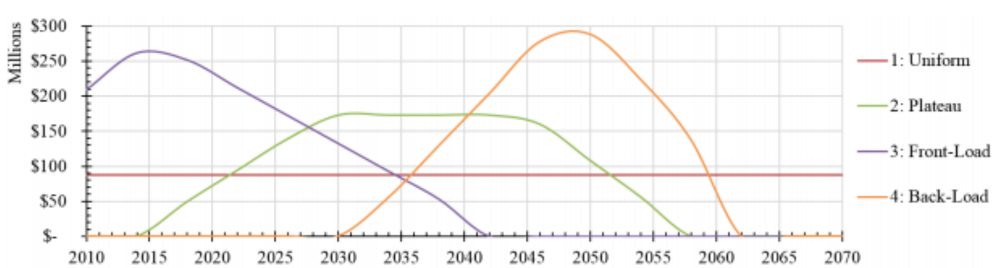


Figure 25: Investment schemes for deployment of TOD around the Expo Line. A cumulative of $5.2 billion dollars is needed.

To meet GHG emissions goals by 2050, the city will need to adopt aggressive development measures early on so that the emission reduction benefits of such development will be experienced. In an evaluation of land development around the Expo Line, a variety of financing schemes were evaluated to gauge how varying development schedules would affect reaching GHG emissions goals. It was determined that in order to meet the 2050 GHG reduction target, a front-loading financing scheme would be the only approach to reduce GHG emissions for the 2050 goal (Nahlik, 2014). This will require early investments in development, which can be aided by City involvement. GHG emissions reductions will stem primarily from reduced transportation emissions associated with shorter distances traveled and decreased household energy usage. Early development will allow the city to collect a greater amount of GHG savings over a longer period of time. Santa Monica's LUCE is grounded in the concept of TOD, however they have experienced some resistance from the community. Previous TOD- related projects have been rejected because of citizen resistance to the projects. Santa Monica should strive to mediate community concerns regarding TOD and garner stronger community support. This will help the city in progressing their vision of TOD with greater political ease and in a shorter time frame.

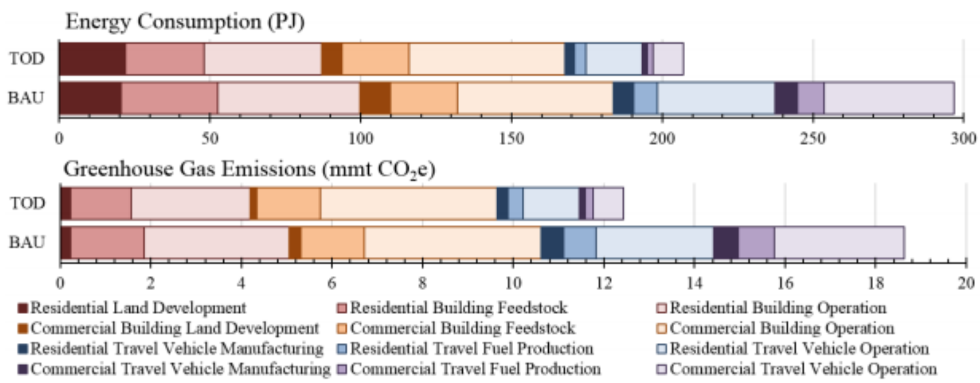


Figure 26: Comparison of Energy Consumption (PJ) and Greenhouse Gas Emissions (MMT CO2e) in Transit Oriented Development and Business as Usual cases.

To encourage TOD, the city can also consider a few approaches to prompt changes in urban development behavior. Santa Monica should consider the implementation of urban growth boundaries, minimum density targets, and required mixes of residential and commercial areas and tax incentives (Nahlik, 2014). Urban boundaries seek to curb urban sprawl by confining high-density urban environments to a confined space. The City should also consider implementing local zoning and planning policies that encourage higher population density, while also improving transit oriented development designs to improve effectiveness. The City can also mandate a certain mix of various types of housing including multifamily housing or small lot units. Santa Monica may consider providing funding for agencies and organizations to stimulate development to further encourage the development process (Cambridge Systematics, 2009). These tactics should be utilized to cultivate urban development that confine growth and achieve TOD objectives.

CHALLENGES

There are obstacles to be encountered with any change to a community's transportation system. Already, there is difficulty garnering political support for implementation. In 2014, The Bergamot Transit Village, a residential, office, and retail development, was rejected after its initial approval. The construction was proposed to accommodate the growing working force and demand for space in the city. However, resident resistance to the new development ultimately scrapped the proposal (Stevens, 2014). This incident is indicative of the community engagement and education that may be needed to facilitate a transition to TOD. The city should work to mediate these concerns, since this development will need to be a collaborative effort that the community supports. The City may run into another obstacle to secure funding for these projects. Much of funding is anticipated to be sourced from private investors, based on market demand, with the movement to TOD. The City may also run into obstacles in navigating land zoning regulations and land availability (Nahlik, 2014).

http://www.roughguides.com/gallery/the-worlds-best-sunset-spots/#/0

ENERGY

COMMUNITY CHOICE AGGREGATION IN SANTA MONICA

INTRODUCTION TO CCA

As the impending consequences of fossil fuel usage and large-scale climate change effects become more apparent, electricity consumers have recognized the fact that cleaner and more dependable sources of energy should be more widely used. Specifically within the context of cities and counties, consumers have acknowledged his need by demanding the procurement and distribution of more renewable energy. Since the 1990s, community choice aggregation has been one framework in which this has been achieved. It is a platform for consumers to aggregate their demand by forming a non-governmental entity that secures electricity from renewable energy sources, which is then distributed via public utility power lines to reach consumers. Through this system, the consumer-utility relationship is changed: consumers may affirm their agency of their electricity by opting into using more renewable energy. By setting up and opting into these systems, municipality residents may actively contribute to dynamically reducing their greenhouse gas emissions, thus improving the sustainability of their communities. CCAs have formed in multiple regions around the United States since the inception of the concept, and the city of Santa Monica is currently exploring the implications of what such a framework would bring to its community (South Bay Clean Power, 2015). This section will detail the background of the CCA, current CCAs in place that Santa Monica may model, and the lasting effects of a CCA in the city within the context of reducing greenhouse gas emissions.

HISTORY OF THE CCA

During energy shortages and oil crises in the 1990s, the idea of a CCA was established by Paul Fenn, a Massachusetts state senate staffer, as a replacement for the traditional investor-owned utility. Fenn saw electricity as a “physical and local thing rather than simply a commodity”, and thus helped draft the first bill that would authorize CCAs in Massachusetts in 1994 (Bates Magazine, 2010). Seen by many as a socialist or idealistic legislator, Fenn met much opposition when he first introduced the concept for a CCA. It was criticized for being impossible to deliver green power on a massive scale as cost-effectively as traditional utilities, or that electricity being produced by distant solar arrays and wind farms would not be transported efficiently. However, as energy deregulation began to take hold on the federal level, more government agents and community groups became interested in the idea of empowering cities and counties to choose their green power sources. Electricity would be de-centralized, coming from a plethora of different sources, but still would use the transmission and distribution lines currently managed by utilities. CCA has since spread to multiple regions of the United States: in 2002, a CCA bill passed in California, making current consumer-utility relationships like at Marin Clean Energy and Sonoma Clean Power possible. As of 2014, CCA laws cover 25% of U.S. annual electricity demand in seven states (California, Illinois, Massachusetts, Ohio, New Jersey, and Rhode Island) with 1300 total municipalities serving every 1 in 20 Americans (5% of the total population). It is recognized as a unique way for achieving high levels of green power in the energy mix at low, competitive prices (Bates Magazine, 2010).

CALIFORNIA CCA LEGISLATION

Since 2002, Californian legislation has helped shape the energy landscape of the state in order to be conducive to the creation of CCAs (Hales, 2014). Legislation has passed that authorizes these retail electricity choice programs to be administered by municipalities, on an opt-in basis, in order to leverage the negotiation of contracts with corporate energy providers including Pacific Gas & Electric (PG&E) and Southern California Edison (SoCal Edison). After mobilizing enough support, Paul Fenn helped to usher in California Assembly Bill No. 117, which essentially allowed for the existence of CCAs. Within its guidelines, groups of individuals are now legally allowed to aggregate their electrical load demand, and file an implementation plan with the California Public Utilities Commission (CPUC). The plan would include the staffing hierarchy, financing, and energy procurement details of a potential CCA. After approval from the CPUC, it may force public electric utilities to invest in cost-effective energy efficiency and conservation programs as well as clean energy sources, as requested by the implementation plan.

Furthermore, Assembly Bill 2514 was passed in 2010 to mandate that public utilities have targets to procure grid-connected energy storage systems as soon as 2015, checked by the CPUC. This was approved as a complement to the Renewable Energy Standard ("RES") adopted by California which forces investor-owned and public utilities to produce 33% of their electricity from renewable energy resources by 2020. This now encourages frameworks like CCAs to be established, due to the fact that they promote cleaner and more energy-efficient resource usage as well (Hales, 2014).

Despite the approval of AB 117 and other bills, certain legislation has been proposed to counter the creation of an environment that encourages CCAs to be made in California. In 2010, PG&E advocated for Proposition 16 to pass, which would have barred communities from forming CCAs unless two-thirds of the region's residents agreed: the measure failed. In 2014, Steven Bradford, a former SoCal Edison executive, pushed Assembly Bill No. 2145 (or, the "Monopoly Protection Act") through the state Assembly. This measure called for local residents to "opt in" to the CCA if it was created, instead of making it an automatic transition after which customers would opt-out if they wished to do so. This would have effectively limited the number of potential CCA customers, since most people do not go out of their way to opt into programs: Sharman himself stated that this would have made new CCAs "dead on arrival." After opposition from CCAs, community environmental groups, and other state legislators, the bill did not pass in the state senate, and that threat to the CCAs was removed. It was an attempt by Californian monopoly utilities to hinder the development of CCAs, which do take over some of the sovereignty that public utilities have in determining their energy mix compositions (Hales, 2014).

EXAMPLES OF CCAS

MARIN CLEAN ENERGY

Since CCAs were made possible to be created in 2002, multiple communities have taken steps towards aggregating their electrical load demand. Marin County, California is a model example of a municipality that has successfully established and implemented a CCA. Marin Clean Energy (MCE) was established in 2010 with the objective of "reducing the global environmental impacts of electricity usage", and currently serves 125,000 customers in Marin County, unincorporated Napa County, and the Cities of Benicia, El Cerrito, Richmond, and San Pablo, California (Marin Clean Energy, 2013). So far, the CCA has been successful: since 2013, 1,542 MWh of electricity, 27,131 therms of natural gas, and 5,304,556 gallons of water have been saved thanks to MCE. Since its inception, MCE has also created 2,400 jobs in California.

Through a partnership with PG&E, the CCA procures renewable energy sources that produce electricity for its consumers, which is transmitted and distributed by the utility's infrastructure. MCE has developed an "Integrated Resources Plan" which quantifies tangible objective for the CCA, including a long-term goal for 100% renewable energy, energy efficiency programs like demand response, and specific amounts of electricity produced by local distributed generation. Figure 33 depicts the breakdown of specific MCE renewable energy sources: the largest percentages of energy come from natural gas, followed by wind, biomass, and solar energy. All seventeen contracts that the CCA has established thus far are with eleven different third-party energy suppliers that MCE does not own; these sources range in distance from Marin County Proper. Figure 33 displays the map of MCE's contracted power supply in 2011. MCE currently does not own any of these generation assets; rather, power purchase agreements (PPAs) of most typically 20-25 years in duration have been utilized thus far. The CCA has stated that it does not have a specific bias towards PPAs or asset ownership. Instead, it examines opportunities for procurement on a case-by-case basis, considering factors like risk allocation, physical asset location, technology, and the possibly supply of electricity to consumers (Marin Clean Energy, 2013).

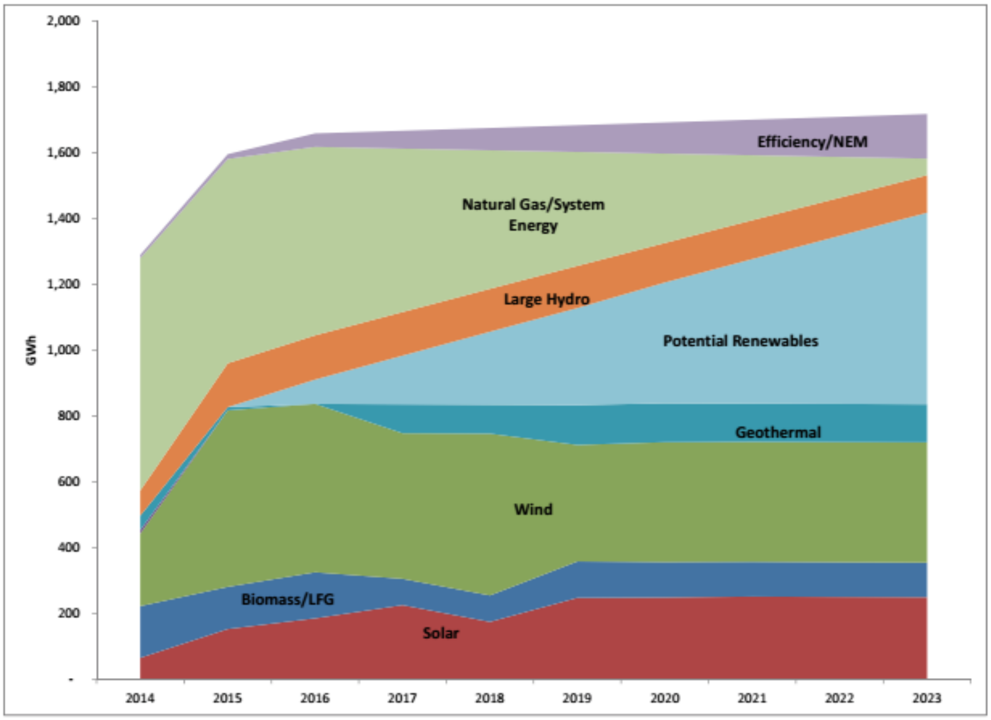


Figure 27: MCE Resource Mix (2014-2023) (Marin Clean Energy, 2013).

As a result of the CCA making these sources more available to consumers, there are four possible electricity options for Marin County consumers to subscribe to: the status quo of regular 22% renewable energy from PG&E (opting out of the CCA), MCE "light green" (50% renewable), MCE "deep green" (100% renewable), and MCE "local sol" (100% local solar) (Marin Clean Energy, 2013). These options vary by clean energy percentage, and the CCA aims to set rates as low as possible in order to compete with that of PG&E. A unique aspect of MCE's plan is the 100% local solar option: the CCA signed a 20-year power purchase agreement with the San Rafael Airport in Marin County for 972 kilowatts of rooftop solar power from 5,000 solar panels, which power about 1,200 households. This has become Marin County's largest solar project and feed-in tariff (FiT) program, which are designed to incentivize the creation of and purchase the power output from small-scale renewable energy projects. Currently, the FITs under MCE are limited to 1 megawatt, with a total capacity of 10 megawatts (Marin Clean Energy, 2013). Table 17 depicts all the current FIT projects that MCE has contracted. The CCA also has certain carbon neutral power content standards, for which short-term (less than one year) contracts are currently being explored through large hydroelectric, unbundled renewable energy certificate (REC), and carbon offset projects.

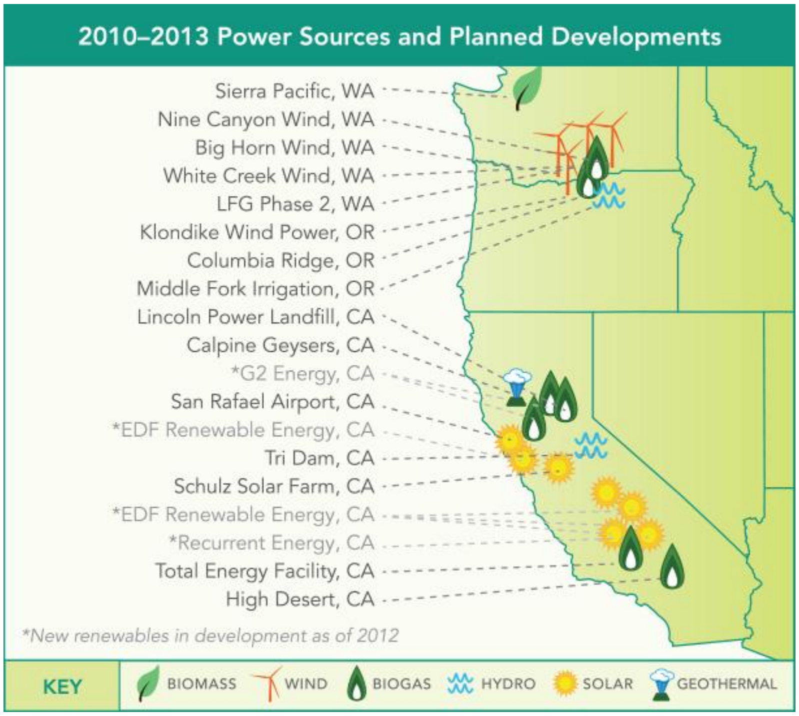


Figure 34: MCE Contracted Power Supply (2011) (Marin Clean Energy, 2013).

Table 17: MCE existing and proposed FIT projects (Marin Clean Energy, 2013).

Project Name	Project Status	Capacity (kW)	Annual Output (kWh)	Commercial Operation Date
San Rafael Airport	Existing	972	1,800	October 2012
Cooley Quarry 100% Local Solar	Under Contract	990	2,000	March 2015
Cooley Quarry	In Queue	500	1,000	March 2015
Richmond NWC Goodrick	In Queue	998	1,800	June 2015
Richmond Parkway	In Queue	998	1,800	June 2015
Larkspur RE	In Queue	261	500	November 2015
Binford Road Storage	In Queue	990	1,800	September 2015
Giant Road Solar	In Queue	990	1,800	May 2015
TOTAL		**6,699**	**12,500**	

SONOMA CLEAN POWER

Another model example of a successful Californian CCA is Sonoma Clean Power, (SCP) which is run by Sonoma County, and the cities of Sonoma, Santa Rosa, Cotati, Windsor, Sebastopol, Cloverdale, Rohnert Park, and Petaluma. It was created in May of 2014, as the result of multiple studies and climate action plans exploring new ways to reduce greenhouse gas emissions. Like with MCE, an implementation plan was drafted and approved by the CPUC, and the goal is to reduce emissions, support local jobs, and provide continuously reliable power at competitive prices. The transmission and distribution is also handled by PG&E, which is the default opt-out alternative for electricity consumers in the area (Sonoma Clean Power, 2013).

With SCP, there are now three options for Sonoma County residential and commercial consumers to choose where they get their electricity from: PG&E (opting out of the CCA, and 28% renewable energy), "CleanStart" (33% renewable energy), and "EverGreen" (100% renewable energy). The three options vary in energy mix and price, with CleanStart costing $100.52 and EverGreen costing $118.02, compared to PG&E's average rate of $107.57 (Sonoma Clean Power, 2013). All electricity procured by the CCA has thus far come from contracts with third-party suppliers, but there are plans to explore possible SCP-owned generation assets. Table 18 shows the different resources planned by SCP in the 2014 implementation plan. In its implementation plan, SCP mandated that only renewable projects located anywhere within the Western Interconnection can be considered as a potential source of electricity, with preference to more local projects. The Western Interconnection is one of two of the largest alternating current power grids in North America. This plan is projected to adequately surpass the minimum renewable energy portfolio standards (RPS) of 33% renewable energy by 2020 mandated by the state of California. Additionally, in order to ensure sufficient electricity reserves to meet the varying peak load at all times, necessary monthly load projects have been made by the CCA. The load capacity requirements are a function of the PG&E area resource adequacy requirements, and SCP's projected peak demand (Sonoma Clean Power, 2013).

SCP's charter also allows for the CCA to purchase RECs: essentially, legal rights to the environmental benefits associated with the investment in generation of renewable energy. One REC is created for each megawatt-hour of renewable energy electricity produced and delivered to the grid. SCP has planned to utilize unbundled RECs, in which the certificate is separated from the associated electrical energy, which produces two distinct products and revenue streams. This encourages the utilization of renewable energy without the new for co-location of the CCA and the supplier: it prevents potentially costly transmission arrangements (Sonoma Clean Power, 2013).

Table 18: SCP Proposed Resource Plan (2014-2023) (Sonoma Clean Power, 2013).

Sonoma Clean Power
Proposed Resource Plan
(GWH)
2014 to 2023

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
SCP Demand (GWh)										
Retail Demand	-396	-1,065	-1,486	-1,512	-1,513	-1,516	-1,519	-1,522	-1,525	-1,528
Distributed Generation	6	18	25	28	29	30	30	31	32	33
Energy Efficiency	0	5	21	23	24	26	27	29	31	32
Losses and UFE	-23	-63	-86	-88	-88	-88	-88	-88	-88	-88
Total Demand	-414	-1,104	-1,526	-1,549	-1,548	-1,548	-1,549	-1,549	-1,550	-1,550
SCP Supply (GWh)										
Renewable Resources										
Generation	0	0	0	0	17	34	52	94	94	94
Power Purchase Contracts	129	378	602	690	749	747	745	717	732	747
Total Renewable Resources	129	378	602	690	766	781	796	811	826	841
Conventional Resources										
Generation	0	0	0	0	0	0	0	0	0	0
Power Purchase Contracts	285	726	924	859	781	767	752	738	724	709
Total Conventional Resources	285	726	924	859	781	767	752	738	724	709
Total Supply	414	1,104	1,526	1,549	1,548	1,548	1,549	1,549	1,550	1,550
Energy Open Position (GWh)	0	0	0	0	0	0	0	0	0	0

SCP, like MCE, has started a feed-in tariff program, known as "ProFIT". It promotes the development of small-scale renewable energy generation installations within the SCP service territory by creating a flat rate of $95 per megawatt-hour (MWh), with the contracts for ten years for baseload generating facilities and twenty years for other generating facilities. SCP has laid down specific criteria for involvement in the ProFIT program, which are outlined in the CCA implementation plan (Sonoma Clean Power, 2013).

HERMOSA BEACH

A third example of a metropolitan-area CCA is in the City of Hermosa Beach, which has been planned but not implemented yet. A study of the potential and benefits of a CCA in the city was conducted by the 2013 UCLA Environment 180 Practicum team, inspired by the city's aspirations to decarbonize its electricity, explore options for carbon neutrality, and become more sustainable as a whole. Hermosa Beach proper currently houses about 20,000 residents that consume 78 gigawatt-hours of electricity annually, served by Southern California Edison (SCE), and investor-owned electric utility. The CCA study prepared by the students was cited heavily in the 2015 "Hermosa Beach Municipal Carbon Neutral Plan" as an option to obtain Californian renewable energy and meet the state's mandated RPS (Hampton, et al., 2014).

The study suggests that if a CCA were to be created, it would be through the South Bay Clean Power as the Joint Powers Authority (JPA) that administers the charter. South Bay Clean Power is a citizen-backed, non-governmental group that has been exploring the possibilities of a CCA in the South Bay region, which would serve cities like Hermosa Beach, Redondo Beach, Torrance, and even Santa Monica. Both Marin Clean Energy and Sonoma Clean Power were cited as successful examples that Hermosa Beach could take note of moving forward if it were to pursue a CCA. Much like those two CCAs, the one in the South Bay would most probably start with power purchase agreements, between the CCA and independent power producers (as stated by the practicum group's report). The report outlines the necessary steps needed to be taken by the city if it were to pursue a CCE, a reasonable timeline of planning and implementation, and funding method recommendations based on MCE. Hermosa Beach, being a less populated city than Marin or Sonoma Counties, only had a total load of 77.9 gigawatt-hours, versus 1,422.21 and 2,874.91 for Marin and Sonoma, respectively. This difference could noticeably affect the rates put in place once the CCA is created (Hampton, et al., 2014).

The benefits of a CCA were projected based off of MCE and SCP's reports, and it was concluded that the amount of renewable energy electricity would be greater with a CCA instead of the status quo Southern California Edison power mix. Table 19 shows a projected 5,978 Megatons of carbon dioxide being avoided with the creation of a CCA (Hampton, et al., 2014). Among other recommendations, the 2013 practicum team suggested CCA as a viable option to decarbonize Hermosa Beach's electricity. However, given the nature of the grid and its current reliability, along with the startup costs of the process of making a CCA, forming a JPA with other South Bay cities would be most economically viable. South Bay Clean Power is currently in the process of recruiting more cities, and Hermosa Beach would be served by that CCA when it is eventually finalized. Joining with other cities via a JPA would provide multiple benefits for Hermosa Beach. The startup, maintenance, and CCA staffing fees of a JPA are generally less than in a situation in which a single city or county pursues a CCA. Additionally, joining forces with multiple cities helps smaller metropolitan areas like Hermosa Beach to have a stronger, more aggregated demand for renewable energy electricity. JPAs help promote cooperation between multiple cities for a common goal, and would help aggregate the electrical loads of these communities in order to negotiate low-cost energy contracts from individual power producers. Generally, as a JPA expands, financial risks are mitigated by separating the budget and assets of a CCA from the general funds of the member cities: in effect, the liability or debts of a JPA would not translate to its member cities. Table 20 shows a potential financial breakdown for cities involved in the South Bay Clean Power JPA (Hampton et al., 2014).

Table 16: Carbon emissions abated in Hermosa Beach after switching to a CCA (Hampton, et al., 2014).

Program	Demand	Emissions (MT of CO2)	Total Emissions (MT of CO2)
SCE	Non-renewables 62.4 GWh Renewables 15.6 GWh	Non-renewables 15,210 MT Renewables 0 MT	15,210 MT
CCA*	Opt-Out 19.97 GWh Light Green (50%) 56.91 GWh Deep Green (100%) 1.12 GWh	Opt-Out 5,338 MT Light Green (50%) 3,894 MT Deep Green (100%) 0 MT	9,232 MT
Difference (Abatement)			**5,978 MT Abated**

*We assumed MCE's enrollment rates, fuel mix, and light/dark green options.

Table 17: Split in CCA startup costs among five South Bay cities, according to their consumption (Hampton, et al.).

City	Total Consumption	% of Total Consumption[259]	CCA Startup Cost Split Amongst 5 Cities[260]
City of Hermosa Beach	77,974,840	8.00%	$135,498.35
Manhattan Beach	91,572,350	9.40%	$159,127.00
Inglewood	376,697,552	38.50%	$654,594.43
Redondo Beach	201,721,751	20.60%	$350,535.69
Palos Verdes Estates	62,774,526	6.40%	$109,084.48
Rancho Palos Verdes	167,553,034	17.10%	$291,160.06

CCA IN SANTA MONICA

CURRENT CONDITIONS

Santa Monica has long been an advocate for addressing the effects of climate change. Since 1990, the city's per capita emissions have dropped from 10.64 to less than 8.8 metric tons of CO_2 equivalent, which is much lower than California's 2009 per capita average of 13.1 (Santa Monica Office of Sustainability and the Environment, 2015). In 2006, Santa Monica updated its Sustainability City Plan with the goal of reducing the community's greenhouse gas emissions to 15% below 1990 levels by the year 2015. By the year 2007, a 7% below 1990 levels reduction was achieved, and by 2012, another 7% was reduced. However, due to an increase in population and greenhouse gas emissions between 2012 and 2015, a new goal of 3% reduction in greenhouse gas emissions was actualized in order to meet the 15% below 1990 levels objective. This resulted in the production of the multi-disciplinary, fifteen-measure "15x15 Climate Action Plan" meant to reduce the community's emissions by an additional 29,000 metric tons of carbon dioxide (Santa Monica Office of Sustainability and the Environment, 2015). Energy use and generation are responsible for more than half of the city's greenhouse gas emissions.

Southern California Edison (SCE), a public electric utility that serves most of Southern California, supplies the electricity for Santa Monica's residential, commercial, and municipal needs. The city's total electricity amount use in 2013 was 826,933,242 kWh, which was supplied by a variety of different types of energies, outlined in Table 21 (Southern California Edison, 2014).

Table 18: Southern California Edison's power content label for 2012 and 2013 (Southern California Edison, 2014).

POWER CONTENT LABEL		
Energy Resources	2013 SCE POWER MIX	2012 CA POWER MIX
Eligible Renewable	22%	15%
Biomass & Waste	1%	2%
Geothermal	9%	4%
Small hydroelectric	1%	2%
Solar	1%	1%
Wind	10%	6%
Coal	6%	8%
Large Hydroelectric	4%	8%
Natural Gas	28%	43%
Nuclear	6%	9%
Other	0%	0%
Unspecified sources of power*	**34%**	**17%**
Total	**100%**	**100%**

* "Unspecified sources of power" means electricity from transactions that are not traceable to specific generation sources.

Although solar electricity has been increasing in usage throughout the city and SCE has committed to using more solar and large hydropower, a large percentage of Santa Monica's energy comes from nonrenewable sources (Southern California Edison). Additionally, an unreliable grid system has hindered two-way electricity flow in SCE's grid network. Despite this, the implementation of a CCA in the community is possible and could effectively reduce greenhouse gas emissions by introducing cleaner sources of electricity. This would assist the city in reducing the final 29,000 metric tons of carbon dioxide needed to meet the goals outlined by the 15x15 Climate Action Plan.

As community choice aggregation has been more utilized in California during the past ten years, Santa Monica has been open to the possibility of its usage. On May 27th, 2014, after a recommendation from the Santa Monica Task Force on the Environment, the City Council voted to oppose California Assembly Bill 2145, which would have required individual consumers to opt into community choice aggregation electricity plans by themselves instead of the current automatic opt-in framework in place. This would have made it more difficult for cities to implement a CCA, due to the increase in public outreach that would have been necessary (Larios, 2014).

SOUTH BAY CLEAN POWER AND SANTA MONICA

Throughout 2014, South Bay Clean Power has been recruiting multiple cities to be at the forefront of the CCA movement, which Santa Monica has the opportunity to do. The group's objective is to bring together fifteen cities in the South Bay region and five cities in the West Side to establish a CCA. This includes Hermosa Beach, Manhattan Beach, Santa Monica, Redondo Beach, Torrance, Carson, Palos Verdes Estates, Inglewood, Gardena, Lomita, Hawthorne, Lawndale, Rancho Palos Verdes, Rolling Hills, Rolling Hills Estates, El Segundo, Malibu, Culver City, West Hollywood, and Beverly Hills (South Bay Clean Power, 2015). South Bay would form the JPA registered with the California Public Utilities Commission (CPUC) in order to establish a CCA (Armour, et al., 2014). A Board of Directors and specific staff hierarchy would then be put in place to administer the CCA. It has been previously recommended in specific case studies (for Hermosa Beach and Torrance) that for individual cities interested in establishing a CCA, the most fruitful and proactive step would be to participate in the South Bay Clean Power JPA (South Bay Clean Power, 2015). The Los Angeles County Board of Supervisors also unanimously passed a motion to assess the feasibility associated with establishing a CCA within the County.

On a broad level, electricity retailers (including utilities and CCAs) must meet the requirement of a 33% local renewable portfolio standard by the year 2020 set by Senate Bill X1-2 (Armour, et al., 2014). CCAs not only meet but greatly exceed this requirement, and provide stability in the state's energy portfolio which has been dominated by natural gas. For Santa Monica specifically, a CCA would dynamically assist the city in addressing its sustainability needs, and introduce new ways of reducing greenhouse gas emissions. By providing the opportunity for local procurement of renewable energy, a CCA in Santa Monica would give the community more of a say about where their electricity is coming from, decarbonize and cheapen electricity options, produce jobs, and stabilize often-fluctuating rates that come from Southern California Edison (Armour, et al., 2014).

After establishing the staff hierarchy of the CCA, the collective would administer the procurement of electricity from renewable energy resources. Like in the case of Marin County, these sources may range in distance from the community, and in energy type: solar, wind, geothermal, etc. (Marin Clean Energy, 2014). Following the example of Marin and Sonoma Counties, these contracts would be for 10-20 years, and would start off as power purchase agreements where the CCA does not yet own the source. The CCA will be tasked with finding suitable renewable energy providers, and would put an emphasis on local energy: for example, solar panel developments in or around Santa Monica, or wind farms in southern California as opposed to northern California.

The South Bay group would also be tasked with finalizing different rate levels: the Sonoma model of two different platforms of participation (CleanStart and EverGreen) gives consumers different choices of renewable energy percentage and fiscal rate (33% for $100.52 and 100% for $118.02, respectively). A two-rate system as an option to the status quo of Southern California Edison would serve as a practical objective for Santa Monica's CCA. In the case of Sonoma, CleanStart is cheaper than the opt-out price of SCE ($100.26), but EverGreen is more expensive: consumers would need to be aware of the benefits that come with the greater costs of a cleaner energy option. By the launch date of Sonoma Clean Power, CleanStart saw an opt-out rate of only 11%, as opposed to the anticipated 25-30%, while EverGreen had over 200 customers enrolled. Both programs combined saved customers $6 million collectively in 2014 (Armour, et al., 2014) Figure 35 depicts a comparison in price for Sonoma Clean Power and PG&E.

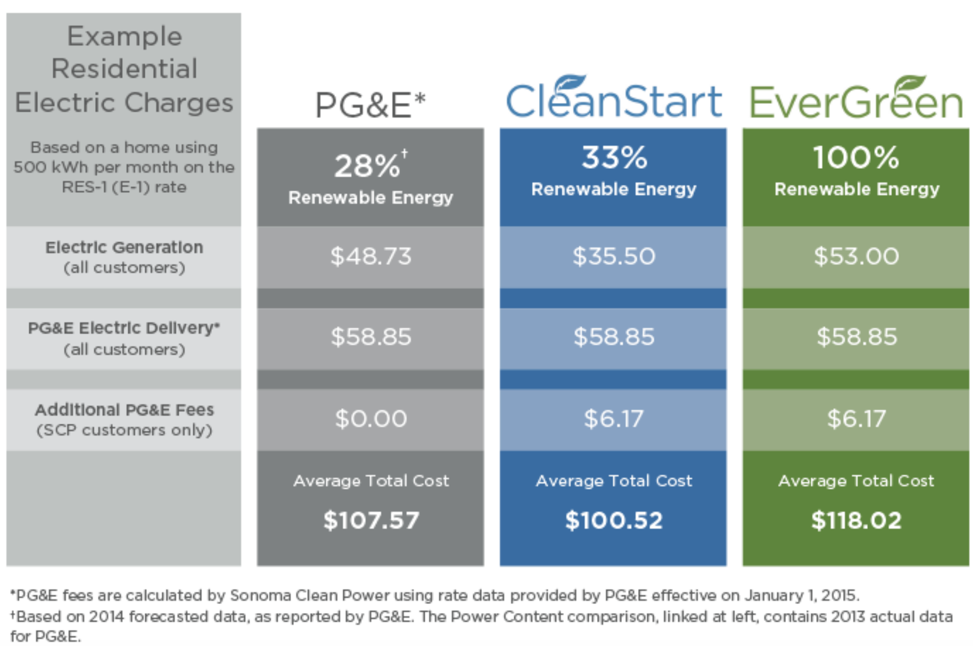


Figure 28: Sonoma Clean Power's CleanStart and EverGreen vs. PG&E (Sonoma Clean Power, 2013).

The South Bay CCA would also need to figure out the details of phase-in implementation. For Sonoma Clean Power, Phase 1 consisted of enrolling up to 20,000 municipal and commercial accounts by the end of 2014. Phase 2 consists of recruiting 60,000 more commercial and residential accounts for 2015, while Phase 3 will begin in 2016 with attempting to enlist all remaining accounts in the county (Armour, et al., 2014). This way, instead of front-loading efforts to enlist all customers at once, the CCA makes a careful, targeted effort to work from the ground up and effectively recruit customers. Figure 36 describes a similar segmented phasing plan for Marin Clean Energy: this approach has been cited as effective due to the ability to start slow and address any unexpected problems met at each phase, on a more manageable scale than instead of tackling all potential consumer accounts at one (Marin Clean Energy, 2014). Such a phasing plan would assist Santa Monica in reaching as many of its near 100,000 residents effectively.

Phase 1. Complete: MCE Member (municipal) accounts & a subset of residential, commercial and/or industrial accounts, comprising approximately 20 percent of total customer load.

Phase 2. Complete: Additional commercial and residential accounts, comprising an approximately 20 percent of total customer load (incremental addition to Phase 1).

Phase 3. Complete: Remaining accounts within Marin County.

Phase 4. Complete: Residential, commercial, agricultural, and street lighting accounts within the City of Richmond.

Phase 5. February 2015: Residential, commercial, agricultural, and street lighting accounts within the unincorporated areas of Napa County, subject to economic and operational constraints.

Figure 29: Marin Clean Energy Phase-in Implementation Plan (Marin Clean Energy, 2014).

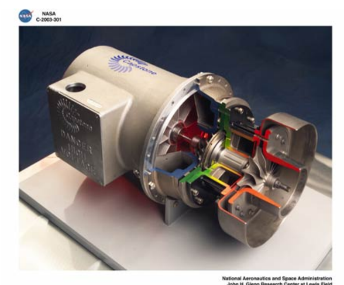
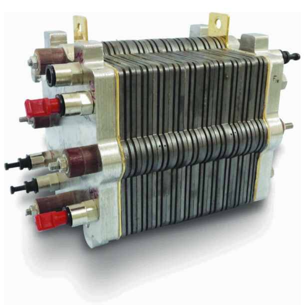
A feed-in tariff in the Santa Monica CCA modeled after the tariffs found in MCE and SCP could become successful as well. With Sonoma's ProFIT program, the CCA is allowed to purchase energy from small-scale renewable electricity installations within the service territory, which incentivizes participation from consumers. In Marin County, although the feed-in tariffs are new, they are currently producing thousands of kilowatt-hours for the community, as the most local option for electricity from solar energy for the community. In general, feed-in tariff programs allow for long-term, fixed pricing that provides stability and confidence to the CCA that could potentially attract local investors to pursue electricity generation projects (Armour, et al., 2014). Specific areas in Santa Monica could be specifically used for solar projects that fit into the feed-in tariff framework. For example, just like the San Rafael Airport being used to house solar panels, the Santa Monica Municipal Airport may also be used as a feed-in tariff.

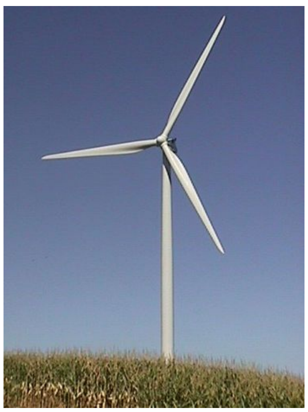
DISTRIBUTED GENERATION

INTRODUCTION TO DISTRIBUTED GENERATION

Distributed generation (DG) is an electric power source connected directly to the distribution network or on the customer site of the meter (Ackermann 2001). Types of DG include traditional combustion generators like micro-turbines, fuel cells, and renewable devices such as solar photovoltaics (PV) and wind.

Types of DG

Micro-turbines: traditional combustion generators 	Micro-turbines are small capacity combustion turbines which can operate using natural gas, propane, and fuel oil. They burn to produce electric energy, heat, and pollutant emissions. Advantages of micro-turbines include high efficiency (>80%), lower emissions than large scale power plants, and proven technology. The waste heat can also be recovered to generate steam for a combined heat and power (CHP), or cogeneration, plant. (El-Khattam 2004)
Fuel cells 	The fuel cell generates electric power from chemical energy through electrochemical processes. A typical fuel cell combines oxygen from air and hydrogen, which is produced in a fuel processor from hydrogen-rich fuels such as natural gas, biogas, or propane to produce water and electricity.
Solar DG	Photovoltaic (PV) panels directly convert photons in sunlight that is incident on the PV cells into electricity, producing electricity that is "free" apart from the initial investment and maintenance costs. Other advantages of PV systems include its emission-free operation and a peak performance that tends to coincide with peak energy demand. Downsides include high initial investment costs and variability in power generation, which is a key characteristic of renewable DG technologies, as their output

	is dependent upon environmental conditions. Solar DG differs from utility-scale solar in that its project size is much smaller and the electricity generated is mainly fed to end-use consumers. In comparison, utility-scale solar projects are usually very large, located away from consumer centers, and the electricity generated is sold to wholesale utility buyers.
Wind DG 	Wind turbines can provide clean energy as individuals or as wind farms. Wind rotates the turbine blades (usually two or three blades that are 10-30m long), which in turn rotate their attached shaft, that operates a pump or generator to produce electricity.

This section will focus on solar DG, specifically rooftop solar PV. Solar distributed generation (DG) refers to electricity produced from solar power generation systems that are connected to the distribution network on the customer's side of the meter.

GROWTH OF SOLAR DG IN CALIFORNIA

Rooftop solar installation has grown exponentially in California, having doubled in capacity within 2013 alone, from 1000 megawatts (MW) to 2000 MW. (Del Chiaro, 2013) This may be attributed to the array of state and federal incentives for solar PV, the availability of third-party ownership structures, as well as the declining costs of solar PV installations; average installation prices have declined annually by 5–7% from 1998 to 2011. (Darghouth, 2012)

FEDERAL AND STATE INCENTIVES FOR SOLAR PV

Net energy metering (NEM)

California's net-energy metering (NEM) law requires investor-owned utilities to offer bill credits to customers with distributed generation systems up to 1 MW in size, compensating them for the excess electricity they produce that is exported to the grid

At certain times of the day, a customer's rooftop solar system may produce more electricity than the customer consumes – this excess electricity is exported to the grid and their meter essentially "runs backwards", providing them with credit for the full retail value of that electricity, which they can then utilize during the times when their solar system output is lower than their consumption.

Under the original law, which took effect in 1996, any net-excess generation remaining at the end of each 12-month period was granted to the utility. However, AB 920 was passed in 2009, allowing PV customers to roll the credit over to the next period indefinitely, or cash it out for compensation by the utility, beginning in 2011.

Solar Investment Tax Credit (ITC)

The solar Investment Tax Credit (ITC) is a 30% tax credit offered by the Federal government for residential and commercial solar systems.

With the ITC, solar generation owners receive a dollar-for-dollar reduction on their taxable income that is equivalent to 30% of their qualified expenditures on solar energy equipment, such as hardware and labor costs. Should the tax credit exceed tax liability, the excess amount may be carried forward to the succeeding taxable year until 2016.

Renewable Energy Portfolio (RPS) and Renewable Energy Credits (RECs)

California's Renewables Portfolio Standard (RPS) requires investor-owned utilities, electric service providers, and community choice aggregators to procure 33% of its total electricity procurement from eligible renewable energy resources by 2020. Utilities are required to obtain a certain percentage of their retail sales of electricity from renewable sources within each of the three compliance periods between 2011 and 2020, and show their compliance with the RPS via what is known as renewable energy credits (RECs).

RECs represent the environmental and renewable attributes of renewable electricity and thus are not subject to the constraints of electricity transmission, distribution, and delivery, making the purchase of renewable energy much more convenient.

A REC is issued for every 1MWh of energy generated from eligible renewable sources, and can be sold either "bundled" with the underlying energy or separate from it, known as "unbundled" RECs, into a REC trading market. RECs usually include primary attributes such as the type of renewable resource which produced it, its vintage (i.e. date when it was created) and the location it was generated at.

They may be bought and sold between multiple parties, and are equivalent to the "currency" of renewable energy markets. Once a REC is utilized by a buyer to fulfill their environmental claims, it is considered permanently retired.

In California, owners of distributed generation systems own the rights to the RECs they generate, which they may choose to sell into the compliance market, providing solar DG owners with an additional financial incentive.

California solar initiative (CSI)

The California Solar Initiative (CSI) is a solar rebate program for California consumers that are customers of the investor-owned utilities - Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E). The program has a total budget of $2.167 billion between 2007 and 2016 and a goal to install 1,940 MW of new solar generation capacity. (Go Solar California, n.d.) The CSI program is funded by electric ratepayers, and overseen by the California Public Utilities Commission.

The CSI Program pays solar customers an incentive that is based on system performance – either an upfront payment based on expected performance, which is the Expected Performance-Based Buydown (EPBB) that is only available for smaller systems, or a monthly payment based on actual performance over five years, known as Performance Based Incentive (PBI).

SCE, which is Santa Monica's electricity provider, administers the CSI rebate under its self-generation incentive program (SGIP). However, its residential goal under the CSI has been exceeded and the program is now closed.

THIRD PARTY OWNERSHIP

The use of third-party-ownership (TPO) structures has grown tremendously in the US, dominating 65% of the PV market in 2013, compared to just an estimated 10-20% several years earlier in 2009. (Davidson, 2015)

In a solar leasing contract, the leasing company undertakes all responsibility of purchasing, installing and maintaining the solar PV system on the customer's roof, which they then lease out to the customer. The customer agrees to pay a specified amount every month to the leasing company over an extended period of time, normally about 20 years, at the end of which ownership of the system is handed back to them.

During this period the lessee consumes electricity from both the PV system and the grid. This arrangement is made economical for the lessees by the fact that, typically, the monthly leasing fees and grid electricity consumption costs combined are lower than what they were initially paying to the utilities for grid electricity alone. In return, lessees forgo all the benefits from incentives such those introduced above to the leasing company, which constitute their business revenue.

Third party solar leasing provides an attractive alternative for consumers who prefer a low down payment option, or do not want to assume risks associated with the solar PV system, since the monthly lease payments are fixed regardless of the system's energy production. Since the high initial investment required and variability in the amount of energy generated by solar PV systems are major limitations to the popularity of solar DG, eliminating these considerations for the customer has been key to the success of solar leasing companies.

SOLAR DG IN SANTA MONICA

Current levels of rooftop solar in Santa Monica

As of 2014, the City of Santa Monica has a total of 4.53 MW of solar capacity installed. The breakdown of installed solar capacity between property types is shown in the Table 22.

Table 19: Breakdown of installed rooftop solar capacity by property type in Santa Monica.

CITY-WIDE TOTAL kW AC
4525.74
TOTAL Residential kW AC (539 sites)
2045.24
TOTAL Institutional kW AC (9 sites)
882.92
TOTAL Commercial kW AC (37 Sites)
1087.43
TOTAL Municipal kW AC (7 sites)
431.06

Potential for rooftop solar

Based upon an analysis prepared by the UCLA Luskin Center for Innovation (DeShazo, Matulka & Wong, 2011), Santa Monica has a theoretical solar potential output of 383,300 MWh, assuming all available roof space in the city is utilized for solar PV installations, Table 23. This translates to 46.3% of the city's annual electricity needs as of 2013,which serves to illustrate the solar potential of the city.

Table 20: Solar output in Annual kWh in Santa Monica by property type.

Use Type	Output in Annual kWh
Commercial	**96,783,248**
Government	**30,241,338**
Industrial	**37,081,481**
Institutional	**7,409,174**
Recreational	**2,259,883**
Residential	**205,929,622**
Other	**3,594,923**
Grand Total	**383,299,669**

SOLAR SANTA MONICA

The Solar Santa Monica program was established by the City of Santa Monica in late 2006 to fulfill its commitment to the Community Energy Independence Initiative that called for electricity self-sufficiency by 2020, which would require nearly 150 MW of distributed generation. (Solar Santa Monica 2009) The mission of Solar Santa Monica is "to accelerate the uptake of solar energy in Santa Monica coupled with robust energy efficiency".

The Solar Santa Monica program has focused on advocating solar and educating the public on smart energy management, by providing support and resources including bid comparisons. In 2008, the program added the Preferred Contractors Network and worked with a limited number of contractors, who were selected through a bidding process, and worked with fixed pricing, thus setting low prices for the market. In early 2009, the preferred contractor status was opened to all qualified contractors, which fit the program's requirements, and Solar Santa Monica encouraged residents to select from the list while providing free bid comparison services. (Solar Santa Monica 2010)

Within the first year of the program's inception, total solar PV capacity doubled in Santa Monica, rising from 350kW to 700kW in 2007. In the year 2009, a further 552kW of solar capacity was installed. (Solar Santa Monica 2010)

In late 2008, Solar Santa Monica began its Top 100 Roofs Campaign, an aggressive marketing and outreach program targeted at the city's largest commercial roofs. A database of these roofs was established while their solar potential was estimated. Findings included over 120 properties which have an estimated solar potential of over 10,000 kW, and that the city-wide potential for parking lot solar is 40 MW. (Solar Santa Monica 2009)

Solar Santa Monica also worked on policy initiatives. In 2008, Solar Santa Monica introduced legislation in Sacramento for a solar feed-in tariff for California cities. The 2009 Solar Cities Act was written by Solar Santa Monica, and introduced as senate bill SB 523, which "would require Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas and Electric Company, to enter into agreements to purchase all of the electricity generated by the owner or operator of a solar energy generation facility located within the territory served by that electrical corporation at specified prices using a contract developed by the commission, as provided." and is "limited to the City of Santa Monica and other pilot cities to be selected by the commission." (California Legislative Information, 2009) It called for a 5% return after taxes for apartment building owners and multi-metered buildings, which was intended to help alleviate the "owner-tenant paradox", where neither the owners nor tenants of a building have any incentive to invest in solar PV. (Solar Santa Monica 2010) However, the FiT pilot program did not take off.

Due to budget cuts and the fact that finding a solar provider has become much easier, the city is no longer proactively pursuing the Solar Santa Monica program.

FEED-IN TARIFF

Introduction to Feed-in Tariffs

Feed-in tariffs (often referred to as "FITs") are designed to incentivize the creation of and purchase the power output from small-scale renewable energy projects. They are specific policy mechanisms in which governments, public utilities, or community choice aggregation entities may reimburse individuals for their production of renewable energy from electricity. These are designed to encourage the investment and distribution of decarbonized electricity, and have become utilized in Germany as well as the United States (most notably in Californian community choice aggregation frameworks).

Germany: Case Study of the German Feed-in Tariff

Introduction to Germany's FiT and Solar PV Growth

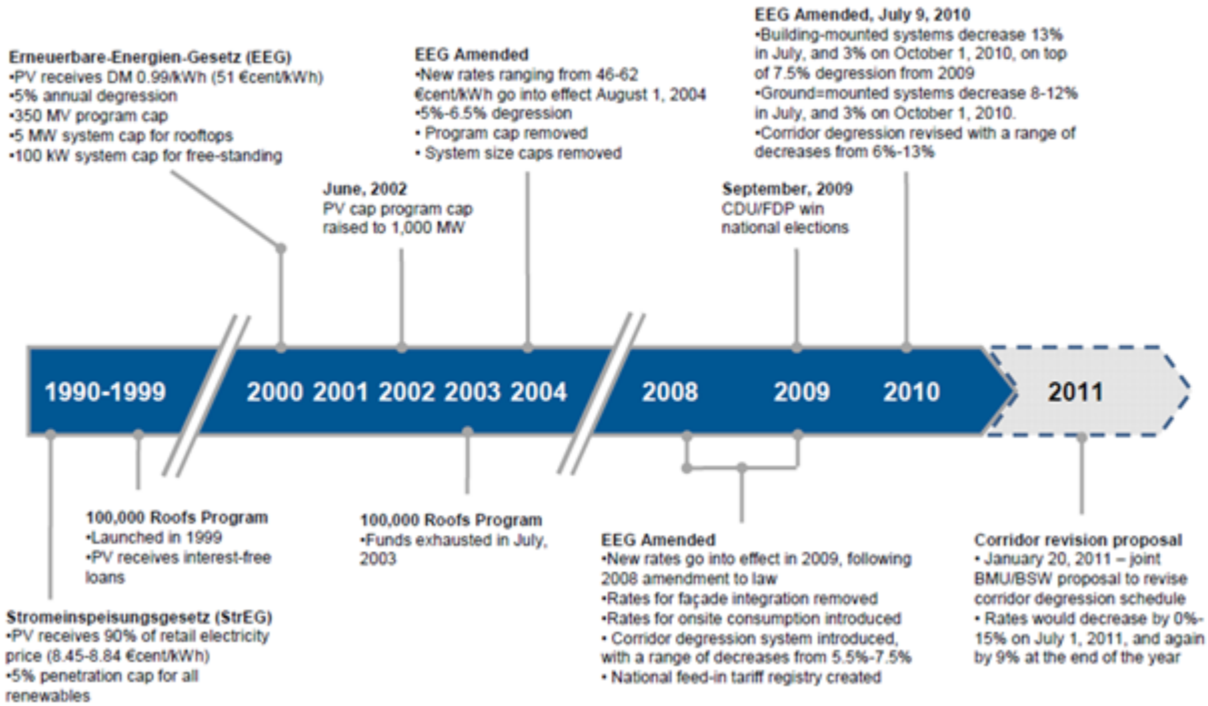


Figure 30: History of German solar PV policy (Fulton & Mellquist, 2011).

Germany initiated a national feed-in tariff for PV in 2000 under its renewable energy policy, the Erneuerbare-Energien-Gesetz (EEG). Since then, it has rapidly become the world's dominant solar energy player. In the following decade, Germany installed some 43 GW of renewables (17% of electricity production), while solar PV capacity surged from 32 MW in 1999 to 17,320 MW in 2010, making Germany by far the world's largest market for solar cells. (Huenteler, 2010) Employment in the PV sector nearly tripled in single year, from 2003 to 2004, in conjunction with the amendment of the FiT during that period.

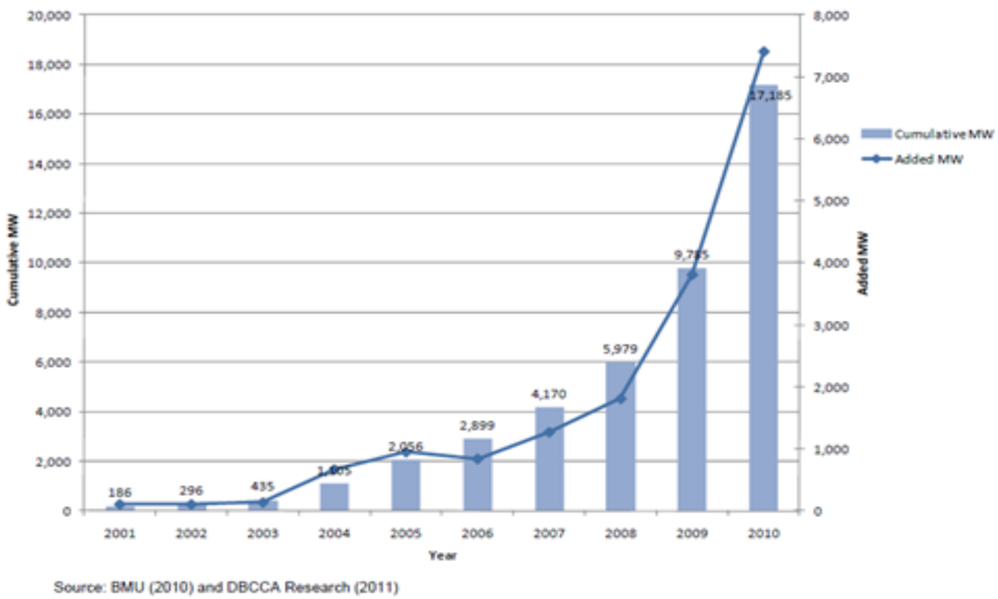


Figure 31: Installed solar PV capacity in Germany annually from 2001-2010. (Fulton & Mellquist, 2011).

In 2014, total power generated by PVs in Germany was 35.2 TWh, which covered approximately 6.9% of Germany's net electricity consumption. Renewable energy as a whole accounted for 31% of net electricity consumption. PV power was able to cover 35% of instantaneous electricity demand on some sunny weekdays, and up to 50% on weekends, Figure 39.

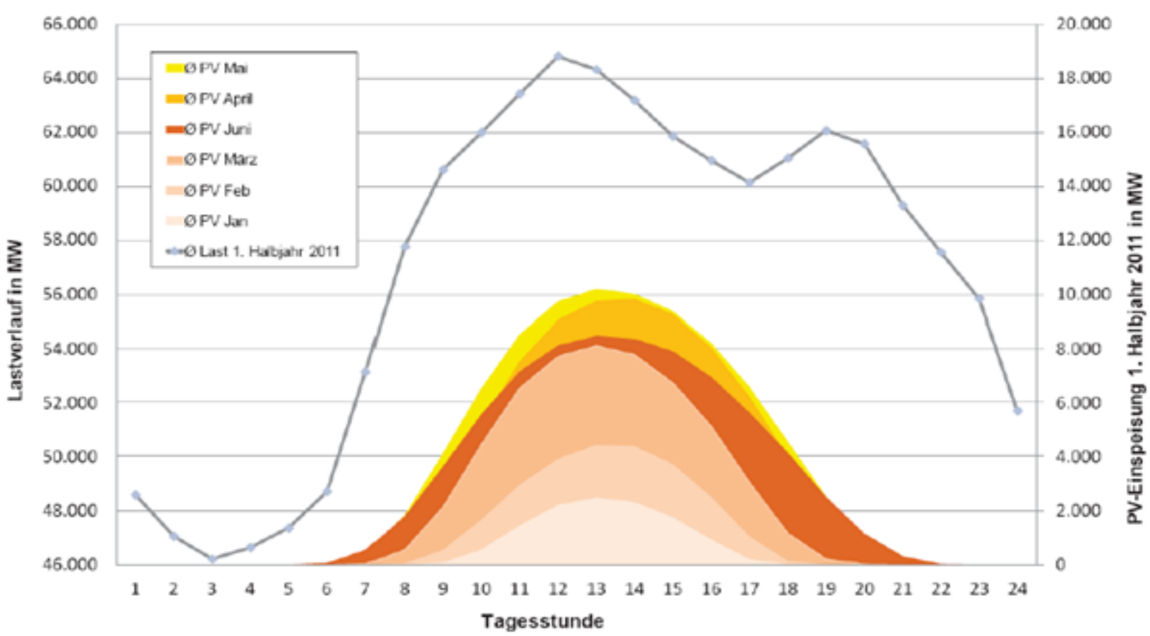


Figure 32: Average daily load profiles and PV feed-in profiles by month in the first half of 2011. (Fraunhofer, 2015).

Design of the German Feed-in Tariff

The EEG stipulates the amount of feed-in tariff and grants priority to solar PV generation, in order to provide investors with reasonable investment returns. In March 2015, plants going into operation receive between 8.65 and 12.50 €-cts/kWh for at least 90 % of the total electricity they produce over the following 20 years. (Fraunhofer 2015)

The PV tariffs are not directly revised, but have an in-built gradual degression that is flexible in nature. For example, if the overall newly installed capacity in a particular year exceeds a certain amount, the degression is raised by x%, and if it falls short it is lowered by y%. The growth corridor which was amended in 2010 stipulates a tariff reduction of 1/ 2/ 3/ 4% if an amount of 3500/ 4500/ 5500/ 6500 MW per year is exceeded. (Fraunhofer 2010) The benefits of such a degression include its high degree of transparency and response to market developments.

The cost calculation methodology (CCM) for Germany's feed-in tariff is based upon the actual cost of renewable energy generation, plus a subsidy for production and a reasonable rate of return. It accounts for the initial construction costs, obtaining licensing and permits, inflation, operation and maintenance, costs of consulting and commissioning, among other inputs. (Burgie & Crandall, 2009) An annuity calculation model is then used to determine the average annual payments needed for the generation system to be profitable, and converts this into a price-per-kilowatt hour that is paid to the generator.

Germany's FiT costs are ultimately borne by the electricity ratepayer, via increased rates to consumers. The EEG surcharge compensates for the difference between the tariff remunerations and the revenues from the generation of the renewable energy. The EEG surcharge amounted to 6.24 €-cts/kWh in 2014, less than half of which, or 2.54 €-cts/kWh, is directly attributable to the renewable energy incentives (Fraunhofer 2015). Excluding external costs, 55% of the EEG surcharge in 2013 was allocated to PV power generation, or 1.40 €-cts/kWh. For scale, a typical three-person household with an annual power consumption of 3,500 kWh paid roughly 29 €-cts/kWh for electricity in 2014. (Fraunhofer 2015)

However, unlike other EU countries like France and Slovenia which distribute the burden proportionately to all ratepayers, Germany has divided support levels, to protect the competitiveness of energy-intensive industries. Certain industries, in particular the metal, chemical and paper industries, receive benefits of reduced rates. (Burgie & Crandall, 2009) Companies with electricity consumption exceeding 10 GWh or whose electricity costs exceed 15% of their gross value added are only required to pay 0.05 €cts/kWh. Those companies whose electricity consumption exceed 100MWh and 20% of their gross value added are exempt from paying fees towards the FiT. Industries are to be relieved of costs totaling an estimated €5.1bil in 2014. (Fraunhofer, 2015)

Maintaining Grid Stability through Technology

The current German grid comprises of a transit grid and a distribution grid. The transit grid consists of approximately 35,000 kilometers of 220 and 380 kV lines; it operates at a high-voltage level and connects Germany to its neighbors, transporting power across long distances. The distribution grid consisting of about 80,000 kilometers of high-voltage lines (60 to 110 kV) for conglomerations and large-scale industry, about 500,000 kilometers of medium-voltage lines (6 to 30 kV) for large facilities, and about 1,100,000 kilometers of low-voltage lines (230 and 400 V) for households and small businesses. (Morris, 2012)

More than 98% of Germany's PV power plants are located in close proximity to customers and connected to a decentralized low-voltage grid. 85% are less than 1MW in capacity. (Fraunhofer, 2015) During sunny days when power generation exceeds consumption on the low-voltage grid, transformers feed power back into the medium voltage grid. Large PV power plants or a local accumulation of smaller plants in sparsely populated regions require that the distribution network and transformer stations be reinforced at certain sites; an equal distribution of PV installations across all of the grid sections reduces the need to expand the grid.

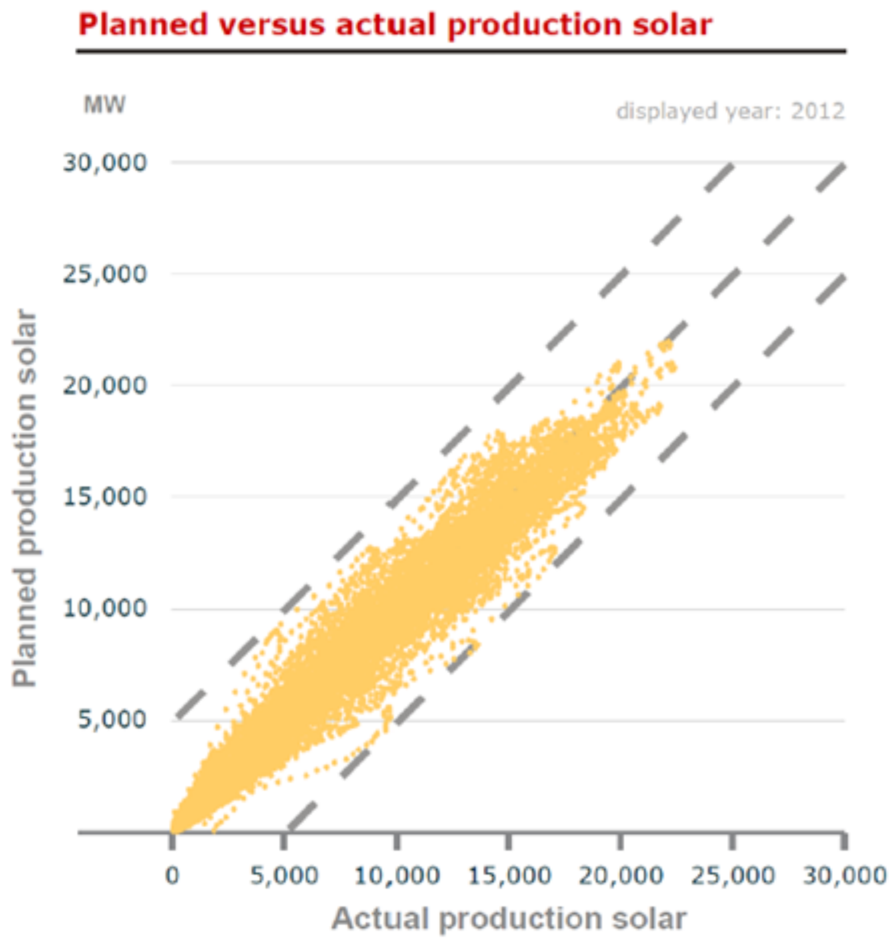


Figure 33: Actual and predicted production of solar power in 2012 (Fraunhofer, 2015).

Reliable national weather forecasts has enabled Germany to accurately predict the generation of solar power, which along with the decentralization of PV power generation, means that it is not usually possible for cloud cover changes to cause serious fluctuations in power production.

One of the simplest ways to help maintain the amount of PV power on the grid at a constant level is to install PV modules in an orientation which provide a more constant power output through the day. In Germany, PV modules installed with an east/west orientation result in lower annual yields per module compared with south orientation, but also provided longer-lasting daily peaks in PV feed-in, which means that complementary power plants do not have to be mobilized until the late afternoon. Single and dual-axis tracking systems are an even more effective alternative, providing this consistency while also increasing annual yield by 15 to 35%. (Fraunhofer, 2015)

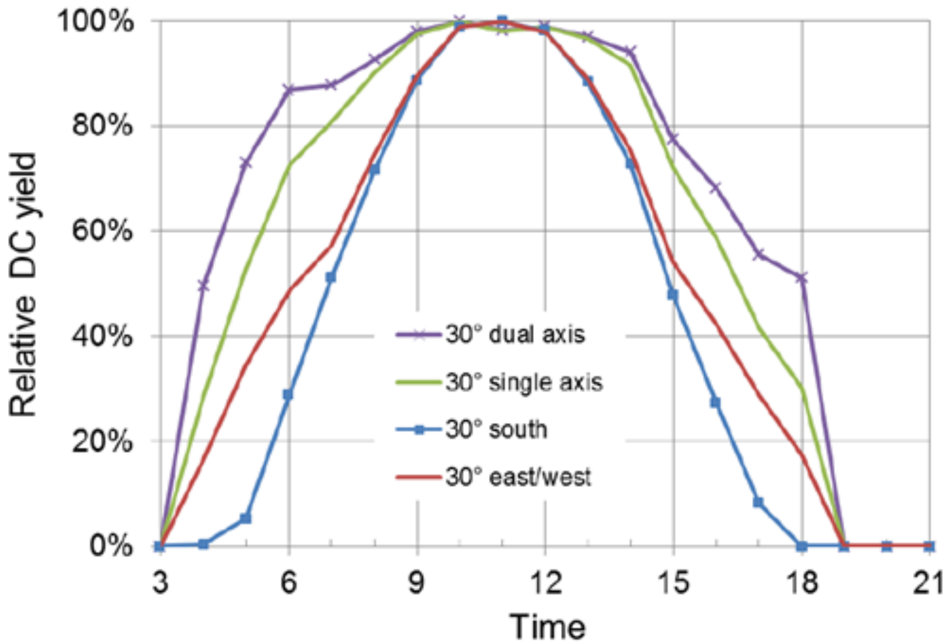


Figure 34: Yield development throughout the course of a day of PV plants installed in a variety of different ways, calculated using the software PVsol on a predominantly clear July day in Freiburg. (Fraunhofer, 2015).

Solar PV in Germany: Moving Forward

Large-scale plants installed in 2011 had achieved grid parity, while since the beginning of 2012, newly-installed, small rooftop installations also achieved grid parity. As the feed-in tariff continues to drop below the gross domestic electricity price, the average feed-in tariff for PV will also approach grid parity.

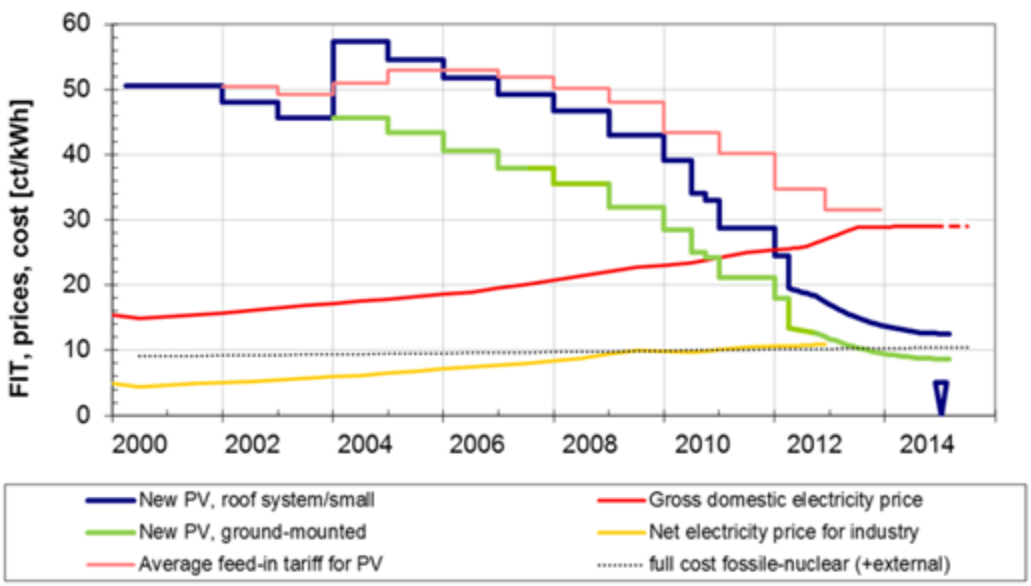


Figure 35: Feed-in tariff for PV power as a function of commissioning date and electricity prices (Fraunhofer, 2015).

Germany's National Renewable Energy Action Plan (NREAP) has proposed trajectories of expected development of solar PV in Germany through this decade, Figure 43. From the graph, we can see that the projected annual additions for PV peaks in 2010 at 6000 MW, then contracts and plateaus at 3500 MW per annum through 2020, by which time a total of 51,753 MW of capacity is expected to be installed in Germany. (Fulton & Mellquist, 2011)

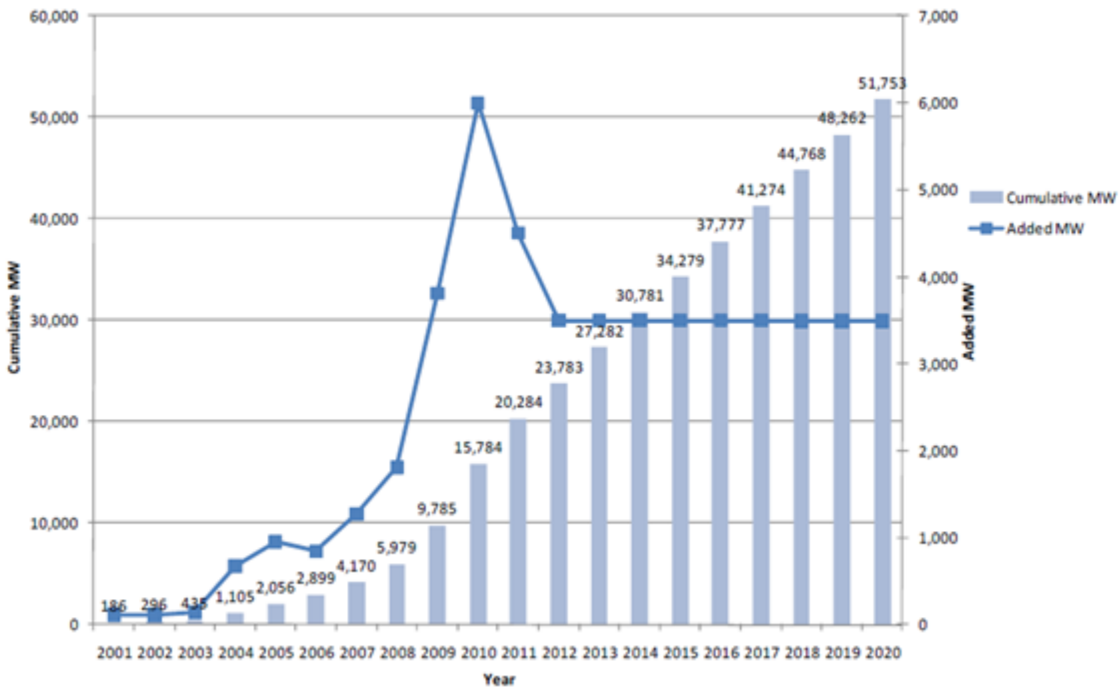


Figure 36: Cumulative installed capacity and projected annual added capacity of solar PV from 2001 to 2020 (Fulton & Mellquist, 2011).

RECOMMENDATIONS

IMPLEMENTATION OF CCA WITH SOUTH BAY CLEAN POWER

The city of Santa Monica should pursue community choice aggregation by joining the Joint Powers Authority presented by the South Bay Clean Power group. South Bay Clean Power has shown progress and initiative in recruiting multiple cities by passing feasibility studies with city governments. Additionally, a CCA through South Bay would provide an opportunity to adequately split the financial charges of running a CCA among the cities. The CCA should be modeled after Marin Clean Energy and Sonoma Clean Power. Specifically, this would mean setting rates to be competitive with Southern California Edison and provide differing percentage options for renewable energy.

INTRODUCTION OF A FEED-IN-TARIFF FOR SOLAR DISTRIBUTED GENERATION

The City should pursue a feed-in-tariff as an incentive to encourage the growth of solar DG in Santa Monica. The City may fund this FiT using revenue generated from the CCA, for example by following Germany's example and including a surcharge in its electricity rates specifically to fund the FiT. Using estimates based off Germany's solar PV generation growth after the implementation of their FiT and scaling it to Santa Monica's scenario, we can expect about 130 MW of additional installed solar PV capacity by 2050, assuming the FiT is implemented in 2020. This translates to a total of about 236 GWh of clean, emissions-free electricity generated annually in 2050, or about 28.5% of the city's 2013 electricity consumption (Southern California Edison 2014).

WATER

http://info.waterdesignbuild.com/blog/bid/320943/Project-Spotlight-Charnock-Well-Field-Restoration

WATER

INTRODUCTION

All water supplies require energy to pump, treat, and distribute. Differences arise in the varying types of processes required for pumping, treating, and distributing to meet standards of different uses. In addition, the amount of energy required for a unit of water "varies with location, source, and use within the state" (Wilkinson, 2007). In California, the areas of greatest demand are not in the region where water supply occurs. In Southern California, much of the water used is pumped from hundreds of miles away. Northern California receives 75% of the state's precipitation, while 75% of the state's population, representing water demand, is located in Southern California (LAO, 2013). Though water demand is expected to decrease as a result of conservation efforts, California's growing population will give rise to greater demands in the future. With California facing its fourth year in drought, Southern California cities such as Santa Monica, are growing concerned with water reliability and whether imported water from Northern California and the Colorado River will continue to meet growing demands. As a result of the unreliability in depending of imported water sources, Santa Monica has been making strides towards water self-sufficiency with its 2010 Urban Water Management Plan and 2014 Sustainable Water Master Plan.

STATEWIDE WATER USE

Water has long posed a challenge for California given the North to South discrepancy in water supply and use, and the thirsty San Joaquin Valley agricultural sector in between. Water not dedicated to environmental purposes is divided between agriculture and urban areas, including residential and commercial users. Below are charts showing the freshwater use in California, Figure 44, and water use in Southern California, Figure 45. Residential and commercial landscaping accounts for roughly half of state urban water use (Mount, Freeman, & Lund, 2014). However, in Southern California about 54% of the water consumption is attributed to urban residential use (Cohen, 2009).

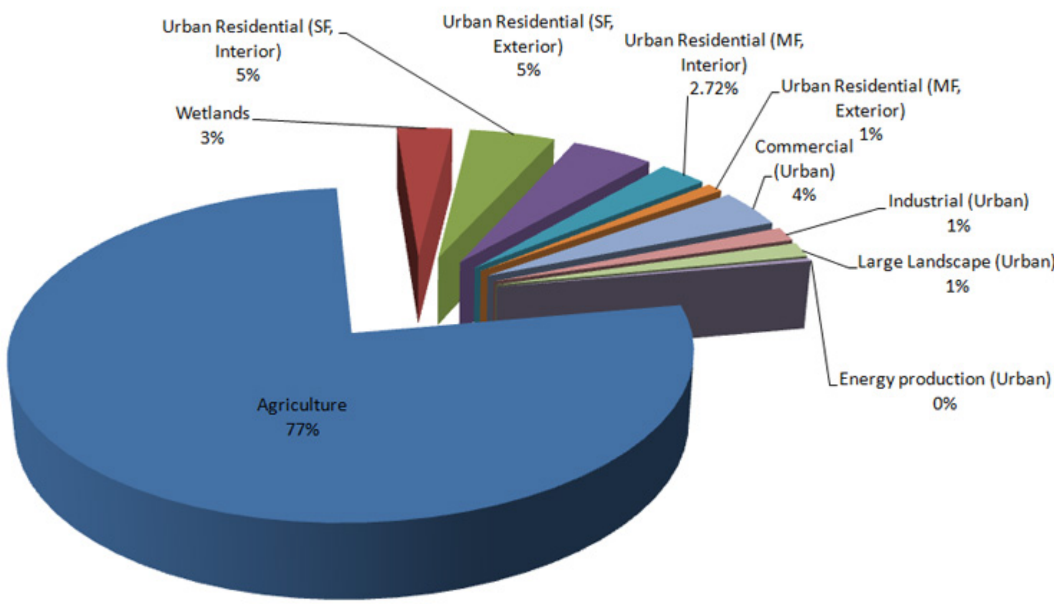


Figure 37: Freshwater use in California, Note: MF - Multifamily, SF - Single Family (Cohen, 2009).

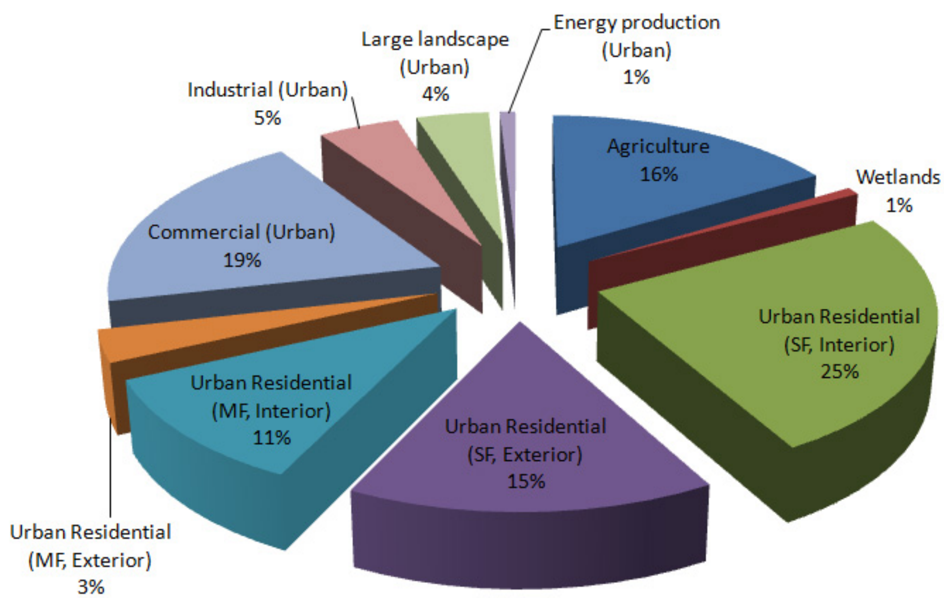


Figure 38: Water use distribution in California's South Coast Hydrologic Region (Cohen, 2009).

Water use varies by region and annual and seasonal climate. Figure 46 articulates the differences in water use by region. Due to less landscape water, "coastal regions use far less water per capita than inland regions—145 gallons per day compared with 276 gallons per day in 2010" (Mount, Freeman, & Lund, 2014). California is currently experiencing its fourth dry year in a row and water sources are now crucially important to the Golden State.

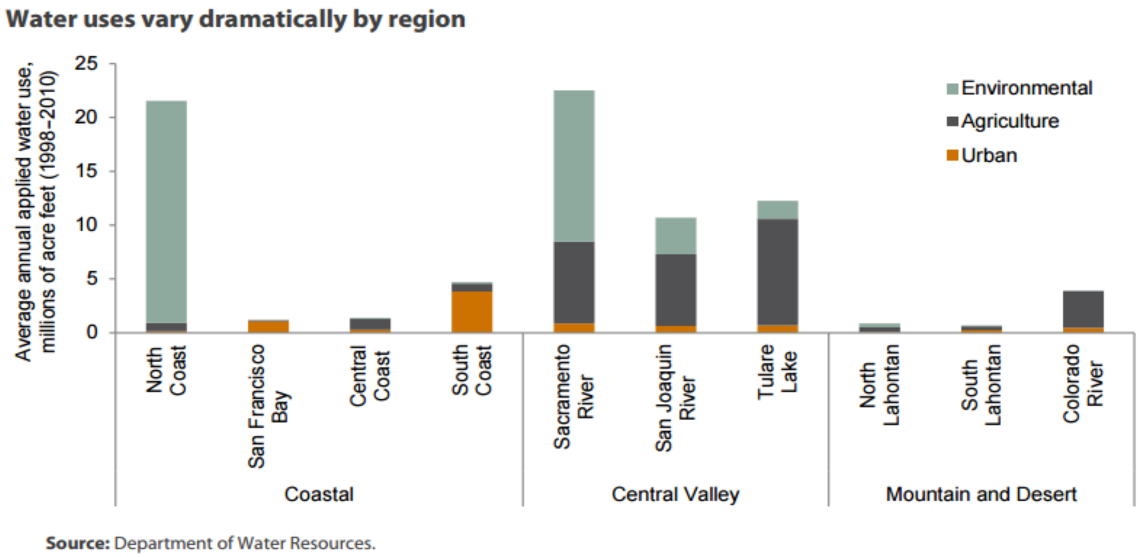


Figure 39: "Water Uses Vary Dramatically by Region" (Mount, Freeman, & Lund, 2014).

Given California's current drought, further stressed by Governor Brown's first ever 25% statewide water cut executive order on April 1 of 2015, water is a topic that demands municipalities' attention (Brown, 2015). Although water use varies by region, they usually share the same source of water- MWD water coming from the State Water Project via the California Aqueduct and the Colorado River via the Colorado River Aqueduct. With the disappearance of these water sources from the drought and an ever-growing population, cities are forced to conserve greatly and become more self-reliant for water.

WATER-ENERGY NEXUS

Another climate-related water challenge is the water-energy nexus. Water requires a lot of energy and making energy requires a lot of water. For Californian municipalities, 56% of energy usage is attributed to water and wastewater treatment plants (CEC, 2014). Energy is needed to pump, treat, distribute, heat, cool, collect once it becomes wastewater, treat to certain standards, and eventually discharged or delivered as recycled water. Below, Figure 47 delineates the range of energy intensities for water use cycle segments, as one can see water supply and conveyance and treatment rank high on energy intensity.

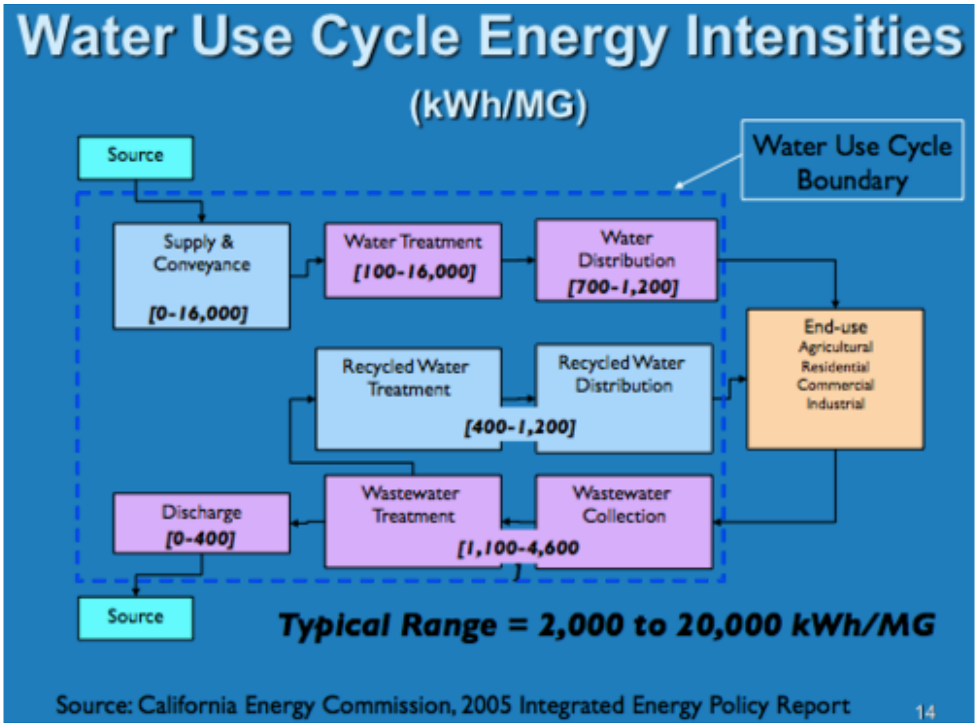


Figure 40: "Water Use Cycle Energy Intensities" within cold water boundaries.

Table 21: Range of Energy Intensities for Water Use Cycle Segments (Klein & Krebs, 2005).

Table 1-2: Range of Energy Intensities for Water Use Cycle Segments

	Range of Energy Intensity kWh/MG	
Water-Use Cycle Segments	**Low**	**High**
Water Supply and Conveyance	0	14,000
Water Treatment	100	16,000
Water Distribution	700	1,200
Wastewater Collection and Treatment	1,100	4,600
Wastewater Discharge	0	400
Recycled Water Treatment and Distribution	400	1,200

Ranges are "determined primarily by the volume of water that is transported, the distance, and the changes in topography along its route."(Klein & Krebs, 2005). When comparing Northern and Southern California, range differences are even more accentuated since Southern California's water supply is more energy intensive than Northern California. Southern California imports half of its water supplies from the Colorado River and State Water Project, therefore its conveyance requires more than 50 times the energy than for Northern California, which is also five times the national average. (Klein & Krebs, 2005)

Water-related energy production releases GHGs into the atmosphere through the use of electricity, natural gas, and diesel fuel. In 2001, as listed in Table 25, water-related energy use was 19% of electricity use, 32% natural gas use, and 88 billion gallons of diesel fuel in California. Upon further examination, of the 19% electricity and 32% natural gas use in California, the residential sectors accounts for 48% of those two values associated with urban water use (Klein & Krebs, 2005). Cities and water agencies can reduce GHG emissions by becoming more energy and water efficient, or by using zero-emissions sources of energy.

Table 22: Water related energy use in California in 2001(Klein & Krebs, 2005).

	Electricity (GWh)	Natural Gas (Million Therms)	Diesel (Million Gallons)
Water Supply and Treatment			
Urban	7,554	19	?
Agricultural	3,188		
End Uses			
Agricultural	7,372	18	88
Residential	27,887	4,220	?
Commercial			
Industrial			
Wastewater Treatment	2,012	27	?
Total Water Related Energy Use	**48,012**	**4,284**	**88**
Total California Energy Use	**250,494**	**13,571**	?
Percent	**19%**	**32%**	?

Source: California Energy Commission

SANTA MONICA'S CURRENT STRATEGIES

URBAN WATER MANAGEMENT PLAN 2010

Santa Monica prepared its Urban Water Management Plan in 2010 in compliance with the Urban Water Management Planning Act as part of the California Water Code, often referred to as Senate Bill x7-7 (SBx7-7, year). According to the Act, "per capita water use within an urban water supplier's service area must decrease by 20% by the year 2020 in order to receive grants or loans administered by DWR (Department of Water Resources)." The City of Santa Monica plans to meet this requirement while implementing plans to become water self-sufficient by 2020.

Santa Monica's water comes from the Metropolitan Water District (MWD), local groundwater extracted from the Santa Monica Basin, and recycled water from Santa Monica Urban Runoff Recycling Facility (SMURRF).

The groundwater of the Santa Monica Basin is "replenished by percolation from precipitation… and by surface runoff from the Santa Monica Mountains" (SA Associates, 2010). Santa Monica has five wells within city boundaries, two in Arcadia and three in Olympic, and five wells outside city boundaries in Charnock. The majority of groundwater produced comes from the five wells located in Charnock, with a combined capacity of 6,000 AFY (acre feet per year), 73% of the total groundwater production capacity. Other wells currently operate below their rated capacity. The Arcadia and Olympic wells have the ability to produce 3,000 AFY, but they are responsible for approximately 1,950 AFY (Pastucha, 2014). With the ten groundwater wells operating at full capacity, Santa Monica should have 9,000 AFY, yet the City has a long-term average volume of 4,277 AFY (Pastucha, 2014).

Santa Monica Urban Runoff Recycling Facility (SMURRF) was built to "eliminate the Santa Monica Bay contamination caused by urban runoff and to provide cost for effective producing treatment high-in reuse landscape for quality water indoor and irrigation plumbing "(SA Associates, 2010). SMURRF has a maximum production capacity of 840 AFY, but has been operating at 20%capacity in the past five years (SA Associates, 2010). Currently, 85 AFY of recycled water from SMURRF is received by "commercial/institutional users receiving recycled water for indoor use through a dual-plumbed system" and serves "parks, medians, Woodlawn Cemetery, and dual plumbed buildings." The city does not have a wastewater treatment plant, therefore SMURRF is the only source of recycled water supply (Pastucha, 2013).

The Metropolitan Water District (MWD) receives its water from the Sacramento and San Joaquin Rivers, as part of the State Water Project, and the Colorado River Aqueduct. These sources are imported from hundreds of miles away, 700 miles of open canals and pipelines for the SWP and 242 miles of aqueduct for the CRA (Metropolitan Water District of Southern California, 2015). The City plans to maximize local sources while minimizing imported MWD water sources.

SUSTAINABLE WATER MASTER PLAN (SWMP) 2014

In accordance with the 2010 Urban Water Management Plan and the Sustainable City Plan, the goal of Santa Monica's Sustainable Water Master Plan (SWMP) is to achieve water self-sufficiency by 2020 with a multi-faceted approach. The City has the capability to meet "approximately 70% of its water demand from local groundwater sources" (Pastucha, 2013). In order to achieve 100% sustainability, Santa Monica has to "close the gap" so it does not have to depend on purchases of imported water. The current local water supply is at 9,000 AFY with SMURRF and groundwater. After further analysis of future demand, economic, and weather projections, it was determined that the City needs 6,500 AFY to "close the gap" by 2020, which is a much higher value than the initial estimate of 3,700 AF (Pastucha, 2014). The SWMP includes "recycled water, storm water collection and treatment, rainwater harvesting, gray-water applications, and other water rights, supply and exchange opportunities to align with the above goal" (Pastucha, 2014). Below is a line chart illustrating the three different options Santa Monica plans to use to "close the gap" of 6,500 AF, the City is following Option 1.

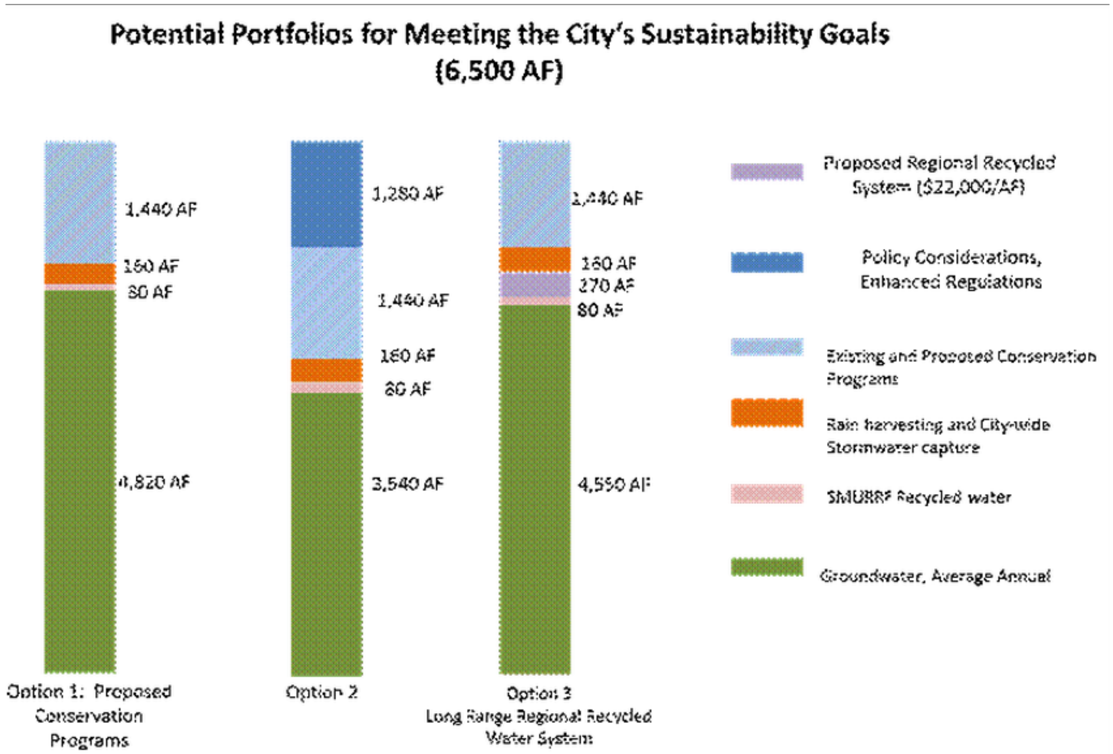


Figure 41: Potential portfolios for meeting Santa Monica's sustainability goals (6,500 AF) (Pastucha, 2014b).

In the SWMP 2013 update, the City chose to pursue a "combination of water conservation programs, additional local groundwater production, and additional supplies from rainwater harvesting and City-wide stormwater capture" to reduce water usage to 135 gallons per capita per day in 2020. The selected option falls short of the city's water use reduction target adopted in the 2010 Urban Water Management Plan (123 GPCD) (Pastucha, 2013), but was recommended to avoid high costs for home, business owners, and the City.

To fund the implementation of the SWMP and reach self-sufficiency, the water rate will increase by 9% annually for five years. The 9% increase, approved in lieu of a 13% increase seen as more extreme, will "place additional vulnerability on fund reserves and debt financing capabilities in later years of the projection" (Kennedy/Jenks Consultants, 2015).

LEADING GLOBAL CITIES

Leading cities in water self-sufficiency may not necessarily be leading cities in GHG emissions, GHG goals are usually sacrificed for water independence. Below is a Figure 49 showing the different electricity demands per unit water of different water treatments using global cities' data. On-site non-potable reclamation and Reverse Osmosis desalination of seawater rank among the highest of energy intensities, while conventional treatment, local rainwater collection, and indirect potable reclamation are on the lower end of energy demands. These values do not include delivery and conveyance of the water post treatment, which may have a significant impact on total energy intensity of water.

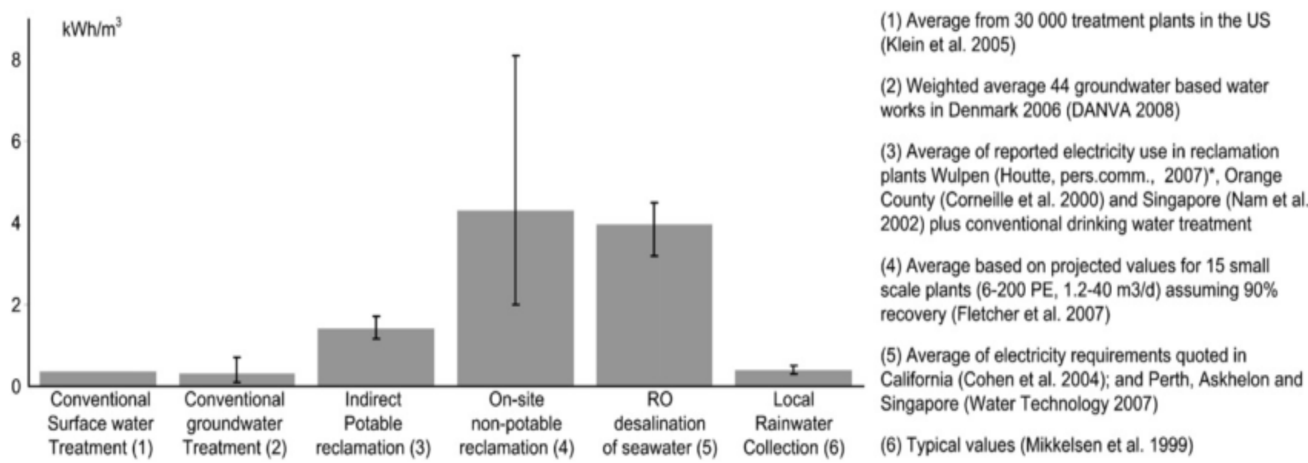


Figure 42: Electricity demand per unit water produced before distribution with minimum and maximum values indicated (Rygaard, Binning, & Albrechtsen, 2011).

BERLIN

Berlin has been able to reach 70% water self-sufficiency mainly from its indirect unplanned potable reclamation system, "where supply is based on water discharged by upstream users" in an unplanned manner. Its water-supply system is "entirely based on local groundwater abstraction replaced by riverwater", which is sourced from treated wastewater (Rygaard, Binning, & Albrechtsen, 2011). Berlin's water system is able to provide for environmental needs of the river while providing for indirect potable use. Berlin uses bank filtration in conjunction with wastewater reclamation, green roofs, sustainable water management, and demand management (Salian & Anton, 2011).

Berlin received federal subsidies for the investment in the wastewater reclamation system, in which the "riverbed/bank acts as a natural filter that removes most organic particles and pathogenic microorganisms"(Salian & Anton, 2011). Thus boosting the city's groundwater resources with wastewater reclamation and artificial aquifer recharge without having to exert additional energy for treatment the riverbed provides. The green roofs are roofs covered with "a layer of vegetation planted over a waterproofing membrane." The benefits of green roofs are absorbing rainwater thus delaying runoff, combatting the urban heat island effect, providing insulation, and increasing urban biodiversity with an increase in green space. Green roofs can indirectly decrease greenhouse gas emissions associated with the demand for air condition since green roofs are able to mitigate the urban heat island effect (EPA, n.d.).

Berlin started much earlier in developing water self-sufficiency due to the reliability issues it faced post World War II until reunification. California's current drought status is the perfect opportunity to educate and increase sensitivity to water use and self-sufficiency. Due to "Berlin's status as a national capital, federal state, and local government", it was fortunate enough to have high level financing available for water management, which may not be available to Santa Monica. The solution of "bank filtration in conjunction with wastewater reclamation" can be seen as a very optimistic goal. However optimistic, indirect potable reuse is a good direction for cities that wish to "close the water loop" and Santa Monica should consider the possibility of extending its recycled water usage in the present and future.

PIMPAMA-COOMEMRA

Pimpama-Coomera, Australia is able to reach 80% self-sufficiency with reuse (50%) and rainwater (30%). "Full integration of water demand management, wastewater reclamation, desalination and rainwater collection can provide self-sufficiencies as high as 80%, as seen in Pimpama-Coomera, Australia" (Rygaard, Binning, & Albrechtsen, 2011). Pimpama-Coomera's rainwater and wastewater reclamation is recycled to the highest non-potable standards for purple pipes of dual reticulated homes. The award-winning Pimpama Coomera Master Plan requires all new homes and businesses in the region of the Gold Coast to have "two separate pipe networks supplying their water. This means they are connected to both the potable (drinking) water network and the new Class A+ recycled water network." The Class A+ recycled water is for suburban environment and community activities such as "flushing toilets, watering gardens or washing cars from late 2008" (Pimpama Coomera Alliance, 2007). Below is a list of Class A+ recycled water uses and unsuitable uses.

CLASS A+ RECYCLED WATER CAN BE USED FOR:	CLASS A+ RECYCLED WATER SHOULD NOT BE USED FOR:
■ Toilet flushing ■ Garden watering and irrigation ■ Filling ornamental ponds ■ Car washing ■ Fire fighting ■ Construction and building purposes ■ Dust suppression ■ Irrigation of food crops ■ External household cleaning	■ Drinking ■ Cooking or other kitchen purposes ■ Personal washing ■ Evaporative coolers ■ Clothes washing

Figure 43: Class A+ recycled water uses (Pimpama Coomera Alliance, 2007).

In addition to mandating purple pipes in new development, the Plan also requires the installation of rainwater tanks for new homes and businesses so that they "connect rainwater to the cold water washing machine tap and an external tap" (Gold Coast Council, n.d.). The purpose is to reduce runoff of stormwater and the amount of drinking water used in and out of the home. The rainwater is used for the bathroom, laundry, gardens, pools, and hot water system such as showers and baths (Mertz, n.d.). With an electricity consumption below 1 kWh/m^3, rainwater collection is a low energy alternative to reclamation and desalination. Rainwater collection is similar to conventional treatment of local groundwater and surface water resources without the high energy costs associated with delivery (Rygaard, Binning, & Albrechtsen, 2011). However, in February 2015, installation of rainwater tanks became optional since a study showed costs of installation and maintenance are generally higher than water savings on bills. Pimpama-Coomera's focus is reducing the use of potable water for nonpotable uses. Even though rainwater tanks proved to be more costly than savings, mandated purple pipes and rainwater are still leading practices Santa Monica can refer to for water self-sufficiency.

WINDHOEK

The city of Windhoek can pride itself in being the only city in the world where large scale direct potable reuse (DPR) is practiced and has been since 1968 (Lahnsteiner & Lempert, 2007). Due to its geographical conditions, Namibia is one of the arid countries in the world and is made up of deserts and semi-deserts with uncertain rainfalls and severe droughts. In order to deal with shortages of potable water, Windhoek's choice was to reuse "municipal wastewater from the largest sewage treatment plant" in the city, which now produces 25% of the city's potable water demand. The New Goreangab Water Reclamation Plant (NGWRP) uses a "multiple barrier" approach including " powdered activated carbon (PAC) dosing, pre-oxidation and pre-ozonation, flash mixing, enhanced coagulation and flocculation, dissolved air flotation, dual media rapid gravity sand filtration, ozonation, BAC filtration, GAC filtration, ultra-filtration (UF), disinfection and stabilisation" (Lahnsteiner & Lempert, 2007). All of these procedures ensure the quality of the water is potable standards according to WHO guidelines, Rand Water Potable Water Quality Criteria, and Namibian Guidelines. The final product is blended with surface water and groundwater, which provides additional safety.

Direct potable water does not require additional pumping to an environmental buffer or aquifer, like indirect potable reuse, which presents an energy and greenhouse gas advantage for DPR product delivery (Khan, 2013). In fact, direct potable reuse does not require the large costs and energy required to build additional purple pipes and uses the existing water distribution infrastructure. Table 26 shows the cost benefits of potable reuse based on case study in Riverside. The costs associated with direct potable reuse are the energy required for advance treating the water to potable standards. Specific energetic costs are site specific when considering indirect and direct potable reuse.

Table 23: Cost benefits of potable reuse based on a City of Riverside case study (Smith, 2012).

Project	Miles of Pipe	Capital Cost ($millions)	Avg User Bill Increase[a] ($/month)
Purple Pipe	172	$550	$42
Potable Reuse	6	$95	$9

[a] Current average water bill:$35/month

To be able to implement the strict water conservation measures and allow direct potable reuse, a not very well accepted practice, Windhoek arranged "adequate education programmes in schools, radio and television, as well as in the printed media." The most effective program was including water awareness in the normal curriculum in schools. The inclusion of water awareness in the school curriculum could also be effective in Santa Monica and is a tactic the city should consider in order to raise acceptance and awareness of water plans the city hopes to apply.

In terms of demand management, Santa Monica has already increased water taxes, provided subsidies for water saving equipment, water saving programs, and reducing unaccounted for water. However, many water "self-sufficient" cities have citizens and governments that are highly aware and supportive of water savings and additional reuse programs, such as direct potable in Windhoek and indirect potable in Berlin and Pimpama Coomera, Australia is an example of a city that expanded its non-potable use of reclaimed water so far that the city is able to reach 80% water self-sufficiency without direct potable reuse. As seen in these cities, the answer is not always direct potable reuse, but a combination of many efforts contributes to water self-sufficiency.

RECOMMENDATIONS

OPPORTUNITIES

The preliminary recommendations in the Sustainable Water Master Plan (Pastucha, 2014) are for the expansion of the existing Arcadia(aka Bundy) Water Treatment Plant, construction of the new Olympic Water Treatment Plant (Gillette/Boeing Settlement Project), rehabilitation of old wells and drill additional new wells in the Olympic, Charnock and Coastal Sub- basins, and development and implementation of "improvements in treatment efficiency to reduce the amount of water lost to brine disposal (reduction of brine water losses from 18% to 9%)" during reverse osmosis treatment taking place at the Bundy/Arcadia plant for groundwater. Of the preliminary recommendations, the options that should be seriously considered in order to reach water self-sufficiency by 2020 are the addition of new groundwater wells and improvement in water treatment efficiency. Reasons will be provided in the 'Challenges" section for why other recommendations are not plausible for Santa Monica.

SMURRF Extension

Outside of the Sustainable Water Master Plan, an additional supply option Santa Monica is considering/implementing is extending SMURRF as a stormwater treatment plant and operating year round rather than only the dry urban runoff is currently treats. Since SMURRF does not have the capacity to treat the stormwater during rain events, the solution is storage. The idea is to store stormwater with large above and underground cisterns then bringing that water to SMURRF to treat when it has the capacity. Since SMURRF has only been operating on 20% of capacity and urban runoff is expected to decrease as a result of conservation measures, adding storage through cisterns is idea for Santa Monica, which has run out of space to build additional treatment plants.

For water storage, Santa Monica hopes to store brackish and storm water in under or above ground cisterns for any future projects as well as around the Pier, the new Pico Library at Virginia Avenue Park, multi-family building at 26th St and Broadway, and at Los Amigos Park (Shapiro, 2015). In addition to typical landscape use, the City can look to extend the use of recycled water for uses such as street cleaning and even have SMURRF perform reverse osmosis, thus extending possible uses of the recycled water by increasing the water quality.

More Groundwater Wells

The City plans to also expand its groundwater sources through the addition of groundwater wells. As mentioned, Santa Monica currently gets its groundwater from five wells within city boundaries and five wells outside city boundaries. The total average groundwater production treated at the Arcadia Water Treatment Plant from the ten wells is 9,000 AFY (Pastucha, 2014). However, this yield can be increased. In a 2010 Water Supply Assessment, it was determined that the City has a maximum sustainable groundwater production capacity of 12,400 AFY (SA Associates, 2010). And an additional study by Richard C. Slade and Associates, LLC (RCS) showed that "the City may have additional local groundwater opportunities within the Olympic, Charnock and Coastal Sub-basins" (Pastucha, 2014). More assessments must be performed on the potential sites to determine quality and quantity of groundwater, but there is great opportunity for Santa Monica in expanding groundwater to close the gap for water self-sufficiency.

CHALLENGES

Renewable Generation Challenges

Wastewater can be anaerobically digested (AD) to produce biosolids that generate biogas containing 50 to 80% methane. The methane rich biogas is captured and can generate renewable energy through a combined heat and power system (CHP) (Wong, 2011; Alternative Fuels Data Center, n.d). The wastewater biosolids can be further supplemented by additional organic waste streams, which increase energy inefficiency and generation potential (Wong, 2011). Presently, the possibility of wastewater-powered renewable energy generation is not an option within Santa Monica's borders since it would require operating a municipal wastewater treatment plant. However, municipal wastewater presents a great opportunity for lowering GHG emissions through renewable energy generation, especially when energy "contained within wastewater is ten times more energy than is necessary to treat that water" (Wong, 2011).

The Hyperion Wastewater Treatment Plant is able to generate energy from wastewater, but they are a culmination of multiple cities' wastewater rather than just one. Santa Monica's wastewater flow is averaged at 11 million gallons per day (MGD) (SA Associates, 2010) and that amount is delivered to Hyperion Wastewater Treatment Plant, where renewable energy can be generated. Hyperion receives an average daily flow of 362 MGD and has a 450 MGD capacity (LA City Sanitation, n.d.). The Hyperion Energy Recovery System generates energy using biogas from anaerobic digestion to fuel turbines and biosolid powder burned in a fluid bed gasification combustion chamber (Science Applications International Corporation, 1995). Even with a wastewater flow of 11 MGD, renewable energy can still be generated using anaerobic digestion (AD) technology and combined heat and power (CHP) (Wong, 2011).

Table 24: Santa Monica's Annual Potential Electricity Production from Methane Biogas Based on Daily Wastewater Flow of 11 MGD (EPA, n.da/b; Alternative Fuels Data Center, n.d; Washington Department of Ecology, n.d).

Low range (50%) of methane (m^3)	**High range (80%) of methane (m^3)**
2,420,361	3,872,577
BTU of Methane	BTU of Methane
86,722,000,000	138,760,000,000
MMBTU	**MMBUT**
86,722	138,760
Low range MMBTU converted to electricity (22% efficiency) using micro-turbine	
19,079	30,527
high range MMBTU converted to electricity (30% efficiency) using micro-turbine	
26,017	41,628
Low range of kWh	**High Range of kWh**
7,630,600	12,209,000

Santa Monica generates sufficient wastewater to create 86,722.25 MMBTU to 138,755.6 MMBTU of renewable natural gas in order to replace existing fossil natural gas used to generate 7,630,618.509 to 12,208,989.614 kWh of electricity per year. The wastewater can generate electricity or natural gas. Compared to the City's overall electricity consumption of 826,933,242 in 2013 and natural gas consumption of 2,859,078 MMBTU in 2011, the City's wastewater can provide for 0.9 to 1.5% of electricity consumption or 3% to 4.8% of natural gas consumption.

However, Santa Monica does not currently have a wastewater treatment plant, nor does it currently have sufficient undeveloped space to accommodate one. Unless Santa Monica partners with other adjacent cities for wastewater treatment, the opportunity of renewable energy through biogas generation is not present. However, if Santa Monica does partner with other cities to provide wastewater treatment, there is opportunity for Santa Monica to buy or claim renewable energy produced by wastewater treatment outside of its borders.

Additional Treatment Plants Challenges/ The infeasibility of additional treatment plants

The City dismissed the option of building new water treatment plans, such as the Olympic Water Treatment Plant, due to concerns over space, funding, and time. The Urban Water Master Plan states that the "City does not currently have the capability to construct a treatment facility within its limits" (SA Associates, 2010). In addition, "recycled wastewater within the City's service area for the next 25 years is uncertain as funding for infrastructure improvements are needed to distribute recycled water from Hyperion to the City." The City's top priority in terms of greenhouse gas emissions and water self-sufficiency is to reach each designated goal by 2020. Expanding recycled wastewater is a huge undertaking that would not be completed by 2020 even if the City had the funding or space so this option will not be elaborated in depth for the purposes of this report. However, it is important to note that, like Pimpama-Coomera and Berlin of the leading cities mentioned earlier, extending recycled wastewater production, use, and pipeage is an option Santa Monica can implement for the future if the City wants to reduce the use of potable water for non-potable uses.

Desalination Challenges

Desalination is an option available to coastal cities, and has been attractive for those desperate for new water sources. Santa Monica, as a coastal city, has the option of desalination. Australia built multiple desalination plants during a prolonged drought. Salinity of the water treated is positively correlated with energy use and GHG emissions. Brackish waters, which are more saline than freshwater but less saline than seawater, require less energy to treat. "Cities in the vicinity of brackish water resources, such as the Baltic Sea, coastal groundwater or estuaries can benefit from significantly lower desalination energy consumptions" (Rygaard, Binning, & Albrechtsen, 2011). Desalination of water with high salinity levels using fossil-based energy sources can increase greenhouse gas emissions, even while improving local water self-sufficiency. "Treating feed water with salinity of 15,000 mg/l instead of ocean water (36 000 mg/l) requires less energy, and the overall environmental life-cycle impact is reduced by almost 50%" (Rygaard, Binning, & Albrechtsen, 2011). Below are multiple charts of different hazards comparing brackish water and seawater that show the potential environmental risks associated with desalinization of seawater (Muñoz & Fernández-Alba, 2007).

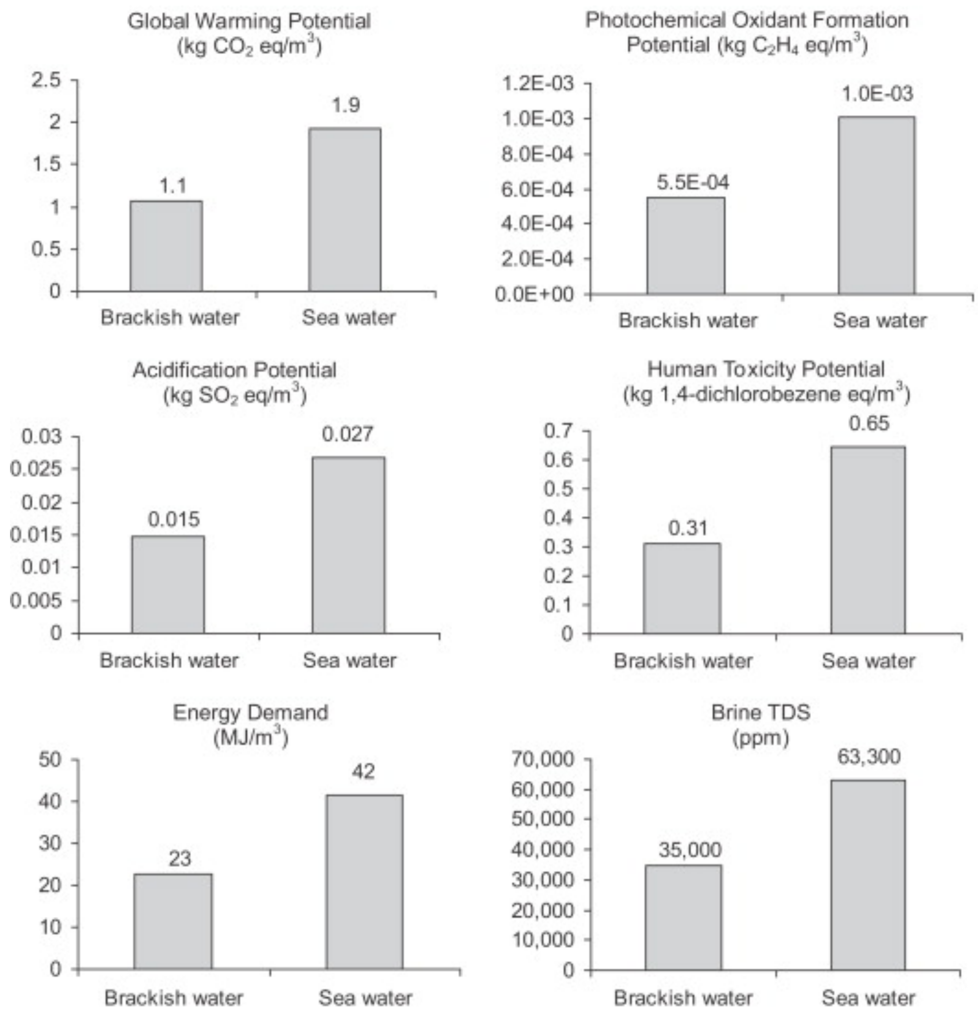


Figure 44: "Life-cycle impact assessment results for brackish groundwater and sea water desalination" (Muñoz & Fernández-Alba, 2007).

Treatment of brackish water is less environmentally harmful than seawater, in addition, other environmental life-cycle assessments have shown that "reclamation of wastewater is preferable to seawater desalination, because of the lower salinity of wastewater compared to seawater" (Rygaard, Binning, & Albrechtsen, 2011). Building a wastewater treatment plant, though not presently feasible, is more feasible and less energy intensive than a desalination plant, making it a better alternative. The idea of a desalination plant in Santa Monica may be tempting for the City to reach water self-sufficiency, but the energy required may prevent Santa Monica from reaching its GHG goals. However, it is mainly due to economics that the possibility of building and operating an oceanfront desalination plant is not present for Santa Monica.

GREENHOUSE GAS IMPACTS

GHG emissions exist directly and indirectly for almost every water source and recommendation. Below is a table of energy intensities associated with current and proposed water sources for the City of Santa Monica. These calculations are based on Santa Monica's electricity and water bills for 2012 and 2014. These values specific to Santa Monica, unless otherwise noted, include pumping, treatment, distribution, and all operational costs associated with the supply. The water supplies listed from greatest energy intensity to lowest: SMURRF requires 33,346.44 kWh/MG, imported water with conveyance and supply requires 9,050.52 kWh/MG, groundwater requires 4,142.67 kWh/MG, then imported without supply and conveyance requiring 215.63 kWh/MG. Energy intensity increases greatly when considering conveyance and treatment of the imported water.

The values listed above are of electricity needed per million gallon (MG), however the volume (MG) of water for each source differs. Therefore, the total GHG emitted per year for each source differs. The different energy requirements of Santa Monica's water supply are shown in Table 28. The volume of water treated for each source has a large impact on total energy expenditures and GHG emissions in a given year.-Santa Monica only produced 31.63 MG water from SMURRF in 2014 while it received 2,699 MG from groundwater in 2012 and imported 2,134 MG in 2012, with volume changing little between 2012 and 2014. Although SMURRF has the highest kWh/MG rate, in 2014, the total electricity use for operating SMURRF was only 1,054,748 kWh while groundwater and imported was 11,181,055 kW and 460,158 kW respectively in 2012. Annually, imported water has the greatest GHG impact, followed by groundwater, then SMURRF.

In a separate study conducted for West Basin Municipal Water District, the energy intensity of imported and local water supplies for potable and non-potable uses were examined. Based on the numbers from the West Basin report, desalination and imported water rank the highest energy intensities when including the amount of water along with the energy for treatment, conveyance, and distribution. Table 28 from the West Basin study shows the estimated energy required per year for an estimated amount of water per source.

Table 25: "Energy Intensity of Water Supplies for West Basin Municipal Water District."

Energy Intensity of Water Supplies for West Basin Municipal Water District

	af/yr	Percentage of Total Source Type	kWh/af Conveyance Pumping	kWh/af MWD Treatment	kWh/af Recycled Treatment	kWh/af Groundwater Pumping	kWh/af Groundwater Treatment	kWh/af Desalination	kWh/af WBMWD Distribution	Total kWh/af	Total kWh/year
Imported Deliveries											
State Water Project (SWP) [1]	57,559	43%	3,000	44	NA	NA	NA	NA	0	3,044	175,209,596
Colorado River Aqueduct (CRA) [1] (other that replenishment water)	76,300	57%	2,000	44	NA	NA	NA	NA	0	2,044	155,957,200
Groundwater[2]											
natural recharge	19,720	40%	NA	NA	NA	350	0	NA	0	350	6,902,030
replenished with (injected) SWP water [1]	9,367	19%	3,000	44	NA	350	0	NA	0	3,394	31,791,598
replenished with (injected) CRA water [1]	11,831	24%	2,000	44	NA	350	0	NA	0	2,394	28,323,432
replenished with (injected) recycled water	8,381	17%	205	0	790	350	0	NA	220	1,565	13,116,278
Recycled Water											
West Basin Treatment, Title 22	21,506	60%	205	NA	0	NA	NA	NA	285	490	10,537,940
West Basin Treatment, RO	14,337	40%	205	NA	790	NA	NA	NA	285	1,280	18,351,360
Ocean Desalination	20,000	100%	200	NA	NA	NA	NA	3,027	460	3,687	82,588,800

Notes:
NA Not applicable
1 Imported water based on percentage of CRA and SWP water MWD received, averaged over an 11-year period. Note that the figures for imports do not include an accounting for system losses due to evaporation and other factors. These losses clearly exist, and an estimate of 5% or more may be reasonable. The figures for imports above should therefore be understood to be conservative (that is, the actual energy intensity is in fact higher for imported supplies than indicated by the figures).
2 Groundwater values include entire basin, West Basin service area covers approximately 86% of the basin. Groundwater values are specific to aquifer characteristics, including depth, within the basin.

Saturday, I

West Basin's key findings include that "current ocean desalination technology is getting close to the level of energy intensity of imported supplies" with ever- improving desalinization technology and that "marginal energy required to treat and deliver water is among the least energy intensive supply options available" (Wilkinson, 2007). Examples in Spain and California show that planned desalination or wastewater reclamation are more energy efficient than the long conveyance of surface water (Rygaard, Binning, & Albrechtsen, 2011). Table 28 from West Basin shows how imported deliveries can have higher energetic costs than recycled water and even desalination when taking realistic volumes of liquid into consideration.

In California, the large energetic cost of imported water can be explained by Northern to Southern California conveyance, which can account for 8,750 more kWh/MG. Electricity use for water treatment, distribution, and wastewater treatment are the same for typical urban water systems of Northern and Southern California, the only difference is in water supply and conveyance. Water supply and conveyance is 150 kWh/MG for Northern California while it is 8,900 kWh/MG for Southern California (Klein & Krebs, 2005). The GHG emissions of water supply and conveyance are included in the GHG emissions boundary for Santa Monica because of its importance to recognize the GHG implications of the City's progress towards water self-sufficiency. Though most cities do not take responsibility for indirect emissions, including them is the most comprehensive and responsible method for cities to account for their emissions and tells a story of the joint journey towards water self-sufficiency and GHG reduction.

RELATING SANTA MONICA'S OPPORTUNITIES TO GREENHOUSE GAS EMISSIONS

Water plans less energy intensive than pumping and treating groundwater, totaling 4,142.67 kWh/MG, will help Santa Monica's dual goals of water self-sufficiency and GHG reduction. However, Santa Monica's lowest GHG emitter is imported water, without considering treatment and conveyance. Depending on imported water does not help the City's water self-sufficiency plans even if it advances the city towards its GHG goal. Based on calculations, expanding groundwater is the best alternative, but this source can only be expanded to an extent based on the safe capacity yield of the Santa Monica Basin.

Although SMURRF is more energy-intensive than anticipated, it is a local source of water and can contribute greatly to water self-sufficiency. "Intensive water treatment and high energy demands can be decoupled from potential climate change impacts by use of emerging greenhouse-gas-neutral energy generation" (Rygaard, Binning, & Albrechtsen, 2011). Renewable energy, particularly solar, can help alleviate the GHG burden of operating SMURRF. As mentioned in the previous "Challenges" section, Santa Monica does not have the large capacity to operate a wastewater treatment plant within its boundaries and the opportunity for biogas generation is not available yet, but solar is an opportunity that can be easily pursued to decrease GHG contribution of water treatment with hopes of biogas generation in the future.

Santa Monica plans on installing large cisterns to store water so SMURRF can operate year round, above its 11.15% capacity in 2013 (historically 20%). SMURRF currently treats urban runoff, which is more polluted and concentrated than the diluted stormwater SMURRF would be treating in the future. The energy required to treat diluted stormwater will be lower than that of dry urban runoff and could lead to a potential decrease in SMURRF's kWh/MG value. However, pumping to and from the rainwater storage tanks can represent additional GHG emissions for SMURRF, though pumping electricity requirements are small compared to treatment.

INFRASTRUCTURE

http://www.archello.com/en/company/moore-ruble-yudell-architects

INFRASTRUCTURE

INTRODUCTION

According to the U.S. GreenBuilding Council, building energy usage currently accounts for 36% of all the energy that is used and 65% of the electricity that is consumed within the U.S. The Council also states that buildings account for 30% of GHG emissions, 30% of raw material use, 30% of waste output and 12% of potable water consumption within the U.S. Within California, buildings comprise nearly 70% of statewide electricity use and 55% of natural gas use . This represents about 20% of all greenhouse gas emissions . Excluding commercial structures, energy use from residential buildings represents 35% of all building energy consumption within the state (CEC, 2015). However, while the amount of energy that is consumed by buildings is substantial, California households only consume 62 million BTUs of energy per home per year, 31% less than the average household in the US (EIA, 2009). However, despite this reduced energy consumption there is still an average spending of $2,200 a year on household energy bills (Energy Star, 2008).

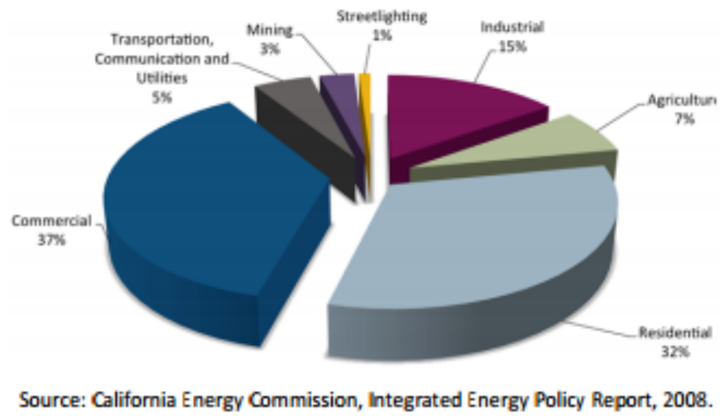


Figure 52: California's energy consumption by sector.

Since 1974 California has maintained among the lowest per capita energy consumption in the country (CEC, 2015).The cause for this partly has to do with the stringent policies California has enacted for conserving energy and protecting its environments and natural resources. An example of California's environmental policies is the creation and adoption of California Environmental Quality Act (CEQA) shortly after the creation of National Environmental Policy Act (NEPA). This Californian act enforces more stringent environmental assessment requirements upon industries than its national counterpart (U.S. Department of Energy, 2013).

One key reason for why CEQA is so effective is how it chose to define certain words such as "significant." "The manner in which the differences between the two processes are addressed must therefore take into account that NEPA does not compel mandatory findings of significance, and that some impacts determined to be significant under CEQA may not necessarily be determined significant under NEPA" (U.S. Department of Energy, 2013).This small change in CEQA forces and encourages industries and other facilities to incorporate greener practices into their workforce as more findings are incorporated into the CEQA reports. Ultimately, this has caused a reduction in GHG emissions in California with industries causing less damage to the environment through pollution and GHG emissions. Along with its policies for protecting the environment California has also developed building codes that are steadily increasing over the years in their energy efficiency requirements.

One example of California's increasing requirements for building efficiency is how the state added a "solar ready" component to all newly constructed buildings. This requirement ensures that all newly constructed buildings within the state of California, and therefore within Santa Monica, will have a portion of its roof reserved purely for solar purposes. The size of the area reserved on roofs varies with roof size. For buildings with roofs less than 10,000 square feet, 80 square feet of roof is reserved and 160 square feet is reserved for buildings with roofs exceeding 10,000 square feet (CEC: Title 24, part 6, 2013). By forcing homes to have space reserved for solar production, California is increasing the likelihood that homeowners will switch to renewable energy to fuel their homes.

Along with the increase in renewable energy, California also offers residents the option to become CALGreen certified. This process, however, requires residents to incorporate and maintain higher efficiency standards in their homes compared to the requirements of the California state energy codes. For homeowners that are willing to meet these increased standards, there are two different tier options. Tier 1 only requires buildings to have an Energy Budget that is does not exceed 85% of the Title 24, part 6 Energy Budget for the Proposed Design Building. Tier 2 requirements, on the other hand, restrict buildings to not have an Energy Budget exceeding 70% of the Title 24, part 6 Energy Budget for the Proposed Design Building (CALGreen, 2014).

In congruence with the reduced energy budget required by CALGreen's Tiers 1 and 2, building owners are also expected to incorporate site mitigation practices to preserve the land and reduce the amount of destruction and erosion caused by construction. At the same time, homeowners are also expected to implement water efficiency standards for both indoor and outdoor water use. In California, this increase in water efficiency standards, along with various water reuse systems such as graywater pipelines, are becoming more and more important as citizens begin to worry about the future availability of water.

SANTA MONICA'S CURRENT STRATEGIES

Within California, the City of Santa Monica has also been viewed as a leader in environmental management and green lifestyle with its building efficiency standards outperforming California's. Santa Monica requires all newly constructed buildings within the City to use 15% less energy than what the California Energy Code requires. Along with this, Santa Monica also requires 70% of the waste created by construction and demolition to be diverted from landfills (Santa Monica Municipal Code, 2015). While these additional requirements have made Santa Monica a leader in green buildings and efficiency, they will not allow the City to reach their goals of 80% GHG reduction by 2050. In order for Santa Monica to reach the GHG reduction goal of 80% by 2050, further improvements on building efficiency, specifically of existing buildings, is necessary.

Of the energy that is consumed by buildings within the residential sector, approximately 80% of potential savings can come from single-family homes (Navigant Consulting, 2014). In addition, 44% of all energy used in homes is for appliances, lighting, and electronics, or "plug loads" (CEC, 2015). With so much energy being consumed by plug loads, it is unsurprising that this sector holds the highest potential rate for energy savings at 20%). Unlike single family homes, multifamily homes' (i.e. 5+ units in a building) highest energy uses, including energy generated from natural gas, are from space heating, which accounts for 22%, and water heating, which accounts for 39% (CEC, 2015). Collectively, along with lighting, these areas account for a total of 72% of the energy consumed by multifamily structures (California Sustainability Alliance, 2015). However, it is estimated that a majority of California's existing multifamily buildings (over 70%) were constructed pre-1978 or before there were efficiency standards Because of this, a potential 30% improvement in energy savings in multifamily buildings is predicted to result in savings of approximately $9 billion nationwide (CEC, 2015). By targeting these single and multifamily homes, Santa Monica is likely to decrease the amount of energy currently being consumed by a significant portion.

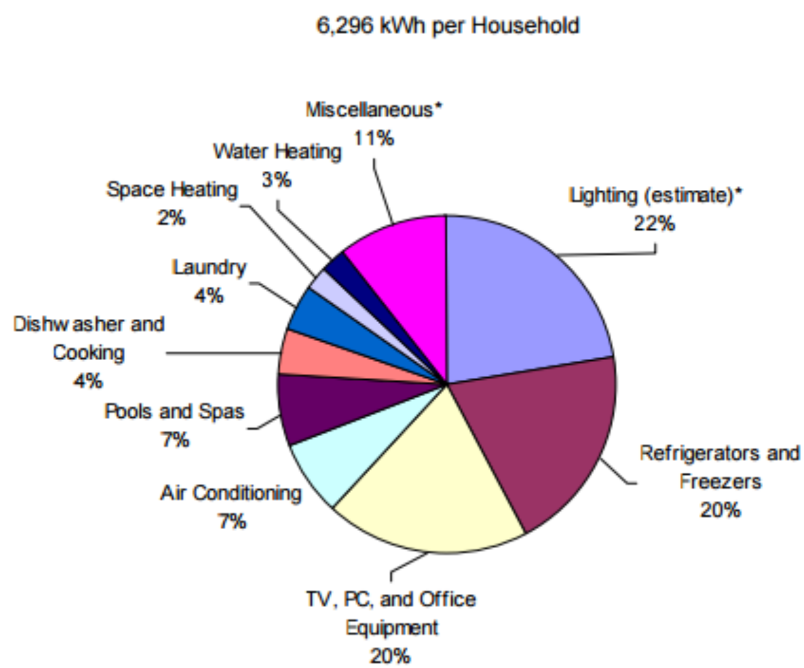


Figure 53: Statewide electricity consumption per household.

CHALLENGES

Single and Multifamily Homes

Finding ways to increase the efficiency of buildings and appliances, however, is but one piece of the puzzle. Another piece, and a potentially more difficult one, is finding ways to convince residents to change their behaviors and daily lifestyles. This difficulty originates from the lack of understanding and knowledge by residents and consumers on the benefits of increasing building efficiency. However, even if residents are better informed the fact remains that "consumer awareness of the characteristics and benefits of efficiency is not sufficient to motivate proactive decisions. Even with 'perfect' information consumers do not always make 'perfectly rational' decisions to prioritize efficiency". "Further, potential participants perceive residential efficiency programs as overly onerous and slow with too few benefits" (Fuller, *et al.*, 2010).

Part of the reason for the negative perception on building efficiency programs is that the payback period, the time it takes for residents to recover the cost on the retrofit or upgrade, is typically too long. On average, most residents in California typically only remain in their household for 5-8 years (CEC, 2015). Because of this, homeowners may not recoup the value of a deep retrofit project while they own the home. A second reason for the negative perception is that energy retrofits and "investments in energy efficiency are not recognized in the property listing, appraisal, or valuation process," meaning that the retrofit will not necessarily raise the value of the home (CEC, 2015). "California lacks a single, well- understood metric for quantifying energy efficiency in the market to help these professionals integrate energy efficiency features and values into their business transactions" (CEC, 2015).

Along with the lack of understanding and negative perception of efficiency programs there are also many social issues incorporated into residential homes, such as differences in class, race, culture, and education between single family homes and multifamily homes. Of the two types of homes, multifamily homes appear to possess the most challenges in terms of increasing energy efficiency. The cause for these challenges stem from the fact that over 90% of residents who live in multifamily homes are renters (CEC, 2015). The people who live in multifamily homes do not control building improvements even if such improvements would reduce the costs of their utility bills (Benningfield Group, 2010). At the same time landlords and building owners may not be able to influence tenant behavior that could help control costs (CEC, 2015).

As stated before, the costs to have energy efficiency retrofits performed on buildings are often extremely high, such that the payback period is too long. On average, fuel-heated buildings require 6 years and electric-heat buildings between 20-25 years before the payback period is reached (Goldman, 1988). However, even if residents and building owners of multifamily homes want to invest in efficiency retrofits, 40% of people who live in multifamily homes are low-income and could not afford retrofits (CEC, 2015). Therefore,

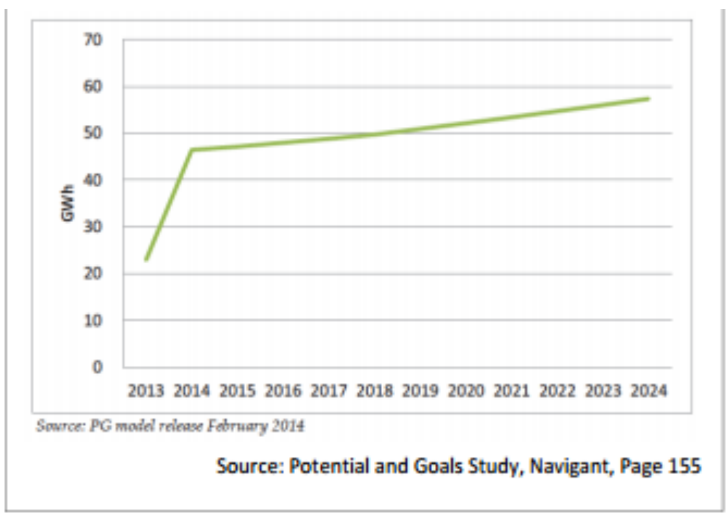


Figure 54: Residential behavior savings potential.

convincing residents to change their lifestyle habits and utilizing retrofit programs offered by government institutions are important steps for Santa Monica and any other city looking to reduce their GHG emissions.

Commercial

In addition to single and multifamily homes, upgrading commercial buildings to higher efficiency will be a major obstacle for Santa Monica. This difficulty is partially due to that fact that commercial buildings vary drastically in terms of size, location, use, and structure. Commercial buildings also tend to possess different owners and tenants who have different "needs, end-uses, interests, and sophistication, particularly as it relates to energy and water efficiency" (CEC, 2015). Of all commercial buildings, restaurants and food stores with refrigeration use about 2 times more energy than large office buildings and 3 times the energy of the average commercial building However, while buildings with refrigeration consume the largest amount of energy, they are not where the highest amount of savings can occur. The largest energy savings potential from nonresidential existing buildings originate from lighting, roof, and HVAC alterations (CEC, 2015). In a survey performed by McGraw Hill, 75% of respondents indicated they would incorporate energy efficiency into their upgrades (Green Outlook, 2011). In this survey, all building managers and owners indicated they would add additional LEED EBO&M (Existing Buildings Operations and Maintenance) to portfolios in the next three years; 83% for Energy Star; and 33% for LEED for new buildings (Green Outlook, 2011). Assuming these findings would be similar for Santa Monica building managers could prove to be a

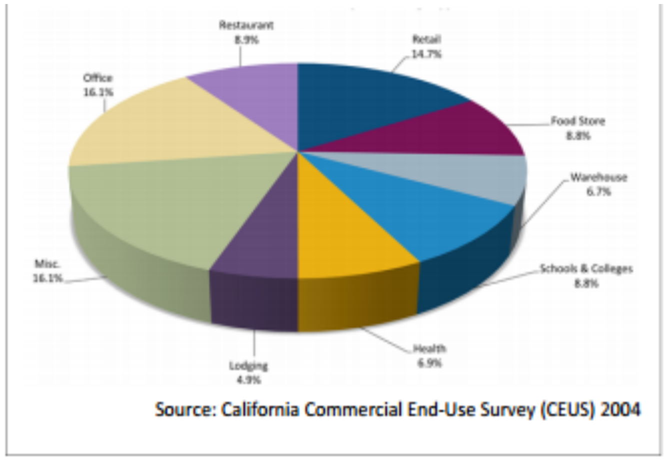


Figure 55: Commercial electrical use by building type.

Leading Global Cities

The challenge of upgrading existing buildings to higher efficiencies is not an issue Santa Monica is facing alone. Cities around the world such as Seattle, Stockholm, and Copenhagen have all developed plans addressing this issue. In Seattle, Washington, there have been multiple incentive and rebate programs created, such as the "Community Power Works" program which helps subsidize the cost of building retrofits. The program has already assisted in upgrading over 3,000 homes, 1.5 million square feet of commercial space, four projects in three major hospitals, and 17 municipal buildings (Seattle: Office of Sustainability, 2015). Along with the Community Power Works program, Seattle also offers homeowners the option of having professionals come to perform and energy audits in their homes. These energy audits provide homeowners with “an "Energy Performance Score" that rates the current efficiency level of their home and suggests energy-efficiency upgrades (Seattle City Light, 2015).

COPENHAGEN

In Copenhagen, Denmark, savings accumulated from climate retrofitting of existing buildings help create a fund that will be used to finance future city projects (CPH Climate Action Plan, 2009). For municipal buildings, Copenhagen decided that even if the retrofit takes up to 10 years before a return on investment is achieved, they will still perform a retrofit (CPH Climate Action Plan, 2009).In addition, Copenhagen also plans to communicate with national and regional governments about energy upgrades in hopes of reducing GHG emissions from buildings worldwide (CPH Climate Action Plan, 2009). Within the Copenhagen Plan, there is also a separation of goals for both buildings, City establishments, and citizens of Copenhagen. These goal distinctions could potentially reduce the amount of energy consumed and GHG’s emitted by a significant amount as “Copenhageners” gain knowledge on how they, as individuals, can assist the City in meeting its GHG reduction goals.

STOCKHOLM

For the City of Stockholm, Sweden, investments into buildings upgrades have been made with the intention of reducing GHG emissions by an average of 18% by the end of 2015. The overall hope is to have a reduction of approximately 27,500 GHG emissions from what they were in 2010. Some specific ways in which they will accomplish this goal is by having buildings being constructed within the new city district Royal Seaport meet greater energy standards than the standards outlined in the general building code (Stockholm Action Plan, 2007).

Table 26: Stockholm’s planned measures within the building sector.

		Change in emissions in thousand tonnes co_2e in 2015 compared with 2010	Change in energy use, GWh
City of Stockholm	Energy-efficiency improvement programme for buildings	−27.5	−220
Private building developers	Energy-efficient construction, Royal Seaport *	−0.8	
Private building owners, various	Energy-efficiency improvements and low-energy buildings	−6.0	−40
	Total	**−34.3**	

Businesses within Stockholm are also making efforts to increase the efficiencies of their office spaces. One business, Jernhusen, which runs and owns railways in Sweden, has started hosting workshops regarding their office, the Kungsbrohuset building, which uses extremely innovative technologies such as partial heating using “heat gains” from nearby train stations to help reduce the amount of energy it consumes through heating (CLUES, 2012).

The purpose of the workshop is to inform business leaders and community members from all over the UK on the benefits of eco-smart buildings. The workshop is designed with educational aspects highlighting drivers that can help in the implementation of greener buildings and barriers that may prevent people and businesses from switching to eco-smart buildings. Drivers for eco-smart buildings include energy security with the ability to produce energy on-site in some offices, a better public image and reputation for businesses, and financial savings in the form of reduced energy bills (CLUES, 2012). Barriers that may inhibit the incorporation of eco-smart buildings in the UK include governance issues, lag of building regulations behind current requirements, lack of data on best practices for buildings leading to inefficient designs, and general lack in education and trust on the current economic climate resulting in an unwillingness to create future plans (CLUES, 2012).

RECOMMENDATIONS

Because California’s building standards have become so stringent, it is no longer necessary for Santa Monica to expand them in order to reach the 80% reduction goal by 2050. Therefore, instead of trying to develop plans for improving energy efficiency for new buildings within Santa Monica, the City should focus on developing plans that would upgrade their existing buildings to higher efficiency standards.

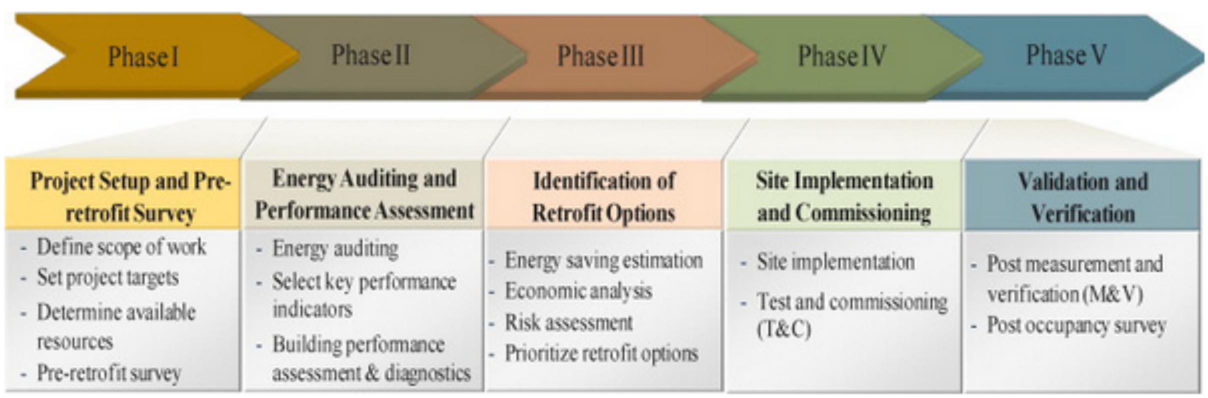


Figure 45: Key Phases in a sustainable building retrofit.

Currently there are no requirements for older buildings to become more efficient, however, there are plans being created at the state level to increase the amount of existing building upgrades. These plans are outlined in Assembly Bill 758: “California’s Existing Building Energy Efficiency Action Plan.” Presently, AB 758 still remains in a draft form, but will be implemented in various phases over the next few years as outlined in Table 30.

Table 27: Implementation phases of AB 758.

Phase 1	● "Began with the American Recovery and Reinvestment Act of 2009 (ARRA) implementation period (2010-2012)." ● ARRA: - "Supported energy efficiency efforts through state and local upgrade programs, workforce training, and financing" - assisted in implementing "an extensive outreach campaign, coupled with statewide and local public relations and marketing efforts." ● Included the development of the *Comprehensive Energy Efficiency Program for Existing Buildings Scoping Report*, which outlined market needs and identified barriers to implementation. ● Will conclude with the full adoption of the AB 758 Action Plan.
Phase 2	"Will focus on implementing the roadmap necessary for foundational *No Regrets Strategies* to take hold and *Voluntary Pathways* to scale to achieve energy efficiency goals, partnerships, and market development."
Phase 3	"Will develop and institute *Mandatory Approaches* that will move energy efficiency practices into the mainstream."

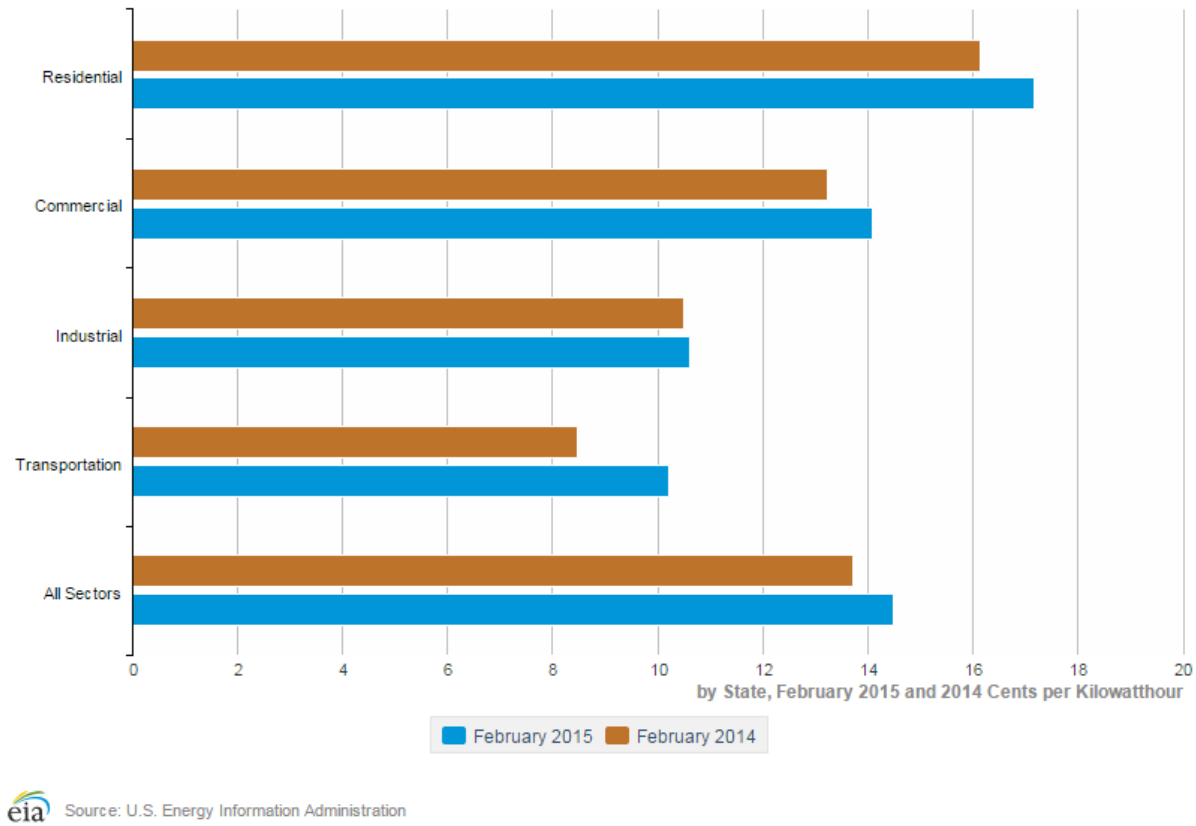
With the plans for increasing building efficiency across the state already in place, Santa Monica's challenge will be finding ways to convince residents of Santa Monica to renovate their homes. This challenge centers mostly around the issue of money, as the cost of performing retrofits in buildings can be extremely expensive and the payback period may not offer enough incentive for homeowners. Finding methods that would be most efficient for buildings in terms of cost effectiveness can be a difficult task. One solution to this problem to have residents perform energy audits.

Energy audits on residential and commercial housing would provide homeowners with building energy data, allowing them to understand building energy use, identify areas with energy wastes, and propose no and low cost energy conservation measures (ECMs) (Ma *et al.*, 2012). With the information gained from energy audits, homeowners would be able to make educated decisions and target very specific sectors within their homes to increase their home's efficiency at the lowest possible costs. Even if homeowners decide they do not want to perform retrofits, the availability of measured data on the performance, cost-effectiveness of retrofit measures, and operating strategies is a resource that could help multifamily building owners and tenants make better-informed decisions about improving the end-use efficiency of their buildings (Goldman *et al.*, 1988). Simply having the knowledge on where a majority of the energy is being consumed within a household can convince residents to change their lifestyles to be more sustainable.

A third option for increasing building retrofits would be to simply increase the amount that energy costs. In a study of residential homes in a Swiss district, residents were surveyed to discover what methods would best incentivize them to have retrofits performed on their homes. The results of this survey were simply that the cost of energy was too low for residents to see the need to make their homes more efficient (Amstalden *et al*., 2007). The cost and time it would take to remodel their homes were too much of a hindrance and the payback period too long for retrofits to be a feasible option for most homeowners. Therefore, raising the energy costs within Santa Monica could pose as a potential solution to convince residents to perform retrofits by making the amount of money that can be saved by having the retrofits performed more attractive. Similar to Copenhagen's fund for future city projects created from the savings made by higher efficiency buildings, raising energy costs within Santa Monica could also bring in more revenue for the City to be used on various projects or programs.

For commercial buildings specifically "there are several key trigger points for [that] can be leveraged for energy efficiency: Building sale, tenant change or renewal of lease. Redesign to a space, e.g. relighting, redecorating, refitting for a new business, etc. Time maintenance agreement comes up for renewal or with operational plan development. Periodic mortgage refinancing (e.g. every 10-15 years)" (CEC, 2015). By targeting these areas as well as requiring building owners to perform energy audits to educate themselves on the efficiency of their buildings, Santa Monica should be able to increase the amount upgrades occurring within existing buildings.

Table 28: Average retail price of electricity to ultimate customers by end-use sector, California.



WASTE

https://www.youtube.com/watch?v=_nqtI48L9QE

WASTE

INTRODUCTION

According to the Environmental Protection Agency (2014), 42% of global greenhouse gas emissions come from the extraction, manufacturing, distribution, usage and disposal of the foods and goods we purchase. Each step of the lifecycle of materials requires energy, so it is important to reduce GHG emissions associated with each stage. However, from a city perspective, it is easier to assess the downstream processes rather than the upstream processes since the city itself controls the disposal of municipal solid waste (MSW). Downstream processes included in this report mostly deal with end-of-life treatment such as recycling, composting, landfilling, and energy recovery. Typically, these processes account for 1 to 5 percent of the total GHG emissions of cities. Currently, waste management strategies consist of reducing, reusing, recycling, composting, energy recovery, and landfilling. General waste hierarchies, as depicted in Figure 56, stress source reduction and prevention, followed by reuse of materials, and then recycling. Energy recovery and landfilling are considered last resort options because they are energy intensive and produce a considerable amount of emissions (EPA, 2014). Energy recovery, or waste-to-energy (WTE), is the process of converting non-recyclable waste into usable sources of energy, such as electricity or fuel. This can be done through combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery (EPA, 2014a). Relevant methods will be discussed in more detail in subsequent sections.

Figure 56: Waste hierarchy diagram (LOCOG).

The majority of the emissions associated with the downstream processes are a result of the decomposition of organic matter in landfills. This process produces methane (CH_4), a potent GHG with thirty-five times the global warming potential (GWP) as carbon dioxide (CO_2) though it has a much shorter lifetime in the atmosphere. In other words, although CH_4 has a shorter residence time in the atmosphere than CO_2, it is more effective at trapping outgoing solar radiation, and thus at warming the earth (EPA, 2014b). According to the Environmental and Energy Study Institute (2013), a 2011 assessment by the EPA concluded that methane from U.S. landfills was responsible for 103 million metric tons of carbon dioxide equivalent (CO_2-e) released into the atmosphere. However, most landfills today have a LFG recovery system that captures the methane for energy use. These systems have collection efficiencies ranging from 60-85 percent depending on the gas collection/extraction system implemented (EPA, 2015).

According to Santa Monica's 15x15 Climate Action Plan, 5% of the total GHG emissions emitted by the City are associated with the disposal and treatment of waste. In order to curb emissions, the City plans to become a Zero Waste City by 2030, with a diversion rate of 95%. The definition of zero waste varies from city to city, where some places call for a diversion rate of 90% or more and others 100% (City of Santa Monica, 2013). As of 2014, Santa Monica diverts approximately 78.9% of its municipal solid waste from landfills and WTE facilities. This is on track of reaching their target of 80% diversion by end of fiscal year 2015, but still proves difficult when accounting for population growth (Resource Recovery and Recycling Division, 2015). In the following sections we highlight what Santa Monica is currently doing to reduce its GHG emissions, discuss what other leading cities and countries are doing globally, and offer recommendations and challenges for Santa Monica to consider going forward.

SANTA MONICA'S CURRENT STRATEGIES

Santa Monica aims to be a Zero Waste City by 2030 with a diversion rate goal of 95% or a disposal rate of 1.1 pounds per person per day. In order to accomplish this, the City has created three planning categories: short-term goals (2013-2015), medium-term goals (2016-2022), and long-term goals (2023-2030). According to baseline analysis of solid waste programs, the total cost to implement the policies will amount to $25,192,020 across single-family residence, multi-family residence, and commercial sectors. Figure 57 articulates the recommended strategies for achieving said goals, and categorizes them based on term length and sector. Some of the more critical strategies outlined by the City of Santa Monica (2013) that will lead to significant reductions in GHG emissions include:

Behavioral Change Marketing:

Source separation is a popular waste management strategy across cities because it is one of the most effective ways to reduce waste sent to landfills. Educating residents and businesses on how to separate recyclables and organic waste from trash can significantly reduce the volume of waste that ends up in landfill and WTE facilities. The city plans to do this by carrying out marketing campaigns that educate the public as to where to dispose of certain materials and why reducing waste is important. Several waste-related events are currently scheduled, including e-waste collection, textile recycling, paper shredding, compost and re-use workshops, and annual city-wide yard sales. Additionally, Sustainable Works, a non-profit city organization, provides free environmental education for businesses, residents, students, and the community. Planning-level estimates project a diversion rate of 4,790 tons across all sectors.

Integrated Waste Management Fee Structure

This will affect the cost of containers across all sectors, including single-family, multi-family, and commercial. Fees for trash will be more than those for recycling and organics, but eliminating the concept of "free recycling" will reflect actual collection service and processing costs. Trash will carry a heavier price and incentivize consumers to recycle more or reduce waste volume altogether.

Wet/Dry Collection

This type of collection scheme separates waste based on "wet discards" (i.e. yard trimmings, food scraps, and soiled paper) and "dry discards" (i.e. paper, glass, and plastics), effectively reducing disposal fees by having a two-bin system. Additionally, this will make separation less contingent on changing consumer behavior and increase diversion rates. However, the city is not currently equipped to handle the volume of recyclables that would need to be processed from such a collection system. Planning-level estimates project a diversion rate of 4,797 tons across all sectors if this system were to be implemented.

Extended Producer Responsibility

The city will advocate for legislation to shift the burden of disposal costs from the taxpayers to the producers. This "take-back program" considers items that are difficult to recycle or made with harmful chemicals to be the responsibility of the producer to dispose of. This will require working with federal, state, and local agencies to see that it is put into law.

Alternative Technology Facility

In order to meet Zero Waste goals, the city anticipates that it will need to invest in emerging energy recovery technologies. Santa Monica is considering organic waste fermentation, gasification, and pyrolysis, which have the ability to significantly increase diversion rates and are low-impact alternatives to incineration. The city does not plan itself to site a WTE facility, but jurisdictions such as Los Angeles and Glendale are evaluating the feasibility of these technologies. Planning-level estimates project a diversion rate of 9,512 tons across all sectors.

Period	Program	Single - Family	Multi-Family	Commercial	Self-Haul	C&D
Short-Term	Require Food Scraps Collection					
	Behavior Change Marketing					
	Environmental Directory On-line Version					
	Integrated Waste Management Fee Structure					
	Bulky Item Collection; Move-In/Move-Out Program					
	Recycling Educational Outreach					
	Mandatory Recycling in Hotels/Motels					
	Business and Restaurant Food Donation					
	Santa Monica Shares /Bulky Item Reuse and Recycling					
Short to Medium-Term	Regional Sustainability Collaboration					
	Rewards Program					
	HHW Collection at Public Events					
	Centralized Garage Sales					
	Disposal Bans					
	Weekly Organics and Recyclables Collection; Bi-weekly Refuse Collection					
	Self-Haul Waste Origin Reporting					
Medium-Term	Packaging Legislation					
	Extended Producer Responsibility					
	Regional Resource Recovery Center					
	Require Food Scraps Collection					
	Expand Single-Use Carry Out Bag and Disposable Container Ordinance					
Medium to Long-Term	Wet/Dry Collection					
	Expand Items Collected in Recycling Cart					
Long-Term	Mandatory Diversion Rate					
	Require Recycling of New Materials					
	C&D Ordinance Revision					
	Expand Mandatory Commercial Recycling					
	Alternative Technology Facility					
	Residuals Processing					

Figure 57: Recommended strategies for achieving a diversion rate goal of 95% by 2030.

Many other leading cities either have implemented, or have it in their waste management plan, to implement these goals. With all 26 strategies in place, however, Santa Monica will reduce its GHG emissions by roughly 68,000 metric tons of CO_2 equivalent (MTCO2E), with most of its reductions coming from the commercial sector. Construction and demolition waste is the largest contributor to the waste stream and the hardest to dispose of since most contain toxic chemicals. By implementing these strategies, it is suggested that the city can achieve a 95% diversion rate (City of Santa Monica, 2013).

Santa Monica Public Works provides residents and businesses with collection options in which fees vary depending on frequency of service, container size, and amount with additional costs for overflow (City of Santa Monica, 2013). As of 2014, homeowners pay $550.44 annually and businesses $1,503.96 annually for trash collection services, one of the highest trash rates for a city (Simpson, 2014). Currently, there is no cost for recycling or green waste containers for residences or businesses, but the Zero Waste Plan calls for fees on all containers to encourage waste reductions and to accurately reflect collection service costs. Naturally, trash will have the highest fee per container, followed by recycling and composting. Additionally, the Community Recycling facility currently composts yard waste, food scraps, and street sweepings collected from Santa Monica in Lamont, CA. The city also provides a free collection service for fats, oils, and grease (FOG) from local restaurants to be converted into biofuel. Another program initiated by the Resource Recovery and Recycling Division is the swap or share program, in which community members are encouraged to share or donate their used goods to neighbors. It is part of the "Neighborgoods" website and includes items such as ladders, tools, electronics, and clothes (City of Santa Monica, 2013).

LEADING GLOBAL CITIES

NETHERLANDS

With some of the most innovative waste technologies globally, the Netherlands is one of the leading countries in waste management today. It has a recycling rate of 63% – one of the highest in Europe – and landfills only 0.3% of its waste. The rest is incinerated in one of its several waste-to-energy facilities (Hammond, 2009; Milios, 2013). The Dutch success owes to a combination of its national waste policy and alternative technologies. Its policy includes producer responsibility or the "polluter pays principle," landfill tax, 35 waste-stream bans (i.e. organic, plastic, and demolition waste are not allowed in landfills), and national waste disposal planning (Hammond, 2009). In addition to its policies, the Netherlands works with companies such as Bammens, VAR, and Bollegraaf, who offer innovative waste technologies.

Bammens supplies underground refuse containers that can hold up to $5m^3$ of waste. They are small pillar boxes that are operated by an electronic system that can tax the public based on how frequently they use it. These containers are more hygienic because they prevent animals from getting into the garbage, can be emptied less frequently and thus reduce transportation costs for collection services, and are more aesthetically pleasing then dumpsters.

VAR is a full-service recycling company that is leading the way in waste recycling technology. The company currently handles five divisions, including minerals, sorting, biogenic, energy, and engineering. It is sited on an old dumping ground, and since 1983 privately owns the land, which gives it the legal range to be at the forefront of emerging technologies. Its newest addition is an anaerobic digestion plant that processes organic waste through composting, fermentation, and timber recycling. Fermentation relies on anaerobic digestion (digestion of organic waste by organisms in the absence of oxygen) to produce methane gas for energy, while aerobic digestion creates nutrient-rich compost to be used as a natural fertilizer. The installation costs €11 million, but most of the waste brought in is resold as high-grade compost, energy, and plastic product.

Bollegraaf supplies recycling machinery that provides single-stream sorting. Unlike Copenhagen, pre-sorting waste in the Netherlands is considered laborious from both an economic and environmental standpoint. As Feller (2015) explains "rising fuel costs and congested roads emphasize the disadvantages of that system." Bollegraaf's single-stream sorting system can separate more than 95% of the combined dry waste (i.e. paper, glass, plastics, etc.) through various technologies (Feller, 2015).

COPENHAGEN

Like The Netherlands, Copenhagen's waste management system heavily relies on energy recovery practices, with 40% of materials incinerated as of 2009. The City obtains energy from three incinerators, with the construction of a fourth to be completed in 2017. The new Amager Bakke plant will have artificial ski slopes in an effort to make incineration facilities more attractive to the community, though most Danes support incineration already. Although Copenhagen does not utilize thermal waste treatment methods, such as gasification and pyrolysis, it claims that its incineration plants are heavily regulated and equipped with the most advanced clean technologies. However clean Copenhagen's combustion facilities are, though, the Global Alliance for Incinerator Alternatives (2012) suggests even the most advanced pollution control devices (i.e. filters and scrubbers) cannot capture hazardous ultra-fine particles such as PCBs, dioxins, and furans. Global estimates suggest that over 2 million people die each year from airborne particulates alone. Additionally, the U.S. EPA asserts that "waste-to-energy incinerators contribute far higher levels of GHG emissions and overall energy throughout their lifecycles than source reduction, reuse and recycling of the same materials" (GAIA, 2012). Based on 2007 EPA data, incineration facilities release approximately 2,988 pounds of CO_2 per megawatt hour, which is more CO_2 per unit of electricity than coal-fired power plants (GAIA, 2012).

The City also plans to make dramatic changes to its waste stream by increasing recycling and composting rates. Currently, most of this waste is incinerated, so expanding recycling programs and taking advantage of energy from organics will reduce the total waste-stream and divert more from incineration (Wong, 2014). Despite its heavy reliance on incineration, Copenhagen is able to landfill only 1.8% of its waste stream (European Commission, 2012).

According to its 2012 Waste Management Plan, Copenhagen plans to be an "Eco-Metropolis" by 2015 (City of Copenhagen, 2012). One way it plans to do so is through innovative waste solutions. This will help maintain the appearance of public spaces by reducing the traffic associated with waste collection and management services. These strategies include vacuum waste systems as well as underground refuse containers and solar cells for waste compaction (European Commission, 2012).

In 1996 a stationary vacuum system was installed in the Nyhvn district of Copenhagen. Two more have since been installed in Havnestaden and Sluseholmen (City of Copenhagen, 2012). The stationary system works by suctioning trash through an underground pipe into a collection station container nearby. Envac's vacuum system is highly advanced and eliminates the need for waste collection trucks, is more hygienic as it keeps pests out, reduces odors, and prevents trash over-flow. Additionally, it reduces maintenance and operation costs because bins are emptied less frequently (Envac, 2015). According to Envac (2012), "the cost for installation varies from place to place, but investment in the Envac system typically ranges from 0.5 to 1% of the building construction costs." Further, the payback period can be anywhere from 1 to 25 years depending on the type and scope of installation (i.e. residential or commercial), but it is typically more cost effective than traditional collection methods. For example, Envac systems are optimal for apartment complexes because they reduce the costs of needing to hire employees and other equipment that is required for the collection services (Envac, 2012). To enhance this effort, Copenhagen is looking into solar compaction for individual trash containers not equipped with the vacuum system and has already incorporated the technology into the vacuum system for the large off-site containers so that they can handle more volume (European Commission, 2012).

In addition to these advanced waste technologies, Copenhagen plans to augment the development of more traditional waste management strategies. These include increasing drop-off locations for public convenience and engaging in consumer behavioral marketing to improve recycling rates (City of Copenhagen, 2012).

STOCKHOLM

Sweden disposes less than 1% of its entire waste stream, making it a leader in waste management. This owes to its flexible and innovative recycling schemes. One way it accomplishes this is by having convenient drop-off locations for recyclables – recycling stations are no more than 300 meters from all residential areas. Residents sort the waste in their homes and then either deliver it to the nearest drop-off location or put it in bins in their neighborhood. The company Envac has developed Optibag, a technology that has the ability to sort colored waste bags, streamlining the sorting process (Swedish Institute, 2014). Additionally, the City is trying to, as they put it "move up the refuse ladder," and incinerate less. They plan to accomplish this by reducing waste at the source through initiatives such as enhancing producer take-back policies on packaging, informing the public of waste reduction strategies and increasing recycling rates (City of Stockholm, 2013).

Figure 58: Envac's Optibag optical sorting system.

Combined heat and power (CHP) plants play a large roll in Stockholm's waste management policy. The Brista 2 CHP incineration facility, which opened in 2014, processes municipal and industrial waste, where the original Brista plant utilizes only biomass. Both plants produce district heat and electricity for the Stockholm area. Brista 2, however, processes 240,000 tons of waste each year, which is about the same amount of municipal waste generated in Stockholm. The plant operates at 95% efficiency, which owes to the large industrial heat pumps that recover the emitted gases from the incineration process to be used as energy. Additionally, the plant generates a profit upwards of a million dollars annually from energy cost savings and importing waste from nearby countries, and has a payback period of less than 1.5 years (EHPE, 2015). However profitable, incineration is still not a sustainable waste management solution nor is it a renewable source of energy (GAIA, 2012).

Bromma and Henriksdal digestion plants convert sewage sludge from local water treatment plants and organic waste into biogas for fuel, electricity, and heat. This significantly reduces the amount of sludge and other organic waste that ends up in landfills. The fermentation process yields biogas and an organic residue, or bio-manure, which is a valuable fertilizer for farmers and homeowners alike. Phosphorus and other nutrients found in organic waste from food scraps and sludge are recycled back to the land, closing the urban to rural gap. In addition, anaerobic digestion of manure provides plants with more available sources of nutrients to be taken up by the roots (Swedish Gas Association, 2011).

EMERGING TECHNOLOGIES

While many of the current waste management technologies may be appropriate for these countries based on their existing waste infrastructures, Santa Monica, having little investment in such equipment, should consider the most advanced waste processing technologies to limit GHG emissions. Three emerging technologies that are becoming more readily available for large-scale commercial use include gasification, self-contained aerobic digestion tanks, and anaerobic digestion.

GASIFICATION

Compared to conventional WTE plants – some argue that incineration is not even a form of WTE – gasification plants can produce roughly two times the amount of electricity and generate a more diverse range of outputs from the synthesis gas (syngas) produced such as chemicals, fertilizers, and transportation fuels. A typical incineration plant can produce about 550 kilowatt-hours of electricity per ton of MSW, whereas gasification can produce as much as 1,000 kilowatt-hours from the same amount of waste (GTC, 2011). Additionally, gasification facilities can process anywhere from 75 to 330 tons per day (EPA, 2012). Instead of burning the waste, like incineration, gasification plants gasify waste at extremely high temperatures, and therefore emit less carbon dioxide making it one of the cleanest WTE technologies on the market (GTC, 2011; Jordan, 2015). The process also involves relatively little oxygen and thus forms fewer oxides compared to the combustion process in which oxygen binds to other molecules to form nitrous oxides and dioxins (Dodge,

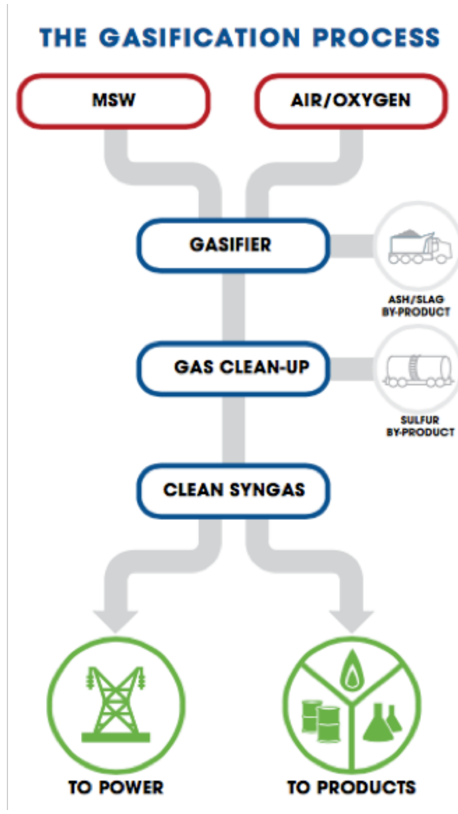


Figure 59: Diagram of the gasification process.

2015). Furthermore, the post-combustion cleaning process for incineration, which occurs after the waste is burned and thus makes it difficult to regulate the pathways of toxins into exhaust streams, is less efficient than the pre-combustion processes of gasification because it requires energy-intensive emission control systems whereas the syngas can be cleaned before it is repurposed (GTC, 2011).

HOTROT AEROBIC DIGESTION TANK

Figure 60: HotRot self-contained composting unit.

HotRot is a New Zealand based company that sells low-impact, low-maintenance aerobic digestion tanks, which convert organic waste into high-quality compost. The HotRot 3518 processes 10-15 tons of organic waste per day and is designed for cities and larger institutions that may require multi-unit installations (HotRot, 2015). The tank requires between 200 and 250 KWh per day, but uses 50-75% less labor compared to other composting technologies not to mention the composting process only takes 8-10 days. According to the EPA, "composting could reduce GHG emissions by 0.9-1.0 tons of CO_2 equivalent for every ton of food waste composted, when compared to landfill with gas capture" (HotRot, 2013). Additionally, operating costs are a fourth of what other enclosed composting systems demand and the HotRot unit(s) take up 50 to 70 percent less space. The system also offers an "Odour free guarantee" and creates no leachate. The aerobic digestion process, which operates under very specific oxygen and temperature requirements, only produces heat, water and CO_2. Although CO_2 is considered a GHG, its evolution from the composting process is not counted in emissions. Additionally, CO_2 is only 1/20th as harmful to the environment as methane (the main by-product of anaerobic degradation). HotRot is currently operating in more than 12 countries and expansion efforts are taking place in the United States and Canada (HotRot, 2015).

DRANCO ANAEROBIC DIGESTION

Compared to conventional digestion technologies, DRANCO (DRy ANaerobic COmposting) is a one-phase digester, which reduces the complexity of the fermentation process. Furthermore, because it does not require any mixing or gas injection it is highly reliable. It maintains a thermophilic temperature (48-55˚C), which significantly reduces heat input and produces a higher biogas yield. The DRANCO vertical fermenter design also prevents buildup in the digester and allows for an easier extraction process (OWS, 2013). Single digesters have the capacity to processes up to 60,000 tons per year, with an average size of about 32,000 tons (Baere and Mattheeuws, 2012). They are also able to generate an estimated 12-14 MMBTU per ton of energy each day, which is approximately 5,110 MMBTU annually (EPA, 2012).

RECOMMENDATIONS

The 5% of GHG emissions that the waste sector contributes can be readily offset by innovative and integrated waste management strategies. Based on the leading waste management practices globally and available technologies, we offer recommendations for Santa Monica to observe in an effort to reduce its GHG emissions in the waste sector.

First and foremost, the City should seek to enhance its existing programs. In regards to its waste management plan, Santa Monica should focus on its behavioral change marketing schemes, as, based on research, changing consumer behavior will be the most effective way to reduce overall consumption in the City. Other key strategies to focus on include programs that facilitate recycling and composting efforts and extended producer responsibility. Based on what other leading waste management cities are currently doing, these strategies appear to be the most important and provide the greatest reduction in GHG emissions from the waste sector. Food waste, paper, and lumber are the largest contributors to Santa Monica's waste stream, so the City should strive to provide services that focus on the reuse and recycling of these materials.

Long-term goals should resist residual processing by incineration as many leading cities plan to reduce incineration rates by increasing recycling rates. And according to the Zero Waste International Alliance (2013), Zero Waste communities must incinerate less than 10% of their refuse to be considered a Zero Waste City, which Santa Monica intends to be. Santa Monica currently diverts some of its waste stream to two incineration facilities in Los Angeles, the Commerce Refuse-To-Energy Facility and the Southeast Resource Recovery Facility (SERRF) (Rohit, 2011).

In 2011, Santa Monica spent $9.5 million processing and disposing waste, not including transportation cost to haul it to landfills (Rohit, 2011). The 82,997 tons of MSW that are disposed of could be processed to generate roughly 91.2 million KWh of electricity per ton each year, assuming 250 tons of waste are processed each day (GTC, 2011). Thus, a gasification facility would be a worthy investment, not to mention the payback period is considerably small when you take into account revenues generated from energy sales, tipping fees (waste processing fee), and recyclables (Dodge, 2015). Further, Dodge (2015) explains "the economics of waste gasification heavily favor recycling – inorganic materials like metal and glass have no value as fuel and make the gasification process less efficient…High-value plastics and papers that can be readily separated are far more valuable as recyclables than as fuel." Moreover, according GAIA (2012), in 2005 there was a negative correlation between incineration and recycling in Denmark, and in 2007 Eurostat reported that 80% of the waste burned was recyclable and compostable. And if that was not reason enough, a report done in 2009 by Friends of the Earth Europe estimated that Europeans dispose of resources totaling upwards of $6 billion each year from burning recyclable material (GAIA, 2012). Current gasification technologies mostly operate in Japan, but some facilities exist in Europe as well as Canada. According to Arena (2012), "economic aspects are probably the crucial factor for a relevant market penetration, since gasification-based WTE tends to have ranges of operating and capital costs higher than those of conventional combustion-based WTE." However, with advancements in technology, gasification is becoming a more affordable and viable option for residual processing of waste and many companies are currently developing smaller gasifiers for cities and other areas with space restrictions (GTC, 2015).

Siting a WTE facility in Santa Monica is not currently in the plan, but installing a gasification plant is something worth considering in order to achieve zero waste goals (Rohit, 2011). Because the gasification processes favors recycling, the plant would facilitate in the diversion of 11,837 tons of recyclable waste that is currently sent to landfill or incineration. Based on 2011 waste data from the City of Santa Monica (2014), residents dispose of approximately 5 pounds of waste per person per day. This translates to 226 tons per day, which would generate 82 million kWh annually (GTC, 2011). Furthermore, according to the EPA (2012), a plant processing 100 tons of MSW per day 300 days a year would save energy equivalent to 33,000-66,000 tons of CO_2 per year depending on its conversion efficiency (these typically range between approximately 70-80%). Over time, the amount of MSW processed at the gasification facility would ideally decrease, but there would still be a net energy gain.

Moreover, Los Angeles in its 2015 Sustainable City pLAn intends to site an organic waste fermentation facility, which would be conducive to Santa Monica's goal of diverting more waste from landfill and enhancing composting efforts (City of Los Angeles Office of the Mayor, 2015). However, the plant would unlikely be able to process the capacity of organic waste generated in Santa Monica, so the city should consider siting its own composting facility to increase its diversion rate and reduce its GHG emissions. Determining which organic waste technology to use is another aspect to consider. Anaerobic digestion would allow the city to take advantage of a renewable energy source, but aerobic digestion requires less maintenance and compost production has a faster turnaround.

Based on Santa Monica's composting needs and limited space, HotRot is a feasible option. According to 2011 waste data, food scraps and yard waste accounted for 9,316 tons of the diverted waste stream, with 7,000 tons coming from the residential sector and 2,316 tons from the commercial (City of Santa Monica, 2014). Two HotRot systems processing 13 tons of organic waste per day (4,745 tons per year) each could provide the capacity to treat the City's current collection of organic waste and make high-quality compost. However, more units would need to be installed as composting rates increased.

The implementation of anaerobic digestion, on the other hand, would provide a source of energy for the city and would be able to processes organic waste equivalent to that of 12 HotRot units. According to Koop and Morris (2012), an Austrian study found that "the production of biomethane turned out to be the best way to make use of biowaste in terms of greenhouse gas emissions and in terms of the energy that can be produced." Furthermore, fermenting the waste reduces carbon-equivalent emissions significantly more than simply composting it, so in terms of climate impact, anaerobic digestion is a better option. Biomethane production can reduce C-e by 171 kilograms per ton of biowaste compared to 15-33 kg by composting (Koop & Morris, 2012). Many of these plants, such as DRANCO distributed by Organic Waste Systems, are in operation in countries such as Belgium and the Netherlands. And according to Baere and Mattheeuws (2012), by 2015 80% of composting facilities in these countries will use anaerobic digestion. In Santa Monica, 50,535 tons of organic, paper, and lumber waste are currently disposed of in landfills or incineration plants. This amount of organic waste, combined with the 9,316 tons already diverted, would amount to 59,851 tons of organic waste each year. If Santa Monica invested in this technology, the City could produce over 110 thousand MMBTU of renewable natural gas annually (City of Los Angeles, 2004). Based on citywide energy use data, the Santa Monica used 2.9 million MMBTU of natural gas in 2006. Thus, digestion alone cannot offset fossil natural gas consumption, but if combined with other technologies, the City could lessen its dependency on imported natural gas.

Furthermore, assuming the collection infrastructure is in place, a single DRANCO facility processing this amount of organic waste would increase the City's diversion rate to 91%. Accounting for improvements in the diversion of recyclables, the City would reach its goal of

95% diversion, assuming these facilities could handle the additional waste input due to population growth.

Additional opportunities lie in advanced recycling technologies that separate and process recyclables with high efficiency. However, large-scale changes will come primarily from policy change at higher levels of government, and the new directive by Mayor Garcetti of Los Angeles could be a step in the right direction. Some of the challenges Santa Monica will face in reaching zero waste in the near and long term include economic and political barriers, changing consumer behavior, acquiring the necessary funds for new waste treatment technologies, and dealing with waste already in landfills.


CONCLUSION
http://www.everystockphoto.com/photo.php?imageId=979536

CONCLUSION

REDUCTION POTENTIAL

SEEC-Clearpath California, a tool developed under the California Statewide Energy Efficiency Collaborative Program, was utilized to analyze the impacts of the report's recommended reduction strategies on Santa Monica's carbon emissions. This was compared against a BAU projection that takes into account state and federal, but not local, actions towards cutting carbon emissions.

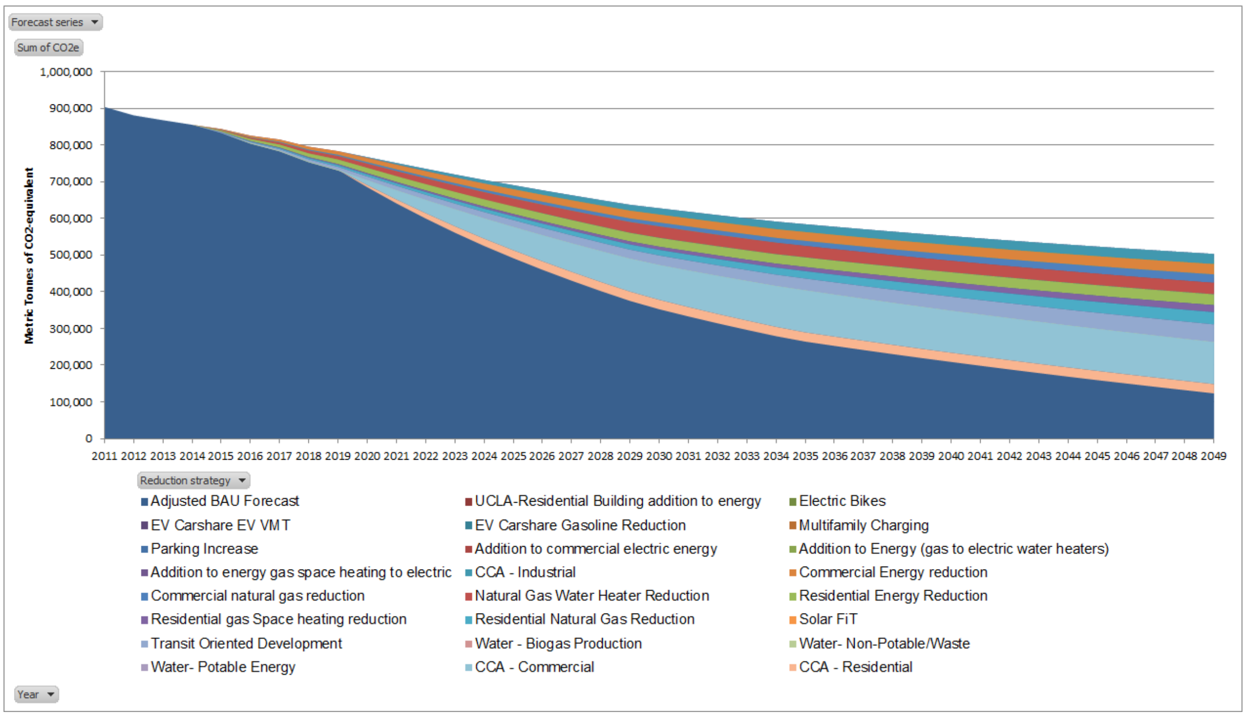


Figure 61: Wedge diagram of total emissions reductions (MTCO2e) and contributing reduction strategies from 2011-2050.

The City will achieve an 81.84% reduction in emissions below 1990 levels by 2050 assuming the recommended scenarios are implemented. This meets the City's previously publicized goal of an 80% emissions reduction below 1990 levels by 2050. The wedge diagram above details the breakdown of reductions by strategy, Figure 61.

The top 9 recommendations detailed in this report provide a cumulative emissions reduction of 10.38 million MTCO2e below a 2011 emissions baseline, Table 32. Implementation of a CCA accounts for 39% of this reduction, followed by residential natural gas reductions at 19% (Fig. 62). It is important to note that the solar FiT recommendation is not included in this analysis, because the generated solar power would not result in further emissions reductions when the grid electricity provided under the CCA is already emissions-free. Nonetheless, the solar FiT will be crucial in helping Santa Monica become self-sufficient in its water and energy needs, and the team recommends that the City implement it.

Table 29: Cumulative CO_2e reduction (in $MTCO_2e$) achieved by each of our top recommendations for the City, below 2011 levels.

Rank	Strategy Name	Cumulative CO2e reduction (MTCO2e)
1	Community Choice Aggregation (All Sectors)	-4,064,008
2	Residential Natural Gas Reductions	-1,980,823
3	Electric Vehicle Measures	-1,187,349
4	Transit Oriented Development	-1,005,530
5	Residential Electricity Efficiency	-781,863
6	Commercial Electricity Efficiency	-705,883
7	Commercial Natural Gas Reductions	-416,430
8	Parking Rate Increase	-242,522
Total		**-10,384,408**

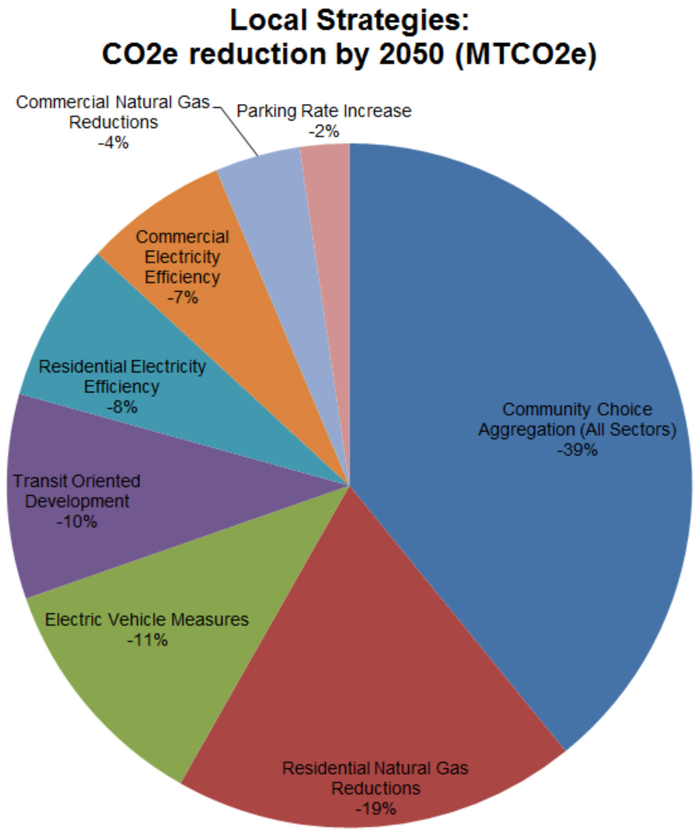


Figure 62: Pie chart showing proportion of CO_2e reductions achieved by each strategy, as a percentage of the sum total of emissions reductions achieved by the top recommendations.

Under the recommendation that the City adopts a stock-based approach to emissions reduction, the team calculated that Santa Monica has a recommended cumulative budget of 4,772,459 $MTCO_2e$ emissions into the future, based upon the IPCC global budget of 1 trillion $MTCO_2e$. Unfortunately, findings suggest that even with aggressive reduction strategies in place, Santa Monica will exceed that budget within the next five years. There is nonetheless a significant reduction of about 7.71 million $MTCO_2e$ in cumulative emissions with the recommended aggressive action to cut emissions, versus BAU projections, Table 33.

Table 30: Cumulative emissions (in MTCO2e) in our recommended stock-based goal based upon IPCC global budget, our BAU scenario and recommended scenario with reduction strategies implemented.

Cumulative Emissions (MTCO2e)	
IPCC 2-degree based goal	4,772,459
Without Recommended Strategies (BAU)	24,649,288
With Recommended Strategies	16,938,660

RECOMMENDATIONS

TRANSPORTATION

The largest source of Santa Monica's GHG emissions is from the transportation sector, which was responsible for 38% of the City's emissions in 2011 (City of Santa Monica, 2013). The City has to pursue policies that will cut the vehicle miles traveled in the City or reduce the carbon intensity of transportation options to reduce these emissions. Santa Monica should continue to develop its EV charging infrastructure in order to support an EV carshare program. EV carshare programs reduce the vehicle miles traveled by conventionally fueled vehicles and each car's accessibility can replace multiple privately owned vehicles. The charging infrastructure needed to sustain this program also encourages the adoption of EVs for personal car use by increasing the charging options available for private users. A fleet of 250 EV cars could cause a carbon dioxide reduction of up to 2,500 metric tons in Santa Monica. Autolib' and Car2go are two privately owned EV carshare services that are considering operating in the Greater Los Angeles area. Santa Monica should contact these services about expanding the home area to incorporate the City. These programs would require the development of extensive charging infrastructure, but should be implemented by 2017.

The City should also consider implementing changes in parking pricing and policy to economically incentivize citizens to use alternative modes of transportation. A significant increase in parking costs results in a decrease in vehicle miles traveled. Santa Monica should also consider the use of preferential permits for carpools, which would provide commuters cheaper parking options if they carpool to work. These programs could result in a three percent reduction in vehicle miles traveled, which could cut the City's emissions by 0.49%. The City has the ability to change parking prices in public lots and should implement parking changes in 2015.

Multifamily charging is a huge obstacle for Santa Monica to reduce private vehicle emissions since 70% of Santa Monica residents are renters. The City should consider modifying the CALGreen code to remove the voluntary aspect and increase the minimum percent of EV parking spaces in multifamily dwellings. This policy and the enforcement of AB2565 beginning July 1, 2015 will result in a three percent increase in EV purchase among Santa Monica residents, further reducing the vehicle miles traveled by conventionally fueled cars. The changes to CALGreen should be pursued immediately so that a change in the code can go into effect in 2017.

Currently, the Big Blue Bus operates on renewable natural gas. While this is a remarkable accomplishment for a municipal fleet, the BBB should continue to push for use of less carbon intensive fuels. Both electricity and hydrogen are prominent fuel sources for bus fleets. The city should evaluate whether or not these fuel sources are infrastructurally and financially feasible for the Big Blue Bus. The adoption of a cleaner fuel source would help significantly in reducing the emissions associated with an already relatively low GHG intensive mode of transit.

Congestion is a primary concern for Santa Monica. The addition of bus-only lanes has been proven to be an effective method of reducing transit times. Consequently, this will also increase ridership on public transit. Santa Monica should consider the implementation of bus only lanes on transit heavy streets. Previous proposals to add a bus-only lane on a portion of Lincoln Blvd were considered. Bus-only lanes are currently also being established on portions of Wilshire Blvd. By September 2015, the bus-only lane on Wilshire Blvd is anticipated to reach Centinela Avenue, right at the city line of Santa Monica. This may be an opportunity for Santa Monica to adopt a bus-only lane.

A bike share is already underway within the City. To enhance range and mobility within the city and hopefully beyond the city, the City should consider the integration of electric bikes with their next generation of bike share. Electric bikes provide many benefits including greater range and ability to more easily traverse varied topography. They also have the added environmental benefit of emitting zero GHG emissions. Santa Monica is an ideal venue for the electric bike with its sunny climate and varied topography is certain regions of the city.

Above all, Santa Monica will have to make long term investments in shaping the way its citizens live and transport themselves. The City is currently undergoing a housing shortage, relative to the number of jobs available in the city. As a result, many of its workers are left to commute in and out of the city on a regular basis. TOD will play a crucial role in the way Santa Monica evaluates its current land use patterns. Santa Monica should consider the development of more housing units, especially with the arrival of the Expo Line. There will be greater use and ability to maximize the environmental benefit of the line if more live closer to the line. To further maximize the benefits of the transit line, Santa Monica should invest early in TOD so that they can realize more of the cumulative GHG benefits over time.

ENERGY

South Bay Clean Power will be establishing a CCA by 2020; by joining it, Santa Monica has the opportunity to be at the forefront of a dynamic movement that began after energy shortages in the 1990s. Case studies have shown the benefits of a potential CCA in nearby South Bay cities (Hermosa Beach and Torrance), and CCAs currently established in Northern California have shown the possibilities of greenhouse gas emissions reductions (Marin Clean Energy and Sonoma Clean Power). The Hermosa Beach study predicted an abatement of 5,978 MT of CO_2 (Hampton, et al., 2014). If implemented in 2016, the Torrance study showed a sum of $17.83 million in savings, and 753 new jobs along with 214,245 tons of total averted greenhouse gas emissions in the most conservative scenario of a 33% renewable energy mix (Armour, et al., 2014). Marin Clean Energy has secured enough resources for multiple levels of renewable energy opt-in levels, including a 100% local solar option. The CCA's incentivization of feed-in tariff programs has also stimulated small-scale renewable energy projects that currently power thousands of households (Marin Clean Energy, 2013). Sonoma Clean Power has also established itself as a legitimate competitor to PG&E in terms of lower rates and greater percentages of renewable energy (Sonoma Clean Power, 2013).

Santa Monica would do well by learning from these CCA models and by being an active participant in the South Bay Clean Power CCA creation process in order to achieve similar results. Rates would be set to rival that of Southern California Edison, more reliable electricity would come from decarbonized sources, and consumers would have more of a say in where their electricity comes from by solidifying their citizen agency as residents of Santa Monica.

The city has little potential for wind DG within its boundaries, but significant potential for solar energy generation via rooftop solar PV panels. As of 2014, the City of Santa Monica has a total of 4.53 MW of solar capacity installed, versus a theoretical potential solar output of 257 MW. This translates to 383,300 GWh/yr, or 46.3% the city's annual electricity needs as of 2013, (DeShazo, Matulka & Wong, 2011), which serves to illustrate the solar potential of the city.

The implementation of a feed-in-tariff (FiT) has helped increase Germany's renewable energy generation exponentially, turning her into the world's leader in solar generation within one and a half decades. Santa Monica can learn from this case study and implement an FiT under its CCA. An FiT offers renewable energy generators long-term price guarantees for the energy that they export into the grid. Using estimates based off Germany's solar PV generation growth after the implementation of their FiT and scaling it to Santa Monica's scenario, we can expect about 130 MW of additional installed solar PV capacity by 2050, assuming the FiT is implemented in 2020. This translates to a total of about 236 GWh of clean, emissions-free electricity generated annually in 2050, or about 28.5% of the city's 2013 electricity consumption (Southern California Edison 2014).

INFRASTRUCTURE

Currently buildings account for 36% of the energy and 65% of the electricity that is consumed within the United States (U.S. Green Building Council, 2011). Within California specifically buildings use consume around 70% of the state's electricity and 55% of its natural gas (CEC, 2015). Overall buildings contribute approximately 30% of the total GHG emissions within the country and 20% within the state (CEC, 2015).

The Building sector can be split into three different categories: single family homes, multifamily homes, and commercial buildings. Among the residential tract, single family homes hold the highest amount of potential energy savings at nearly 80% (Navigant Consulting, 2014). A majority of the energy that is consumed within single family residential homes is from lighting, appliances, and other various plug loads (CEC, 2015). Multifamily homes, on the other hand, have most of their energy consumed through space heating (22%) and water heating (39%) (CEC, 2015). Commercial buildings that have refrigeration systems such as restaurants currently consume the most energy, but it is areas such as lighting, roofs, and HVAC systems that possess the highest amounts of potential savings for nonresidential buildings (CEC, 2015).

For Santa Monica to reduce the GHG emissions from buildings they will need to focus on increasing building efficiency in existing buildings, especially those built prior to 1978 as efficiency standards had not been implemented before then (CEC, 2015). Since there are no laws forcing existing buildings to be upgraded, however, it will be up to Santa Monica to find ways convince residents to perform building retrofits. This task may prove to be especially challenging for Santa Monica as every within the building sector comes with their own set of challenges.

One of the largest challenges for single family homes is educating homeowners on the efficiencies of their homes and where improvements could be made. Along with this Santa

Monica will also have to find ways to incentivize homeowners to apply the knowledge into retrofits as most homeowners view retrofits as being too costly with too few benefits (Fuller, *et al*., 2010). These challenges also carry over to the multifamily sector, but with this section Santa Monica has the added difficulty in that a majority of people who live in multifamily homes have no influence over renovations that occur within the building. Any changes made to a multifamily housing unit are typically decided upon by the landlord or building owner, not the tenants. Multifamily buildings also bring with the added social issues such as differences in race, culture, class, and education among the different tenants which could hinder any retrofitting projects within the building, particularly when dealing low-income tenants. The challenges associated with commercial buildings lie mainly in the fact that these buildings typically have multiple owners and consumers all of whom may have different needs and desires.

Building retrofits can be costly to the extent that even if tenants and homeowners wanted to have a retrofit performed many not be able to afford the project. Therefore, finding ways to reduce the costs associated with retrofits could prove to be extremely beneficial for Santa Monica. One way in which this could be done is to have energy costs within Santa Monica be raised. This action would not only make the energy savings potential from building upgrades more attractive for homeowners, but the funds generated from increasing the costs of energy could be used to implement various city programs around building efficiency education or building retrofits themselves.

In terms of new construction, Santa Monica need only follow that California state code whose standards for buildings are becoming extremely stringent. By following these codes all new buildings constructed within Santa Monica from 2030 onward will be net zero energy (Fogel, 2013).

WATER

Out of all the other sectors, water contributes the lowest amount to Santa Monica's GHG inventory, though it represents a large portion of municipal spending and greater municipal influence for reducing GHGs. Santa Monica's Urban Water Management Plan and Sustainable Water Master Plan served as the basis for the recommendations made in this report. Santa Monica has to "close the gap" of 6,500 AFY in order to reach self-sufficiency. The City plans on reaching that goal using conservation programs, rain harvesting, SMURRF recycled water, and increasing annual groundwater volumes (SWMP, 2014). Additional options for Santa Monica were analyzed in this report including additional treatment plants and desalination.

Opportunities for Santa Monica's water sector exist in the addition of more groundwater wells, operating SMURRF year round and expanding the water being treated there, extending the non-potable uses of SMURRF's recycled water, and improvements to treatment processes at existing treatment plants, such as Arcadia and SMURRF. The more hard to reach opportunities include renewable biogas generation from the treatment of wastewater, which could generate between 7,630,618.509 to 12,208,989.614 kWh per year. And recommendations determined infeasible for Santa Monica are additional water or wastewater treatment plants due to space and the desalination of seawater due to environmental concerns. GHG implications of each recommendation must be taken into consideration since Santa Monica has a dual goal of water self-sufficiency and GHG reduction.

Even though Santa Monica does not have available space to accommodate a wastewater treatment plant, which presents an opportunity for biogas generation, the City is recommended to look into the possibility of partnering with adjacent cities for wastewater. In turn, Santa Monica would be able to claim the renewable energy offsets created by such a partnership. The option of renewable energy generation is even more desirable after calculating the energy intensities of Santa Monica's water supply. SMURRF water has the highest energy unit per unit of water (33,346.44 kWh/MG) , but the City is recommended to increase the amount of water treated at SMURRF through the usage of large cisterns. SMURRF currently does not have the capacity to treat stormwater during rain events. Cisterns allow the City to store stormwater so it does not have to be treated all at once, but treated based on the available capacity at SMURRF. This setup will allow SMURRF to operate yearlong rather than limited to dry urban runoff.

After SMURRF, Santa Monica's imported water, with supply and conveyance, is the second most energy intensive source in terms of unit of energy per unit of water (9,050.52 kWh/MG). By reducing the City's dependence on imported water from MWD, Santa Monica is reducing GHG emissions and increasing its water self-sufficiency. Supply and conveyance of imported water normally would not be included in a city's boundaries, but it is important for Santa Monica to visualize the decrease in GHG as a result of importing less water and relying on local sources.

Groundwater energy intensity is below imported water (with supply and conveyance) and SMURRF with 4,142.67 kWh/MG. Santa Monica has already made plans to extend groundwater volumes, which should be a priority for the City since it has lower GHG emissions than SMURRF recycled water and is an excellent source of local water. However, there is a limit to how much water can be safely yielded from the Santa Monica Basin so preparations should be made now to improve SMURRF's energy efficiency and potential biogas generation.

WASTE

Although the waste sector only represents one twentieth of Santa Monica's total GHG emissions, reaching zero waste will require significant improvements to the City's infrastructure and changes in consumer behavior. However, advances in the waste sector will contribute to GHG reductions in other sectors as well, such as transportation and energy, so investing in waste reduction programs and waste technologies will help the City reach its overall GHG reduction goal. In 2011, Santa Monica spent $9.5 million processing and disposing waste, not including transportation cost to haul it to landfills (Rohit, 2011). These costs, along with the GHG emissions associated with transporting and handling the waste, could be offset by changing how we dispose of it. Furthermore, the 82,997 tons of MSW that are disposed of has an energy potential of roughly 91.2 million kWh of electricity per ton each year, assuming 250 tons of waste are processed each day (GTC, 2011).

The City should continue to develop its behavioral change marketing schemes, as well as augment programs that promote recycling and composting. Reducing the volume of waste by encouraging reuse and facilitating diversion is paramount to GHG reduction efforts. In addition, placing the burden of disposal on the producer with take-back policies will encourage more eco-friendly packaging, which will be less toxic and difficult to dispose of. These initial strategies will facilitate the implementation of advanced waste technologies, which require sufficient levels of separation.

Siting a gasification facility would be a worthy investment for Santa Monica, not to mention the payback period is considerably small when you take into account revenues generated from energy sales, tipping fees (waste processing fee), and recyclables (Dodge, 2015). Furthermore, because the gasification processes favors recycling, the plant would facilitate in the diversion of 11,837 tons of recyclable waste that is currently sent to landfill or incineration. Subtracting the amount recycled along with the diversion of organic waste (50,535 tons) would result in only 20,625 tons being gasified, 6% of the entire waste stream. With an input of 230 tons, a gasification plant could generate 110 therms per ton each day (Carlton, 2012). Based on energy data, only 29 therms of natural gas were used in 2006, so a gasification facility would significantly augment the availability of alternative fuel within the City (City of Santa Monica, 2015).

Moreover, the City should consider siting its own composting facility to increase its diversion rate and reduce its GHG emissions. The implementation of anaerobic digestion would provide both a source of energy for the city and high quality compost for agriculture. Furthermore, fermenting the waste reduces carbon-equivalent emissions significantly.

Biomethane production can reduce C-e by 171 kilograms per ton of biowaste (Koop & Morris, 2012). Many of these plants, such as DRANCO, are in operation in countries such as Belgium and the Netherlands. In Santa Monica, 50,535 tons of organic, paper, and lumber waste are currently disposed of in landfills or incineration plants. This amount of organic waste, combined with the 9,316 tons already diverted, would amount to 59,851 tons of organic waste each year. If Santa Monica invested in this technology, the City could produce 43,656 MMBTU of Biogas. Furthermore, assuming the collection infrastructure is in place, a single DRANCO facility processing this amount of organic waste would increase the City's diversion rate to 91%. Accounting for improvements in the diversion of recyclables, the City would reach its goal of 95% diversion, assuming these facilities could handle the additional waste input due to population growth.

Additional improvements would require incorporating advanced recycling technologies in order to separate and process recyclables with high efficiency. However, changes in the City's infrastructure will be subject to policy change at higher levels of government. Some of the challenges Santa Monica will face in reaching zero waste in the near and long term include economic and political barriers, changing consumer behavior, acquiring the necessary funds for new waste treatment technologies, and dealing with waste already in landfills.

REFERENCES

Ackermann, T., Andersson, G., & Söder, L. (2001). Distributed generation: A definition. Electric power systems research: 57(3), 195-204.

Alternative Fuels Data Center. (n.d). Renewable Natural Gas (Biomethane). *U.S Department of Energy.*

Amos, A., & Berntson, E. (1999). Turning up the heat: How global warming threatens life in the sea. Redmond, Wash. Marine Conservation Biology Institute

Amstalden, R. W., Kost, M., Nathani, C., & Imboden, D. M. (2007). Economic potential of energy-efficient retrofitting in the Swiss residential building sector: The effects of policy instruments and energy price expectations. *Energy Policy*: *35*(3), 1819-1829.

Archer, D., H. Kheshgi, and E. Maier-Reimer. (1998). The dynamics of fossil fuel CO2 neutralization by marine CaCO3. Global Biogeochem. Cycles 12:259-276. http://geosci.uchicago.edu/~archer/reprints/gbc98/neutral_gbc.pdf

Archer, D., and A. Ganopolski. (2005). A movable trigger: Fossil fuel CO2 and the onset of the next glaciation. Geochem. Geophys. Geosys. 6(Q05003). Retrieved from http://geosci.uchicago.edu/~archer/reprints/archer.ms.next_ice_age.pdf

Arena, U. (2012). Process and technological aspects of municipal solid waste gasification. A review. *Waste Management*: 32(4), 625-639. doi:10.1016/j.wasman.2011.09.025

Armour, N., Montgomery, A., Kong, D., and Yang, Q. (2014). Community Choice Aggregation in Torrance, CA. USC Sol Price School of Public Policy.

Atkins. (2013). *City of Santa Monica Bergamot Transit Village Center EIR*. Retrieved from http://www.smgov.net/PDFPagesHandler.ashx/439/452/uploadedFiles/Departments/PCD/Environmental-Reports/Bergamot-Transit-Village-Draft-EIR.pdf

Autolib'. (2011). An urban revolution. Retrieved from https://www.autolib.eu/en/our-commitment/urban-revolution/

Bates Magazine. (2010). Power by the People. *Bates Magazine News*. Web. Accessed May 2015.

Benningfield Group. (2010). Overlooked and untapped: Unlocking the energy-efficiency potential in multifamily housing. NOTE: This report uses a mix of national and CA centric data sets.

Bottles, S. (1987). Los Angeles and the Automobile the Making of the Modern City. Berkeley: University of California Press.

Bradley, R. (2011). Global warming and political intimidation: How politicians cracked down on scientists as the earth heated up. Amherst: University of Massachusetts Press.

Brebbia, C. (2014). Urban Transport XX. WIT Press.

Brown, L. (2006). Plan B 2.0: Rescuing a planet under stress *and a civilization in trouble* (p. 168). New York: W.W. Norton &.

Brown, J. (2015). Executive Order B-29-15. Executive Department State of California.

Burgie, B. & Crandall, K. (2009). The Application of Feed-in Tariffs and Other Incentives to Promote Renewable Energy in Colorado. Denver: Colorado Public Utilities Commission.

California Air Resources Board. Sustainable Santa Monica. Accessed 27 April, 2015. Retrieved from http://www.coolcalifornia.org/case-study/sustainable-santa-monica

California Building Standards Commission. (2014). California Green Building Standards Code (Part 11 of Title 24, California Code of Regulations).

California Energy Commission. (2004). *Water and Wastewater Industry Energy Efficiency: A Research Roadmap.*

California Energy Commission. (2014). Building Energy Efficiency Standards For Residential and Nonresidential Buildings: Title 24 Part 6.

California Energy Commission. (2015). Energy Efficiency: California's Existing Building Energy Efficiency Action Plan. Retrieved from http://www.energy.ca.gov/ab758/documents/index.html

California Environmental Protection Agency (CalEPA). (2011). State Joins Santa Monica-Malibu Unified School District to Announce its Implementation of Environmental Curriculum. Retrieved from http://www.calepa.ca.gov/pressroom/Releases/2011/Santa%20Monica.pdf

California Environmental Protection Agency Air Resources Board. (n.d.). Assembly Bill 32 Overview. Retrieved from http://www.arb.ca.gov/cc/ab32/ab32.htm

California Legislative Information (2009). SB-523 Solar Feed-in Tariff Pilot Program. Retrieved from http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100SB523. Last accessed on May 12, 2015.

California Sustainability Alliance. (2015). Multifamily Housing Opportunity. Managed by Navigant Consulting

Cambridge Systematics. (2009). Moving Cooler An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. Washington, D.C.: Urban Land Institute.

Car2go. (2014). *A free floating car sharing solution for Copenhagen and Frederiksberg*. Retrieved from http://www.frederiksberg.dk/~/media/eDoc/2/5/7/2578828-2755482-1-pdf.ashx

Carballo, L. M., Leon, P., Ramis, I., & Bravo, P. (2014, January). BiciMAD and the rise of the bicycle in Madrid. Madrid, Spain: National Congress of the Environment.

Challenging Lock-in Through Urban Energy Systems (CLUES). (2012). Making energy efficiency and innovation pay: an example of Kungsbrohuset office building, Stockholm, Sweden Workshop Summary Report. https://www.ucl.ac.uk/clues/files/Stockholm_report

Chester, M., Pincetl, S., Elizabeth, Z., Eisenstein, W., & Matute, J. (2013). Infrastructure and automobile shifts: Positioning transit to reduce life-cycle environmental impacts for urban sustainability goals. *Environ. Res. Lett.* Environmental Research Letters, 015041-015041.

Chiaro, B. (2013). California More Than Doubles Solar Power Market In 2013. *Solar Industries Magazine.* Retrieved from http://solarindustrymag.com/e107_plugins/content/content.php?content.13637.

City of Copenhagen. (2009). The Technical and Environmental Administration. http://www.energycommunity.org/documents/copenhagen.pdf

City of Copenhagen. (2012). CPH 2025 Climate Plan. Retrieved from http://kk.sites.itera.dk/apps/kk_pub2/pdf/983_jkP0ekKMyD.pdf .

City of Copenhagen. (2012a). Waste Management Plan 2012. Retrieved from https://subsite.kk.dk/Nyheder/2009/April/~/media/30EC1D727EBE4A909908CCA9EBBF3D97.ashx

City of Los Angeles Bureau of Sanitation. (2004). Brecht II DRANCO – anaerobic digestion facility. Retrieved from http://lacitysan.org/solid_resources/strategic_programs/alternative_tech/PDF/AnaerobicDigestionFacility.pdf

City of Los Angeles Office of the Mayor. (2015). Plan: Transforming Los Angeles. Retrieved from https://d3n8a8pro7vhmx.cloudfront.net/mayorofla/pages/17002/attachments/original/1428470093/pLAn.pdf?1428470093

City of Santa Monica. (1997). Parks and Recreation Master Plan. Santa Monica, CA: City of Santa Monica.

City of Santa Monica. (2006). Creative Capital: Culture, Community, Vision. Retrieved from http://www.smgov.net/uploadedFiles/Portals/Culture/Resources/SM%20Creative%20Capital%20Plan.pdf

City of Santa Monica. (2011). Santa Monica Bike Action Plan. ES-3.

City of Santa Monica. (2013). 15x15 Climate Action Plan. Retrieved from http://www.smgov.net/uploadedFiles/Departments/OSE/Home_Page_Item_with_Image/CAP_Final.pdf

City of Santa Monica. (2013). City of Santa Monica: Zero waste strategic operations plan. Retrieved from http://www.smgov.net/departments/council/agendas/2013/20130319/s2013031904-A-1.pdf

City of Santa Monica. (2014). Sustainable City Plan: City of Santa Monica. Retrieved from http://www.smgov.net/uploadedFiles/Departments/OSE/Categories/Sustainability/Sustainable-City-Plan.pdf

City of Santa Monica. (2014a). Human Services Grants Program: FY 2011-15. Retrieved from http://www.smgov.net/uploadedFiles/Departments/CCS/About/Divisions/Human_Services_Grants_Program_2011-15.pdf

City of Santa Monica. (2015). City of Santa Monica. Retrieved from http://www.smgov.net

City of Santa Monica. (2015a). Expo Integration Study. Santa Monica, CA: City of Santa Monica.

City of Seattle. (2014). 2012 Seattle Community Greenhouse Gas Emissions Inventory.

City of Stockholm. (2007). Stockholm action plan for climate and energy. Retrieved from http://carbonn.org/uploads/tx_carbonndata/StockholmActionPlanForClimateAndEnergy2010-2020[1].pdf

City of Stockholm. (2012). The Stockholm Environment Programme 2012-2015. Retrieved at http://international.stockholm.se/globalassets/ovriga-bilder-och-filer/the-stockholm-environment-programme-2012-2015.pdf. Last accessed 12/17/14.

City of Stockholm. (2013). Stockholm Plan for Climate and Energy 2012-2015, with an outlook to 2030.

City of Stockholm. (2013a). Waste Management Plan for Stockholm 2013-2016. Retrieved from http://www.stockholm.se/avfallsplan

Cohen, N. (2011). Green cities an A-to-Z guide. p. 215-216. Thousand Oaks, CA: Sage.
Cohen, Y. (2009). *Graywater- A Potential Source of Water*.

Copenhagen (CPH) Climate Plan. (2009). Copenhagen Climate Neutral by 2025. Retrieved from http://www.energycommunity.org/documents/copenhagen.pdf

The Copenhagenize Index 2013. (2013). Retrieved May 19, 2015, from http://copenhagenize.eu/index/index.html

Danish Architecture Centre (DAC). (n.d). "Copenhagen: Cities Can Run on Wind Energy." *Sustainable Cities*. 21 Jan. 2014. Web.

Darghouth, N. et al. (2012). Tracking the sun IV: an historical summary of the installed cost of photovoltaics in the United States from 1998 to 2010. Published by Lawrence Berkeley National Laboratory.

Davidson C., Daniel S., and Robert M. (2015). Exploring the market for third-party-owned residential photovoltaic systems: insights from lease and power-purchase agreement contract structures and costs in California. *Environmental Research Letters,* 10.2: 024006.

DeShazo J.R., Matulka R. & Wong N. (2011). Los Angeles Solar Atlas. UCLA Luskin School of Public Affairs.

Dodge, E. (2015). Plasma gasification: Clean renewable fuel through vaporization of waste. Retrieved form http://www.waste-management-world.com/articles/print/volume-10/issue-4/features/plasma-gasification-clean-renewable-fuel-through-vaporization-of-waste.html

Donegan, S., Smith, G., & Llc, E. (2012). Greenhouse Gas Emissions in King County.

EcoCorp. (2000). Technology. Retrieved from http://www.ecocorp.com/Technology.html

EHPE. (2015). Brista II. Retrieved from http://www.ehpa.org/technology/best-practices/large-heat-pumps/brista-ii/

El-Khattam, W., & Salama, M. M. A. (2004). Distributed generation technologies, definitions and benefits. Electric power systems research, 71(2), 119-128.

Emanuel, K. (2006). Hurricanes: Tempests in a greenhouse. *Physics Today Phys. Today,* 74-75.

Energy Star. (2009). A Guide to Energy-Efficient Heating and Cooling. Retrieved from http://www.energystar.gov/ia/partners/publications/pubdocs/HeatingCoolingGuide%20FINAL_9-4-09.pdf

Envac. (2012). FAQ: The Stationary Vacuum System. Retrieved from http://www.envac.us/products-services/our_technology_2_2_2/faq_stationary_vacuum_systems_1_2_2

Envac. (2015). Self-Emptying Litterbins. Retrieved from http://www.envac.us/products-services/our_products_1_2_2/self-emptying-litterbins

Environmental and Energy Study Institute. (2013). Fact Sheet: Landfill Methane. Retrieved from http://www.eesi.org/papers/view/fact-sheet-landfill-methane

EPA. (1998). Transportation Control Measures: Bicycle and Pedestrian Programs. *TRAQ Technical Overview,* 2-3. Retrieved May 19, 2015, from http://www.epa.gov/otaq/stateresources/rellinks/docs/S98002.pdf

EPA. (2007). Atmospheric Concentrations of Greenhouse Gases.

EPA. (2012). State of Practice for Emerging Waste Conversion Technologies. Retrieved from http://nepis.epa.gov/Adobe/PDF/P100FBUS.pdf

EPA. (2014). Climate Change and Waste. Retrieved from http://epa.gov/climatechange/climate-change-waste/

EPA. (2014a). Energy Recovery From Waste. Retrieved from http://www.epa.gov/waste/nonhaz/ municipal/wte/

EPA. (2014b). Greenhouse Gases. Retrieved from http://epa.gov/climatechange/ghgemissions/gases/ch4.html

EPA. (2015). LFG Energy projects. Retrieved from http://www.epa.gov/lmop/faq/lfg.html

EPA. (n.d). "Causes of Climate Change."Web.

EPA. (n.da). Combined Heat and Power Partnership. *Biomass CHP Catalog.*

EPA. (n.db). Interactive Units Converter. *Coalbed Methane Outreach Program (CMOP)*.

EPA. (n.dc). *Reducing Urban Heat Islands : Compendium of Strategies Green Roofs*.

European Commission (2012). Waste Production and Management. Retrieved from http://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2012/07/Section-7-Waste-production_Copenhagen.pdf

Feely, R., & Doney, S. (2008). Ocean Acidification: The Other CO2 Problem. *Limnol. Oceangr. E-Lectures Limnology and Oceanography E-Lectures*.

Feller, G. (2015). Waste Management World. Dutch Successes. Retrieved from http://www.waste-management-world.com/articles/print/volume-11/issue-1/features/dutch-successes.html

Fogel, Ca. (2013). California's Zero Net Energy Policies and Initiatives: NASEO Getting to Zero Conf. Powerpoint Presentation. Retrieved from http://www.cpuc.ca.gov/NR/rdonlyres/C27FC108-A1FD-4D67-AA59-7EA82011B257/0/3.pdf

Fraunhofer ISE (2010). Evaluation of different feed-in tariff design options – Best practice paper for the International Feed-In Cooperation. Freiberg, Germany: Fraunhofer Institute for Solar Energy Systems ISE.

Fraunhofer ISE (2015). Recent Facts about Photovoltaics in Germany. Freiberg, Germany: Fraunhofer Institute for Solar Energy Systems ISE.

Fulton, M., & Mellquist, N. (2011). The German feed-in tariff for PV: Managing volume success with price response. Deutsche Bank Group.

GAIA. (2012). Incinerators: Myths vs. Facts About "Waste to Energy." Retrieved from http://www.no-burn.org/downloads/Incinerator_Myths_vs_Facts%20Feb2012.pdf

Gasification Technologies Council (GTC). (2011). Gasification: The Waste-To-Energy Solution. Retrieved from http://www.gasification.org/uploads/downloads/GTC_ Waste_to_ Energy.pdf

Gasification Technologies Council (GTC). (2015). Waste gasification. Retrieved from http://www.gasification.org/gasification-applications/waste/

Gattuso, J. (2011). *Ocean acidification*. Oxford, England: Oxford University Press.

Gerdes, Justin. (2012). "Copenhagen's Seawater Cooling Delivers Energy And Carbon Savings." *Forbes*. Forbes Magazine.

Glasnapp, J., Du, H., Dance, C., Clinchant, S., Pudlin, A., Mitchell, D., & Zoeter, O. (2014). Understanding dynamic pricing for parking in Los Angeles: survey and ethnographic results. *Lecture Notes in Computer Science*, *8527*, 316-327.

Go Solar California website. Retrieved from http://www.gosolarcalifornia.ca.gov/csi/ rebates.php. Last accessed on May 12, 2015.

Goldman, C., Greely, K., & Harris, J. (1988). Retrofit experience in US multifamily buildings: Energy savings, costs, and economics. *Energy*, *13*(11), 797-811.

Green Outlook 2011, Green Trends Driving Growth. McGraw Hill Construction. (2011). Gustafsson, S. I., & Karlsson, B. G. (1989). Life-cycle cost minimization considering retrofits in multi-family residences. *Energy and Buildings*, *14*(1), 9-17.

Groves, M. (2011). Placards can bring a curbside surprise. *Los Angeles Times*. Retrieved from http://articles.latimes.com/2011/may/22/local/la-me-disabled-parking-20110522

Hales, R. (2014). California's 'monopoly protection act, AB 2145, is dead. *CleanTechnical*. Web.

Hammond, Becky. (2009). Trash Planet: The Netherlands. Retrieved from http://www.earth911.com/earth-watch/trash-planet-the-netherlands/

Hampton, Jessi, Jonathan Ho, Jessica Leigh, David Limjoco, Steven Odom, Francis Villanueva, and Adrian Salazar. (2014). The city of Hermosa Beach: Assessing community choice aggregation. Rep. UCLA Institute of the Environment and Sustainability. Web.

HotRot Organic Solutions. (2013). http://www.hotrotsolutions.com

Houghton, J. (2001). *Climate change 2001: The scientific basis : Contribution of Working Group I to the third assessment report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Huenteler J, Schmidt ST, Kanie N. (2010). Japan's post Fukushima challenge-implications from the German experience on renewable energy policy. *Energy Policy*; 45:6–11.

Hymon, S. (2014, May 12). Bikes and walking transit = lower greenhouse gas emissions. Retrieved May 20, 2015, from http://thesource.metro.net/2014/05/12/bikes-and-walking-transit-lower-greenhouse-gas-emissions/

ICLEI. (2013). U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions.

Intergovernmental Panel on Climate Change (2014). Fifth Assessment Report.

Intergovernmental Panel on Climate Change, issuing body. (2015). *Climate change 2014: Synthesis report : longer report*.

IPCC. (2001). Climate change 2001: The scientific basis (third assessment report). Cambridge, UK: Cambridge University Press

Jordan, L. (2015). Waste Management World. The Gasification Debate. Retrieved from http://www.waste-management-world.com/articles/print/volume-14/issue-4/trash-talking/the-gasification-debate.html

Kennedy/Jenks Consultants. (2015). *Water Rate and Revenue Plan City of Santa Monica, Water Resources Division*.

Khan, S. (2013). *Drinking Water Through Recycling*.

King, E. F. (2013, February 7). Lincoln Boulevard Bus Only Lane [Press release].

Klein, G., & Krebs, M. (2005). California's Water – Energy Relationship.

Kubani, D. (2011). City Council Report: Strategy for a Sustainable Local Economy. Retrieved from http://www.smgov.net/departments/council/agendas/2011/20111101/s2011110104-B.htm

Kubani, D. (2012). City Council Report: Addition of Arts and Culture Goal Area to the SCP. Retrieved from http://www.smgov.net/departments/council/agendas/2012/20120508/s2012050808-B.htm

Lahnsteiner, J., & Lempert, G. (2007). Water management in Windhoek, Namibia. *Water Science & Technology*, *55*(1-2), 441. http://doi.org/10.2166/wst.2007.022

Larios, D. (2014). "Santa Monica Opposes State Changes to Energy Rights." *Santa Monica Opposes State Changes to Energy Rights*. Santa Monica Lookout.

Legislative Analyst's Office (LAO). (2013). Population Centers Rely Heavily on Imported Water. *2013 Cal Facts.*

"Local Power." *Community Choice Aggregation - Definition by CCA Inventor Local Power Inc.* N.p., 2015. Web. May 2015.

Lowe, M., Aytekin, B., & Gereffi, G. (2009). Public Transit Buses: A Green Choice Gets Greener. In *Manufacturing Climate Solutions Carbon-Reducing Technologies and U.S. Jobs*. Durham: Center on Globalization, Governance & Competitiveness.

Ma, Z., Cooper, P., Daly, D., & Ledo, L. (2012). Existing building retrofits: Methodology and state-of-the-art. *Energy and buildings*, *55*, 889-902.

Marin Clean Energy. (2014) "Revised Community Choice Aggregation Implementation Plan and Statement of Intent." Marin Clean Energy. Web. May 2015.

Marin Clean Energy. (2014). Marin Clean Energy: Integrated Resource Plan Annual Update. Print.

Merrian C. Fuller, et al. (2010). Driving Demand for Home Energy Improvements. Berkeley: LBNL, p. 23; Lowell Ungar, Rodney Sobin, Neal Humphrey, et al, Guiding the Invisible Hand: Policies to Address Market Barriers to Energy Efficiency, paper presented at ACEEE Summer Study on Energy Efficiency in Buildings, p. 6-324.

Milios, Leonidas. (2013). Municipal Waste Management in the Netherlands. PDF

Mount, J., Freeman, E., & Lund, J. (2014). Water Use in California.

Mountlake Terrace. (2010). *Chapter 19.126 electric vehicle infrastructure*. Retrieved from http://www.codepublishing.com/WA/MountlakeTerrace/#!/MountlakeTerrace19/MountlakeTerrace19126.html

Nahlik, M., & Chester, M. (2014). Policymaking Should Consider the Time-dependent Greenhouse Gas Benefits of Transit-oriented Smart Growth. *Transportation Research Board*.

Nahlik, M., & Chester, M. (2014). Transit-oriented smart growth can reduce life-cycle environmental impacts and household costs in Los Angeles. *Transport Policy,* 21-30.

Navigant Consulting. (2014). 2013 California Energy Efficiency Potential and Goals Study, page 164. Retrieved from http://www.cpuc.ca.gov/NR/rdonlyres/29ADACC9-0F6D-43B3-B7AA-C25D0E1F8A3C/0/2013CaliforniaEnergyEfficiencyPotentialandGoalsStudyNovember262013.pdf

NeighborGoods. (2013). City of Santa Monica Swap or Share. *Sugar Packet Inc.* Retrieved from http://neighborgoods.net/groups/city-of-santa-monica-shares

Normander, Bo. (2012) "Copenhagen Aspires to Be the First Carbon Neutral Capital in the World." *Worldwatch Institute*.

Office of Energy & Sustainable Development. (2014). Berkeley Climate Action Plan 2014 update. Retrieved from http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/CAP%20Work%20Session_2014_current.pdf

Office of Governor Edmund G. Brown Jr. (n.d.). Executive Order B-16-2012. Retrieved form http://gov.ca.gov/news.php?id=17508

Office of Governor Edmund G. Brown Jr. (n.d.). Executive Order B-18-12. Retrieved from http://gov.ca.gov/news.php?id=17508

Office of Sustainability and the Environment. (2010). Average vehicle ridership. Retrieved from http://www.smgov.net/Departments/OSE/Categories/Sustainability/Sustainable_City_Progress_Report/Transportation/Average_Vehicle_Ridership.aspx

Office of Sustainability and the Environment. (2014). Jobs/Housing Balance. Retrieved May 20, 2015, from http://www.smgov.net/Departments/OSE/Categories/Sustainability/Sustainable_City_Progress_Report/Economic_Development/Jobs_-_Housing_Balance.aspx

Office of Transportation and Air Quality. (2013). Fast facts: U.S. transportation sector greenhouse gas emissions 1990-2011. Retrieved from: http://www.epa.gov/oms/climate/documents/420f13033a.pdf

OnTheMap. (n.d.). Retrieved May 20, 2015, from http://onthemap.ces.census.gov/

Oxford e-Research Centre. (2015, May 11). TrillionthTonne.org. Retrieved May 11, 2015, from http://trillionthtonne.org/

Pastucha, M. (2013). Sustainable Water Master Plan Status Update 2013.

Pastucha, M. (2014a). *Attachment A: Sustainable Water Master Plan Executive Summary*.

Pastucha, M. (2014b). Sustainable Water Master Plan Update 2014, (January).

Polakoff, J. (2015, May 14). Car2go hits the road. *Easy Reader News*. Retrieved from http://www.easyreadernews.com/96506/car2go-hits-the-road/

Resource Recovery and Recycling Division. (9 March, 2015). Interview

Rohit, P. (2011). Santa Monica Mirror. Santa Monica's Expensive Trash Bill. Retrieved from http://www.smmirror.com/articles/News/Santa-Monicas-Expensive-Trash-Bill/32528

Rosemain, M., & Mawad, M. (2015, January 28). Billionaire Bollore looks at car-sharing Los Angeles unit. *Bloomberg Business*. Retrieved from http://www.bloomberg.com/news/articles/2015-01-28/billionaire-bollore-eyes-los-angeles-in-car-sharing-expansion

Rygaard, M., Binning, P. J., & Albrechtsen, H.-J. (2011). Increasing urban water self-sufficiency: new era, new challenges. Journal of Environmental Management, 92(1), 185–94. http://doi.org/10.1016/j.jenvman.2010.09.009

SA Associates. (2010). City of Santa Monica Urban Water Management Plan.

Salian, P., & Anton, B. (2011). Making urban water management more sustainable : Achievements in Berlin. SWITCH, 1–27.

Santa Monica Municipal Code. (2015). Article 8: Building Regulations. Retrieved from http://qcode.us/codes/santamonica/view.php?&frames=on

Santa Monica Office of Sustainability and the Environment. By Santa Monica City Council. N.p., 13 Jan. 2015. Web.

Santa Monica Office of Sustainability and the Environment. (2015). *Community Choice Aggregation Feasibility Study - City of Santa Monica*. By Dean Kubani. N.p., Web. May 2015.

Santa Monica Land Use & Circulation Element. Santa Monica, Calif.: [City of Santa Monica], 2010. Print.

Science Applications International Corporation. (1995). *Case Studies in Residual Use and Energy Conservation at Wastewater Treatment Plants*.

Seattle City Light. (2015). Home Energy Evaluation. Retrieved from http://www.seattle.gov/light/conserve/hea/

Seattle: Office of Sustainability and Environment. (2015). Buildings and Energy. http://www.seattle.gov/environment/buildings-and-energy/community-power-works

Seattle Office of the City Clerk. (n.d). *Seattle.gov Resolution Number: 31312*. City of Seattle Legislative Information Service

Silverstein, Ken. (2008). "Financing Green Projects." *Renewable Energy World*. N.p., Web. May 2015.

Shahan, Z. (2013, June 14). Electric cars much cheaper than you think, cheaper than gasmobiles (charts). *Clean Technia*. Retrieved from http://cleantechnica.com/2013/06/14/the-electric-car-price-slide-chart/

Shoup, D. (2012, October 22). Curbing the parking crunch by cutting disabled placard abuse. *Los Angeles Times*. Retrieved from http://articles.latimes.com/2012/oct/22/opinion/la-oe-shoup-disabled-parking-abuse-20121022

Simpson, D. (2014). Santa Monica Daily Press: Trash Fees Going Up. Retrieved from Solar Santa Monica (2009). Second Annual Solar Santa Monica Report.

Solar Santa Monica (2010). Third Annual Solar Santa Monica Report.

Sonoma Clean Power. *Community Choice Aggregation: Implementation Plan and Statement of Intent*. By Sonoma Clean Power. Sonoma Clean Power, 2013. Web.

South Bay Clean Power. *South Bay Clean Power: Community Choice Aggregation*. 5 May 2015. Clean Energy for a more prosperous and healthy future.

"South Bay Clean Power." *South Bay Clean Power*. WordPress.com, n.d. Web. May 2015.

South Coast AQMD. (2006). *Santa Monica dedicates "green" hydrogen fueling station.* Retrieved from www.aqmd.gov/home/library/public-information/2006-news-archives/santa-monica-hydrogen-station

South Coast AQMD. (2015). *SCAQMD opens one of the largest capacity hydrogen fueling stations in California*. Retrieved from www.aqmd.gov/home/library/public-information/2015-news-archives/hydrogen-station-opening

Southern California Edison. (2014) Electricity use report for: City of Santa Monica 2013. Web.

Southern California Edison. (n.d.). Among the nation's leading utilities for renewable energy." *Cleaner Power*. Web.

State & County QuickFacts. (2015). Retrieved May 20, 2015, from http://quickfacts.census.gov/qfd/states/06/0670000.html

State of California. (n.d.). California Climate Change Portal. Web. Accessed May 2015.

Stevens, M. (2014, May 14). Santa Monica kills massive development; residents claim victory. *LA Times*.

Sustainable Works. (2015). Santa Monica Green Business Certification Program. Retrieved from http://www.smgbc.org/index.htm

Suzuki, H., & Cervero, R. (2013). *Transforming cities with transit transit and land-use integration for sustainable urban development* (pp. 53-55). Washington, D.C.: World Bank.

Swedish Gas Association. (2011). Biogas In Sweden. PDF: 1-27

Swedish Institute. (2014). The Swedish Recycling Revolution. Retrieved from https://sweden.se/nature/the-swedish-recycling-revolution/

Tuohy, J. (2015). City, BlueIndy car share deal raises sparks. *IndyStar*. Retrieved from http://www.indystar.com/story/news/2015/04/28/city-reaches-deal-blueindy-electric-car-share-service/26515019/

U.S. Census Bureau. (2011). Inflow/outflow analysis. Retrieved from http://onthemap.ces.census.gov

U.S. Department of Energy. (2013). NEPA and CEQA: Integrating State and Federal Environmental Reviews. Draft for Public Review and Comment. Retrieved from http://energy.gov/sites/prod/files/NEPA_CEQA_Draft_Handbook_March_2013_ 0.pdf

U.S. Department of Energy. (n.d.). Alternative Fuels Data Center. Retrieved from http://www.afdc.energy.gov/vehicles/electric_emissions.php

U.S. Energy Information Administration (EIA). (2009). Household Energy Use in California. Data from the Residential Energy Consumption Survey 2009. Retrieved from http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ca.pdf

U.S. Environmental Protection Agency. (2014). *Climate Change Indicators in the United States* (3rd ed.). Washington, DC: U.S. Environmental Protection Agency.

U.S. Green Building Council. (2013). EPA Green Buildings. Retrieved from http://www.epa.gov/oaintrnt/projects/

Walker Parking Consultants. (2012). *City of Santa Monica parking rate study*. Retrieved from http://www.smgov.net/departments/Council/.../s201207107-A-2.pdf

Washington State Department of Ecology. (n.d). *How Wastewater Treatment Plants Make Biosolids*.

Wilkinson, Robert C. (2007). Analysis of the Energy Intensity of Water Supplies for West Basin Municipal Water District. *West Basin Municipal Water District.*

Wilshire Bus Rapid Transit Project. (n.d.). Retrieved May 19, 2015, from http://www.metro.net/projects/wilshire/

Wong, D. (2014). Waste management Policy in Denmark. Retrieved from http://www.legco.gov.hk/yr13-14/english/sec/library/1314in09-e.pdf

Wong, G. (2014). *Implementation update: 15x15 Climate Action Plan*. Retrieved from http://www.smgov.net/uploadedFiles/Departments/OSE/CAP_Implemtenation_Update.pdf

Wong, S. (2011). Tapping the Energy Potential of Municipal Wastewater Treatment : Anaerobic Digestion and Combined Heat and Power in Massachusetts. Massachusetts Department of Environmental Protection

The World Bank Group. (2015). The World Bank. Retrieved from www.worldbank.org/

Yang, C., Mccollum, D., & Sperling, D. (2010). Achieving 80% Reduction In Transport Greenhouse Gas Emissions, Using the USA as a Case Study. *International Transport Forum,* 6-7. Retrieved May 1, 2015.

Zero Waste International Alliance. (2013). Retrieved from http://zwia.org