CLIMATE SMART SAN JOSE

A People-Centered Plan for a Low-Carbon City

Detailed Modeling Assumptions

Contents

Baseline Assumptions 7

  Energy Baseline 7

  Water Baseline 13

General eCBA Assumptions 20

  Energy eCBAs 20

  Water eCBAs 23

  All eCBAs 24

1.1 Transition to a renewable energy future 26

  Climate Smart San José 26

  San José Clean Energy 27

  Assumptions 27

  Net Energy Metering 28

  Assumptions 29

  Off-grid Generation 30

  Assumptions 31

1.2 Embrace our Californian climate 32

  Climate Smart San José 32

  Dishwashers - Residential 32

  Assumptions 33

  Clothes Washers - Residential 33

  Assumptions 34

  Toilets - Residential 34

  Assumptions 35

  Showers - Residential 35

  Assumptions 35

  Switching From Baths - Residential 36

  Assumptions 36

  Faucets - Residential 37

  Assumptions 37

  Leaks - Residential 38

  Assumptions 38

  Graywater System - Residential 38

  Assumptions 39

  Domestic Rainwater Storage - Residential 39

Assumptions 39
Drip Irrigation - Residential 40
Assumptions 40
Drought Resilient Plants - Residential....................40
Assumptions 40
Faucets - Commercial 41
Assumptions 41
Toilets - Commercial....................42
Assumptions 42
Graywater System - Commercial 42
Assumptions 43
2.1 Densify our city to accommodate our future neighbors 44
Climate Smart San José....................44
Residential Density 44
Assumptions 45
Bike Plan 46
Assumptions 47
2.2 Provide affordable, efficient homes for our families....................48
Climate Smart San José....................48
Lights - Residential....................48
Assumptions 49
Home Electronics - Residential 49
Assumptions 50
Refrigerators - Residential....................50
Assumptions 51
Ovens - Residential 51
Assumptions 51
Water Heaters - Residential 52
Assumptions 52
Central AC - Residential....................52
Assumptions 53
Ground-Source Heat Pumps - Residential....................53
Assumptions 54
Air-Source Heat Pumps - Residential....................54
Assumptions 55

Smart Thermostat - Residential 55
Assumptions 55
Insulation - Residential 56
Assumptions 56
Thermal Envelope Retrofits - Residential 56
Assumptions 57
Thermal Envelope New Construction - Residential 57
Assumptions 58
2.3 Create smart, personalized mobility choices 59
Climate Smart San José 59
Passenger Car Electric Vehicles 60
Assumptions 60
SUV Electric Vehicles 61
Assumptions 62
Personal Passenger Car Autonomous Vehicles 63
Assumptions 63
Personal SUV Autonomous Vehicles 64
Assumptions 65
Shared Passenger Cars 66
Assumptions 67
Shared Autonomous Passenger Cars 67
Assumptions 68
Shared Shuttles 69
Assumptions 70
Shared Autonomous Shuttles 70
Assumptions 71
2.4 Provide high-quality public transit infrastructure 73
Climate Smart San José 73
Caltrain 73
Assumptions 74
BART 75
Assumptions 75
High Speed Rail 76
Assumptions 77
Bus Rapid Transit 77

Assumptions 78
Next Network 79
Assumptions 79
3.1 Create local, accessible jobs in our city 81
Climate Smart San José 81
Accessible Jobs 81
Assumptions 82
3.2 Productive, high-performance commercial real estate 84
Climate Smart San José 84
Thermal Envelope Retrofits - Commercial 84
Assumptions 85
Thermal Envelope New Construction - Commercial 85
Assumptions 86
HVAC - Commercial 86
Assumptions 87
Smart Thermostat - Commercial 87
Assumptions 88
Recommissioning - Commercial 88
Assumptions 88
Lights - Commercial 89
Assumptions 89
Office Equipment - Commercial 90
Assumptions 90
3.3 Clean, efficient commercial logistics 91
Climate Smart San José 91
Large Pickup and Van Electric Vehicles 91
Assumptions 92
Local Delivery Van Electric Vehicles 92
Assumptions 93
Heavy Duty Vehicle Hybrid-Electric Vehicles 93
Assumptions 94
Heavy Duty Vehicle Compressed Natural Gas Vehicles 94
Assumptions 95
Heavy Duty Vehicle Fuel Efficient Vehicles 95
Assumptions 96

Heavy Duty Vehicle All-Electric Vehicles 96
Assumptions 97
Sources 98

Baseline Assumptions

Energy Baseline

Area of Assumption	Assumption Description	Incorporated in Baseline	Justification
Regulations	Renewable Portfolio Standard	Explicitly included	Incorporated in emission rates
Regulations	Pavley, Advanced Clean Cars, and Low Carbon Fuel Standard	Implicitly included	Incorporated in EMFAC2014 model City of San José “Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo” (2016)
Regulations	State Truck and Bus Regulation, which requires HD vehicles to be retrofit with DPF or replaced with trucks having 2007 or 2010 standard engines	Implicitly included	Incorporated in EMFAC2014 model CARB “EMFAC2014 Volume III - Technical Documentation” (2015)
Regulations	Tractor-Trailer Greenhouse Gasoline (TTGHG) Regulation	Implicitly included	Incorporated in EMFAC2014 model CARB “EMFAC2014 Volume III - Technical Documentation” (2015)
Regulations	Federal HD Greenhouse Gasoline regulations which required lower GHG emissions through retrofit aerodynamic improvements, low rolling resistant tires, and fuel-efficient new engine designs	Implicitly included	Incorporated in EMFAC2014 model CARB “EMFAC2014 Volume III - Technical Documentation” (2015)
Energy	Direct access has CO2 intensity of 0.296 tCO2e/MWh	Explicitly included	Intensity is still less than the maximum RPS20/30-compliant intensity, assuming half is coal
Energy	Grid intensity after 2020 inferred by probable power mix	Explicitly included	Done in order to be RPS compliant

Energy	Expiration of coal-fired power plant contracts will continue	Implicitly included	Incorporated in Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo
Energy	Large hydro can supply around 15% of power in the average year	Explicitly included	Done in order to predict the power mix
Energy	PG&E will retire the Diablo Canyon Nuclear Power Plant by 2025 and not replace with any nuclear energy in the future	Explicitly included	Done in order to predict the power mix
Energy	Passenger Cars and light duty trucks charge in residential buildings	Explicitly included	Done in order to avoid double counting charging EVs
On-Road Vehicles	The average miles per gallon of gasoline equivalent calculated from FuelEconomy.gov by fuel type can be used as a proxy for average miles per gallon of gasoline equivalent by fuel type in San José	Explicitly included	Done in order to determine proxy alternative fuel split in San José (Source: FuelEconomy.Gov)
On-Road Vehicles	2020 Passenger Car fuel economies will be CAFE compliant	Explicitly included	SPUR “Fossil Free Bay Area” (2016)
On-Road Vehicles	Heavy Duty Vehicles will be compliant with federal standards for the next decade	Explicitly included	New York Times “New Rules Require Heavy-Duty Trucks to Reduce Emissions by 25% Over the Next Decade” (2016)
On-Road Vehicles	San José Public Fleet fuel breakdown applies to all Public Service vehicles	Explicitly included	Done in order to determine proxy alternative fuel split in San José (Source: email from city of San José)
On-Road Vehicles	Biodiesel and Hydrogen alternative fuels have the same average MPGe as Diesel	Explicitly included	Done in order to determine VMT split for Biodiesel and Hydrogen
On-Road Vehicles	Hybrid electric and All-electric vehicles make up "ELEC" VMT fuel category of the EMFAC2014 model	Explicitly included	Both types of vehicles use electricity
On-Road Vehicles	Passenger Cars and light duty trucks are the only vehicle classes that have Hybrid electric and All-electric vehicles	Explicitly included	EMFAC 2014 model attributed electric vehicle VMTs to only these two classes in all years
On-Road Vehicles	Hybrid Electric Vehicle VMT in San José started in 2000	Explicitly included	US Launch of Toyota Prius

On-Road Vehicles	All-Electric Vehicle VMT in San José started in 2011	Explicitly included	Approximate start of Nissan Leaf (Dec. 2010)
On-Road Vehicles	Number of All-Electric Vehicles and Hybrid-Electric Vehicles based on number of-Electrics Per 1000 People and Hybrid Electrics Per 1000 People + Plug in Hybrid Electrics Per 1000 People respectively	Explicitly included	Clean Edge "Metro Index Datasets: 2016 U.S. Clean Tech Leadership Index" (2016)
On-Road Vehicles	Daily miles traveled in Table 11 in Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo includes electric vehicles	Implicitly included	Electric vehicles are On-Road Vehicles that would've been captured in the model
On-Road Vehicles	Adjusted the VMT distribution from EMFAC2014 that was applied San José's Annual VMT	Implicitly included	Done in order to include electric vehicles and their 0 emissions into the tCO2e calculations
On-Road Vehicles	Trips are proportionate to VMT by Calendar Year, Vehicle Class, and Fuel Type (not speed)	Explicitly included	EMFAC 2014 model outputs trips in the same runs that output VMT and emissions
On-Road Vehicles	Trip/VMT proportion for Diesel applies to non-Electric alternative fuels	Explicitly included	Done in order to estimate number of trips based on VMT
On-Road Vehicles	Trip/VMT proportion for Electric applies to Hybrid and All-Electric Vehicles	Explicitly included	Done in order to estimate number of trips based on VMT
On-Road Vehicles	Each Public Service vehicle has 1 trip per workday	Explicitly included	Done in order to estimate number of trips per year for Public Service vehicles
Boating	All boats in San José are recreational	Implicitly included	Boating emissions reported in Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo were for recreational boats

Boating	Proportion of gasoline and diesel boat emissions in San José are proportional to those nationwide in 2015 and that proportion will remain constant	Explicitly included	US Energy Information Administration "Annual Energy Outlook 2017" (accessed 2017) https://www.eia.gov/outlooks/aeo/data/browser/#/?id=46-AEO2017&cases=ref2017&sourcekey=0
Airport Equipment	Proportion of gasoline and diesel use for airport equipment provided for 2014 in Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo will stay constant	Explicitly included	Done in order to project emissions in later years
Off-road Equipment	Gasoline is the sole fuel for Off-road Equipment	Explicitly included	Done in order to attribute MT CO2e emissions for Off-road Equipment
Trains	All Caltrain, Capitol Corridor, and Altamont Corridor trains in San José solely run on diesel	Explicitly included	Caltrain "Peninsula Corridor Fact Sheet" (2014) BayRail Alliance "Caltrain Electrification" (accessed 2017) Capitol Corridor Joint Powers Authority "2014 Vision Plan Update: Final Report" (2014) Altamont Corridor Rail Project "Altamont Corridor Rail Project Scoping Meeting" (2009)
Trains	Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo: Planned Project- California High Speed Rail stop built in San José in 2029	Not included	Not incorporated in Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo emission estimates
Trains	Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo: Planned Project- ACEforward project completed through 2025	Implicitly included	Incorporated in Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo emission estimates

Trains	Caltrain passenger boarding Diridon and Tamien stations in the morning and alighting in the evening are 100% commuting passengers	Explicitly included	Done in order to estimate number of trips for Caltrain
Trains	Caltrain passenger counts for 2016 can be applied to 2014	Explicitly included	Done in order to estimate 2014 Caltrain passenger counts and forecast from there
Trains	Daily pass by trips multiplied by the average ridership for ACE and Capitol Corridor annualized will yield the number of trips for each train line	Explicitly included	Done in order to estimate number of trips for ACE and Capitol Corridor in 2014
Trains	Tamien North Train Miles in City reported in Appendix D is a more accurate figure to calculate Vehicle Miles Traveled in San José	Explicitly included	Since the vast commuting majority of passengers head north
Biking & Walking	1.8% of commuters to work walk and 1.2% bike, and these percentages will stay constant unless measures are done	Explicitly included	Done in order to determine Walking and Biking VMT and Trips City of San José, “Envision San José 2040 General Plan” (2011)
Biking & Walking	Biking and walking are not included in the VMT reported in Appendix D	Explicitly included	Walking and Biking are not modes of vehicular transportation, and most likely would not have been included
Biking & Walking	2 commuting trips in a day	Explicitly included	Going from home to work and going from work back to home
Biking & Walking	Average distance that people commute in California if walking or biking is equivalent to the average distance people commute in SJ for walking and biking, and that distance will stay constant	Implicitly included	California Department of Transportation “2010-2012 California Household Travel Survey Final Report” (2013)
Other Mobility Assumptions	Proportion of VMT by vehicle class for Santa Clara sub area can be applied to annual VMT reported by City of San José	Explicitly included	Done in order to get VMT by vehicle class for San José
Other Mobility Assumptions	Can linearly interpolate, back cast, and extrapolate for VMT, Trips, Commute Trips, GGE, and MT CO2e	Explicitly included	Done in order to get data between the given intervals

Other Mobility Assumptions	San José 2040 land use - land zoning policies in place do not affect commute mode splits	Implicitly included	Based upon meeting with Department of Transportation
Other Mobility Assumptions	Ratio of Passenger Car and SUV Trips that are for Commuting stays constant	Explicitly included	Done in order to determine commute mode splits
Other Mobility Assumptions	Commute for 261 days in a year	Explicitly included	Most likely number of weekdays in a year US Office of Personnel Management “Pay & Leave” (accessed 2017)
Other Mobility Assumptions	50% Transit, Biking, and Walking trips are for commuting	Explicitly included	Bay Area Council Economic Institute "The Economic Impacts of Infrastructure Investment" (accessed 2017)
Other Mobility Assumptions	Transit category consists of the Trains and the Buses category	Explicitly included	Majority of the Buses category VMT is from the Urban Buses subcategory Bay Area Council Economic Institute "The Economic Impacts of Infrastructure Investment" (accessed 2017)
Other Mobility Assumptions	GGE to CO2e Conversion is the same for all gasoline and diesel vehicles	Explicitly included	Done in order to estimate carbon emissions of non-passenger car vehicles
Other Mobility Assumptions	Drive alone-Carpool proportion for 2011-2014 will stay constant	Explicitly included	City of San José, “2016 General Plan Annual Review” (2016) and based upon meeting with Department of Transportation

Water Baseline

Area of Assumption	Assumption Description	Incorporated in Baseline	Justification
Great Oaks Water Company	Volume of average supply available in a year is 4296 MG	Explicitly Included	Provided in Table 7-1 in the 2015 UWMP
Great Oaks Water Company	2010 and years following 2015 take on volume of average supply plus any planned projects	Explicitly Included	Drought influenced amount of groundwater that was pumped, other years are assumed to be average years
Great Oaks Water Company	Can use groundwater pumped for projections for supply	Implicitly Included	Since groundwater makes up 100% of Great Oak's supply, groundwater pumped equals the volume of supply
Great Oaks Water Company	Service population is entirely in San José	Implicitly Included	2015 UWMP states that the "vast majority of Great Oaks' service area is within the city of San José."
Great Oaks Water Company	2015 "Loss" rate of 4% applies to all years 2010-2040 to account for system losses	Explicitly Included	Losses not provided in projections
Great Oaks Water Company	Demand projections do not include future water savings from codes, standards, ordinances, or transportation and land use plans as stated in the Great Oaks Water Company 2015 Urban Water Management Plan	Implicitly Included	2015 UWMP statement of exclusion
Great Oaks Water Company	Great Oaks Water Company 2015 Urban Water Management Plan: Planned Project- Groundwater well to be built in 2017 expected to increase water supply by 806 MG	Explicitly Included	Increased Water Volume by projected well increase in 2017
San José Municipal Water System	Service population is entirely in San José	Implicitly Included	2015 UWMP states that it services 4 different areas of the city, and doesn't mention areas outside of the city
San José Municipal Water System	Demand for "Other" remains at a constant 0.4% (rate from 2015 demand data in UWMP)	Explicitly Included	Other demand type not provided in projections

San José Municipal Water System	Groundwater supply after 2015 is 0	Explicitly Included	2015 UWMP does not include Groundwater in forecasts; Groundwater made up 6.5% of 2015 supply
San José Municipal Water System	2015 UWMP's Supply 2035 forecast % by type breakdowns apply to all years	Explicitly Included	Supply projection breakdown by type only provided for 2035 which is listed as a normal year. Other projections did not have type breakdown, only totals
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Demand projections include future water savings as stated in the San José Municipal Water System 2015 Urban Water Management Plan	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- No irrigating landscapes between 10 am and 8 pm, unless using a bucket, hand-carried container, or a hose with a shut-off nozzle	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Sprinklers cannot run more than 15 minutes per station per day	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- No excessive water runoff is allowed	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Leaking or broken water pipes, irrigation systems, and faucets must have repairs initiated within five working days and repaired as soon as practical	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- No cleaning of structures or paved surfaces with a hose without a positive shut-off nozzle	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- No cleaning of vehicles with a hose without a positive shut-off nozzle	Implicitly Included	2015 UWMP statement of inclusion

San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Commercial car washes must use water recycling equipment, a bucket and handwashing, or a hose with positive shut-off nozzle	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- No serving water in food service establishments unless requested by the customer	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Restaurants that use pre-rinse spray valves must use ones that are low-flow	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Hotels/motels must provide guests the option to decline daily linen washing	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Potable water cannot be used for building or construction purposes, such as dust control, without written exception by City	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Water cannot be used from a hydrant without prior City approval	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Measure to reduce demand- Potable water cannot be used for irrigation purposes where a recycled water service is currently plumbed to the site	Implicitly Included	2015 UWMP statement of inclusion
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Planned Project- Groundwater well to be built in NSJ/Alviso starting in 2017 expected to increase water supply by 391.0212 MG	Not Included	Groundwater not included in projection forecasts
San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Planned Project- Groundwater well to be built in Edenvale starting in 2020 expected to increase water supply by 619.1169 MG	Not Included	Groundwater not included in projection forecasts

San José Municipal Water System	San José Municipal Water System 2015 Urban Water Management Plan: Planned Project- Groundwater well to be built in Coyote starting in 2025 expected to increase water supply by 358.4361 MG	Not Included	Groundwater not included in projection forecasts
San José Water Company	Can use San José specific service area projections provided in the San José Water Company 2040 General Plan 2010 Water Supply Assessment	Explicitly Included	Done in order to find the proportion of San José Water Company's service population that is in San José
San José Water Company	2040 San José Service Population take same ratio as 2035	Explicitly Included	Done in order to estimate San José service population for 2040
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignments A, R	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment D Phase 1, 2	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment H remainder	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment C remainder	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment E Phase 1	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment E Phase 2	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment E Phase 3	Implicitly Included	Increase in recycled water supply projections appear to include this measure

San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment Q Phase 1	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment Q Phase 2	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment Q Phase 3	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment Q Phase 4	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment P Phase 1	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment P Phase 2	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment P Phase 3	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment L	Implicitly Included	Increase in recycled water supply projections appear to include this measure
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Measure to expand recycled water use- Alignment K	Implicitly Included	Increase in recycled water supply projections appear to include this measure

San José Water Company	Demand projections include ongoing conservation efforts such as retrofits and audits which will decrease per capita usage by 0.2 percent each year until 2040 as stated in the San José Water Company 2015 Urban Water Management Plan	Implicitly Included	2015 UWMP statement of inclusion
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- Garden City Mixed Use Project	Implicitly Included	2015 UWMP statement of inclusion
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- North First and Brokaw Corporate Campus	Implicitly Included	2015 UWMP statement of inclusion
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- Silvery Towers Residential Project	Implicitly Included	2015 UWMP statement of inclusion
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- Skypoint Office Project	Implicitly Included	2015 UWMP statement of inclusion
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- Dam Improvements / Seismic Retrofits will be implemented in 2022 expected to increase water supply by 13,800 MG	Not Included	Moderate increase in supply projections do not appear to include this planned project
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- Main and Madrone Pipelines Restoration will be implemented in 2019 expected to increase water supply by 600 MG	Not Included	Moderate increase in supply projections do not appear to include this planned project
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- Potable Reuse Program will be implemented in 2021 expected to increase water supply by 20,200 MG	Not Included	Moderate increase in supply projections do not appear to include this planned project
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- South County Recycled Water Program will be implemented in 2020 expected to increase water supply by 1,700 MG	Not Included	Moderate increase in supply projections do not appear to include this planned project
San José Water Company	San José Water Company 2015 Urban Water Management Plan: Planned Project- Wolfe Road Recycled Water Pipeline will be implemented in 2017 expected to increase water supply by 600 MG	Not Included	Moderate increase in supply projections do not appear to include this planned project

Other Water Baseline Assumptions	Multi Year Dry Years take value of 3rd year	Explicitly Included	Used 3rd year in order to take the most conservative approach
Other Water Baseline Assumptions	Individual water supply company single and dry year values are done in 5-year increments	Explicitly Included	Difference year to year most likely negligible due to there being only minor differences in 5-year increments
Other Water Baseline Assumptions	Recycling numbers contribute to the water supply as opposed to the water demand	Explicitly Included	Recycling water gets expended as supply for the demand
Other Water Baseline Assumptions	Supply/Demand grows in a linear function (for linear interpolations between years with available data)	Explicitly Included	Projections between the 5-year intervals not provided in any of the UWMPs
Other Water Baseline Assumptions	SCVWD reported water losses account for both the water supplied and water managed by SCVWD	Implicitly Included	Tables 4-1 and 4-2 in the SCVWD 2015 UWMP list out losses and sales to other agencies, and matches the numbers presented in figure 3-5 of the same document for water use by retailers
Other Water Baseline Assumptions	SCVWD water losses to San José retailers are proportionate to the amount of water sold to San José retailers	Explicitly Included	Losses to specific retailers not provided in 2015 SCVWD UWMP
Other Water Baseline Assumptions	SCVWD 2010 water losses reported in the 2009-2010 water audit represent total system losses for 2010	Explicitly Included	Losses for total system losses in 2010 not provided in 2010 SCVWD UWMP
Other Water Baseline Assumptions	SCVWD 2010 total water supplied and managed is portrayed in Figure 2-9 in SCVWD's Treated Water Deliveries and the outflows from the Santa Clara Plain and Coyote Valley	Explicitly Included	Table(s) of SCVWD supply and demand breakdown not provided in 2010 SCVWD UWMP
Other Water Baseline Assumptions	System water losses from the SFPUC and the SBWR Program to San José retailers are negligible	Explicitly Included	Excluded due to the relatively small magnitude of water supplied to the retailers

Other Water Baseline Assumptions	Approx. 50% of Residential water flows to outdoor uses	Explicitly Included	About half of Residential water use is outdoors as reported in the Santa Clara Valley Water District 2015 Urban Water Management Plan
Other Water Baseline Assumptions	Approx. 20% of Commercial and Industrial water flows to outdoor uses	Explicitly Included	SJMWS 2010 Water Supply Assessment for the 2040 General Plan assumed 20% of commercial is used for outdoor irrigation, and assumed industrial use would closely follow commercial
Other Water Baseline Assumptions	Approx. 90% of Government water flows to outdoor uses	Explicitly Included	Meeting with SJMWS
Other Water Baseline Assumptions	Indoor-Outdoor water flow ratios will stay the same	Explicitly Included	Haven't yet identified pathway to change the ratios

General eCBA Assumptions

Energy eCBAs

Area of Assumption	Assumption Description	Justification/ Source
On-Road Vehicles	Battery costs are primary driver of EVs, and will drop in price by 30% by 2020 from 2013	SPUR “Fossil Free Bay Area” (2016)
On-Road Vehicles	Innovative Electric Vehicle Charging Infrastructure will continue to see slight reductions in CAPEX	As inductive and fast charging become mass produced, the initial cost of the Infrastructure will decline
On-Road Vehicles	Some charging will take place in public initially, but then move towards more charging being done in home	Done in order to account for battery and charging technology improvements
On-Road Vehicles	Electric charging availability dependent on EV Passenger Car eCBA	Majority of Electric Vehicle category

On-Road Vehicles	Lifetime duration of vehicles assumed to be between 8-10 years	Inside EVs “How Long Will A Tesla, LEAF, Or Other EV Battery Last?” (2017) Work Truck “Determining the Optimal Lifecycle for Truck Fleets” (2014)
Trains	CAPEX, reduced VMT, and/or ridership is the same for each public transit station of that type (e.g. High Speed Rail, Caltrain)	Done in order to estimate San José proportion of these values if not provided
Shared Mobility	Shared mobility vehicles have same impacts as car sharing vehicles	Done in order to gauge the effects of shared mobility
Shared Mobility	Charging stations need per unit dependent on Passenger Car EV eCBA	Done in order to estimate charging stations needed per unit for shared vehicles
Shared Mobility	Hybrid Electric and All Electric cars displaced by shared mobility are minimal	Gasoline and Diesel cars vastly outnumber hybrid electric and all electric
Shared Mobility	Initial number of car shares is 35 in 2017 and are all 4 person non autonomous vehicles	City of San José “Car Sharing” (accessed 2017)
Cost of Energy	Cost of gasoline is \$3.066/ Gallon	Bureau of Labor Statistics “Average Energy Prices, San Francisco-Oakland-San José – April 2017” (2017)
Cost of Energy	Cost of diesel is \$2.26248/ Gallon	US Energy Information Administration “Weekly Retail Gasoline and Diesel Prices” (accessed 2017)
Cost of Energy	Cost of compressed natural gas is \$2.08/ Gallon of Gasoline Equivalent	CNG Now “CNG Calculator” (accessed 2017)
Cost of Energy	Cost of residential electricity is \$0.1921/ kWh with assumption that SJCE has 10% more renewable bundled rate	San José Clean Energy Community Choice Aggregation Business Plan (2017)
Cost of Energy	Cost of residential natural gas is \$1.470415/ therm with assumption that Residential Natural Gas Rate is for Non-CARE resident and is average of Baseline and Excess rates for 7/1/17	PG&E “Gas Rates” (accessed 2017)
Cost of Energy	Cost of local commercial electricity is \$0.20053/ kWh with assumption that Local Commercial Sector Uses Medium Commercial Rate from 7/1/17	San José Clean Energy Community Choice Aggregation Business Plan (2017)

Cost of Energy	Cost of non-local commercial electricity is $ 0.20346/ kWh with assumption that Non-Local Commercial Sector Uses A10 Commercial Rate from 7/1/17	PG&E "Electric Rates" (accessed 2017)
Cost of Energy	Cost of commercial natural gas is $0.818655/ therm with assumption that Commercial Natural Gas Rate is for Small Commercial and is average of First 4,000 therms and Excess Rates for Summer and Winter	PG&E "Gas Rates" (accessed 2017)
Conversions	1 gallon of gasoline equivalent = .031 kWh	Department of Energy "Fuel Conversion Factors to Gasoline Gallon Equivalents" (accessed 2017)
Conversions	1 therm = 29.3001 kWh	Unit Conversion "Therms to Kilowatt-Hours Conversion Calculator" (accessed 2017)
Residential Energy Usage	Electricity: Heating % of Electricity is 5% kWh/ yr. Air Conditioning and Other % of Electricity is 25% kWh/yr. Electronics % of Electricity is 20% kWh/ yr. Additional categories like lighting not required for this analysis Natural Gas: Space Heating and Other % of Natural Gas is 41% therm/ yr. Water Heating % of Natural Gas is 49% therm/ yr. With assumption that 'Other' refers to HVAC and that these usage splits will stay constant if nothing is deployed	Home Energy Saving Toolkit (2017)
Commercial Energy Usage	Assumed that categories do not add to total due to rounding and that the data for cooking for Office distribution withheld either because the Relative Standard Error (RSE) was greater than 50 percent or fewer than 20 buildings were sampled	US Energy Information Administration "Commercial Buildings Energy Consumption Survey" (accessed 2017)
Commercial Energy Usage	Assume the average of the Office, Retail, and Pacific distributions applies to San José	Done in order to find the appropriate commercial BTU profile for San José
Commercial Energy Usage	Assume Natural Gas make up Space, Water Heating, and Cooking categories of distribution of BTU and Electricity makes up rest of categories	Done in order to identify split of energy consumption in San José commercial buildings
Commercial Energy Usage	Assume Computing is Office Equipment as well	For commercial buildings, it makes sense to include computers as a part of office equipment for the Office Equipment eCBA

Water eCBAs

Area of Assumption	Assumption Description	Justification/ Source
Indoor Water Efficiency	Indoor appliance use behavior does not change over time	Done in order to estimate application efficiency over time
Indoor Water Efficiency	Only water appliances in commercial buildings are toilets and faucets	Done in order to estimate commercial water consumption
Indoor Water Efficiency	2 bathrooms with 1 shower, toilet, and faucet each and 1 kitchen with a faucet per household	About 3 people per household in San José
Indoor Water Efficiency	Urinals count as water closets	Done in order to estimate number of water closets in a commercial building
Indoor Water Efficiency	Each water closet has a faucet and a toilet	Done in order to estimate number of faucets and toilets in a commercial building
Indoor Water Efficiency	0 OPEX for faucet aerators and showerheads	If faucet aerator or showerhead stops working, would buy new one
Outdoor Water Efficiency	Only detached and attached households have lawns	Multifamily housing units less likely to have lawns
Outdoor Water Efficiency	Lawns make up 100% of unmetered outdoor water usage	Done in order to estimate effects of Outdoor eCBAs
Outdoor Water Efficiency	All lawns currently use spray irrigation and have not been converted to drought-resilient plants yet	Done in order to estimate effects of Outdoor eCBAs
Commercial Water Usage	Assume commercial buildings follow minimum number of water closets noted in California Department of Industrial Relations Title 8. Subchapter 7. General Industry Safety Orders. Group 2. Safe Practices and Personal Protection. Article 9. Sanitation. 3364. Sanitary Facilities. A)	California Department of Industrial Relations “Title 8” (accessed 2017)

Residential Cost of Water	Average Monthly Water Usage per household in San José in 2007 is 15 hundred cubic feet (CCF)	City of San José and Santa Clara Valley Water District “How We Measure Water” (accessed 2017) 2007 is a good representation because it was a pre-recession and pre-drought year
Residential Cost of Water	Effective water rate for average monthly usage is $3.924 based on averaged rates across all areas for 0-14 HCF and 15-28 HCF	City of San José “Drinking Water Rates” (2017)
Commercial Cost of Water	Averaged rate across all areas	City of San José “Drinking Water Rates” (2017)

All eCBAs

Area of Assumption	Assumption Description	Justification/ Source
Housing	Households by type proportional to number of housing units by type	Done in order to break down households by housing unit type City of San José “Development Activity Highlights and Five-Year Forecast (2017-2021)” City of “San José Fact Sheet: History & Geography” (accessed 2017)
Housing	Projections for calendar year equate to end of fiscal year period (e.g. FY2015-2016 = 2016)	Source: Development Activity Highlights (2016)
Housing	New developments follow same detached/attached ratio as 2014	Done in order to break out Single Family developments by detached and attached categories
Housing	312,227 Households in San José in 2014 and housing continues to grow while keeping People Per Household ratio of 3.23 constant	City of “San José Fact Sheet: History & Geography” (accessed 2017)
Housing	Only Single Family – Detached and Single Family – Attached homes have lawns/ roofs that are suitable for domestic rainwater capture, drought-	These eCBAs depend on roofs and lawns and so the deployment of these eCBAs is limited by the growth in single family homes

	resilient plan lawn conversion, drip irrigation, Net Energy Metering, and Off-grid Generation	
Housing	Median Price of House in San José is $811,637 Median Price Per Sq Ft in San José $528 Which makes Average Area of Residential Home in San José 1,537 square feet	Zillow "San José Home Prices & Values" (accessed 2017)
Commercial Buildings	Commercial building population is Office and Retail buildings and they have the same energy profile	Office and retail buildings make up majority of San José Building Stock
Commercial Buildings	Commercial building stock will grow proportional to job baseline growth, growth rate will be equal for all commercial building sizes, and each size consumes energy and water proportional to their size	San José Building Stock Assessment 2016
Commercial Buildings	It is assumed that there is 151 square feet per person in an office space	The Mehigan Company, Inc. "What is the average square footage of office space per person?" (2016)
Pricing	Geometric Growth of Cost of Fuel and Water is .005	This represents modest price increases till 2050

1.1 Transition to a renewable energy future

Climate Smart San José

A fitting start to Climate Smart San José, it all begins with transitioning to a renewable energy future. Strategy 1.1 focuses on the energy sources of San José and their renewable energy and GHG free makeup. Transitioning from fossil fuels to electricity has a reduced effect if the electricity comes from dirty sources itself. By the same train of thought, cleaning up the supply of electricity enhances the effect of this conversion; therefore, transitioning to a renewable energy future makes the other strategies more effective. This transition will predominantly occur in San José through two channels: San José Clean Energy and local renewable generation.

The City Council recently approved the city’s community choice aggregation plan, San José Clean Energy (SJCE), which allows the city to determine the renewable energy mix that supplies its power. It is assumed that SJCE will have a renewable energy mix at least 10% above PG&E which would mean 60% renewably sourced at 2030, and an eventual increase to 100% renewable by 2045. This power mix affects the grid intensity of SJCE, and leads to a much lower emissions factor than that of PG&E. The renewable energy makeup will consist of some biomass and waste, geothermal, and small hydro; however, the majority of it (and the majority of the growth) will be focused in solar and wind energy. This is due to the ability of solar and wind to more easily scale up to utility level. In addition, it is also assumed that any non-renewable energy used by SJCE will be greenhouse gas free such as nuclear or large hydro. Given the upcoming closure of Diablo Canyon Nuclear Power Plant, the energy mix from large hydro will need to increase to maintain the 100% GHG free goal while experiencing the gradual reduction of nuclear power until 2025. However, the reliance on large hydro itself will be decreasing as San José continues to become more renewable. One important aspect of this renewable conversion is from local sources such as net energy metering and off-grid generation.

Net energy metering, the process of installing energy generation in homes or communities with the potential for selling the energy back to the grid, can help incentivize installing renewable energy panels by providing more means of funding. Similar to net energy metering, off-grid generation includes building solar panels at the household level; however, all energy generated by these solar panels stay within the system (i.e. energy is not sold back to the grid). Climate Smart San José assumes that the vast majority of local renewable generation will occur from solar panels on the rooftops of homes, office buildings, parking lots, etc. These systems will be connected to the grid in order to ensure that no generated energy is wasted. Storage devices such the Tesla Power Wall will be necessary to include in the systems in order to retain energy and more effectively deal with California’s duck curve of power generation. The first part of the duck curve is formed due to the major solar energy generation during the daytime which results in a low net load on the grid. The second half of the curve comes later in the day, while the sun wanes and solar energy generation is lower, as people come back from work and start expending much more electricity than just an empty household. The net load on the grid drastically increases, and strains the system as a whole. Building and designing around the duck curve will be an important challenge to overcome for this strategy to be successful.

Strategy 1.1 is important because it makes many of the other eCBAs more effective. By making electricity greener, it becomes even more worth it to invest in electricity or natural gas like for ovens and HVAC. The calculated emission rate from SJCE is included in all of the eCBAs that would potentially be supplied by it or via net energy metering, and is used to calculate their carbon emissions. The other eCBAs, like those in buildings or transportation, also impact SJCE by being included as part of its overall load. As those sectors are further electrified, the load on SJCE increases as well. The primary costs associated with transitioning to a renewable energy future are largely based on the levelized cost of energy for each of the energy sources. These figures are in dollars per megawatt, and roughly determine the capital and operating cost of the energy source over its lifetime. Although it may currently be costly to invest in renewable energy, it is imperative to do for San José to achieve its climate goals.

San José Clean Energy

San José's City Council recently approved the city's community choice aggregation plan, San José Clean Energy (SJCE), which allows the city to determine the renewable energy mix that supplies its power. As it is assumed that SJCE will have a renewable energy mix at least 10% above PG&E which would mean 60% renewably sourced at 2030, and an eventual increase to 100% renewable by 2045, SJCE could lead to a carbon abatement of 27.65 million tCO2e at a saving of $33/tCO2e.

The San José Clean Energy eCBA calculates the distribution of local renewable energy, utility renewable energy, and non-renewable energy by dividing the net energy metered generated energy by the total load. The non-renewable energy is based on the deployment of the CCA, and the utility renewable energy is the remainder after local renewables and non-renewables are taken into account. This distribution is then applied to the individual fuel sources (biomass and waste, geothermal, small hydro, solar, wind, coal, large hydro, natural gas, nuclear, and unspecified (purchased)). Biomass and waste, geothermal, small hydro, and nuclear are assumed to maintain a constant percentage as used by PG&E in the baseline. As San José is expected to use GHG-free resources, coal, natural gas and unspecified (purchased) are assumed to be zero. The remainder of the renewable percentage gets applied to solar and wind equally, with the remainder of the GHG-free resources being applied to large hydro. LCOEs are applied to this distribution to find the overall cost of generating the electricity.

The assumption that SJCE will eventually be 100% renewable is important becomes it means the renewable energy mix continually improves upon PG&E's baseline. Combined with an increasing energy load over time, this makes SJCE an especially important eCBA for San José's climate goals.

The SJCE eCBA is important because it makes many of the other eCBAs more effective. By making electricity greener, it becomes even more worth it to invest in electricity or natural gas like for ovens and HVAC. The calculated emission rate from SJCE is included in all of the eCBAs that would potentially be supplied by it, and is used to calculate their carbon emissions. The other eCBAs also impact SJCE by being included as part of its overall load.

Some challenges the CSSJ faced in this analysis include determining the mix of energy sources year by year for SJCE as well as the emission rate for a source like Purchased Power.

Assumptions

Assumption	Justification/ Source
Operational and Capital Costs follow San José Clean Energy Community Choice Aggregation Business Plan and operational costs increase by an inflation rate of 3% after 2030	San José Clean Energy Community Choice Aggregation Business Plan (2017)
Biomass and waste, geothermal, small hydro, and nuclear are assumed to maintain a constant percentage as used by PG&E in the baseline	Done in order to determine power mix
Coal, natural gas and unspecified (purchased) are assumed to be zero	San José is expected to use GHG-free resources
All homes and business in San José will be opted into SJCE	Done in order to estimate citywide environmental impact
All Net Energy Metered homes will connect to SJCE	Done in order to fully integrate Net Energy Metering eCBA with SJCE

Levelized Cost of Biomass & Waste is $46/MWh	Based on 20-Year Levelized Cost of Renewable Resources in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Geothermal is $100/MWh	Based on high end of range of 20-Year Levelized Cost of Geothermal in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Small Hydro is $47.20/MWh	Based on 20-Year Levelized Cost of Market Power Purchase Agreement in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Solar is $46/MWh	Based on 20-Year Levelized Cost of Renewable Resources in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Wind is $46/MWh	Based on 20-Year Levelized Cost of Renewable Resources in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Coal is $47.20/MWh	Based on 20-Year Levelized Cost of Market Power Purchase Agreement in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Large Hydro is $47.20/MWh	Based on 20-Year Levelized Cost of Market Power Purchase Agreement in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Natural Gas is $45.70/MWh	Based on 20-Year Levelized Cost of Wholesale Market in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Nuclear is $47.20/MWh	Based on 20-Year Levelized Cost of Market Power Purchase Agreement in San José Clean Energy Community Choice Aggregation Business Plan (2017)
Levelized Cost of Unspecified (purchased) is $47.20/MWh	Based on 20-Year Levelized Cost of Market Power Purchase Agreement in San José Clean Energy Community Choice Aggregation Business Plan (2017)

Net Energy Metering

Solar panels are quickly becoming more common sites on rooftops of houses, but there is a large potential to do even more. Net energy metering, the process of installing energy generation in homes or communities with the potential for selling the energy back to the grid, can help incentivize installing renewable energy panels by providing more means of funding. Increases in net energy metering could lead to a carbon abatement of 6.90 tCO2e at a cost of $355/tCO2e.

To calculate the carbon abatement of net energy metering, the CSSJ first determines the total solar potential in MW of San José, and how much of that solar potential is already in use for net energy metering as well as off-grid sites (Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile, 2017; Shining Cities, 2017; California Distributed Generation Statistics, 2017). The split of the data is in residential and non-residential, so the next step is calculating the solar potential by the different sectors (residential, commercial, industrial, and municipal) (Department of Energy, 2017). The solar potential breakdown by sector is determined by leveraging known values for the residential and municipal sectors suitable areas for solar and corresponding solar potential, and applying it to the industrial and commercial sector suitable areas. This analysis assumes that the proportion of the total area of buildings to suitable area for solar stays constant regardless of sector. Once these steps are complete, it is assumed that each MWh of renewable net energy metering will displace an MWh of less clean emissions from PG&E. The cost of each MW deployed is calculated using an LCOE (Lazard, 2017). The cost of Tesla Power Walls needed per MW is also included as it is assumed some form of storage is required for the generated energy to be used in the household (Tesla Power Wall, 2017).

Net energy metering is integrated into the San José Clean Energy eCBA. It is assumed that all of the load provided by Net Energy Metering makes up the local renewable energy portion of CCA.

The primary challenge with net energy metering is making renewable energy generation cost effective at the household level. It also may be difficult for many households to pay for the initial investment cost for the solar panels. Difficulties in this analysis include determining the number of Tesla Power Walls needed per MW, and determining the split of solar power potential between the non-residential sectors.

Assumptions

Assumption	Justification/ Source
Total Energy Generation Potential (MWh) in 2016 is 2,420,600	Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile (2017)
Technical solar potential of residential sector is 1,639 MW and grows by single family home growth	Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile (2017)
Technical solar potential of industrial, commercial, and municipal sectors is 1,761 MW	Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile (2017)
Total Solar PV already installed as of 2016 is 174 MW in DC MW	Shining Cities (2017)
Conversion factor from DC to AC is 0.769	Shining Cities (2017)
Total Solar PV already installed in NEM residential buildings is 77 in AC MW	California Distributed Generation Statistics (2017)
Total Solar PV already installed in NEM non-residential buildings is 54 in AC MW	California Distributed Generation Statistics (2017)
Residential Suitable Area is 11,518,500 square meters	Department of Energy, SLED (accessed, 2017)
Total Solar PV already installed in municipal buildings is 6.3113 MW	Solar on City Sites 040517 (2017) Spreadsheet
Unshaded, useable, municipal area is 1,765,163 square feet	San José Solar Phase 1, 2, and 3 Solar Power Generation Site Viability Evaluation (2010)

Total Area of Buildings (sq. ft.) - Industrial is 27,092,204	Department of Energy, SLED (accessed 2017)
Total Area of Buildings (sq. ft.) – Commercial is 94,229,955	Department of Energy, SLED (accessed 2017)
Total Area of Buildings (sq. ft.) – Residential is 473,603,027	Department of Energy, SLED (accessed 2017)
Fixed O&M ($/kW-yr.) is $21	NREL Distributed Generation Renewable Energy Estimate of Costs (2016)
Cost of Tesla Power Wall is $6,200 with a capacity of 13.5 kWh	Tesla Power Wall (accessed 2017)
Solar PV - Rooftop Residential CAPEX is $2400/kW	Lazard's Levelized Cost of Energy Analysis – Version 10.0 (2016)
Natural Gas CAPEX is $1300/kW	Lazard's Levelized Cost of Energy Analysis – Version 10.0 (2016)

Off-grid Generation

Solar panels are quickly becoming more common sites on rooftops of houses, but there is a large potential to do even more. Similar to net energy metering, off-grid generation includes building solar panels at the household level; however, all energy generated by these solar panels stay within the system (i.e. energy is not sold back to the grid). Since Climate Smart San José opts for Net Energy Metering, off-grid generation does not abate any carbon, but would do so at a cost of $1,056/tCO2e.

To calculate the carbon abatement of off-grid generation, the CSSJ first determines the total solar potential in MW of San José, and how much of that solar potential is already in use for net energy metering as well as off-grid sites (Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile, 2017; Shining Cities, 2017; California Distributed Generation Statistics, 2017). The split of the data is in residential and non-residential, so the next step is calculating the solar potential by the different sectors (residential, commercial, industrial, and municipal) (Department of Energy, 2017). The solar potential breakdown by sector is determined by leveraging known values for the residential and municipal sectors suitable areas for solar and corresponding solar potential, and applying it to the industrial and commercial sector suitable areas. This analysis assumes that the proportion of the total area of buildings to suitable area for solar stays constant regardless of sector. Once these steps are complete, it is assumed that each MWh of renewable off-grid generation will displace an MWh of less clean emissions from PG&E. The cost of each MW deployed is calculated using an LCOE (Lazard, 2017). The cost of Tesla Power Walls needed per MW is also included as it is assumed some form of storage is required for the generated energy to be used in the household (Tesla Power Wall, 2017).

The primary challenge with off-grid generation is making renewable energy generation cost effective at the household level. This is made even more difficult given the inability to sell energy back to the grid. It also may be difficult for many households to pay for the initial investment cost for the solar panels. Difficulties in this analysis include determining the number of Tesla Power Walls needed per MW, and determining the split of solar power potential between the non-residential sectors.

Assumptions

Assumption	Justification/ Source
Total Energy Generation Potential (MWh) in 2016 is 2,420,600	Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile (2017)
Technical solar potential of residential sector is 1,639 MW and grows by single family home growth	Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile (2017)
Technical solar potential of industrial, commercial, and municipal sectors is 1,761 MW	Cities-LEAP and State and Local Energy Data (SLED) City Energy Profile (2017)
Total Solar PV already installed as of 2016 is 174 MW in DC MW	Shining Cities (2017)
Conversion factor from DC to AC is 0.769	Shining Cities (2017)
Total Solar PV already installed in NEM residential buildings is 77 in AC MW	California Distributed Generation Statistics (2017)
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Residential Suitable Area is 11,518,500 square meters	Department of Energy, SLED (accessed, 2017)
Total Solar PV already installed in municipal buildings is 6.3113 MW	Solar on City Sites 040517 (2017) Spreadsheet
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Total Area of Buildings (sq. ft.) - Industrial is 27,092,204	Department of Energy, SLED (accessed 2017)
Total Area of Buildings (sq. ft.) – Commercial is 94,229,955	Department of Energy, SLED (accessed 2017)
Total Area of Buildings (sq. ft.) – Residential is 473,603,027	Department of Energy, SLED (accessed 2017)
Fixed O&M ($/kW-yr.) is $21	NREL Distributed Generation Renewable Energy Estimate of Costs (2016)
Cost of Tesla Power Wall is $6,200 with a capacity of 13.5 kWh	Tesla Power Wall (accessed 2017)
Solar PV - Rooftop Residential CAPEX is $2400/kW	Lazard's Levelized Cost of Energy Analysis – Version 10.0 (2016)
Natural Gas CAPEX is $1300/kW	Lazard's Levelized Cost of Energy Analysis – Version 10.0 (2016)

1.2 Embrace our Californian climate

Climate Smart San José

Embracing our Californian climate focuses on the water aspect of the ESP, and encourages the entire city to realize how precious water is, not only during a drought. Events like a multi-year drought demonstrate the difficulty in controlling and increasing the water supply. Therefore, resisting the effects of a potential drought must come from somewhere else. Reductions in the demand side of the water cycle can increase San José's resiliency to a drought as well as decrease its dependence on imported water simply because less of it is being consumed. These demand-side reductions can be split by sector (e.g. residential and commercial) and also by use (outdoor and indoor). Strategy 1.2 breaks out each of these segments in order to more holistically reduce demand.

Indoor water consumption makes up about 50% of that water consumption for the residential sector, and 80% for commercial. Upgrading appliances like toilets, faucets, and clothes washers etc. to be more efficient, both at home and at work, can greatly reduce water consumption by 2040. The upgrades for each of these appliances typically revolve around consuming less water to perform each of the actions. For example, gallons per flush is the metric for toilets, while gallons per minute is the one for faucets. There is clearly a behavioral aspect to this as well since it does not matter how efficient an appliance is if it is always running. A 10-minute shower versus a 25-minute shower can have major impacts on the overall water consumption of a household. It is then important to note that changing habits, such as taking showers instead of baths, can have as much of an impact as upgrading an appliance.

Although there are several ways of upgrading water-consuming appliances throughout a household, the major opportunity for San José's water reduction lies in outdoor water consumption which uses about 50% of all residential water, and 20% of commercial water. Most of that outdoor water use goes towards landscaping and keeping lawns green. Water evaporation and overwatering of plants lead to a low efficiency rate for this water use. The Pathway uses a variety of methods to crack down on this water consumption sector. Xeriscaping eliminates the need for watering altogether as the replaced foliage are all native to California. Drip irrigation, domestic rainwater storage, and graywater systems are all potential alternatives to keeping that lawn while reducing the burden on the water supply. Drip irrigation is a much more effective means of watering plants because it waters the roots of the plant instead of filtering from the top. Domestic rainwater storage involves homeowners capturing and storing rainwater, typically from their rooftops. There are several challenges to it though since rainfall may not be consistent; and therefore, difficult to be relied upon. In California especially, the winter months are the prime rainy season, but the summer months are the time of more water consumption due to hungry lawns, which creates a timing imbalance between supply and demand.

The other way of reducing outdoor water use is through graywater systems. Graywater systems are of particular interest to the city since they allow the re-use of several types of waste water which is the basis for one of the Green Vision goals. These systems collect the water from faucets, showers, and baths, dishwashers, and clothes washers and repurposes them for landscaping. This means that if enough people switch to more efficient showerheads, the amount of water that can be re-used from showers will go down. Similarly, if a household has drip irrigation, it becomes slightly less worth it invest in drought resilient plants.

Embracing our Californian climate is a call to action. It is up to each and every citizen of San José to treat water as a valuable resource and use it responsibly. The city performed admirably during the drought, succeeding in each of its water conservation goals. It is important as a city to maintain those ideals and that urgency during the drought to continue paving a way forward for a more water efficient society since there is still a lot that can be improved upon.

Dishwashers - Residential

Upgrading to efficient dishwashers present an opportunity to reduce energy and water consumption per load at the same time. If residents were to opt for more efficient dishwashers instead of the cheaper alternatives, 0.03 million tCO2e and 1.86 MG of water would be abated at a saving of $360/tCO2e and a cost of $1.62/gallon.

To determine the savings from upgrading a household's dishwasher, the frequency of use is determined per person (0.85 times per week) and then scaled to be per household and per year (Pacific Institute, 2014). To determine a proxy for an efficient dishwasher (2.4 gallons per load) and a cheaper alternative (5 gallons per load), Energy Star most efficient 2017 dishwashers are compared to the Federal standard (Energy Star Most, 2017). The annual energy and water consumption for each of these are compared in order to determine the savings of choosing the replacement over the reference. The average cost of a dishwasher is used as the reference capital cost (Angie's List, 2015).

Over time, a tech learning curve is applied to the replacement energy and gallons per load. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. The average gallons used by the dishwasher after deployment are included in the potential abatement from a residential graywater system eCBA.

The major challenge facing dishwashers is the higher upfront cost for the initial investment. Energy and water savings may make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	**Justification/ Source**
Average dishwasher follows Federal Standards	Done in order to estimate reference dishwasher
Average household uses dishwasher .85 times per week	Pacific Institute “Urban Water Conservation and Efficiency Potential in California Issue Brief” (2014)
The Beko DIT28430 is the replacement dishwasher at 2.4 gallons per load, 220 kWh per year based on 4 loads a week, and price at $700 Highest Efficiency and Federal Standards	Energy Star “Most Efficient Dishwashers” (2017)
Average cost of a dishwasher is $550	Angie's List “How Much Do Home Appliances Cost?” (2015)
The lifetime duration of a dishwasher is 10 years and the OPEX is assumed to be marginal at $0	Angie's List “How Much Do Home Appliances Cost?” (2015)
Average dishwasher uses 5 gallons per load and 307 kWh per year based on 4 loads a week	Energy Star “Most Efficient Dishwashers” (2017)

Clothes Washers - Residential

Upgrading to efficient clothes washers present an opportunity to reduce energy and water consumption per load at the same time. If residents were to opt for more efficient clothes washers instead of the cheaper alternatives, .02 million tCO2e and 9.28 MG of water would be abated at costs of $680/tCO2e and a $0.38/gallon.

To determine the savings from upgrading a household's clothes washer, the frequency of use is determined per person (2.3 times per week) and then scaled to be per household and per year (Pacific Institute, 2014). To determine a proxy for an efficient clothes washer (12.79 gallons per load) and a cheaper alternative (15.88 gallons per load), the CSSJ looks through PG&E's Marketplace and identifies the Samsung WF45M5500AZ and the Samsung

WA45H7000AW as the replacement and reference units respectively (PG&E, 2017). The annual energy and water consumption for each of these are compared in order to determine the savings of choosing the replacement over the reference.

Over time, a tech learning curve is applied to the replacement energy and gallons per load. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. The average gallons used by the clothes washer after deployment are included in the potential abatement from a residential graywater system eCBA.

The major challenge facing clothes washers is the higher upfront cost for the initial investment. Energy and water savings may make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Average household uses clothes washer 2.3 times per week	Pacific Institute "Urban Water Conservation and Efficiency Potential in California Issue Brief" (2014)
The lifetime duration of a clothes washer is 10 years and the OPEX is assumed to be $100/year	Angie's List "How Much Do Home Appliances Cost?" (2015)
The replacement CAPEX is $600 at 12.79 gallons per load	PG&E "Samsung WF45M5500AZ" (accessed 2017)
The reference CAPEX is $398 at 15.88 gallons per load	PG&E "Samsung WA45H7000AW" (accessed 2017)
The replacement energy use is 105 kWh per year based on 8 loads per week	AJ Madison "Samsung WF45M5500AZ" (accessed 2017)
The reference energy use is 169 kWh per year based on 8 loads per week	AJ Madison "Samsung WA45H7000AW" (accessed 2017)

Toilets - Residential

If residents were to opt for more efficient toilets instead of the cheaper alternatives, 11.93 MG of water would be abated at a saving of $1.07/gallon.

To determine the savings from upgrading a household's toilets, the frequency of use is determined per person (4.8 flushes per day) and then scaled to be per household and per year (Pacific Institute, 2014). To determine a proxy for an efficient toilet (1.1 gallons per flush) and a Federal standard alternative (1.6 gallons per flush), the CSSJ leverages Google Shopping and identifies the Tofino Complete 1-piece 1.1 GPF and the TOTO Drake Two-Piece Elongated 1.6 GPF Toilet as the replacement and reference units respectively (Watersense, accessed 2017). The annual water consumption for each of these are compared in order to determine the savings of choosing the replacement over the reference. Over time, a tech learning curve is applied to the replacement gallons per flush. To estimate the capital costs, it is assumed that there are two toilets per household.

The major challenge facing toilets is the higher upfront cost for the initial investment. Water savings may make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Average person flushes toilet 4.8 times per day	Pacific Institute "Urban Water Conservation and Efficiency Potential in California Issue Brief" (2014)
Two toilets per household	Assumed to estimate capital costs
Toilet lifetime duration is 50 years	ATD Home Inspection "Average Life Span of Homes, Appliances, and Mechanicals" (accessed 2017)
Marginal OPEX is $0	SSWM "Low-flush Toilets" (accessed 2017)
The replacement CAPEX for 1 toilet is $299 at 1.1 gallons per flush	Home Depot website (accessed 2017)
The reference CAPEX for 1 toilet is $229 at 1.6 gallons per flush	Google Shopping (accessed 2017)

Showers - Residential

If residents were to opt for more efficient shower heads instead of the cheaper alternatives, 36.44 MG of water would be abated at a saving of $3.05/gallon.

To determine the savings from upgrading a household's showerhead, the frequency of use is determined per person (4.7 showers a week at 8.7 minutes per shower) and then scaled to be per household and per year (Pacific Institute, 2014). A throttle factor of 0.72 is assumed for both the replacement and reference shower heads. To determine a proxy for an efficient showerhead (1.5 gallons per minute) and a Federal standard alternative (2.5 gallons per minute), the CSSJ leverages Google Shopping and identifies the Delta 3-Spray 2-11/16 in. Water Efficient Fixed Shower Head and the Delta 1-Spray Fixed Shower Head as the replacement and reference units respectively. The annual water consumption for each of these are compared in order to determine the savings of choosing the replacement over the reference. To estimate the capital costs, it is assumed that there are two showers per household.

Over time, a tech learning curve is applied to the replacement gallons per minute. The average gallons used by the showers per year after deployment are included in the potential abatement from a residential graywater system eCBA.

The major challenge facing showerheads is the higher upfront cost for the initial investment. Water savings may make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Average person uses shower 4.7 times a week for 8.7 minutes with a throttle factor of 0.72	Pacific Institute "Urban Water Conservation and

	Efficiency Potential in California Issue Brief" (2014)
Showerhead lifetime Duration is 100 years	ATD Home Inspection "Average Life Span of Homes, Appliances, and Mechanicals" (accessed 2017)
Two showers per household	Assumed to estimate capital costs
The replacement CAPEX for 1 showerhead is $7.54 at 1.5 gallons per minute	Home Depot website (accessed 2017)
The reference CAPEX for 1 showerhead is $8 at 2.5 gallons per minute	Home Depot website (accessed 2017)
OPEX assumed to be $0	Angie's List "How Much Do Home Appliances Cost?" (2015)

Switching From Baths - Residential

If residents were to opt for more efficient shower heads instead of the cheaper alternatives, 22.50 MG of water would be abated at a saving of $2.89/gallon.

To determine the savings from changing behaviors from taking baths to showers, the frequency of use is determined per person (2.24 baths a week become 2.24 showers a week at 8.7 minutes per shower) and then scaled to be per household and per year (Pacific Institute, 2014). A throttle factor of .72 is assumed for the replacement shower heads. To determine a proxy for an efficient showerhead (1.5 gallons per minute) and a Federal standard alternative (2.5 gallons per minute), the CSSJ leverages Google Shopping and identifies the Delta 3-Spray 2-11/16 in. Water Efficient Fixed Shower Head and 18 gallons a bath as the replacement and reference units respectively. The annual water consumption for each of these are compared in order to determine the savings of choosing the replacement over the reference. To estimate the capital costs, it is assumed that there are two showers per household.

Over time, a tech learning curve is applied to the replacement gallons per minute. The average gallons used by the showers per year after deployment are included in the potential abatement from a residential graywater system eCBA.

The major challenge in this eCBA is promoting a behavior change in a populace. Choosing to take baths instead of showers is a habit, and may not be able to be easily changed depending on circumstance. A challenge in this analysis was determining the replacement unit to use, since the comparison of this and the reference of baths forms the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Average person uses shower 4.7 times a week for 8.7 minutes with a throttle factor of 0.72 and uses bath 2.24 times a week with 18 gallons per bath	Pacific Institute "Urban Water Conservation and Efficiency Potential in California Issue Brief" (2014)
Showerhead lifetime Duration is 100 years	ATD Home Inspection "Average Life Span of Homes, Appliances, and Mechanicals" (accessed 2017)
Two showers per household	Assumed to estimate capital costs

The replacement CAPEX for 1 showerhead is $7.54 at 1.5 gallons per minute	Home Depot website (accessed 2017)
OPEX assumed to be $0	Angie's List "How Much Do Home Appliances Cost?" (2015)

Faucets - Residential

If residents were to opt for add efficient faucet aerators, 13.59 MG of water would be abated at a saving of $2.95/gallon.

To determine the savings from adding faucet aerators to a household, the frequency of use is determined per person (10.1 minutes per day) and then scaled to be per household and per year (Pacific Institute, 2014). To determine a proxy for an efficient faucet aerator (.5 gallons per minute for bathroom sinks and 1.5 gallons per minute for kitchen sinks) and a faucet without an aerator (2.2 gallons per minute), the CSSJ leverages Google Shopping and identifies the NEOPERL 0.5 GPM Dual-Thread Water-Saving PCA Spray Faucet Aerator and the 1.5 GPM Dual-Thread Auto-Clean Water-Saving Faucet Aerator as the bathroom sink and kitchen sink replacement units (Silicon Valley Energy Watch, 2017; Watersense, 2017). It is assumed that there are two bathroom sinks and one kitchen sink, so the average GPM is calculated to be 0.833. The annual water consumption for this is compared to the reference GPM of 2.2 in order to determine the savings of choosing the replacement over the reference.

Over time, a tech learning curve is applied to the replacement gallons per minute. The average gallons used by the faucets per year after deployment are included in the potential abatement from a residential graywater system eCBA.

A challenge in this analysis was determining the replacement unit to use, since the comparison of this and the reference of traditional faucets forms the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Average person uses faucet for 10.1 minutes a day	Pacific Institute "Urban Water Conservation and Efficiency Potential in California Issue Brief" (2014)
3 faucets per household – 2 bathroom faucets and 1 in the kitchen	Assumed to estimate capital costs
Use between each of the 3 faucets is even	Done in order to determine usage by gallons per minute
OPEX assumed to be $0	If faucet aerator breaks, then a new one would be bought
1.5 gpm faucet used for kitchen sinks	Silicon Valley Energy Watch "DIY Home Energy Saving Toolkit" (2017)
0.5 gpm faucet used for bathroom sinks	Silicon Valley Energy Watch "DIY Home Energy Saving Toolkit" (2017)
Replacement unit CAPEX for 1 1.5 gpm faucet aerator is $3.20	Home Depot (accessed 2017)

Replacement unit CAPEX for 1 0.5 gpm faucet aerator is $3.04	Home Depot (accessed 2017)
Reference unit flow rate is assumed to be 2.2 gpm	Watersense (accessed 2017)
Reference unit CAPEX is assumed to be $0 since no aerator would be added	Assumed to estimate capital costs

Leaks - Residential

10% of households annually have leaks that waste up to 90 gallons of water per day (EPA, 2017). If residents were to check for leaks every 5 years to eliminate these wastes, 0.69 MG of water would be abated at a cost of $9.56/gallon.

Using the EPA's 10% of households losing 90 gallons of water per day number as a reference unit, that means that the average saving of fixing leaks for a household is 9 gallons of a water a day. The average cost of fixing a leak is applied every 5 years to ensure that the loss of 9 gallons of water a day for the average household does not occur (Homewyse, 2017).

A challenge in this analysis was determining the lifetime duration and cost of fixing a leak, and having both of those values be San José specific.

Assumptions

Assumption	Justification/ Source
10 percent of households have leaks that waste 90 gallons a day	EPA (accessed 2017)
CAPEX of water audit is $0	San José Water Company (accessed 2017)
Average cost of fixing a leak is $299 in zip code 95113 (San José)	Homewyse (accessed 2017)

Graywater System - Residential

Reusing wastewater has been a priority of San José since Green Vision, and it makes sense given the desire to optimize the use of precious resources (Green Vision 2014 Annual Report, 2014). Water from faucets, showers, baths, clothes washers, and dishwashers can be used again for outdoor water purposes which accounts for nearly 50% of total residential water consumption (CITE). If residents were to install graywater systems in their homes to capture this wastewater, 63.1 MG of water would be able to be re-used at a cost of $10/gallon.

To determine the savings from installing graywater systems, average annual water consumption for San José for showers, baths, clothes washers, dish washers, and faucets is added up. This calculation represents the potential re-use capabilities of graywater systems. The CSSJ assumes two showers, two baths, one clothes washer, one dishwasher, and three faucets which adds to a total of nine graywater systems required per household. The Aqua2use Gravity - No Pump graywater system is used as the replacement unit, and multiplied by nine to determine the total overall cost (Water Wise Group, 2017).

The calculation of annual water consumption for each of the water sources (e.g. showers and faucets) is done in the respective eCBA. For example, if enough people switch from taking baths to showers, the amount of water that can be re-used from baths will go down, but that of showers will increase.

The major challenges facing graywater is the initial investment and behavior change to re-using water. However, this behavior shift is necessary in order to maximize the use of each drop of water, particularly in trying times like a drought.

Assumptions

Assumption	Justification/ Source
Graywater sources are clothes washer, dishwasher, bathtub, shower, and faucets	Pacific Institute "Overview of Graywater Use" (2010)
CAPEX and OPEX of Residential Graywater System is $399 and $0 respectively	Water Wise Group (accessed 2017)
Separate graywater systems needed for all faucets, showers, baths, clothes washers, and dishwashers	Done in order to maximize amount of reusable water

Domestic Rainwater Storage - Residential

Outdoor water use makes up roughly 50% of San José's total residential water consumption (CITE). Domestic rainwater storage would allow San José residents to capture rainwater throughout the year to use for landscape irrigation instead of using potable water for the same task. If residents were to install domestic rainwater storage systems, 4.39 MG of water would be abated at a cost of $10.75/gallon.

To determine the savings from installing domestic rainwater capture and storage systems the CSSJ calculates the size of a typical house in San José using the median price of a house ($811,637) and the median price per square foot ($528/square feet) (Zillow, 2017). The average size of a home is assumed to equal the size of the roof. Using the average annual rainfall in San José, the potential annual water capture is calculated, and it is inherently assumed that all water captured will be used (Santa Clara Valley Water District FAQ, 2015; US Climate Data 2017).

A challenge facing domestic rainwater storage is its dependence on the weather to be effective. If another drought were to occur, the investment in this rainwater capture will have been wasted.

Assumptions

Assumption	Justification/ Source
Only detached and attached households suitable for rainwater capture	Need roof or lawn in order to do rainwater capture
Possible to have enough storage to capture total annual rainfall and apply when needed	California has a Mediterranean climate where it rains more in the Winter when the need for water is less. Proper storage would allow residents to keep water until Summer when the water is needed
CAPEX of Domestic Rainwater Storage is $3000	Mercury News (2014)
Average Annual Inches of Rainfall San José is 15.09 inches	US Climate Data (2017)
Assume Supply (gallons) = INCHES OF RAINFALL X 0.623 X CATCHMENT AREA (sq. ft. of roof) X .90 (runoff coefficient for a metal or asphalt roof)	Santa Clara Valley Water District FAQ (2015)

Lifetime duration of domestic rainwater storage is 20 years	Rainwater Harvesting (2008)

Drip Irrigation - Residential

Outdoor water use makes up roughly 50% of San José's total residential water consumption (CITE). Traditional sprinklers can be inefficient delivery systems for watering lawns due to evaporation. Drip irrigation on the other hand precisely waters the roots of the plants, increasing the efficiency of each drop of water expended by about 35% (EPA, 2017). If residents were to install drip irrigation systems as in the Lawn Buster Program, 4.88 MG of water would be abated at a cost of $2.48/gallon.

To determine the savings from installing drip irrigation, the average residential water consumption is reduced by the 35% at the cost of $600 per lawn. The resulting average annual water consumption output is integrated with the drought resilient plants eCBA. Meaning with drip irrigation, it becomes slightly less worth it invest in drought resilient plants.

The major challenge facing drip irrigation is the higher upfront cost for the initial investment. Water savings may make it more cost-effective over its lifetime, but some households may not be able to make that capital cost.

Assumptions

Assumption	**Justification/ Source**
35% increased efficiency of drip irrigation over traditional spray irrigation	EPA (accessed 2017)
CAPEX for drip irrigation sprinklers is $600	Lawn Busters FAQ (accessed 2017)
OPEX for maintaining any lawn is $151	Home Advisor (accessed 2017)
Lifetime duration for drip irrigation sprinklers is 3 years	Berry Hill (accessed 2017)

Drought Resilient Plants - Residential

Outdoor water use makes up roughly 50% of San José's total residential water consumption (CITE). However, many of these lush lawns consist of non-native plants to San José, thereby needing more water than is naturally sustainable. If residents were to replace their lawns with drought-resilient plans as in the Lawn Buster Program, 55.93 MG of water would be abated at a saving of $3.44/gallon.

It is estimated that drought resilient plants use 10% of the water of normal lawns in San José, making them incredibly effective at reducing water consumption (Lawn Busters, 2017). This 10% is taken out of the already reduced, average annual water consumption output of the drip irrigation eCBA, as it assumes that drip irrigation will slightly reduce the full benefits of lawn conversion.

The major challenges facing drought resilient plants is 1) upfront cost for lawn conversion and the most likely bigger challenge of 2) enabling a behavior change in society of the aesthetic of natural and native lawns.

Assumptions

Assumption	**Justification/ Source**
Replaced lawns use 10% of the water	Lawn Busters Infographic (accessed 2017)

CAPEX for lawn conversion is $1,100	Lawn Busters FAQ (accessed 2017)
OPEX for maintaining any lawn is $151	Home Advisor (accessed 2017)

Faucets - Commercial

Similar to homes, faucets are a major source of water consumption in the commercial sector. If buildings were to install efficient faucet aerators, 48.3 MG of water would be abated at a saving of $3.50/gallon.

To determine the savings from adding faucet aerators to a building, the frequency of use is determined per person (10.1 minutes per day) and then scaled to be per building and per year (Pacific Institute, 2014). The CSSJ assumes one person per every 151 square feet to estimate the number of people per building size (The Mehigan Company, Inc., 2016). To determine a proxy for an efficient faucet aerator (.5 gallons per minute for bathroom sinks and a faucet without an aerator (2.2 gallons per minute), the CSSJ leverages Google Shopping and identifies the NEOPERL 0.5 GPM Dual-Thread Water-Saving PCA Spray Faucet Aerator as the bathroom sink replacement unit. Commercial kitchen sinks are not included in this analysis annual water consumption for the bathroom sinks is compared to the reference GPM of 2.2 in order to determine the water savings of choosing the replacement over the reference. To estimate the capital costs of switching out all of the faucets, the number of water closets per building size is estimated with an assumption of one faucet per water closet.

Over time, a tech learning curve is applied to the replacement gallons per minute. The average gallons used by the faucets per year after deployment are included in the potential abatement from a commercial graywater system eCBA.

A challenge in this analysis was determining the replacement unit to use, since the comparison of this and the reference of traditional faucets forms the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Average person uses faucet for 10.1 minutes a day	Pacific Institute "Urban Water Conservation and Efficiency Potential in California Issue Brief" (2014)
All faucets are bathroom faucets	Assumed to estimate capital costs and gpm
OPEX assumed to be $0	If faucet aerator breaks, then a new one would be bought
0.5 gpm faucet used for bathroom sinks	Silicon Valley Energy Watch "DIY Home Energy Saving Toolkit" (2017)
Replacement unit CAPEX for one 0.5 gpm faucet aerator is $3.04	Home Depot (accessed 2017)
Reference unit flow rate is assumed to be 2.2 gpm	Watersense (accessed 2017)
Reference unit CAPEX is assumed to be $0 since no aerator would be added	Assumed to estimate capital costs

Toilets - Commercial

Similar to homes, toilets are a major source of water consumption in the commercial sector. If buildings were to install more efficient toilets instead of cheaper alternatives, 9.28 MG of water would be abated at a saving of $3.31/gallon.

To determine the savings from upgrading a building's toilets, the frequency of use is determined per person (4.8 flushes per week) and then scaled to be per building and per year (Pacific Institute, 2014). The CSSJ assumes one person per every 151 square feet to estimate the number of people per building size (The Mehigan Company, Inc., 2016). To determine a proxy for an efficient toilet (1.1 gallons per flush) and a Federal standard alternative (1.6 gallons per flush), the CSSJ leverages Google Shopping and identifies the Tofino Complete 1-piece 1.1 GPF and the TOTO Drake Two-Piece Elongated 1.6 GPF Toilet as the replacement and reference units respectively. The annual water consumption for each of these are compared in order to determine the savings of choosing the replacement over the reference. To estimate the capital costs of switching out all of the toilets, the number of water closets per building size is estimated with an assumption of one toilet per water closet. Over time, a tech learning curve is applied to the replacement gallons per flush.

The major challenge facing toilets is the higher upfront cost for the initial investment. Water savings may make it more cost-effective over the lifetime of the appliance. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Average person flushes toilet 4.8 times per day	Pacific Institute "Urban Water Conservation and Efficiency Potential in California Issue Brief" (2014)
Toilet lifetime duration is 50 years	ATD Home Inspection "Average Life Span of Homes, Appliances, and Mechanicals" (accessed 2017)
Marginal OPEX is $0	SSWM "Low-flush Toilets" (accessed 2017)
The replacement CAPEX for 1 toilet is $299 at 1.1 gallons per flush	Home Depot website (accessed 2017)
The reference CAPEX for 1 toilet is $229 at 1.6 gallons per flush	Google Shopping (accessed 2017)

Graywater System - Commercial

Reusing wastewater has been a priority of San José since Green Vision, and it makes sense given the desire to optimize the use of precious resources (Green Vision 2014 Annual Report, 2014). Water from commercial faucets can be used again for outdoor water purposes which accounts for nearly 20% of total commercial water consumption (CITE). If buildings were to install graywater systems to capture this wastewater, 14.01 MG of water would be able to be reused at a cost of $2.61/gallon.

To determine the savings from installing graywater systems, average annual water consumption for San José for commercial faucets is totaled by building type. This calculation represents the potential re-use capabilities of graywater systems. To estimate the capital costs of installing graywater systems in each building type, the number of water closets per building size is estimated with an assumption of one faucet per water closet (California Department of Industrial Relations, 2017). The GWTS 1000 graywater system is used as the replacement unit, and multiplied by the number of water closets to determine the total overall cost by building size (Water Wise Group, 2017).

The calculation of annual water consumption for faucets is done in the commercial faucets eCBA. For example, if more efficient faucets are deployed, the less potential water that can be re-used by a graywater system.

The major challenges facing graywater is the initial investment and behavior change to re-using water. However, this behavior shift is necessary in order to maximize the use of each drop of water, particularly in trying times like a drought.

Assumptions

Assumption	**Justification/ Source**
Commercial graywater sources are faucets	Pacific Institute "Overview of Graywater Use" (2010)
CAPEX of Commercial Graywater System is $9,900	Water Wise Group (accessed 2017)
OPEX of Commercial Graywater System is $150	The Guardian (2014)

2.1 Densify our city to accommodate our future neighbors

Climate Smart San José

Densify our city to accommodate our future neighbors is an important strategy for San José. Residential density is a major component of the General Plan, and carries many benefits. It increases walking and biking VMT while also decreasing auto VMT, and reduces building energy and water consumption. It will also increase biking and walking trips while working in tandem with San José's 2020 Bike Plan and upcoming Bike Plan update which work to achieve this mode shift through building a biking network of at least 500 miles. Densifying is practically an inevitability for San José with its projected population growth. If about 400,000 people, around the size of present day Oakland, are going to move int0 San José over the next thirty years, the city will need to adjust its current infrastructure and promote compact infill in order to fit all of the new populace.

Compact infill refers to the development of unused developable (i.e. brownfield) lands. It is one of the many potential policies San José can implement while preparing for its growth spurt. Another is mixed use development which combines the residential and commercial sectors into cohesive building units. Urban villages embody this concept with their designs that blend housing and retail. Another concept that can be included during densification is transit-oriented development, which focuses development around transit hubs like Diridon and the upcoming Berryessa BART station. These stations will become more accessible particularly for nearby walkers and bikers, and increase their ridership. However, the biggest potential value add from residential density it its effect on VMT. Passenger cars and smaller commercial vehicles will be traveling fewer miles per trip because each destination is closer together. The VMT per capita per day will then decrease, which will have huge impacts on the overall carbon emissions of the city, because transportation is the primary sector of carbon emissions. In addition to its effect on VMT, residential density also impacts building energy and water consumption as more multi-family housing is used. The CSSJ assumes that residential building and water energy consumption would be cut in half for each resident living in a dense environment. Therefore, it is tantamount that San José is strategic during its population growth, and ensures that densification occurs in order to minimize the overall impact of each additional citizen.

The other aspect of densification is the San José 2020 Bike Plan which is currently being updated to represent their current progress and future goals. In its quest to become less of an automobile dominated city, the Bike Plan has been a major priority for San José since 2009. The goal to create a comprehensive biking network of 500 miles is complex. These miles will be biking and pedestrian friendly – meaning safe and with proper signage that promote Vision Zero. There is a lot of infrastructure that needs to be put in place in order to influence behaviors. For example, as a resident considering biking to work, not only does there need to be a path to get to the office, there also needs to be available bike parking both at home and at work, lighting along the route for the commute back home, and potentially showers at work to avoid being sweaty in the office. That is a lot that needs to be put into place for mode shift to occur; however, the transferring from a gas guzzling vehicle to a completely carbon free bicycle will have a large effect on the city's emissions if enough people switch.

The Bike Plan and residential density need to work hand in hand in order for the densification of San José to be most effective. Increases in San José's public transit use, walking, biking, and any reductions in VMT, energy and water consumption impact other strategies. The VMT reductions reduced the benefits of electrifying vehicles and appliances, but slightly enhanced the effects of public transit. Densification goes a long way in helping the City of San José achieve many of its goals.

Residential Density

Residential density is a major component of the General Plan, and carries many benefits. It increases walking and biking VMT while also decreasing auto VMT, and reduces building energy and water consumption. When deployed to the General Plan Scenario, residential density abates 10.60 million tCO2e and 39.73 MG of water at savings of $94/tCO2e and $9/gallon.

The CSSJ measures the effectiveness of densification using elasticities which impact other variables in turn for each deployment of residents. For example, for VMT reduction, there is a 12% elasticity for residential density (CARB, "Impacts" 2014) from the additional population. Because it is assumed that this population growth will occur in already developed areas, a 10% elasticity is added on to incorporate compact infill (City of San José, 2015), and these reductions are applied to Passenger Vehicles, and small Commercial vehicles. To demonstrate, if the density of San José doubled, VMT would go down 22%. A limitation of these elasticities is that they are suitable in general city-wide applications. San José is making a concerted effort to accommodate population growth in 'urban villages'. To this end, the CSSJ also includes a 3.1x multiplier ('Urban Village Bonus') that accounts for the city's urban village strategy which will generate synergistic benefits from the combination of greater residential density, compact infill, mixed use development, and transit oriented development. This factor is calibrated to ensure that the daily VMT per capita does not fall unreasonably low when compared to other cities like Boston. This leads to an enhanced effectiveness of densification with the same amount of dollars spent. Altogether, the costs associated with residential density are based on the marginal cost to implement compact infill housing and provide pedestrian and biking facilities (Next 10, 2017).

Over time, the effect of adding 1000 residents diminishes due to the rising population as it becomes harder to densify by 1%. However, this effect gets balanced out by the fact that overall VMT increases over time, again due to the rising population, which means that the overall impact of density remains stable.

In addition to its effect on VMT, residential density also impacts building energy and water consumption as more multi-family housing is used. The CSSJ assumes that residential building and water energy consumption would be cut in half for each resident living in a dense neighborhood (CARB, "Residential" 2014); CA DWR, 2005). The CSSJ also assumes that Transit-Oriented Development will occur, increasing the ridership of local transit hubs such as Diridon and the upcoming Berryessa BART station at an elasticity of 25% (PSRC, 2015). Increases in San José's public transit use, walking, biking, and any reductions in VMT, energy and water consumption were integrated into many other eCBAs. The VMT reductions reduced the benefits of electrifying vehicles and appliances, but slightly enhanced the effects of public transit. Densification goes a long way in helping the City of San José achieve many of its goals.

A challenge in this analysis was distinguishing between the densities of the total San José land area versus just the growth areas given the VMT occurs over the whole land area. Another topic for further review is the inclusion of effects of other built environment factors besides density such as mixed use developed and distance to downtown. The CSSJ assumes that those other factors will occur; however, exact effects from them were not quantified.

Assumptions

Assumption	Justification/ Source
Elasticity of residential density on VMT is 12%	CARB "Impacts of Residential Density on Passenger Vehicle Use and Greenhouse Gas Emissions" (2014)
Elasticity of compact infill on VMT is 10%	City of San José "Greenhouse Gas Reduction Strategy" (2015)
California cost premiums for compact infill can be applied and scaled to San José's average household price	Next 10 "Right Type, Right Place" (2017)
Each resident in a dense environment uses 50% of energy of a normal resident in a non-dense environment	CARB "Residential Energy Use and GHG Emissions Impact of Compact Land Use Types" (2014)

Each resident in a dense environment uses 50% of water of a normal resident in a non-dense environment	CA DWR "California Water Plan Update" (2005)
Elasticity of residential density on Trains and Buses mode shift is 25%	PSRC "Transit-Supportive Densities and Land Uses" (2015)
San José land area will not change	Done in order to estimate % increase in density
CAPEX of walking and biking infrastructure comparable to Portland biking infrastructure cost per resident	Done in order to estimate CAPEX of walking and biking infrastructure
Biking and walking infrastructure do not have an operating cost	Primary cost will be the CAPEX
Value of Portland's Biking Infrastructure is $57,000,000	Journal of Physical Activity and Health "Costs and Benefits of Bicycling Investments in Portland, Oregon" (2011)
Portland Metro Population is 2,191,785	Portland State University "2008 Oregon Population Report" (2009)
Urban Villages will have a 3.1x multiplier effect on residential density elasticities	Done to describe idea that dense, walkable, mixed-use and transit-oriented urban villages within the city are necessary to achieve Paris alignment

Bike Plan

San José's 2020 Bike Plan and upcoming Bike Plan update focus on attracting mode shift from autos to biking and walking. In order to achieve this mode shift, one of the key actions the city is doing is build a biking network of at least 500 miles. These miles will be biking and pedestrian friendly – meaning safe, and with proper signage that promote Vision Zero. Altogether, this biking network will abate .74 million tCO2e at a saving of -$142/tCO2e.

In order to calculate the potential effects of San José's bike plan, the CSSJ leverages data from Portland's successful biking infrastructure. To find the effect of adding on biking miles, the CSSJ used a factor of Portland's commute mode split divided by its trail miles/land area ratio (US Census Bureau, 2016; Portland Bureau of Transportation, 2017; American Fact Finder, 2017). Each additional mile in San José will increase the city's miles/land area ratio which will increase its biking and walking commute and trip mode splits. It is assumed that these additional walkers and bikers will come from passenger car and SUV users, and will reduce their number of trips, thereby reducing their VMT. To find the cost of the infrastructure, the CSSJ uses the total valuation of the Portland's biking infrastructure and divided by the number of trail miles (Journal of Physical Activity and Health, 2011). The cost also includes an operational maintenance cost based per mile (Advocacy Advance, 2014).

The Bike Plan does not have any variables that vary over time, it assumes a constant increase in mode shift for each mile.

There are no integration points with this eCBA. The increase in walking and biking from residential density is done in a separate calculation.

A challenge in this analysis was determining an appropriate mode shift resulting from the Bike Plan per additional mile of deployment. Portland is used as the primary leader, but it is worth further research to isolate the effects for San José and portray more of a distribution of growth as opposed to a constant increase.

Assumptions

Assumption	Justification/ Source
Trail miles have unlimited lifetime duration with proper maintenance	Done in order to estimate projected trail miles
Portland Land Area is 133.43 square miles	US Census Bureau “QuickFacts: Portland city, Oregon” (2016)
Portland Trail Miles has 350 miles worth of trail miles and currently 7.2% of commuters bike to work	Portland Bureau of Transportation “Bicycles in Portland Fact Sheet” (2017)
In 2000, 1.8% of commuters biked to work	American Fact Finder “Journey to Work: 2000” (accessed 2017)
Value of Portland’s Biking Infrastructure is $57,000,000	Journal of Physical Activity and Health “Costs and Benefits of Bicycling Investments in Portland, Oregon” (2011)
Portland’s Maintenance of Bike Infrastructure Per Month is $55	Advocacy Advance “How Communities are Paying to Maintain Trails, Bike Lanes, and Sidewalks“ (2014)
San José currently has 285 on street miles and 57 trail miles counting towards is biking network	City of San José “Memorandum: Accept the Bike Plan 2020 Annual Report” (2017)

2.2 Provide affordable, efficient homes for our families

Climate Smart San José

Providing affordable and efficient homes for our families means going above and beyond simply replacing old appliances with Energy Star equivalents. It really means to enable and empower households to invest in the cleaner and more efficient options for their homes that will show up as savings on their energy bills down the line. Appliances like lights, refrigerators, and oven are considered as well as home electronic energy consumption like TVs, phone chargers, and home office equipment which have “phantom loads” that consume energy even if not in use. The major factor though is heating and cooling costs which make up for about 50% of a home’s total energy consumption; therefore, multiple eCBAs are focused on lowering these costs. Strategy 2.2 can be broken down into two major components, using less energy overall, and converting from natural gas to electricity.

There are many energy efficient devices that a homeowner can replace. The array of options can actually be confusing from a homeowner’s perspective because there are so many options, but everyone’s budget is different. Lights make up about 22% of total residential consumption, and LED replacements for the most often used ones can cut into that consumption. Power strips that facilitate turning off electronics when they are not in use are simple enablers to a good habit. On the HVAC side, energy efficient ACs, smart thermostats like Nest, insulation, and thermal envelopes can drastically cut down on these costs. These eCBAs all have the common goal of maintain the house at the desired temperature with as little energy as possible. All of these help make the residential energy consumption bar smaller.

The other aspect of this strategy is the electrification of the home, which minimizes the contribution from natural gas and expands the contribution of electricity to home energy consumption. Residents can accomplish this through a variety of ways. Electric ranges mitigate natural gas use in the kitchen, but the major use of natural gas is in heating. Electric, tank less, water heaters save energy by reducing natural gas use and avoids needing to keep water preheated. An additional bonus is that they remove the limit of hot water whereas people used to be capped to the size of the tank. For air heating and cooling, a single ground or air heat pumps can serve a home’s HVAC needs while being much more efficient than furnaces or AC units, and are completely electric. All of these appliances that rely on electricity instead of natural gas are essential for San José to comply with the residential zero net energy regulation starting in 2020.

Zero net energy homes consume less energy than they generate. Zero net energy ready homes would be zero net energy if they had sufficient on-site power generation. The state requirement that all newly constructed homes in California be zero net energy will have an incredible impact on future home design. What the legislation does not address is the challenge that is retrofitting homes built pre-2020 to be ZNE or ZNE ready. The retrofits represent the major opportunity for ZNE homes in San José, and will require many local contractors well-versed in energy retrofits. Another challenge is facing this strategy is the high upfront cost to invest in these cleaner alternatives. The 2020 ZNE regulation will help alleviate the issue since things like tight thermal envelopes and all-electric appliances will be the norm. As they reach economies of scale, prices for everything energy efficient will drop as well.

As a whole, this strategy of providing affordable, efficient homes for our families complements strategy 1.1 since San José Clean Energy which will be serving the vast majority of San José residents. As SJCE continually gest greener sourced, residents will be reducing their electricity consumption thus making a large impact on residential building energy from both the supply and demand sides.

Lights - Residential

Lights are a major facet of home energy accounting for about 22% of total residential consumption (Silicon Valley Energy Watch, 2017). There are several alternatives to inefficient incandescent lightbulbs such as LEDs and CFLs. If households were to opt for 40 LED lightbulbs instead of CFLs which are already more efficient than incandescent ones, then 40,000 tCO_2e would be abated at a rate of saving of -\$2,460/tCO_2e.

60-watt equivalent LEDs and CFLs are used as the replacement and reference units respectively. Bulbs were found via Google Shopping, and wattage, life hours, and price per bulb were used to calculate the overall costs and savings (1000 bulbs, 2017). The CSSJ assumes 40 light bulbs in a household will be on for two hours a day (National Geographic, 2017; Department of Energy, 2017). The emission factor from San José Clean Energy is also included in the calculation of the carbon emissions.

Over time, a tech learning curve is applied to the replacement LED wattage, lowering its wattage while retaining its 60-watt equivalency. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. Overall, this leads to a low energy consumption for lighting for both the reference and replacements units, in part because both units will have major efficiency gains over the traditional 60-watt incandescent light bulbs.

As previously discussed, San José Clean Energy and its emission factor plays a major factor into light bulb energy consumption. This is the only integration point for the light bulb eCBA.

The challenges facing implementation of more efficient light bulbs include the higher initial investment cost as well as the allegedly harsh lighting that LEDs can make. It should be noted that the LED's life hours of 25,000 are more than double that of the CFL's at 10,000, meaning that the reference unit will need to be replaced around 1.5 times before the LEDs. This effect, combined with the lower energy consumption, leads the lifetime cost of the replacement to be much lower than the reference. Dimmable and multi-color LEDs also serve as options to counter the harsh lighting. Challenges in this analysis included choosing which lightbulbs to use as the reference and replacement, and also the overall energy consumption with the assumptions for number of lightbulbs and amount of time turned on. More San José specific numbers could be used in order to more directly connect the consumption to the region.

Assumptions

Assumption	Justification/ Source
0 OPEX for lights	If lightbulb stops working, would buy new one
Every household has 40 lightbulbs to replace	Done in order to maximize lighting efficiency
Replacement unit CAPEX for one 12-Watt, 60 Watt equivalent LED bulb with 25,000 life hours is $3	1000 Bulbs website (accessed 2017)
Reference unit CAPEX for one 14-Watt, 60 Watt equivalent CFL bulb with 10,000 life hours is $1.05	1000 Bulbs website (accessed 2017)
Used 2 hours a day to approximate usage	Department of Energy "How Energy-Efficient Light Bulbs Compare with Traditional Incandescents" (accessed 2017)
Average household has 40 light bulbs	National Geographic "The Great Energy Challenge" (accessed 2017)

Home Electronics - Residential

Home electronic energy consumption like TVs, phone charging, home office equipment etc. represent roughly 20% of residential electricity usage (Silicon Valley Energy Watch, 2017). However, a portion of that energy consumption is due to "phantom loads" which occur when a device continues to use energy even though not in use. If these devices were to be turned off when not in use, .11 million tCO2e could be abated at a saving of $804/tCO2e.

Common household electronics are included in this eCBA for phantom load reduction. The included electronics are: TV that is less than 40 inches, DVD player, audio system, desktop computer, monitor, speakers, computer modem, and a multi-function printer (Take Control and Save, 2012). Each of these devices has a phantom load that can be reduced to zero if simply turned off. In order to facilitate this process, three power strips were included as a capital cost for each household (Google Shopping, 2017), and the resulting phantom load output was assumed to be reduced to zero.

The only variables that are assumed to change over time are the baseline household energy consumption as well as the emission factor from San José Clean Energy. Because it is difficult to speculate what home electronics will be used and what their corresponding phantom load consumption will be in the future, the phantom load savings over time were assumed to be constant.

San José Clean Energy and its emission factor plays a major factor into the home electronics energy saving eCBA. This is the only integration point for the home electronics eCBA.

A major challenge faced in this analysis was determining the home electronics of an average household in San José. To find a more accurate carbon abatement value and cost, San José specific home electronic usage would need to be determined over time, with the potential phantom loads savings included for each device.

Assumptions

Assumption	Justification/ Source
Average household has Plasma TV (<40”), DVD player, Audio system, Cordless phone, Desktop Computer, monitor and speakers, Computer modem, and Multi-function printer which requires three power strips altogether, and will not turn off cordless phone	Take Control and Save “Phantom Loads” (2012)
Need to replace surge protectors every two years	How-To Geek " Why (and When) You Need to Replace Your Surge Protector” (2015)
Replacement unit CAPEX for one surge protector is $24.70	Google Shopping (accessed 2017)

Refrigerators - Residential

Refrigerators tend to use relatively high amounts of energy, and have therefore been included in San José’s Greenhouse Gas Reduction strategy. If residents were to opt for energy efficient fridges instead of the cheaper alternatives, .05 million tCO2e could be abated at a saving of $80/tCO2e.

To determine a proxy for an energy efficient refrigerator and a cheaper alternative, fridges were identified as reference and replacement units based on being standard size fridges (i.e. non-compact) with a freezer section (PG&E, 2017). The Frigidaire FFTR1814QB and the Whirlpool WRR56X18FW are the reference and replacement units respectively. The annual energy consumption for each of these models is compared in order to determine the energy savings of choosing the replacement over the reference (AJ Madison, 2017). An operational cost is assumed to apply to both fridges, regardless of the model (Angie’s List, 2015).

Over time, a tech learning curve is applied to the replacement kWh/year energy consumption. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year.

The major challenge facing refrigerators is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
One fridge per household	Done in order to estimate annual household energy use
Lifetime duration of a refrigerator is 17 years	City of San José “Greenhouse Gas Reduction Strategy” (2015)
OPEX is assumed to be $140/year	Angie’s List “How Much Do Home Appliances Cost?” (2015)
Replacement CAPEX is $760	PG&E “Whirlpool WRR56X18FW” (accessed 2017)
Reference CAPEX is $370	PG&E “Frigidaire FFTR1814QB” (accessed 2017)
Replacement energy use is 293 kWh per year	AJ Madison “Whirlpool WRR56X18FW” (accessed 2017)
Reference energy use is 404 kWh per year	AJ Madison “Frigidaire FFTR1814QB” (accessed 2017)

Ovens - Residential

A staple of a household, ovens are an important applicant to replace particularly since they represent an opportunity to convert from natural gas to electric. If residents were to opt for energy efficient ovens instead of the natural gas equivalents, 0.98 million tCO2e could be abated at a cost of $120/tCO2e.

To determine a proxy for an energy efficient refrigerator and a cheaper alternative, ovens were identified as reference and replacement units. The Samsung NX58F5500SS and the Whirlpool WFE515S0ES are the reference and replacement units respectively (Google Shopping, 2017). The annual energy consumption for each of these models is compared in order to determine the energy savings of choosing the replacement over the reference. It is assumed that 60% of meals are cooked at home, and that it takes 1 hour to fully heat the oven to 350 degrees (Smarter Home, 2017).

Over time, a tech learning curve is applied to the replacement kWh/year energy consumption. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year.

The major challenge facing ovens is the behavior shift needed for residents to go from natural gas ranges to electric. Also of note, electric induction ovens require specific pans to cook with, further raising the necessary investment cost. However, electrifying the home as much as possible is a key component of the ESP, which makes this an important hurdle to overcome. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
0 OPEX for ovens	Angie’s List “How Much Do Home Appliances Cost?” (2015)

Replacement CAPEX is $639	Google Shopping (accessed 2017)
Reference CAPEX is $650	Google Shopping (accessed 2017)
60% of meals cooked at home	Washington Post "The slow death of the home-cooked meal" (2015)
Meals require an hour to reach temperature of 350 degrees and it takes an electric oven 2 KWh to achieve this	Smarter House "Energy Saving Tips" (accessed 2017)
Meals require an hour to reach temperature of 350 degrees and it takes an electric oven .11 therms to achieve this	Smarter House "Energy Saving Tips" (accessed 2017)

Water Heaters - Residential

Electric, tank less, water heaters save energy by reducing natural gas use and avoids needing to keep water preheated. An additional bonus is that they remove the limit of hot water whereas people used to be capped to the size of the tank. If residents were to opt for tank less water heaters instead of the traditional ones with tanks, 6.86 million tCO2e could be abated at a saving of $65/tCO2e.

A conventional gas storage and an electric heat pump water heater are used as the replacement units respectively (Smarter House, 2017). The annual energy consumption for each of these models is compared using a typical energy consumption spent on water heating in San José (Silicon Valley Energy Watch, 2017). The replacement unit is assumed to consume less energy by the proportion of its efficiency over the reference unit. These calculations are necessary in order to determine the energy savings of choosing the replacement over the reference.

Over time, a tech learning curve is applied to the replacement efficiency. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year.

The major challenge facing tank less water heaters is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost.

Assumptions

Assumption	**Justification/ Source**
Replacement water heater has a CAPEX of $1,660, OPEX of $190, and an efficiency of 2.2	Smarter House "Replacing your Water Heater" (accessed 2017)
Reference water heater has a CAPEX of $850, OPEX of $350, and an efficiency of 0.6	Smarter House "Replacing your Water Heater" (accessed 2017)

Central AC - Residential

Heating and cooling costs make up for about 50% of a home's total energy consumption (Department of Energy, 2017). This makes HVAC related eCBAs especially important as they represent a larger chunk of the residential energy pie. Since Climate Smart San José opts for ground-source heat pumps, the efficient central AC eCBA does not abate any carbon, but would do so at a saving of $13,339/tCO2e.

A 13-14 SEER (standard efficiency) and a 22-24 SEER (highest efficiency) units were used as the reference and replacement units respectively (Energy Star, 2017; Central Air Conditioner Prices, 2017). The annual energy consumption for each of these models is compared using a typical energy consumption spent on cooling costs in San José (Silicon Valley Energy Watch, 2017). The replacement unit is assumed to consume less energy by the proportion of its SEER over the reference unit. These calculations are necessary in order to determine the energy savings of choosing the replacement over the reference.

Over time, a tech learning curve is applied to the replacement SEER. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year.

The major challenge facing energy efficient central AC units is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
HVAC OPEX is assumed to be $91	Energy Star, "ENERGY STAR Most Efficient 2017 — Central Air Conditioners and Air Source Heat Pumps" (accessed 2017)
Replacement Central AC has a CAPEX of $1,660, OPEX of $190, and an efficiency of 2.2	Central Air Conditioner Prices "Central Air Conditioner Prices" (accessed 2017)
Reference AC has a CAPEX of $850, OPEX of $350, and an efficiency of 0.6	Central Air Conditioner Prices "Central Air Conditioner Prices" (accessed 2017)

Ground-Source Heat Pumps - Residential

Heating and cooling costs make up for about 50% of a home's total energy consumption (Department of Energy, 2017). This makes HVAC related eCBAs especially important as they represent a larger chunk of the residential energy pie. If residents were to opt for more energy efficient ground-source heat pumps units instead of a cheap AC and furnace, 5.55 million tCO2e could be abated at a cost of $101/tCO2e.

A 16 EER ground-source heat pump was used as the replacement unit (Energy Star, 2017). A 13-14 SEER Central AC unit and a GOODMAN GMSS961005CN furnace were used as the reference units (Central Air Conditioner Prices, 2017; Alpine Home Air, 2017). The replacement unit is assumed to consume less energy by the proportion of its coefficient of performance over the reference units, which are assumed to have the equivalent of a coefficient of performance of 1. The coefficient of performance of the replacement unit is calculated by dividing its EER by 3.412. These calculations are necessary in order to determine the energy savings of choosing the replacement over the reference.

Over time, a tech learning curve is applied to the replacement coefficient of performance. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. Ground-source heat pumps are also integrated with the thermal envelope eCBAs. Ground-source heat pump savings are only applied after the thermal envelope savings have already been accounted for. This means that the savings associated with ground-source heat pumps are potentially less than if thermal envelopes were not included.

The major challenge facing energy efficient ground heat pumps is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Ground Loop Heat Pump at full capacity COP	Done in order to determine COP of replacement
Heat pump and furnaces have same OPEX as Central AC	Done in order to estimate OPEX
Ground-source heat pump EER is 16	Energy Star “Geothermal Heat Pumps Key Product Criteria” (accessed 2017)
Lifetime duration of heat pump is 25 years	Department of Energy “Geothermal Heat Pumps” (accessed 2017)
Replacement ground-source heat pump has a CAPEX of $7,113	Home Advisor “How much does it cost to install a geothermal heating or cooling system?” (accessed 2017)
Reference central AC has a CAPEX of $2,770	Central Air Conditioner Prices “Central Air Conditioner Prices” (accessed 2017)
Reference furnace has a CAPEX of $993	Alpine Home Air “GOODMAN GMSS961005CN” (accessed 2017)
Percent of heat pump energy that goes towards the pump is 24%	Bernheim + Dean, Inc. “Zero Net Energy Case Study Buildings” (2014)

Air-Source Heat Pumps - Residential

Heating and cooling costs make up for about 50% of a home’s total energy consumption (Department of Energy, 2017). This makes HVAC related eCBAs especially important as they represent a larger chunk of the residential energy pie. Since Climate Smart San José opts for ground-source heat pumps, the air-source heat pump eCBA does not abate any carbon, but would do so at a saving of $13,339/tCO2e.

A 12.5 EER air-source heat pump was used as the replacement unit (Energy Star, 2017). A 13-14 SEER Central AC unit and a GOODMAN GMSS961005CN furnace were used as the reference units (Central Air Conditioner Prices, 2017; Alpine Home Air, 2017). The replacement unit is assumed to consume less energy by the proportion of its coefficient of performance over the reference units, which are assumed to have the equivalent of a coefficient of performance of 1. The coefficient of performance of the replacement unit is calculated by dividing its EER by 3.412. These calculations are necessary in order to determine the energy savings of choosing the replacement over the reference.

Over time, a tech learning curve is applied to the replacement coefficient of performance. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year.

The major challenge facing energy efficient ground heat pumps is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	Justification/ Source
Air heat pumps have same lifetime duration as ground heat pumps	Done in order to estimate lifetime duration for air heat pumps
Heat pump and furnaces have same OPEX as Central AC	Done in order to estimate OPEX
Reference central AC has a CAPEX of $2,770	Central Air Conditioner Prices “Central Air Conditioner Prices” (accessed 2017)
Reference furnace has a CAPEX of $993	Alpine Home Air “GOODMAN GMSS961005CN” (accessed 2017)
Percent of heat pump energy that goes towards the pump is 24%	Bernheim + Dean, Inc. “Zero Net Energy Case Study Buildings” (2014)
Replacement air-source heat pump has a CAPEX of $5,383	Home Advisor “How much do heat pumps cost to install or replace?” (accessed 2017)
Air-source heat pump EER is 12.5	Energy Star “Air-Source Heat Pumps and Central Air Conditioners Key Product Criteria” (accessed 2017)

Smart Thermostat - Residential

Heating and cooling costs make up for about 50% of a home’s total energy consumption (Department of Energy, 2017). This makes HVAC related eCBAs especially important as they represent a larger chunk of the residential energy pie. If residents were to opt for smart thermostats such as Nest instead of traditional equivalents, .76 million tCO2e could be abated at a saving of $257/tCO2e.

Smart thermostats optimize heating and cooling of homes, and ultimately reduce the amount of energy expended to maintain temperatures. Nest thermostats are used as the replacement unit, and are reported to reduce heating costs by 12% and cooling costs by 15% (Nest, 2015). These percent reductions are applied to the heating and cooling energy consumption of San José homes to get the carbon abatement.

Over time, a tech learning curve is applied to heating and cooling savings. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. Smart thermostats are also integrated with the thermal envelope eCBAs. Smart thermostat savings are only applied after the thermal envelope savings have already been accounted for. This means that the savings associated with smart thermostats are potentially less than if thermal envelopes were not included.

The major challenge facing smart thermostats is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost.

Assumptions

Assumption	Justification/ Source
Marginal OPEX of Smart Thermostat over regular thermostat is 0	Done in order to estimate OPEX

Reduces heating costs by 12% and cooling costs by 15%	Nest "Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results" (2015)
Replacement unit CAPEX is $250	Nest "How much will it cost to have my Nest thermostat professionally installed?" (accessed 2017)
Lifetime duration of smart thermostat is 10 years	Nest "When do I need to replace my Nest Protect?" (accessed 2017)

Insulation - Residential

Heating and cooling costs make up for about 50% of a home's total energy consumption (Department of Energy, 2017). This makes HVAC related eCBAs especially important as they represent a larger chunk of the residential energy pie. Since Climate Smart San José opts for thermal envelope retrofits, the insulation eCBA does not abate any carbon, but would do so at a saving of $147/tCO2e.

Insulation increases a home's ability to maintain temperatures which reduces heating and cooling costs by as much as 25% (City of San José, 2017). These percent reductions are applied to the heating and cooling energy consumption of San José homes to get the carbon abatement, and the percent reductions from insulation are assumed to be constant.

The major challenge facing insulation is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over its lifetime, but some households may not be able to make that capital cost.

Assumptions

Assumption	Justification/ Source
Marginal OPEX of insulation and thermal envelopes is 0	Done in order to estimate OPEX
CAPEX of insulating is $240	Go Smith "Attic Insulation Prices and Installation Costs in San José, CA" (accessed 2017)
Energy savings of insulating is 25%	City of San José "Home Energy Savings Tips" (accessed 2017)
Lifetime duration of insulation is over 40 years	Moonworks "How Long Does Insulation Last? And Other Insulation Questions" (2016)

Thermal Envelope Retrofits - Residential

Heating and cooling costs make up for about 50% of a home's total energy consumption (Department of Energy, 2017). This makes HVAC related eCBAs especially important as they represent a larger chunk of the residential energy pie. If residents were to retrofit their homes to create better thermal envelopes, 2.47 million tCO2e could be abated at a saving of $5/tCO2e.

Tighter thermal envelopes increase a home's ability to maintain temperatures by reducing thermal leaks which reduces heating and cooling costs. To calculate the carbon abatement from thermal envelope retrofits, the CSSJ assumes determines the energy savings from air sealing and insulating a home in climate zone 4 (PG&E, 2017; Energy Star, 2017). It is important to note that the CSSJ assumes that retrofits will not cut as much heating and cooling costs as new construction homes since new homes can be designed to maximize insulation and minimize thermal leaks. Those energy savings are then applied to the average heating and cooling energy consumption in San José. The cost to do retrofit these homes is assumed to be the cost of an energy audit plus the cost of the insulation.

The CSSJ assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. The thermal envelope eCBAs are integrated with smart thermostats and ground-source heat pumps as part of the zero net energy ready building packages. This integration is done by finding the average heating and cooling costs of San José homes after the deployments of thermal envelope retrofits and thermal envelopes for new construction. These heating and cooling costs are lower than the baseline, and reduce the average effects of ground-source heat pumps and smart thermostats since it is assumed that the thermal envelope deployments will occur before those measures are taken.

The major challenge facing thermal envelops is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over its lifetime, but some households may not be able to make that capital cost. Two of the challenges faced in this analysis are accurately estimating the marginal cost of thermal envelope retrofits, as well as determining the reduction in heating and cooling costs after the fact.

Assumptions

Assumption	Justification/ Source
Assume thermal envelope retrofits will be half as effective as thermal envelopes for new construction	Retrofits need to deal with the current construction of the house, but new construction can plan for additional insulation in the design phase
Marginal OPEX of insulation and thermal envelopes is 0	Done in order to estimate OPEX
CAPEX of insulating is $240	Go Smith “Attic Insulation Prices and Installation Costs in San José, CA” (accessed 2017)
CAPEX of Energy Audit is $395	The Mercury News “Now might be good time for a home energy audit” (2010)
Heating and cooling energy reduction due to insulation and air sealing for Climate Zone 4 is 17%	Energy Star “Methodology for Estimated Energy Savings from Cost-Effective Air Sealing and Insulating” (accessed 2017)
San José is in Climate Zone 4	PG&E “California Climate” (accessed 2017)

Thermal Envelope New Construction - Residential

Heating and cooling costs make up for about 50% of a home’s total energy consumption (Department of Energy, 2017). This makes HVAC related eCBAs especially important as they represent a larger chunk of the residential energy pie. If residents were to build new homes with better thermal envelopes, 0.19 million tCO2e could be abated at a cost of $833/tCO2e.

Tighter thermal envelopes increase a home’s ability to maintain temperatures by reducing thermal leaks which reduces heating and cooling costs. To calculate the carbon abatement from thermal envelope retrofits, the CSSJ assumes determines the energy savings from air sealing and insulating a home in climate zone 4 (PG&E, 2017; Energy Star, 2017). Those energy savings are then applied to the average heating and cooling energy consumption in San José. To calculate the cost of the thermal envelope, the CSSJ calculates the size of a typical house in San José using the median price of a house ($811,637) and the median price per square foot ($528/square feet) (Zillow, 2017). The average incremental cost to build a zero net energy ready home is then applied to San José's typical home size of 1,537 square feet (California ZNE Homes, 2017).

It is assumed that this incremental cost will decrease over time as tighter thermal envelopes become the norm. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. The thermal envelope eCBAs are integrated with smart thermostats and ground-source heat pumps as part of the zero net energy ready building packages. This integration is done by finding the average heating and cooling costs of San José homes after the deployments of thermal envelope retrofits and thermal envelopes for new construction. These heating and cooling costs are lower than the baseline, and reduce the average effects of ground-source heat pumps and smart thermostats since it is assumed that the thermal envelope deployments will occur before those measures are taken.

The major challenge facing thermal envelops is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over its lifetime, but some households may not be able to make that capital cost. The primary challenge faced in this analysis is determining the reduction in heating and cooling costs after a tighter thermal envelope has been put in place.

Assumptions

Assumption	Justification/ Source
Cost premium of new thermal envelopes will decrease based on economies of scale	Efficient Thermal Envelopes are likely to become the normal standard for homebuilding
Marginal OPEX of insulation and thermal envelopes is 0	Done in order to estimate OPEX
Heating and cooling energy reduction due to insulation and air sealing for Climate Zone 4 is 17%	Energy Star "Methodology for Estimated Energy Savings from Cost-Effective Air Sealing and Insulating" (accessed 2017)
San José is in Climate Zone 4	PG&E "California Climate" (accessed 2017)
Incremental cost of building a ZNE home is between $2,000 and $8,000 per square foot	California ZNE Homes "Frequently Asked Questions" (accessed 2017)

2.3 Create smart, personalized mobility choices

Climate Smart San José

Since their inception, personal vehicles have been a status symbol in society. Speed, power, and aesthetic have been the driving forces behind automobile trends. Tesla's all-electric Model S was the first to successfully add environmentally friendly into that mix. As more and more electric vehicles enter the market, especially at capital cost that can compete with gasoline or diesel equivalents, EVs will become the norm. This strategy not only includes this electrification of the private vehicle fleet, but also the other innovations and potential disruptors that will occur over the next 30 years. The effects of potential disruptors like shared mobility and autonomous vehicles are still being researched, but the CSSJ Pathway recognizes them as potentially greener alternatives to traditional gasoline personal.

One of the first things people associate with sustainability, passenger car electric vehicles are already in the market, and San José leads the US in EV purchases. SUV electric vehicles are also starting to enter the market which is important since some automobile owners cannot be satisfied with a passenger car alone. These vehicles are priorities for California in order to comply with the Clean Car Standards and Zero Emission Vehicle goals. Historically, the two main challenges facing passenger car electric vehicles has been 1) the premium for an electric vehicle over a gasoline equivalent and 2) the potential lack of charging infrastructure in place to support a saturated market. There is an expected electric battery drop in the early 2020's which will help mitigate the premium, and the city of San José has made electric vehicles a priority, building 53 public charging stations (City of San José, 2017). Continued advances in cutting costs and improving infrastructure will lead to EVs eventually dominating the market. The electrification of passenger vehicles is already occurring, but the next two innovations will drive down emissions even further.

Climate Smart San José considers shared mobility a very intriguing opportunity to drive down emissions. When talking about shared mobility, the CSSJ refers to car sharing and ridesharing. The CSSJ envisions cars that can be accessed by anyone and are smart and connected. This is important because the car sharing is meant to allow different parties heading to the same destination or destinations along the same route use the vehicle for transportation. This ability reduces the overall amount of VMT driven, and can also delay the need for car purchases which reduces the number of overall vehicles on the road. It is also assumed that this shared transportation can be all-electric, using public charging stations when not in use. Although shared mobility is currently used on average as an alternative to public transit, it can also potentially aid it. The first and mile of public transit is well known and well documented. Public transit is great for covering large differences, but without methods of traveling that first or last mile to the transit station or to the final destination, travelers tend to opt for other transportation methods. Enter shared mobility and micro transit services like Chariot which can conveniently direct multiple passengers to these stations. Optimal implementation and management plans of shared mobility are still being developed, but they represent a lot of opportunity to cut down on VMT and therefore emissions.

Autonomous vehicles are even further into the future than electric or shared vehicles. Autonomous vehicles will enable efficient transit and increase fuel economies, but will likely lead to a rise in VMT since driving can be repurposed to more productive activities. AVs will initially mirror the current baseline and be gasoline dominant, but as more and more electric vehicles saturate the market, the CSSJ assumes that AVs will follow the trend and electrify. Shared vehicles will also eventually have the opportunity to be autonomous. Although it is easy to imagine a future where AVs effortlessly zoom along and take people from point A to point B, there are still many challenges that lie ahead. 1) The technology has not yet been fully developed. 2) Once the technology is created, it will take time for an economy of scale to kick in as well as have the proper infrastructure set in place to make it viable. 3) The regulation for AVs is still very much in its infancy stages. 4) Until the market is fully saturated with AVs, it is difficult to determine the exact effects AVs will have when there are non-autonomous vehicles in play. These are some of the major challenges that will need to get addressed before AVs can be fully enter the everyday passenger market.

All that said, the concept of electric, shared AVs perfectly embody this strategy of smart, personalized mobility choices.

Passenger Car Electric Vehicles

One of the first things people associate with sustainability, passenger car electric vehicles are already in the market, and San José leads the US in EV purchases (Inside EVs, 2017) These vehicles are priorities for California in order to comply with the Clean Car Standards and Zero Emission Vehicle goals. With about a 70% market share, passenger car electric vehicles abate 8.70 million tCO2e at a cost of $108/tCO2e.

The CSSJ follows SPUR's assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a passenger car EV and a traditional gasoline equivalent (SPUR, 2016). The CSSJ also accounts for the addition of home, public, and work charging stations needed per EV based on an NREL assessment of California's plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. Beyond these goals, passenger car EVs can greatly help reduce carbon emissions due to their cleaner source of fuel and increased mileage per gallon of gasoline equivalent. However, the greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy. As more EVs come online and the load of SJCE increases, the bigger the effect of going from 50% renewable to 60% renewable and from 60% renewable to ultimately 100%.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between gasoline and passenger car EVs is small. Gasoline vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Historically, the two main challenges facing passenger car electric vehicles has been 1) the premium for an electric vehicle over a gasoline equivalent and 2) the potential lack of charging infrastructure in place to support a saturated market. This makes the expected battery price drop even more important. In terms of charging infrastructure, a difficulty in this analysis was determining their trend moving forward, and whether or not the market will actually adjust to eventually supplant gasoline as the dominant fuel. The CSSJ assumes that more EV charging will occur at home given the assumption that battery life will continue to improve, and also that additional policies, such as the Zero Emission Vehicle goals, will spur the uptake of EVs.

Assumptions

Assumption	Justification/ Source
CAPEX of Passenger Car Electric Vehicle is $28,800	BAAQMD "Bay Area, Plug-In Electric Vehicle Readiness Plan" (2013)
CAPEX of Gasoline Passenger Car is $18,490	BAAQMD "Bay Area, Plug-In Electric Vehicle Readiness Plan" (2013)
CAPEX of Home Charging Station is $1,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
CAPEX of Work Charging Station is $6,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
CAPEX of Public Charging Station is $6,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)

Maintenance of Home Charging Station is $150	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Work Charging Station is $250	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Public Charging Station is $300	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
# of San José Public Charging Stations 2017 is 53	City of San José “Electric Vehicles and Infrastructure” (accessed 2017)
Bay Area Projected Number of ZEVs is 247,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done at home, Bay Area # of Home Charging Stations to support ZEV 2020 is 216,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done at home, Bay Area # of Work Charging Stations to support ZEV 2020 is 25,200	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done at home, Bay Area # of Public Charging Stations to support ZEV 2020 is 5,533	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Home Charging Stations to support ZEV 2020 is 200,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Work Charging Stations to support ZEV 2020 is 41,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Public Charging Stations to support ZEV 2020 is 12,397	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)

SUV Electric Vehicles

Not to be overlooked by passenger car electric vehicles, SUV electric vehicles are an important aspect of the personal vehicle market since some automobile owners cannot be satisfied with a passenger car alone. This makes these vehicles priorities for California in order to comply with the Clean Car Standards and Zero Emission Vehicle goals. In total, SUV electric vehicles will abate 6.63 million tCO2e at a saving of $45/tCO2e.

The CSSJ follows SPUR’s assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between an SUV EV and a traditional gasoline equivalent (SPUR, 2016). The CSSJ also accounts for the addition of home, public, and work charging stations needed per EV based on an NREL assessment of California’s plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. Beyond these goals, SUV EVs can greatly help reduce carbon emissions due to their cleaner source of fuel and increased mileage per gallon of gasoline equivalent. However, the greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy. As more EVs come online and the load of SJCE increases, the bigger the effect of going from 50% renewable to 60% renewable and from 60% renewable to ultimately 100%.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between gasoline and SUV EVs is small. Gasoline vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Historically, the two main challenges facing passenger car electric vehicles has been 1) the premium for an electric vehicle over a gasoline equivalent and 2) the potential lack of charging infrastructure in place to support a saturated market. This makes the expected battery price drop even more important. In terms of charging infrastructure, a difficulty in this analysis was determining their trend moving forward, and whether or not the market will actually adjust to eventually supplant gasoline as the dominant fuel. The CSSJ assumes that more EV charging will occur at home given the assumption that battery life will continue to improve, and also that additional policies, such as the Zero Emission Vehicle goals, will spur the uptake of EVs.

Assumptions

Assumption	Justification/ Source
Honda CR-V price of $24,045 is CAPEX of SUV reference vehicle	Honda CR-V was bestselling SUV in May 2017 Honda “CR-V” (accessed 2017)
Hyundai all-electric prototype price of $39,000 is CAPEX of SUV All-Electric Car	Electrek “Hyundai’s upcoming all-electric long-range SUV to reportedly start at ~$39,000” (2017)
CAPEX of Home Charging Station is $1,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
CAPEX of Work Charging Station is $6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
CAPEX of Public Charging Station is $6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Home Charging Station is $150	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Work Charging Station is $250	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
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If most charging done at home, Bay Area # of Work Charging Stations to support ZEV 2020 is 25,200	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done at home, Bay Area # of Public Charging Stations to support ZEV 2020 is 5,533	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)

If most charging done in public, Bay Area # of Home Charging Stations to support ZEV 2020 is 200,000	NREL "California Statewide Plug-in Electric Vehicle Infrastructure Assessment" (2014)
If most charging done in public, Bay Area # of Work Charging Stations to support ZEV 2020 is 41,000	NREL "California Statewide Plug-in Electric Vehicle Infrastructure Assessment" (2014)
If most charging done in public, Bay Area # of Public Charging Stations to support ZEV 2020 is 12,397	NREL "California Statewide Plug-in Electric Vehicle Infrastructure Assessment" (2014)

Personal Passenger Car Autonomous Vehicles

Once a thing of science fiction, autonomous vehicles are quickly approaching everyday reality. Autonomous vehicles will enable efficient transit and increase fuel economies, but will likely lead to a rise in VMT since driving can be repurposed to more productive activities. With an eventual rise towards electric, autonomous vehicles, personal passenger car AVs will abate 1.58 tCO2e at a cost of $315/tCO2e.

To calculate the carbon abatement of AVs, the CSSJ first determines the year-by-year distribution of AVs between electric and gasoline. It starts of 100% gasoline, and is assumed to linearly increase to 100% electric by the end of 2050. That affects the marginal costs and benefits of AVs since gasoline vehicles are cheaper upfront but have a worst MPGe than EVs. AVs are also assumed to increase the fuel economy and the amount of VMT per replaced car by thirty-one and six percent respectively (Barcham, 2014). For electric AVs, the CSSJ follows SPUR's assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a passenger car EV and a traditional gasoline equivalent (SPUR, 2016). The CSSJ also accounts for the addition of home, public, and work charging stations needed per EV based on an NREL assessment of California's plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. The greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy.

AVs will initially mirror the current baseline and be gasoline dominant, but as more and more electric vehicles saturate the market, the CSSJ assumes that AVs will follow the trend and electrify. This will increase their carbon effectiveness while San José Clean Energy continues to get greener as well.

Although it is easy to imagine a future where AVs effortlessly zoom along and take people from point A to point B, there are still many challenges that lie ahead. 1) The technology has not yet been fully developed. 2) Once the technology is created, it will take time for an economy of scale to kick in as well as have the proper infrastructure set in place to make it viable. 3) The regulation for AVs is still very much in its infancy stages. 4) Until the market is fully saturated with AVs, it is difficult to determine the exact effects AVs will have when there are non-autonomous vehicles in play. These are some of the major challenges that will need to get addressed before AVs can be fully enter the everyday passenger market.

Assumptions

Assumption	**Justification/ Source**
Fuel Economy gain from Autonomous Vehicles is 31%	Barcham "Climate and Energy Impacts of Automated Vehicles" (2014)
VMT/unit increase from Autonomous Vehicle is 6%	Barcham "Climate and Energy Impacts of Automated Vehicles" (2014)
CAPEX to add Autonomous Vehicle system to a car is $8,500	IHS Markit "Self-Driving Cars Moving into the Industry's Driver's Seat" (2014)

CAPEX of Passenger Car Electric Vehicle is $28,800	BAAQMD “Bay Area, Plug-In Electric Vehicle Readiness Plan” (2013)
CAPEX of Gasoline Passenger Car is $18,490	BAAQMD “Bay Area, Plug-In Electric Vehicle Readiness Plan” (2013)
CAPEX of Home Charging Station is $1,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
CAPEX of Work Charging Station is $6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
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# of San José Public Charging Stations 2017 is 53	City of San José “Electric Vehicles and Infrastructure” (accessed 2017)
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If most charging done at home, Bay Area # of Work Charging Stations to support ZEV 2020 is 25,200	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done at home, Bay Area # of Public Charging Stations to support ZEV 2020 is 5,533	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Home Charging Stations to support ZEV 2020 is 200,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Work Charging Stations to support ZEV 2020 is 41,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Public Charging Stations to support ZEV 2020 is 12,397	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)

Personal SUV Autonomous Vehicles

SUV autonomous vehicles are potentially another major component of the automobile industry as more consumers may opt for larger vehicles when they will not need to worry about driving or parking them. Autonomous vehicles will enable efficient transit and increase fuel economies, but will likely lead to a rise in VMT since driving can be repurposed to more productive activities. With an eventual rise towards electric, autonomous vehicles, SUV passenger car AVs will abate 1.41 tCO2e at a cost of $353/tCO2e.

To calculate the carbon abatement of AVs, the CSSJ first determines the year-by-year distribution of AVs between electric and gasoline. It starts of 100% gasoline, and is assumed to linearly increase to 100% electric by the end of 2050. That affects the marginal costs and benefits of AVs since gasoline vehicles are cheaper upfront but have a worst MPGe than EVs. AVs are also assumed to increase the fuel economy and the amount of VMT per replaced car by thirty-one and six percent respectively (Barcham, 2014). For electric AVs, the CSSJ follows SPUR's assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a passenger car EV and a traditional gasoline equivalent (SPUR, 2016). The CSSJ also accounts for the addition of home, public, and work charging stations needed per EV based on an NREL assessment of California's plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. The greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy.

AVs will initially mirror the current baseline and be gasoline dominant, but as more and more electric vehicles saturate the market, the CSSJ assumes that AVs will follow the trend and electrify. This will increase their carbon effectiveness while San José Clean Energy continues to get greener as well.

Although it is easy to imagine a future where AVs effortlessly zoom along and take people from point A to point B, there are still many challenges that lie ahead. 1) The technology has not yet been fully developed. 2) Once the technology is created, it will take time for an economy of scale to kick in as well as have the proper infrastructure set in place to make it viable. 3) The regulation for AVs is still very much in its infancy stages. 4) Until the market is fully saturated with AVs, it is difficult to determine the exact effects AVs will have when there are non-autonomous vehicles in play. These are some of the major challenges that will need to get addressed before AVs can be fully enter the everyday passenger market.

Assumptions

Assumption	**Justification/ Source**
Honda CR-V price of $24,045 is CAPEX of SUV reference vehicle	Honda CR-V was bestselling SUV in May 2017 Honda "CR-V" (accessed 2017)
Hyundai all-electric prototype price of $39,000 is CAPEX of SUV All-Electric Car	Electrek "Hyundai's upcoming all-electric long-range SUV to reportedly start at ~$39,000" (2017)
Fuel Economy gain from Autonomous Vehicles is 31%	Barcham "Climate and Energy Impacts of Automated Vehicles" (2014)
VMT/unit increase from Autonomous Vehicle is 6%	Barcham "Climate and Energy Impacts of Automated Vehicles" (2014)
CAPEX to add Autonomous Vehicle system to a car is $8,500	IHS Markit "Self-Driving Cars Moving into the Industry's Driver's Seat" (2014)
CAPEX of Home Charging Station is $1,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
CAPEX of Work Charging Station is $6,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
CAPEX of Public Charging Station is $6,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)

Maintenance of Home Charging Station is $150	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
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If most charging done at home, Bay Area # of Work Charging Stations to support ZEV 2020 is 25,200	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done at home, Bay Area # of Public Charging Stations to support ZEV 2020 is 5,533	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Home Charging Stations to support ZEV 2020 is 200,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Work Charging Stations to support ZEV 2020 is 41,000	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)
If most charging done in public, Bay Area # of Public Charging Stations to support ZEV 2020 is 12,397	NREL “California Statewide Plug-in Electric Vehicle Infrastructure Assessment” (2014)

Shared Passenger Cars

Vehicles are unused 95% of the time (Wired, 2015). Shared vehicles are the key to this wasteful situation. Shared vehicles and the act of sharing rides can cut down on the number of vehicles required to satisfy transportation needs, and the CSSJ also assumes that each shared vehicle will be electric which also contributes to its carbon abatement. In total, shared, electric passenger cars will abate 7.05 million tCO2e at a saving of $309/tCO2e.

In order to calculate this carbon abatement, the CSSJ assumes that shared vehicles and ridesharing reduces the overall amount of VMT that would have been driven if the passengers had used personal vehicles by 27% (Transportation Sustainability Research Center, 2015). Another key assumption is that each shared vehicle will replace 11 vehicles over its lifetime (Transportation Sustainability Research Center, 2015). Meaning, a single shared vehicle will postpone the purchase of up to 11 vehicles. As this eCBA also assumes the deployed shared vehicles are electric, the CSSJ follows SPUR’s assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a passenger car EV and a traditional gasoline equivalent (SPUR, 2016). It is also assumed that shared vehicles will use public charging stations and base the number required on an NREL assessment of California’s plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. The greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between gasoline and passenger car EVs is small. Gasoline vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Although shared vehicles are a potential solution to the first/last mile problem, they are currently more often being used as alternatives to public transportation. Therefore, the CSSJ assumes that the deployment of shared vehicles will lead to decreases in public transit. This effect is calculated by estimating the mode shift from public transit to shared vehicles per shared vehicle and then the subsequent conversion from trips to VMT using a trips/VMT ratio from the baseline for trains and buses to find the VMT changes.

As with the other EV eCBAs, lack of charging infrastructure will be a challenge for shared, electric passenger cars. An additional hurdle for these vehicles will be the behavioral shift that will need to occur in order to maximize efficiency. People will need to adjust to potentially having to share rides with strangers traveling towards a similar direction.

Assumptions

Assumption	Justification/ Source
CAPEX of Passenger Car Electric Vehicle is $28,800	BAAQMD “Bay Area, Plug-In Electric Vehicle Readiness Plan” (2013)
Honda CR-V price of $24,045 is CAPEX of SUV reference vehicle	Honda CR-V was bestselling SUV in May 2017 Honda “CR-V” (accessed 2017)
CAPEX of Passenger Car Electric Vehicle is $28,800	BAAQMD “Bay Area, Plug-In Electric Vehicle Readiness Plan” (2013)
CAPEX of Public Charging Station is $6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Public Charging Station is $300	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Shared vehicles will replace 11 other vehicles over their lifetime and reduce the amount of the VMT that would have been driven by 27% (low part of range)	Transportation Sustainability Research Center “Mobility and the Shared Economy: Impacts Synopsis” (2015)

Shared Autonomous Passenger Cars

Shared, autonomous vehicles and the act of sharing rides can cut down on the number of vehicles required to satisfy transportation needs, and will enable efficient transit and increase fuel economies. The CSSJ also assumes that each shared vehicle will be electric which also contributes to its carbon abatement. With an eventual rise towards electric, shared passenger car AVs will abate 0.34 tCO2e at a saving of $200/tCO2e.

To calculate the carbon abatement of AVs, the CSSJ first determines the year-by-year distribution of AVs between electric and gasoline. It starts of 100% gasoline, and is assumed to linearly increase to 100% electric by the end of 2050. That affects the marginal costs and benefits of AVs since gasoline vehicles are cheaper upfront but have a worst MPGe than EVs. AVs are also assumed to increase the fuel economy and the amount of VMT per replaced car by 31% and 6% percent respectively (Barcham, 2014). However, the CSSJ also assumes that shared vehicles and ridesharing reduces the overall amount of VMT that would have been driven if the passengers had used personal vehicles by 27% (Transportation Sustainability Research Center, 2015). The two VMT percentages are netted out to get an overall VMT reduction of 21%. Another key assumption is that each shared vehicle will replace 11 vehicles over its lifetime (Transportation Sustainability Research Center, 2015). Meaning, a single shared vehicle will postpone the purchase of up to 11 vehicles. As this eCBA also assumes the deployed shared vehicles are electric, the CSSJ follows SPUR's assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a passenger car EV and a traditional gasoline equivalent (SPUR, 2016). It is also assumed that shared vehicles will use public charging stations and base the number required on an NREL assessment of California's plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. The greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy.

AVs will initially mirror the current baseline and be gasoline dominant, but as more and more electric vehicles saturate the market, the CSSJ assumes that AVs will follow the trend and electrify. This will increase their carbon effectiveness while San José Clean Energy continues to get greener as well. To account for the electric battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between gasoline and passenger car EVs is small. Gasoline vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Although shared vehicles are a potential solution to the first/last mile problem, they are currently more often being used as alternatives to public transportation. Therefore, the CSSJ assumes that the deployment of shared vehicles will lead to decreases in public transit. This effect is calculated by estimating the mode shift from public transit to shared vehicles per shared vehicle and then the subsequent conversion from trips to VMT using a trips/VMT ratio from the baseline for trains and buses to find the VMT changes.

As with the other EV eCBAs, lack of charging infrastructure will be a challenge for shared, electric passenger cars. An additional hurdle for these vehicles will be the behavioral shift that will need to occur in order to maximize efficiency. People will need to adjust to potentially having to share rides with strangers traveling towards a similar direction. Many challenges exist for the AV component of shared vehicles: 1) the technology has not yet been fully developed. 2) Once the technology is created, it will take time for an economy of scale to kick in as well as have the proper infrastructure set in place to make it viable. 3) The regulation for AVs is still very much in its infancy stages. 4) Until the market is fully saturated with AVs, it is difficult to determine the exact effects AVs will have when there are non-autonomous vehicles in play. These are some of the major challenges that will need to get addressed before AVs can be fully enter the everyday passenger market.

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Shared vehicles will replace 11 other vehicles over their lifetime and reduce the amount of the VMT that would have been driven by 27% (low part of range)	Transportation Sustainability Research Center “Mobility and the Shared Economy: Impacts Synopsis” (2015)
Fuel Economy gain from Autonomous Vehicles is 31%	Barcham “Climate and Energy Impacts of Automated Vehicles” (2014)
VMT/unit increase from Autonomous Vehicle is 6%	Barcham “Climate and Energy Impacts of Automated Vehicles” (2014)
CAPEX to add Autonomous Vehicle system to a car is $8,500	IHS Markit “Self-Driving Cars Moving into the Industry’s Driver’s Seat” (2014)

Shared Shuttles

Micro transit services such as Chariot present another alternative to personal vehicle transit. This eCBA expands upon the shared passenger cars and scales those effects to shuttles. In total, shared, electric shuttles will abate 0.77 million tCO2e at a saving of $210/tCO2e.

In order to calculate this carbon abatement, the CSSJ assumes that shared vehicles and ridesharing with shuttles reduces the overall amount of VMT that would have been driven by 43% if the passengers had used personal vehicles (Transportation Sustainability Research Center, 2015). This increased VMT reduction is attributed to the increased capacity of the shared vehicle, in this case, a shuttle. Another key assumption is that each shared vehicle will replace 11 vehicles over its lifetime (Transportation Sustainability Research Center, 2015). To bring that into proportion for the shuttle, the 11 vehicles is multiplied by a factor of the number of passengers in a shuttle (14) divided by a traditional shared vehicle (4). As this eCBA also assumes the deployed shared vehicles are electric, the CSSJ follows SPUR’s assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a passenger car EV and a traditional gasoline equivalent (SPUR, 2016). It is also assumed that shared vehicles will use public charging stations and base the number required on an NREL assessment of California’s plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. The greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between gasoline and passenger car EVs is small. Gasoline vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Although shared vehicles are a potential solution to the first/last mile problem, they are currently more often being used as alternatives to public transportation. Therefore, the CSSJ assumes that the deployment of shared vehicles will lead to decreases in public transit. This effect is calculated by estimating the mode shift from public transit to shared vehicles per shared vehicle and then the subsequent conversion from trips to VMT using a trips/VMT ratio from the baseline for trains and buses to find the VMT changes.

As with the other EV eCBAs, lack of charging infrastructure will be a challenge for shared, electric shuttles. An additional hurdle for these vehicles will be the behavioral shift that will need to occur in order to maximize efficiency. People will need to adjust to potentially having to share rides with strangers traveling towards a similar direction.

Assumptions

Assumption	Justification/ Source
CAPEX of Passenger Car Electric Vehicle is $28,800	BAAQMD "Bay Area, Plug-In Electric Vehicle Readiness Plan" (2013)
Honda CR-V price of $24,045 is CAPEX of SUV reference vehicle	Honda CR-V was bestselling SUV in May 2017 Honda "CR-V" (accessed 2017)
CAPEX of Public Charging Station is $6,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
Maintenance of Public Charging Station is $300	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
Shared vehicles will replace 11 other vehicles over their lifetime and reduce the amount of the VMT that would have been driven by 43% (high part of range)	Transportation Sustainability Research Center "Mobility and the Shared Economy: Impacts Synopsis" (2015)
MPGe All-Electric Large Pickup in 2017 is 75 MPGe	Business Insider "The very first electric pickup truck has arrived — and it could take on Ford one day" (2017)
Incremental Cost of All-Electric Shuttle is $100,000	CARB Heavy-Duty "Heavy-Duty Technology and Fuels Assessment Overview" (2015)
CAPEX of Large Pickup and Van is $27,110	Ford "2017 F-150" (accessed 2017)

Shared Autonomous Shuttles

Micro transit services such as Chariot present another alternative to personal vehicle transit. Shared, autonomous vehicles and the act of sharing rides can cut down on the number of vehicles required to satisfy transportation needs, and will enable efficient transit and increase fuel economies. This eCBA expands upon the shared passenger cars and scales those effects to shuttles. With an eventual rise towards electric, shared shuttle AVs will abate .12 tCO2e at a saving of $1,350/tCO2e.

To calculate the carbon abatement of AVs, the CSSJ first determines the year-by-year distribution of AVs between electric and gasoline. It starts of 100% gasoline, and is assumed to linearly increase to 100% electric by the end of 2050. That affects the marginal costs and benefits of AVs since gasoline vehicles are cheaper upfront but have a worst MPGe than EVs. AVs are also assumed to increase the fuel economy and the amount of VMT per replaced car by 31% and 6% percent respectively (Barcham, 2014). However, the CSSJ also assumes that shared vehicles and ridesharing with shuttles reduces the overall amount of VMT that would have been driven if the passengers had used personal vehicles by 43% (Transportation Sustainability Research Center, 2015). This increased VMT reduction is attributed to the increased capacity of the shared vehicle, in this case, a shuttle. Another key assumption is that each shared vehicle will replace 11 vehicles over its lifetime (Transportation Sustainability Research Center, 2015). To bring that into proportion for the shuttle, the 11 vehicles is multiplied by a factor of the number of passengers in a shuttle (14) divided by a traditional shared vehicle (4). As this eCBA also assumes the deployed shared vehicles are electric, the CSSJ follows SPUR's assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a passenger car EV and a traditional gasoline equivalent (SPUR, 2016). It is also assumed that shared vehicles will use public charging stations and base the number required on an NREL assessment of California's plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. The greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy.

AVs will initially mirror the current baseline and be gasoline dominant, but as more and more electric vehicles saturate the market, the CSSJ assumes that AVs will follow the trend and electrify. This will increase their carbon effectiveness while San José Clean Energy continues to get greener as well. To account for the electric battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between gasoline and passenger car EVs is small. Gasoline vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Although shared vehicles are a potential solution to the first/last mile problem, they are currently more often being used as alternatives to public transportation. Therefore, the CSSJ assumes that the deployment of shared vehicles will lead to decreases in public transit. This effect is calculated by estimating the mode shift from public transit to shared vehicles per shared vehicle and then the subsequent conversion from trips to VMT using a trips/VMT ratio from the baseline for trains and buses to find the VMT changes.

As with the other EV eCBAs, lack of charging infrastructure will be a challenge for shared, electric shuttles. An additional hurdle for these vehicles will be the behavioral shift that will need to occur in order to maximize efficiency. People will need to adjust to potentially having to share rides with strangers traveling towards a similar direction. Many challenges exist for the AV component of shared vehicles: 1) the technology has not yet been fully developed. 2) Once the technology is created, it will take time for an economy of scale to kick in as well as have the proper infrastructure set in place to make it viable. 3) The regulation for AVs is still very much in its infancy stages. 4) Until the market is fully saturated with AVs, it is difficult to determine the exact effects AVs will have when there are non-autonomous vehicles in play. These are some of the major challenges that will need to get addressed before AVs can be fully enter the everyday market.

Assumptions

Assumption	Justification/ Source
CAPEX of Passenger Car Electric Vehicle is $28,800	BAAQMD "Bay Area, Plug-In Electric Vehicle Readiness Plan" (2013)
Honda CR-V price of $24,045 is CAPEX of SUV reference vehicle	Honda CR-V was bestselling SUV in May 2017 Honda "CR-V" (accessed 2017)
CAPEX of Public Charging Station is $6,000	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
Maintenance of Public Charging Station is $300	Clean Technica "EV Charging Station Infrastructure Costs" (2014)
Shared vehicles will replace 11 other vehicles over their lifetime and reduce the amount of the VMT that would have been driven by 43% (high part of range)	Transportation Sustainability Research Center "Mobility and the Shared Economy: Impacts Synopsis" (2015)

MPGe All-Electric Large Pickup in 2017 is 75 MPGe	Business Insider “The very first electric pickup truck has arrived — and it could take on Ford one day” (2017)
Incremental Cost of All-Electric Shuttle is $100,000	CARB Heavy-Duty “Heavy-Duty Technology and Fuels Assessment Overview” (2015)
CAPEX of Large Pickup and Van is $27,110	Ford “2017 F-150” (accessed 2017)
Fuel Economy gain from Autonomous Vehicles is 31%	Barcham “Climate and Energy Impacts of Automated Vehicles” (2014)
VMT/unit increase from Autonomous Vehicle is 6%	Barcham “Climate and Energy Impacts of Automated Vehicles” (2014)
CAPEX to add Autonomous Vehicle system to a car is $8,500	IHS Markit “Self-Driving Cars Moving into the Industry’s Driver’s Seat” (2014)

2.4 Provide high-quality public transit infrastructure

Climate Smart San José

This strategy presents another avenue for San José residents to travel without entering their own personal gasoline vehicle. Public transportation has the potential to reduce the need to drive, and is much more efficient than personal vehicles because they move so many people at one time. It is clear that San José will be heavily advancing its public infrastructure over the next decade with updates to Caltrain and its local bus network and the exciting rollouts of BART, BRT, and the California High Speed Rail. This next generation of public infrastructure can be broken up into the trains and buses. Updates to both San José's train and bus system are important in order cover the local and long distance needs of the residents.

Trains typically require more infrastructure, but once built, can move more people at any given time. They also connect to other cities which allows long distance commuters to more easily come in and out of the city. For example, Caltrain has been connecting San José to San Francisco via the Peninsula Corridor Diridon and Tamien stations for years. They are in the middle of an electrification project, thereby converting their diesel trains into electric ones. This change will increase the commuter rail's operational efficiency, and more frequent trains will lead to increased ridership. The BART Silicon Valley Extension will bring another train system to San José with the first station being at Berryessa and another three in Alum Rock, Downtown San José, and Diridon. Other stations that are part of extension include Milpitas and Santa Clara. The BART extension will provide San José residents another vital means of public transit to navigate around the Bay. Lastly, the California's High Speed Rail project will allow rapid transportation throughout the state, and is a multi-decade project with its initial phase 1 rollout from Diridon to north of Bakersfield being released in 2025, and the full phase 1 from San Francisco to Anaheim in 2029. By 2040, the project will extend up to Sacramento and down to San Diego. These line additions present an incredible opportunity for San José residents as they will be able to travel to almost anywhere in the state with ease.

In contrast with trains, buses with their generally lower capital costs, are more flexible in their routes, and generally focused in local travel. VTA's opening of three bus rapid transit lines (Alum Rock, Stevens Creek, and El Camino) will continue to add to San José's burgeoning public transit system. What makes bus rapid transit special is the separation of bus only lanes. This separation can be physical via construction, but increases the costs. These buses will have more frequent service than normal buses, leading to more passengers, and will be hybrid-electric as opposed to the traditional diesel. The other exciting bus project is VTA's Next Network Program which contains an increased focus on ridership. VTA, with public input, has decided on an 83/17 split between ridership and coverage. This prioritization on ridership (used to be 70/30 split) combined with a shift to hybrid-electric buses will ultimately make buses more effective in converting drive alone commuters, and the hybrid-electric aspect will make the mode shift even more beneficial. Climate Smart San José assumes that this bus network will continue to increase in capacity well past 2030 in order to accommodate the increase in residents.

The key to this strategy in ensuring that these developments are successful and high-quality will depend on the development around the stations. Diridon will become a major transit center with connections to almost every transit network. The other stations downtown, at Berryessa, Alum Rock, or the plethora of bus stops are also very important everyone in the city will not be able to fit within a half mile of Diridon. These other stations represent other access points to San José's soon to be rich, public infrastructure, so it is important that they are not forgotten. Although they may be negatively affected by more shared vehicles from strategy 2.3, this public infrastructure strategy combined with the transit-oriented development from the densification strategy will work hand in hand with this one in order to maximize the success of both of them.

Caltrain

The Caltrain Electrification Project between San José and San Francisco, slated for 2020, will increase the commuter rail's operational efficiency while also abating 1.23 million tCO2e at a rate of saving of $46/tCO2e. The project will electrify their currently diesel trains, and alleviate traffic congestion with more frequent trains and increased ridership at Diridon and Tamien stations.

To calculate the associated carbon reductions and cost of the Caltrain's electrification, the CSSJ relies upon Caltrain's daily VMT reduction of 619,000 miles per day by 2040 and the reported capital cost of $1.98 billion (Caltrain "Key," 2017). Since these numbers represent the entire system, the CSSJ takes San José's proportion of the costs and VMT reductions by dividing them by a factor of the number of San José stops (2) in the Peninsula Corridor (28) (Caltrain "Status," 2017). The reduced VMT is applied to long distance passenger cars and SUVs since it is assumed that Caltrain riders will commute in and out of the city. The CSSJ also calculates the VMT of Caltrain itself by using the number of train miles in the city, and multiplying by the estimated number of train trips. The VMT is then used to calculate the electricity required to run the trains using an energy consumption factor from BART and applying it to commuter trains by finding the ratio of commuter and transit rail emission factors (PG&E, 2007; EPA, 2014). It then becomes possible to determine how much cleaner the trains will operate due to the project.

The effects of Caltrain's electrification will vary over time. The daily reduction in VMT is linearly interpolated and forecasted for the years before and after 2040 respectively; the years after 2040 assume the same rate of growth used in the linear interpolation. The amount of carbon generated by the electrified trains will also differ over time. The CSSJ assumes through a tech learning curve that the kWh/mile energy consumption will decrease. It is also assumed that the PG&E emission factor will also decrease as PG&E complies with the RPS standards and increases its share of renewables.

As with the other public transit eCBAs, additional VMT resulting from residential density and accessible jobs, and reduced VMT from shared mobility get integrated into the Caltrain eCBA throughout its lifetime.

Caltrain faces a challenge from shared mobility as people may opt to use shared cars as opposed to hopping on transportation. The first/last mile problem is also a major hurdle without major densification and transit oriented development. Challenges the CSSJ faced while analyzing Caltrain were proportioning San José's VMT reductions and share of capital costs. Further research is required to more accurately fine-tune San José's shares of these total figures.

Assumptions

Assumption	Justification/ Source
Caltrain and BART energy consumption in 2010 follows most common BART train KWh/car-mile in 2007	Done in order to estimate Caltrain energy consumption
Energy Consumption BART is 3.3708 kWh/mile	PG&E "Energy Efficiency Assessment of BART Train Cars" (2007)
Transit Rail Emissions Factor (kg/passenger mile) is 0.133 and Commuter Rail Emissions Factor is 0.174 kg/passenger mile	EPA "Emission Factors for Greenhouse Gas Inventories" (2014)
Reduced Daily VMT in 2040 is 619,000 miles	Caltrain "Key Regional Benefits" (accessed 2017)
Increased Ridership in 2040 is 21%, the number of Caltrain Peninsula Corridor Stops is 28 while the number of San José Caltrain Stops is 2, and the construction of the project is from 2017-2019	Caltrain "Status Update: July 2017" (2017)
Reference Trains Per Peak Hour Per Direction is 5	Caltrain "February 2014 Caltrain Annual Passenger Counts: Key Findings" (2014)

Replacement Trains Per Peak Hour Per Direction 6	Caltrain “Peninsula Corridor Electrification Project” (accessed 2017)
CAPEX of Caltrain Electrification is $1,980,000	Caltrain “PCEP Cost” (accessed 2017)

BART

The BART Silicon Valley Extension will bring the train to San José with the first at Berryessa and another three in Alum Rock, Downtown San José, and Diridon. Other stations that are part of extension include Milpitas and Santa Clara. The BART extension will provide San José residents another vital means of public transit which will abate 0.88 million tCO2e at a cost of $4,176/tCO2e.

The CSSJ uses BART’s reported daily ridership for the four San José stations, and applies a fraction of the overall capital cost of $7 billion (4 San José stations out of 6 total) (VTA “Phase 1 FAQ,” 2017; VTA “Phase 2 FAQ,” 2017). To estimate the additional operating expenditures, the average operating cost per station minus portions paid by revenues was applied to each of the four new stations. The daily ridership of each station is annualized and assumed to replace passenger car and SUV trips. The CSSJ then converts passenger car and SUV trips into VMT using VMT/trip ratios by vehicle type and fuel that were previously calculated in the baseline. Similarly to the other train eCBAs, the CSSJ also calculates the VMT of BART by using the proportioned number of train miles in the city (16 miles * 4 San José stations / 6 total), and multiplying by the estimated number of train trips. The VMT is then used to calculate the electricity required to run the trains using an energy consumption factor from BART.

As with the other public transit eCBAs, the daily ridership is linearly interpolated and forecasted for the years before and after a new station opens (2018 for Berryessa and 2026 for the rest). The tech learning curve for the kWh/mile energy consumption is applied, and it is also assumed that the PG&E emission factor will also decrease as PG&E complies with the RPS standards and increases its share of renewables.

Similarly to other public transit eCBAs, additional VMT resulting from residential density and accessible jobs, and reduced VMT from shared mobility get integrated into the BART eCBA throughout its lifetime.

BART also faces challenges from the first/last mile problem and shared mobility as people may opt to use shared cars as opposed to hopping on transportation. The first/last mile problem is also a major hurdle without major densification and transit oriented development. Challenges the CSSJ faced while analyzing BART were proportioning San José’s VMT reductions and share of capital costs. Further research is required to more accurately fine-tune San José’s shares of these total figures.

Assumptions

Assumption	**Justification/ Source**
Caltrain and BART energy consumption in 2010 follows most common BART train KWh/car-mile in 2007	Done in order to estimate Caltrain energy consumption
BART San José riders will not go to Santa Clara station	Santa Clara station is not in city of San José
Energy Consumption BART is 3.3708 kWh/mile	PG&E “Energy Efficiency Assessment of BART Train Cars” (2007)
Daily Ridership at Berryessa Station in 2030 is 25,000 and the train frequency of 15 minutes is assumed to be the same throughout San José.	VTA “Phase I – Berryessa Extension” (2017)

Construction of phase 1 is from 2012-2017	
Daily Ridership at Alum Rock/28th St Station in 2035 is 10,300, Daily Ridership at Downtown San José Station in 2035 is 24,300, Daily Ridership at Diridon Station in 2035 is 9,600, and Daily Ridership at Santa Clara Station in 2035 is 7,800. Full extension is 16 miles, and construction is from 2018-2025	VTA "VTA's BART Silicon Valley Phase ll Extension Project" (accessed 2017)
Daily Ridership at Milpitas Station in 2030 is 20,000	VTA "Berryessa Extension Milpitas Station" (2017)
BART trains start at 4am and end at 12am on weekdays and that is assumed to continue everyday	BART "Overview" (accessed 2017)
CAPEX of phase 1 is $2,300,000,000	VTA "Phase 1 FAQ" (accessed 2017)
CAPEX of phase 2 is $ 4,700,000,000	VTA "Phase 2 FAQ" (accessed 2017)
BART's FY16 operating budget is $902.9 million, 83.9% of operating costs paid by passenger fares, parking, advertising and other sources of revenue, and there were 45 stations in FY16. It assumed that each station carries the operational expense equally.	BART "BART 2016 Factsheet (2016)

High Speed Rail

California's High Speed Rail project will allow rapid transportation throughout the state, and is a multi-decade project with its initial phase 1 rollout from Diridon to north of Bakersfield being released in 2025, and the full phase 1 from San Francisco to Anaheim in 2029. By 2040, the project will extend up to Sacramento and down to San Diego. Altogether, the high speed rail will abate .66 million tCO2e at a cost of $2,784/tCO2e.

To calculate the carbon abatement and costs, the capital costs, operational costs, and VMT reductions, the CSSJ portioned the 10,000,000 daily VMT reduction by 2040 to San José by dividing by the number of stops (24) (California High-Speed Rail, 2016; High Speed Rail Authority, 2016). This VMT reduction was applied to long distance passenger cars and SUV given the long distance nature of the mode of transport. To estimate the VMT and cost of the high speed rail, the CSSJ takes the Bay Area's proportion of costs and track, and takes out San José's portion using its proportion of train miles compared to the Bay Area (Bay Area Economic Council, 2008). The estimated number of train trips through San José, energy consumption factor for intercity rail, and PG&E emissions factor, were combined with the train track miles to find the energy consumed by high speed rail.

As with the other public transit eCBAs, the daily VMT reduction is linearly interpolated and forecasted for the years before and after 2040. The tech learning curve for the kWh/mile energy consumption is applied, and it is also assumed that the PG&E emission factor will also decrease as PG&E complies with the RPS standards and increases its share of renewables.

Similarly to other public transit eCBAs, additional VMT resulting from residential density and accessible jobs, and reduced VMT from shared mobility get integrated into the high speed rail eCBA throughout its lifetime.

High speed rail also faces challenges from the first/last mile problem and shared mobility as people may opt to use shared cars as opposed to hopping on transportation. Challenges the CSSJ faced while analyzing high speed rail were proportioning San José's VMT reductions and share of capital costs. Further research is required to more accurately fine-tune San José's shares of these total figures. Also, airline emission reductions were not included as part of this analysis, but are worthy of further research as well.

Assumptions

Assumption	Justification/ Source
Medium Cost Estimates for High Speed Rail	Done in order to estimate costs
High Speed Rail line in San José follows same route as Caltrain	Done in order to estimate train miles in the city for High Speed Rail
High speed rail enhancements made to Los Angeles-Anaheim corridor	Enhancements included in High Speed Rail 2016 Business Plan
Reduced Daily VMT in 2040 is 10,000,000	California High-Speed Rail "Sustainability Report" (2016)
Tamien North Train Miles in City is 4.13 Tamien South Train Miles in City is 15.87	City of San José "Appendix D Community-wide GHG Emissions Inventory and Forecasts Memo" (2016)
Energy Consumption BART is 3.3708 kWh/mile	PG&E "Energy Efficiency Assessment of BART Train Cars" (2007)
Transit Rail Emissions Factor (kg/passenger mile) is 0.133 and Commuter Rail Emissions Factor is 0.174 kg/passenger mile	EPA "Emission Factors for Greenhouse Gas Inventories" (2014)
CAPEX Full Phase 1 is $64,238,000,000 with 15 stops in Full Phase 1. There are 5 stops in Initial Phase 1 San José to North of Bakersfield Line and 9 stops in Full Phase 1 San Francisco to Bakersfield line. In 2040, there will be 24 stops. Assumed CAPEX for each area divided by number of stations in area. OPEX is provided in 5-year intervals and linearly interpolated between them	High Speed Rail Authority "Business Plan" (2016)
Trains During Peak Hours Per Direction in 2030 is 57 while Trains During Off Peak Hours Per Direction in 2030 is 71	SYSTRA "Ridership and Revenue Forecasts" (accessed 2017)
Bay Area Planned Miles of Track is 132 which is 17.36% of total while the Central Valley has 363 Planned Miles of Track.	Bay Area Economic Council "California High Speed Rail Economic Impacts in the San Francisco Bay Area (2008)

Bus Rapid Transit

VTA's opening of three bus rapid transit lines (Alum Rock, Stevens Creek, and El Camino) will continue to add to San José's burgeoning public transit system. The Alum Rock The marginal abatement of making these lines rapid transit with separated lines and stops instead of regular bus routes will abate .27 million tCO2e at a cost of $683/tCO2e.

The CSSJ calculates San José's share of additional bus riders, capital costs, and operational costs using the number of planned stops by route in San José out of the total project (VTA, 2009). Each additional rider is considered an additional trip, which is then converted into reduced passenger car and SUV VMT by multiplying the number of trips by the average VMT/Trip ratio of passenger cars and SUVs. Because the El Camino line has been delayed three years since the initial projection, the original additional ridership numbers were also delayed three years to 2033. In terms of the actual buses, the BRT buses are hybrid-electric which increases its fuel economy over their gasoline and diesel equivalents (Duluth Transit Authority, 2017). The CSSJ estimates the number of trips for each bus using the BRT frequency, and uses the trips and route lengths to estimate the total VMT per route.

As with the other public transit eCBAs, the daily additional ridership is linearly interpolated and forecasted for the years before and after 2033. Because VTA is a local transit agency, it is assumed that the BRT system will use San José Clean Energy power as opposed to PG&E; therefore the emission factor will vary over time with SJCE.

Similarly to other public transit eCBAs, additional VMT resulting from residential density and accessible jobs, and reduced VMT from shared mobility get integrated into the BRT eCBA throughout its lifetime. BRT also has San José Clean Energy integrated with it for its emission factor.

Bus Rapid Transit also faces challenges from the first/last mile problem and shared mobility as people may opt to use shared cars as opposed to hopping on transportation. Challenges the CSSJ faced while analyzing Bus Rapid Transit were proportioning San José's VMT reductions and share of capital and operational costs. Further research is required to more accurately fine-tune San José's shares of these total figures.

Assumptions

Assumption	Justification/ Source
Alum Rock BRT line in 2017 will also reduce VMT by the ratio of its expected ridership	Alum Rock BRT line already deployed
VMT Reduction from Environmental Assessment is delayed 3 years (to 2033)	Since El Camino construction doesn't end until 2020 when it was originally going to end in 2017
El Camino 2030 Daily Ridership is 32,938, Alum Rock 2030 Daily Ridership is 34,764, and Stevens Creek Corridor 2030 Daily Ridership is 15,840. In contrast, El Camino 2030 Daily Ridership With No Project would be 26,820, Alum Rock 2030 Daily Ridership With No Project would be 21,767, and Stevens Creek Corridor 2030 Daily Ridership With No Project would be 10,837. El Camino Length is 16.6 miles, Alum Rock Length is 6.9 miles, and Stevens Creek Length is 8.6 miles. Also, CAPEX Stevens Creek is $145,200,000 and the marginal increase in annual O&M costs with the project is $24,900,000	VTA "Bus Rapid Transit Strategic Plan" (2009)
3 of El Camino's 16 total stops are in San José	VTA "El Camino Real BRT Project" (accessed 2017)

All of Alum Rock's 11 stops are in San José, its CAPEX is $148,000,000, and its construction period is 2014-2017	VTA "Alum Rock-Santa Clara Bus Rapid Transit" (accessed 2017)
CAPEX of El Camino line is $233,000,000	VTA "Independent Study Validates El Camino Real BRT Project Environmental Analysis" (2015)
El Camino Construction Dates 2018-2020	VTA "El Camino Real Bus Rapid Transit (BRT) Project" (2015)
Stevens Creek Construction Dates are 2017-2019 and has 5 out of its 13 are in San José	VTA "Stevens Creek Bus Rapid Transit (BRT) Project" (2014)
MPGe of Hybrid Electric Rapid Transit Bus in 2009 was 5.6	Duluth Transit Authority "Hybrid Buses" (accessed 2017)

Next Network

VTA's Next Network Program details an increased focus from the authority on ridership. VTA, with public input, has decided on an 83/17 split between ridership and coverage. This prioritization on ridership (used to be 70/30 split) combined with a shift to hybrid-electric buses will abate 9.56 million tCO2e at a saving of $0.29/tCO2e.

To calculate the carbon abatement, the Next Network eCBA multiplies the 8% increase in ridership to the baseline (CITE Next Network Final Plan Memo). Each additional rider is considered an additional trip, which is then converted into reduced passenger car and SUV VMT by multiplying the number of trips by the average VMT/Trip ratio of passenger cars and SUVs. Similar to BRT, the hybrid-electric increases its fuel economy over their gasoline and diesel equivalents (Duluth Transit Authority, 2017). It is assumed that the VMT of the bus network will not change since the service hours will not change, only the routes (VTA "Attachment," 2017).

As with the other public transit eCBAs, the daily additional ridership is linearly interpolated and forecasted for the years before and after 2020. Because VTA is a local transit agency, it is assumed that the bus system will use San José Clean Energy power as opposed to PG&E; therefore the emission factor will vary over time with SJCE.

Similarly to other public transit eCBAs, additional VMT resulting from residential density and accessible jobs, and reduced VMT from shared mobility get integrated into the Next Network eCBA throughout its lifetime. Next Network also has San José Clean Energy integrated with it for its emission factor.

Local buses also face challenges from the first/last mile problem and shared mobility as people may opt to use shared cars as opposed to hopping on transportation. Challenges the CSSJ faced while analyzing the Next Network were proportioning San José's VMT reductions and share of capital and operational costs. Further research is required to more accurately fine-tune San José's shares of these total figures. Also, the CSSJ assumes additional capacity increases for local buses than originally reported in the years 2031-2050 to further account for the increased effectiveness due to densification.

Assumptions

Assumption	**Justification/ Source**
Next Network will have 0 marginal CAPEX	VTA has plans to upgrade to Hybrid-Electric buses regardless of the routes
Next Network bus VMT will not change since there is no change in service hours	VTA "Attachment C" (2017)

Marginal OPEX Increase ($'000s)	VTA “Transit Choices Report” (2016)
Overall Increase in Ridership 2020 is 8% and it is fully realized in 2020. Bus (Non-Express) Operating Expenses are 63% of $230,000,000 total Operating Expenses. The 8% additional ridership is directly proportional to the marginal OPEX.	VTA “Next Network Final Plan Memo” (2017)

3.1 Create local, accessible jobs in our city

Climate Smart San José

Creating accessible jobs and San José's Jobs-Employed Resident ratio are key components of the General Plan. Accessible jobs are local jobs within San José that can be easily commuted to via transit, auto, or walking and biking. Jobs-Employed Resident ratio is the factor of number of jobs in the city to the number of residents who are in employed. San José's J/ER was .86 in 2014, meaning for there was 1 job in the city for every employed resident. A J/ER of less than 1 means that there are not enough jobs within the city to sufficiently provide for the populace. It's also possible that there are enough jobs for the population, but those jobs are not well-suited for the population, and therefore, the local population does not have them. The goal of the General Plan is to support a J/ER of 1.3 which will aim to satisfy the local populace while also incentivizing out of towners into the city. Currently, more people leave San José than come in, which can wreak havoc on traffic as well as the local economy. Accessible jobs reduce carbon by eliminating the need for San José commuters to leave San José for work or making it easier to commute to using alternative forms of transit. As the city grows in population, it will need to maintain that increased focus on job growth, particularly ones for San José residents.

San José's plans for Urban Villages take accessible jobs into account. These communities are meant to be pedestrian friendly residences while also providing local jobs for the "village." In a sense, these villages will be self-sustaining which will reduce the need for anyone to drive to work. That mode shift from driving to potentially walking or biking can have a huge impact on emissions because of the gasoline substitution for a completely carbon free alternative. Similarly to residential density, it is assumed that the deployment of accessible jobs will work hand in hand with the 2020 Bike Plan to ensure maximum effectiveness on both fronts.

In addition to its effect on VMT, the CSSJ also assumes that transit-oriented development will occur with the deployment of accessible jobs. This will increase the ridership of local transit hubs such as Diridon and the upcoming Berryessa BART station, and those coming into San José will be able to more easily travel to their jobs via public transit. Increases in San José's public transit use, walking, biking, and any reductions in VMT were integrated into the public transit eCBAs from strategy 2.4 which increases their effectiveness.

Accessible jobs carry these great potential benefits, but it is important to emphasize the need for jobs that are suitable for the San José population. If jobs are brought into the city, but no one wants them or can work them, the J/ER will be well above the desired range. Too high of a J/ER may mean outside residents are working jobs in San José, but then spending that hard-earned money in outside of the city, thus taking away the economic benefits. Too high of a ratio may also mean a high unemployment rate which will also negatively impact the city. This strategy is not an easy one to implement, but it has a lot of potential for the city both economically as well as environmentally.

Accessible Jobs

Accessible jobs and San José's Jobs-Employed Resident ratio are key components of the General Plan. More people leave San José than come in, which can wreak havoc on traffic as well as the local economy (The Mercury News, 2015). If San José were to make all of its job growth accessible to San José residents, it could abate 24.66 million tCO2e at a saving of -$175/tCO2e.

Accessible jobs reduce carbon by eliminating the need for San José commuters to leave San José for work. Those coming into San José be able to more easily travel to their jobs via public transit. The CSSJ measures the effectiveness of accessible using elasticities which impact other variables in turn for each deployment of jobs. For example if the number of accessible jobs doubled, VMT would go down 19% (National Center for Sustainable Transportation, 2017). The CSSJ also includes a factor of 3.1 that triples the effect of adding people to San José to compensate for residential density, compact infill, mixed use development, and transit oriented development all occurring at the same time. This factor is calibrated to ensure that the daily VMT per capita does not fall unreasonably low when compared to other cities like Boston. This leads to an enhanced effectiveness of accessible jobs with the same amount of dollars spent.

Over time, the effect of adding 1000 jobs diminishes due to the rising job population. However, this effect gets balanced out by the fact that the number of jobs increases over time, which means that the overall impact of accessible jobs remains stable.

In addition to its effect on VMT, the CSSJ also assumes that Transit-Oriented Development will occur, increasing the ridership of local transit hubs such as Diridon and the upcoming Berryessa BART station at an elasticity of 25% (PSRC, 2015). Increases in San José's public transit use, walking, biking, and any reductions in VMT were integrated into the public transit eCBAs. The VMT additions slightly enhanced the effects of public transit.

A challenge in this analysis was determining the original number of accessible jobs within San José. The CSSJ assumes that all jobs currently in San José are regionally accessible, but that may not be the case. Another topic for further review is the inclusion of effects of other built environment factors besides accessible jobs such as employment density and distance to downtown. The CSSJ assumes that those other factors will occur; however, exact effects from them were not quantified.

Assumptions

Assumption	Justification/ Source
All jobs in and projected to be in San José are already regionally accessible	Done in order to estimate % increase in regionally accessible jobs
Marginal CAPEX and OPEX for job accessibility are 0	Baseline already includes additional jobs
CAPEX of walking and biking infrastructure comparable to Portland biking infrastructure cost per resident	Done in order to estimate CAPEX of walking and biking infrastructure
Biking and walking infrastructure do not have an operating cost	Primary cost will be the CAPEX
Elasticity of VMT decrease from Regionally Accessible Jobs	National Center for Sustainable Transportation "A Framework for Projecting the Potential Statewide Vehicle Miles Traveled (VMT) Reduction from State-Level Strategies in California" (2017)
Elasticity of VMT decrease from Employment Density	CARB "Impacts of Employment Density on Passenger Vehicle Use and Greenhouse Gas Emissions" (2014)
California cost premiums for compact infill can be applied and scaled to San José's average household price	Next 10 "Right Type, Right Place" (2017)
Elasticity of residential density on Trains and Buses mode shift is 25%	PSRC "Transit-Supportive Densities and Land Uses" (2015)
San José land area will not change	Done in order to estimate % increase in density
Value of Portland's Biking Infrastructure is $57,000,000	Journal of Physical Activity and Health "Costs and Benefits of Bicycling Investments in Portland, Oregon" (2011)

Portland Metro Population is 2,191,785	Portland State University “2008 Oregon Population Report” (2009)
Urban Villages will have a 3.1x multiplier effect on accessible job elasticities	Done to describe idea that dense, walkable, mixed-use and transit-oriented urban villages within the city are necessary to achieve Paris alignment

3.2 Productive, high-performance commercial real estate

Climate Smart San José

Similarly to the residential sector, commercial buildings have the potential to drastically cut energy costs and reduce carbon. The focus on productive and high-performance in this strategy is necessary as energy innovations will need to be cost-effective in order to gain sway with the commercial sector. It will be important to incentivize businesses to invest in clean energy products and practices in order to minimize emissions from the city as a whole. As with homes, measures for commercial buildings can be segmented into the two major components, using less energy overall, and converting from natural gas to electricity.

Shrinking the total amount of energy that is consumed by a growing commercial sector requires several energy efficiency upgrades. Office lights are on for many hours of the day which makes the replacement of lights with LEDs instead of fluorescents even more important. Another important energy consumer within commercial buildings are office equipment such as servers. Upgrading office equipment to Energy Star rated models provides another avenue of energy reduction. However, again as with the residential sector the major opportunities lie in the HVAC of the buildings. Tighter thermal envelopes will reduce the amount of thermal loss. Finding and sealing air leaks is a good first step to reduce heating and cooling costs. They make HVAC systems more effective by making it easier for them to keep the room a temperate temperature. Another key measure for commercial buildings to reduce their heating and cooling bills is through frequent recommissioning. Recommissioning is the process of investigating the HVAC system of a building and ensuring that the systems are working seamlessly with each other. Optimizing the systems can drastically improve the overall efficiency while costing than investing in a full upgrade. Recommissioning for each building is recommended every 5 years to keep things working at top shape.

The other component of this strategy is the conversion from natural gas to electricity. It is assumed that the vast majority of natural gas consumed in commercial buildings is for HVAC purposes. Therefore, replacing these HVAC systems with all-electric systems is incredibly important. Climate Smart San José assumes that commercial HVAC systems will be replaced with all-electric air-source heat pump equivalents. They will be much more efficient than their central AC and furnace equivalents, while also consuming no therms. This measure will greatly electrify the commercial sector, and help the strategy achieve its goal.

Once all of these measures are combined, zero net energy ready commercial buildings will then become more standard. Clearly, the key to maximizing the number of ZNE ready commercial buildings will be through focusing on HVAC. Net energy metering will be required in order to push these buildings to the full ZNE label, but using all of these measures will minimize the amount of locally generated energy required to achieve ZNE status. It is already common to see LEED certified buildings around the Bay Area. ZNE certifications are much rarer, but encouragement in the private sector to continue to go green will help incentivize progress. The commercial sector emits more tCO2e than even the residential sector which means that they must be included in the conversation in order to be Paris compliant as a city.

Thermal Envelope Retrofits - Commercial

As with residential energy consumption, HVAC makes up a large portion of commercial building energy costs. If buildings were to be retrofitted to create better thermal envelopes, .41 million tCO2e could be abated at a cost of $83/tCO2e.

Tighter thermal envelopes increase a building's ability to maintain temperatures by reducing thermal leaks which reduces heating and cooling costs. To calculate the carbon abatement from thermal envelope retrofits, the CSSJ assumes determines the energy savings from air sealing and insulating a home in climate zone 4 (PG&E, 2017; Energy Star, 2017). It is important to note that the CSSJ assumes that retrofits will not cut as much heating and cooling costs as new construction homes since new homes can be designed to maximize insulation and minimize thermal leaks. Those energy savings are then applied to the average heating and cooling energy consumption in San

José. To calculate the cost of building a better thermal envelope, the marginal cost of insulating a 5,000 square foot house is then applied to the average size of each San José commercial building stock.

The CSSJ assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. The commercial thermal envelope eCBAs are integrated with commercial recommissioning and HVAC as part of the zero net energy ready building packages. This integration is done by finding the average heating and cooling costs of San José buildings after the deployments of thermal envelope retrofits and thermal envelopes for new construction. These heating and cooling costs are lower than the baseline, and reduce the average effects of recommissioning and HVAC since it is assumed that the thermal envelope deployments will occur before those measures are taken.

The major challenge facing thermal envelops is the higher upfront cost for the initial investment, but energy savings will eventually make it more cost-effective over its lifetime. Two of the challenges faced in this analysis are accurately estimating the marginal cost of thermal envelope retrofits, as well as determining the reduction in heating and cooling costs after the fact.

Assumptions

Assumption	Justification/ Source
Thermal envelope retrofits will not be able to insulate as much as new construction retrofits	Retrofits need to deal with the current construction of the house, but new construction can plan for additional insulation in the design phase
Marginal OPEX of insulation and thermal envelopes is 0	Done in order to estimate OPEX
Heating and cooling energy reduction due to insulation and air sealing for Climate Zone 4 is 17%	Energy Star “Methodology for Estimated Energy Savings from Cost-Effective Air Sealing and Insulating” (accessed 2017)
San José is in Climate Zone 4	PG&E “California Climate” (accessed 2017)
Marginal cost of insulating a 5,000 square foot house is $10,000	Trillium Architects “Construction Costs” (accessed 2017)

Thermal Envelope New Construction - Commercial

As with residential energy consumption, HVAC makes up a large portion of commercial building energy costs. If new buildings were to be constructed with better thermal envelopes, .23 million tCO2e could be abated at a cost of $908/tCO2e.

Tighter thermal envelopes increase a building’s ability to maintain temperatures by reducing thermal leaks which reduces heating and cooling costs. To calculate the carbon abatement from thermal envelope retrofits, the CSSJ assumes determines the energy savings from air sealing and insulating a home in climate zone 4 (PG&E, 2017; Energy Star, 2017). Those energy savings are then applied to the average heating and cooling energy consumption in San José. To calculate the cost of retrofitting the thermal envelope, a 10% premium to the construction cost for each San José commercial building stock (Green Building Advisor, 2013).

The CSSJ assumes this premium will decrease over time as tighter thermal envelopes become the norm. It is also assumed that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. The commercial thermal envelope eCBAs are integrated with commercial recommissioning and HVAC as part of the zero net energy ready building packages. This integration is done by finding the average heating and cooling costs of San José buildings after the deployments of thermal envelope retrofits and thermal envelopes for new construction. These heating and cooling costs are lower than the baseline, and reduce the average effects of recommissioning and HVAC since it is assumed that the thermal envelope deployments will occur before those measures are taken.

The major challenge facing thermal envelops is the higher upfront cost for the initial investment, but energy savings will eventually make it more cost-effective over its lifetime. Two of the challenges faced in this analysis are accurately estimating the marginal cost of thermal envelopes for new construction, as well as determining the reduction in heating and cooling costs after the fact.

Assumptions

Assumption	Justification/ Source
Cost premium of new thermal envelopes will decrease based on economies of scale	Efficient Thermal Envelopes are likely to become the normal standard for homebuilding
Marginal OPEX of insulation and thermal envelopes is 0	Done in order to estimate OPEX
Heating and cooling energy reduction due to insulation and air sealing for Climate Zone 4 is 17%	Energy Star “Methodology for Estimated Energy Savings from Cost-Effective Air Sealing and Insulating” (accessed 2017)
San José is in Climate Zone 4	PG&E “California Climate” (accessed 2017)
10% premium in construction costs for tight thermal envelopes for new construction	Green Building Advisor “Ten Misconceptions About the Passive House Standard” (2013)

HVAC - Commercial

As with residential energy consumption, HVAC makes up a large portion of commercial building energy costs. If buildings were to replace their HVAC systems with electric air source heat pumps, 7.28 million tCO2e could be abated at a cost of $94/tCO2e.

To determine this carbon abatement, the number of tons of AC needed for each size of commercial building stock is found with the key assumption that every 400 square feet requires another ton of AC (McDermott Group, 2017). Average cost of 5 tons along with the standard SEER of 14 are used as the reference unit. A 12.5 EER air-source heat pump was used as the replacement unit (Energy Star, 2017). A 14 SEER, 5 ton Central AC unit and a GOODMAN GMSS961005CN furnace were used as the reference units (Central Air Conditioner Prices, 2017; Alpine Home Air, 2017). The replacement unit is assumed to consume less energy by the proportion of its coefficient of performance over the reference units, which are assumed to have the equivalent of a coefficient of performance of 1. The coefficient of performance of the replacement unit is calculated by dividing its EER by 3.412. The cost for a single air-source heat pump for 2.5 tons is then applied to the tonnage needed for each size of the commercial building stock. These calculations are necessary in order to determine the energy savings of choosing the replacement over the reference.

The CSSJ assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. The commercial HVAC eCBA is integrated with the commercial thermal envelope eCBAs as part of the zero net energy ready building packages. This integration is done by finding the average heating and cooling costs of San José buildings after the deployments of thermal envelope retrofits and thermal envelopes for new construction. These heating and cooling costs are lower than the baseline, and reduce the average effects of HVAC since it is assumed that the thermal envelope deployments will occur before commercial HVAC is implemented.

The major challenge facing commercial HVAC is the higher upfront cost for the initial investment, but energy savings will eventually make it more cost-effective over its lifetime.

Assumptions

Assumption	Justification/ Source
Every 400 square feet requires another ton of AC for commercial buildings	McDermott Group "Rule of Thumb HVAC Sizing" (2017)
Air heat pumps have same lifetime duration as ground heat pumps	Done in order to estimate lifetime duration for air heat pumps
Heat pump and furnaces have same OPEX as Central AC	Done in order to estimate OPEX
Reference 5 ton, central AC has a CAPEX of $3,590	Central Air Conditioner Prices "Central Air Conditioner Prices" (accessed 2017)
Reference furnace has a CAPEX of $993	Alpine Home Air "GOODMAN GMSS961005CN" (accessed 2017)
Percent of heat pump energy that goes towards the pump is 24%	Bernheim + Dean, Inc. "Zero Net Energy Case Study Buildings" (2014)
Replacement air-source heat pump has a CAPEX of $5,383	Home Advisor "How much do heat pumps cost to install or replace?" (accessed 2017)
Air-source heat pump EER is 12.5	Energy Star "Air-Source Heat Pumps and Central Air Conditioners Key Product Criteria" (accessed 2017)

Smart Thermostat - Commercial

As with residential energy consumption, HVAC makes up a large portion of commercial building energy costs. If businesses were to opt for smart thermostats such as Nest instead of traditional equivalents, .88 million tCO2e could be abated at a saving of $291/tCO2e.

Smart thermostats optimize heating and cooling of buildings, and ultimately reduce the amount of energy expended to maintain temperatures. Nest thermostats are used as the replacement unit, and are reported to reduce heating costs by 12% and cooling costs by 15% in homes (Nest, 2015). The CSSJ applies these savings to San José's commercial buildings, assuming that 12% savings on heating and cooling can be achieved across each of the building sizes. To find the cost of installing a sufficient number of smart thermostats in a building, it is assumed that one thermostat can cover the average San José home size, and that same ratio is applied to each of the building sizes.

Over time, a tech learning curve is applied to heating and cooling savings. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. Smart thermostats are also integrated with the thermal envelope eCBAs. Smart thermostat savings are only applied after the thermal envelope savings have already been accounted for. This means that the savings associated with smart thermostats are potentially less than if thermal envelopes were not included.

The major challenge facing smart thermostats is the higher upfront cost for the initial investment. Energy savings will eventually make it more cost-effective over the lifetime of the appliance, but some households may not be able to make that capital cost.

Assumptions

Assumption	Justification/ Source
Marginal OPEX of Smart Thermostat over regular thermostat is 0 Explicitly included	Done in order to estimate OPEX
Reduces heating and cooling costs by 12%	Not the full 15% given the larger size of commercial buildings Nest "Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results" (2015)
Replacement unit CAPEX is $250	Nest "How much will it cost to have my Nest thermostat professionally installed?" (accessed 2017)
Lifetime duration of smart thermostat is 10 years	Nest "When do I need to replace my Nest Protect?" (accessed 2017)

Recommissioning - Commercial

As with residential energy consumption, HVAC makes up a large portion of commercial building energy costs. Recommissioning a building involves assessing the performance of a buildings operating systems to ensure that they are at peak efficiency. If buildings were to be recommissioned every five years, 1.14 million tCO2e could be abated at a saving of $275/tCO2e.

To determine this carbon abatement, energy savings of 15% are applied to each commercial building stock size (Schneider Electric, 2009). The range of costs from $.13 / square foot to $.30 / square foot is applied with the assumption that larger buildings will cost less per square foot to be recommissioned than smaller buildings (CA Commissioning Collaborative, 2006).

The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year. This eCBA is integrated with the commercial thermal envelope eCBAs as part of the zero net energy ready building packages. This integration is done by finding the average heating and cooling costs of San José buildings after the deployments of thermal envelope retrofits and thermal envelopes for new construction. These heating and cooling costs are lower than the baseline, and reduce the average effects of recommissioning since it is assumed that the thermal envelope deployments will occur before recommissioning is implemented.

The major challenge facing recommissioning is the upfront cost, but energy savings will eventually make it cost-effective over its lifetime.

Assumptions

Assumption	Justification/ Source
Recommission Cost / Sq Ft decreases as Building Size Increases	Larger buildings more likely to get bulk deals from recommissioning
Recommissioning brings about heating and cooling savings of 15%	Schneider Electric "Building Optimization: Recommissioning Your Building to Deliver Peak Performance" (2009)

It costs between $.13 / square foot and $.30 / square foot for commercial recommissioning	CA Commissioning Collaborative “California Commissioning Guide” (2006)
Recommissioning should be done every 5 years	Sobieski “Is It Time to Recommission Your Building?” (2014)
It will cost more per square foot to recommission smaller buildings than larger	Larger buildings are more likely to get bulk deals due to their sheer size

Lights - Commercial

Lights are a major facet of commercial energy even though there are several alternatives to inefficient incandescent lightbulbs such as LEDs and CFLs. If commercial buildings were to upgrade their lighting with LEDs instead of fluorescent bulbs, they could abate .05 million tCO2e at a saving of $1,745/tCO2e.

The number of light bulbs needed for each building size is determined using the assumption that 3 watts of typical lightbulbs are needed per square foot of office space (My LED Lighting Guide, 2017). This value is then applied to each of the building sizes, and converted from watts to lightbulbs using the reference unit (T5 fluorescents). The energy consumption and cost is then compared to the replacement unit (LEDs) wattage (32) using an assumed annual operating hours of 3,110 (1000 Bulbs, 2017).

Over time, a tech learning curve is applied to the replacement LED wattage, lowering its wattage while retaining its watt equivalency. The CSSJ also assumes that San José Clean Energy will get continually greener sourced, thus lowering its emission factor each year.

The challenges facing implementation of more efficient light bulbs include the higher initial investment cost as well as the allegedly harsh lighting that LEDs can make. It should be noted that the LED’s life hours of 85,000 are more than double that of the fluorescent’s at 20,000, meaning that the reference unit will need to be replaced around 4 times before the LEDs. This effect, combined with the lower energy consumption, leads the lifetime cost of the replacement to be lower than the reference. Dimmable and multi-color LEDs also serve as options to counter the harsh lighting. Challenges in this analysis included choosing which lightbulbs to use as the reference and replacement, and also the overall energy consumption with the assumptions for number of lightbulbs and amount of time turned on. More San José specific numbers could be used in order to more directly connect the consumption to the region.

Assumptions

Assumption	Justification/ Source
0 OPEX for lights	If lightbulb stops working, would buy new one
Replacement unit CAPEX for 1 32-Watt LED bulb with 85,000 life hours is $80.57	1000 Bulbs website (accessed 2017)
Reference unit CAPEX for 1 48-Watt T5 fluorescent bulb with 20,000 life hours is $11.94	1000 Bulbs website (accessed 2017)
Lighting Wattage Needed Per Square Foot is 3	My LED Lighting Guide “How to Reduce Office Energy Costs” (accessed 2017)
Annual Operating Hours of commercial lights is 3110 per bulb	PSEG Long Island New York “Energy Efficient Lighting Solution Test Cases” (accessed 2017)

Office Equipment - Commercial

Another important energy consumer within commercial buildings are office equipment such as servers. If commercial buildings were to upgrade their office equipment they could abate .18 million tCO2e at a saving of $597/tCO2e.

To determine this carbon abatement, it is assumed that upgrading office equipment to Energy Star rated models will save 50% of their energy costs (Energy Star, 2017). This percent saving in energy efficiency is assumed to remain constant. To estimate the cost of the upgrades, it is also assumed that 2.2 PCs and servers are needed per 1,000 square feet of office space (Energy Star, 2017). This value is then applied to each of the building sizes, and multiplied by the costs of the reference (Lenovo ThinkServer TS140) and replacement units (Supermicro-Superserver-6016Tt-Tf Intel Xeon) respectively (Google Shopping, 2017).

The only variable that varies over time is the emission factor which is due to the assumption that San José Clean Energy will get continually greener sourced.

The major challenge facing energy efficient office equipment units is the higher upfront cost for the initial investment. A challenge in this analysis was determining the reference and replacement units to use, since the comparison of these two form the basis of the eCBA.

Assumptions

Assumption	**Justification/ Source**
Energy star products use between 30%-75% less electricity than standard equipment	Energy Star ”Office Equipment” (2017)
2.2 PCs and servers are needed per 1,000 square feet of office space	Energy Star “Space Use Information – Office” (2017)
Replacement unit CAPEX is $800 per server	Google Shopping website (2017)
Reference unit CAPEX is $300 per server	Google Shopping website (2017)

3.3 Clean, efficient commercial logistics

Climate Smart San José

Clean and efficient commercial logistics can change the way business is done. Electrified fleets that are more efficient than their gasoline or diesel equivalents will vastly increase the number of charging stations needed. For example, large pickups and vans are common commercial vehicles, but have a relatively undeveloped market for electric vehicles. However, change is on its way with multiple EV prototypes on their way from Tesla and others. Similarly, hybrid-electrics models of local delivery vans and heavy-duty vehicles exist, they just are too expensive to fully enter the market. Once those costs go down and the efficiency increases, it is very possible to imagine a world where all commercial vehicles are electric.

Large pickups and vans as well as local delivery trucks represent local commercial transport services. Many business use pickups and vans as their company vehicles, while local delivery trucks are as common as mailmen. There exists an opportunity to electrify both of these, thereby electrifying the majority of local commercial transport. Charging stations will need to be put in place at their respective work locations, which would allow the vehicles to be in use throughout the day while being able to charge overnight. Having charging stations at work will overcome one of the major hurdles with electric vehicles. Once battery lives prove that they can last an entire work day at a reasonable cost, these vehicles will become more prevalent in the market.

In contrast to the more local commercial vehicles, heavy duty vehicles tend to travel long distances. They also represent a major portion of emissions due to their infamy for being gas guzzlers. Therefore, they have been prioritized in California through the Sustainable Freight Action Plan to identify ways of making these vehicles greener. These vehicles have already been subject to federal standards, and are making gains in reducing their carbon emissions by increasing their efficiency. Compressed natural gas heavy duty vehicles are already in the market, but their premium in cost over diesel equivalents in addition to lack of refueling infrastructure make them insufficient long term. Hybrid-electric options are beginning to enter the market, but will also carry a high premium. Both of these alternative fuels represent stop gaps between fossil fuels and all-electrics. Although there are no all-electric heavy-duty vehicles currently in the market, it is safe to assume that there eventually will be. They will be able to leverage public charging stations as they make their way throughout the country. Advances in charging infrastructure and electric batteries will propel all-electric heavy-duty vehicles, and Climate Smart San José projects them to be the future of freight.

Businesses will not immediately convert their fleets to electrics as soon as the technology is unveiled. It will take years, regulations, and probably incentives before electric fleets become viable. However, these fleets can raise uptake by being more cost effective or more efficient. Once there is a clear value add from investing in these vehicles from a business perspective, uptake will occur.

Large Pickup and Van Electric Vehicles

Large pickups and vans are common commercial vehicles, but have a relatively undeveloped market for electric vehicles. However, change is on its way with multiple EV prototypes on their way from Tesla and others (Business Insider, 2017). These vehicles are the first step to electrifying the commercial sector, and have the potential to abate 8.82 million tCO2e at a cost of $66/tCO2e.

Data from those prototypes provide the capital costs and MPGe of large pickup truck EVs (Business Insider, 2017). The CSSJ follows SPUR’s assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a large pickup truck and van EV and a traditional gasoline equivalent (SPUR, 2016). The CSSJ also assumes that all charging for these vehicles will be done at work, and base the number required on an NREL assessment of California’s plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. Beyond these goals, large pickup truck and van EVs can greatly help reduce carbon emissions due to their cleaner source of fuel and increased mileage per gallon of gasoline equivalent. However, the greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy. As more EVs come online and the load of SJCE increases, the bigger the effect of going from 50% renewable to 60% renewable and from 60% renewable to ultimately 100%.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between gasoline and large pickup truck and van EVs is small. Gasoline vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Historically, the two main challenges facing electric vehicles has been 1) the premium for an electric vehicle over a gasoline equivalent and 2) the potential lack of charging infrastructure in place to support a saturated market. This makes the expected battery price drop even more important. In terms of charging infrastructure, a difficulty in this analysis was determining their trend moving forward, and whether or not the market will actually adjust to eventually supplant gasoline as the dominant fuel.

Assumptions

Assumption	Justification/ Source
Ford F-150 price is CAPEX of Large Pickups and Vans reference vehicle CAPEX of Large Pickup and Van is $27,110	Ford F Series was bestselling Pickup Truck in May 2017 Ford “2017 F-150” (accessed 2017)
MPGe All-Electric Large Pickup in 2017 is 75 MPGe and CAPEX of Large Pickup and Van EV is $50,000	Business Insider “The very first electric pickup truck has arrived — and it could take on Ford one day” (2017)
CAPEX of Work Charging Station is $6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Work Charging Station is $250	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Each Large Pickup and Van Electric Vehicle needs its own charging station	Done in order to estimate number of charging stations per Large Pickup and Van vehicle deployed

Local Delivery Van Electric Vehicles

Local delivery vans represent a major portion of emissions due to their relatively low fuel economy and the high idle emissions (National Resources Canada, 2017). However, change is on its way with multiple EV prototypes on their way (CARB, 2015). Local delivery van EVs have the potential to abate 15.76 million tCO2e at a cost of $3/tCO2e.

Data from these studies provide the capital costs and MPGe of local delivery van EVs (Business Fleet, 2017). The CSSJ follows SPUR’s assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between local delivery vans EV and traditional gasoline or diesel equivalent (SPUR, 2016). The CSSJ also assumes that all charging for these vehicles will be done at work, and base the number required on an NREL assessment of California’s plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. Beyond these goals, local delivery van EVs can greatly help reduce carbon emissions due to their cleaner source of fuel and increased mileage per gallon of gasoline equivalent. However, the greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy. As more EVs come online and the load of SJCE increases, the bigger the effect of going from 50% renewable to 60% renewable and from 60% renewable to ultimately 100%.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between diesel and electric local delivery vans is small. Diesel vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle.

Historically, the two main challenges facing electric vehicles has been 1) the premium for an electric vehicle over a diesel equivalent and 2) the potential lack of charging infrastructure in place to support a saturated market. This makes the expected battery price drop even more important. In terms of charging infrastructure, a difficulty in this analysis was determining their trend moving forward, and whether or not the market will actually adjust to eventually supplant diesel as the dominant fuel.

Assumptions

Assumption	Justification/ Source
Each Local Delivery vehicle needs its own charging station	Done in order to estimate number of charging stations per Local Delivery vehicle deployed
CAPEX of Work Charging Station is $6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Work Charging Station is $250	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
MPGe of All-Electric Delivery Vehicle is 30 MPGe	Business Fleet “Workhorse Touts Efficiency of Electric Delivery Trucks” (2017)
Incremental CAPEX of EV Local Delivery Truck is $90,000	CARB “Heavy-Duty Technology and Fuels Assessment Overview” (2015)
CAPEX of traditional local delivery truck is $44,528	Commercial Truck Trader (accessed 2017)

Heavy Duty Vehicle Hybrid-Electric Vehicles

Heavy duty vehicles represent a major portion of emissions due to their infamy for being gas guzzlers. Therefore, they have been prioritized in California through the Sustainable Freight Action Plan to identify ways of making these vehicles greener. One way is to create hybrid-electric heavy-duty vehicles, which abate 1.83 million tCO2e at a cost of $235/tCO2e in the CSSJ Pathway. Although not as green as fully electric vehicles, hybrid-electrics represent a stop gap between the current diesel heavy market and a future with all-electrics.

Prototypes already exist for hybrid-electric heavy-duty vehicles; it is just a matter of pricing them so to make it more economical for them to enter the market. The CSSJ follows SPUR’s assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a hybrid-electric heavy-duty vehicle and a traditional gasoline or diesel equivalent (SPUR, 2016). The CSSJ also assumes that all charging for these vehicles will be done at public charging stations, and base the number required on an NREL assessment of California’s plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. Beyond these goals, hybrid-electrics can greatly help reduce carbon emissions due to their cleaner source of fuel and increased mileage per gallon of gasoline equivalent. However, the greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy. As more EVs come online and the load of SJCE increases, the bigger the effect of going from 50% renewable to 60% renewable and from 60% renewable to ultimately 100%.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between diesel and hybrid-electric heavy-duty vehicles is small. Diesel vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle. To find the cost of the reference vehicle, the ratio of the lease payments between a diesel and a hybrid-electric heavy-duty vehicle is applied to the market price of the Nikola One (Nikola, 2017).

Historically, the two main challenges facing electric vehicles has been 1) the premium for an electric vehicle over a diesel equivalent and 2) the potential lack of charging infrastructure in place to support a saturated market. This makes the expected battery price drop even more important. In terms of charging infrastructure, a difficulty in this analysis was determining their trend moving forward, and whether or not the market will actually adjust to eventually supplant diesel as the dominant fuel.

Assumptions

Assumption	Justification/ Source
Most Heavy-Duty Vehicle Hybrid Electric and All-Electric vehicle charging done in public	Heavy Duty vehicles likely to travel long distances and be forced to use Public charging stations
CAPEX of Public Charging Station is $6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
Maintenance of Public Charging Station is $300	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
MPGe of a Nikola One is 13 MPGe and the Lease Payment Nikola One is $5,000 a month versus Lease Payment Diesel Nikola One Equivalent is $2,200	Nikola “Nikola One” (accessed 2017)
CAPEX of Hybrid-Electric Heavy-Duty Vehicle is $375,000	Fleetcarma “Are Heavy-Duty Electric Trucks The Future For Fleet Owners?” (2016)

Heavy Duty Vehicle Compressed Natural Gas Vehicles

Heavy duty vehicles represent a major portion of emissions due to their infamy for being gas guzzlers. Therefore, they have been prioritized in California through the Sustainable Freight Action Plan to identify ways of making these vehicles greener. One way is to create compressed natural gas heavy duty vehicles, which abate .28 million tCO2e at a saving of $161/tCO2e in the CSSJ Pathway. Although not as green as fully electric vehicles, CNG vehicles represent a stop gap between the current diesel heavy market and a future with all-electrics.

Natural gas heavy duty vehicles are already in the market; it is just a matter of pricing them so to make it more economical for them to enter the market. The CSSJ assumes these vehicles will follow a similar drop in capital costs once economies of scale are reached. The CSSJ also assumes that all refueling for these vehicles will be done at public stations, and assume 10 vehicles per refueling station (NGVAmerica, 2017). Beyond these goals, CNG heavy duty vehicles can greatly help reduce carbon emissions due to their cleaner source of fuel with what is assumed to be the same MPGe as the diesel equivalent. To find the cost of the reference vehicle, the ratio of the lease payments between a diesel and a hybrid-electric heavy-duty vehicle is applied to the market price of the Nikola One (Nikola, 2017).

The CSSJ again leverages a tech learning curve which drops the price until the margin between diesel and compressed natural gas heavy duty vehicles is small.

The two main challenges facing electric vehicles also face CNG vehicles. These challenges are 1) the premium for a CNG vehicle over a diesel equivalent and 2) the potential lack of refueling infrastructure in place to support a saturated market. This makes the expected battery price drop even more important. In terms of refueling infrastructure, a difficulty in this analysis was determining their trend moving forward, and whether or not the market will actually adjust to eventually supplant diesel as the dominant fuel.

Assumptions

Assumption	Justification/ Source
Heavy Duty Compressed Natural Gas vehicles have same MPGe as regular Heavy-Duty vehicles On-Road Vehicles	Done in order to estimate fuel economy
Heavy Duty Compressed Natural Gas Vehicle stations take on Fast Fill Station I CAPEX	Done in order to estimate CAPEX
MPGe of a Nikola One is 13 MPGe and the Lease Payment Nikola One is $5,000 a month versus Lease Payment Diesel Nikola One Equivalent is $2,200	Nikola “Nikola One” (accessed 2017)
CAPEX of Hybrid-Electric Heavy-Duty Vehicle is $375,000	Fleetcarma “Are Heavy-Duty Electric Trucks The Future For Fleet Owners?” (2016)
Assume 10 vehicles per Fast Fill 1 refueling station with a CAPEX of $800,000 for the station	NGVAmerica “CNG Station Construction and Economics” (accessed 2017)
CAPEX of CNG Heavy Duty Vehicle is $200,000	Green Car Reports “Why Aren't Natural Gas-Powered Long-Haul Semi Trucks Selling Better?” (2017)
Assumed Additional Maintenance of CNG Station Per Month is $1,500	Government Fleet “Exploring the Total Cost of CNG” (2013)

Heavy Duty Vehicle Fuel Efficient Vehicles

Heavy duty vehicles represent a major portion of emissions due to their infamy for being gas guzzlers. Therefore, they have been prioritized in California through the Sustainable Freight Action Plan to identify ways of making these vehicles greener. One way is to make diesel heavy duty vehicles more fuel efficient, which abate 1.8 million tCO2e at a saving of $550/tCO2e in the CSSJ Pathway. Although not as green as fully electric vehicles, fuel efficient vehicles represent a stop gap between the current diesel heavy market and a future with all-electrics.

To calculate the carbon abatement, the CSSJ assumes that the factor of what the percent reductions in carbon emissions from federal standards over the next 10 years could have been (40%) versus what they are (25%) applies to MPG (New York Times, 2016). Although more efficient vehicles will be initially more expensive, the CSSJ assumes these vehicles will follow a drop in capital costs once economies of scale are reached. To find the cost of the reference vehicle, the ratio of the lease payments between a diesel and a hybrid-electric heavy-duty vehicle is applied to the market price of the Nikola One (Nikola, 2017).

The CSSJ again leverages a tech learning curve which drops the price until the margin between traditional heavy-duty vehicles and these fuel efficient equivalents is small.

The primary challenge for more fuel efficient vehicles is the potential for the standards to be rolled back. However, given that strides continue to be made in carbon emission efficiency for heavy duty vehicles, and that saving fuel benefits the trucking industry, the standards seem likely to stay. An issue in this analysis is the conversion of carbon emission efficiency savings to MPG.

Assumptions

Assumption	Justification/ Source
Fuel efficient Heavy-Duty vehicles will have same CAPEX as regular Heavy-Duty vehicles	Done in order to estimate CAPEX
MPGe of a Nikola One is 13 MPGe and the Lease Payment Nikola One is $5,000 a month versus Lease Payment Diesel Nikola One Equivalent is $2,200	Nikola "Nikola One" (accessed 2017)
CAPEX of Hybrid-Electric Heavy-Duty Vehicle is $375,000	Fleetcarma "Are Heavy-Duty Electric Trucks The Future For Fleet Owners?" (2016)
CAPEX of Fuel Efficient Heavy-Duty vehicle is $200,000 since assuming that the upper range of prices is for the most efficient	Cost Owl "How Much Does a New Semi Truck Cost?" (2017)
Standard Increase in MPG is 25% with potential increase of 40%	New York Times "New Rules Require Heavy-Duty Trucks to Reduce Emissions by 25% Over the Next Decade" (2016)

Heavy Duty Vehicle All-Electric Vehicles

Heavy duty vehicles represent a major portion of emissions due to their infamy for being gas guzzlers. Therefore, they have been prioritized in California through the Sustainable Freight Action Plan to identify ways of making these vehicles greener. Although not close to being in the market yet, the CSSJ considers the potential effect of fully electric heavy-duty vehicles. Altogether, they abate 14.49 million tCO2e at a cost of $140/tCO2e in the CSSJ Pathway.

Hybrid-electric heavy-duty vehicles are close to being released in the commercial marketplace; therefore it is logical to assume that full electric heavy duty vehicles are still several years away. As with the other EV eCBAs, the CSSJ follows SPUR's assumption that EV battery costs will go down by 30% by 2020, thus narrowing the gap in price between a hybrid-electric heavy-duty vehicle and a traditional gasoline or diesel equivalent (SPUR, 2016). The CSSJ also assumes that all charging for these vehicles will be done at public charging stations, and base the number required on an NREL assessment of California's plug-in electric vehicle infrastructure in order to achieve their Zero Emission Vehicle goals. Beyond these goals, hybrid-electrics can greatly help reduce carbon emissions due to their cleaner source of fuel and increased mileage per gallon of gasoline equivalent. However, the greenness of the electric grid determines the overall effectiveness of EVs, which increases the importance of San José Clean Energy. As more EVs come online and the load of SJCE increases, the bigger the effect of going from 50% renewable to 60% renewable and from 60% renewable to ultimately 100%.

To account for the battery price drop, the CSSJ leverages a tech learning curve which drops the price until the margin between diesel and electric heavy-duty vehicles is small. Diesel vehicles will still have a lower upfront investment cost, but the increased MPGe of the EV (which has the same tech learning rate applied) makes it more efficient over the lifetime of the vehicle. To find the cost of the reference vehicle, the ratio of the lease payments between a diesel and a hybrid-electric heavy-duty vehicle is applied to the market price of the Nikola One (Nikola, 2017).

Historically, the two main challenges facing electric vehicles has been 1) the premium for an electric vehicle over a diesel equivalent and 2) the potential lack of charging infrastructure in place to support a saturated market. This makes the expected battery price drop even more important. In terms of charging infrastructure, a difficulty in this analysis was determining their trend moving forward, and whether or not the market will actually adjust to eventually supplant diesel as the dominant fuel.

Assumptions

Assumption	Justification/ Source
Most Heavy-Duty Vehicle Hybrid Electric and All-Electric vehicle charging done in public	Heavy Duty vehicles likely to travel long distances and be forced to use Public charging stations
Heavy Duty All-Electric vehicles have same costs as Hybrid Heavy Duty Vehicles	Done in order to estimate CAPEX
MPGe of a Nikola One is 13 MPGe and the Lease Payment Nikola One is \$5,000 a month versus Lease Payment Diesel Nikola One Equivalent is \$2,200	Nikola “Nikola One” (accessed 2017)
CAPEX of Hybrid-Electric Heavy-Duty Vehicle is \$375,000	Fleetcarma “Are Heavy-Duty Electric Trucks The Future For Fleet Owners?” (2016)
CAPEX of Public Charging Station is \$6,000	Clean Technica “EV Charging Station Infrastructure Costs” (2014)
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