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Climate LA

Technology Pathways for LA to Achieve 80x50 in Buildings and Transportation

Cities Center of Competence - Urban Development

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Urban Development

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About the Report

About Siemens

Infrastructure is the backbone of a city's economy and urban development projects help to create a livable and sustainable smart city. With automated and intelligent infrastructure technologies, Siemens expertise is integrating hardware and software to improve quality of life, capacity, and efficiency in metropolitan areas. Siemens established the Center of Competence Cities (CoC Cities) to specifically address the needs of urban planners and to enter into a structured dialogue and base-lining assessment with urban decision-makers.

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Color and visual guidelines

We have used colors and visual cues in powerful ways to enhance the meaning and clarity of data visualization throughout this report. Please refer to the following as you are browsing:

- **CO_2eq**
- **Transport**
- **Buildings**
- **Energy**
- **Projected Data (any color above + stripes)**

Siemens would like to thank...

The City of Los Angeles' Mayor's Office of Sustainability for their guidance during the development of this report, especially **Lauren Faber O'Connor, Elena Guevara, and Kathryn Goldman**.

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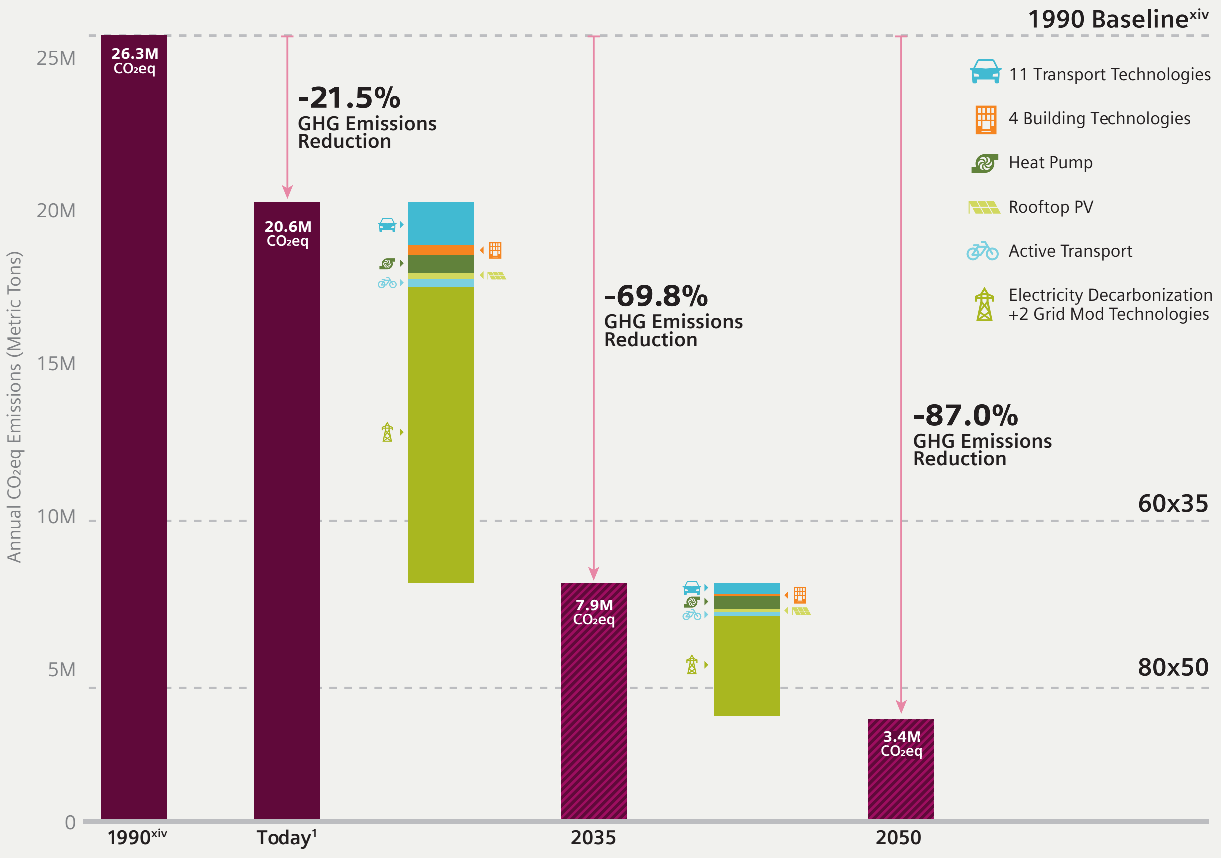
Overview

Based on an analysis using Siemens City Performance Tool (CyPT), the City of Los Angeles' (LA's) greenhouse gas reduction targets for 2035 and 2050 are achievable. Success will require transitioning to 100% generation of renewable electricity and to 45% of passenger travel by transit and active transport, through the implementation of LA's and California's current policy agendas and an additional 19 infrastructure technology measures. These measures were chosen by Siemens with input from the Mayor's Office of Sustainability, as well as input from 11 City and County Agencies of Los Angeles In this report, we discuss how these measures, as wide-ranging as electric heat pumps, electric vehicles, more frequent Metro service, smart grid operations systems, and commercial building automation, will help reduce LA's greenhouse gas (GHG) emissions by more than 60% by 2035 (60x35) and 80% by 2050 (80x50) – all while improving local air quality and creating local jobs. The analysis quantifies economic and environmental impacts of implementing these technologies, providing an evidence base for the City to use in prioritizing its investments. It is intended to serve as part of the basis for refreshing LA's Sustainable City pLAn first published in April 2015, and as a starting point for discussions around which policies LA will need to pass in order to achieve this pathway.

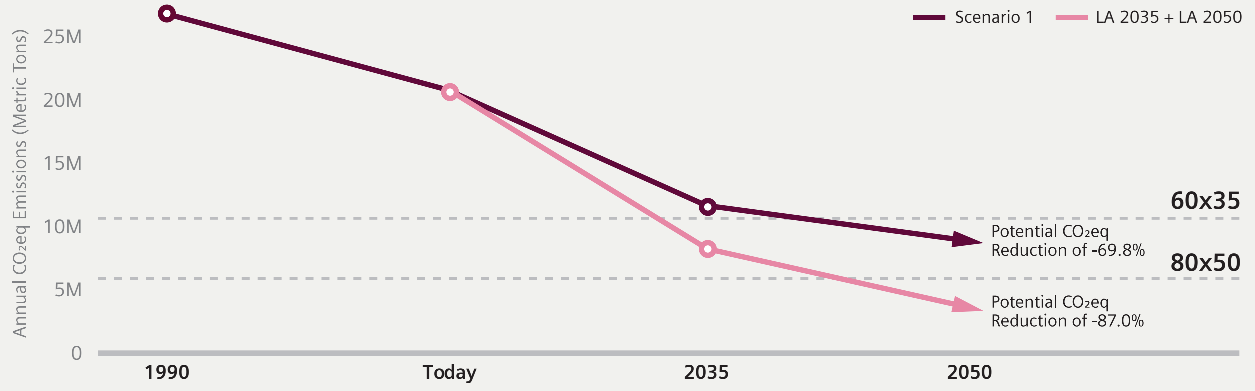
Deep Carbon Reduction Can Be Achieved



This chart shows the CyPT estimate of LA's GHG emissions in 1990, today, 2035, and 2050 from energy use in buildings and transportation. It also shows how the transition to 100% renewable electricity, transportation mode shifts, and the implementation of 19 infrastructure technology measures will reduce emissions -69.8% based on 1990 levels by 2035, and -87.0% by 2050. Based on this chart, grid decarbonization – even with 100% renewable electricity (in green) – isn't sufficient to reach LA's 80x50 target. Investing in LA's public transit networks and in electric mobility is intrinsic to meeting and exceeding emissions reductions targets.

1 Siemens calculations using the CyPT model.

Economic and Environmental Impacts



Emissions Reductions

-69.8% by 2035

-87.0% by 2050

Cost Per Capita

$65k

Capital and Operating Expenditures b/w Today and 2050

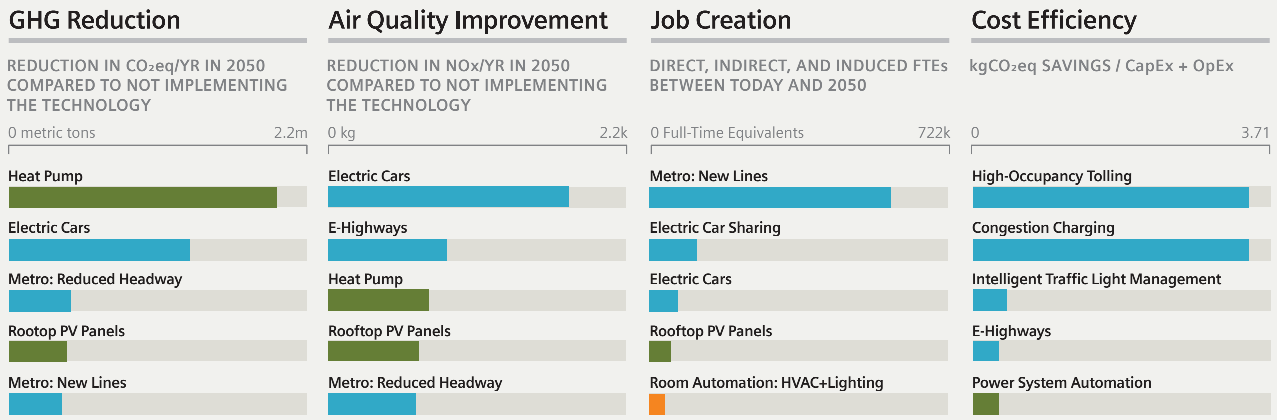
Jobs Generated

1.8M

Full-Time Equivalents b/w Today and 2050

This chart shows two scenarios, one (Scenario 1) under which LA decarbonizes its grid and mode share shifts to 45% transit and active transport by 2050, and the other (in light pink) under which an additional 19 infrastructure technologies have been implemented. Only under the second scenario does LA reach and exceed its GHG reduction target. In this LA2035 + LA2050 scenario, the implementation of these 19 technologies would reduce emissions beyond the target reductions, generate 1.8 million full-time equivalent positions between today and 2050, and cost roughly $65,000 per capita in capital and operating expenditures between today and 2050.

High-Performing Technologies



We analyzed and compared the performance of 19 technologies in terms of impact on GHG reductions, air quality, costs, and job creation. The five top-performing technologies in terms of GHG reductions are electric heat pumps, electric cars, reduced headway on Metro trains, rooftop PV panels, and expansion of the Metro rail network. To achieve the GHG reductions projected by the CyPT in the LA2035 + LA2050 Scenario, half of the heating consumed by buildings in LA would have to be generated by electric heat pumps instead of natural gas furnaces, requiring extensive retrofitting and installation of as many as 1.7 million heat pumps. One hundred percent of the cars on LA's roads would have to be battery electric vehicles, requiring an almost complete turnover of the current consumer fleet. Average headway (or the time between trains) on Metrorail lines would have to drop from 11 minutes today to just 4 minutes by 2050. Finally, the nine new Metrorail lines in Measure M would have to be constructed and, in conjunction, ridership on all rail would have to increase compared to today.

Background

Led by the Mayor's Office of Sustainability, LA is becoming one of the most sustainable cities in the world. LA published its first-ever Sustainable City pLAn in 2015, providing a comprehensive and actionable vision for protecting the environment, growing the economy and improving equity for every Angeleno. The City reports its progress on the pLAn each year and is committed to updating the pLAn every four years.

LA is a leader in clean energy, energy efficiency, and climate resilience.

Not only is Los Angeles one of the largest markets in the United States for alternative energy vehicles, but also the City, under Mayor Eric Garcetti, has made great strides in becoming **a leader in clean, efficient transportation.** The Los Angeles Department of Transportation (LADOT) has plans to convert its entire bus fleet to electric buses (eBuses) by 2030.[i] The Los Angeles Department of Water and Power (LADWP), the municipally owned and water electric utility, operates a popular electric vehicle (EV) charger rebate program for consumers, called "Charge Up L.A.!"[ii] The City itself has the most publicly available EV chargers of any U.S. city.[iii] Launched in 2017, Blue LA is an electric carsharing program, intentionally located in a transit-underserved area and targeted towards untraditional users of carsharing programs.[iv] The Los Angeles Cleantech Incubator, a venture fund and start-up incubator supported by the City, has a portfolio of electric mobility (eMobility) companies – many of which are already rolling out programs in the city and county.[v] Combined with the transport tech giants that already sit in the region, among them Hyperloop, Tesla, and SpaceX, these start-ups are setting a new trajectory for clean mobility in LA.

Los Angeles is **also a leader in clean, renewable energy**. While the State of California contemplates whether it wants to push its renewable portfolio standard (RPS) mandate to 100%, the LADWP is considering its own 100% renewable mandate.[vi,vii] LADWP is also collaborating with partners to ensure that consumer-produced clean energy, like rooftop solar arrays, offer both economic and environmental benefits, while providing additional stability to the grid. Programs like these have resulted in LA having the most installed solar power of any city in the U.S.[iii]

LA is also driving towards reducing energy consumption and becoming **a leader in energy efficiency**. Effective in 2017, the Los Angeles Existing Building Energy and Water Efficiency (EBEWE) Ordinance requires public and private buildings above certain size thresholds to disclose energy and water consumption, and have action plans for energy and water efficiency.[viii] The ordinance is further bolstered by the LA Better Buildings Challenge, a nationally funded effort aimed at large, commercial buildings.[ix]

In LA, sustainability and resilience go hand-in-hand and, propelled by a grant from 100 Resilient Cities, LA is a **leader in climate resilience**.[x] Released in March 2018, Resilient Los Angeles is the first citywide resilience strategy for LA, which includes 15 goals and 96 actions for Angelenos, neighborhoods, the City, and partners to implement so that LA continues to be safe, strong, and prepared for the stresses and shocks of climate change and other threats.[xi]

Mayor Garcetti is **leading US Mayors in taking action on climate**. When President Trump announced his plans to withdraw from the Paris Climate Agreement,

Contributors to the Analysis

Through an iterative data collection process, and in-person workshop, 10 agencies were able to weigh in on the CyPT analysis on LA's sustainable future. Their contributions included providing data about how people use LA's energy, buildings, and transport infrastructure today and how things might change out to 2050. Siemens extends a special thanks to those 10 agencies for their support.

Agency	Contribution
Los Angeles County Metropolitan Transit Authority (LA Metro)	Passenger miles traveled, Metro rail and bus networks, fleet information
Los Angeles Department of Transportation (LADOT)	Passenger miles traveled, bus networks, fleet information, bikeshare, pedestrian and cyclist data
Los Angeles Department of Water and Power (LADWP)	Electricity mix, electricity consumption
Los Angeles Office of Planning	Passenger miles traveled, building footprint
Mayor's Office of City Services	Building footprint, building energy use
National Resources Defense Council (NRDC)	Building energy use
Port of Los Angeles	Freight miles traveled
Southern California Association of Governments (SCAG)	Population, passenger miles traveled, freight miles traveled
Southern California Gas Company (SoCal Gas)	Heating consumption
US Green Buildings Council (USGBC)	Commercial building energy use, consumption patterns in buildings

Mayor Garcetti led a coalition of 60 Climate Mayors in denouncing his actions and committing to adopt the goals of the Agreement. As of now, 402 Mayors have joined Climate Mayors and committed to uphold the Paris Agreement, including the 10 largest cities in the U.S.

Los Angeles is joined by New York, Boston, Mexico City, London, Paris, Melbourne, and Durban in climate action planning that puts cities on a pathway to help the world meet the commitments of the Paris Agreement by reducing city-wide greenhouse gas emissions and implementing actions that help prepare for climate change. Through the **C40 Deadline 2020 program, all 90 C40 cities around the world will adopt similar climate action plans by 2020.**

To support these efforts, as well as the update to LA's Sustainable City pLAn, Siemens partnered with the Mayor's Office of Sustainability to produce this report. **With the support of the Sustainability Director and her staff, Siemens performed a City Performance Tool (CyPT) analysis assessing how infrastructure technologies could enable LA to reach its greenhouse gas reduction goals.**

The 2015 Sustainable City pLAn sets targets for LA to reduce GHGs 60% by 2035 (60x35) and 80% by 2050 (80x50) relative to 1990 across all GHG emissions sectors. This analysis considers how LA can meet those same targets applied to the combined sectors of energy use in buildings and transportation, which represent the two largest sectors of GHG emissions in LA. The scenario we present here represents a series of assumptions about how Los Angeles might grow and change over the next 30+ years. To build this future "scenario" of the city, we drew on publicly accessible data on how

Angelenos generate and use energy, move around the City, live, and work today in order to understand why, and from which sectors, emissions are generated. In forecasting emissions out to the future, we looked at other studies and estimates about how the region is expected to grow, and examined policies and programs that will shape the electricity grid, built environment, and mobility networks in the future. Two documents particularly helpful in shaping our assumptions are LADWP's Integrated Resource Plan, a public document outlining the utility's plan to incorporate renewables into its electricity mix, and the LA County Metropolitan Transit Authority's (LA Metro's) Measure M funding plan, a public document outlining the transit agency's plan to build out LA's rail, bus, and road networks.

Using these sources, plus input from 10 agencies and organizations in the City and County of LA, our future forecast for LA in 2050 assumes a 21% increase in LA's population between today and 2050; a transition to 65% of electricity supplied by renewables in 2035 and 100% in 2050; 7.5% reduction in average residential unit size by 2035 and 11% by 2050; and a shift in passenger mode share[2] of 14% transit and active transport today to 26% in 2035 and 45% in 2050.[xii] With these changes to how electricity is generated and with how people move around the city, GHG emissions from energy use in buildings and transportation are projected to drop by roughly 40% in 2035 and 58% in 2050 - falling short of the targets of 65% and 80% reduction. This means that more effort, from the City, the public, and the private sector, is needed to meet the targets.

2 Measured by passenger miles travelled instead of trips

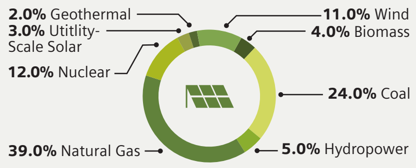
LA Today to 2050

LA has already reduced GHG emissions by 20% below 1990 levels as of 2013 across all sectors[xiv], but in order to reach its targets of 60x35 and 80x50, it will need to accelerate its actions to decarbonize the grid and move people onto transit, all while maintaining a high quality of life for the 4.0 million people who call Los Angeles home. Our analysis draws on plans from LADWP, LADOT, LA Metro, and others to estimate how LA in 2035 and 2050 might look different from today.

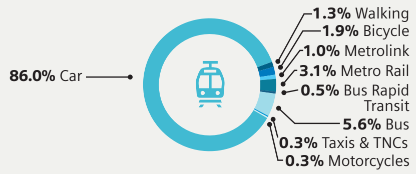
LA Today

POPULATION
4.0M

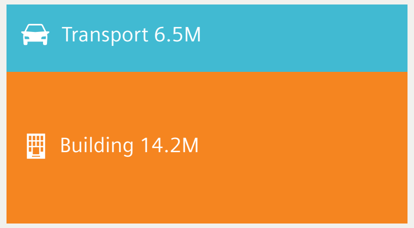
ELECTRICITY MIX
33% Renewable



MODE SHARE
14% Transit & Active Transport



CYPT-ESTIMATED ANNUAL GHG EMISSIONS*
20.7MMT
(Million Metric Tons)

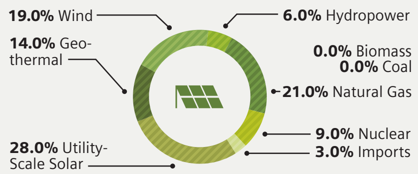


Today

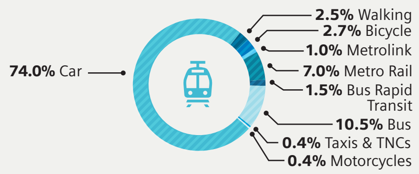
LA 2035

POPULATION
4.2M

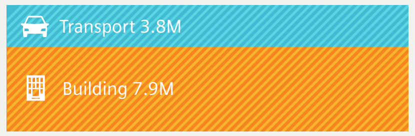
ELECTRICITY MIX
65% Renewable



MODE SHARE
26% Transit & Active Transport



CYPT-ESTIMATED ANNUAL GHG EMISSIONS*
11.7MMT
(Million Metric Tons)



2035 BAU

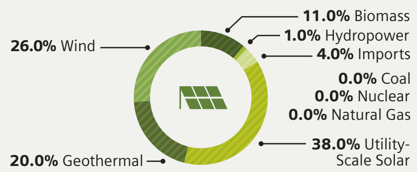
ESTIMATED % REDUCTIONS IN GHG EMISSIONS**
-43.5%

TARGET % REDUCTIONS IN GHG EMISSIONS**
-60%

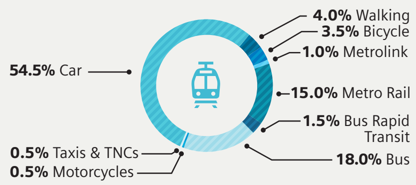
LA 2050

POPULATION
4.9M

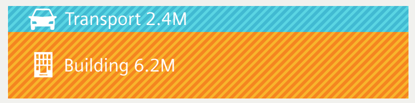
ELECTRICITY MIX
100% Renewable



MODE SHARE
45% Transit & Active Transport



CYPT-ESTIMATED ANNUAL GHG EMISSIONS*
8.6MMT
(Million Metric Tons)



2050 BAU

ESTIMATED % REDUCTIONS IN GHG EMISSIONS**
-58%

TARGET % REDUCTIONS IN GHG EMISSIONS**
-80%

* For energy, buildings, and transport sectors only. See the section on "City Performance Tool" for more information on the methodology and scope of the CyPT.

** Based on 1990 Levels

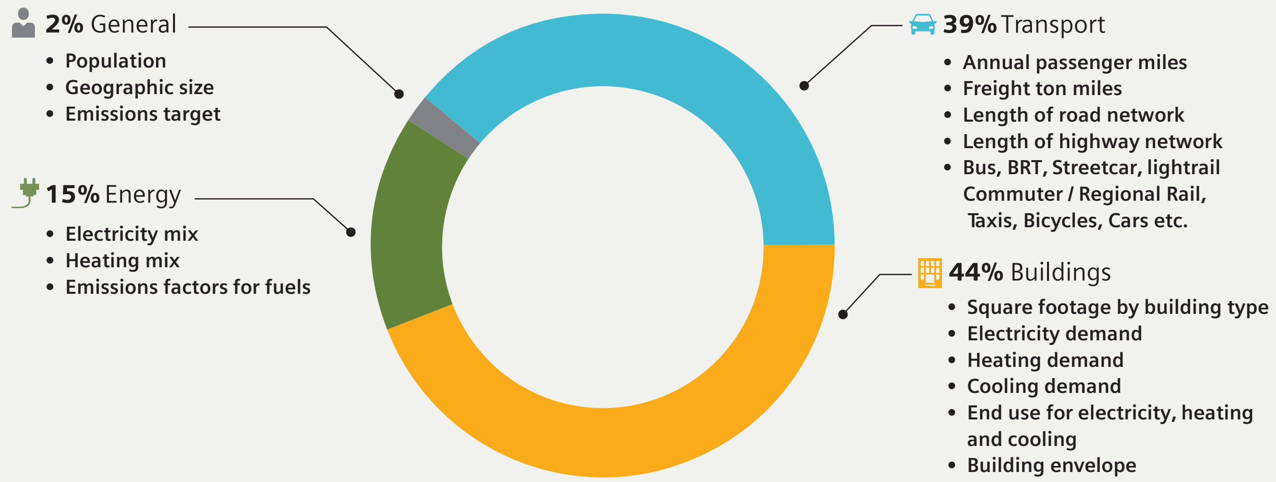
City Performance Tool

For this deep decarbonization analysis, Siemens used the City Performance Tool (CyPT) to identify how technologies from transport, building, and energy sectors can mitigate carbon dioxide equivalent (CO_2e) emissions, improve air quality, and add new jobs.

The CyPT model has assessed environmental and economic development opportunities available to cities across the globe, including San Francisco, Copenhagen, London, Mexico City, Seoul, Washington, DC, and Vienna. Siemens collaborated with each city to identify infrastructure solutions that best fit the city's energy demand and production characteristics. For example, in Copenhagen, the CyPT analysis revealed that implementing 15 energy efficiency technologies in just 40 building owners' portfolios could reduce annual emissions by 10 percent. The Copenhagen city government is now discussing ways to act on that recommendation, whether by piloting those energy efficiency technologies in a public building or by creating an incentive program to encourage building owners to retrofit their portfolios. The Minneapolis report revealed that, apart from renewable energy, electric cars were the single most effective lever in reducing emissions. Minneapolis' Sustainability Department is now launching a series of inclusive conversations across city and county agencies, the electric utility, and the public to help build an electric vehicle strategy.

Configuring the CyPT requires more than 350 inputs from a city's transport, energy and buildings sectors, including population and growth, the supply mix of electricity generation, transport modalities, and travel patterns, building energy use, and the built environment footprint.

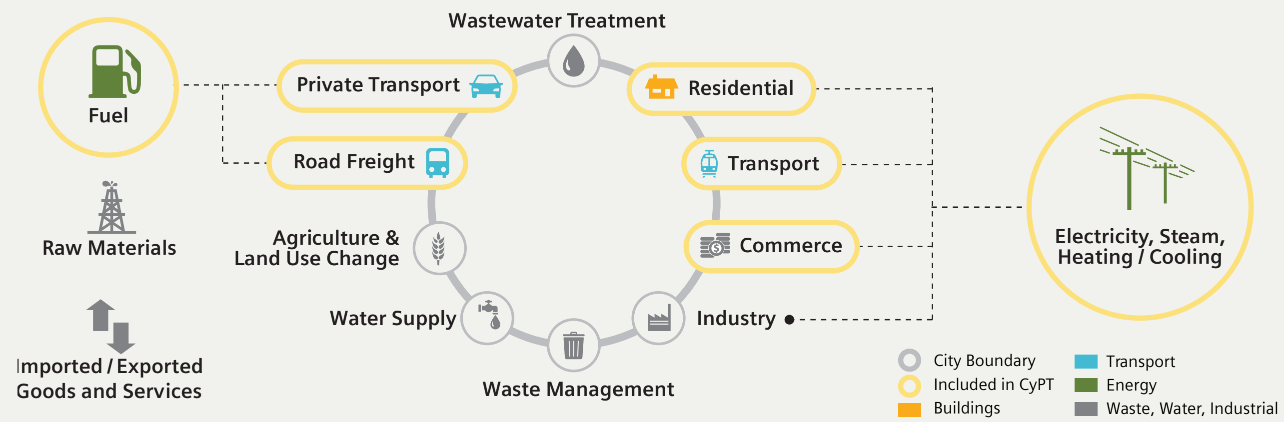
CyPT Inputs



The CyPT can be customized through more than 350 city-specific data inputs, which when combined, project how a city is expected to grow and change as its population and infrastructure expand. More than half of the inputs that go into the CyPT look at how people move around the city, live, and work.

Scope of Emissions Model

The CyPT utilizes the 2012 GPC Protocol for Community-Wide Emissions as its methodology for estimating GHG emissions. It covers Scopes 1, 2, and 3 emissions for energy generation and energy use in buildings and transportation. Essentially, this means that the CyPT takes into consideration both direct emissions occurring within the City boundaries (such as from exhaust fumes) and indirect emissions from the conversion of chemical energy to power, heat or steam of purchased energy from outside the city. The included Scope 3 emissions refer to the emissions produced as a result of fuel production and extraction. This also includes the construction and production of renewable power plants.



Starting with the city's population, energy performance, and emissions baseline, the model estimates the future impacts of more than 70 technologies (only 60 percent of which are sold by Siemens) along the following three drivers:

1. Cleaner underlying energy mix: Shifting the energy generation mix from non-renewable to renewable energies (e.g., photovoltaics) and/or improving the efficiency of the current fossil fuel sources (e.g., Combined Cycle Gas Turbines).
2. Improved energy efficiency in buildings and transport: Replacing existing technologies with more energy efficient technologies. For example, replacing traditional street lighting with LEDs and/or demand-oriented street lighting.
3. Modal shift in transportation: Modeling changes in the modal split of the city. For example, by creating a new metro line, a city potentially moves passengers away from high-emitting cars and into the metro.

The outputs of the model are CO_2eq emissions, nitrogen oxides (NOx), particulate matter 10 (PM10), gross full-time equivalents (FTE), and capital and operating expenses.[3,xiii]

3 An FTE is a person-year of work, calculated as 2,080 hours of work in the U.S.

Buildings and Energy

The CyPT analysis looks at how six building and building energy technologies can improve energy efficiency in homes and businesses in LA. Their implementation results in a further 8.2% and 15.0% reduction in annual GHG emissions based on 1990 levels in 2035 and 2050, respectively, on top of the significant GHG reductions brought about by a transition to renewable electricity on the grid.

LA's mild and sunny climate has traditionally resulted in low energy consumption in homes. The average energy use intensity (EUI) for homes today is 44 kBTtu/ft^2 (compared to a national average for cities of 47) – about a third of which goes to lighting, appliances, and ventilation and another third, which goes to heating warm water.[xv,xvi] Most of the energy consumed is electricity, with natural gas powering space heating and, to a lesser extent, water heating. However, Angelenos, occupy larger homes on average compared to residents of cities with similar overall density – more than 1,200 ft^2 per household. **Combined with a projected population increase of 21% between today and 2050, the proliferation of electrically connected devices, not to mention the greater variation of temperatures experienced in LA, energy consumption in homes is projected by the CyPT model to rise by almost 20% from today to 2050.**

Electric heat pumps, rooftop solar power, and window glazing for residential homes are the top three measures for reducing GHG emissions.

Commercial buildings in LA, by contrast, have very high average EUI relative to cities in similar climates – and even relative to cities in far colder climates. Across government, commercial office, education, healthcare, retail, and hospitality categories, average EUI for commercial buildings in LA is 112 kBtu/ft^2, compared to a national average of 82 kBTU/ft^2 and an average for mixed-dry/hot-dry climates of 68.4.[xvii] Hospitals, hotels, and commercial office buildings have the highest average energy consumption of all non-residential building categories included in this analysis.

Residential Data

Avg Residential Unit Size
1,263 ft^2

Total Electricity Consumption
8,437 GWh

Avg Energy Use Intensity
44 kBtu/ft^2

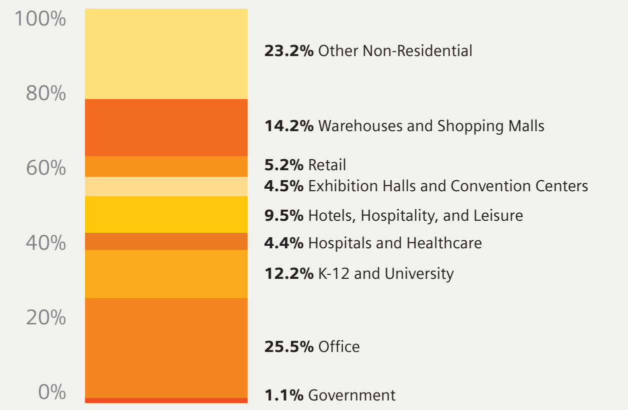
Non-Residential Data

Total Commercial Building Ft
661M ft^2

Total Electricity Consumption
10,851 GWh

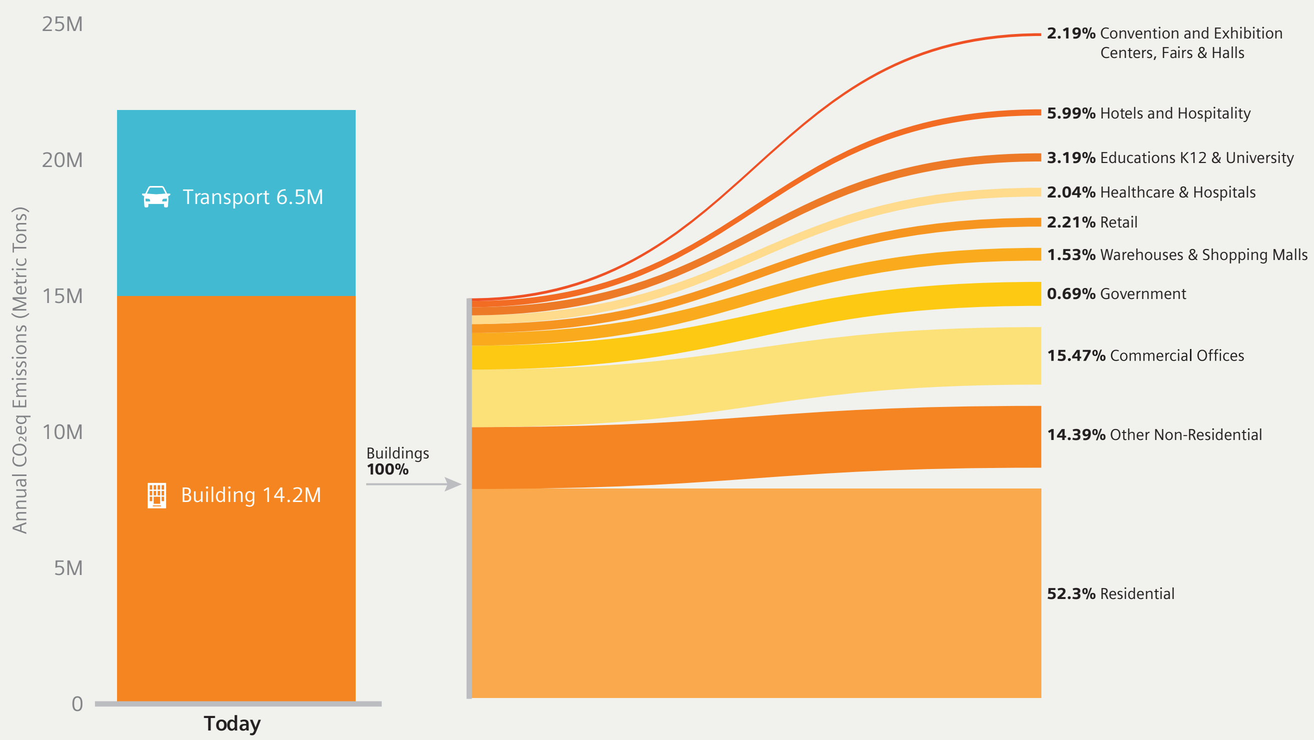
Avg Energy Use Intensity
112 kBtu/ft^2

Breakdown of Sq Footage of Commercial Buildings



Anyone who has ever landed in LAX (Los Angeles International Airport) is familiar with the numerous buildings that make up the city's landscape. While 15% of LA's city footprint is streets and 12% is parks, much of the remaining roughly 70% of LA is devoted to homes, businesses, and industry. In the CyPT, we exclude LA's port, airport, and industrial areas, but capture the energy used by its 1.3M households and 661 million square feet of businesses.

GHG Emissions



Even in a city as car-dominated as LA, emissions from homes and businesses still account for more than 70% of the emissions represented by the CyPT model.

CyPT Levers

Residential / Non-Residential Buildings		Today	2035	2050
LEVER	UNIT			
Window Glazing	% of building stock w/ lever	53%	67%	80%
Home Automation	% of building stock w/ lever	0%	16%	30%
Room Automation: Lighting + HVAC	% of building stock w/ lever	0%	27%	50%
Building Automation	% of building stock w/ lever	22%	50%	75%

Energy		Today	2035	2050
LEVER	UNIT			
Rooftop PV Panels	Share of total electricity generation	0%	3%	6%
Electric Heat Pump	Share of total heating	6%	29%	50%

Combined, residential and commercial buildings in LA account for about 70% of the GHG emissions covered by the CyPT. These include emissions from the generation, transmission and distribution, and consumption of electricity and other fuels (like natural gas) in homes and non-residential buildings. So, for example, by the CyPT model's calculation, the emissions produced by plugging a cell phone in to an outlet at home would include the emissions produced from generating the electricity needed to power that phone, as well as from transmitting that electricity across the electric grid to reach the outlet.

The analysis reveals that electric heat pumps, rooftop solar power, and window glazing for residential homes are the top three measures for reducing GHG emissions. Heat pumps are also a top measure for improving air quality. Rooftop solar is the top performing lever in terms of job creation.

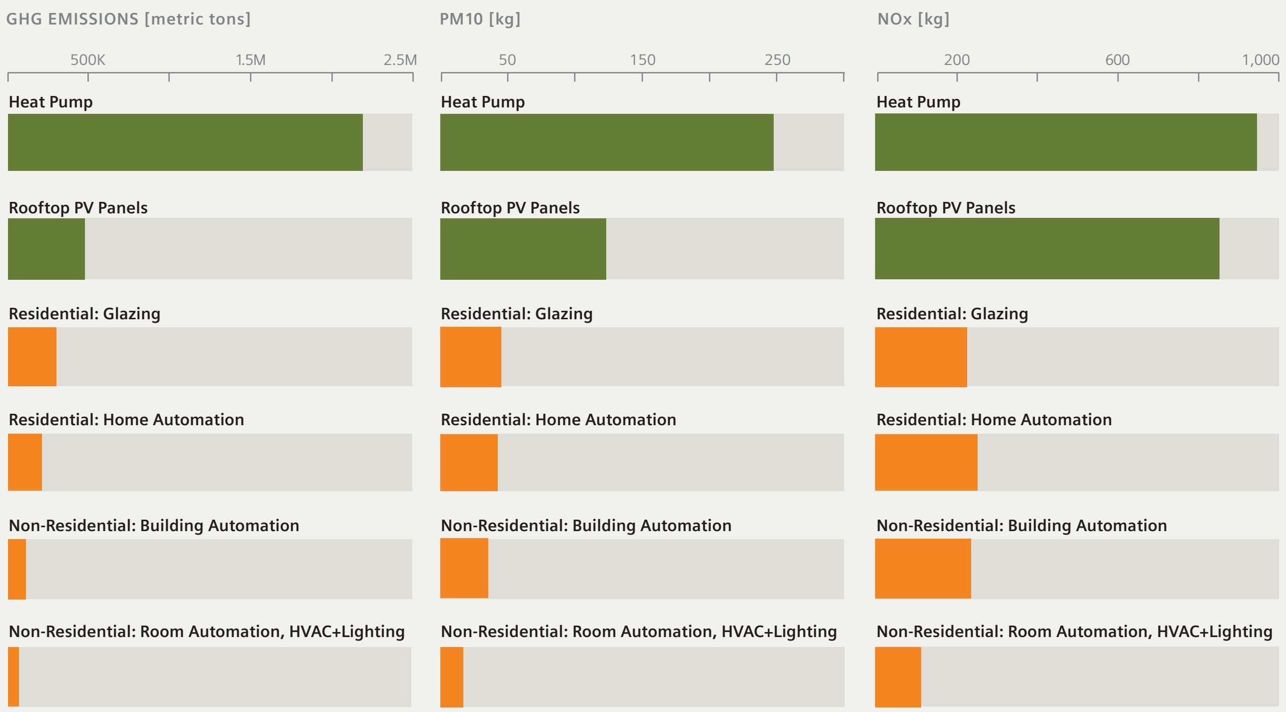
Transitioning to 50% of building heating by electric heat pumps is no small feat: doing so will require extensive retrofitting of existing buildings, and possible policy interventions for new buildings constructed in the City of LA. **However, emissions reduction from heat pumps is almost five times that of emissions reduction from the next highest building energy efficiency lever, window glazing in 80% of homes.**

The "home automation" lever refers to a system of software and sensors that automatically adjust HVAC and lighting, and is similar in scope and effect to the "building automation" lever for non-residential buildings. The costs and benefits of these systems would likely fall to residents and businesses, and the systems' mass commercialization means it is increasingly feasible to install systems independently or, with the help of professionals, very quickly.

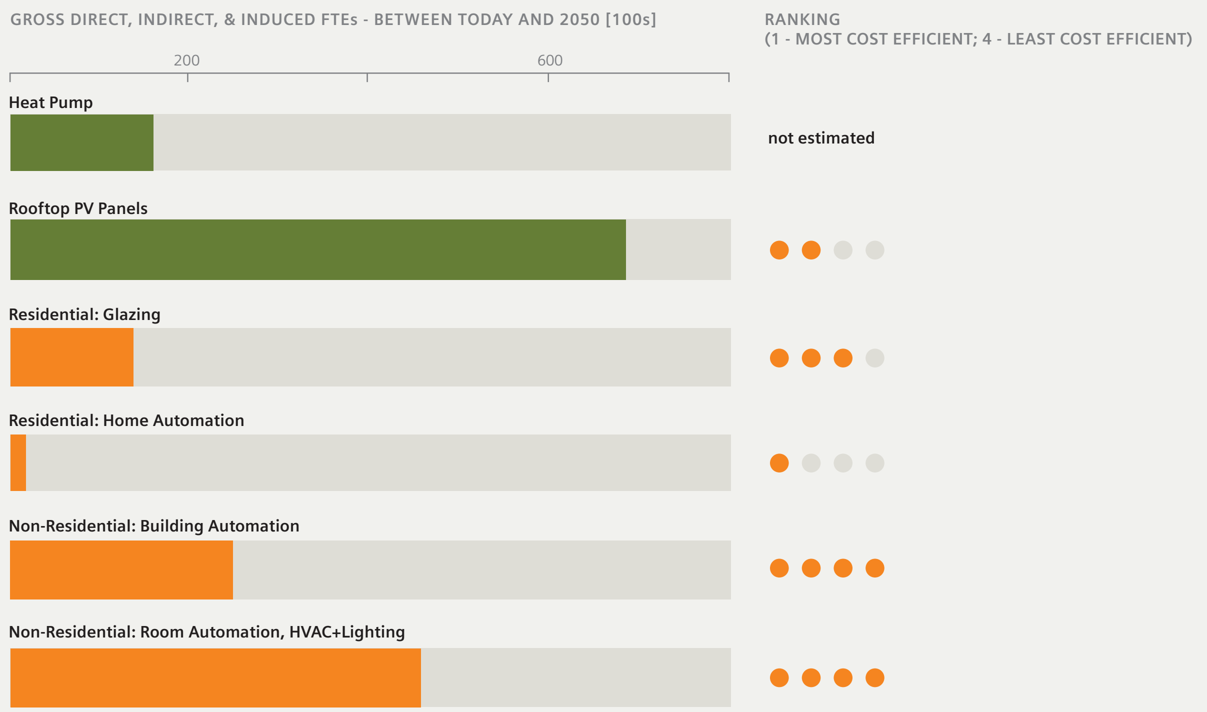
CyPT Lever Impacts

Installing rooftop PV panels and home automation systems are the two most cost efficient building and energy technologies, based on the ratio of total GHG emissions reductions to capital and operating expenses. These expenses are inclusive of the costs to local government, homeowners, and businesses, rendering these technologies especially attractive options for implementation.

Reduction in CO_2eq/yr in 2050 Compared to Not Implementing the Technology



Job Creation / Cost Efficiency



Transportation

Despite a year of falling transit ridership in LA and record-high car purchases in the state of California, including by first-time owners, the public sector and the public remain committed to a multi-modal future.[xviii] The roll-out of LA Metro Bikeshare, a public bikesharing program; BlueLA, an electric carsharing pilot; new DASH and Metro Rapid Transit bus routes; and the $120 billion Measure M program, with planned upgrades to Metro rail, commuter rail, highways, and connections to ports and airports from now to 2060 – are all signs of how the City and County is actively investing in accessible, equitable mobility networks.

Our analysis is aggressive in its assumptions of public uptake of new and existing transit and active transport options. Ten of the 11 transportation measures we model address both the supply and demand of passenger transport. High-occupancy toll lanes and a congestion charge have been shown to reduce demand for travel by car while providing additional revenues for transport network improvements. Running more trains more often, switching to all-electric buses (eBuses), adding electric Bus Rapid Transit (eBRT) routes, and switching over to multi-modal electronic and mobile ticketing (eTicketing) will likely induce travel by public transit. Finally, an aggressive roll-out of an electric car sharing program, from 100 cars today to 13,000 in 2035 and 25,000 in 2050, could shift behavior from individual ownership towards shared ownership of cleaner cars.

For passenger transport these technologies hold the most promise for reducing GHG emissions: adoption of 100% all-electric cars, reducing the headway of Metro trains from 11 minutes today to 4 minutes in 2050, and adding nine new Metro lines. High-occupancy toll lanes and congestion charging are the two most cost efficient measures, based on reduction in GHG emissions over dollar invested for capital and operating expenditures. Out of any measure modelled, building new Metro lines has the highest impact on jobs creation, resulting in more than 600,000 indirect, direct, and induced full-time equivalent positions (or person-years of employment) generated by 2050. All transportation measures rank highly in reducing harmful NOx and PM10 pollutants, which, among other deleterious effects, cause acid rain and pulmonary issues.

Although passenger transportation represents the largest share- more than 85%- of overall emissions from transportation, pollution from freight is a prevailing problem in the City and County of Los Angeles. This analysis does not consider transportation emissions from within the Port of Los Angeles or Los Angeles International Airport (LAX); however, it does look at emissions from the approximately 11,000 trucks and 30 trains going into and out of the ports daily, along corridors inside the City of LA's boundaries. Because 99.9% of those trucks are diesel, with an average fuel economy of only 8 miles per gallon (MPG), they represent a significant portion of the total annual PM10 and NOx levels citywide, and concentrated near the main highway arteries around the port. eHighway, one of the 19 levers in our LA2035 + LA2050 scenario, simulates electrifying 75% of the most trafficked freight corridors in LA. Overhead catenary lines installed along those corridors would allow hybrid electric or fully electric trucks to charge as they are driving, enabling long-

Transitioning to 100% electric cars on the road, including cars passing through the City's boundaries, would have the largest reduction in emissions and the highest positive impact on air quality.

Passenger Transport

Avg Miles Traveled Per Person, Per Day
14.9 miles / person / day

No. of Cars on the Road (Cars Per Household)
2.5M (2)

Avg Fuel Economy
23.5 MPG
(2020: 27.6 / 2025: 33.6 / 2050: 46.1)

Freight Transport

Annual Freight-Ton Miles / Vehicle Miles Traveled
2.6 ton-miles / person / day
(520 million VMT) ▲35% in 2050

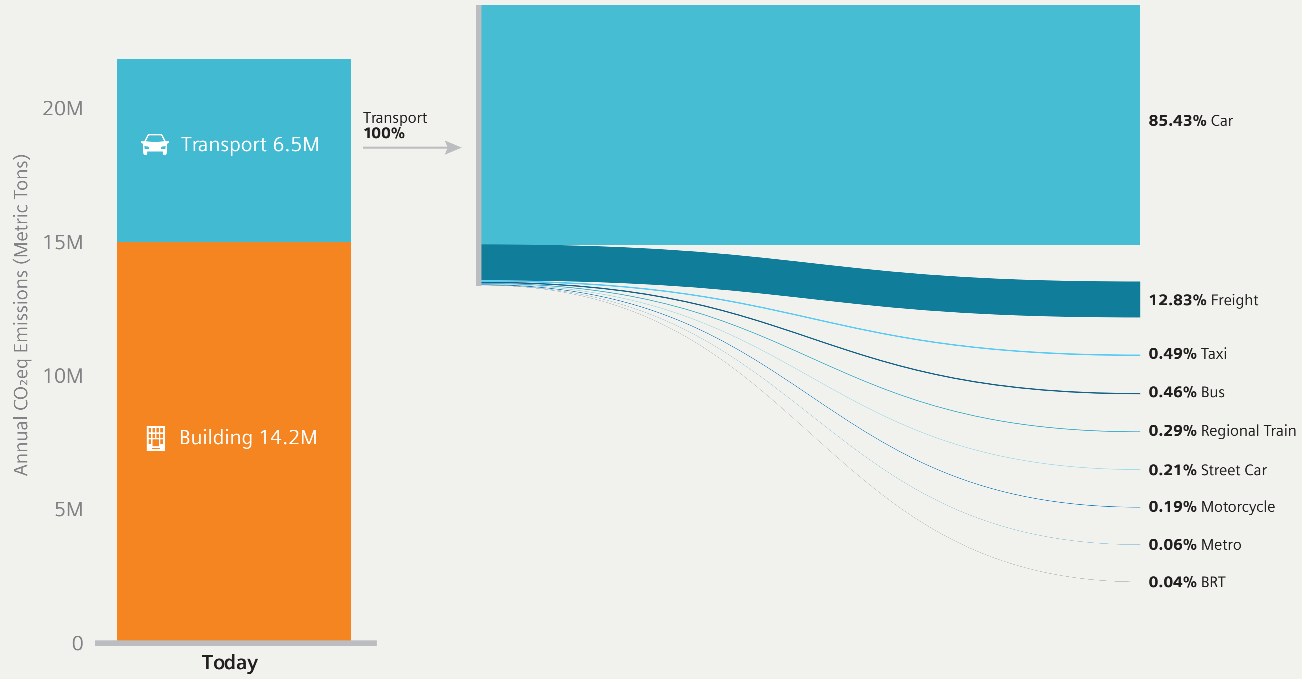
Avg. Daily No. of Trips To/From Port of Los Angeles
11K (trucks); 30 trains

Avg Fuel Economy
8 MPG

Mobility is the name of the game in Los Angeles. With the world's 10th busiest port, 4th busiest airport, and most congested streets, Los Angeles and Angelenos rely on cars and trucks not just for getting around, but also for supporting their livelihood. Stringent statewide fuel efficiency regulations have led to increasing efficiency and lower emissions for vehicles of all types, but air quality in LA is still poor; and even sunny days can be marred by smog.

GHG Emissions

GHG emissions from transportation stem from how that transportation mode is fueled. For a fully electric car, for example, GHG emissions result from the generation and transmission of the electricity ultimately consumed by the car as it charges its battery and drives around the city. For a diesel bus, on the other hand, GHG emissions result from the production and consumption of the diesel oil.



haul transport and reducing local emissions to close to zero. LA is already piloting eHighway technology on a 1.1 mile test track in Carson, CA, outside of the Ports.

In conjunction with more transit and cleaner freight, Angelenos needs to also transition to owning and riding alternative energy vehicles in order to achieve LA's sustainability goals. **Out of the 19 levers modeled, CyPT results estimate that transitioning to 100% electric cars on the road, including cars passing through the City's boundaries, would have the largest reduction in emissions and the highest positive impact on air quality.** This is because the emissions factor (or the amount of GHG emissions produced due to the generation, transmission, and consumption of the energy) for electricity is much lower than the emissions factors for gas or diesel.

Even if all of the cars on LA's roads are clean, without a broad shift to shared mobility, including transit, congestion will continue to be an issue for LA. Given that Angelenos experience the worst traffic of any city in the world, a simple swap-out of one vehicle for another – although impactful with regards to emissions and air quality – will not reduce overall traffic congestion in the city. That is why our analysis includes not only electric vehicles, but also the simulation of an extensive build-out of the rail, bus, and BRT networks, and an expansion of current electric carsharing programs.

For example, we model the expansion of electric carsharing programs from 100 vehicles today to 25,000 shared cars by 2050, equivalent to one shared car for approximately every 200 people. According to UC-Berkeley professor Dr. Susan Shaheen, each shared car can replace between seven and 12 cars on the road. This suggests that even 25,000 shared cars would be able to shift behavior from private ownership and single-occupancy vehicles to shared ownership and multiple-occupancy vehicles. By reducing the number of cars on the road, an eCar sharing program would not only reduce congestion, but also reduce emissions even if conventional gas-powered cars remain on LA's roads.

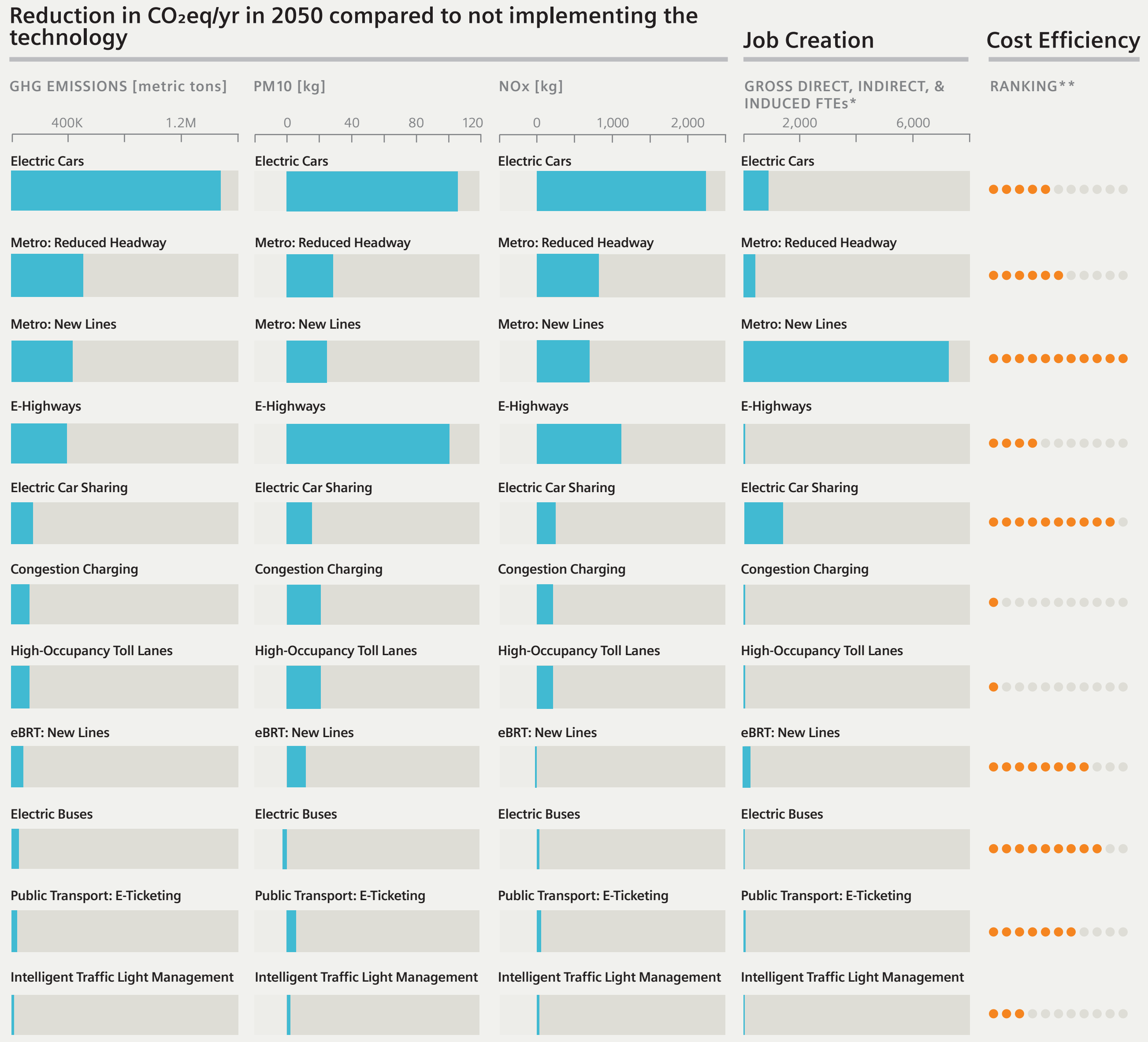
What we have seen in our experience with other cities around the world is that shifting people out of individually owned cars and onto transit and into walking and cycling requires a systemic approach where demand-management measures are matched by supply-driven measures. **High occupancy tolling and congestion charging, running Metrorail with faster headways, building bus-only lanes and re-designing bus routes, creating segregated bike lanes, and expanding bikeshares. All of these strategies when deployed in conjunction, either citywide or by district, can encourage a mode shift to more transit, walking and cycling.**

CyPT Levers

Public Transit		Today	2035	2050
LEVER	UNIT			
Metro: Reduced Headway	Seconds between trains	660	435	240
Metro: New Lines	Number of new lines	n.a.	5	9
eBuses	% of public bus fleet	0%	100%	100%
eBRT: New LInes	Total number of lines	2	4	6
Private Transportation		**Today**	**2035**	**2050**
LEVER	UNIT			
Electric Car Sharing	Number of car sharing cars	100	13,000	25,000
Electric Cars	% of cars on the road	1%	60%	100%
Infrastructure		**Today**	**2035**	**2050**
LEVER	UNIT			
High-Occupancy Tolling	Increase in passengers/car	n.a.	35%	65%
Congestion Charging	% Reduction in Traffic	n.a.	9%	9%
Public Transportation: eTicketing	Users as share of travelers	0%		100%
Intelligent Traffic Light Management	% of traffic signals w/ coordinated fixed time, rule-based, or adaptive control	88%	85%	100%
eHighway	% of freight corridors electrified	0%	95%	75%

The 11 technologies modeled cover commercially available transport technologies; however, there are three key emerging technologies that the city is beginning to work toward that this CyPT analysis does not address. They hold the promise of facilitating a transition towards more sustainable transportation – but perhaps without the same expectation of behavioral shift from Angelenos. **Autonomous vehicles, public sector-controlled microtransit, and multi-modal trip planning and payment platforms could be "game-changers" for mobility in LA.** Early simulations from Eno Center for Transportation, RAND Institute, Rocky Mountain Institute, McKinsey, World Resources Institute, and others predict that these technologies could ease congestion by between 20 and 50%, improve road safety by up to 95%, and induce as much as a 10% increase in public transit ridership. Subsequent studies on the future of mobility in LA should put more emphasis on understanding the possible benefits and consequences of uptake of these three technology-enabled levers.

CyPT Lever Impacts



*Between today and 2050 [100s]

** 1-most cost efficient; 11-least cost efficient

Electricity

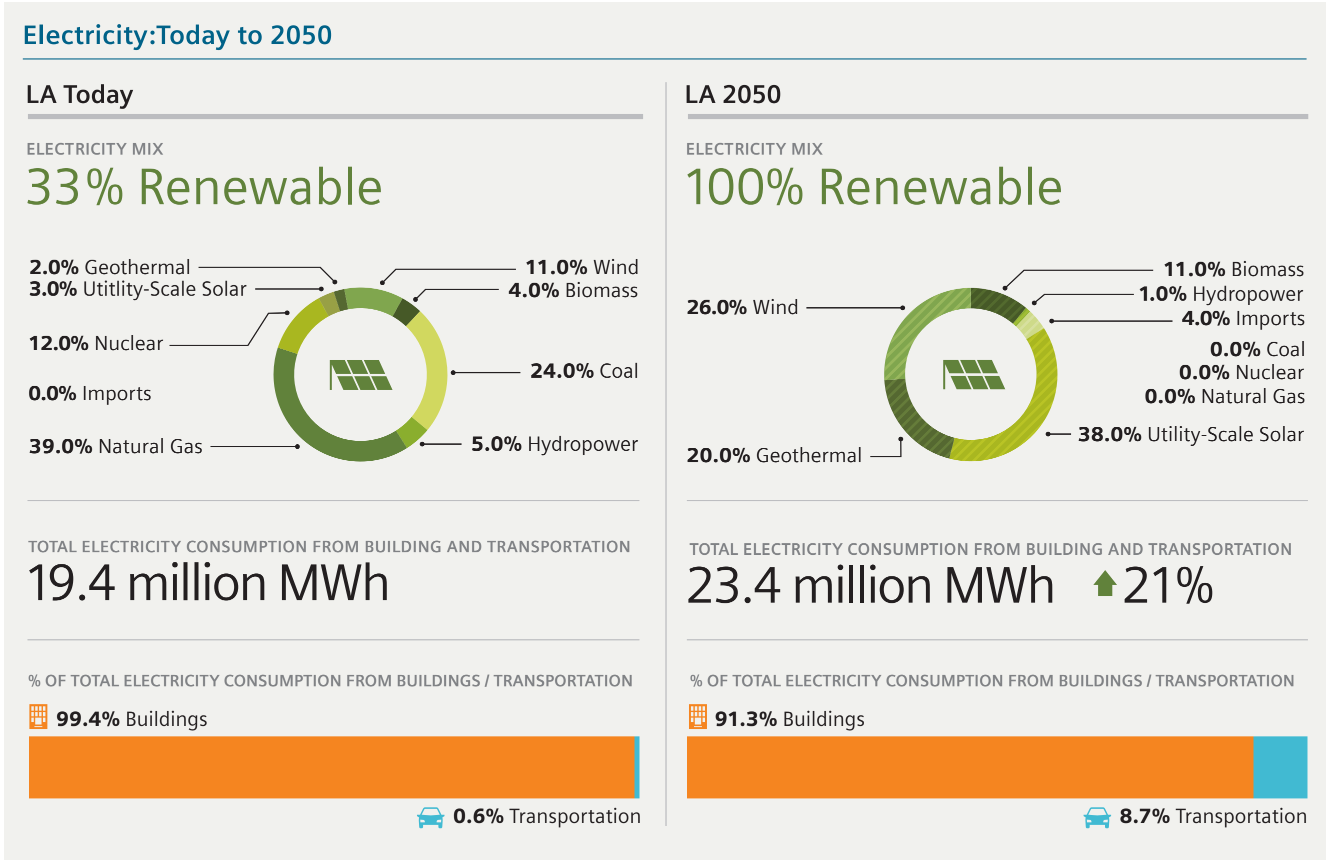
Due to the critical role of LA's municipal utility, the Los Angeles Department of Water and Power (LADWP), we incorporated a specific focus on electricity for the first time in any of Siemens 40+ CyPT analyses. Siemens looked at the impact to the grid of 10 levers in three categories: energy efficiency, eMobility, and thermal electrification. Our analysis shows that the implementation of these 11 levers would result in a 21% increase in electricity consumption from today's level of consumption to 2050's.

Even with the implementation of five energy efficiency levers (roughly categorized as building automation in 30% to 75% of homes and businesses), building electricity consumption in the future will be greater than it is today by 10.7%, in part due to the larger population and building footprint we expect in the future LA. The uptake of electric bus fleets, eBRT, electric carsharing, electric cars, and freight electrification with e-highways would lead to a staggering 1,663% increase in transportation electricity consumption by 2050. To support fleet conversion, roughly 196,000 EV chargers for cars and 500 EV charges for buses are needed, as well as 135 miles of overhead catenary lines for eTrucks on highways. Furthermore, an additional 3.3 million electric heat pumps would increase electricity consumption for heating by almost 30%.

Altogether, these investments would reduce LA's GHG emissions almost 25% from 1990 levels, on top of the significant emissions reductions benefits from decarbonizing the grid and implementing smart grid control and monitoring software. Despite their positive environmental benefits, however, they will undoubtedly complicate grid operations, as these new types of loads (especially electric vehicles and electric heat pumps) are used at different times of the day and with varying frequencies.

Indeed, many of the benefits of the 17 building, energy, and transportation measures in our model are contingent on the reliability of the electricity grid. Although LADWP experiences very few electricity outages today, incorporating renewables at utility-scale, from distributed sources, and from new sources altogether (like electric vehicles) in the future could strain the performance of the grid. They are also likely to raise technical transmission and distribution (T&D) losses on the grid to above the 12% experienced today, which is in comparison to T&D losses of 7 - 9% on a well performing grid.[xix,xx] By planning now for a modernized grid, LA can avoid having to rely on fossil fuel-based back up generation.

Participants in the CyPT workshop, representing a variety of agencies and stakeholder interests,



unanimously agreed that modernizing the grid is the highest priority in ensuring a resilient electric future. **Implementing software to help understand when, where, and why electricity is being used; to provide transparency to consumers about pricing; to do predictive analytics for grid maintenance; and to incorporate alternative sources of energy (like rooftop PV panels or microgrids, which use the grid as back-up) are just some of the reasons cited for the importance of power system automation and smart grid monitoring and control measures – even though these measures have relatively low direct impacts on GHG reduction.**

Distribution management technologies, distributed power generation, virtual power plants, and microgrids are just four possible technology solutions to better manage peak demands, while providing reliable energy.

Distribution Management Technologies are a suite of communication and transmission tools that ensure availability of a minimally sufficient amount of electricity where and when it is needed. It can include Smart Metering, which is the digital monitoring of consumption data shared bidirectionally between consumer and energy provider. When combined with Active Load tools, the energy provider has some control over consumption and can use this to mitigate peak demand. For example, such systems can delay or reduce electricity consumption of non-essential functions during peak times. This means that EVs could charge gradually throughout the night, rather than at maximum speed immediately after being plugged in in the evening after work.

Distributed Generation (or Distributed Energy Resources, or DERs) is smaller-scale production of energy near where it will be used. DERs include micro-generation schemes like residential rooftop solar panels. Its benefits include decreased energy loss by avoiding long-distance transfer and increased resilience by having multiple electricity sources.

Its challenges include integrating with a grid that may be optimized for centralized, unidirectional transmission, and managing the maintenance of dispersed production points. Distributed generation is easily combined with renewable generation, as well as energy storage or microgrid schemes.

Virtual Power Plants integrate DERs with Distribution Management Technologies, to improve grid performance by aggregating, storing, and managing the electricity produced by DERs. This can help offset the intermittent nature of renewable generation, but requires the digitization of all grid assets, which may pose difficulties when attempting to install equipment in many private buildings or homes.

There is speculation that batteries in EVs could be used as additional, distributed, small-scale storage by drawing and storing electricity from the grid at times when renewables are producing excessive energy and feeding it back into the grid during peak demand hours or when renewables are less productive. This functionality would be enabled by Virtual Power Plant technologies.

Microgrids are another way to avoid straining the main electricity grid with extreme peak demand. They are independently controlled distribution networks. Microgrids can "island" (operate independently from the main grid) and/or connect to the main local grid. When microgrids are combined with distributed generation and appropriate energy

Energy Efficiency

Wide commercialization of building automation technologies is already leading to reductions in home and business energy use. These trends are expected to continue, and escalate, with commercial buildings especially undergoing retrofits and renovations or being built to new, stringent standards.

CyPT Levers	Infrastructure Impacts
1. Window glazing in 80% of homes	Private investment in double- or triple-paned window glazing
2. Home automation in 30% of homes	Private investment in home automation systems, like Nest
3. Room automation for lighting and HVAC in 50% of businesses 4. Buildings automation in 75% of businesses	Private investment in room and building automation systems, with new lighting, HVAC sensors, and software installed

Effects on Electricity Consumption	Reduction in Emissions
+10.7% from Today's Building Electricity Consumption	**-1.8%** Based on 1990 levels

Implementing software to help understand when, where, and why electricity is being used; to provide transparency to consumers about pricing; to do predictive analytics for grid maintenance; and to incorporate alternative sources of energy (like rooftop PV panels or microgrids, which use the grid as back-up) are just some of the reasons cited for the importance of power system automation and smart grid monitoring and control measures – even though these measures have relatively low direct impacts on GHG reduction.

storage, such as through Virtual Power Plants, they can provide a single, stable interaction with the main grid, counteracting the variable nature of solar and wind generation. Microgrids also avoid the transmission losses of more centralized systems, and offer resilience against grid failure. It can be challenging to run microgrids in conjunction with main grids when they aren't optimized for bidirectional energy flow or able to handle variable amounts of electricity.

Microgrids could create self-contained grids for charging vehicles, simultaneously avoiding the issues of connecting with a main grid and filling the need for additional electricity to fuel cars in the future. For example, aggregated charging areas such as a 30-charger parking lot could run off electricity generated by on-site solar panels and distributed through a microgrid.

eMobility

Because of the low levels of penetration of eCars and eBuses in the U.S. market (less than a percent of all cars on the road are alternative fuel vehicles), little research has been done to understand what the effects of widespread electrification will be on the electric grid – until now. Utilities across the country are looking at the two TE's (transport and thermal electrification) as possible antidotes to the utility "death spiral" brought on by decentralized energy and energy efficiency.

CyPT Levers	Infrastructure Impacts
1. 100% electric bus fleets 2. 6 eBRT lines 3. 25,000 electric car sharing cars 4. 100% electric cars 5. 75% of freight corridors electrified	Public and private investment in: • 196k EVBV chargers for cars • 428 chargers for buses • 135 miles of overhead catenary lines for highways

Effects on Electricity Consumption	Reduction in Emissions
+1,663% from Today's Transportation Electricity Consumption	**-10.1%** Based on 1990 levels

Thermal Electrification

In an article David Roberts from Vox wrote about Siemens CyPT analysis for the City of San Francisco, he called the electric heat pump "boring but important...the humble home appliance [that] could be San Francisco's secret climate weapon." The same is true for Los Angeles. Whereas in colder, wetter climates, the efficiency of the air source heat pump is quite low (it requires more electricity input per heating output), in LA's climate it is quite high – higher even than Phoenix or Houston. However, electric heat pumps are often times more expensive than their competitor options, and as Roberts suggests, policies and incentives will need to make investing in heat pumps more attractive to consumers.

CyPT Levers	Infrastructure Impacts
1. Electric heat pumps generating 50% of heating consumption by homes and businesses	Public and private investment in 3.3M electric heat pumps

Effects on Electricity Consumption	Reduction in Emissions
+28.5% from Today's Electricity Consumption for Heating	**-10.9%** Based on 1990 levels

Putting It All Together

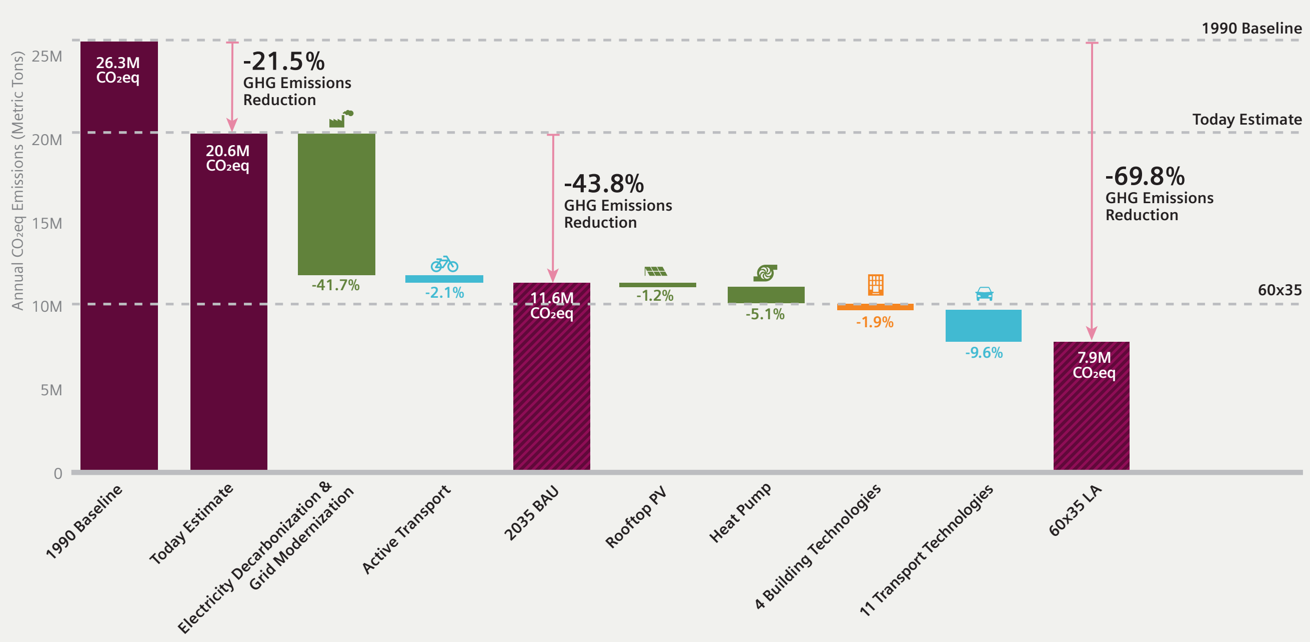
The CyPT analysis covering LA's energy, buildings, and transport sectors demonstrates that LA does have a path forward to exceeding ambitious greenhouse gas reduction targets of 60x35 and 80x50 for energy use in buildings and transportation. **With a cleaner grid, greater use of expanded public transit networks, increased automation in homes and businesses, and investments in eMobility, LA's building and transportation emissions could fall 68.9% by 2035 and 87.0% by 2050. Emissions reductions would be accompanied by 72% improvement in air quality and almost two million local jobs.**[xxi]

Because this analysis focuses on two timeframes, mid-term (2035) and long-term (2050), it is tempting to assume that LA doesn't need to take action now to ensure future sustainability. Siemens comparison of the top-performing technologies across sectors provides insight into where LA and Angelenos could invest their resources, starting today. Installing electric heat pumps in new or retrofitted buildings, equipping buildings and streets for eMobility, improving the reliability and frequency of Metro trains, and incentivizing building owners to install solar panels are just a few of the actions that could have the most impact.

Three near term actions we recommend LA consider, due to their potential readiness for adoption, are: building six new eBRT (electric Bus Rapid Transit) routes], expanding LA's electric carsharing program through public-private financing, and investing in grid management software (Smart Grid Monitoring and Control) to foster a more resilient, reliable, and flexible grid, which is imperative for LA's energy future. Smart Grid Monitoring and Control is also a key step in preparing for electrification of buildings and transportation in the next 10 years. Conducting more in-depth analyses of how to prepare the grid for 20% more electricity consumption (10.7% increase in building electricity and 1,663% increase in transportation electricity consumption) is an obvious follow-on project stemming from this analysis.

Underlying all of these technologies and their successful implementation is people. The projected 1.8 million full-time equivalent positions created between today and 2050 include multiplier effects (e.g., jobs created indirectly or induced by the directly investment, which could range from additional retail and restaurants to parts manufacturing or fabrication facilities). Roughly 35% of the projected jobs will require special skills and training. LA must continue to graduate more engineers than any other Metro area in the region, to have the solar power technicians, transportation engineers, and building mechanics needed to install and maintain LA's infrastructure. **LA's path forward is clear. Thanks to early efforts by the Mayor's Office on Sustainability, to an enthusiastic and engaged public, and to a supportive Mayor and City Council it is also attainable.** As LA continues to invest in upgrading its ports, airports, roads, trains, buildings, and grid, the private sector can and should step in by helping to design, build, and finance pilot projects that scale and the projects needed for wholesale transformations of LA's energy, buildings, and transportation systems.

LA2035



LA2035 Economic and Environmental Impacts

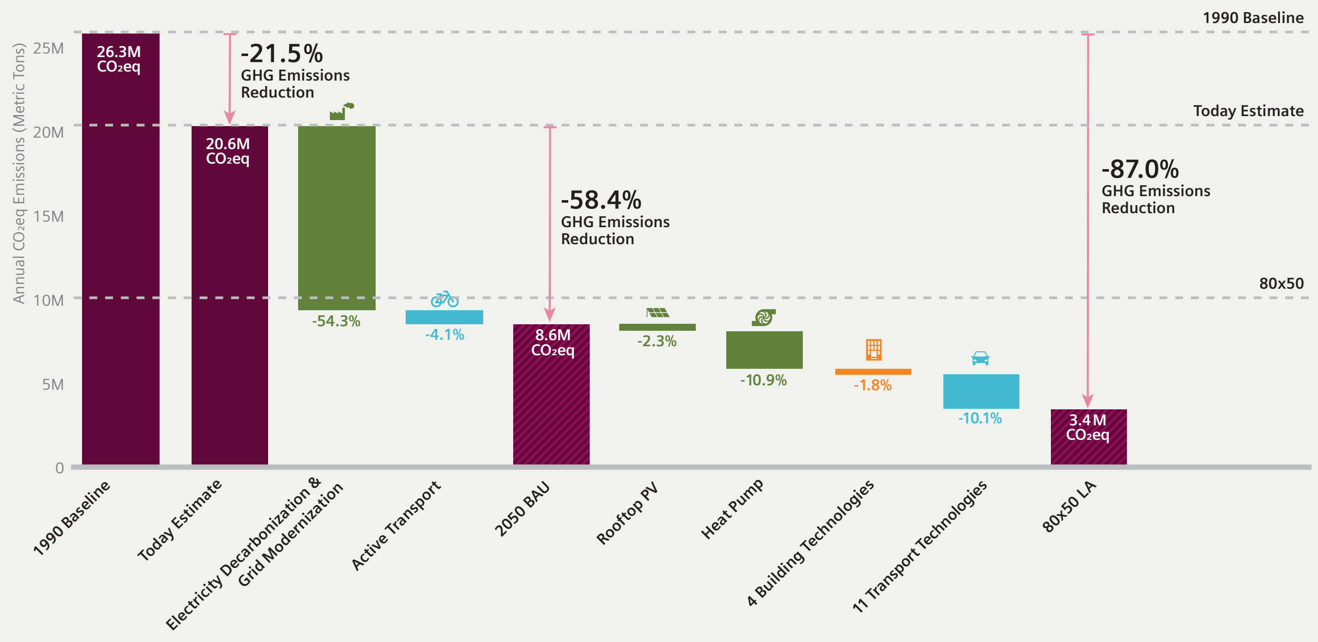
18.4M Potential CO_2eq Reduction (in metric tons) from 1990 Levels

-69.8% Potential CO_2eq Reduction (%) from 1990 Levels

$113B Capital and Operating Expenditures between Today and 2035

620K Full-Time Equivalents Generated between Today and 2035

LA2050



LA2050 Economic and Environmental Impacts

22.9M Potential CO_2eq Reduction (in metric tons) from 1990 Levels

-87.0% Potential CO_2eq Reduction (%) from 1990 Levels

$315B Capital and Operating Expenditures between Today and 2050

1.8M Full-Time Equivalents Generated between Today and 2050

Endnotes

i Streetsblog LA, "LA City Approves Full LADOT Transit Electrification by 2030," 9 Nov 2017: https://la.streetsblog.org/2017/11/09/l-a-city-approves-full-ladot-transit-electrification-by-2030/

ii Los Angeles Department of Water and Power, Accessed 2018, https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_afrLoop=3330742642854&_afrWindowMode=0&_afrWindowId=null#%40%3F_afrWindowId%3Dnull%26_afrLoop%3D3330742642854%26_afrWindowMode%3D0%26_adf.ctrl-state%3Dyuyquzp34_34

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iv Blue LA, Accessed 2018, https://www.bluela.com/

v Los Angeles Cleantech Incubator, Accessed 2018, https://laincubator.org/

vi California Energy Commission, Accessed 2018, http://www.energy.ca.gov/portfolio/

vii SD24, Accessed 2018, http://sd24.senate.ca.gov/news/2017-05-02-california-senate-leader-introduces-100-percent-clean-energy-measure

viii Los Angeles Department of Building and Safety, Accessed 2018, https://www.ladbs.org/services/green-building-sustainability/existing-buildings-energy-water-efficiency-program

ix Better Buildings Challenge, Accessed 2018, http://la-bbc.com/

x 100 Resilient Cities, Accessed 2018, http://www.100resilientcities.org/cities/los-angeles/

xi Resilience by Design, Accessed 2018, http://www.resilience.la/#intro

xii Population growth estimates were sourced from SCAG, the Southern California Association of Governments. Electricity mix assumptions were sourced from LADWP's Integrated Resource Plans. Reductions in residential unit sizes were sourced from the Urban Land Institute (ULI) and other market projections. The shift in passenger mode share was assumed by the team based on input from the City.

xiii The CyPT utilizes the 2012 GPC Protocol for Community-Wide Emissions as its methodology for estimating GHG emissions. It covers Scopes 1, 2, and 3 emissions for energy generation and energy use in buildings and transportation. Essentially, this means that the CyPT takes into consideration both direct emissions occurring within the City boundaries (such as from exhaust fumes) and indirect emissions from the conversion of chemical energy to power, heat or steam of purchased energy from outside the city. The included Scope 3 emissions refer to the emissions produced as a result of fuel production and extraction. This also includes the construction and production of renewable power plants.

xiv Los Angeles Climate Action Report found here: https://www.lamayor.org/sites/g/files/wph446/f/landing_pages/files/pLAn%20Climate%20Action-final-highres.pdf

xv EIA, Residential Energy Consumption Survey (2009), https://www.eia.gov/consumption/residential/data/2009/index.php?view=consumption

xvi Information on residential electricity consumption comes from LADWP, as well as from the US Department of Energy's Residential Energy Consumption Survey (RECS).

xvii EIA, Commercial Buildings Energy Consumption Survey (2012), https://www.eia.gov/consumption/commercial/data/2012/c&e/pdf/e1-e11.pdf

xviii San Diego Tribune, "California vehicle sales exceed 2 million for third straight year," 22 Feb 2018, http://www.sandiegouniontribune.com/business/energy-green/sd-fi-car-sales-20180222-story.html

xix LADWP, Integrated Resource Plan, 2017

xx Based on Siemens technical expertise with electric utilities around the world.

xxi Full-time equivalent positions