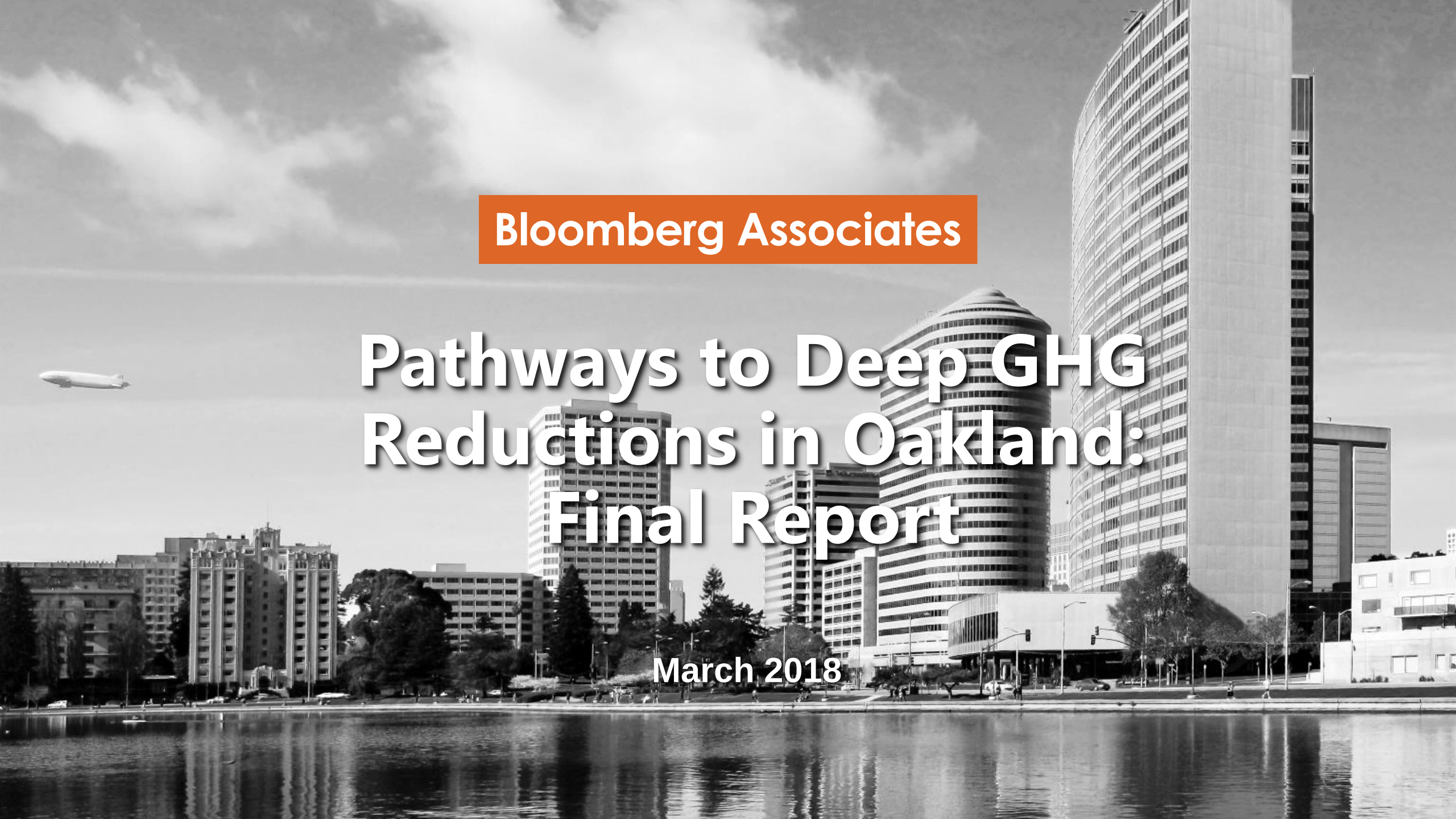


Bloomberg Associates

Pathways to Deep GHG Reductions in Oakland: Final Report

March 2018

Acknowledgements

The Bloomberg Associates Sustainability Practice has worked with the City of Oakland to identify opportunities and measure the impact of deep greenhouse gas (GHG) reductions. A number of people have contributed their time and energy to this effort. Specific thanks to the following people for their contributions:

- **Oakland Public Works** – Becky Dowdakin, Daniel Hamilton, Shayna Hirshfield-Gold
- **OakDOT** – Ryan Russo, Michael Ford, Iris Starr
- **Bureau of Planning and Building** – Darin Raneletti
- **City Administrator's Office** – Christine Daniel, Alex Orologas
- **Oakland Climate Fellows** – Mukta Kelkar, Ben Linthicium, Allison Hooks, Yoni Carnice
- **AECOM** – Claire Bonham-Carter, Amruta Sudhalkar

About Bloomberg Associates

Bloomberg Associates is an international consulting service founded by Michael R. Bloomberg as a philanthropic venture. Its mission is to help city governments improve the quality of life of their citizens.

Directed by a team of globally recognized experts and industry leaders, the consultancy works to improve urban environments by collaborating with cities to develop best practices, build consensus and foster key relationships. Through its guidance and mentorship, Bloomberg Associates delivers actionable insights and plans across multiple disciplines.

Table of Contents

Introduction.....1

Progress to Date.....8

Pathways to 80 by 50 Reduction.....12

Policy Considerations.....27

Conclusion.....44

Appendices

A. Buildings Technical Materials.....48

B. Transportation Technical Materials.....86

C. Stakeholder Engagement.....116

Introduction

Oakland is a recognized climate leader, but must accelerate action to achieve its GHG reduction goals

Oakland is a recognized leader in taking action to reduce its greenhouse gas (GHG) emissions and preparing the city for climate change.

The City Council **approved the City's first Energy and Climate Action Plan (ECAP) in 2011**, which set **goals to reduce GHG emissions 36% below 2005 levels by 2020 and 83% by 2050**. The City is a signatory to the Global Covenant of Mayors for Climate and Energy and the U.S. Climate Alliance to meet the commitments of the Paris Climate Accord.

Despite this leadership on the national and global stage, the **City is not on track to achieve its climate goals**. Bloomberg Associates was engaged by the City to identify the actions that Oakland needs to take to meet its targets.

To complete this analysis, **Bloomberg Associates utilized the CURB climate action planning tool**. The final results of the analysis are presented in this report.

Oakland is the first U.S. city to use CURB to conduct in-depth GHG analysis

CURB was developed by the World Bank, C40, Bloomberg Philanthropies, Global Covenant of Mayors, and others to assist cities in the creation of climate action plans to reduce GHG emissions. The tool was designed to:

- Provide '**strategic-level' analysis** to help the city identify and prioritize low carbon infrastructure and GHG reduction actions
- Help cities make the best use of limited funding by **focusing on the actions with greatest impact**
- Allow cities to **quickly see the emission implications and cost effectiveness of potential actions**

Oakland is the first city in North America to use the tool in-depth as a key input into its climate planning and will share its experience as a pilot with other cities.

CURB measures the GHG impacts of more than 1,000 actions across six sectors:

Private Building Energy*

Municipal Buildings & Public Lighting

Electricity Generation

Solid Waste

Waste & Wastewater

Transportation*

*Given that 86% of Oakland's GHG emissions are generated by private buildings and transportation, analysis focused on these sectors in CURB.

The analysis utilized CURB to support data-driven climate action planning in Oakland

Bloomberg Associates and the City of Oakland, with technical support from CURB's development team, piloted a unique six-part methodology to utilize CURB to support data-driven climate action planning.

1 Gathered Baseline Data

Identified data from the best available sources to estimate where Oakland's building, transportation, and energy systems are today and to forecast population and economic trends.

2 Engaged Local and National Experts

Interviewed more than 30 local and national experts and hosted a series of sector-specific workshops with more than 50 Bay Area experts to refine the baseline data and collaboratively estimate the city's projected trajectory and actions needed to achieve GHG reduction goals.

3 Outlined Key Assumptions

The analysis assumes Oakland reaches 100% carbon-free energy by 2030. A carbon-free energy grid is the backbone of future deep GHG reductions and is critical to Oakland achieving an 83% reduction by 2050. The analysis also rests upon core (in-boundary) assumptions for buildings and transportation that are detailed in the next section of the report.

Oakland tracks both core (in-boundary) and consumption-based emissions, however this analysis is limited to core GHG emissions due to the parameters of the CURB tool.

4 Developed GHG Reduction Scenarios

Developed two scenarios for the CURB tool:

- **Projected Trajectory**: Assumes technological advances and market adoption/penetration, stated State and Federal policies, existing City policies and funded programs, and limited City actions responding to market trends
- **Deep Decarbonization**: the actions needed to achieve an 83% reduction in GHG emissions by 2050

5 Analyzed Gaps Between Scenarios

Compared GHG emissions reductions from the Projected Trajectory to the reductions achieved in Deep Decarbonization to identify the key gaps between what the city is projected to achieve and what it needs to achieve to meets its GHG reduction goals. This part of the analysis identified the keys gaps where City action is required.

6 Identified Policy Areas and Case Studies

Based upon the gap analysis and the modeled GHG reduction impacts, the analysis identified priority policy areas where City action is needed. These policy areas should help shape the ECAP update.

The report also includes case studies from other cities around the world that could serve as models for Oakland in the targeted areas it needs to take action to achieve deep GHG reductions.

The analysis was limited by several important factors

Data Availability

- There are no comprehensive, detailed databases on the conditions or types of systems in Oakland's building stock or vehicles, nor is there detailed mode share information for the city. As a result, the analysis utilizes proxy data or educated assumptions based on research and expert interviews.

Underlying Assumptions

- Analysis that models more than 30 years into the future is an inherently projective exercise that involves a series of key underlying assumptions. While transparently documented in this report, the analysis relies upon assumptions on technology development, market changes and the impacts of State-level policies. It does not incorporate any assumptions regarding behavioral changes that could change consumption patterns (e.g., increasing plug loads for electronics). These are largely outside the City's control, yet for the purposes of this analysis, shape the determination of where City action is needed.

Core Versus Consumption Emissions

- Oakland is a leading city in measuring consumption-based emissions in addition to core (in-boundary) emissions. Reducing consumption-based emissions over the long term is critical to reducing the impacts of climate change; however, it often falls outside the scope of traditional city-level powers and responsibilities. Due to the setup of CURB, this analysis was limited to core (in-boundary) emissions.

Constraints of the CURB Tool

- The structure for transportation actions in CURB includes grouping many individual potential actions within broader categories (e.g., passenger mode shift). The outputs of the tool, therefore, do not allow for granular analysis in the impact of any one individual action to shift modes. This particularly limited the assessment of the economic costs of transportation actions to shift modes and electrify vehicles.

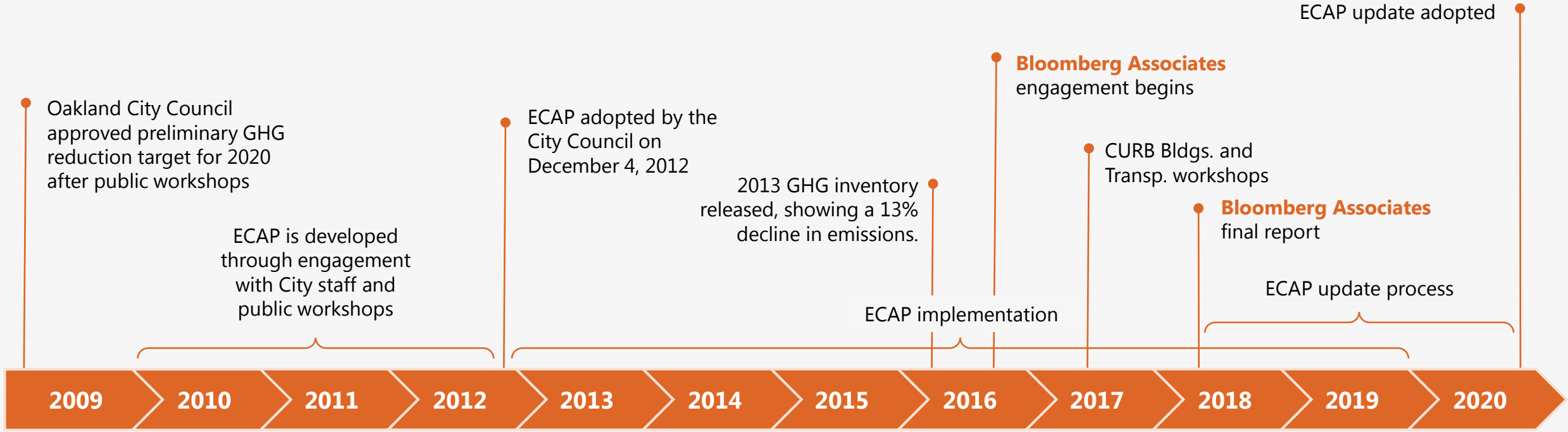
Climate Change

- This analysis does not account for the impacts that climate change may have on energy consumption patterns. While a warming climate is likely to shift heating and cooling loads in Oakland, this analysis does not attempt to forecast the extent or pace of such changes.

CURB's outputs can help inform Oakland's policies and investments, including the update of its Energy and Climate Action Plan (ECAP)

Oakland's ECAP **outlines and prioritizes the actions the City will take to reduce energy consumption and GHG emissions in Oakland**. ECAP **establishes GHG reduction targets and actions**, as well as frameworks for coordinating implementation and reporting on progress.

Oakland will **begin updating its ECAP in 2018, for adoption in 2020**. Bloomberg Associates' analysis is intended to serve as a **decision support tool for the updated plan**, identifying the critical actions needed to put Oakland on a pathway to meet its long-term GHG reduction goals and facilitating communication with key stakeholders.



Taking action to reduce GHG emissions provides many benefits to Oakland residents

	Buildings Co-Benefits	Transportation Co-Benefits
Social Equity	• Energy costs have a disproportionate impact on lower income residents • Energy efficiency measures lower energy bills, saving money for households and businesses	• Improving public transit service and pedestrian and bicycle infrastructure is likely to benefit those without access to a private vehicle
Local Economy	• Reduction in building energy use reduces costs • When a business or household lowers their energy costs, the savings can be spent elsewhere in the local economy, resulting in additional jobs	• Reducing transportation costs through alternative modes of transportation (e.g., walking, biking, and mass transit) can provide savings over private car usage • These savings can be spent elsewhere in the local economy, resulting in additional jobs
Energy Independence	• Reducing the use of imported fossil fuels lowers the community's vulnerability to energy price and supply shocks	• Reducing fossil fuel usage lowers the community's vulnerability to energy price and supply shocks
Deferred Infrastructure	• Reducing energy consumption can help defer the need for new sources of energy generation	• Reduced vehicle use will result in less wear and tear on roads, decreasing frequency of repairs
Public Health	• Reducing fossil fuel use in buildings and energy generation reduces the emission of air pollutants, improving air quality and lowering risks of asthma, respiratory disorders, heart attacks and cancer	• Transit-oriented urban design reduces the number of vehicles on the road, reducing congestion and improving regional air quality • Active forms of transportation (e.g., walking and biking) reduce obesity and other health risks and improve public health

Progress to Date

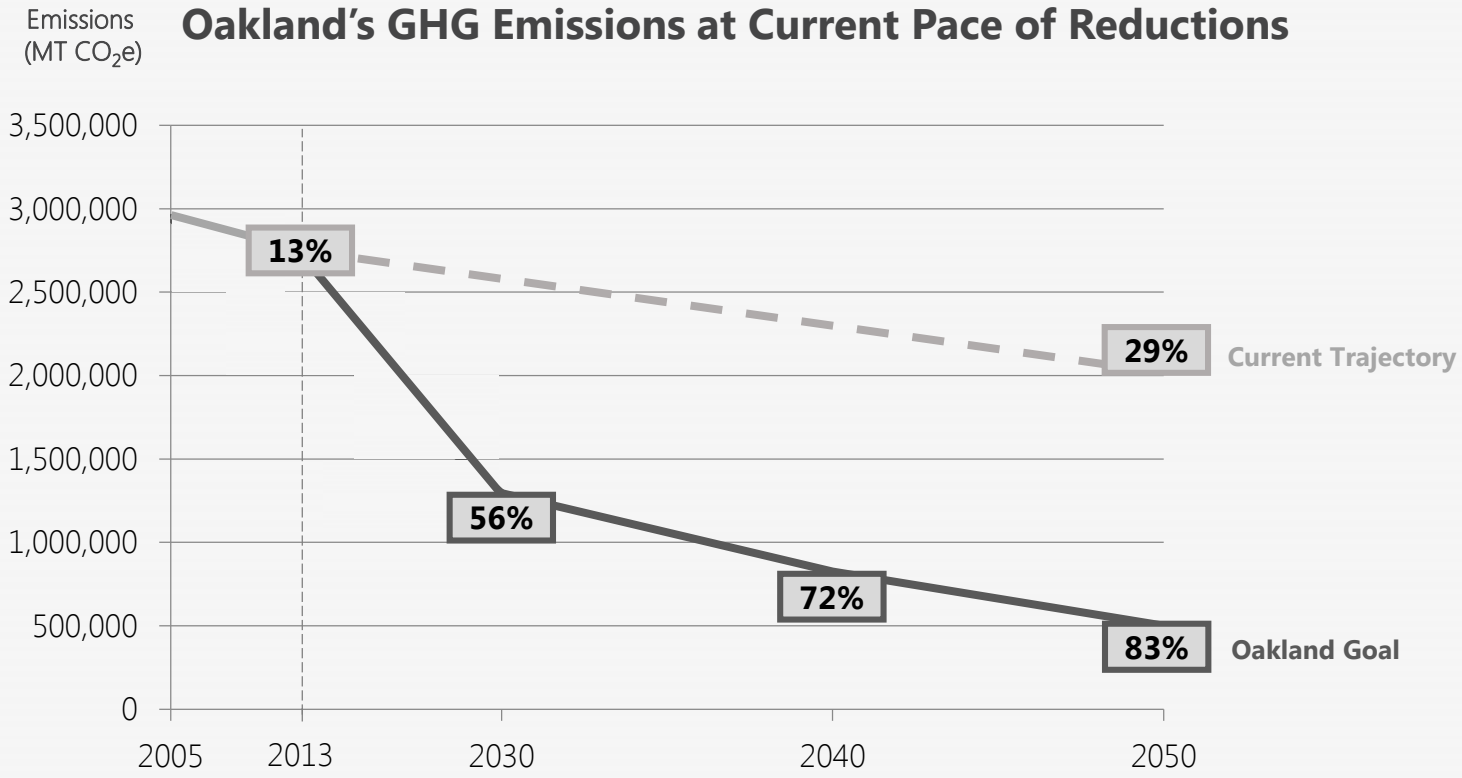
At its current pace, Oakland will not meet its 2050 GHG reduction goal

In 2009, **Oakland adopted an ambitious greenhouse gas (GHG) goal** to reduce its core emissions 83% by 2050 from a 2005 baseline.

In 2013, Oakland's GHG emissions decreased 13% from its 2005 baseline. **If Oakland continues on its Current Trajectory, it will only achieve a 29% decrease in emissions by 2050,** accounting for population and economic growth – far short of its adopted target.

Oakland needs to accelerate action if it hopes to achieve its near- or long-term GHG goals. This report seeks to identify which actions the city needs to take.

Oakland's GHG Emissions at Current Pace of Reductions

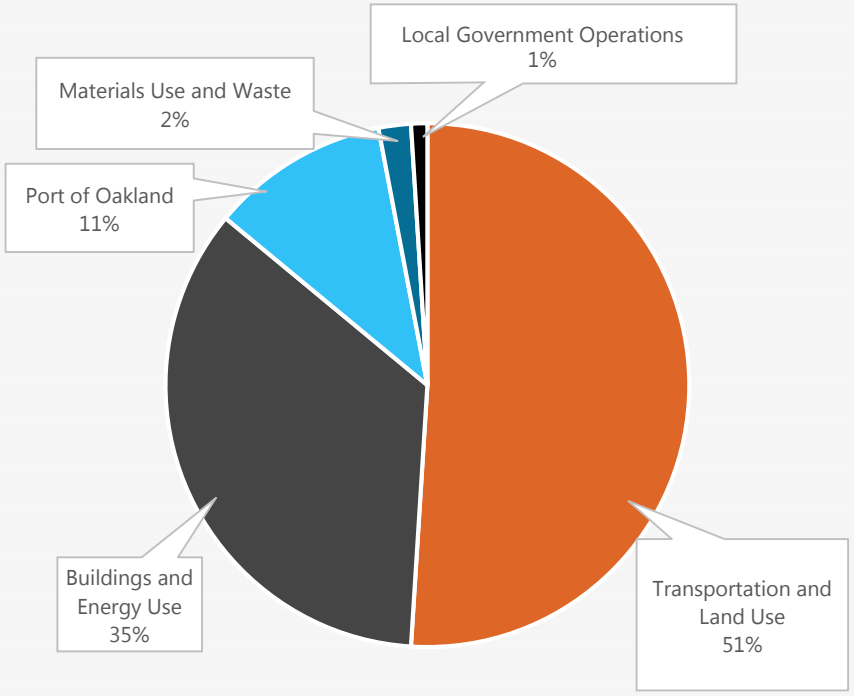


Source: Bloomberg Associates Analysis, CURB

Oakland's most significant GHG reductions have come from the Port and Buildings

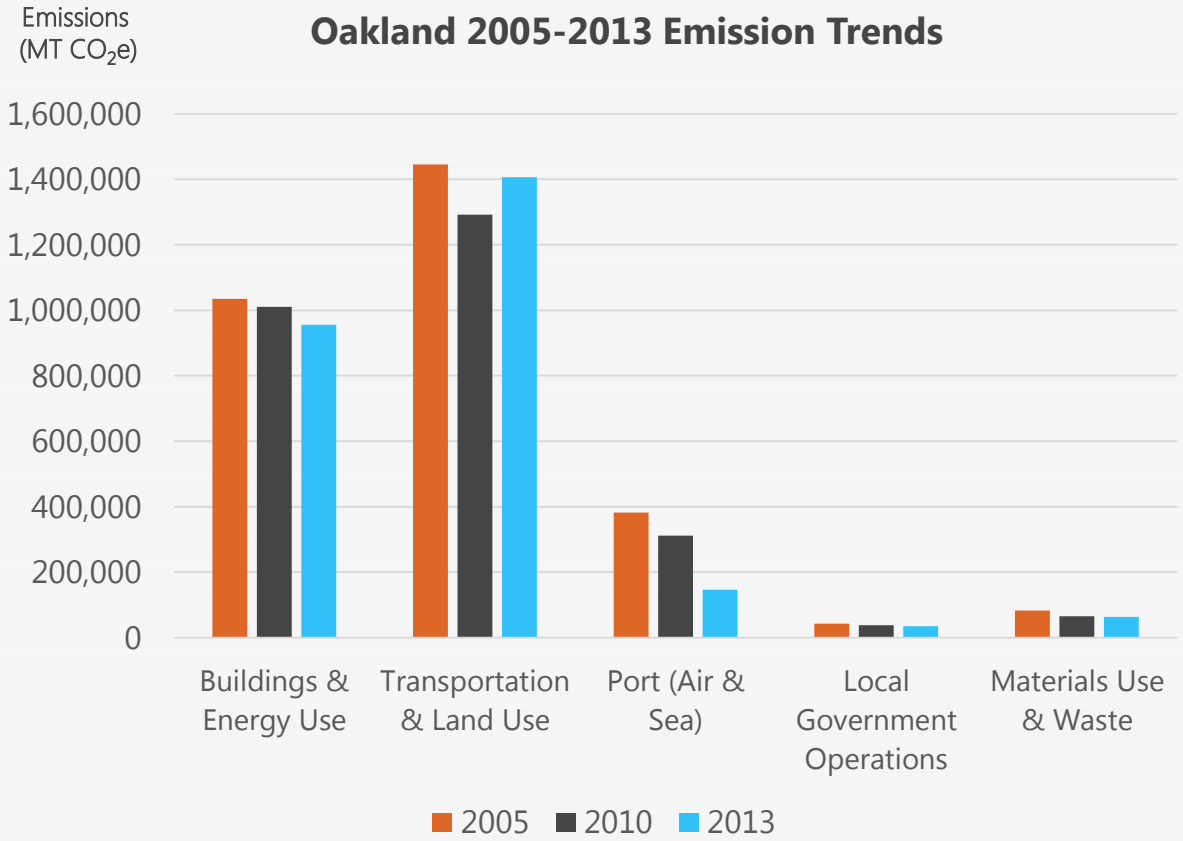
In 2013, Oakland's largest sources of emissions were **Transportation and Land Use** (51%) and **Buildings and Energy Use** (35%). All other sources were responsible for only 14% of emissions.

Oakland 2013 Core Emissions



Oakland has made progress in reducing GHG emissions across the city. Overall, **core emissions were 13% lower in 2013 than in 2005**.

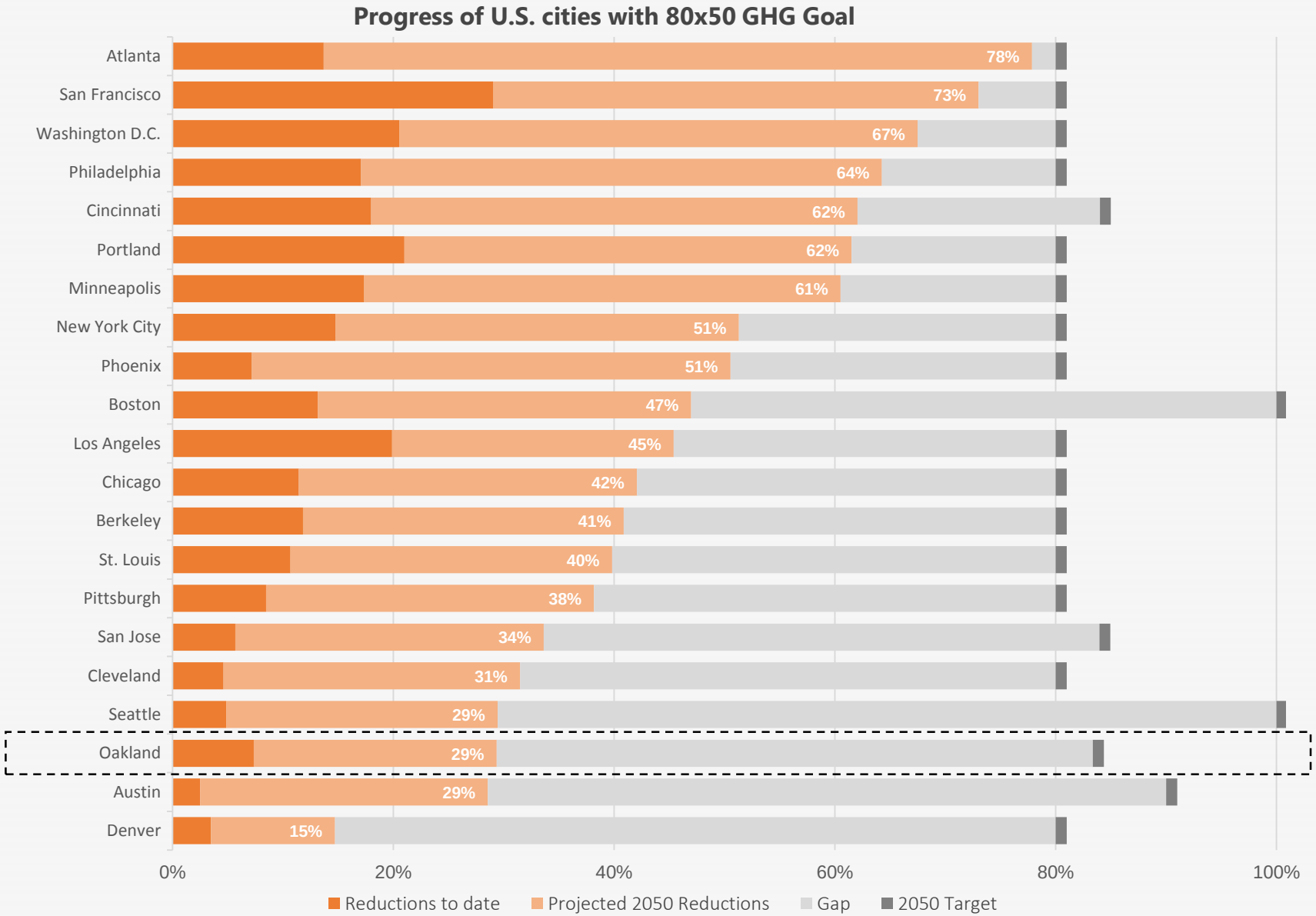
Oakland 2005-2013 Emission Trends



Note: While GHG data is available for 2015 in Oakland, the CURB tool and the analysis in this report is based on 2013 baseline data

Source: Oakland 2013 GHG Inventory

Oakland is not alone; many U.S. cities are not on track to meet their climate goals and need to accelerate action



- U.S. cities that have set aggressive GHG reduction goals have shown demonstrable progress in reducing emissions in recent years; however, **no large U.S. city is currently on track to meet its 2050 GHG reduction goals**
- While Oakland's projected emission reductions are behind some of the leading large cities in the U.S., the city is well ahead of most cities that have not set GHG reduction goals
- Oakland's per-capita emissions are among the lowest in the nation, making further emission reductions more challenging compared with other cities that start with higher per-capita emissions

Source: Bloomberg Associates


Pathways to 80 by 50 Reduction

CURB enables users to understand how changes to distinct building systems and a city's transportation sector impacts GHG emissions

To understand what the City needs to do to put it on a pathway to meet its GHG targets, Bloomberg Associates developed and modeled two GHG scenarios.

The first forecasts the GHG impacts of expected changes to the city's buildings and transportation systems if the City takes minimal additional action (its "**Projected Trajectory**") in 2030 and 2050. The second models the scale of change needed to achieve Oakland's long-term GHG goal ("**Deep Decarbonization**") in 2030 and 2050. Within these scenarios, the analysis focused on 60 distinct actions.

Buildings

CURB categorizes buildings in two ways…

- **Type**: Existing or New
- **Use**: Residential or Commercial

… and includes actions across **seven building systems:**

- Lighting
- Appliances
- Space Heating
- Cooling
- Water Heating
- Water Fixtures
- Building Envelope

Transportation

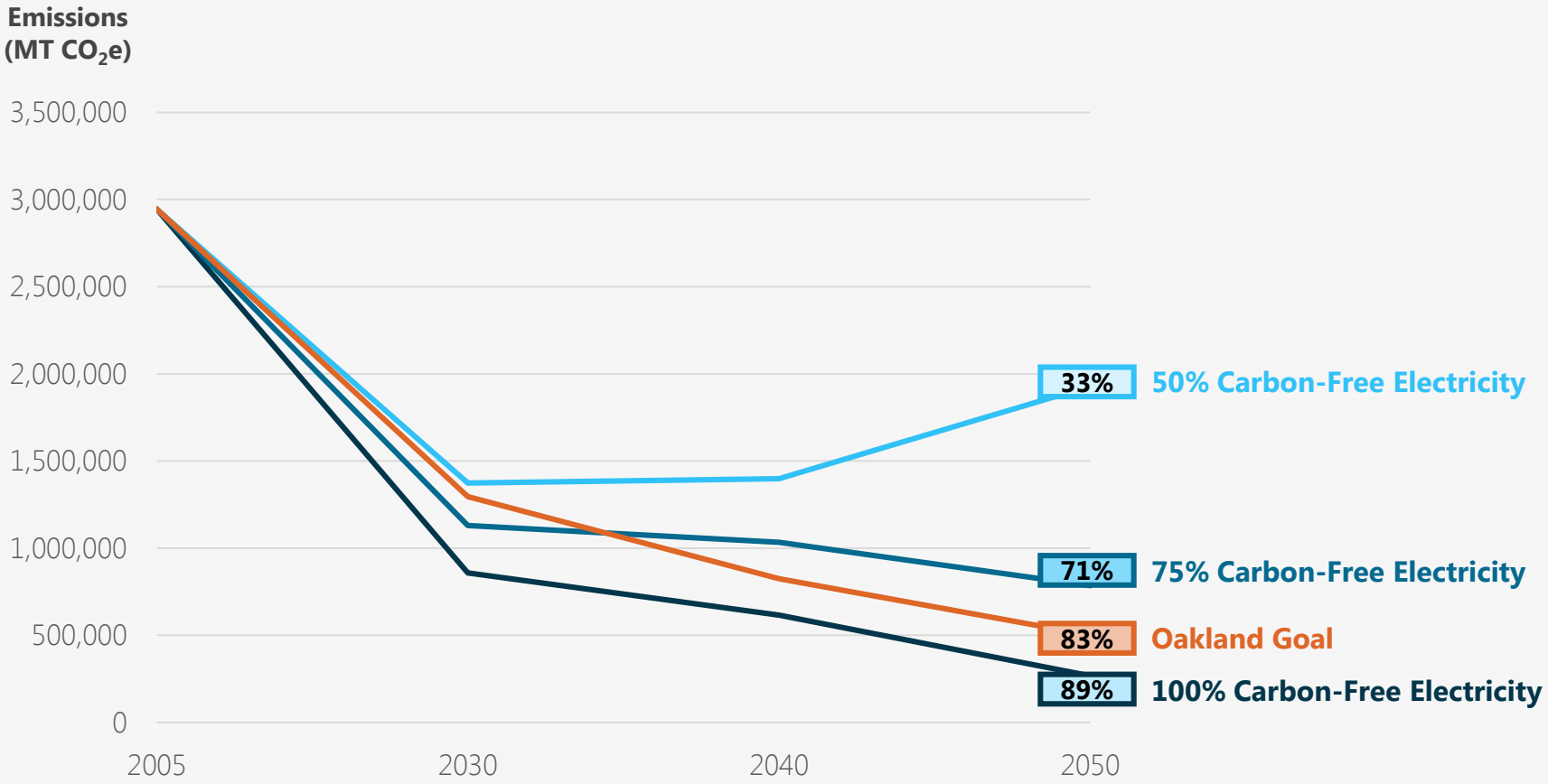
CURB organizes transportation into **four sets of potential actions** across **11 modes of transportation**:

- Transit Oriented Development
- Passenger Mode Shift
- Vehicle Electrification
- Fuel Efficiency

Both scenarios were modeled assuming an electric grid powered by 100% carbon-free energy, which is critical to meet Oakland's goal

- **Oakland can meet its near-term targets** under the Deep Decarbonization scenario **if at least 50% of its electricity is carbon-free**
- **Meeting its 2050 goal without a 100% carbon-free grid would require significantly more City action** than the current Deep Decarbonization scenario **and is likely not possible**

Emissions Reductions from Deep Decarbonization Scenario



Source: Bloomberg Associates Analysis, CURB

This analysis relied on variety of sources to develop the key assumptions for the Projected Trajectory and Deep Decarbonization scenarios

Document Review

Bloomberg Associates reviewed key documents, reports, white papers, and articles to better understand the current conditions of Oakland's building and transportation sectors and opportunities to reduce the GHG emissions.

Buildings documents

Transportation documents

Expert Interviews

Bloomberg Associates interviewed 30 local and national experts to build out the Projected Trajectory and Deep Decarbonization scenarios.

Workshops

Bloomberg Associates convened more than 30 experts at three in-person workshops to develop estimates for all CURB inputs for buildings and transportation.

12+ buildings experts met on July 27 in Oakland City Hall.

20+ transportation experts met on September 14 in Oakland City Hall.

Key assumptions for the Projected Trajectory and Deep Decarbonization scenarios

Key overarching CURB assumption

- **Oakland's electricity grid will be served by 100% carbon-free energy by 2030.**

Key building-related assumptions

- **California's energy efficiency laws will continue to drive significant improvements in building efficiency**, particularly for new buildings. These mandates should lead to near-zero net energy for all new construction by 2020 for residential buildings and 2030 for commercial properties.
- Oakland's current renovation program is reaching 1-2% of multi family properties per year. At best that program will upgrade 66% of multi-family properties in Oakland by 2050.

Key transportation-related assumptions

- **California incentives will increase adoption rate of zero/low emission vehicles for private autos and light-duty trucks** over historical trends. New sales of electric/low emissions vehicles will increase from current 5% of total sales to 40% by 2030 and 90% by 2050.
- **Fuel efficiency improvements will continue to be driven by CAFE standards set by the State and Federal Government.**
- 2030 projections do not account for autonomous vehicles due to uncertainty over near-term technological and regulatory hurdles; by 2050 AVs will be a normalized part of the transportation system.

More detailed assumptions can be found in Appendix A and B 'Technical Materials'.

Developing the Projected Trajectory and Deep Decarbonization scenarios

Bloomberg Associates worked with more than 60 experts to estimate the current condition of building and transportation systems (e.g., efficiency and fuel sources of heating systems, mode share split, and fuel sources and efficiency of vehicles), their projected conditions in 2030 and 2050 without significant City action, and the conditions they need to be in 2030 and 2050 to enable the City to meet its GHG targets. This resulted in more than 950 data points modeled by CURB.

Projected Trajectory

Bloomberg Associates estimated the Projected Trajectory of Oakland's emissions, assuming:

- **Projected technological advances & market adoption/penetration** (e.g., market adoption of electric heat pumps)
- **Stated State & Federal policies** (e.g., California Title 24 Building Code updates)
- **Existing City policies and funded programs** (e.g., Community Choice Energy program; NOT unfunded building retrofit plan)
- **Limited City actions responding to market trends** (e.g., revised building codes to legalize new technologies; NOT future programs incentivizing adoption of new building technology)

	CURB Tool Options	Today	2030	2050
New Residential			Projected Trajectory	Projected Trajectory
	Mid-Range Efficiency		25%	25%
	High-			
Existing Residential				
	Mid-			
	High-			
New Commercial	Mid-			
	High-			
Existing Commercial				
	Mid-			
	High-			

		CURB Tool Options	Today	2030 Projected Trajectory	2050 Projected Trajectory
Mode Share	Transportation Mode	Private Autos and Trucks	69.1%	55.1%	48.0%
		Motorcycle	1.6%	1.6%	1.6%
		Taxi/TNC 1or2 pass.	1.6%	10.0%	5.0%
		TNC Pooled Ride	Not avail.	2.0%	5.0%
		Shared Minibus	Not avail.	3.0%	10.0%
		Standard Bus/BRT	11.9%	10.0%	8.0%
		BART	6.5%	7.0%	8.0%
		Amtrak	1%	1.0%	2.0%
		Ferryboat	0.1%	0.3%	0.4%
		Biking	3.3%	5.0%	6.0%
		Walking	4.9%	5.0%	6.0%

Deep Decarbonization

The Deep Decarbonization scenario models Oakland's GHG emissions based on the changes necessary to achieve the City's 2050 GHG reduction goal.

	CURB Tool Options	Today	2030	2050
New Residential			Deep Decarbonize	Deep Decarbonize
	Mid-Range Efficiency		0%	0%
	Hi			
Existing Residential				
	M			
	Hi			
New Commercial	M			
	Hi			
Existing Commercial				
	M			
	Hi			

		CURB Tool Options	Today	2030 Deep Decarbonization	2050 Deep Decarbonization
Mode Share	Transportation Mode	Private Autos and Trucks	69.1%	40.0%	20.0%
		Motorcycle	1.6%	1.6%	1.6%
		Taxi/TNC 1or2 pass.	1.6%	3.0%	3.0%
		TNC Pooled Ride	Not avail.	5.0%	5.0%
		Shared Minibus	Not avail.	9.0%	10.0%
		Standard Bus/BRT	11.9%	15.0%	19.9%
		BART	6.5%	8.0%	14.0%
		Amtrak	1%	3.0%	3.0%
		Ferryboat	0.1%	0.4%	1.0%
		Biking	3.3%	7.5%	10.0%
		Walking	4.9%	7.5%	12.5%

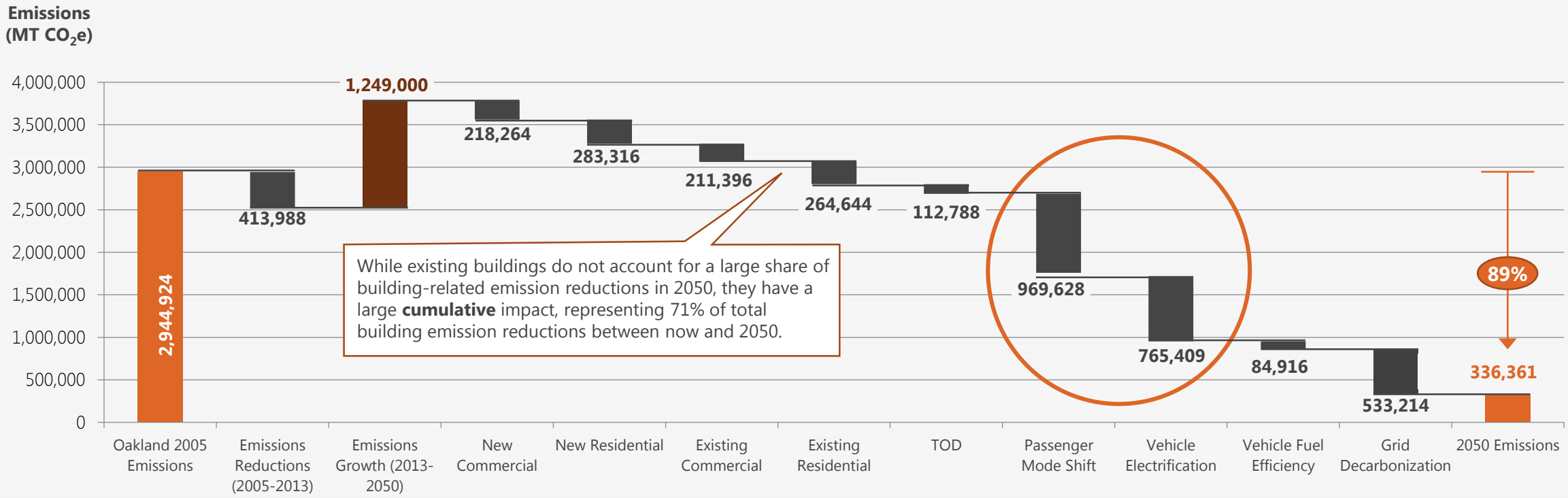
Transportation offers the largest opportunities for GHG reductions in the 2030 Deep Decarbonization scenario, but Oakland must make progress in all areas

2030 Emissions Reductions in Deep Decarbonization Scenario

Source: Bloomberg Associates Analysis, CURB

Shifting to less carbon intensive modes of transport and electrifying vehicles offer the largest GHG reductions in the 2050 Deep Decarbonization scenario

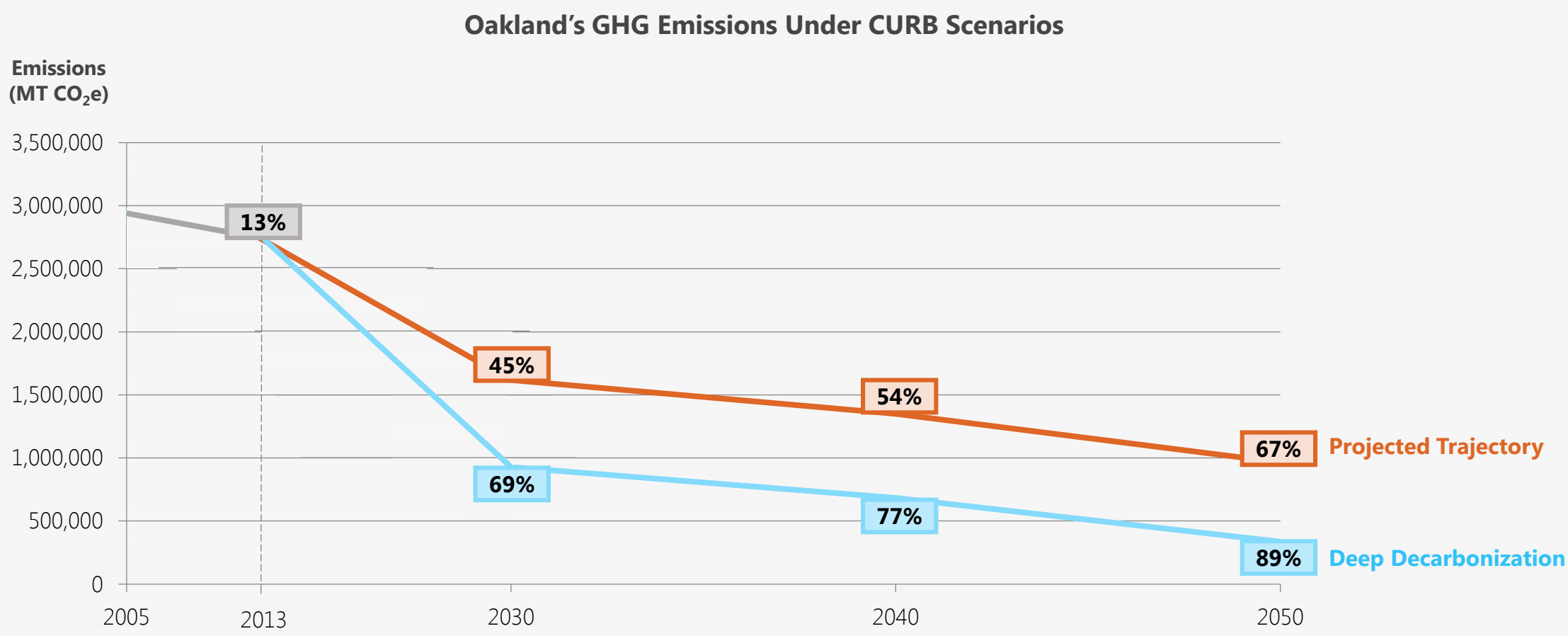
2050 Emissions Reductions in Deep Decarbonization Scenario



Source: Bloomberg Associates Analysis, CURB

Comparing the two scenarios identifies the changes needed in Oakland's buildings and transportation systems

Achieving the necessary level of GHG emission reductions will require City action.



Source: Bloomberg Associates Analysis, CURB

As an example, comparing adoption rates of window types highlights where gaps exist between the scenarios

City action is needed to increase adoption rates of low-energy windows in Oakland's existing building stock.

Windows example

	CURB Options	Today	2030			2050		
			PT	DD	**Delta**	PT	DD	**Delta**
New Residential	Single Paned		0%	0%	0%	0%	0%	**0%**
	Double-Glazed		0%	0%	0%	0%	0%	**0%**
	Double G Low-E		98%	98%	0%	95%	95%	**0%**
	Triple-Glazed		2%	2%	0%	5%	5%	**0%**
Existing Residential	Single Paned	86%	46%	30%	**-16%**	12%	0%	**-12%**
	Double-Glazed	14%	40%	0%	**-40%**	40%	0%	**-40%**
	Low-E	-	10%	70%	**60%**	43%	95%	**52%**
	Triple-Glazed		4%	0%	**-4%**	5%	5%	**0%**
New Commercial	Single Paned		5%	0%	**-5%**	3%	0%	**-3%**
	Double-Glazed		0%	0%	0%	0%	0%	**0%**
	Double G Low-E		95%	100%	5%	97%	100%	**3%**
	Triple-Glazed		0%	0%	0%	0%	0%	**0%**
Existing Commercial	Single Paned	84%	64%	34%	-30%	28%	0%	**-28%**
	Double-Glazed	16%	27%	0%	-27%	34%	0%	**-34%**
	Low-E		9%	66%	57%	38%	100%	**62%**
	Triple-Glazed		0%	0%	0%	0%	0%	**0%**

More detailed assumptions can be found in Appendix A and B 'Technical Materials'.

Short-term City actions in buildings should focus on space heating and building envelope

There are many differences in the near-term improvements expected to occur in building systems under the Projected Trajectory and what is needed in the Deep Decarbonization scenario. This is particularly pronounced and important from a GHG perspective for Space Heating and Building Envelopes, which represent almost one-third of Oakland's overall GHG reduction potential.

Gap Assessment between 2030 Projected Trajectory and Deep Decarbonization Scenarios

		New Buildings		Existing Buildings	
System	Overall GHG ↓ Potential	Residential	Commercial	Residential	Commercial
Lighting	2%				
Appliances	1%				
Space Heating	**18%**				
Water Heating and Fixtures	3%				
Cooling	1%				
Building Envelope	**12%**				

Legend

- **Low** = Minimal City action required to achieve goals
- **Medium** = Moderate City action required to achieve goals
- **High** = Significant City action required to achieve goals
- = **Priority City action area**

Source: Bloomberg Associates Analysis, CURB

In the long-term, Oakland must eliminate fossil fuel use in all buildings

In the long-term, the biggest gap between the scenarios exists in eliminating fossil fusels for Space Heating and improving Building Envelopes in existing buildings.

Gap Assessment between 2050 Projected Trajectory and Deep Decarbonization Scenarios

		New Buildings		Existing Buildings	
System	Overall GHG ↓ Potential	Residential	Commercial	Residential	Commercial
Lighting	2%				
Appliances	1%				
Space Heating	**18%**				
Water Heating and Fixtures	3%				
Cooling	1%				
Building Envelope	**12%**				

Legend

- **Low** = Minimal City action required to achieve goals
- **Medium** = Moderate City action required to achieve goals
- **High** = Significant City action required to achieve goals
- = **Priority City action area**

Source: Bloomberg Associates Analysis, CURB

Short-term City actions needed to reduce private vehicle trips

Short-term differences exist in the share of Private Autos and Trucks, and to a lesser extent Bus/BRT, as well as the rate of vehicle electrification for Private Autos and low-capacity taxis.

Mode Type	Today	2030			
	Mode Share	Mode Share		Vehicle Electrification	Fuel Efficiency
		Projected Trajectory	Deep Decarbonization		
Overall GHG Reduction Potential		39.8%		50.6%	n/a
Private Autos and Trucks	69.1%	55.1%	**40%**		
Motorcycle	1.6%	1.6%	1.6%		
Taxi or 1-2 Passenger TNC	1.6%	10%	**3%**		
TNC Pooled Ride	N/A	2%	5%		
Shared Minibus	N/A	3%	9%		
Bus/BRT	11.9%	10%	**15%**		
BART	6.5%	7%	8%		
Amtrak	1%	1%	3%		
Ferryboat	0.1%	0.3%	0.4%		
Biking	3.3%	5%	7.5%		
Walking	4.9%	5%	7.5%		

	2030
Overall GHG ↓ Potential	5.6%
New TOD Households	

Legend

- **Low** = Minimal City action required to achieve goals
- **Medium** = Moderate City action required to achieve goals
- **High** = Significant City action required to achieve goals
- = **Priority City action area**

Source: Bloomberg Associates Analysis, CURB

Long-term City action needed to electrify key vehicle types and shift to low-carbon travel modes

In the long-term, significant gaps will continue to exist in the mode share and electrification of private vehicles. Gaps also exist in the share of passengers taking mass transit and walking.

Mode Type	Today	2050			
	Mode Share	Mode Share		Vehicle Electrification	Fuel Efficiency
	Mode Share	Projected Trajectory	Deep Decarbonization		
Overall GHG Reduction Potential		39.8%		50.6%	n/a
Private Autos and Trucks	69.1%	48%	**20%**		
Motorcycle	1.6%	1.6%	1.6%		
Taxi or 1-2 Passenger TNC	1.6%	5%	3%		
TNC Pooled Ride	N/A	5%	5%		
Shared Minibus	N/A	10%	10%		
Bus/BRT	11.9%	8%	19.9%		
BART	6.5%	8%	**14%**		
Amtrak	1%	2%	3%		
Ferryboat	0.1%	0.4%	1%		
Biking	3.3%	6%	10%		
Walking	4.9%	6%	**12.5%**		

	2030
Overall GHG ↓ Potential	5.6%
New TOD Households	

Legend

- **Low** = Minimal City action required to achieve goals
- **Medium** = Moderate City action required to achieve goals
- **High** = Significant City action required to achieve goals
- = **Priority City action area**

Source: Bloomberg Associates Analysis, CURB

The CURB analysis shows that a few changes are key to reducing Oakland's GHG emissions

While cities must take an "all of the above" approach to climate action to achieve deep reductions, the analysis shows that not all actions are equal. Given the projected changes that will occur to Oakland's building and transportation systems as new technologies are adopted and State and Federal regulations take effect, **there are a few changes that have an outsized impact on the city's GHG emissions**.

1. **Shift to 100% carbon-free energy**
2. **Eliminate fossil fuels from building heating systems**
3. **Improve building insulation and windows**
4. **Significantly shift people away from private auto trips**
5. **Accelerate the electrification of vehicles**

Policy Considerations

To achieve the changes identified in this analysis, Oakland should focus on a few key actions

This analysis identifies the specific actions the City needs to take to change its building and transportation systems to go beyond the Projected Trajectory and achieve its GHG reduction goals.

Near-Term Actions (2018-2030)

- Update codes for new buildings to eliminate gas heating systems by 2030
- Accelerate the electrification of space heating systems and dramatically improve building envelopes in existing buildings

Long-Term Actions (2030-2050)

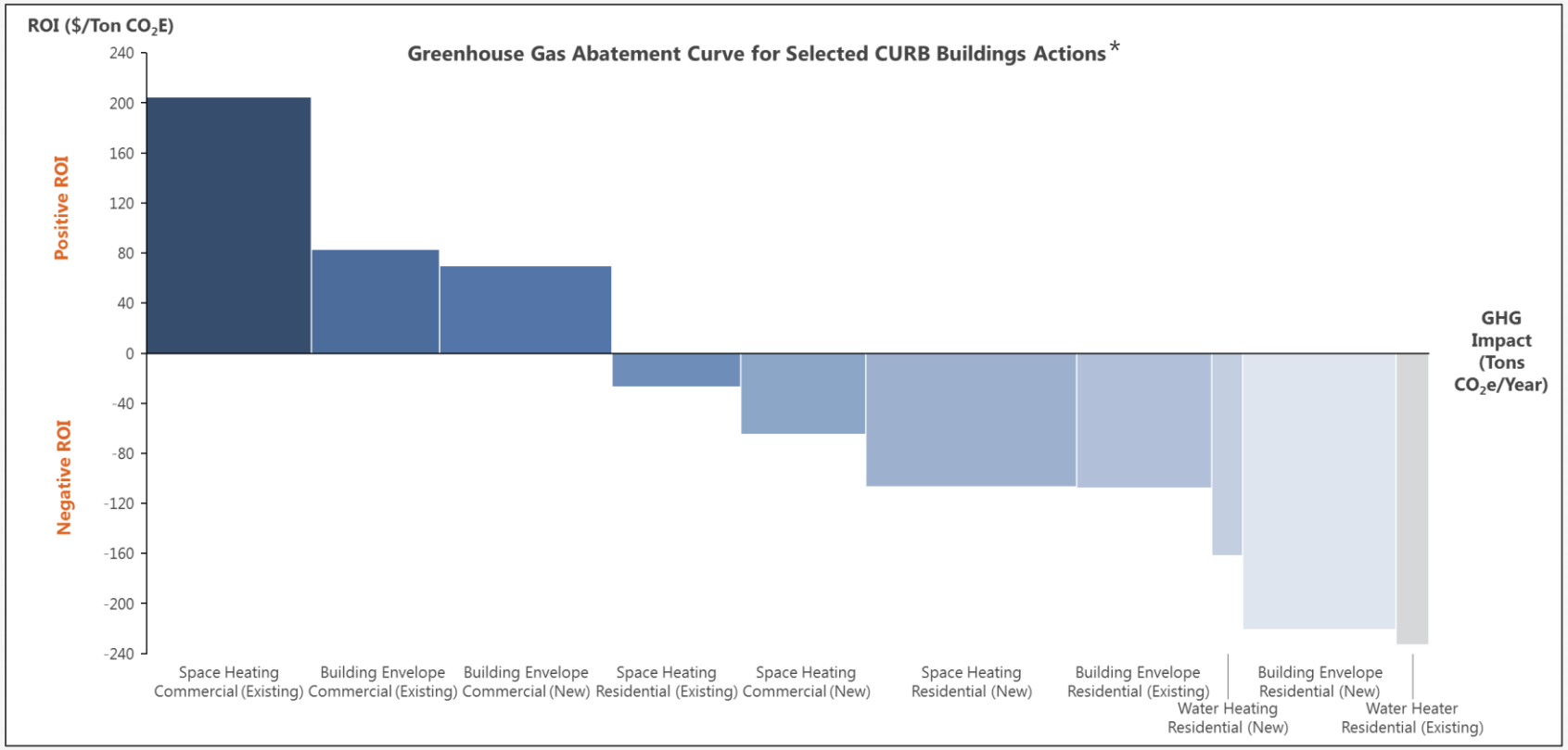
- Eliminate fossil fuel use in all buildings

- Increase mass transit options and coverage
- Continue to build out pedestrian and bike infrastructure
- Accelerate the electrification of private vehicles and low capacity taxi/TNC vehicles

- Continue to support large regional activities to expand transit options
- Prioritize low carbon modes of transportation in infrastructure investments
- Ensure the electrification of shared mobility vehicles

Many of the buildings actions needed to achieve Oakland's goal have a positive ROI; others may require financial incentives or mandates for widespread adoption

Oakland's GHG Abatement Curve outlines the cost effectiveness of each building action relative to its potential impact on GHG emissions; however it does not identify who pays that cost or receives that benefit.



*Collectively, all other buildings actions reduce GHG emissions by 32,000 tons of CO_2e per year (6% of total buildings-related reductions), at a weighted average ROI of $-1,000.

Key Takeaways

- Commercial Buildings actions tend to produce a positive ROI; property owners should be able to take action without additional economic incentives from the City
- Oakland will need to place particular emphasis on the residential building stock – and may need to commit financial resources to incentivize residential retrofits
- Due to limitations of CURB, this analysis is not available for transportation actions

Source: Bloomberg Associates Analysis, CURB

Successful cities use four key types of policies to achieve transformational change and reduce GHG emissions

1 Lead by Example

Small in overall GHG impact, but critical to provide highly-visible examples, demonstrate value and pilot new technologies.

2 Incentivize Action

Spur early action through incentives that catalyze other actors, create examples, and produce more reductions sooner (greater cumulative impact).

3 Require Results

Enact performance-based standards or targets that do not target specific actors or technologies, but focus on impacts.

4 Mandate Action

Takes full advantage of City policymaking, regulatory, and enforcement authorities. Principal burden of implementation is on private actors with City setting policy, enforcing actions, and potentially providing assistance.

The City of Oakland has several efforts planned or underway impacting GHG emissions from the buildings sector

Policy/Program	Status	Description	Impact
BayREN Single Family and Multifamily Renovation Programs	Operational since 2013	Since 2013, both the Single Family and Multifamily programs have provided technical assistance and rebates for energy efficiency retrofits across the 9 county Bay Area region. Region-wide the Single Family program has delivered 5,407 projects and the Multifamily program has delivered 21,306 retrofitted units as of September 2017.	Pilot resulted in energy retrofits of an estimated 1,400 homes in Oakland. Improved efficiency by 23% in single family, 15% in multifamily.
Green Building Ordinance for Private Development	Completed November 2010. Effective January 2011	Ordinance that requires high levels of energy performance in new construction for residential and commercial private development, as well as additions and alterations to existing buildings.	Lowered energy use in new construction by an estimated 10% from State code.
PACE Financing	First provider authorized in 2010; 4 additional providers approved in 2015. Ongoing in market	Offer property-based financing home improvements including but not limited to energy efficiency, water efficiency, solar energy improvements. While property owners enroll in the program voluntarily and this program is not directly administered by the City, the City of Oakland must approve companies to contract in Oakland.	545 PACE-financed retrofits were completed in FY 2016. Lifetime savings from these projects are 17,244 metric tons of CO2 and 45 GWh of electricity use avoided.
Downtown Commercial Retrofit Program	Completed	Enhanced incentives and technical assistance using ARRA funding to help downtown commercial property owners improve energy efficiency. Called the "Oakland Shines" campaign, it emphasized Class B buildings as part of its plan to reach 80% of downtown businesses.	Project generated 191 retrofits of commercial buildings, with 4.5 GWh of electricity use avoided and 67,470 therms of gas avoided.
Weatherization and Energy Retrofit Loan Program	Completed; looking to expand	Retrofit Program serves 20-40 properties per year, offers loans of $6,500 to $30,000 to owner occupied low to moderate income households. Loan funds can be used for variety of energy efficiency projects.	Reduced energy bills by an average of 30%.

The City of Oakland has several efforts planned or underway impacting GHG emissions from the transportation sector

City Policy/Program	Status	Description	Impact
OakDOT Strategic Plan	Released 2017	The Strategic Plan outlines the Departs of Transportation's goals and strategies for improving equity, sustainable infrastructure, mode share, safety, and government responsiveness.	The transportation policies, plans, and programs outlined in this table are all so recent that it is too early to assess their impacts. It is also difficult to assess local impacts without understanding the regional impacts, due to the geographic centrality of Oakland within the transportation flows of the broad Bay Area region. Over time, it will be important to measure the impact through changes to mode share and vehicle miles travelled.
Bicycle & Pedestrian Plans	Pedestrian Plan was accepted June 13th 2017; Bicycle Plan Update in progress (first plan passed in 2007)	The Pedestrian Plan outlines the Department of Transportation's goals to improve walkability and pedestrian safety, repair existing streets to encourage walking, and increase funding for pedestrian improvements. The Bicycle Plan details proposed new bike facilities in Oakland. 48 miles of new bike paths were constructed between 2007 and 2016.	
Complete Streets Policy	Adopted in April 2013	Plan to provide streets that are safe and convenient for all users. Actions include streetscape design, traffic signal upgrades, and bicycle and pedestrian facilities design.	
Expansion of Ford GoBike Bike Share System	System launched and in process of expansion.	Ford GoBike was established in 2016. By the end of 2017, the City of Oakland will have 70 parking stations and 850 bikes.	
Expansion of BRT corridors	Under construction beginning in 2017	Implementing BRT along International Boulevard, which carried 12% of AC Transit patrons in 2011 (more than any other corridor).	
Parking and Mobility Policies and Programs	Part of OakDOT Strategic Plan	Parking subsidies for downtown employees were discontinued in 2010. Special parking permits for designated car share organizations since 2015. Developing demand-based parking programs.	

Actions in other cities offer examples of what Oakland could do to reduce emissions from buildings

Not exhaustive

Lead by Example	• Require all new municipal buildings to meet net-zero energy standards (Vancouver)
Incentivize Leaders	• Launch GHG/energy reduction challenge programs for targeted building types (e.g., hotels, offices) (New York City, Chicago) • Provide grants, loans, or rebates for retrofits in targeted building types (e.g. affordable housing) or systems (Toronto, Denver, Palo Alto) • Exempt buildings from benchmarking or audit requirements for taking specified actions (Boston, New York City)
Require Results	• Enact performance-based energy codes that require set % of GHG reductions from individual buildings (New York City, proposed) • Require targeted buildings to undergo retro-commissioning on a regular basis (New York City) • Conduct periodic compliance studies of energy codes or use a 3rd party compliance review for code enforcement (Pittsburgh) • Require point-of-sale energy audits (Austin)
Mandate Action	• Mandate that building systems be brought up to current code upon any updates to those systems (Berkeley, New York City) • Require new or substantially retrofitted buildings to meet passive house standards (Brussels) • Require public displays of energy performance (New York City) • Require targeted buildings to perform annual benchmarking (27 U.S. cities) • Require targeted buildings to perform regular audits (New York City)

Actions in other cities offer examples of what Oakland could do to reduce emissions from transportation

Not exhaustive

Lead by Example

- Install City-owned EV chargers (Raleigh, NC)
- Electrify public transit vehicles and City-owned vehicles (Los Angeles, New York City, Seattle)
- Support electric car share systems (Paris, Los Angeles)

Incentivize Leaders

- Streamline permitting for electric vehicle charging and service equipment (Chicago, Austin)
- Tax credits for alternative fuel charging (Washington D.C.)
- Engage private fleets to accelerate conversion to low-emission vehicles (Hamburg)
- Zero/low emission vehicle purchase subsidies (Seattle, Riverside)

Require Results

- Require transit expansion to serve dense areas outside of city center (Boston, Johannesburg)
- Preferred treatment for zero/low emission vehicles, including fast lanes, parking discounts, reduced congestion fee (San Jose, Sacramento, Milan)

Mandate Action

- Create low emission zones (London, + 220 other cities)
- Congestion pricing (Oslo, London, Stockholm)
- Vehicle bans in city centers (Oslo, Madrid – planned)

Several cities have enacted programs to accelerate change in the specific building and transportation systems targeted for Oakland

Bloomberg Associates produced case studies of eight programs implemented in other cities that are accelerating change in the buildings and transportation systems targeted for Oakland.

1 Lead by Example

Vancouver
Net Zero Standards for Municipal Buildings

Seattle
Vehicle Electrification

2 Incentivize Action

Melbourne
Building Energy Efficiency Incentives

Chicago
EV Purchase Subsidies

3 Require Results

Brussels
Passive House Standards & Subsidies

Milan
Low Emission Zone and Congestion Charge

4 Mandate Action

Austin
Point-of-Sale Energy Audits

Nottingham
Workplace Parking Levy

Net Zero Standards for Municipal Buildings: Vancouver

Vancouver has required all new City-owned buildings, including housing, offices, and schools, to meet LEED Gold standards since 2004 and will eliminate GHG emissions from all new City-owned buildings starting in 2018.

Program Overview

In 2004, Vancouver passed the **Green Building Strategy that mandated all new City-owned buildings be designed to LEED Gold standards.**

In 2015, the **Renewable Energy Strategy for City-Owned Buildings** expanded Vancouver's ambitions, setting goals to:

- Build all new city-owned buildings will be built to zero emissions standards beginning in 2018
- Reduce GHG by 55% and achieve 70% renewable energy by 2025
- Reach 100% renewable energy and eliminate all GHG emissions across all municipal buildings by 2040

Results

- Municipal buildings have seen a **23% decrease in total annual green house gas emissions** between 2007 – 2016
- Demonstrating the value of city leadership: Vancouver has experienced a **20% decrease in annual GHG emissions for all new buildings** between 2007- 2016, despite less strict standards for non City-owned buildings
    - By 2013, Vancouver surpassed 220 LEED certified projects

Note: Currently, Vancouver's grid is more than 30% renewable, which can supply electricity demand in buildings. Further investments in renewable generation capacity will aim to supply transportation demand and can contribute to building's reduction in remaining fossil fuel use (primarily natural gas).

CITY OF VANCOUVER

Policy Area	Standards for Municipal Buildings
Cost	$100,000 for a new position at the Office of the Chief Building Official to enforce LEED Gold standards
Status	Enacted in 2004
Action Type	Lead by example

Energy Efficiency Incentives: Melbourne

Melbourne's 1200 Building Program incentivizes building upgrades for energy and water efficiency by providing information and access to creative financing options.

Program Overview

Launched in 2010, the 1200 Buildings Program targets certain ownership groups – 'institutional leaders' as well as underperforming buildings – offering these building owners information on and incentives for efficiency upgrades. The program provides:

- **Large-scale renewable electricity procurement** – participation in the program gives businesses the option to purchase renewable energy through the Melbourne Renewable Energy Project, a long-term purchasing contract held by the City of Melbourne that provides 100% renewable energy
- **Help accessing Environmental Upgrade Financing** – a system where building owners can enter an agreement with a private finance institution and the City of Melbourne's Sustainable Melbourne Fund (SMF), for a loan to finance building upgrades. The building owners are able to repay their loan through the SMF with added incentives such as longer lending periods, greater security and lower rates
- **Information on the building retrofitting and solar opportunities** – the organization helps businesses understand the costs, processes and other considerations of installing solar panels and other upgrades to a building

Results

- By 2013, the program helped fund **$4.9 million in retrofits that estimate a savings of 5,350 tons of CO2e emissions a year**
- By 2015, the program had acquired **53 signatures from major commercial companies** including GPT Group, ING, Stockland and Asia Pacific Group, to enter the program
- Now 16 other cities across Australia have adopted programs for Environmental Upgrade Financing

1200 BUILDINGS

Policy Area	Encourage building upgrades for energy and water efficiency
Cost	$380,000 on consultants, staff and marketing and TBD from the Sustainable Melbourne Fund for financing
Status	Launched 2010
Action Type	Incentivize leaders

Passive House Standards and Subsidies for New Buildings: Brussels

Brussels requires all new buildings, including houses, offices, and schools, to meet rigorous energy-efficiency regulations – known as Passive House standards – for heating, cooling, and energy consumption.

Program Overview

Passive House energy legislation was passed in two parts:

- In 2007, Brussels passed **an ordinance to regulate the energy performance of buildings** and encourage the early adoption of Passive House standards. The performance requirements apply to energy consumption, heating and cooling, and building envelope; they vary for new buildings and retrofits
- In 2011, Brussels passed **the Passive House Law requiring all new buildings to comply with ultra-energy efficiency standards**, beginning in 2015

Critically, Brussels also **provided financial incentives for the creation of Passive House buildings.**

- From 2007 to 2014, the Exemplary Buildings (BatEx) program utilized funds from energy providers to award €45 million (~$55 million) in subsidies.
- BatEx funded projects that strived to be zero-emission, prioritized the use of eco-friendly construction materials, were simple and feasible in technical and financial terms, and had reasonable payback timelines.

Results

The combination of stringent regulations and subsidies have resulted in:

- An initial 17% reduction in energy consumption (in comparison with buildings not covered) and a new reduction of 25% in energy consumption after the 2011 law
- 243 BatEx projects, representing 6.7 million square feet of new Passive House buildings
- 3,000 additional Passive House buildings constructed in Brussels (beyond BatEx projects)

brussels environment .brussels

Policy Area	Eliminate fossil fuel use in new buildings
Cost	BatEx distributed €45 million (~$55 million) in subsidies to winning projects
Status	Passed 2011, in effect as of 2015
Action Type	Mandate action, incentivize leaders

Point of Sale Energy Audits: Austin

Austin's Energy Conservation Audit and Disclosure (ECAD) ordinance requires energy audits and disclosures for all homes and buildings within Austin City limits, served by Austin Energy, that meet certain age/size requirements. As part of a real estate transaction, ECAD's energy disclosures uncover energy improvement opportunities. Non-compliance with the ordinance can result in a misdemeanor and fines.

Program Overview

ECAD was approved by Austin City Council in November 2008 and took effect in June 2009. **It requires residential building owners to disclose a home energy audit, conducted by a certified ECAD Energy Professional, prior to sale.** An ECAD energy audit is required for:

- **Residential properties that are 10 years or older** and results must be disclosed to potential buyers
- **Multi-Family buildings that are 10 years or older** and results must be made available to all potential and current residents
- **Commercial buildings that are 10,000 sq. ft. or larger** and energy ratings must be reported to the City by June 1 of each year

EACD auditors evaluate properties and make recommendations for improving the energy-efficiency of windows, attic insulation, air conditioning and heating systems, and the air duct system.

- Austin Energy provides a variety rebates, incentives, and loans for energy-efficiency upgrades.

Results

An estimated 98% of the 3,000 to 4,500 homes that are audited each year receive at least one energy efficiency recommendation:

- 68% need in-home weatherization
- 58% need solar shading
- 68% need HVAC air duct system renovation
- 79% need additional attic insulation

Although ECAD does not require energy improvements, Austin Energy provides a variety of energy efficiency upgrade incentives, which are estimated to save an annual:

- ~8 million kWH of energy (equivalent to powering 650 homes)
- ~5,000 tons of CO2

AUSTIN ENERGY

Policy Area	Time of sale energy audit requirements
Costs	Each audit costs home or building owners an estimated $100 - $200 per unit
Status	Took effect June 2009
Action Type	Mandate action

Vehicle Electrification: Seattle

Drive Clean Seattle is designed to accelerate the city's transition away from fossil fuels. By investing in publically accessible charging stations, it aims to reduce GHG emissions from the City's fleet 50% by 2025 and cut oil used for transportation 50% by 2035.

Program Overview

Mayor Murray announced the Drive Clean Seattle resolution in 2016, which was passed by the City Council in late 2016. **The program invests in publicly accessible charging stations** to create a robust network of charging infrastructure. Seattle plans to **install 400 charging stations over the next 5-7 years.**

In addition to charging stations, the program includes plans to:

- **Electrify the City's fleet** to reduce fleet's GHG emissions by 50% by 2025. Will achieve this through a combination of cleaner fuels, more efficient vehicles, and significant investment in electric vehicles
- **Electrify existing transit options** by converting Seattle's trolley bus, streetcar, and light rail systems to carbon-free electricity. Also supports the expansion of light rail throughout the region and partners with regional transit agencies to identify opportunities to continue to use carbon-free electricity as a transit fuel
- **Review City regulations, policies, and codes** to encourage electric vehicles and private sector investment in cleaner transportation choices

Drive Clean Seattle required a coordinated effort across multiple city departments, including the Office of Sustainability and Environment, the Department of Transportation, Seattle City Light (the City's municipal electric utility), the Department of Construction and Inspections, and the Department of Finance and Administrative Services.

Results

As of May 2017, Seattle had:

- Installed 100 charging stations at 20 publicly locations
- Joined with Los Angeles, San Francisco, and Portland in sending to automakers a request for information — the first step in a formal bidding process —to buy or lease larger and heavy-duty electric vehicles for their fleets with plans to purchase about 850 over the next three years

Policy Area	Vehicle Electrification
Costs	Current budget includes ~$1.7 million for 170 charging stations Total cost of charging stations ~$5 million ($10-$15k per station)
Status	In-progress, launched in 2016
Action Type	Lead by example, incentivize leaders

EV Purchase Subsidies: Chicago

Drive Clean Chicago is a $14 million incentive program operated by the Chicago Department of Transportation (CDOT) with funding from the Federal Congestion Mitigation Air Quality program. It provides vouchers and rebates to fleet owners, leased vehicle operators, manufacturers, vehicle technology vendors, and station developers to accelerate the adoption of alternative fuel vehicles and infrastructure.

Program Overview

Drive Clean Chicago began in 2016. Funds provide:

- **$10 million in vouchers for all-electric and hybrid trucks and busses**; commercial truck owners or leasers can receive up to $30k for the purchase of a new vehicle that operates 75% of the time in Chicago
- **$1.275 million in vouchers for alternative fuel taxis**; taxi fleet owners can receive up to $10k towards conversion or incremental cost of a new vehicle that operates 75% of the time in Chicago
- **$1.425 million in rebates for CNG fueling and DC fast charging stations** located in Chicago; fleet owners/station owners can receive a 30% rebate on capital cost for station development

Results

As of July 2017, CDOT had awarded the full $10 million for trucks and $1.275 million for taxis, as well as $600k for charging stations.

With these funds, Drive Clean Chicago has supported the deployment of more than 400 carbon-free vehicles for area fleets, which has resulted in the country's first privately-run 100% zero emission electric bus fleet for tenants at the Prudential Plaza-Aon building. It has also helped to purchase/build 220 alternative fuel stations. Drive Clean Chicago's successes have led to an estimated:

- Savings of 200,000 barrels of oil
- Reduction of 2,585 metric tons of GHG emissions

Policy Area	Vehicle Electrification
Costs	$14 million
Status	Passed in 2016, applications accepted through 2018
Action Type	Incentivize leaders

Low Emission Zone and Congestion Charges: Milan

The City of Milan has implemented a Low Emission Zone and Congestion Charge that aim to reduce traffic congestion and improve air quality. Vehicles entering the zoned area in the city center are automatically charged a daily fee that funds sustainable mobility projects.

Program Overview

In 2008 Milan implemented a **pollution charge based upon vehicle pollution class**. Vehicles entering an 8.2 km^2 (4.5% of city) area in the center of the city are **charged €0-10 (~$0-12), based upon the emission intensity of the vehicle**.

- The system is operated through 43 electronic gates using automatic number plate recognition technology that identifies the pollution class of the vehicle from vehicle registration data

After a **public referendum received 79% support in 2011, the scheme was expanded to include a congestion charge** beginning in 2012. Vehicles entering into the regulated area are charged €5 (~$6) for daily access.

- Entrance tickets vary for residents, service vehicles, and parking garages and all types of public transit and low emission vehicles are exempt from the charge
- Beginning in 2017, diesel vehicles without particulate filters are banned from entering Area C; the ban is in effect during the day Monday-Friday and does not extend to residents

Results

Total revenue generated in 2012 was €30 million (~$36 million). These funds are invested in sustainable mobility projects, including:

- €3.8 million (~$4.5 million) in park and ride facilities on Metro Line 3
- €3 million (~$3.6 million) in improvements to bike share system
- €10 million (~$12.2 million) investments in public transport fleets

Area C has seen a 34% decrease in traffic congestion, 24% reduction in road casualties, and 49% reduction in circulation of polluting vehicles. Various pollutants have also been reduced:

- 18% reduction in total PM10
- 10% reduction in exhaust PM10
- 42% reduction in Ammonia
- 18% reduction in nitrogen oxide
- 35% reduction in carbon dioxide

Comune di Milano

Policy Area	Reducing private vehicle trips and incentivizing vehicle electrification
Costs	€14 million (~$17 million) annual operating cost
Status	Emission charge since 2008, congestion charge since 2012
Action Type	Require results

Workplace Parking Levy: Nottingham

Nottingham's Workplace Parking Levy (WPL) is a congestion charge that encourages employers to reduce the number of free staff parking spaces. Funds raised from this annual fee go directly towards improving the city's transport infrastructure.

Program Overview

In 2012, Nottingham implemented an annual parking levy, which was charged to all employers who provide 11 or more workplace parking places.

- **WPL charges employers an annual fee of £379 (~$525) per parking space**; the levy affects 42% of Nottingham's parking spaces – a total of 25,000 across the city
- **All revenue generated by the WPL goes directly towards improving the city's public transport infrastructure**
- **WPL is implemented primarily through an online portal, where employers can pay annual fees**. The implementation of the online payment system minimizes costs for the city

Results

The levy raises ~£9 million (~$12.5k) annually, which is used to fund improvements in the city's transport infrastructure, including:

- Purchase of 45 new fully electric buses
- Doubling the size of the city's tram network
- £6.1 million (~$8.5 million) investments in improved cycling routes

In its first 3 years of operation, the workplace parking levy:

- Contributed to a 33% overall decline in carbon emissions (compared to 2005 levels) of which 13% is estimated to be as a result of modal shift to public transport, biking, and walking
- Initial academic research has shown the policy has a statistically significant impact on traffic congestion, with an associated 40% rise in public transport use

Policy Area	Mode shift away from private vehicles
Costs	~£500,000 (~$700,000) annually (<5% of what WPL generates each year)
Status	On-going, began in 2012
Action Type	Mandate action

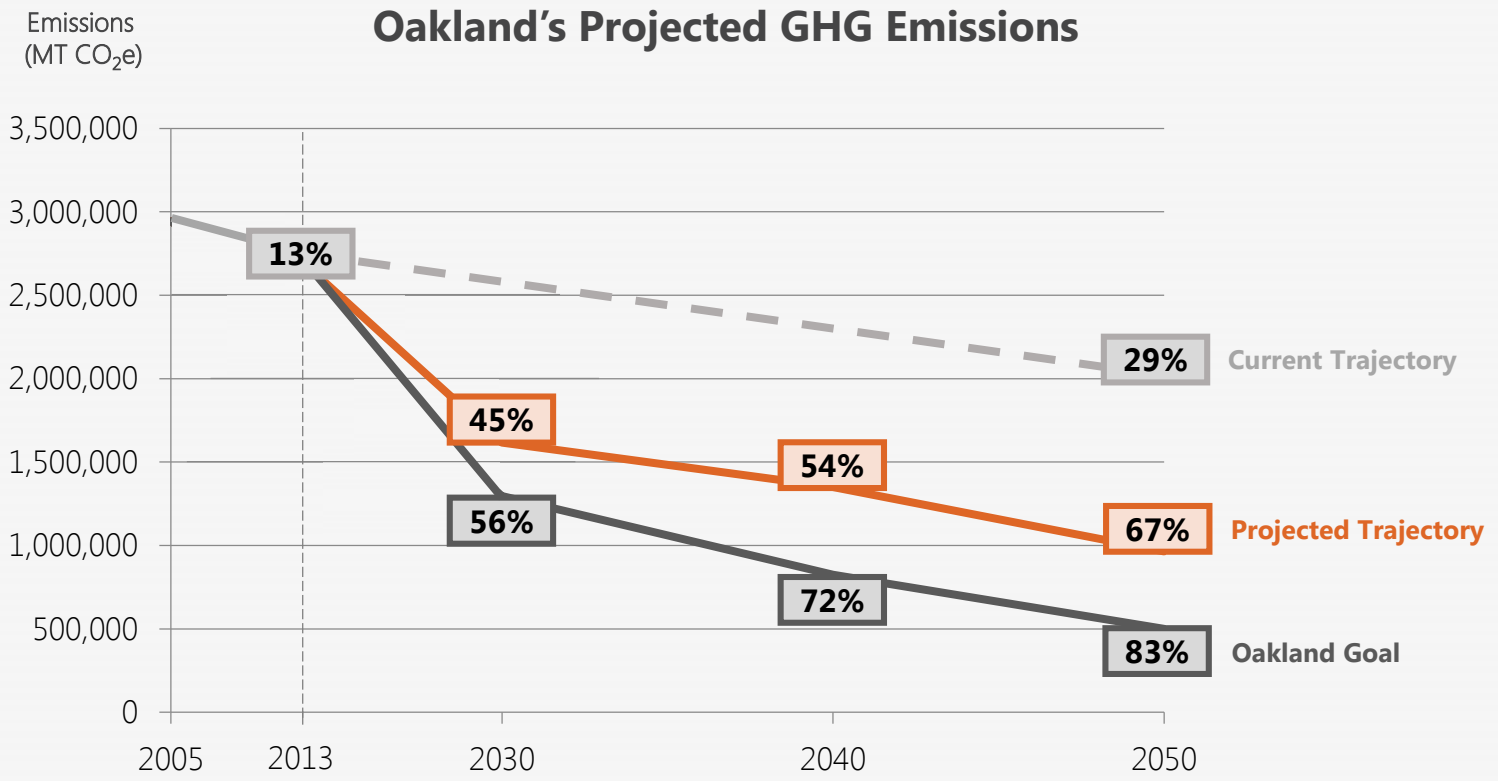
Conclusion

Without additional City action, Oakland will not meet its 2050 GHG reduction goal

In 2013, Oakland's GHG emissions decreased 13% from its 2005 baseline. **If Oakland continues on its Current Trajectory, it will only achieve a 29% decrease in emissions by 2050,** accounting for population and economic growth – far short of its adopted target.

Even accounting for expected changes, including market trends and technological advances, State and Federal policies, and adopted and funded City policies (Projected Trajectory) **Oakland will not achieve its 2050 goal**.

Meeting the 2050 goal is technically feasible, but will require significant City leadership, investment, and policy changes in both the near-term and long-term.



Source: Bloomberg Associates Analysis, CURB

To meet its 2050 GHG goal, Oakland must take targeted near- and long-term actions to achieve five key changes to its buildings and transportation systems

Five changes need to be achieved to meet Oakland's GHG reduction goal:

1. Shift to 100% carbon-free energy
2. Eliminate fossil fuels from building heating systems
3. Improve building insulation and windows
4. Significantly shift people away from private auto trips
5. Accelerate the electrification of vehicles

City action is needed to achieve these changes:

Near-Term Actions (2018-2030)

- Update codes for new buildings to eliminate gas heating systems by 2030
- Accelerate the electrification of space heating systems and dramatically improve building envelopes in existing buildings
- Increase mass transit options and coverage
- Continue to build out pedestrian and bike infrastructure.
- Accelerate the electrification of private vehicles and low capacity taxi/TNC vehicles

Long-Term Actions (2030-2050)

- Eliminate fossil fuel use in all buildings
- Continue to support large investments in transit
- Prioritize low carbon modes of transportation in infrastructure investments
- Ensure the electrification of shared mobility vehicles

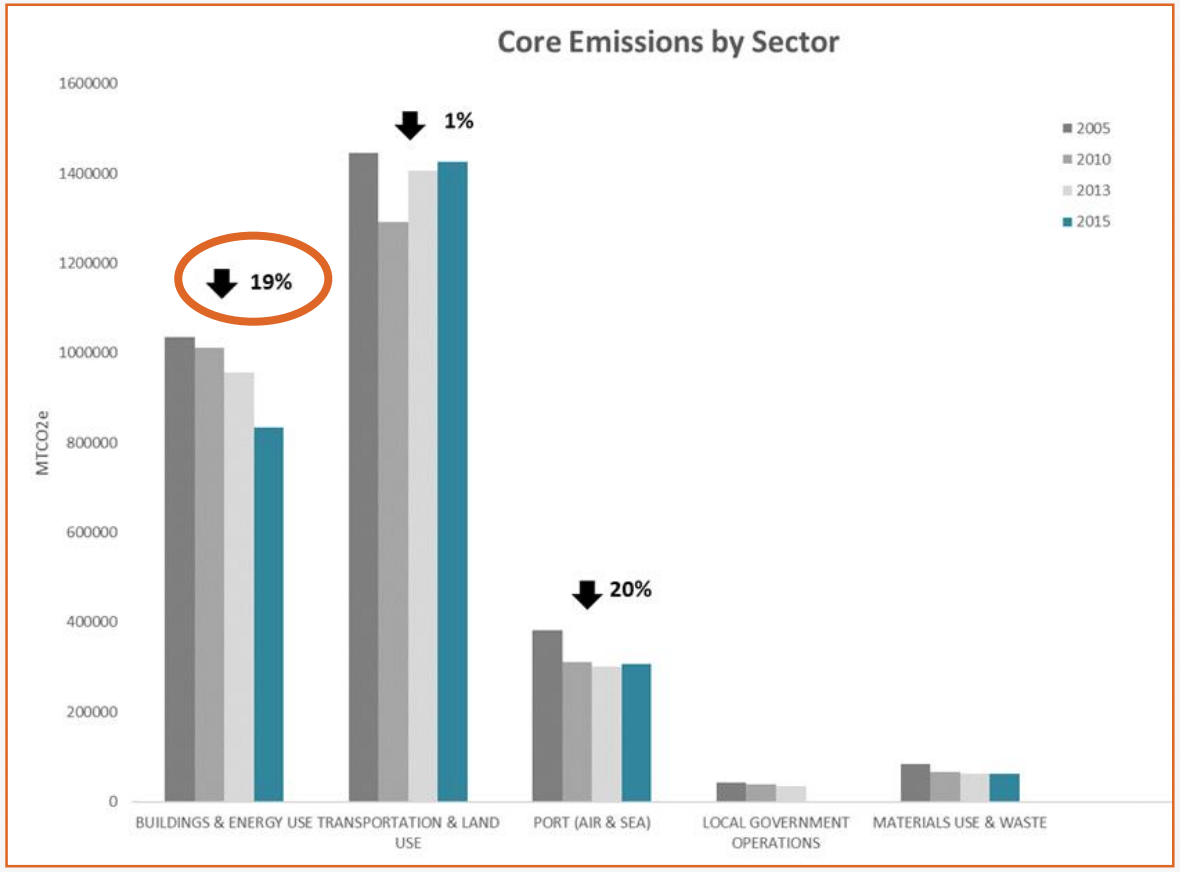
The actions need to aggressively reduce Oakland's GHG emissions can be implemented through a range of City policies and investments

Serve as the basis for the update of Oakland's Energy and Climate Action Plan (ECAP)	• The action areas identified in this analysis should serve as the focus for policy priorities in the next ECAP, to be released in 2020 • The technical and financial components of this analysis can help justify Oakland's sustainability priorities to Council and the public
Incorporate top CURB actions into the Capital Improvement Program (CIP) prioritization framework	• The changes and actions identified by this analysis provide a clear set of criteria that should be included as one factor in evaluating potential projects for City investments • Investments that advance one of the priority changes (e.g., shift people from private auto trips) should be given additional credit during project prioritization
Incorporate top CURB actions into other funding processes	• The City should leverage other funding sources (e.g., seismic retrofits, affordable housing) that impact Oakland's buildings and transportation systems to address priority actions where appropriate (e.g., including window upgrades as part of seismic retrofits, ensuring high efficiency heating systems in affordable housing)
Use priorities as key inputs into department-level plans and policies	• Department plans, such as neighborhood-specific plans, should incorporate policies that align with the changes identified by this analysis (e.g., shifting people away from private auto trips) • Scan citywide codes and policies to identify opportunities to achieve the priority changes (e.g., update the City's Green Building Ordinance with a focus on space heating)

Appendix A – Buildings Technical Materials

Building emissions have fallen significantly from the 2005 baseline

While CURB uses a 2013 baseline and the analysis used that dataset, it is important to acknowledge progress that Oakland has made in more recent years. Oakland's most recent data shows that 2015 emissions from building and energy use were 19% lower than the 2005 baseline.



This progress has been primarily driven by a gradual cleaning of Oakland's electricity mix.

Source: Oakland 2015 GHG Inventory

Achieving further reductions will require Oakland to change the specific systems within buildings

CURB provides 28 different options for modeling actions within Oakland's buildings.

CURB categorizes buildings in two ways…

1. **Type**:
   Existing or New

2. **Use**:
   Residential or Commercial

… and models the impact that **seven building systems** have on building-related GHG emissions:

- Lighting
- Appliances
- Space Heating
- Cooling
- Water Heating
- Water Fixtures
- Building Envelope

Methodology

Bloomberg Associates utilized a four-step process to identify where City action is needed to achieve Oakland's GHG goal, based on two scenarios for 2030 and 2050:

- **Projected Trajectory** projects the expected impacts of market forces together with State and Federal policies
- **Deep Decarbonization** projects where the City needs to be to achieve its GHG reduction goals

1 Baseline Conditions

Gather baseline data on current building systems and input into CURB tool

	CURB Options	Baseline
Building Type		Sq Meters
	Retail	2,277,137
	Office	3,398,594
	Hospitals	563,656
	Education	174,876
	Hotels	501,239
	Warehouse	1,751,152

2 Projected Trajectory and Deep Decarbonization

Develop 2030 and 2050 Projected Trajectory and Deep Decarbonization Scenarios, based upon information gathered during interviews, workshops, and discussion with City of Oakland staff

	CURB Options	Today	2030	
			Projected Trajectory	Deep Decarbonize
New Residential	Mid-Range Efficiency	25%	25%	0%
	High-Range Efficiency	75%	75%	100%
Existing Residential	Standard	25%	25%	0%
	Mid-Range Efficiency	61%	61%	15%
	High-Range Efficiency	14%	14%	85%
New Commercial	Mid-Range Efficiency	25%	25%	0%
	High-Range Efficiency	75%	75%	100%
Existing Commercial	Standard	55%	50%	0%
	Mid-Range Efficiency	45%	45%	55%
	High-Range Efficiency	-	5%	45%

3 Gap Analysis

Identify gaps between Projected Trajectory and Deep Decarbonization to identify areas where additional City actions are needed to achieve the City's long-term goal

New Buildings			
Residential		Commercial	
2030	2050	2030	2050
City action required to shift remaining 25% of new buildings to high efficiency appliances	No additional City action required between 2030 and 2050 if 2030 target is reached.	City action required to shift remaining 25% of new buildings to high efficiency appliances	No additional City action required between 2030 and 2050 if 2030 target is reached.

4 Priority City Actions

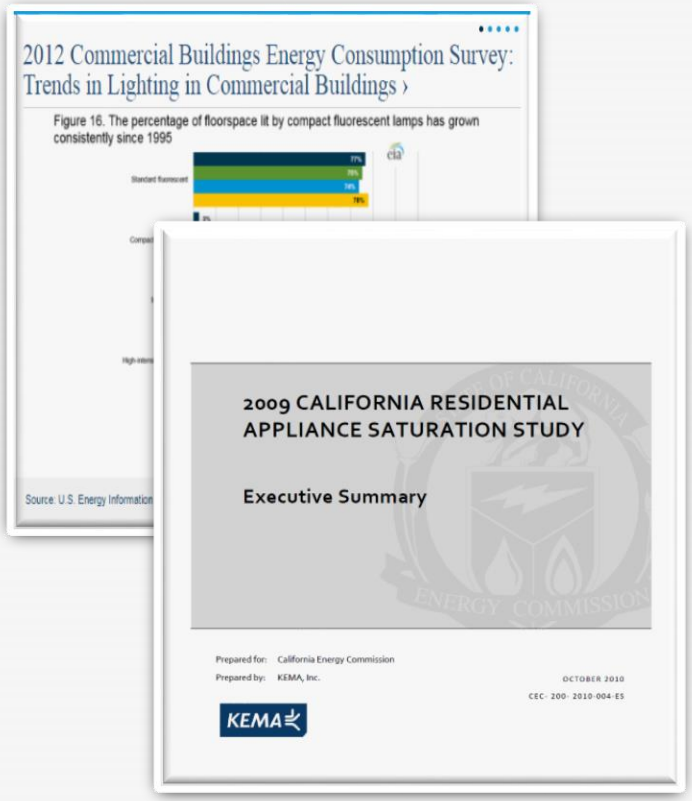
Overlay gap analysis with potential GHG reduction impact to identify priority action areas

		New Buildings		Existing Buildings	
System	GHG ↓ Potential	Residential	Commercial	Residential	Commercial
		2030	2030	2030	2030
Lighting	2%				
Appliances	1%				
Space Heating	18%				
Water	3%				
Cooling	1%				
Building Envelope	12%				

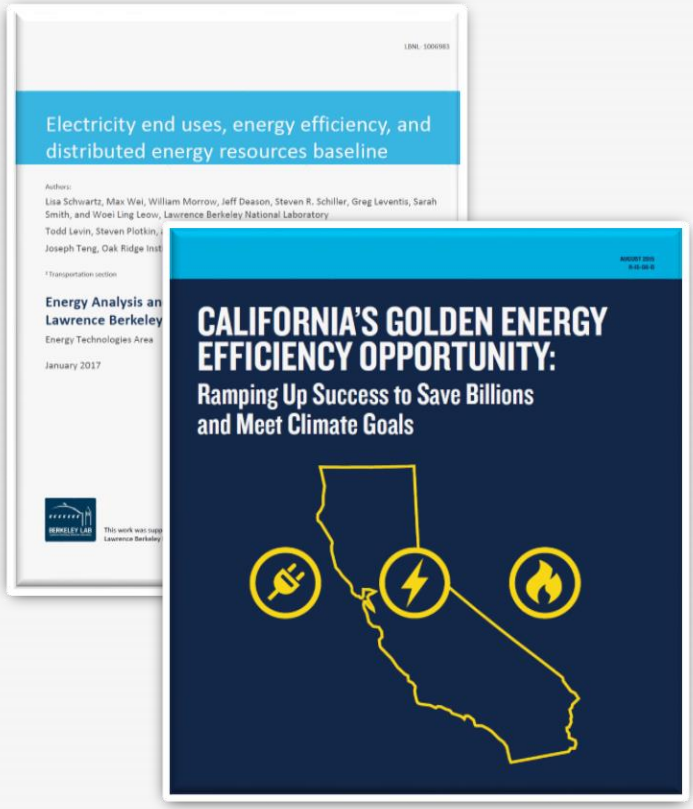
Bloomberg Associates reviewed key documents

Bloomberg Associates reviewed key documents, reports, and white papers to understand the condition of Oakland's building stock and opportunities to reduce emissions from buildings sector.

End Use Surveys



CA-Focused Technical Studies

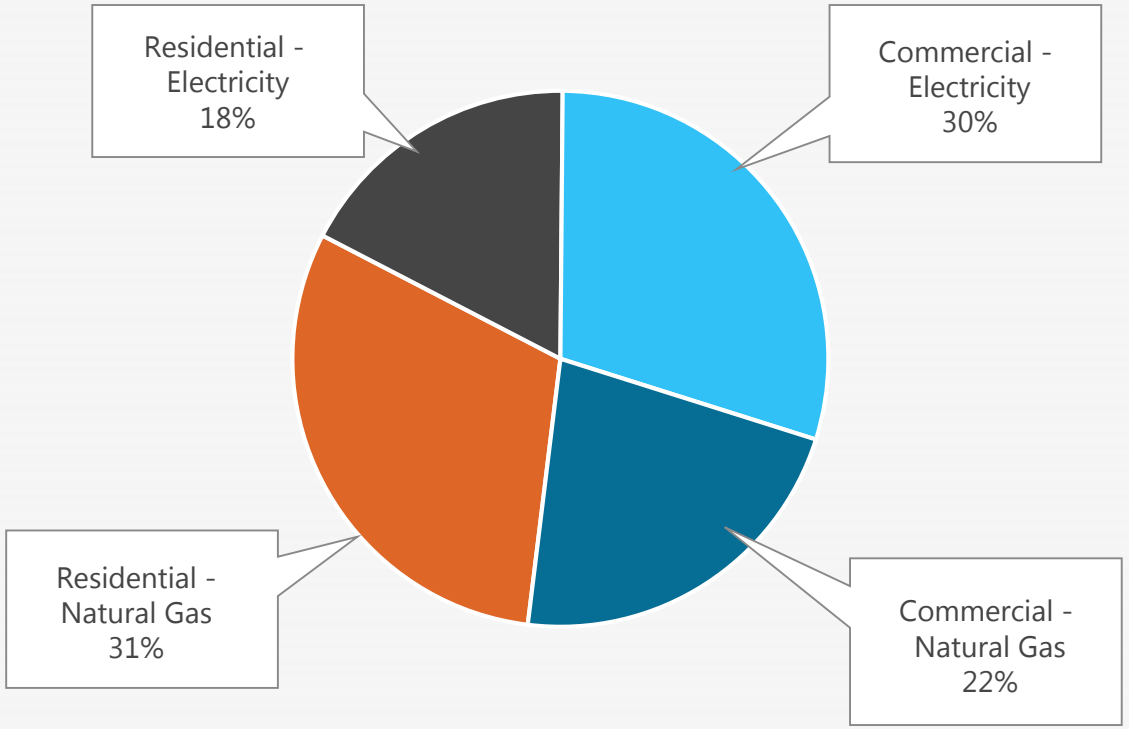


National Best Practices

Publically available data provides a broad overview of Oakland's current building stock…

Oakland's current building emissions are evenly divided across four sources.

MT CO_2e Attributable to Oakland's Buildings



Estimated Footprint of Oakland's Buildings

Building Type	Square Meters
Retail	2,277,137
Office	3,398,594
Hospitals	563,656
Education	174,876
Hotels	501,239
Warehouse	1,751,152
Total Commercial	**8,666,654**
Low Income Res	2,525,842
Low-Med Res	2,545,119
Med-High Res	4,709,659
High Income Res	3,258,703
Residential Total*	**13,039,422**
Grand Total	**21,706,076**

*Residential sq. m based on CURB extrapolation from number of housing units

Source: City of Oakland

… but must be supplemented by a number of assumptions in CURB

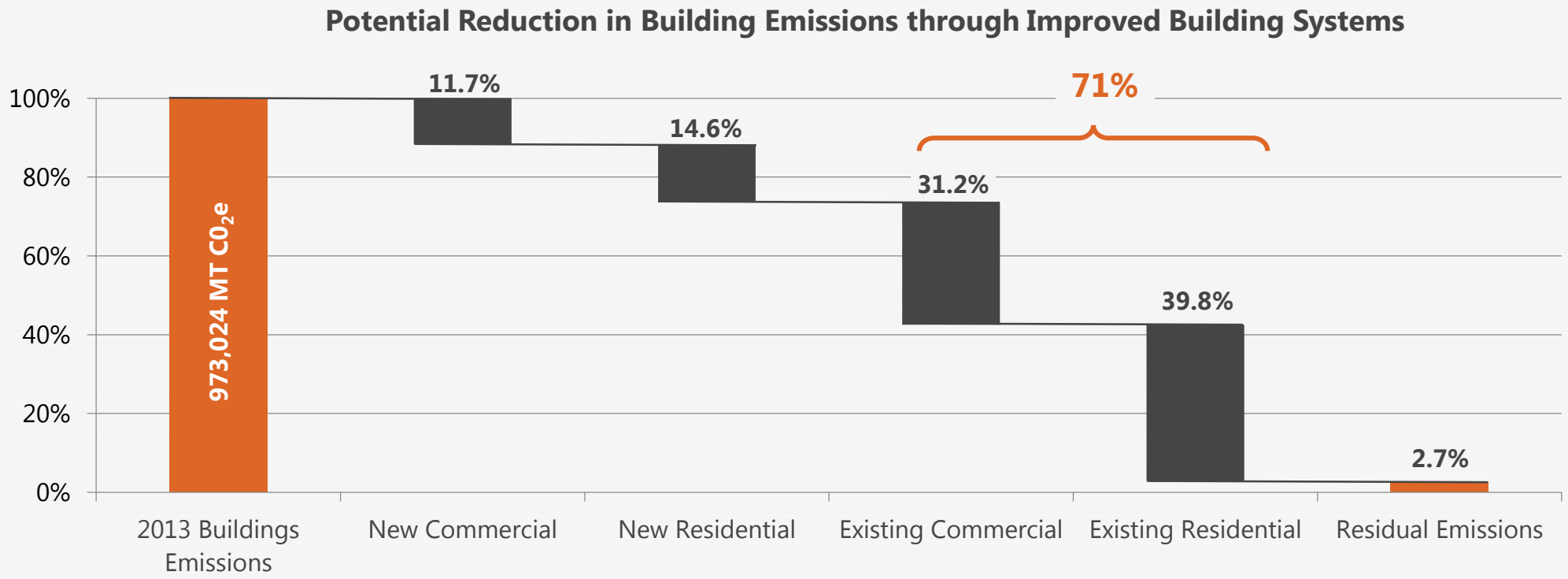
Expert interviews, literature review, and in-person workshops helped refine core assumptions related to Oakland's baseline conditions.

Key Baseline Assumptions Include:

- Population Growth Rates (1.09% per year)
- Increase in Housing Units (0.9% per year)
- Increase in Commercial Sq. Footage (1.2% per year)
- Building Redevelopment Rates (1% per year)
- Proportion of Housing by Housing Type (53% apartment / 47% house)

Based on these baseline conditions, CURB estimates 71% of buildings emissions can be reduced by focusing on the existing building stock

CURB uses these baseline inputs and assumptions to develop a preliminary analysis of where potential emissions reductions could come from. This information can be used to quickly identify which actions are likely to have the greatest impact.



Source: Bloomberg Associates Analysis, CURB

The analysis developed two scenarios for 2030 and 2050 to compare against Oakland's GHG reduction goals

The next step of the analysis develops and compares scenarios for 2030 and 2050 alongside Oakland's GHG reduction goals, to better understand the potential pathways to GHG reductions.

Projected Trajectory Scenario

Estimates for the Projected Trajectory of Oakland's emissions assumed:

- **Projected technological advances & market adoption/penetration** (e.g., market adoption of electric heat pumps)
- **Stated State & Federal policies** (e.g., California Title 24 Building Code updates)
- **Existing City policies and funded programs** (e.g., Community Choice Energy program; NOT unfunded building retrofit plan)
- **Limited City actions responding to market trends** (e.g., revised building codes to legalize new technologies; NOT future programs incentivizing adoption of new building technology)

The Projected Trajectory was then compared with Oakland's goals. Those insights to ground the work with local and national experts to figure out what else needed to happen.

Deep Decarbonization Scenario

Collaboration with local and national experts helped to identify the rate of change required in each building system included in CURB to achieve Oakland's GHG goals and put the City on the pathway to Deep Decarbonization.

Key assumptions for Projected Trajectory scenario

Projecting ahead to 2030 and 2050 inherently involves making assumptions about what the world will look like, based upon the best information available to us today. Below are the key assumptions underlying the buildings Projected Trajectory analysis:

Electricity Mix

- Oakland's electricity grid will be served by 100% renewable energy by 2030

Energy Efficiency Mandates

- California's energy efficiency laws will continue to drive significant improvements in building efficiency, particularly for new buildings
- These mandates should lead to near-zero net energy for all new construction by 2020 for residential buildings and 2030 for commercial properties

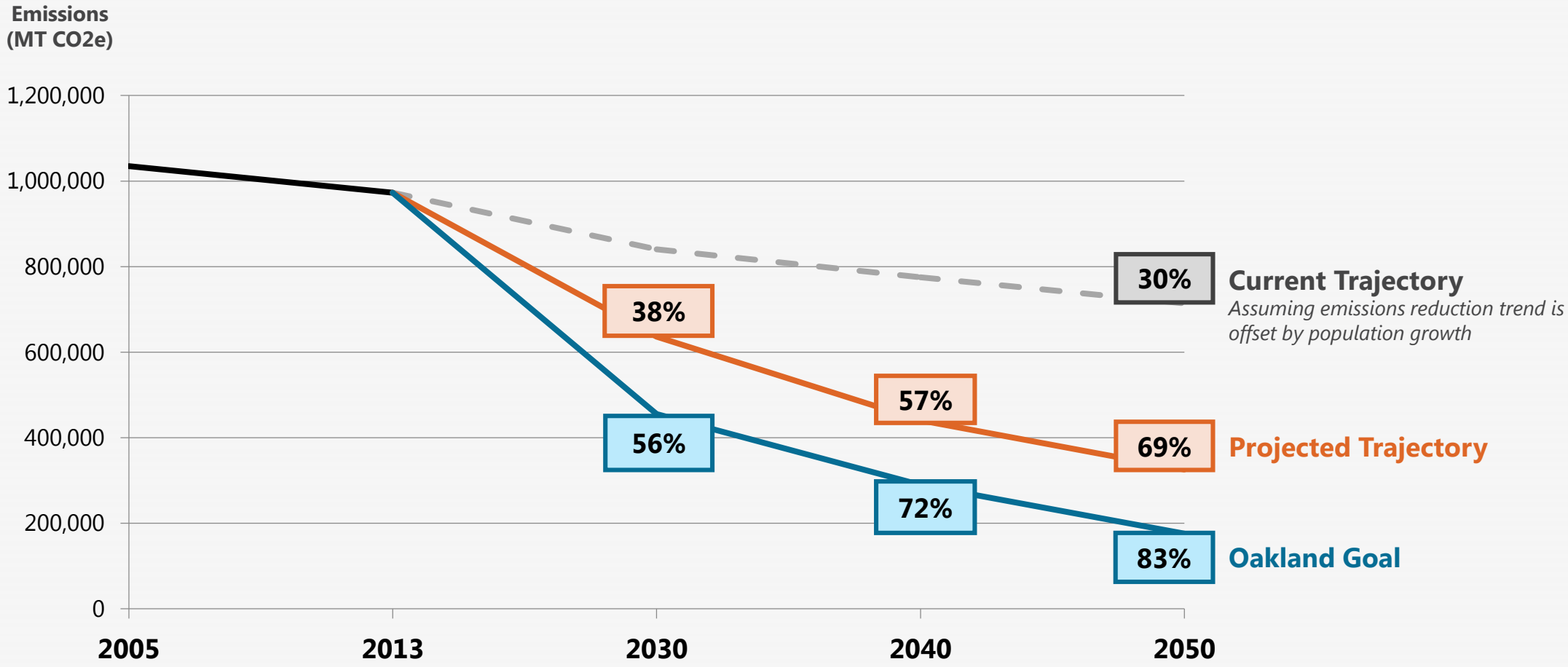
Current Renovation Programs

- Oakland's current renovation program is reaching 1-2% of multi family properties per year. At best that gets to 66% of multi family properties by 2050
- The statewide target for retrofitting 50% of existing commercial buildings by 2030 will also drive adoption of energy efficient technologies in existing commercial buildings

Oakland will not achieve its GHG reduction goals on the Projected Trajectory

While the Projected Trajectory produces significant reductions from the 2005 baseline, it does not enable the City to meet its reduction targets for the building sector. Oakland needs to take additional actions to close a 18 percentage point gap in 2030 and a 14 percentage point gap in 2050.

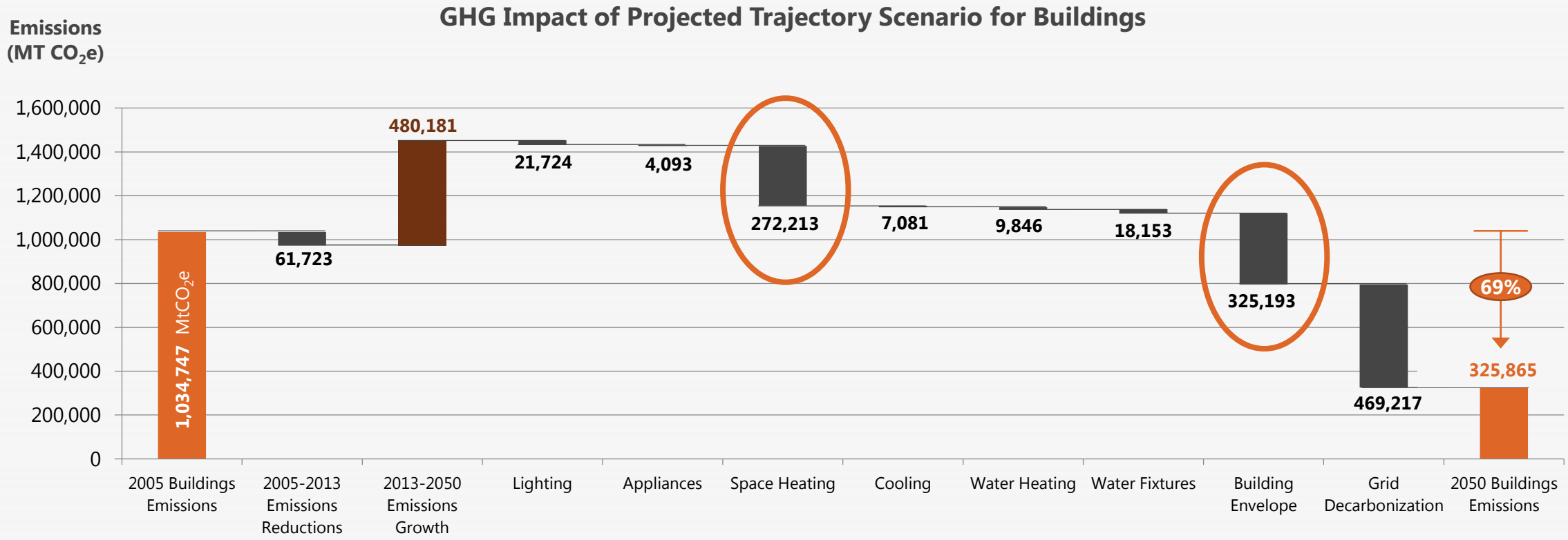
Oakland's Projected Building-Related Emissions



Source: Bloomberg Associates Analysis, CURB

Building-related GHG emissions on the Projected Trajectory (2050)

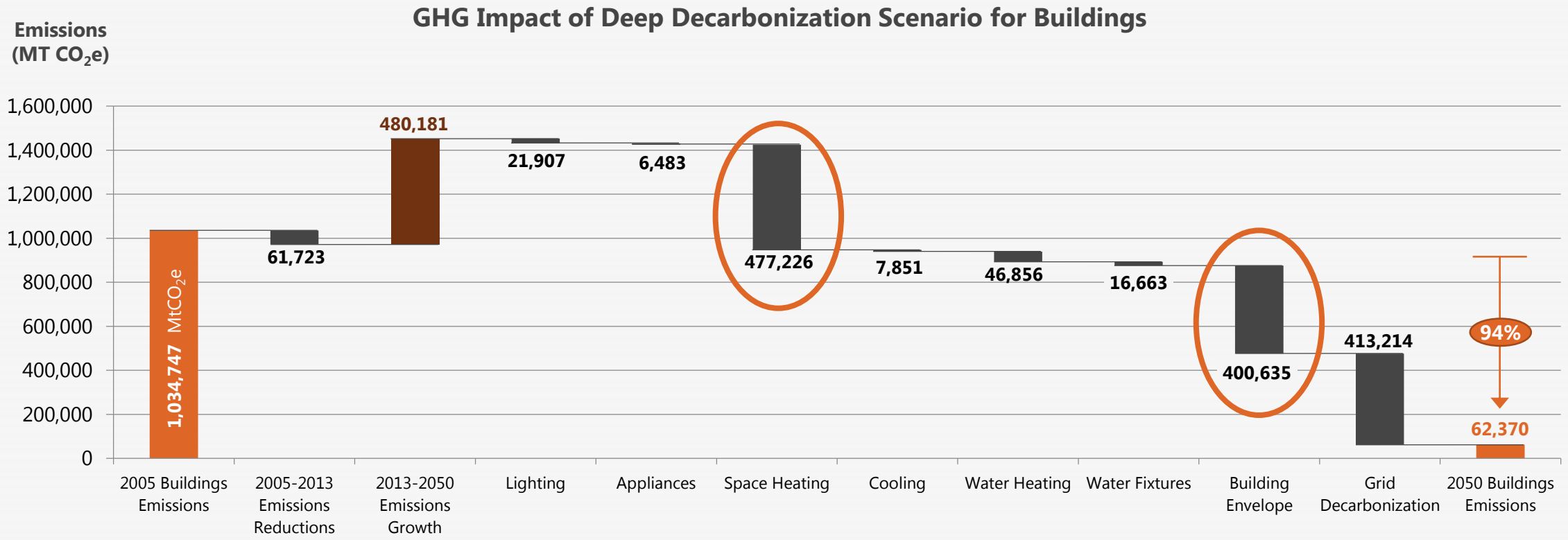
The Projected Trajectory scenario produces an 69% reduction in buildings-related emissions by 2050. 41% of this reduction is attributable to the shift to a 100% renewable energy electric grid. Other major factors include anticipated improvements in Space Heating and Building Envelopes.



Source: Bloomberg Associates Analysis, CURB

Building-related GHG emissions in the Deep Decarbonization scenario (2050)

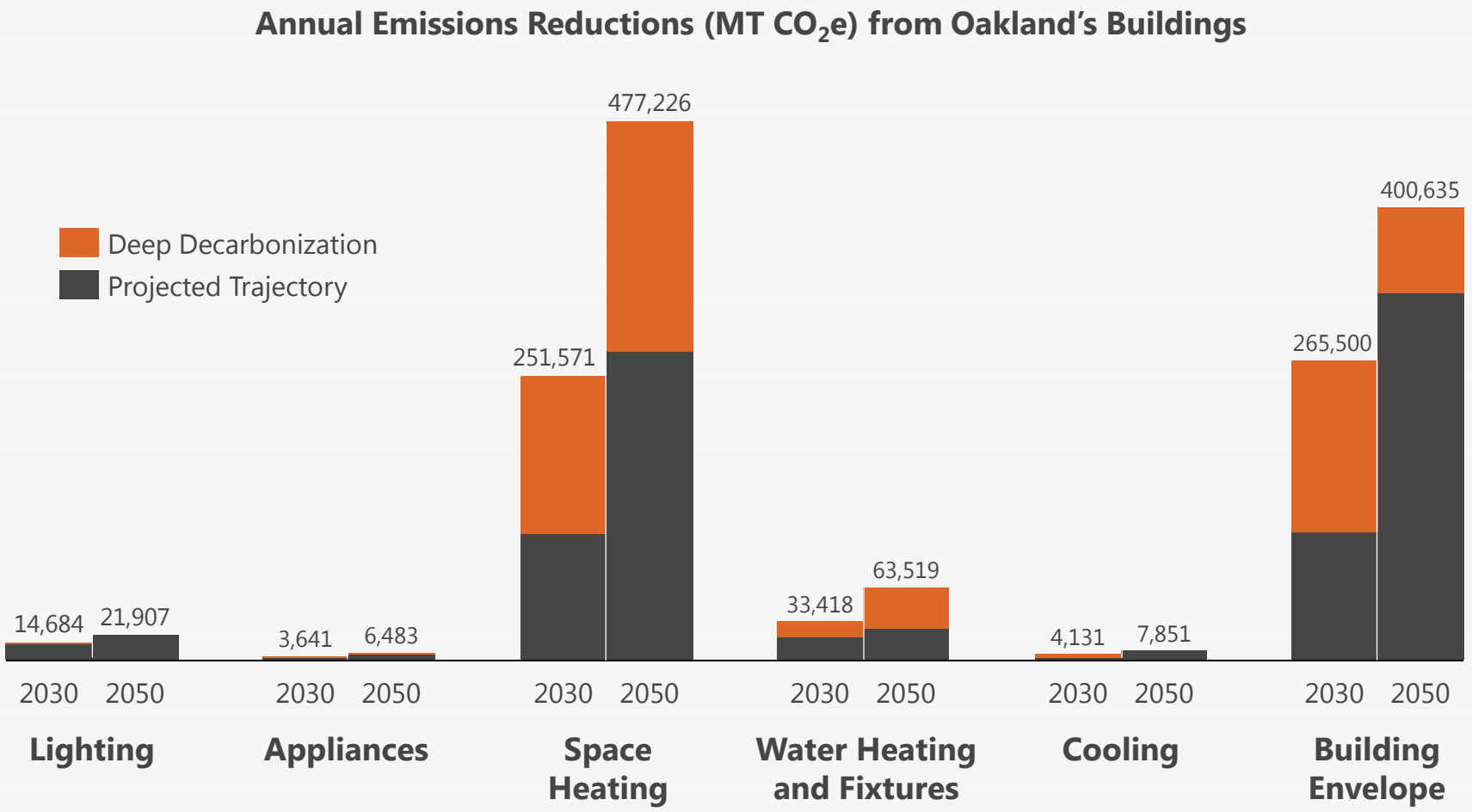
The Deep Decarbonization scenario produces a 94% reduction in buildings emissions by 2050. Reductions beyond the Projected Trajectory come primarily from more aggressive actions in Space Heating and the Building Envelope.



Source: Bloomberg Associates Analysis, CURB

Significant differences are apparent between emissions in the Projected Trajectory and Deep Decarbonization scenarios

City action is needed to produce 55% of the required buildings-related reductions by 2030, but only 33% by 2050. Particular focus is needed on Space Heating systems and the Building Envelope, which account for 90% of buildings-related emissions reductions in 2050.



Source: Bloomberg Associates Analysis, CURB

Gap analysis methodology

Windows example

Bloomberg Associates identified gaps between the Projected Trajectory (PT) and Deep Decarbonization (DD) scenarios to identify where City action is needed to achieve goals.

	CURB Options	Today	2030			2050		
			PT	DD	Delta	PT	DD	Delta
New Residential	Single Paned		0%	0%	0%	0%	0%	0%
	Double-Glazed		0%	0%	0%	0%	0%	0%
	Double G Low-E		98%	98%	0%	95%	95%	0%
	Triple-Glazed		2%	2%	0%	5%	5%	0%
Existing Residential	Single Paned	86%	46%	30%	-16%	12%	0%	-12%
	Double-Glazed	14%	40%	0%	-40%	40%	0%	-40%
	Low-E	-	10%	70%	60%	43%	95%	52%
	Triple-Glazed		4%	0%	-4%	5%	5%	0%
New Commercial	Single Paned		5%	0%	-5%	3%	0%	-3%
	Double-Glazed		0%	0%	0%	0%	0%	0%
	Double G Low-E		95%	100%	5%	97%	100%	3%
	Triple-Glazed		0%	0%	0%	0%	0%	0%
Existing Commercial	Single Paned	84%	64%	34%	-30%	28%	0%	-28%
	Double-Glazed	16%	27%	0%	-27%	34%	0%	-34%
	Low-E		9%	66%	57%	38%	100%	62%
	Triple-Glazed		0%	0%	0%	0%	0%	0%

Delta = Deep Decarbonization – Projected Trajectory

Gaps were color-coded to highlight areas where significant gaps exist:

- **Low** — **Minimal City action required** to achieve goals
- **Medium** — **Moderate City action required** to achieve goals
- **High** — **Significant City action required** to achieve goals

New Buildings				Existing Buildings			
Residential		Commercial		Residential		Commercial	
2030	2050	2030	2050	2030	2050	2030	2050
No city action required	No city action required	City action required to shift 5% of new buildings to Low-E window technology	No city action required	Significant City action required to improve insulation in 30% of homes in need of Low-E window technology	City action required to improve insulation in the remaining 12% of homes in need of Low-E window technology	City action needed to improve insulation in 39% of properties needing to adopt Low-E window technology	City action needed to improve window technologies in 34% of properties

Filtering actions by overall GHG reduction potential enables the City to target its efforts for maximum impact

To reduce building emissions, significant City action is needed to electrify Heating Systems and improve Insulation and Windows in existing buildings.

Extent to which City Action is Required to Achieve Deep Decarbonization

Building System	Overall GHG Reduction Potential	New Buildings				Existing Buildings			
		Residential		Commercial		Residential		Commercial	
		2030	2050	2030	2050	2030	2050	2030	2050
Lighting	2%								
Appliances	1%								
Space Heating	**18%**								
Water Heating & Fixtures	3%								
Cooling	1%								
Building Envelope	**12%**								

Legend

- **Low** — **Minimal City action required** to achieve goals
- **Medium** — **Moderate City action required** to achieve goals
- **High** — **Significant City action required** to achieve goals
- **Priority City action area**

Source: Bloomberg Associates Analysis, CURB

Short-term City actions should focus on space heating and building envelope

		New Buildings		Existing Buildings	
System	Overall GHG ↓ Potential	Residential 2030	Commercial 2030	Residential 2030	Commercial 2030
Lighting	2%				
Appliances	1%				
Space Heating	**18%**				
Water Heating & Fixtures	3%				
Cooling	1%				
Building Envelope	**12%**				

New Buildings City Focus Areas

- City action needed to **increase adoption of electric space heating systems**
- Because new buildings are likely to see slower turnover in their buildings systems, adopting **more ambitious actions in the next ten years can have a disproportionate impact** on emissions by 2050

Existing Buildings City Focus Areas

- While nearly all building systems in most existing buildings require updates, short-term City action should **prioritize retrofits in space heating systems** while also **dramatically improving the building envelope**
- Heating and cooling have a much longer turnover period than other systems (up to 30 years). Prioritizing these in the short term can avoid having to retrofit the same systems before their useful life is up

Legend

- **Low** = Minimal City action needed to reach goal
- **Medium** = Moderate City action needed to reach goal
- **High** = Significant City action needed to reach goal
- = Priority City action area

Source: Bloomberg Associates Analysis, CURB

In the long-term, Oakland must eliminate fossil fuel use in all buildings

		New Buildings		Existing Buildings	
System	Overall GHG ↓ Potential	Residential	Commercial	Residential	Commercial
		2050	2050	2050	2050
Lighting	2%				
Appliances	1%				
Space Heating	**18%**				
Water Heating & Fixtures	3%				
Cooling	1%				
Building Envelope	**12%**				

Existing Buildings City Focus Areas

- Continued progress must be made to **retrofit space heating systems** in existing buildings, while **dramatically improving the building envelope**
- **Relative impact of existing buildings will shrink** over time as buildings are torn down and rebuilt; however, existing buildings represent 71% of the cumulative GHG reductions

New Buildings City Focus Areas

- Most actions for new buildings should be prioritized in the short-term
- Continued updates to building codes to account for further technological developments will be important, but are not modeled in CURB

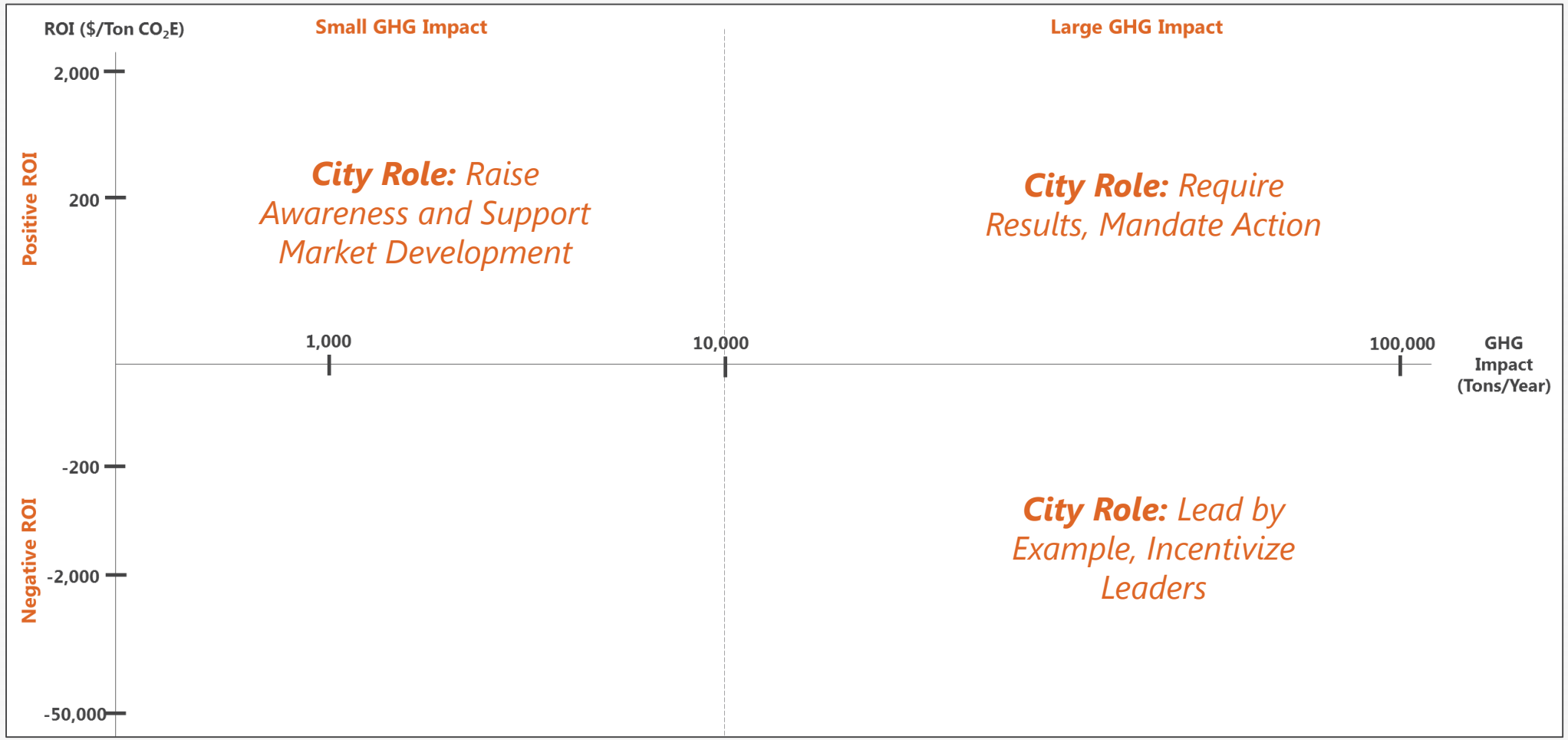
Legend

- **Low** = Minimal City action needed to reach goal
- **Medium** = Moderate City action needed to reach goal
- **High** = Significant City action needed to reach goal
- = Priority City action area

Source: Bloomberg Associates Analysis, CURB

CURB's financial analysis function compares the implementation cost, net present value, and GHG impact of each potential action

Comparing return on investment with GHG impact can help Oakland determine the types of policies it should focus on for a given action.

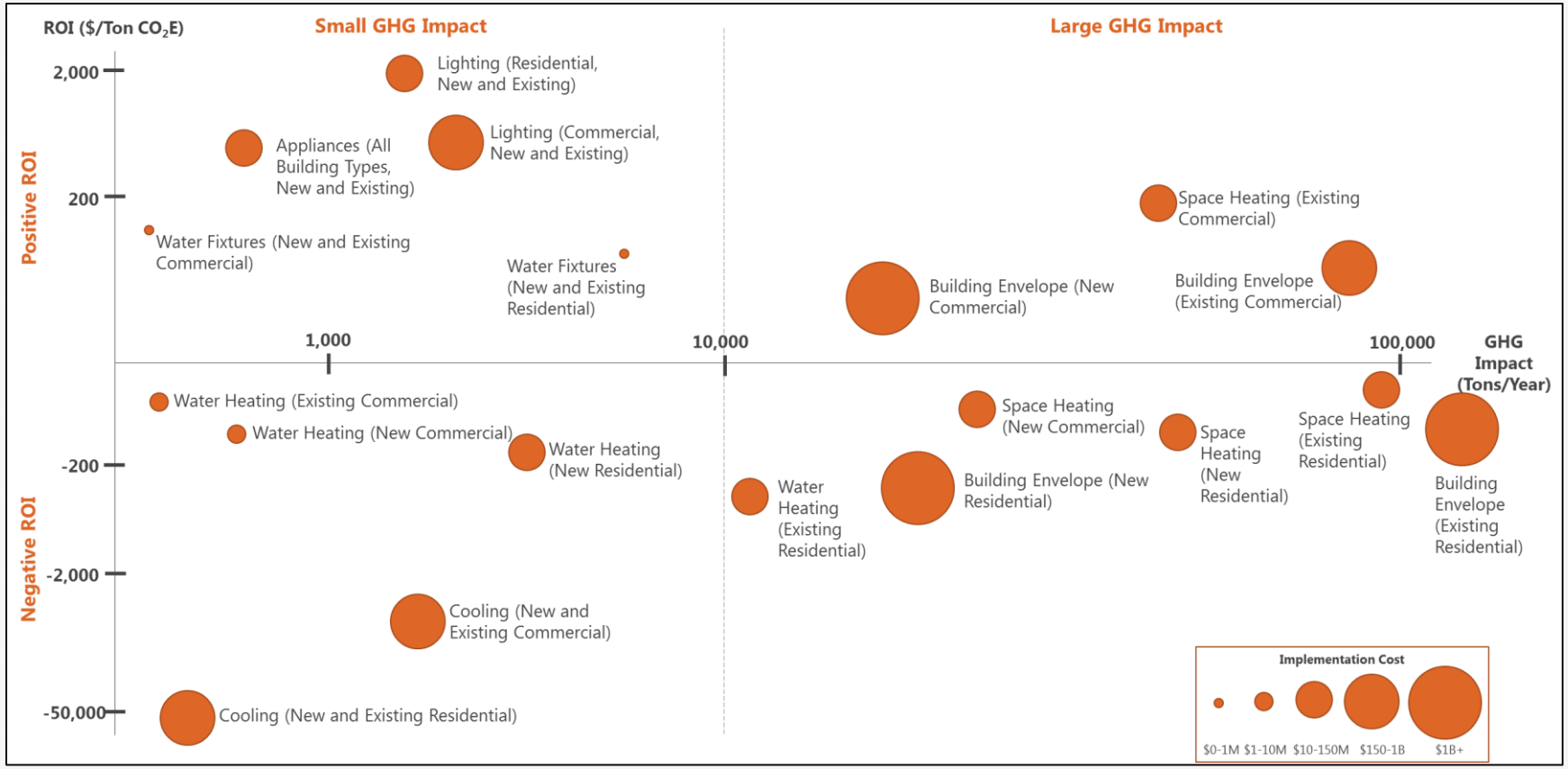


Source: Bloomberg Associates Analysis, CURB

2050 Deep Decarbonization: Cost per ton CO_2e

Within buildings, Building Envelopes, Space Heating, and Residential Water Heating account for 94% of potential reductions for buildings-related emissions. In these categories, Commercial Buildings generally offer a positive ROI.

Return on Investment and Annual GHG Impact of CURB Buildings Actions in Deep Decarbonization Scenario



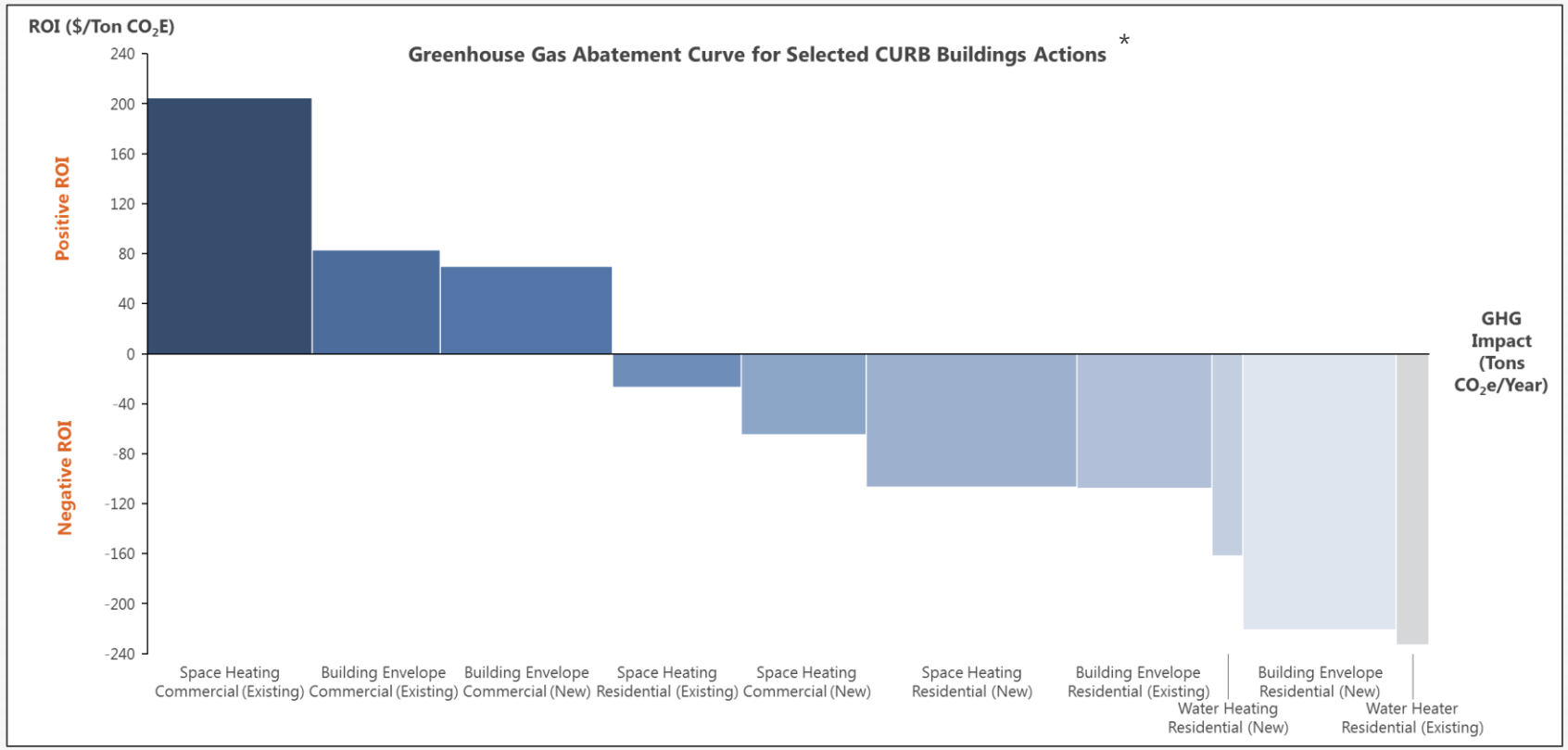
These actions represent 94% of the GHG abatement potential for Oakland's buildings

Note: Given wide range of ROI and GHG Impact values, axes and action placement are approximate. Given limited flexibility with cooling technology options available in CURB, cost estimates are likely to be overstated while GHG impact is likely to be understated.

Source: Bloomberg Associates Analysis, CURB

Oakland's GHG Abatement Curve outlines the economic impact of each action with large GHG impact

The GHG Abatement Curve displays economic data for each selected action; however, it does not identify who pays that cost or receives that benefit. Oakland can tailor its policies to adjust the burden for actions with a negative ROI.



*Collectively, all other buildings actions reduce GHG emissions by 32,000 tons of CO_2e per year (6% of total buildings-related reductions), at a weighted average ROI of $-1,000.

Key Takeaways

- Commercial Buildings actions tend to produce a positive ROI; property owners should be able to take action without additional economic incentives from the City
- Oakland will need to place particular emphasis on the residential building stock – and may need to commit financial resources to incentivize residential retrofits

Source: Bloomberg Associates Analysis, CURB

Estimated implementation costs, savings, and GHG impacts of building system changes in the Deep Decarbonization scenario

Building Type	Building Status	Building System	NPV (cumulative)	Implementation Cost	Annual Savings	Payback Period	Emissions Abatement ('000 tons)	Abatement Cost / Ton
Residential	New	Lighting	$ (127,874,814)	$ 59,934,046	$ 17,060,513	3.5	1,164	$ (1,919)
		Appliances	$ (19,930,988)	$ 58,268,018	$ 5,588,394	10.4	548	$ (625)
		Space Heating	$ 291,404,940	$ 122,375,585	$ (6,583,596)	-18.6	55,259	$ 107
		Cooling	$ 384,987,157	$ 493,107,141	$ 305,746	1612.8	175	$ 40,091
		Water Heating	$ 57,037,906	$ 43,587,995	$ (436,959)	-99.8	5,387	$ 162
		Water Fixtures	$ (19,006,664)	$ 540,538	$ 1,621,587	0.3	3,167	$ (115)
		Building Envelope	$ 422,973,932	$ 1,770,744,308	$ 32,568,252	54.4	35,251	$ 221
	Existing	Lighting	$ (199,832,756)	$ 38,846,212	$ 11,521,685	3.4	3,960	$ (1,952)
		Appliances	$ (12,312,419)	$ 112,343,908	$ 3,908,441	28.7	1,863	$ (288)
		Space Heating	$ 91,072,716	$ 99,809,500	$ 3,067,266	32.5	95,494	$ 27
		Cooling	$ 865,630,708	$ 743,787,069	$ 182,527	4074.9	605	$ 55,476
		Water Heating	$ 111,329,353	$ 36,025,123	$ (6,340,932)	-5.7	12,423	$ 233
		Water Fixtures	$ (38,790,110)	$ 611,833	$ 2,072,737	0.3	11,210	$ (145)
		Building Envelope	$ 305,696,587	$ 1,319,347,008	$ 27,872,750	47.3	108,555	$ 108
Commercial	New	Lighting	$ (131,823,778)	$ 370,820,221	$ 34,104,623	10.9	2,526	$ (877)
		Appliances	$ (37,322,962)	$ 48,111,934	$ 6,964,937	6.9	516	$ (1,216)
		Space Heating	$ 109,634,179	$ 70,676,232	$ 343,046	206.0	36,766	$ 65
		Cooling	$ 223,616,403	$ 408,498,304	$ 6,590,848	62.0	1,084	$ 3,465
		Water Heating	$ 4,515,844	$ 3,515,452	$ 153,606	22.9	639	$ 130
		Water Fixtures	$ (404,344)	$ 10,054	$ 34,876	0.3	58	$ (126)
		Building Envelope	$ (145,908,121)	$ 1,222,299,628	$ 64,427,853	19.0	32,725	$ (70)
	Existing	Lighting	$ (198,471,060)	$ 392,236,519	$ 33,481,463	11.7	7,034	$ (1,059)
		Appliances	$ (33,610,974)	$ 31,748,563	$ 3,612,503	8.8	714	$ (1,203)
		Space Heating	$ (499,463,869)	$ 43,448,580	$ 34,535,154	1.3	64,052	$ (205)
		Cooling	$ 280,980,323	$ 315,878,983	$ 4,419,019	71.5	2,267	$ 4,019
		Water Heating	$ 1,547,280	$ 2,346,273	$ 20,329	115.4	352	$ 65
		Water Fixtures	$ (692,976)	$ 9,153	$ 36,892	0.2	182	$ (159)
		Building Envelope	$ (208,709,859)	$ 669,589,062	$ 15,828,100	42.3	88,969	$ (83)

Source: Bloomberg Associates Analysis, CURB

Emissions reduction potential of buildings actions

2050 Emissions Reduction from 2013 Baseline Emissions

	New Residential	New Commercial	Existing Residential	Existing Commercial	Total
Lighting	<1%	<1%	<1%	1.0%	1.9%
Appliances	<1%	<1%	<1%	<1%	1.2%
Space Heating	2.3%	2%	7.7%	6%	18%
Water Heating	<1%	<1%	1.5%	<1%	2.4%
Water Fixtures	<1%	0%	<1%	0%	.6%
Cooling	<1%	<1%	<1%	<1%	1.2%
Building Envelopes	1.8%	1.3%	4.9%	4.1%	12.1%
TOTAL	**5.6%**	**4.5%**	**15.3%**	**12.0%**	**37.4%**

Source: Bloomberg Associates Analysis, CURB

Detailed Buildings Tables

Lighting

CURB – Emissions Reduction Potential: 1.9%

		CURB Tool Options	Today	2030		2050	
				Projected Trajectory	Deep Decarbonize	Projected Trajectory	Deep Decarbonize
New Residential	Tech	CFL		0%	0%	0%	0%
		LED		100%	100%	100%	100%
	Controls	None		70%	50%	0%	0%
		Occupancy Controls		30%	50%	100%	100%
Existing Residential	Tech	Incandescent	46%	0%	0%	0%	0%
		CFL	54%	10%	0%	0%	0%
		LED	0%	90%	100%	100%	100%
	Controls	None	100%	80%	50%	60%	20%
		Occupancy Controls	0%	20%	50%	40%	80%
New Commercial	Tech	LED		100%	100%	100%	100%
		Fluorescent T-8		0%	0%	0%	0%
	Controls	None		10%	0%	0%	0%
		Occupancy Controls		70%	80%	75%	75%
		Daylighting		10%	0%	0%	0%
		Combined		10%	20%	25%	25%
Existing Commercial	Tech	CFL	6%	0%	0%	0%	0%
		LED	7%	80%	100%	100%	100%
		Fluorescent T-12	20%	0%	0%	0%	0%
		Fluorescent T-8	67%	20%	0%	0%	0%
	Controls	None	67%	59%	44%	24%	0%
		Occupancy Controls	20%	28%	43%	51%	75%
		Daylighting	7%	7%	7%	19%	15%
		Combined	6%	6%	6%	6%	10%

Source: Bloomberg Associates Analysis, CURB

Lighting

CURB – Emissions Reduction Potential: 1.9%

Lighting systems should advance at required rates with minimal City action. Some work is required to increase adoption of occupancy controls.

New Buildings				Existing Buildings			
Residential		Commercial		Residential		Commercial	
2030	2050	2030	2050	2030	2050	2030	2050
LED lighting will be adopted at rates needed to achieve targets. City action needed to shift additional **20% of new buildings to occupancy controls**	No City action required. LED lighting and occupancy controls will be adopted at rates needed to achieve targets	LED lighting will be adopted at rates needed to achieve targets City action needed to shift additional **20% of new buildings to occupancy controls**	No City action required LED lighting and occupancy controls will be adopted at rates needed to achieve targets	City action required to **shift final 10% of existing buildings to LED** and to **increase use of occupancy controls in additional 30%** of existing buildings	LED lighting will be adopted at rates needed to achieve targets City action needed to shift **additional 40% of existing buildings to occupancy controls**	City action required to **shift final 20% of existing buildings to LED** and to **increase use of occupancy controls in additional 15%** of existing buildings	LED lighting will be adopted at rates needed to achieve targets City action needed to shift **additional 28% of existing buildings to occupancy controls**

Legend

Low	0-10% gap
Medium	11-30% gap
High	>30% gap

Note: Heat Map shading based on gaps in lighting technology only.

Source: Bloomberg Associates Analysis, CURB

Appliances

CURB – Emissions Reduction Potential: 1.2%

	CURB Tool Options	Today	2030		2050	
			Projected Trajectory	Deep Decarbonize	Projected Trajectory	Deep Decarbonize
New Residential	Mid-Range Efficiency		25%	0%	25%	0%
	High-Range Efficiency		75%	100%	75%	100%
Existing Residential	Standard	25%	25%	0%	25%	0%
	Mid-Range Efficiency	61%	61%	15%	61%	5%
	High-Range Efficiency	14%	14%	85%	14%	95%
New Commercial	Mid-Range Efficiency		25%	0%	25%	0%
	High-Range Efficiency		75%	100%	75%	100%
Existing Commercial	Standard	55%	50%	0%	0%	0%
	Mid-Range Efficiency	45%	45%	55%	37%	0%
	High-Range Efficiency	-	5%	45%	63%	100%

Source: Bloomberg Associates Analysis, CURB

Appliances

CURB – Emissions Reduction Potential: 1.2%

City action needed to increase adoption of high efficiency appliances by 2030. Additional work needed on existing commercial buildings through 2050.

New Buildings				Existing Buildings			
Residential		Commercial		Residential		Commercial	
2030	2050	2030	2050	2030	2050	2030	2050
City action required to **shift remaining 25% of new buildings to high efficiency appliances**	No additional City action required between 2030 and 2050 if 2030 target is reached	City action required to **shift remaining 25% of new buildings to high efficiency appliances**	No additional City action required between 2030 and 2050 if 2030 target is reached	Significant City action required to **shift 71% of existing buildings to high efficiency appliances**	City action required between 2030 and 2050 to shift additional **10% of existing homes to high efficiency appliances**, if 2030 target is reached	Significant City action needed **to shift 50% of existing buildings from standard appliances to mid-range and high efficiency**	After achieving 2030 targets, significant additional City action required between 2030 and 2050 to **shift an additional 45% of existing commercial buildings** to high efficiency

Legend

Low	0-10% gap
Medium	11-30% gap
High	>30% gap

Source: Bloomberg Associates Analysis, CURB

Space Heating

CURB – Emissions Reduction Potential: 18%

	CURB Tool Options	Today	2030		2050	
			Projected Trajectory	Decarbonize	Projected Trajectory	Decarbonize
New Residential	Low Efficiency Boiler		5%	0%	0%	0%
	Standard Efficiency Boiler (T24)		0%	0%	0%	0%
	High Efficiency Boiler Gas		45%	0%	20%	0%
	High Efficiency Boiler Electric		0%	50%	25%	45%
	Electric Heater		0%	0%	0%	0%
	Electric Heat Pump		50%	50%	55%	55%
Existing Residential	Low Efficiency Boiler (Below Standard)	74%	11%	0%	0%	0%
	Standard Efficiency Boiler	-	35%	10%	20%	0%
	High Efficiency Boiler Gas	8%	36%	15%	35%	0%
	High Efficiency Boiler Electric		0%	35%	15%	35%
	Electric Heater	18%	9%	10%	10%	5%
	Electric Heat Pump		9%	30%	20%	60%
New Commercial	Low Efficiency Boiler		9%	0%	0%	0%
	Standard Efficiency Boiler (T24)		16%	5%	5%	0%
	High Efficiency Boiler Gas		0%	0%	0%	0%
	High Efficiency Boiler Electric		40%	40%	40%	40%
	Electric Heater		3%	5%	0%	0%
	Electric Heat Pump		32%	50%	55%	60%
Existing Commercial	Low Efficiency Boiler	28%	16%	10%	8%	0%
	Standard Efficiency Boiler	56%	54%	35%	37%	0%
	High Efficiency Boiler Gas		10%	10%	10%	0%
	High Efficiency Boiler Electric	-	0%	10%	15%	40%
	Electric Heater	10%	10%	5%	10%	0%
	Electric Heat Pump	5%	10%	30%	20%	60%

Source: Bloomberg Associates Analysis, CURB

Space Heating

CURB – Emissions Reduction Potential: 18%

Significant City action required to electrify heating systems in all building types by 2030. Continued action required through 2050 for existing buildings.

New Buildings				Existing Buildings			
Residential		Commercial		Residential		Commercial	
2030	2050	2030	2050	2030	2050	2030	2050
Significant City action required to shift an additional **50% of new residential buildings** to electric systems	Assuming 2030 targets are met, **no City action required for new residential buildings**	Significant City action required to electrify heating systems in an additional **20% of new commercial buildings**	Limited City action required to **shift remaining 5% of existing buildings to heat pumps**	Significant City action required to **shift an additional 55% of existing residential buildings to electric heating systems**	City action required to **shift remaining 30% of existing residential buildings to heat pumps**	Significant City action required to **shift an additional 30% of existing commercial buildings to electric heating systems**	Significant City action needed to shift **an additional 55% of existing buildings to electric heating and increase efficiency of electric systems in another 10%**

Legend

Low	0-10% gap
Medium	11-30% gap
High	>30% gap

Source: Bloomberg Associates Analysis, CURB

Water Heating

CURB – Emissions Reduction Potential: 2.4%

	CURB Tool Options	Today	2030		2050	
			Projected Trajectory	Decarbonize	Projected Trajectory	Decarbonize
New Residential	Standard Efficiency Gas Boiler		13%	0%	4%	0%
	High Efficiency Gas Boiler		79%	46%	90%	0%
	High Efficiency Electric Boiler		0%	46%	0%	50%
	Electric Heat Pump		6%	8%	5%	50%
	Solar Hot Water		2%	0%	1%	0%
Existing Residential	Standard Efficiency Gas Boiler	87%	71%	40%	60%	0%
	High Efficiency Gas Boiler	5%	9%	30%	20%	0%
	Electric Heat Pump	5%	12%	20%	13%	100%
	Solar Hot Water	8%	8%	10%	7%	0%
New Commercial	Standard Efficiency Gas Boiler		0%	0%	0%	0%
	High Efficiency Gas Boiler		95%	51%	95%	0%
	Electric Heater		0%	19%	0%	40%
	Electric Heat Pump		0%	25%	0%	51%
	Solar Hot Water		5%	5%	5%	9%
Existing Commercial	Standard Efficiency Gas Boiler	95%	65%	22%	30%	0%
	High Efficiency Gas Boiler	-	30%	44%	65%	0%
	Electric Heater	-	0%	29%	0%	40%
	Electric Heat Pump	5%	2%	2%	0%	50%
	Solar Hot Water		3%	3%	5%	10%

Source: Bloomberg Associates Analysis, CURB

Water Fixtures

CURB – Emissions Reduction Potential: .6%

	CURB Tool Options	Today	2030		2050	
New Residential			Projected Trajectory	Decarbonize	Projected Trajectory	Decarbonize
	Standard		5%	0%	5%	0%
	Low-Flow		95%	100%	95%	100%
Existing Residential	Standard	86%	20%	0%	5%	0%
	Low-Flow	14%	80%	100%	95%	100%
New Commercial	Standard		0%	0%	5%	0%
	Low-Flow		100%	100%	95%	100%
Existing Commercial	Standard	54%	10%	0%	5%	0%
	Low-Flow	46%	90%	100%	95%	100%

Source: Bloomberg Associates Analysis, CURB

Water Fixtures

CURB – Emissions Reduction Potential: 3%

Significant City action required to electrify water heating systems in all building types in both 2030 and 2050.

New Buildings				Existing Buildings			
Residential		Commercial		Residential		Commercial	
2030	2050	2030	2050	2030	2050	2030	2050
City action needed to **shift 46% of new buildings to electric boilers** City action also needed to install low flow water systems in additional 5% of new homes	City action needed to shift **remaining 46% of new buildings to electric heat pumps**	City action needed to **electrify additional 44% of new** commercial buildings by 2030	City action required to **electrify remaining 51% of new commercial buildings**	Significant City action required to **electrify water heating systems in 10% of existing homes** while **increasing the efficiency of gas boilers in 21% of existing homes** City action needed to **install low flow water systems in additional 20% of existing homes**	Significant City action required to shift **remaining 70% of existing buildings to heat pumps**	City action needed to **electrify 29% of existing** buildings by 2030, while **increasing efficiency of gas boilers in 14% of existing buildings** City action required to **increase adoption of low flow water systems in 10% of existing** properties	Significant City action required to **electrify water heating systems in remaining 66% of buildings**

Legend

Low	0-10% gap
Medium	11-30% gap
High	>30% gap

Source: Bloomberg Associates Analysis, CURB

Cooling

CURB – Emissions Reduction Potential: 1.2%

	CURB Tool Options	Today	2030		2050	
			Projected Trajectory	Decarbonize	Projected Trajectory	Decarbonize
New Residential	High Efficiency Chillers		45%	14%	45%	14%
	Air Source Heat Pumps (mini splits)		10%	6%	10%	6%
	Ground / Water Source Heat Pumps		45%	80%	45%	80%
Existing Residential	Low Efficiency Chillers			0%	0%	0%
	Medium Efficiency Chillers	14%	7%	0%	0%	0%
	High Efficiency Chillers		7%	5%	5%	0%
	Air Source Heat Pumps / (A/C)	86%	8%	5%	0%	0%
	Ground Source Heat Pumps		78%	90%	95%	100%
New Commercial	High Efficiency Chillers		59%	59%	59%	60%
	Air Source Heat Pumps (RTU)		41%	36%	0%	0%
	Ground Source Heat Pumps		0%	5%	41%	40%
Existing Commercial	Low Efficiency Chillers	20%	11%	4%	4%	0%
	Medium Efficiency Chillers	13%	16%	6%	7%	0%
	High Efficiency Chillers		10%	23%	26%	37%
	Air Source Heat Pumps	67%	63%	40%	0%	0%
	Ground Source Heat Pumps		0%	27%	63%	63%

Source: Bloomberg Associates Analysis, CURB

Cooling

CURB – Emissions Reduction Potential: 1.2%

Short-term City action required most to increase use of higher efficiency cooling systems. Limited additional action required between 2030 and 2050.

New Buildings				Existing Buildings			
Residential		Commercial		Residential		Commercial	
2030	2050	2030	2050	2030	2050	2030	2050
City action required to **shift 35% of new buildings to ground source heat pumps**	No City action required, assuming 2030 targets are met	City action required to shift **5% of new buildings to ground source heat pumps**	No additional action required for new commercial buildings.	City action required to **shift 12% of existing buildings to ground source heat pumps**	Limited City action required to **increase shift remaining 5% of existing buildings to heat pumps**	City action required to **shift 40% of existing buildings to higher efficiency cooling systems**	City action required to **shift 11% of existing buildings to high efficiency chillers**

Legend

Low	0-10% gap
Medium	11-30% gap
High	>30% gap

Source: Bloomberg Associates Analysis, CURB

Building Envelope

CURB – Emissions Reduction Potential: 12.1%

Wall Insulation

		Today	2030		2050	
			PT	DD	PT	DD
New Residential	No Insulation		0%	0%	0%	0%
	Improved 1		5%	0%	0%	0%
	Improved 2		5%	5%	5%	0%
	Advanced		90%	95%	95%	100%
Existing Residential	No Insulation	54%	46%	0%	36%	0%
	Improved 1	21%	24%	46%	23%	0%
	Improved 2	25%	16%	24%	22%	50%
	Advanced	-	4%	30%	14%	50%
New Commercial	No Insulation		0%	0%	0%	0%
	Improved 1		16%	5%	16%	0%
	Improved 2		0%	0%	0%	0%
	Advanced		84%	95%	84%	100%
Existing Commercial	No Insulation	84%	76%	30%	56%	0%
	Improved 1	16%	16%	42%	16%	0%
	Improved 2	-	8%	8%	16%	50%
	Advanced	-	0%	20%	12%	50%

Roof Insulation

		Today	2030		2050	
			PT	DD	PT	DD
New Residential	No Insulation		0%	0%	0%	0%
	Improved 1		5%	0%	0%	0%
	Improved 2		5%	0%	5%	0%
	Advanced		90%	100%	95%	100%
Existing Residential	No Insulation	14%	10%	0%	5%	0%
	Improved 1	61%	60%	20%	52%	0%
	Improved 2	25%	20%	50%	22%	50%
	Advanced	-	10%	30%	21%	50%
New Commercial	No Insulation		0%	0%	0%	0%
	Improved 1		5%	0%	0%	0%
	Improved 2		5%	0%	5%	0%
	Advanced		90%	100%	95%	100%
Existing Commercial	No Insulation	57%	50%	20%	34%	0%
	Improved 1	43%	41%	30%	28%	0%
	Improved 2	-	9%	34%	31%	50%
	Advanced	-	0%	16%	7%	50%

PT = Projected Trajectory Scenario
DD = Deep Decarbonization Scenario

Source: Bloomberg Associates Analysis, CURB

Building Envelope

CURB – Emissions Reduction Potential: 12.1%

Windows

		Today	2030		2050	
			Projected Trajectory	Deep Decarbonize	Projected Trajectory	Deep Decarbonize
New Residential	Single Paned		0%	0%	0%	0%
	Double-Glazed		0%	0%	0%	0%
	Double G Low-E		98%	98%	95%	95%
	Triple-Glazed		2%	2%	5%	5%
Existing Residential	Single Paned	86%	46%	30%	12%	0%
	Double-Glazed	14%	40%	0%	40%	0%
	Low-E	-	10%	70%	43%	95%
	Triple-Glazed		4%	0%	5%	5%
New Commercial	Single Paned		5%	0%	3%	0%
	Double-Glazed		0%	0%	0%	0%
	Double G Low-E		95%	100%	97%	100%
	Triple-Glazed		0%	0%	0%	0%
Existing Commercial	Single Paned	84%	64%	34%	28%	0%
	Double-Glazed	16%	27%	0%	34%	0%
	Low-E		9%	66%	38%	100%
	Triple-Glazed		0%	0%	0%	0%

Source: Bloomberg Associates Analysis, CURB

Building Envelope

CURB – Emissions Reduction Potential: 12.1%

Continued City action required to improve insulation in existing buildings for both 2030 and 2050.

New Buildings				Existing Buildings			
Residential		Commercial		Residential		Commercial	
2030	2050	2030	2050	2030	2050	2030	2050
City action required to improve insulation in small number of new buildings (wall insulation in 5% of buildings, roof insulation in 10% of buildings)	City action required to improve wall insulation in 5% of new buildings	City action required to shift 11% of new buildings to advanced wall insulation, 10% of new buildings to advanced roof insulation, and 5% of new buildings to Low-E window technology	City action required to shift remaining 5% of buildings to advanced wall insulation	Significant City action required to improve insulation in the 46% of homes with no wall insulation, 50% of homes with no/poor roof insulation, and 60% of homes in need of improved windows	City action required to improve insulation in the remaining 46% of homes with poor wall insulation, 20% of homes with poor roof insulation, and 25% of homes in need of improved windows	City action needed to improve insulation in 46% of properties with no wall insulation, 30% of properties with no roof insulation, and 57% needing to install improved windows	City action needed to improve wall insulation in 64% of properties, roof insulation in 50% of properties, and window technologies in 34% of properties

Legend

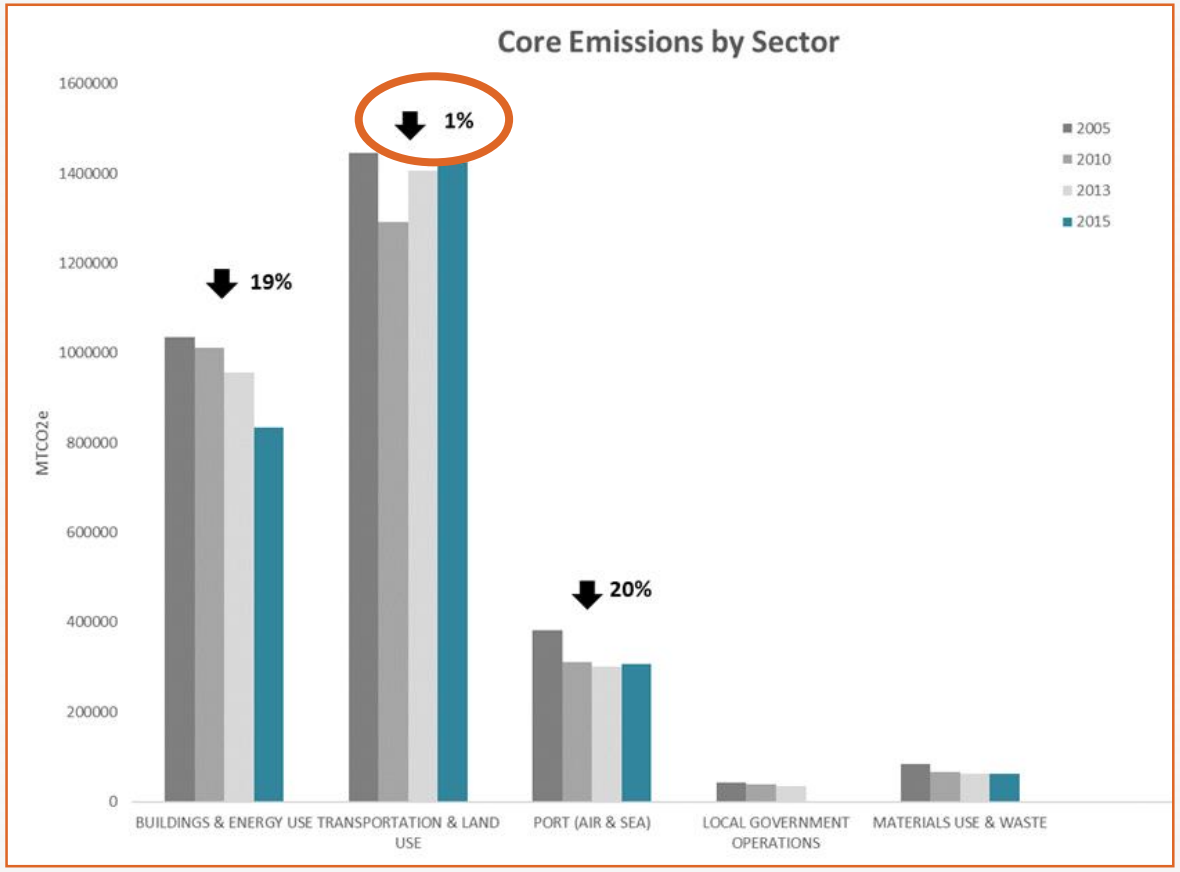
Low	0-10% gap
Medium	11-30% gap
High	>30% gap

Source: Bloomberg Associates Analysis, CURB

Appendix B – Transportation Technical Materials

Transportation emissions are trending down, but slower than other sectors

While CURB uses a 2013 baseline and the analysis used that dataset, it is important to acknowledge progress that Oakland has made in more recent years. Oakland's most recent data shows that 2015 emissions from then transportation sector were only 1% lower than the 2005 baseline.



Transportation emissions went down during the 2008 recession but are now trending upwards. Growth in population is driving an increase in transportation-related emissions.

Source: Oakland 2015 GHG Inventory

Achieving further reductions will require Oakland to transition to less carbon-intensive vehicles and shift passengers to more efficient modes of travel

CURB organizes its transportation inputs into four sets of potential 'actions' influencing future GHG emissions:

1. **Transit-Oriented Development**
2. **Passenger Mode Shift**
3. **Vehicle Electrification**
4. **Vehicle Fuel Efficiency**

As a result, discussions have focused on ways to reduce GHG emissions based on three associated 'actions':

1. **Reduce average trip length** via urban design
2. **Reduce per capita emissions per trip** via **increasing load factor**
3. **Reduce emissions per trip by shifting to lower carbon modes or fuels**

Developing scenarios for 2030 and 2050

Bloomberg Associates utilized a four-step process to develop scenarios for 2030 and 2050 in CURB to generate GHG estimates.

- **Projected Trajectory** projects the expected impacts of market forces together with State and Federal policies
- **Deep Decarbonization** projects where the City needs to be to achieve it's GHG reduction goals

1 Baseline Conditions

Gather baseline data on current building systems and input into CURB tool

		CURB Tool Options	Baseline		
			Fuel Type (% of vehicles)		
Fuel Type	Transportation Mode		Elec	Lo Em	Gas
		Private Automobile	.2%	5%	94.8%
		Light-Duty Truck	0%	0%	100%
		Medium-Duty Truck	0%	0%	100%
		Motorcycle	0%	0%	100%

2 Projected Trajectory and Deep Decarbonization

Develop 2030 and 2050 Projected Trajectory and Deep Decarbonization Scenarios, based upon information gathered during interviews, workshops, and discussion with City of Oakland staff

		CURB Tool Options	2030					
			Projected Trajectory (% of vehicles)			Deep Decarbonization (% of vehicles)		
Fuel Type	Transportation Mode		Elec	Lo Em	Gas	Elec	Lo Em	Gas
		Private Automobile	10%	20%	70%	30%	40%	30%
		Light-Duty Truck	3%	7%	90%	20%	35%	45%
		Medium-Duty Truck	1%	60%	39%	0%	80%	20%
		Motorcycle	10%	0%	90%	80%	0%	20%

3 Gap Analysis

Identify gaps between Projected Trajectory and Deep Decarbonization in order to identify areas where additional City actions are needed to achieve desired outcomes

2050			
Private Auto	Light-Duty Truck	Med-Duty Truck	Motorcycle
30% gap between 2030 and 2050 D.D.	30% gap between 2050 C.T. and D.D.	No gap between 2050 C.T. and D.D.	20% gap between 2050 and 2030 D.D.

4 Priority City Actions

Overlay gap analysis with potential GHG reduction impact to identify priority action areas

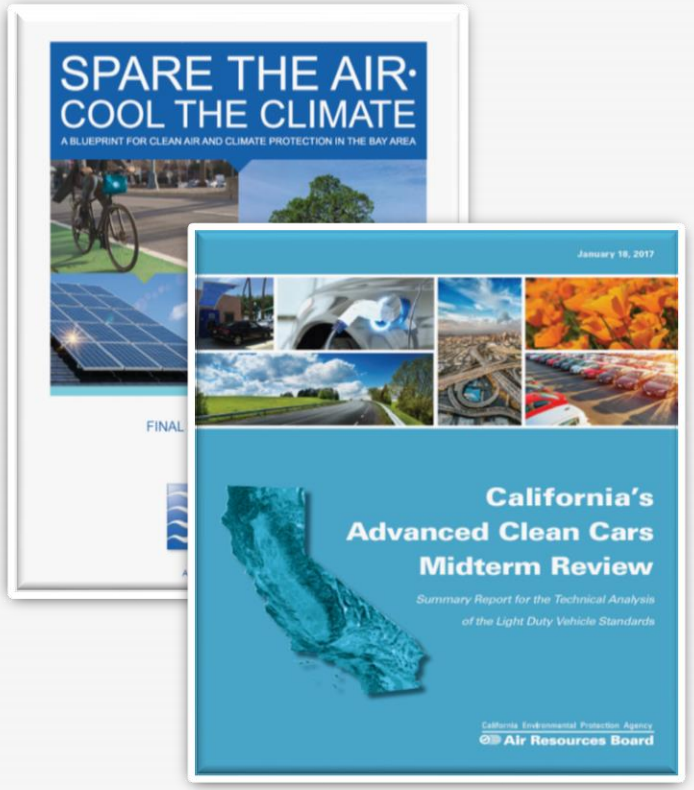
Mode Type	Today	2030	
	Mode Share	Mode Share	
		P.T.	D.D.
Reduction Potential		19%	
Private cars and trucks	69.1%	55.1%	40%
Motorcycle	1.6%	1.6%	2%
Taxi/TNC 1or2 Pass.	1.6%	10%	3%
TNC Pooled Ride	N/A	2%	6.7%
Shared Minibus	N/A	3%	10%
Bus/BRT	11.9%	10%	10%
Subway	6.5%	7%	5%
Light Rail/Commuter Rail	1%	1%	4%
Ferryboat	0.1%	0.3%	0.3%
Biking	3.3%	5%	9%
Walking	4.9%	5%	10%

Bloomberg Associates reviewed key documents

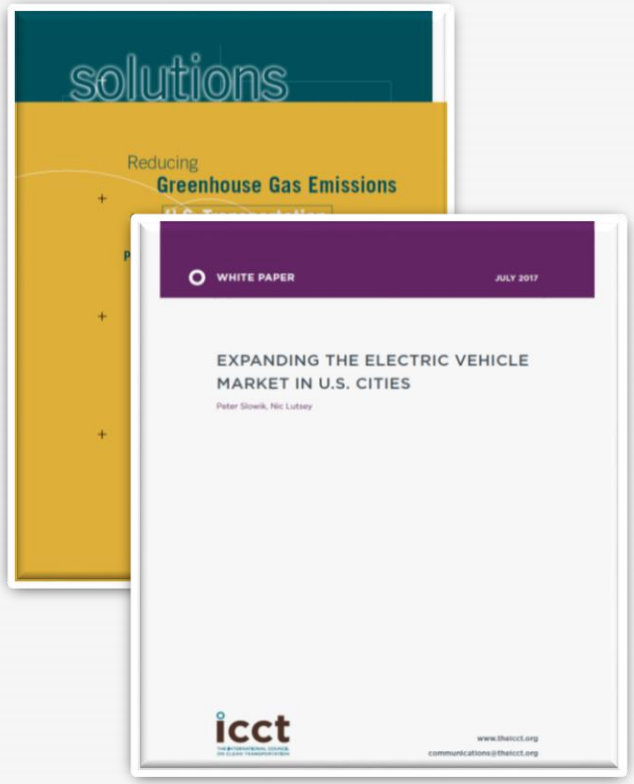
Bloomberg Associates reviewed key documents, reports, white papers, and articles to better understand the current state of transportation in Oakland and opportunities to reduce the carbon intensity of the transportation sector.

Bay Area Planning Studies

CA-Focused Technical Studies



National Best Practices



Publically available data provides a broad overview of Oakland's current transportation system…

The current transportation system in Oakland relies heavily on private automobiles for over 2/3 of all trips. While public transit has significant ridership, the introduction of TNCs is threatening to reduce transit ridership and add more car trips to the road.

The current mode share distribution in Oakland is dominated by private auto use:

	Transportation Mode	Mode Share
Baseline Mode Share	Private Autos and Trucks	69.1%
	Motorcycle	1.6%
	Taxi/TNC 1or2 pass.	1.6%
	TNC Pooled Ride	Not avail.
	Shared Minibus	Not avail.
	Standard Bus/BRT	11.9%
	BART	6.5%
	Amtrak	1%
	Ferryboat	0.1%
	Biking	3.3%
	Walking	4.9%

The current makeup of vehicles in Oakland is largely gas-powered, with some hybrid vehicles:

	Vehicle Types	Fuel Type (% of vehicles)		
		Electric	Low Emission	Gas
Baseline Vehicle Fuel Types	Private Autos	0.2%	5%	94.8%
	Light-Duty Truck	0%	0%	100%
	Medium-Duty Truck	0%	0%	100%
	Motorcycle	0%	0%	100%
	Taxi	1%	15%	84%
	TNC Pool	1%	15%	84%
	Shared Minibus	0%	4%	96%
	Standard Bus/BRT	0%	2%	98%

Source: OakDOT, AC Transit, MTC, American Community Survey

… but must be supplemented by a number of detailed assumptions in CURB

Expert interviews, literature review, and the in-person workshop helped refine core assumptions related to Oakland's baseline conditions.

Key Baseline Assumptions Include:

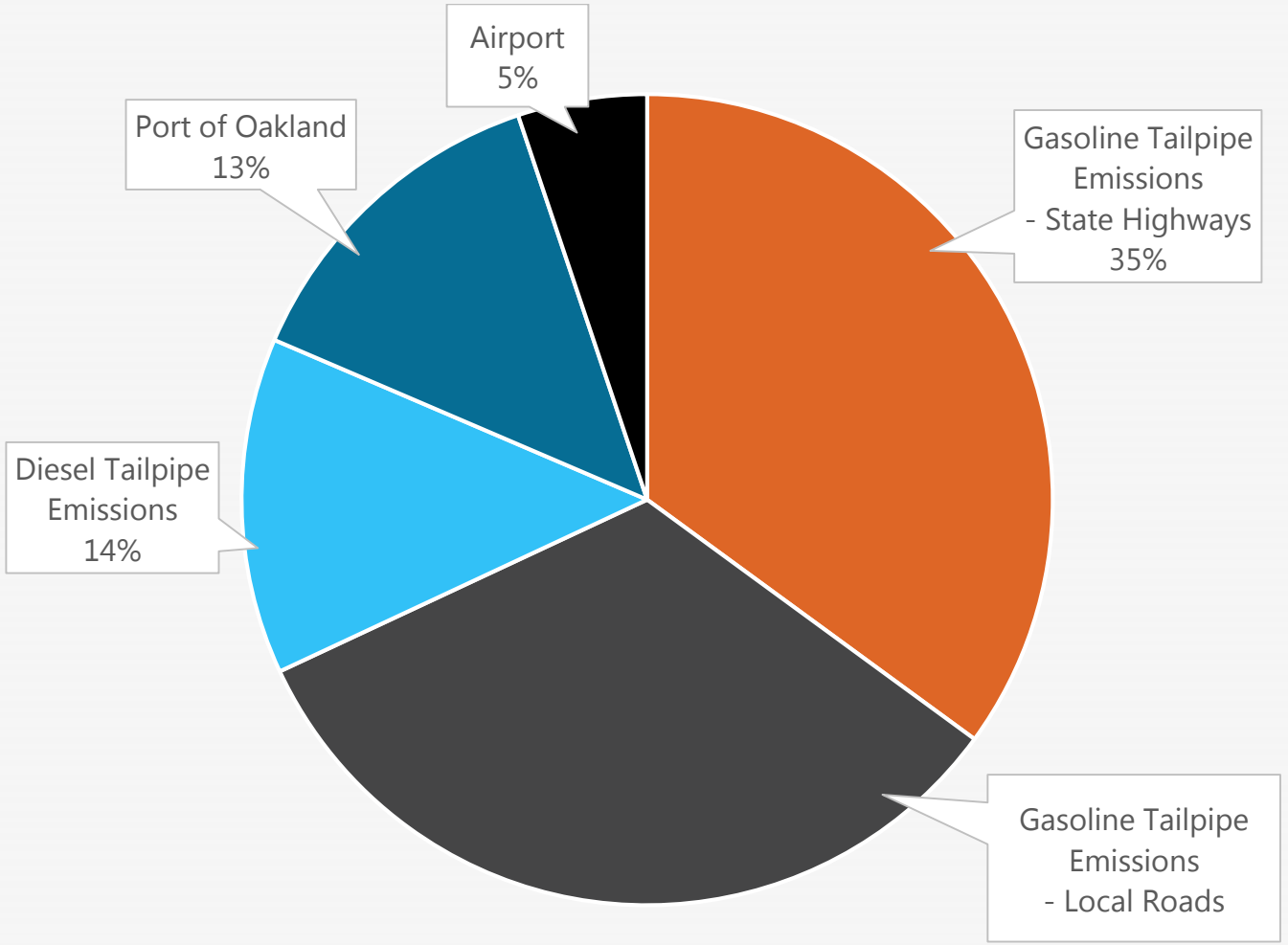
- Population Growth Rates (1.09% per year)
- Current TOD trends will continue (~2/3 of new units are transit-oriented)
- Adoption rates for EVs will increase over historical trends (% of total sales: today=5%, 2030=40%, 2050=90%)
- AVs will be a normalized part of the transportation system by 2050

Oakland's transportation emissions are driven by gasoline tailpipe emissions

According to the Oakland GHG Inventory, the largest sources of transportation emissions are:

- Gasoline tailpipe emissions on State Highways in Oakland represent **35%** of total Transportation and Mobile Source emissions
- Gasoline tailpipe emissions on local roads in Oakland represent **33%** of total Transportation and Mobile Source emissions
- The other largest sources of emissions are: diesel tailpipe emissions on local roads (14%), the Port of Oakland (13%), and the airport (5%)

Oakland 2013 Transportation Emissions



Source: Oakland GHG Inventory

Transportation actions have the potential to significantly reduce Oakland's GHG emissions

CURB uses these baseline inputs and assumptions to develop a preliminary analysis of where potential emissions reductions could come from. This information can be used to quickly identify which actions are likely to have the greatest impact. For transportation, multiple actions can produce the same GHG impact (e.g., with a carbon-free grid, shifting a vehicle trip to walking has the same impact as electrifying the private automobile that would have been used for that trip). As a result, the total GHG emissions reduction potential is greater than 100%.

Transit-Oriented Development	**10%** Potential reduction in transportation-related GHG emissions
Passenger Mode Shift	**68%** Potential reduction in transportation-related GHG emissions
Vehicle Electrification	**87%** Potential reduction in transportation-related GHG emissions

Note: CURB does not currently include functionality to provide this preliminary analysis for the Vehicle Fuel Efficiency action

Source: Bloomberg Associates Analysis, CURB

The analysis developed two scenarios for 2030 and 2050 to compare against Oakland's GHG reduction goals

The next step of the analysis develops and compares scenarios for 2030 and 2050 alongside Oakland's GHG reduction goals, to better understand the potential pathways to GHG reductions.

Projected Trajectory Scenario

The estimated the Projected Trajectory of Oakland's emissions assumed:

- **Projected technological advances & market adoption/penetration** (e.g., market adoption of electric vehicles)
- **Stated State & Federal policies** (e.g., US EPA/CARB fuel economy standards)
- **Existing City policies and funded programs** (e.g., Community Choice Energy program; NOT unfunded bike/walk plans)
- **Limited City actions responding to market trends** (e.g., revised building codes to enable electric vehicle chargers; NOT future programs incentivizing adoption of chargers in residential buildings)

The Projected Trajectory was then compared with Oakland's goals. Those insights were used to ground the work with local and national experts to figure out what else needed to happen.

Deep Decarbonization Scenario

Collaboration with local and national experts helped to identify the rate of change required to achieve Oakland's GHG goals and put the City on the pathway to Deep Decarbonization.

Key assumptions for the Projected Trajectory scenario (1 of 2)

Projecting ahead to 2030 and 2050 inherently involves making assumptions about what the world will look like, based upon the best information available to us today. Below are the key assumptions underlying the Transportation Projected Trajectory analysis:

Transit-Oriented Development

- Transit-oriented development patterns will continue along current trends, based upon availability of buildable sites in the transit-accessible core of Oakland
- A 'transit-oriented household' is defined as: Development within ¼ mile of a transit stop, including BART stations, rapid bus routes, BRT stations, and bus stops served by a frequency of service interval of 15 minutes or less during AM and PM peak commutes

Passenger Mode Shift

- Mode share is currently shifting from private autos and buses to TNCs
- 2030 projections don't account for autonomous vehicles due to uncertainty over near-term technological and regulatory hurdles; by 2050 AVs will be a normalized part of the transportation system
- Reductions in private autos by 2030 is due to shift to 1 to 2 passenger TNC trips, expansion of other TNC trip types (TNC Pooled Rides and Shared Minibus), and introduction of bike share and electric bicycles
- Early growth of TNC mode share was driven by low-efficiency TNC trips (1 or 2 passengers in passenger vehicles) but the greatest GHG reduction potential is a shift to more efficient TNC mode share, both pooled rides (>2 passengers in passenger vehicles) and shared minibus (multi passenger rides in larger vehicles)
- Mode share for buses is being lost to TNCs as they expand market saturation and options to travelers. Planned BRT corridors will likely not reverse this trend, and bus share will continue to shift to TNC modes
- Planned BART's core capacity improvements will likely result in modest increases in mode share for subway
- Investments in improving walkability and pedestrian infrastructure outlined in the OakDOT Strategic Plan will help achieve 2030 goal, but additional actions are required to achieve 2050 goals

Key assumptions for the Projected Trajectory scenario (2 of 2)

Projecting ahead to 2030 and 2050 inherently involves making assumptions about what the world will look like, based upon the best information available to us today. Below are the key assumptions underlying the Transportation Projected Trajectory analysis:

Vehicle Electrification

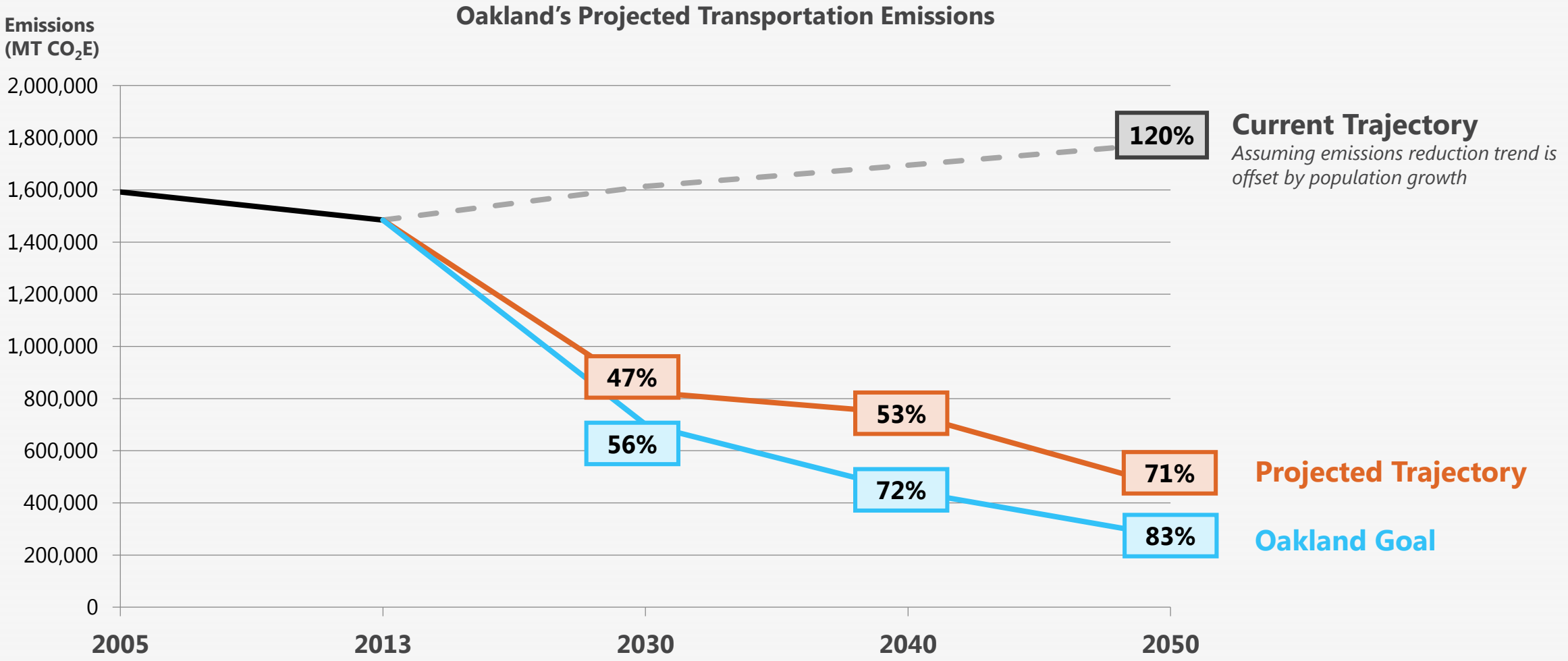
- California incentives for zero/low emission vehicles will increase adoption rate for private autos and light-duty trucks over historical trends: estimates for new sales of electric/low emissions vehicles increase from current 5% of total sales to 40% by 2030 and 90% by 2050
- Shared minibus vehicles (passenger vans) will likely be owned by TNC companies rather than drivers, leading to a faster fleet transition to zero and low-emissions vehicles
- Average age of vehicles on the road is 10.8 years
- Charging infrastructure is essential for transition to EVs; Initial buildout of charging network will be led by private sector but requires City and Utility action to accelerate siting and permitting
- CARB Advanced Clean Transit regulations (once finalized), together with continued improvement in fuel cell and electric bus technologies, will shift bus fleet to zero and low emissions vehicles
- 'Gas' includes both gasoline (petrol) and diesel, in percentages corresponding to baseline through 2030, beyond 2030 assume diesel passenger vehicles are fazed out

Vehicle Fuel Efficiency

- While it is difficult to project fuel efficiency improvement rates over the long-term, there are likely decreasing efficiency gains over time
- Average age of vehicles on the road is 10.8 years
- Efficiency gains for taxi and TNC pool cars will be driven by Corporate Average Fuel Economy (CAFE) standards set by the State of California and the Federal Government, together with incentives to speed the adoption of electric and fuel efficient vehicles
- CA will likely adopt a renewable diesel standard for 2030, helping improve fuel efficiency for medium-duty trucks

Oakland will not achieve its GHG reduction goals on the Projected Trajectory

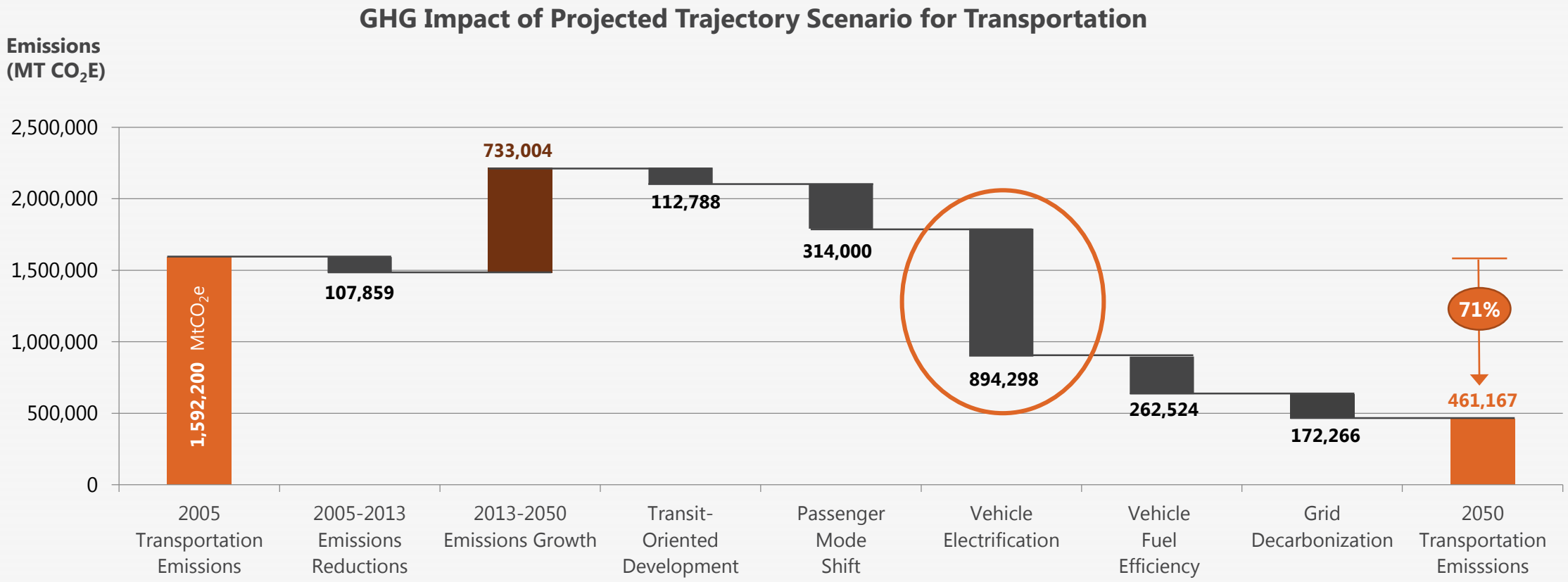
While the Projected Trajectory produces significant reductions from the 2005 baseline, it does not enable the City to meet its reduction targets for the transportation sector. Oakland needs to take additional actions to close a nine percentage point gap in 2030 and a 12 percentage point gap in 2050.



Source: Bloomberg Associates Analysis, CURB

Projected Trajectory of transportation emissions to 2050

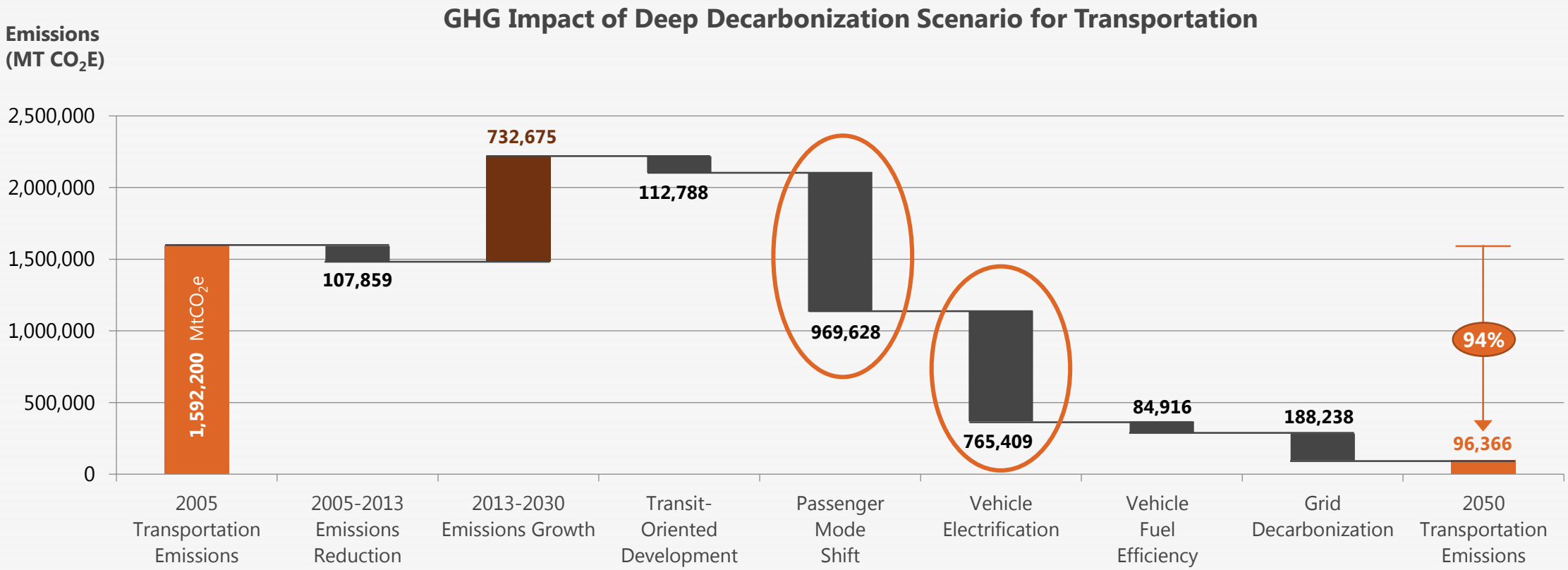
The Projected Trajectory scenario produces a 71% reduction in transportation emissions by 2050. This reduction is primarily due to the switch to electric and hybrid vehicles.



Source: Bloomberg Associates Analysis, CURB

Deep Decarbonization of transportation emissions to 2050

The Deep Decarbonization scenario produces a 94% reduction in transportation emissions by 2050. Reduction beyond the Projected Trajectory come primarily from more aggressive actions in passenger mode shift and vehicle electrification.



Source: Bloomberg Associates Analysis, CURB

Gap analysis methodology

Vehicle electrification example

Bloomberg Associates identified gaps between the Projected Trajectory and Deep Decarbonization scenarios to identify where City action is needed to achieve goals.

Vehicle Electrification	Transportation Mode	CURB Tool Options	Baseline			2030						Delta		
			Fuel Type (% of vehicles)			Projected Trajectory (% of vehicles)			Deep Decarbonization (% of vehicles)			% Gap		
			Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas
		Private Automobile	0.2%	5%	94.8%	10%	20%	70%	30%	40%	30%	20%	20%	-40%
		Light-Duty Truck	0%	0%	100%	3%	7%	90%	20%	35%	45%	17%	28%	-45%
		Medium-Duty Truck	0%	0%	100%	1%	60%	39%	0%	80%	20%	-1%	20%	-19%
		Motorcycle	0%	0%	100%	10%	0%	90%	80%	0%	20%	70%	0%	-70%

Delta = Deep Decarbonization – Projected Trajectory

Gaps were color-coded to highlight areas where significant gaps exist:

- **Low** — **Minimal City action required** to achieve goals
- **Medium** — **Moderate City action required** to achieve goals
- **High** — **Significant City action required** to achieve goals

2030							
Private Auto	**Light-Duty Truck**	**Med-Duty Truck**	**Motorcycle**	**Taxi**	**TNC Pool**	**Shared Minibus**	**Bus**
20% gap between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**17% gap** between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**1% gap** between Projected Trajectory and Deep Decarbonization; However limited City action needed given CA is likely to adopt a renewable diesel standard for 2030	**70% gap** between Projected Trajectory and Deep Decarbonization; However, limited potential for City actions to speed adoption of electric motorcycles	**15% gap** between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**15% gap** between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**No gap** between Projected Trajectory and Deep Decarbonization; no City action needed to speed adoption of electric vehicles	**5% gap** between Projected Trajectory and Deep Decarbonization; CARB Advanced Clean Transit rules will likely require the bus fleet will transition at rates needed to achieve goals

Summary transportation gap analysis

To reduce transportation emissions, significant City action is needed to provide viable public transit alternatives to private vehicles and to speed electrification for key vehicles types.

Extent to which City Action is Required to Achieve Deep Decarbonization

		Mode Share		Vehicle Electrification	
Overall GHG Reduction Potential		**39.8%**		**50.6%**	
Mode Type	Current Mode Share	2030	2050	2030	2050
Private Autos and Trucks	69.1%	**40%**	**20%**		
Motorcycle	1.6%				
Taxi or 1-2 Passenger TNC	1.6%	**3%**			
TNC Pooled Ride	N/A				
Shared Minibus	N/A				
Bus/BRT	11.9%	**15%**			
BART	6.5%		**14%**		
Amtrak	1%				
Ferryboat	0.1%				
Biking	3.3%				
Walking	4.9%		**12.5%**		

Legend

Low **Minimal City action required** to achieve targets | **Medium** **Moderate City action required** to achieve targets | **High** **Significant City action required** to achieve targets | = **Priority City action area**

Note: This analysis is predicated on the assumption of 100% carbon-free energy grid by 2030
Source: Bloomberg Associates Analysis, CURB

Short-term City actions needed to reduce private vehicle trips

Short-term City focus should be on areas with large GHG reduction potential, a high gap between the Projected Trajectory and Deep Decarbonization scenarios, and to avoid "lock in" of high-carbon technologies.

	Today	2030			
Mode Type	Mode Share	Mode Share		Vehicle Electrification	Fuel Efficiency
		Projected Trajectory	Deep Decarbonization		
Overall GHG Reduction Potential		**39.8%**		**50.6%**	**n/a**
Private Autos and Trucks	69.1%	55.1%	**40%**		
Motorcycle	1.6%	1.6%	1.6%		
Taxi or 1-2 Passenger TNC	1.6%	10%	**3%**		
TNC Pooled Ride	N/A	2%	5%		
Shared Minibus	N/A	3%	9%		
Bus/BRT	11.9%	10%	**15%**		
BART	6.5%	7%	8%		
Amtrak	1%	1%	3%		
Ferryboat	0.1%	0.3%	0.4%		
Biking	3.3%	5%	7.5%		
Walking	4.9%	5%	7.5%		

	2030
GHG Reduction Potential	**5.6%**
New TOD Households	

Vehicle Electrification City Focus Areas

- In the short-term, City action needed to increase electrification of private vehicles and 1 to 2 passenger taxis and TNC vehicles

Legend

- **Low** = Minimal City action required to achieve goals
- **Medium** = Moderate City action required to achieve goals
- **High** = Significant City action required to achieve goals
- = **Priority City Action Area**

Mode Share City Focus Areas

- City action needed to reduce private auto trips and 1 to 2 passenger taxi/TNC trips and increase bus trips

Note: Priority City actions predicated on assumption of 100% renewable electric grid

Long-term City action needed to electrify key vehicle types and shift to low-carbon travel modes

Because the City must take an "all of the above" approach to reach its GHG goals, longer-term actions should focus on areas with lower GHG impact or where the Projected Trajectory will have a lower impact between 2030 and 2050.

Mode Type	Today	2050			
	Mode Share	Mode Share		Vehicle Electrification	Fuel Efficiency
		Projected Trajectory	Deep Decarbonization		
Overall GHG Reduction Potential		**39.8%**		**50.6%**	**n/a**
Private Autos and Trucks	69.1%	48%	**20%**		
Motorcycle	1.6%	1.6%	1.6%		
Taxi or 1-2 Passenger TNC	1.6%	5%	3%		
TNC Pooled Ride	N/A	5%	5%		
Shared Minibus	N/A	10%	10%		
Bus/BRT	11.9%	8%	19.9%		
BART	6.5%	8%	**14%**		
Amtrak	1%	2%	3%		
Ferryboat	0.1%	0.4%	1%		
Biking	3.3%	6%	10%		
Walking	4.9%	6%	**12.5%**		

	2030
GHG Reduction Potential	**5.6%**
New TOD Households	

Vehicle Electrification City Focus Areas

- In the longer term, continued City action needed to increase electrification of private vehicles and shared minibus vehicles

Legend

- **Low** = Minimal City action required to achieve goals
- **Medium** = Moderate City action required to achieve goals
- **High** = Significant City action required to achieve goals
- = **Priority City action area**

Mode Share City Focus Areas

- Even when vehicles are electrified, continued City action needed to reduce private vehicle trips and increase public transit and walking

Note: Priority City actions predicated on assumption of 100% renewable electric grid

Detailed Transportation Tables

Baseline, Projected Trajectory and Deep Decarbonization – Transit-Oriented Development

	CURB Tool Options	Today	2030		2050	
Proportion of New Households			Projected Trajectory	Deep Decarbonization	Projected Trajectory	Deep Decarbonization
	New Transit-Oriented Development Households	43%	65%	65%	65%	65%
	Transit-Oriented Development Trip Reduction Factor*	25%	25%	25%	25%	25%

* CURB Tool allows a maximum 25% trip reduction factor

Source: Bloomberg Associates Analysis, CURB

Gap Analysis – Transit-Oriented Development

CURB – Emissions Reduction Potential: 5.6%

There is no gap between Projected Trajectory and Deep Decarbonization for transit-oriented development: Current development trends and policy direction will achieve goals for proportion of new households located in transit accessible areas.

2030	2050
No gap between Projected Trajectory and Deep Decarbonization; No additional City action needed to meet TOD goals.	**No gap** between Projected Trajectory and Deep Decarbonization; No additional City action needed to meet TOD goals.

Source: Bloomberg Associates Analysis, CURB

Baseline, Projected Trajectory and Deep Decarbonization – Passenger Mode Shift

		CURB Tool Options	Today	2030 Projected Trajectory	2030 Deep Decarbonization	2050 Projected Trajectory	2050 Deep Decarbonization
Mode Share	Transportation Mode	Private Autos and Trucks	69.1%	55.1%	40.0%	48.0%	20.0%
		Motorcycle	1.6%	1.6%	1.6%	1.6%	1.6%
		Taxi/TNC 1or2 pass.	1.6%	10.0%	3.0%	5.0%	3.0%
		TNC Pooled Ride	Not avail.	2.0%	5.0%	5.0%	5.0%
		Shared Minibus	Not avail.	3.0%	9.0%	10.0%	10.0%
		Standard Bus/BRT	11.9%	10.0%	15.0%	8.0%	19.9%
		BART	6.5%	7.0%	8.0%	8.0%	14.0%
		Amtrak	1%	1.0%	3.0%	2.0%	3.0%
		Ferryboat	0.1%	0.3%	0.4%	0.4%	1.0%
		Biking	3.3%	5.0%	7.5%	6.0%	10.0%
		Walking	4.9%	5.0%	7.5%	6.0%	12.5%

Source: Bloomberg Associates Analysis, CURB

Gap Analysis - Passenger Mode Shift

CURB – Emissions Reduction Potential: 39.8%

City action needed to achieve targeted reductions in low-efficiency TNC and private automobile trips.

2030										
Private Auto and Trucks ⇩	**Motorcycle**	**Taxi/TNC 1or2 Pass.**	**TNC Pooled Ride** ⇩	**Shared Minibus** ⇧	**Bus/BRT** ⇧	**BART**	**Amtrak**	**Ferryboat**	**Biking** ⇧	**Walking** ⇧
15% gap between Projected Trajectory and Deep Decarbonization, some City action needed to shift away from private autos	**No gap** between Projected Trajectory and Deep Decarbonization; no City action required	**7% gap** between Projected Trajectory and Deep Decarbonization ; City action needed to shift trips away from less efficient TNC modes	**3% gap** between Projected Trajectory and Deep Decarbonization; some City action needed to shift towards high-capacity TNC ride types	**6% gap** between Projected Trajectory and Deep Decarbonization; some action needed to shift towards high-capacity TNC ride types and larger vehicles	**5% gap** between Projected Trajectory and Deep Decarbonization; City action required to increase ridership	**1% gap** between Projected Trajectory and Deep Decarbonization; no City action required	**2% gap** between Projected Trajectory and Deep Decarbonization; no City action required	**<1% gap** between Projected Trajectory and Deep Decarbonization; no City action required	**2.5%** between Projected Trajectory and Deep Decarbonization, some City action needed to increase bicycling trips	**2.5% gap** between Projected Trajectory and Deep Decarbonization, some City action needed to increase walking trips
2050										
Private Auto and Trucks ⇩	**Motorcycle**	**Taxi/TNC 1or2 Pass.**	**TNC Pooled Ride**	**Shared Minibus** ⇧	**Bus/BRT** ⇧	**BART** ⇧	**Amtrak**	**Ferryboat** ⇧	**Biking** ⇧	**Walking** ⇧
20% gap between 2030 and 2050 Deep Decarbonization; Aggressive City action needed to reduce private auto mode share	**No gap** between 2050 Projected Trajectory and Deep Decarbonization; no City action needed from 2030 to 2050	**No gap** between 2030 Projected Trajectory and 2050 Deep Decarbonization ; no City action needed from 2030 to 2050	**No gap** between 2030 and 2050 Deep Decarbonization; limited City action needed to shift towards high-capacity TNC ride types	**No gap** 2050 Projected Trajectory and Deep Decarbonization; some City action needed after 2030 to shift towards high-capacity TNC ride types in larger vehicles	**4.9% gap** between 2030 and 2050 Deep Decarbonization; Limited City action needed to shift trips onto buses	**6% gap** between 2050 Projected Trajectory and Deep Decarbonization; Limited City action needed to shift trips onto subway (BART)	**No gap** between 2030 and 2050 Deep Decarbonization; limited City action needed to shift trips onto rail	**<1% gap** between 2050 Projected Trajectory and Deep Decarbonization; limited City action needed to shift trips onto ferryboats	**2.5% gap** between 2030 and 2050 Deep Decarbonization; limited City action needed to increase bicycling trips	**5% gap** between 2030 and 2050 Deep Decarbonization; Some City action needed after 2030 to increase walking trips

Legend Low 0-4% point gap | Medium 5-15% point gap | High >15% point gap | ⇧ ⇩ Indicates if mode share is **increasing** or **decreasing**

Source: Bloomberg Associates Analysis, CURB

Baseline, Projected Trajectory, and Deep Decarbonization: Private Vehicles – Vehicle Electrification

		CURB Tool Options	Baseline			2030						2050					
			Fuel Type (% of vehicles)			Projected Trajectory (% of vehicles)			Deep Decarbonization (% of vehicles)			Projected Trajectory (% of vehicles)			Deep Decarbonization (% of vehicles)		
Fuel Type	Transportation Mode		Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas
		Private Automobile	0.2%	5%	94.8%	10%	20%	70%	30%	40%	30%	50%	15%	35%	70%	30%	0%
		Light-Duty Truck	0%	0%	100%	3%	7%	90%	20%	35%	45%	34%	33%	33%	70%	30%	0%
		Medium-Duty Truck	0%	0%	100%	1%	60%	39%	0%	80%	20%	30%	70%	0%	40%	60%	0%
		Motorcycle	0%	0%	100%	10%	0%	90%	80%	0%	20%	25%	0%	75%	100%	0%	0%

Source: Bloomberg Associates Analysis, CURB

Baseline, Projected Trajectory and Deep Decarbonization: Commercial Vehicles – Vehicle Electrification

		CURB Tool Options	Baseline			2030						2050					
Fuel Type	Transportation Mode		Fuel Type (% of vehicles)			Projected Trajectory (% of vehicles)			Deep Decarbonization (% of vehicles)			Projected Trajectory (% of vehicles)			Deep Decarbonization (% of vehicles)		
			Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas
		Taxi	1%	15%	84%	25%	50%	25%	40%	60%	0%	75%	25%	0%	80%	20%	0%
		TNC Pool	1%	15%	84%	25%	50%	25%	40%	60%	0%	75%	25%	0%	80%	20%	0%
		Shared Minibus	0%	4%	96%	25%	25%	50%	25%	50%	25%	50%	50%	0%	80%	20%	0%
		Standard Bus/BRT	0%	2%	98%	40%	40%	20%	35%	65%	0%	50%	50%	0%	50%	50%	0%

Source: Bloomberg Associates Analysis, CURB

Gap Analysis - Vehicle Electrification

CURB – Emissions Reduction Potential: 50.6%

City actions needed to shift to electric vehicles in both short- and long-terms.

2030							
Private Auto	**Light-Duty Truck**	**Med-Duty Truck**	**Motorcycle**	**Taxi**	**TNC Pool**	**Shared Minibus**	**Bus**
20% gap between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**17% gap** between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**No gap** between Projected Trajectory and Deep Decarbonization; Limited City action needed given CA is likely to adopt a renewable diesel standard for 2030	**70% gap** between Projected Trajectory and Deep Decarbonization; However, limited potential for City actions to speed adoption of electric motorcycles	**15% gap** between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**15% gap** between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**No gap** between Projected Trajectory and Deep Decarbonization; no City action needed to speed adoption of electric vehicles	**5% gap** between Projected Trajectory and Deep Decarbonization; CARB Advanced Clean Transit rules will likely require the bus fleet will transition at rates needed to achieve goals

2050							
Private Auto	**Light-Duty Truck**	**Med-Duty Truck**	**Motorcycle**	**Taxi**	**TNC Pool**	**Shared Minibus**	**Bus/BRT**
20% gap between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**36% gap** between Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**10% gap** between Projected Trajectory and Deep Decarbonization; However limited City action needed given CA is likely to adopt a renewable diesel standard for 2030	**20% gap** between 2030 and 2050 Deep Decarbonization; However, limited potential for City actions to speed adoption of electric motorcycles	**5% gap** between 2030 and 2050 Deep Decarbonization; no City action needed to speed adoption of electric vehicles	**5% gap** between 2030 and 2050 Deep Decarbonization; no City action needed to speed adoption of electric vehicles	**30% gap** between 2050 Projected Trajectory and Deep Decarbonization; City action needed to speed adoption of electric vehicles	**No gap** between 2030 and 2050 Deep Decarbonization; CARB Advanced Clean Transit rules will likely require the bus fleet will transition at rates needed to achieve goals

Legend Low 0-10% gap | Medium 10-20% gap | High >20% point gap

Source: Bloomberg Associates Analysis, CURB

Baseline, Projected Trajectory and Deep Decarbonization: Private Vehicles – Fuel Efficiency

		CURB Tool Options	2030						2050					
			Projected Trajectory (% improvement)			Deep Decarbonization (% improvement)			Projected Trajectory (% improvement)			Deep Decarbonization (% improvement)		
			Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas
Fuel Efficiency	Transportation Mode	Private Automobile	14%	60%	60%	14%	60%	60%	22%	44%	44%	22%	44%	44%
		Light-Duty Truck	14%	60%	60%	14%	60%	60%	22%	44%	44%	22%	44%	44%
		Medium-Duty Truck	14%	16%	16%	14%	16%	16%	22%	37%	37%	22%	37%	37%
		Motorcycle	14%	60%	60%	14%	60%	60%	22%	44%	44%	22%	44%	44%

Source: Bloomberg Associates Analysis, CURB

Baseline, Projected Trajectory and Deep Decarbonization: Commercial Vehicles – Fuel Efficiency

		CURB Tool Options	2030						2050					
Fuel Efficiency	Transportation Mode		Projected Trajectory (% improvement)			Deep Decarbonization (% improvement)			Projected Trajectory (% improvement)			Deep Decarbonization (% improvement)		
			Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas	Elec	Lo Em	Gas
		Taxi	14%	60%	60%	14%	60%	60%	22%	44%	44%	22%	44%	44%
		TNC Pool	14%	60%	60%	14%	60%	60%	22%	44%	44%	22%	44%	44%
		Shared Minibus	14%	16%	16%	14%	16%	16%	22%	37%	37%	22%	37%	37%
		Standard Bus/BRT	14%	21%	21%	14%	21%	21%	22%	35%	35%	22%	35%	35%

Source: Bloomberg Associates Analysis, CURB

Gap Analysis - Vehicle Fuel Efficiency

There is no gap between Projected Trajectory and Deep Decarbonization for private vehicle fuel efficiency: Current and projected fuel efficiency standards at State and Federal levels together with market forces will achieve goals.

2030 + 2050							
Private Auto	**Light-Duty Truck**	**Medium-Duty Truck**	**Motorcycle**	**Taxi**	**TNC Pool**	**Shared Minibus**	**Bus/BRT**
No gaps between Projected Trajectory and Deep Decarbonization; The private automobile fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals	**No gaps** between Projected Trajectory and Deep Decarbonization; The light-duty truck fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals	**No gaps** between Projected Trajectory and Deep Decarbonization; The medium-duty truck fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals	**No gaps** between Projected Trajectory and Deep Decarbonization; The motorcycle fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals	**No gaps** between Projected Trajectory and Deep Decarbonization; The taxi vehicle fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals	**No gaps** between Projected Trajectory and Deep Decarbonization; The TNC pool vehicle fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals	**No gaps** between Projected Trajectory and Deep Decarbonization; The shared minibus vehicle fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals	**No gaps** between Projected Trajectory and Deep Decarbonization; The bus fleet will achieve fuel efficiency improvements at rates at or near what is required to achieve goals

Legend Low 0-10% gap | Medium 10-20% gap | High >20% point gap

Source: Bloomberg Associates Analysis, CURB

Appendix C – Stakeholder Engagement

Bloomberg Associates interviewed 30 experts

Bloomberg Associates interviewed local, regional, and national experts to develop estimates for the existing conditions in building and transportation systems and to identify the key opportunities to reduce the carbon intensity of those sectors.

Buildings Interviewees

Cliff Rechtschaffen, **CA Office of the Governor**
Johanna Partin, **Climate Neutral Cities Alliance**
Mariana DiMascio, **Appliance Standards Awareness Project**
Ariella Maron, **Buro Happold**
Chris Rhine, **Buro Happold**
Julina Parsley, **Buro Happold**
Chris Garvin, **Terrapin Bright Green**
Jim Edelson, **New Buildings Institute**
Laurie Kerr, **Urban Green Council**
Hillary Firestone, **National Resources Defense Council**

Transportation Interviewees

Chris Benner, **UC Santa Cruz**
Austin Brown, **UC Davis Policy Institute for Energy, Env, & Economy**
Emily Castor, **Lyft**
Erin Cooper, **EMBARQ**
Stacy Davis, **Oak Ridge National Laboratory**
Jessie Denver, **SF Dept. of Environment**
Gina Goodhill, **Tesla**
Susan Handy, **UC Davis**
Shruti Hari, **Metropolitan Transportation Commission**
Sal Llamas, Chief Operating Officer, **AC Transit**
Nick Nigro, **Atlas Public Policy**
Val Menotti, **BART**
Nic Lutsey, **International Council on Clean Transportation**
Joel Ramos, **TransForm**
Steve Raney, **Joint Venture Silicon Valley**
Andrew Salzberg, **Uber**
Dan Sperling, **Institute for Transportation Studies at UC Davis**
Cathleen Sullivan, **Alameda Co. Transportation Commission**
Glen Tepke, **Metropolitan Transportation Commission**
Egon Terplan, **SPUR**

Bloomberg Associates convened two sector-specific workshops with experts

Bloomberg Associates convened 30+ Bay Area experts to develop the existing and projected conditions of Oakland's building and transportation systems for CURB and to identify the key opportunities to reduce the carbon intensity of Oakland's those sector.

Buildings Workshop Attendees

Norm Bourassa, **Lawrence Berkeley National Lab**
Amy Dryden, **Build It Green**
Shayna Hirshfield Gold, **Public Works, City of Oakland**
Daniel Hamilton, **Public Works, City of Oakland**
Miya Kitahara, **DNV-GL**
Cole Roberts, **Arup**
Meg Waltner, **Arup**
Wes Sullens, **US Green Building Council**
Andrea Traber, **Integral Group**
Scott Wentworth, **Former City of Oakland**
Alison Williams, **Lawrence Berkeley National Lab**
Kerem Yilmaz, **Global Covenant of Mayors**

Transportation Workshop Attendees

Ratna Amin, **SPUR**
Richard Battersby , **Public Works, City of Oakland**
Dave Burch, **Bay Area Air Quality Management District**
Danielle Dai, **OakDOT**
Becky Dowdakin, **Public Works, City of Oakland**
Michael Ford, **OakDOT**
Ellen Greenberg, **Caltrans**
Jason Haight, **A3 Gig Car Share**
Daniel Hamilton, **Public Works, City of Oakland**
Dermot Hikisch, **A3 Gig Car Share**
Amanda Leahy, **Kittleson & Associates**
Hugh Louch, **Alta Planning and Design**
Ruth McLachlin, **Greenfield Labs**
Melanie Nutter, **Nutter Consulting**
Ed Pike, **Energy Solutions**
Robert Rees, **Fehr and Peers**
Ryan Russo, **OakDOT**
Peter Slowik, **International Council on Clean Transportation**
Emily Stapleton, **Ford GoBike Bay Area**
Iris Starr, **OakDOT**
Amruta Sudhalkar, **AECOM**
Fern Uennatornwaranggoon, **Environmental Defense Fund**
Francecsa Wahl, **Tesla**