

# CAP-AND-TRADE IN CALIFORNIA:

HEALTH AND CLIMATE  
BENEFITS GREATLY  
OUTWEIGH COSTS

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Photo: K. Richardson

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Climate XChange was founded in 2013 with a mission to develop and promote effective and viable policy solutions to reduce carbon emissions. We built and promoted winning climate policies in our home state of Massachusetts and have since brought our expertise, resources and guidance to state-level carbon pricing campaigns around the country. At a time when climate action has been heavily politicized and the federal government is not taking action, it has been left up to state governments to lead the way.

Climate XChange provides research, education, and advocacy tools to promote carbon pricing and bold leadership on climate change. We achieve this through multiple means, such as authoring economic research, providing technical assistance to policymakers crafting state policy, running the Climate Action Business Association, convening the State Carbon Pricing Network, and running a national newsletter. We believe that effective change on carbon pricing can be achieved at the nexus of cutting-edge research, compelling media, and strategic advocacy.

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## I. EXECUTIVE SUMMARY

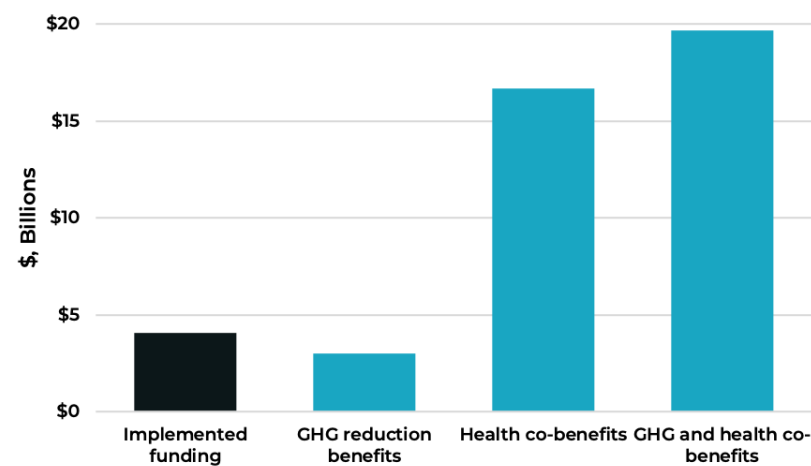
California has an economy-wide cap-and-trade system that began in 2012 and has since expanded, now covering electricity, transportation, industrial use, and heating of buildings. While several countries and regions have cap-and-trade systems covering parts of their economies, only Canada has a system covering as much of their energy use as California, with the former going into effect only in 2019. Through November of 2019, California's system has raised close to \$12 billion, of which \$4 billion has been invested in programs to further reduce greenhouse gas (GHG) emissions and to provide "co-benefits." These co-benefits include reducing deaths and illnesses from air pollutants that accompany GHG emissions, and economic benefits such as job creation. Most of these programs are designed to cut emissions from transportation, the state's largest emitting sector.

The goal of this study is to compare the costs of the GHG-reduction programs to the social value of both reducing the worldwide dangers of climate change and of improving health outcomes for California's population; to determine whether the programs are a cost-effective means for spending large amounts of state resident's and employer's funds. Our findings should also be a useful guide to other states or regions contemplating the use of carbon pricing to create a price incentive to reduce emissions and to generate funds for programs to cut GHG emissions and to provide co-benefits.

California has a highly-developed accounting system for estimating the amount of GHG emissions that are reduced by its programs. These can be turned into a dollar value by applying a "social cost of carbon" to the emission reductions. Further, a dollar value can be placed on the reductions of other local pollutants, which save lives and improve health. Together, the reduction in GHG emissions and in other pollutants have benefits close to five times the cost of the programs.

The same sources that emit greenhouse gases emit other toxic air pollutants, such as particulate matter (PM<sub>2.5</sub>) and ozone, which are harmful to human health. Reducing greenhouse gas emissions therefore also reduces these pollutants, which generates significant public health benefits. Health co-benefits are typically measured by reduced premature mortality,

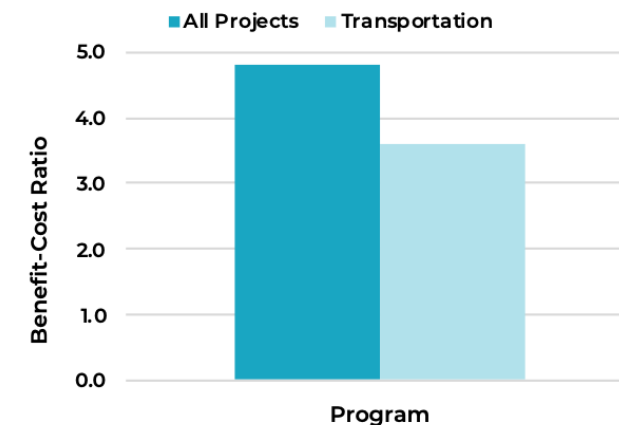
FIGURE 1: Costs and Benefits of Implemented Programs



cardiovascular and respiratory diseases, and avoided emergency room visits from pollution exposure. The value of health co-benefits from emissions reductions are enormous, substantially greater than the value of reducing GHGs, as shown in Figure 1 below. Poor air quality and exposure to pollution have been linked to asthma, decreased lung function and other respiratory issues, cancer, increased risk of heart attack, and associated premature death. We measure the value of reduced mortality using the U.S. Department of Transportation's numbers, including the value of a human life at \$9.6 million.

When the GHG reductions and health co-benefits are combined, they are much larger than the cost of the programs ("implemented funding"), totaling \$19.7 billion in benefits versus \$4.1 billion in implemented costs. As shown in Figure 2 below, the benefits are about 4.8 times the cost of the programs overall, and 3.6 times the costs for transportation programs.

FIGURE 2: Benefit-Cost Ratios for Implemented Cap-and-Trade Investments



These numbers do not include other co-benefits of the programs, which have been studied less than the health co-benefits. But the results show that California's investments from its cap-and-trade dollars provide greenhouse gas and health benefits close to five times their costs. This indicates that

**In California, the reduction in greenhouse gas emissions and in other pollutants have benefits close to five times the cost of the programs.**

California's cap-and-trade system is highly successful, both in reducing the severe planetary dangers of climate change, and in aiding the health of its own population. It would appear that continuing to ramp down the level of allowed emissions, as California plans to do, thereby generating greater revenues for investment, will continue to bring extensive benefits both in-state and worldwide.

## PRIORITY POPULATIONS

California also mandates that a substantial fraction of its cap-and-trade funds benefit "Priority Populations" (PP's), which includes both disadvantaged communities (based on environmental and socioeconomic criteria) and low-income communities and households, totaling to about half the state's population.<sup>1</sup> In California's 2019 Annual Report to the Legislature on California Climate Investments, the state estimated that 60% of projects implemented since August 2017 are located in, and benefiting priority populations.<sup>2</sup> However, projects that span multiple census tracts, such as bus and train lines, can classify 100% of project funds as "located in and benefiting" priority populations — as long as any portion of the project falls within at least one priority census tract. For this reason we find that the state may be overestimating what portion of investment is truly benefiting priority populations. The state needs to more carefully consider the value of benefits to PP's.

Moreover, when the cap-and-trade program was extended through 2030, it barred local air pollution control districts from placing their own regulations on CO<sub>2</sub> pollution — a policy tradeoff that risks exacerbating existing public health inequities. The state can partially rectify this problem by creating data-driven, inclusive processes to channel cap-and-trade investments into the communities that need them the most.

1 | Author derived using data from: California Air Resources Board, 2019. "Priority Population Investments."; California Office of Environmental Health Hazard Assessment, 2018. "CalEnviroScreen 3.0 Results Spreadsheet."

2 | California Air Resource Board, 2019. "2019 Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds."



## II. INTRODUCTION

California, along with Canada, has the world's most extensive carbon pollution pricing system — an economy-wide cap-and-trade for greenhouse gases (GHGs) that began in 2012, and covers about 85% of GHG emissions in the state. Several large jurisdictions, including the European Union and the Northeast and Mid-Atlantic U.S. states, have systems that cover parts of the economy, most often electricity generation; none of them cover GHGs economy-wide. Canada has recently created such a system, as a mix of provincial and national policies.

Under the cap-and-trade program, fossil fuel suppliers, power plants, and major industrial polluters must submit a permit, or allowance, for each metric ton of carbon dioxide equivalent (CO<sub>2</sub>e) that they produce each year. California “caps” pollution in the state by circulating a limited number of allowances each year, with the cap decreasing yearly in line with long-term climate goals. Most of these allowances are sold at government auctions, yielding a market-based price for carbon and raising substantial government revenue. The allowances can then be “traded” among purchasers and sold to suppliers of fossil fuels who need them to sell their fuels.

California has relatively high prices for its allowances to emit CO<sub>2</sub>, approximately \$17 per metric ton CO<sub>2</sub>e as of November 2019 (although this is still low compared to some estimates of the social cost of carbon).<sup>3</sup> As a result, and given the large size of its economy, California has raised over \$12 billion from selling allowances at quarterly auctions as of November 2019.<sup>4</sup> This money is deposited into the state's Greenhouse Gas Reduction Fund (GGRF) and has been invested in or designated for future California Climate Investments, which are programs to reduce carbon emissions, improve public health, increase climate resilience, and create other co-benefits. California has also allocated a slightly larger amount of the allowance budget to financial protection for households and small businesses,<sup>5</sup> and to freely allocated permits to certain categories of large businesses.

A large majority of the investment funds have been allocated for transportation and sustainable development. These programs include electrifying bus lines, extending train lines, and providing subsidies for buying electric vehicles, at a cost of over \$10.2 billion



Photo: Christian Morris, Climate XChange

once fully implemented.<sup>6</sup> California law now requires that at least 35% of these funds must be located in and benefitting disadvantaged or low-income communities and households. Disadvantaged communities are defined by California's Environmental Protection Agency (CalEPA) using CalEnviroScreen, a tool that evaluates census tracts according to 22 different measures of pollution exposure, environmental effects, health sensitivities, and socioeconomic factors.

### LIMITS OVER COMMUNITY-BASED CONTROL OF EMISSIONS

In 2017, Governor Brown signed into law AB 398, which extended California's cap-and-trade program through 2030. As a flagship program in California's climate plans, cap-and-trade is expected to contribute 38% of California's needed emission reductions between 2020 and 2030, more than any other policy.<sup>7</sup>

3 | California Air Resources Board, 2019. “California Cap-and-Trade Program Summary of California-Quebec Joint Auction Settlement Prices and Results.” Trade Auction Proceeds.”

4 | California Air Resources Board, 2019. “California Cap-and-Trade Program, Summary of Proceeds to California and Cosigning Entities.”

5 | Rebates to households are provided through “consigning” the value of allowances to utilities, and then that value is given as equal reductions per household on electricity and natural gas bills.

6 | “Allocated” cost of \$10.2 billion projects; “implemented” to date of \$4.1 billion.

7 | California Scoping Plan 2017

Controversially, the extension bill also limits local government action by prohibiting “an air district from adopting or implementing an emission reduction rule for carbon dioxide from stationary sources that are also subject to a specified market-based compliance mechanism.”<sup>8</sup>

Local control over CO<sub>2</sub> sources, such as power plants and vehicles, can also reduce other pollutants that endanger human health like particulates. This local control is particularly important for disadvantaged communities, which are often disproportionately burdened by pollution.

Market mechanisms such as cap-and-trade are typically designed to tackle large-scale, cumulative emissions over a broad geographic area as efficiently as possible. However, if passing such programs results in the rollback of vital governmental control over local emissions that harm community health, the government must find ways to reassert local control over how pollution and its impacts are distributed throughout the state, be it through cap-and-trade or other programs.

The investment of cap-and-trade revenue back into communities presents an opportunity to claim, to a limited degree, control over where pollution reduction and other benefits occur in the state. Through a combination of data-driven practices and representative government structures, California and other states can fund inclusive programs that reduce pollution in disadvantaged communities and maximize additional economic, health, and social benefits.

### HEALTH AND OTHER CO-BENEFITS FROM CALIFORNIA CLIMATE INVESTMENTS

More generally, what is California getting for its rather large expenditure of funds, planned to total over \$10 billion to date? This question can be viewed narrowly, in terms of reduction of GHGs. It also however, has broader implications because measures to reduce GHG emissions (mainly CO<sub>2</sub> and methane) also reduce other air pollutants that severely damage human health, such as particulate matter (PM<sub>2.5</sub>), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), and ozone. Reducing these

8 | AB 398, 2017. California State Legislature.

9 | Luskin Center for Innovation, UCLA, 2018. “Employment Benefits from California Climate Investments and Co-investments.”

### California has raised over \$12 billion from selling allowances at quarterly auctions as of November 2019.

pollutants can have massive benefits in communities, especially those that have been disproportionately overburdened by pollution due to over-exposure to gasoline and diesel vehicle fumes.

Cutting use of fossil fuels also has other side benefits, such as increasing employment and creating new job opportunities in the state. This is because fossil fuel spending often goes out of state, and tends to be capital-intensive rather than labor-intensive. A 2018 study found that California Climate Investments creates 8.8 jobs per \$1 million invested, compared to 1.6 jobs created per \$1 million invested in the oil and gas industry — thereby significantly expanding job opportunities.<sup>9</sup>

To date, California has required that projects funded by cap-and-trade identify their co-benefits, with CARB reporting three co-benefits and GHG reductions from each program. But these benefits have not been quantified in dollar terms. In this report we quantify the monetary benefits from reducing GHGs, using social costs for the dollar per ton benefits. We then quantify the reductions in deaths and illnesses that can be expected to occur due to co-benefits, relying on studies on the amount of PM<sub>2.5</sub> and other pollutants that are reduced along with CO<sub>2</sub> and methane. Using generally recognized estimates of the value of saving one human life and reducing illnesses, these same studies allow us to calculate the dollar value of the health co-benefits from climate investments and directly compare them to project costs.

### BENEFITS VASTLY EXCEED THE COSTS OF CLIMATE INVESTMENTS

We can then look at the GHG and co-benefit dollar values and compare them to the expected cost of California's projects. While there is much uncertainty about these values, it is evident that the co-benefits add greatly to the GHG benefits, in general exceeding them. Combining the GHG and health co-benefits shows that California's projects have benefits several times larger than their costs.

This study gives a detailed account of the costs of California's programs, their benefits in both GHG and health co-benefits, and their benefit-cost ratios.





Photo: Christian Morris, Climate XChange

### III. FOCUS ON TRANSPORTATION

California’s transportation sector is the largest source of GHG emissions, making up 40% of total emissions in the state.<sup>10</sup> Passenger vehicles alone make up 28% of the state’s total emissions, more than any other sector. Transportation emissions have even increased between 2013 and 2017, even though in 2012 former Governor Jerry Brown called for the state to reduce greenhouse gas emissions from the transportation sector to 80% below 1990 levels by 2050.<sup>11</sup> The state has several regulations and programs in place to help achieve these goals, including California Climate Investments. To incentivize the transition away from highly polluting vehicles, there must be large-scale investments to improve public transportation systems and make low-carbon transportation more accessible and affordable.

Over 55% of implemented California Climate Investments (CCI) funding has gone towards transportation-focused programs – a total of \$2.3 billion by August 2019.<sup>12</sup> They constitute four of the top five highest-funded programs and make up over two-thirds of all CCI projects. Implemented transportation funds have reduced statewide emissions by 2.9% annually since 2013. The program is expected to reduce emissions by 5.9% once all the funds that have already been allocated are implemented – excluding the expected 1.5 million

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MTCO<sub>2</sub>e reduced annually by the High Speed Rail, which would reduce emissions by an additional 0.4%.<sup>13</sup>

Due to the large transportation investments being made, it is important to look at how they reduce emissions and benefit California’s population. Compared to other CCI programs, like the investments in energy efficiency in buildings and agricultural improvements including the Dairy Digester Research and Development Program, transportation yields relatively lower reductions in GHG’s per dollar spent, as shown in Figure 2. Moreover, benefits of CCI transportation projects are determined geographically; the people receiving the programs’ benefits depend almost entirely on where the projects are located.

The Transit and Intercity Rail Capital Program (TIRCP), which receives 10% of Greenhouse Gas Reduction Funds annually, funds projects that improve and expand transit service, shift transit away from polluting vehicles to low- and zero-carbon fleets, and increase connectivity between bus and rail systems. The TIRCP serves as a key example of why the location of these projects is so important, since project benefits only reach areas where the projects physically are located. For instance, new buses benefit residents where the bus route travels and new transit stops or stations benefit residents living or working near them.

10 | California Air Resources Board, 2019. “California Greenhouse Gas Emissions Inventory: 2000 - 2017.”  
11 | Office of Governor Edmund G. Brown Jr., 2012. “Executive Order B-16-2012.”  
12 | California Air Resource Board, 2019. “2019 Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds.”  
13 | California High-Speed Rail Authority, 2019. “Good for the Environment.”

### IV. GHG REDUCTION DISCUSSION AND TABLES

Using the EPA and US Interagency Working Group’s social cost of carbon (IWG-SCC), adjusted to 2020 dollars, we estimated the global cost savings of avoided damages due to a reduction in carbon dioxide emissions. These cost savings are therefore equivalent to the benefit of reducing greenhouse gas emissions. The value of avoided damages of climate change incorporates impacts such as health consequences, reduced agricultural production, heat waves, and property loss. Values vary greatly depending on discount rates – the IWG provides values for discount rates of 2.5%, 3% and 5% – and we use the average value of \$63.82 for the 2.5% and 3% discount rates.<sup>14</sup> We estimate that the global greenhouse gas reduction benefit from all implemented California Climate Investments is over \$3 billion, with transportation benefits amounting to \$797 million.

We found that the monetary benefits of reducing CO<sub>2</sub> emissions on their own do not outweigh the costs of these programs. On average, the benefit-cost ratio of transportation programs is only 0.5 – using the social

**We estimate that the global GHG reduction benefit from all implemented California Climate Investments is over \$3 billion, with transportation benefits amounting to \$797 million.**

cost of carbon provided by the IWG.<sup>15</sup> Using a higher estimate for the social cost of carbon would deliver larger GHG cost savings and benefit-cost ratios. However, in this study we have conservatively used the Interagency Working Group’s 2016 numbers due to their representing a U.S. government consensus.<sup>16</sup>

Since the greenhouse gas reduction benefits calculated by the IWG’s figures by themselves may not warrant investing billions in transportation, it is important to include the additional social and economic co-benefits of reducing emissions, as we discuss in the following section.

**FIGURE 3:** Global benefits of GHG reductions from implemented California Climate Investments

Program	Greenhouse gas cost savings, \$millions	Greenhouse gas benefit-cost ratio
All Programs	\$3,028	0.74
All Transportation Programs	\$797	0.50
Transit and Intercity Rail Capital Program	\$149	0.44

**NOTE:** GHG reduction benefits calculated at an average of 3.0% and 2.5% discount rates, using the IWG’s cost of carbon figures.

14 | United States Environmental Protection Agency, 2016. “Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis.”  
15 | Some experts believe that the IWG-determined social cost of \$63.82 per ton is low, and their estimates range from \$75 to \$417 per ton. See:  
• Peter Howard, Derek Sylvan, 2015. “The Economic Climate: Establishing Consensus on the Economics of Climate Change.”  
• Kevin Rennert, Cora Kingdon, Resources for the Future, 2019. “Social Cost of Carbon 101.”  
• Katharine Ricke et. al., 2018, “Country-level social cost of carbon,” Nature Climate Change.  
• The Report of the High-Level Commission on Carbon Prices found that the carbon price needed to achieve the Paris Agreement target is at least \$40-\$80 per metric ton CO<sub>2</sub> by 2020 and \$50-\$100 per metric ton CO<sub>2</sub> by 2030.  
16 | In 2017, President Trump issued an executive order disbanding the IWG and stated the IWG social cost of carbon estimate is no longer representative of federal government policy. In a 2018 document, the EPA gives a new “interim” domestic estimate of the social cost of carbon at \$7 per ton CO<sub>2</sub> in 2020.



## V. CO-BENEFIT DISCUSSION AND TABLES

### A. CO-BENEFITS OF GHG REDUCTIONS

Over the past few years, CARB funding guidelines have changed to highlight the additional benefits individuals, households, communities, and businesses receive from California Climate Investments. These “co-benefits” include social, economic and environmental benefits that go beyond greenhouse gas emission reductions.

**THE CALIFORNIA AIR RESOURCES BOARD OFFERS QUANTITATIVE METHODOLOGIES TO TRACK TWELVE DIFFERENT CO-BENEFITS:**<sup>17</sup>

**I. JOBS:** the number of jobs supported by California Climate Investments projects.

**II. AIR POLLUTANT EMISSIONS:** emissions of select air pollutants, including particulate matter (PM<sub>2.5</sub> and diesel PM), nitrogen oxide (NO<sub>x</sub>), and reactive organic gases (ROG).

**III. TRAVEL COST SAVINGS:** changes in travel costs as a result of switching travel modes.

**IV. VEHICLE MILES TRAVELED (VMT):** changes in VMT as a result of transportation mode shift, or limiting expansive, vehicle-dependent forms of development.

**V. ENERGY AND FUEL COST SAVINGS:** changes in energy and fuel costs as a result of changing the quantity of energy or fuel used, conversion to alternative energy or fuel, and renewable energy or fuel generation.

**VI. WATER SAVINGS:** changes in water use from a change in agricultural irrigation; efficiency measures in facilities; green infrastructure intended for water capture and infiltration; and tree or vegetation planting requiring more irrigation.

**VII. SOIL HEALTH AND CONSERVATION:** the acres of agricultural land on which soil health practices are implemented; natural or agricultural land that is conserved or protected; natural or agricultural land that is converted for development; and agricultural land on which compost produced by a project could be applied.

**VIII. CLIMATE ADAPTATION:** changes in resilience and vulnerability to the effects of climate change, including extreme heat, drought, sea level rise and inland flooding, agricultural productivity, species habitat and wildfire.

**IX. COMMUNITY ENGAGEMENT:** the level of community engagement in planning, design and implementation of community scale projects.

**X. HEART AND LUNG HEALTH:** expected changes in the occurrences of premature cardiopulmonary mortality, hospitalizations for cardiovascular and respiratory illnesses, and emergency room visits for respiratory illnesses and asthma due to changes in emissions of criteria and toxic air pollutants.

**XI. ANTI-DISPLACEMENT:**<sup>18</sup> displacement refers to the changes in residence caused by neighborhood transformation. In the future, CARB will be tracking disinvestment displacement, reinvestment displacement, and displacement caused by enhanced market competition.\*

**XII. ACCELERATED IMPLEMENTATION OF TECHNOLOGY:**<sup>19</sup> the development or diffusion of a given technology faster than it would have occurred without California Climate Investments.\*

**\* NOTE:** This co-benefit is not assessed because it is difficult to identify the impact of factors other than CCI projects on the outcome of this co-benefit.

<sup>17</sup> | California Air Resources Board, 2019. “CCI Co-benefit Assessment Methodologies.”

<sup>18</sup> | Xu, Ruoying, Center for Resource Efficient Communities, 2017. “Methods to Assess Co-Benefits of California Climate Investments: Anti-Displacement.”

<sup>19</sup> | Xu, Ruoying, Center for Resource Efficient Communities, 2017. “Methods to Assess Co-Benefits of California Climate Investments: Accelerated Implementation of Technology.”

Transportation projects typically create jobs, air pollutant emission reductions, reductions in VMT, and energy and fuel cost savings.

Co-benefits are determined by the agencies administering each program, based on the project’s purpose, highest benefits, and other factors (with the top three reported to CARB) although programs typically generate more co-benefits than reported. Agencies administering the programs must report project data on everything from GHG and pollutant reductions, like particulate matter and ozone, to water use savings and the number of jobs created. Transportation projects typically create jobs, air pollutant emission reductions, reductions in VMT, and energy and fuel cost savings.

Data for many co-benefits are also not available yet (as of early 2020), because there is a delay in reporting and CARB expanded the amount of information collected in recent reporting cycles. As a result, there is limited information on how much residents have benefited from implemented CCI projects.<sup>20</sup> In future years, more information about the co-benefits of California Climate Investments will be available.

In 2018, state agencies developed the Third Investment Plan for CCI funds, which recommends that the Legislature prioritize programs that have a community focus, generate health benefits, support job training and contribute to a long-term transformation to resilient, low-carbon communities.<sup>21</sup> Many of these co-benefits are difficult for state governments to reasonably measure and track, but are also substantial. For example, increasing transit stops in priority population census tracts also increases residents’ access to jobs, grocery stores, and healthcare. These impacts are extensive, complex, and can’t fully be reflected in a dollar estimate. However, this highlights the importance of community engagement by those impacted most, and an inclusive governance structure to give communities direct influence in projects that change their surrounding environment.

### B. NATURE OF HEALTH CO-BENEFITS AND THE VALUATION OF POLLUTION

Public health benefits of reducing carbon emissions are also important to highlight. The same sources that emit carbon dioxide emit other pollutants harmful to human health, such as volatile organic compounds and NO<sub>x</sub>, SO<sub>x</sub>, PM<sub>2.5</sub> particles from vehicle exhaust, power plants, agricultural and industrial activities.

Poor air quality and exposure to pollution has been linked to asthma, decreased lung function and other respiratory issues, cancer, increased risk of heart attack, and premature death.<sup>22</sup> People with preexisting heart or lung diseases, children, and elderly adults are most likely to be impacted by exposure and face a higher chance of illness. Reducing pollutants therefore reduces the risks of these illnesses. Projects funded by the CCI reduce harmful pollutants simultaneously with greenhouse gas emissions, producing both long- and short-term benefits to public health. Decreasing pollution also reduces the number of emergency room visits from cardiovascular and respiratory problems, work and school days lost, and the burden of healthcare costs.

Photo: Amanda Griffiths, Climate XChange



<sup>20</sup> | Methods to calculate co-benefits were not established until 2018, so agencies did not have the option to report co-benefits prior to 2018. Source: California Air Resources Board, 2017. “2017 Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds.”

<sup>21</sup> | California Air Resource Board, 2019. “2019 Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds.”

<sup>22</sup> | United States Environmental Protection Agency, 2018. “Health and Environmental Effects of Particulate Matter (PM).”



**On average, the transportation wedges reduced premature mortality by 706 lives and decreased asthma-related emergency room visits by 1,223 visits per year; the economy-wide wedges reduced premature mortality by 1,129 lives and decreased asthma-related emergency room visits by 1,947 visits per year.**

The reduction in deaths and illnesses from reduced emissions of  $PM_{2.5}$  and other local pollutants have been estimated in several academic studies. Of seven such studies that we reviewed, three provided sufficient data to estimate the dollar cost savings due to reduced mortality and morbidity — by Thompson et al., Hamilton et al., and Balbus et al., the first covering worldwide impacts, and the second and third estimates focused on the United States.<sup>23, 24</sup> Thompson et al. and Balbus et al. use the EPA's Environmental Benefits Mapping and Analysis (BenMAP) software, which estimates the economic value of health impacts from changes in ground-level ozone ( $O_3$ ) and particulate matter ( $PM_{2.5}$ ). BenMAP measures health impacts from particulate matter and ozone that include premature death, non-fatal heart attacks, aggravated asthma, and lost days of school.<sup>25</sup>

Thompson (2014) looks at three different mitigation policies — economy-wide cap-and-trade, clean energy standards in the electricity sector and a transportation policy aimed at reducing emissions from light-duty passenger and heavy duty vehicles — each of which is designed to reduce GHGs by 500 million tons/year. Thompson et al. assess the costs and health benefits of  $PM_{2.5}$  and ozone emissions in the United States, estimating reductions in human mortality and illnesses related to air pollution. Thompson et al. look at eight studies that estimate increased mortality risk due to changes in ozone or particulate matter concentrations. If the transportation policy was implemented, estimates range

from about 300 to 1,500 avoided deaths from ozone reduction, and 20,000 to 47,000 avoided deaths from  $PM_{2.5}$  reductions in 2030. If the economy-wide cap-and-trade program was implemented, estimates range from about 100 to 400 avoided deaths from ozone reduction, and 10,000 to 22,000 avoided deaths from  $PM_{2.5}$  by 2030.

Balbus (2015) estimates health co-benefits from climate change mitigation using a wedge-based approach. Balbus et al. define a U.S. wedge as “an activity that avoids emissions of [around] 750  $MtCO_2$  per year after 50 years, or [around] 19  $GtCO_2$  cumulatively.” These activities fall into three main sectors — transportation, buildings, and power plants — and include increased fuel efficiency and fuel substitution for each sector. Along with reductions in  $CO_2$ , many wedge activities reduce  $PM_{2.5}$ ,  $SO_x$  and  $NO_x$ ; reductions in air pollutants were assumed to scale proportionally with reductions in  $CO_2$  in this study. On average, the transportation wedges reduced premature mortality by 706 lives and decreased asthma-related emergency room visits by 1,223 visits per year; the economy-wide wedges reduced premature mortality by 1,129 lives and decreased asthma-related emergency room visits by 1,947 visits per year.

Hamilton et al. (2017) looked at empirical studies of global public health benefits of climate mitigation, and estimated country-level impacts of air pollutants on human health.<sup>26</sup> The study examines  $PM_{2.5}$  damages, which includes the mortality from cancer, cardiovascular disease and all causes of mortality

23 | Balbus, John M., et al., 2015. “A Wedge-Based Approach to Estimating Health Co-Benefits of Climate Change Mitigation Activities in the United States.”

24 | Thompson, Tammy M., et al., 2014. “A Systems Approach to Evaluating the Air Quality Co-Benefits of US Carbon Policies.”

25 | United States Environmental Protection Agency, 2018. “How BenMAP-CE Estimates the Health and Economic Effects of Air Pollution.”

26 | Hamilton, Kirk, et al., 2017. “Multiple benefits from climate change mitigation: assessing the evidence.”



Photo: Amanda Griffiths, Climate XChange

linked to exposure, and ozone damages. Combined, these estimates are calculated as the “total air pollution” co-benefits. The study estimates the median deaths from ambient  $PM_{2.5}$  exposure from the World Health Organization's Global Burden of Disease Study 2010, which examines global distribution and trends of major diseases, injuries and other health risk factors.<sup>27</sup> In the United States, this was estimated at 103,027 deaths, which represents a cost of \$87 to \$126 per metric ton of  $CO_2$  emitted. Our analysis greatly depends on the value of a human life; to value the benefits of reduced premature mortality rates, both studies use the EPA's estimated value of statistical life (VSL) employed in BenMAP.<sup>28</sup> The VSL is how much

society is willing to pay in aggregate to reduce its risk of death to avoid one additional death across the population. Balbus et al. used a VSL of \$6.324 million (the primary value used in the BenMAP software) in their analysis, which was determined by the average value in 26 economic studies.<sup>29</sup> Thompson et al. also use the EPA estimated VSL in the BenMAP version 4.0.67 that estimates increased mortality risk due to changes in ozone and  $PM_{2.5}$  concentrations. Studies examined by Hamilton et al. used a range of VSL \$5.0 to \$6.2 million for health estimates in the United States. In our calculations, this VSL has been adjusted to a more recent estimate in 2016 from the U.S. Department of Transportation of \$9.6 million.<sup>30</sup>

27 | World Health Organization, The Partnership for Maternal, Newborn & Child Health, 2012. “Global Burden of Disease 2010 Study published.”

28 | BenMAP uses 2000 dollars.

29 | United States Environmental Protection Agency, 2008. “Environmental Benefits Mapping and Analysis Program User's Manual Appendices.”

30 | United States Department of Transportation, 2016. “2016 Revised Value of a Statistical Life.”



C. RESULTS FROM THE HEALTH CO-BENEFITS STUDIES

Given that we are using these studies to evaluate California’s investment spending, which is largely for transportation, we have used a separate estimate to calculate the health co-benefits of transportation programs using only the transportation numbers from the Balbus and Thompson studies. Thompson gives widely varying low and high estimates for the value of the benefits, of \$22 billion and \$981 billion, from which we took their median value, of \$287 billion.<sup>31</sup> This yielded a value per metric ton of GHG reduced of \$574/ton – \$770/ton with an adjusted VSL – far above the cost of the programs or the value of GHG reduced.

Balbus provided a “wedge-based” approach, using ten different CO<sub>2</sub> reduction wedges. Three of these were for transportation – increasing the efficiency of light duty and heavy duty vehicles, and reducing vehicle miles traveled of light duty vehicles. We combined the results for these three methods of reducing GHGs. The results found a mean value of \$74 per ton, yielding an estimate of \$100/ton with the adjusted VSL.

Combining these two studies yielded an average value of \$435 in health benefits per ton of CO<sub>2</sub> for transportation projects.

To determine the benefits of non-transportation programs, we used an economy-wide co-benefit

Combining these two studies yielded an average value of \$435 in health benefits per ton of carbon dioxide for transportation projects.

estimate. Hamilton et al. estimate that in the United States, PM<sub>2.5</sub> impacts were valued at a range of \$103 to \$622, and ozone damages were valued at a range of \$13 to \$39 per ton CO<sub>2</sub>e. In total, air pollution damages amounted to \$116 per ton CO<sub>2</sub>e for a low estimate, and \$662 per ton for the high estimate, yielding a mean of \$389 per ton. Once adjusted to the 2016 VSL, this estimate was \$522 per ton. For all ten CO<sub>2</sub> reduction wedges identified by Balbus et al., identified a low co-benefit estimate of \$40 per ton and a high estimate of \$198 per ton. This yielded mean benefits of \$119 per ton – \$160 per ton with the adjusted VSL. An economy-wide cap-and-trade program was among the emission reduction policies examined by Thompson et al. Reducing emissions by 500 million tons per year, yielded benefits between \$11 billion and \$473 billion. Looking at their median value of \$139 billion, yielding benefits of \$278 per ton. Once adjusted for the 2016 VSL, this gave an estimate of \$373 per ton.

Using an average of these three economy-wide estimates, we used a value of \$351 per ton of CO<sub>2</sub> to evaluate health co-benefits of non-transportation programs.



Photo: Amanda Griffiths, Climate XChange

31 | Thompson et al., Table 1, page 918. Their 95% confidence interval has a low end of \$22 billion to a high end of \$981 billion for the air pollution benefits of investing funding into clean transportation; from which they estimate a median value of \$287 billion.

VI. GHG AND HEALTH BENEFITS COMPARED TO COST

A. GHG AND HEALTH CO-BENEFITS

At the economy-wide health co-benefit estimate per ton, health co-benefits are about five times the GHG benefits of California’s implemented funds to date – at about \$16.7 billion versus \$3.0 billion – as shown in Figure 4 below. Looking solely at transportation programs, the health co-benefits estimate is \$5.4 billion, almost seven times the GHG reduction benefits of implemented transportation funds. For all CCI programs, the health co-benefits greatly outweigh the GHG reduction benefits on their own.

FIGURE 4: Health co-benefits, \$billions

Program	Total implemented funding	Greenhouse gas reduction benefits	Health co-benefits	Total benefits	Benefit-cost ratio, total benefits
All programs	\$4.1	\$3.0	\$16.7	\$19.7	4.8
Transportation programs <sup>32</sup>	\$1.7	\$0.8	\$5.4	\$6.3	3.6

B. COMPARING BOTH GHG AND HEALTH CO-BENEFITS TO COST OF PROJECTS

The overall cost of implemented funds was about \$4.1 billion, while those for transportation programs were \$1.7 billion, excluding High-Speed Rail. Compared to the combined GHG and health co-benefits, the benefit-cost ratio was 4.8 for all programs and 3.6 for transportation programs – remarkably high numbers.

These benefit-cost numbers demonstrate that when the value of reducing GHGs and the health co-benefits are combined, they far exceed the cost of implementing the programs, whether these are all forty-five programs funded by cap-and-trade or just the transportation programs.

FIGURE 5: Costs and Benefits of California Climate Investments

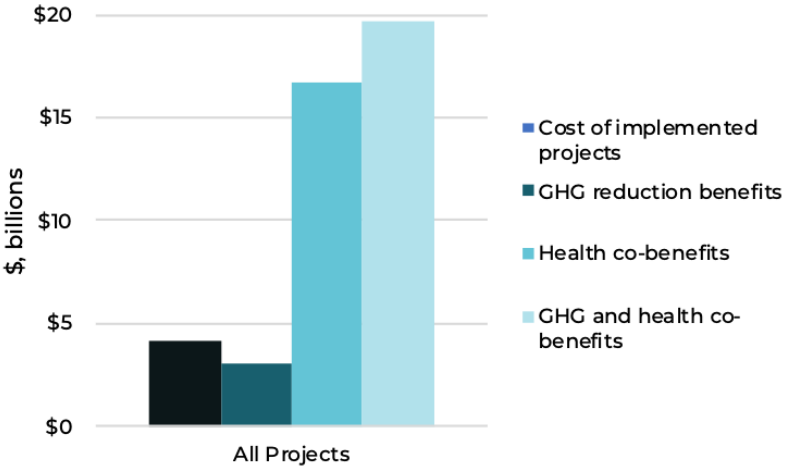
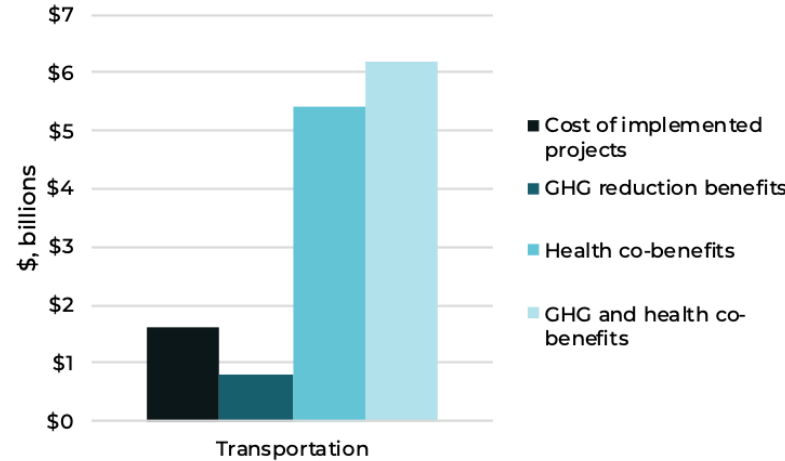


FIGURE 6: Costs and Benefits of Transportation Programs



32 | Excludes High-Speed Rail



The highest-funded transportation programs yielded benefits between double and six times the costs.

Figure 7 below shows the six transportation programs with the highest implemented funds to date, out of a total of seventeen. Funding of transportation programs vary greatly, as high as \$625 million for the High Speed Rail, and as low as \$928,000 for the Vehicle Retirement and Replacement program. The Low Carbon Transit Operations Program has

the highest benefit-cost ratio, at 6.4, and the Clean Vehicle Rebate Project followed with a benefit-cost ratio of 4.9. With the exception of the Zero-Emission Truck and Bus Pilot Program, which had a benefit-cost ratio of 0.6, the highest-funded transportation programs yielded benefits between double and six times the costs.

FIGURE 7: Summary of benefits and costs for largest transportation programs, \$millions

Program	Total implemented funding	Greenhouse gas reduction benefits	Health co-benefits	Total benefits	Benefit-cost ratio, total benefits
High Speed Rail <sup>33</sup>	\$ 625	—	—	—	—
Clean Vehicle Rebate Project	\$ 579	\$365	\$2,489	\$2,854	4.9
Transit and Intercity Rail Capital Program	\$ 339	\$149	\$1,018	\$1,167	3.4
Hybrid & Zero Emission Truck and Bus Voucher Incentive Project	\$ 277	\$68	\$462	\$530	1.9
Low Carbon Transit Operations Program	\$ 248	\$204	\$1,391	\$1,595	6.4
Zero-Emission Truck and Bus Pilot	\$ 83	\$7	\$46	\$53	0.6

NOTE: GHG reduction benefits calculated at an average of 3.0% and 2.5% discount rates. Total benefits include GHG reduction benefits and health co-benefits.

33 | The High-Speed Rail Program is not expected to be completed until at least 2029, so greenhouse gas emission reductions have not been reported. The High-Speed Rail Program connects California's most populated cities and regions via a new rail system; the Transit and Intercity Rail Capital Program modernizes and improves existing transit (bus, ferry, rail) lines.

Figure 8 shows the six non-transportation programs with the highest implemented funding to date. These programs also generate massive benefits, with the highest coming from the CALFIRE Forest Health and Dairy Digester Research and Development programs targeting emissions from forest fires and agriculture. Total benefits of the Dairy Digester Program<sup>34</sup> were 46.4 times higher than the implemented funds, and the Forest Health Program, which aims to prevent forest fires and improve fire-related education and emergency response, has benefits 15.8 times greater than the program's costs to date. Affordable housing and household energy efficiency programs have benefits just higher than their costs, 1.1 and 1.5 times larger, respectively.

FIGURE 8: Summary of benefits and costs for largest non-transportation programs, \$millions

Program	Total implemented funding	Greenhouse gas reduction benefits	Health co-benefits	Total benefits	Benefit-cost ratio, total benefits
Affordable Housing & Sustainable Communities	\$ 433	\$75	\$412	\$487	1.1
Community Air Protection	\$ 165	\$5	\$25	\$29	0.2
CALFIRE Forest Health Programs	\$ 136	\$332	\$1,825	\$2,157	15.8
Single- & Multi-Family Energy Efficiency & Renewables	\$ 128	\$29	\$159	\$187	1.5
Dairy Digester Research & Development Program	\$ 115	\$817	\$4,496	\$5,313	46.4
Urban Greening Program	\$ 98	\$2	\$13	\$15	0.2
Fire Prevention Grants Program <sup>35</sup>	\$ 76	—	—	—	—

NOTE: GHG reduction benefits calculated at an average of 3.0% and 2.5% discount rates. Total benefits include GHG reduction benefits and health co-benefits.

34 | The Dairy Digester Research and Development Program reduces methane emissions from dairy and livestock production and decreases use of fossil fuels. Methane emissions lead to the formation of ozone, which is harmful to human health, as the health studies found. The European Commission Joint Research Centre found that global methane emissions could cause between 40,000 and 90,000 additional premature deaths globally by 2050, compared to 2018 projections. In addition, when methane is turned into fuel it reduces use of fossil fuels, providing further health benefits. European Commission Joint Research Centre, 2018. "Reducing methane emissions can play a key role in reducing ozone worldwide."

35 | The Fire Prevention Program does not have quantified emissions reduction.



# VII. BENEFITS TO PRIORITY POPULATIONS

## A. DEFINITIONS AND FUNDING GUIDELINES

Under SB 535, Disadvantaged Communities are defined by California's Environmental Protection Agency (CalEPA) using results of the California Communities Environmental Health Screening Tool (CalEnviroScreen 3.0).<sup>36</sup> Overall scores are determined based on several geographic, socioeconomic, public health and environmental hazard criteria, as well as CalEPA Pollution Burden scores and Population Characteristic scores. The 25% highest scoring census tracts, along with other low-population census tracts with high amounts of pollution, are classified as disadvantaged communities by CalEPA. There are 22 census tracts that do not have CalEnviroScreen scores due to unreliable data, but score in the highest 5% of Pollution Burden, that are also included as disadvantaged communities under SB 535.

SB 535 required that a minimum of 25% of the revenue in the Greenhouse Gas Reduction Fund (GGRF) be allocated to projects that provide at least one benefit to disadvantaged communities, with at least 10% to be allocated to projects located within disadvantaged communities.<sup>37</sup>

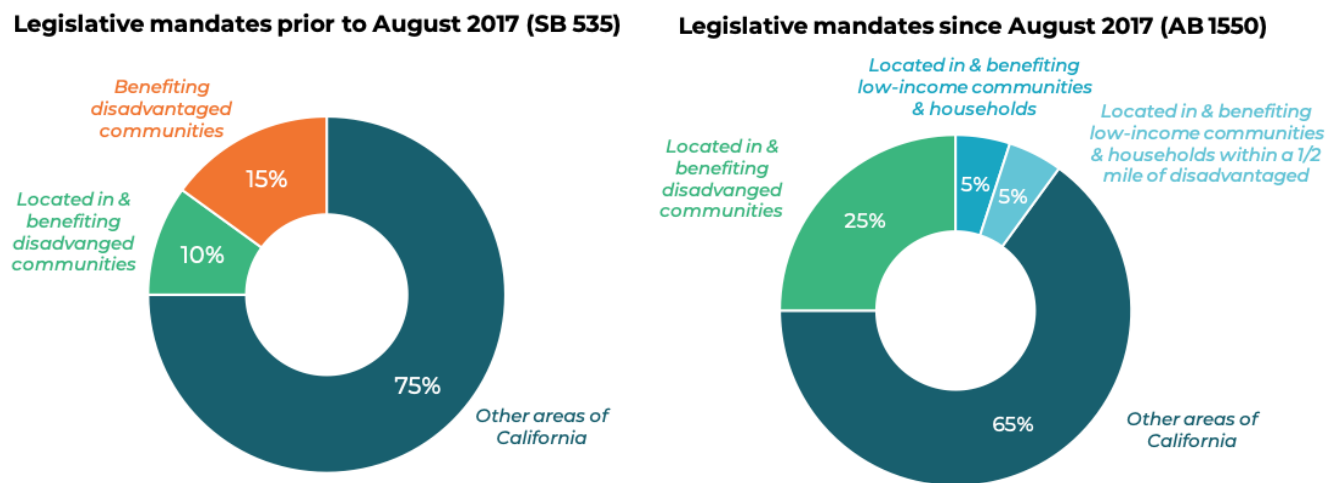
In 2016, new legislation established higher investment minimums for disadvantaged communities

and created investment requirements for low-income communities and households. Low-income households and communities are defined at the individual household or census tract level, as at or below 80% of the state-wide median income or the threshold designated as low-income by the Department of Housing and Community Development's (HCD) State Income Limits.<sup>38</sup>

Under AB 1550, projects located in and benefitting disadvantaged communities increased from 10% to 25%.<sup>39</sup> AB 1550 established new investment minimums in low-income communities and households as well. Projects that benefit, and are located within, low-income households or individuals in low-income communities must receive 5% of funding; an additional 5% of funding must benefit low-income households or communities that are outside of, but within a half mile of, disadvantaged communities.<sup>40</sup>

Disadvantaged communities, low-income communities and low-income households are collectively defined as "priority populations." Effective January 1, 2017, all CCI projects funded after August 2017 must provide benefits to priority populations as directed by AB 1550 guidelines.

FIGURE 9: California Climate Investments legislative mandates



36 | California Environmental Protection Agency, 2017. "Designation of Disadvantaged Communities Pursuant to Senate Bill 535 (De León)."  
37 | De León, 2012. Senate Bill 535.  
38 | California Air Resources Board, 2017. "Identification of Low-Income Communities under AB 1550 Methodology and Documentation for Draft Maps."  
39 | Gomez, 2016. Assembly Bill 1550.  
40 | California Air Resources Board, 2018. "California Climate Investments: Investment Targets for Agencies Administering; FY 2018-19 Funds."

## B. BENEFITS TO PRIORITY POPULATIONS

### WHAT DOES BENEFITTING A PRIORITY POPULATION MEAN?

Under SB 535, projects were reported to benefit disadvantaged communities if they were located within these communities, or if they are outside of disadvantaged communities, projects must provide a "direct, meaningful, and assured benefit to a disadvantaged community; and meaningfully addresses an important community need."<sup>41</sup> AB 1550 guidelines refine this definition, so that only projects located within disadvantaged communities are considered to benefit priority populations. To count towards achieving the required investment minimums, AB 1550 also includes projects that are located within low-income communities, as well as projects that benefit low-income households and are within a half mile of disadvantaged census tracts.

The California Air Resources Board developed guidelines for agencies administering California Climate Investments. Among the criteria for transportation, benefits for priority populations include:

- 1. REDUCE AIR POLLUTANTS** and toxic air contaminant emissions in priority populations through incentives for clean transportation and technology, improvements to transportation infrastructure, or reductions in vehicle miles traveled.<sup>42</sup>
- 2. PROVIDE GREATER MOBILITY** and increased access to clean transportation by adding or improving transit stops and stations within a priority population, improving connectivity between travel modes and communities, or increasing access to shared-mobility transportation options (vanpooling, ride-sharing, car-sharing).<sup>43</sup>
- 3. IMPROVE SAFETY**, comfort, and service of the transportation system within a priority population.

41 | California Air Resources Board, 2015. "Funding Guidelines for Agencies that Administer California Climate Investments."  
42 | California Air Resources Board, 2018. "California Climate Investments: Evaluation Criteria for Providing Benefits to Priority Populations, Clean Transportation and Equipment."  
43 | California Air Resources Board, 2018. "California Climate Investments: Evaluation Criteria for Providing Benefits to Priority Populations, Transit"  
44 | California Department of Transportation, 2019. "Transit and Intercity Rail Capital Program (TIRCP)."  
45 | California Air Resources Board, 2018. "California Climate Investments: Investment Targets for Agencies Administering; FY 2018-19 Funds."  
46 | California Air Resource Board, 2019. "2019 Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds."

These projects transform the state's rail systems and bus and ferry systems to reduce emissions, vehicle miles traveled and congestion.

## C. HOW MUCH ARE PRIORITY POPULATIONS REALLY BENEFITING?

### TRANSIT AND INTERCITY RAIL CAPITAL PROGRAM (TIRCP)

One of the highest funded CCI programs is the Transit and Intercity Rail Capital Program (TIRCP). Established in 2014, the TIRCP uses cap-and-trade revenue to fund improvements that modernize and decarbonize California's transit systems. These projects transform the state's rail systems and bus and ferry systems to reduce emissions, vehicle miles traveled and congestion. The primary objective of the TIRCP is to reduce greenhouse gas emissions, but it also improves service to increase ridership, increase connectivity between existing rail systems and improve transit safety throughout the state.<sup>44</sup> So far, the program has added almost 20 zero-emission light rail vehicles, 200 zero-emission buses, and 55 lower-emission buses throughout California. TIRCP has also added new trolley stations and trolley vehicles, completed rail segments to extend transit lines and electrified the Caltrain commuter rail between San Jose and San Francisco.

Projects are evaluated to receive funding based on how well they would meet TIRCP objectives. By statute, the TIRCP is allocated 10% of quarterly auction funds in the GGFR, and receives additional annual funding determined by CalSTA.<sup>45</sup> Since the program started, TIRCP has been allocated \$869.1 million; \$338.9 million of that has been implemented to fund transportation projects. In 2018 alone, \$40.6 million was implemented.<sup>46</sup>



As of May 2019, a total of 21 projects have been funded under the TIRCP. These include projects to replace propane and diesel vehicles with zero-emission electric buses, expand transit connections between cities, and build new transit stations to increase public access.

Co-benefits of the TIRCP include a reduction of 63 million vehicle miles traveled, 341,000 pounds of NOx and 3,900 pounds PM<sub>2.5</sub>.<sup>47</sup>

BENEFITS TO PRIORITY POPULATIONS

CARB looks at transportation project benefits holistically; they are not split by how much they benefit priority populations or the general public, partly because it is difficult to track components of these projects.<sup>48</sup> It is also difficult to determine how many priority population census tracts actually benefit from these projects, because state agencies are required to only report one tract to CARB. Counties, depending on their size, typically have hundreds of census tracts.<sup>49</sup>

CARB might be overestimating the benefits that priority populations receive, because the projects are not broken up by the amount that priority populations benefit versus non-priority populations.

If a project crosses through at least one census tract that is designated as a priority population, then 100% of the project funds are classified as located within and benefiting priority populations under AB 1550.<sup>50</sup> This means that if a bus line has one stop in a priority population census tract the entire cost of improving the bus line is counted as located within and benefiting priority populations.

To date, based on its estimating methods, CARB has reported that a total of \$2.4 billion have benefitted priority populations, 58% of total funding that has been implemented so far, even though only 35% is required by AB 1550. However, breaking this down further gives different results. Much of the historical benefits of investments would not qualify under AB 1550; of the \$2.2 billion awarded under SB 535, approximately \$440 million was invested in projects that are located in and benefit disadvantaged communities — benefits that qualify under the new legislation. This makes up only 20% of investments awarded under SB 535. CARB has reported that just over \$1.1 billion of funding since August 2017 has benefitted priority populations, 60% of implemented funding awarded under AB 1550. In total, \$1.6 billion under SB 535 and AB 1550 has benefitted priority populations, according to the AB 1550 definition, only 38% of cumulative CCI funding.

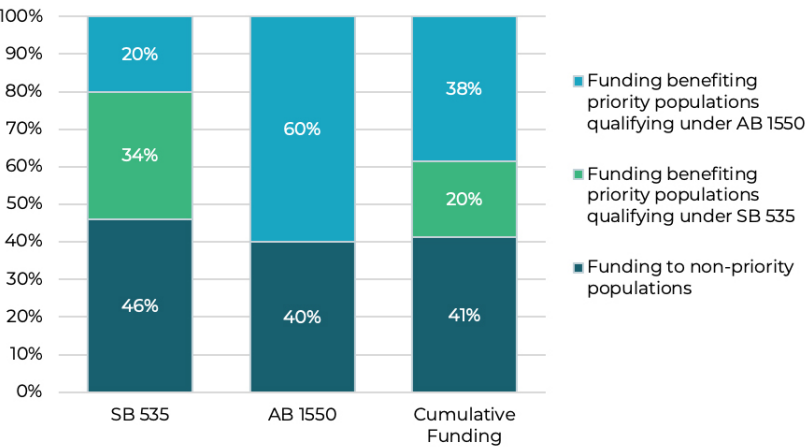


FIGURE 10: Funding benefiting priority populations<sup>51</sup>

NOTE: SB 535 funding that qualifies as benefiting priority populations under AB 1550 is funding that was located within and benefited disadvantaged community census tracts. SB 535 funding that benefited disadvantaged communities, but does not qualify as benefiting priority populations under AB 1550 (green), occurred outside of disadvantaged communities.

47 | California Air Resource Board, 2019. "2019 Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds."

48 | Conversation with Bailey Smith of California Air Resources Board, August 6, 2019.

49 | See, for example, pages 15 to 17 of this study concerning Orange County: <https://communityresilience.uci.edu/wp-content/uploads/2018/02/UCI-OC-GGRF-Report-FINAL-1.pdf>.

50 | Email conversation with Bailey Smith of California Air Resources Board, November 1, 2019.

51 | Funding under SB 535 was allocated prior to August 2017. AB 1550 requirements apply to CCI funding allocated since August 2017.

However, even if 58% of total funding went to priority populations, assuming that the census tract problem cited above did not exist, this is only slightly more than the 51% of the population that is considered priority populations. Since there is no data available on the population of low-income households outside of qualifying census tracts, this 51% estimate is likely higher once those households are included.

Original mandates that required 25% of California Climate Investments to benefit disadvantaged communities were aligned with the percentage of disadvantaged community populations relative to the state's total population. Disadvantaged communities were determined as the census tracts with the 25% highest CalEnviroScreen scores based on investment requirements mandated by SB 535, and make up about one quarter of California's population. Current investment requirements should be consistent with this — proportional to the population of priority populations — and therefore higher than what is currently required.

A higher percentage of transportation program funding benefits priority populations — a total of 85% of implemented transportation funding, according to CARB. However, much of this funding does not also qualify as benefiting priority populations under AB 1550. Even higher, the California Department of Transportation has reported that 97% of the Transit and Intercity Rail Capital Program funding has benefitted priority populations — far higher than the 25% required by law.<sup>52</sup> However, data for funding under AB 1550 has not been released yet, so all benefits from implemented funding qualify under old legislation, but do not necessarily qualify under current legislation. These projects span multiple census tracts, and, for most projects, only one tract has been listed for project location. Therefore, it is difficult to determine the percentage of funding that would qualify under AB 1550 — funding that is located within and benefits disadvantaged communities.

In addition, transportation programs vary in how people receive benefits. For the Clean Vehicle Rebate program, which gives up to \$7,000 for the purchase of a qualifying electric vehicle, individuals — rather than entire communities — receive the benefit.<sup>53</sup> Therefore, tracking who receives the benefits of this project is much easier to do. There is an income cap of

It is difficult to determine the percentage of funding that would qualify under AB 1550 — funding that is located within and benefits disadvantaged communities.

\$150,000 for single filers or \$300,000 for joint filers to be eligible for a rebate.<sup>54</sup> While there is an increased rebate for consumers with household incomes less than or equal to 300% of the federal poverty level, only 31% of program funding has benefitted priority populations. Compared to the Clean Vehicle Rebate, it is difficult to assess which communities are receiving the benefits of public transportation projects. This estimate takes total spending for each project into account, even though whole projects do not benefit only priority populations because they span over multiple census tracts, and appears to be a higher estimate than how much these communities are actually benefiting.



Photo: Christian Morris, Climate XChange

52 | California Air Resources Board, 2018. "Funding Guidelines for Agencies that Administer California Climate Investments," page 37.

53 | Center for Sustainable Energy, 2019. California Clean Vehicle Rebate Project.

54 | Center for Sustainable Energy, 2019. California Clean Vehicle Rebate Project Income Eligibility.



## VIII. FUTURE RESEARCH AND RECOMMENDATIONS

Further research is required to address questions beyond the scope of this report. Due to the wide range in health co-benefit estimates, it is difficult to determine an exact dollar value of these benefits, and compare them to the costs of projects. Furthermore, these estimates focus on benefits of reduced PM<sub>2.5</sub> and ozone emissions, but do not take into account other health benefits of clean transportation. There are additional unquantified public health benefits of reduced vehicle miles traveled and switching to active transportation, such as walking or biking, from passenger vehicle travel that are not included in our estimates. Increased physical activity from active transportation, as well as reduced traffic-related fatalities and injuries from fewer vehicles on the road and increased safety, have significant health benefits as well.<sup>55</sup> Therefore, public health benefits are even higher once these impacts are included.

Another shortcoming is the lack of empirical evidence on the public health benefits of reducing methane emissions. Methane emissions lead to the formation of ozone, which is detrimental to human health. But it is unclear if an estimate of benefits for CO<sub>2</sub> emission reductions accurately reflects the health benefits from reducing methane emissions. The Dairy Digester Research and Development Program has massive public health benefits, however it is unclear what the true estimate of this program is with the current information available. It is also unclear what the conversion of methane emissions to carbon dioxide equivalent emissions used by CARB is.

The degree to which California's estimate of the benefits to priority populations is accurate requires a closer look into the locations and results of each transportation project. When projects run through multiple census tracts, benefits to priority populations should be examined more closely. Benefits from transportation are complex, extensive, and cannot be simplified to "0%" or "100%" of funds benefiting priority populations, as state agencies

currently report. In the future, transit agencies will have the option to break up benefits if they're able to provide documentation of which portion of the project would benefit low-income or disadvantaged communities.<sup>56</sup> Agencies will therefore be able to split projects into percentages of how much of the project funding benefits priority population census tracts compared to the rest of the population. This estimate should also reflect where the projects are located, breaking down if projects are found in priority or non-priority population census tracts. Future benefits should focus less on the dollar amount of funding to define benefits and highlight the real-life impacts the projects provide.

California's use of extensive, modern socioeconomic and environmental data to determine CalEnviro-Screen scores is worth highlighting, and should be replicated by other states. To define and determine priority population census tracts, states must first collect comprehensive socioeconomic and environmental data and build out GIS mapping of these factors, which can be done following California's existing practices. These data practices must also be balanced with administrative capacity and feasibility of executing investment requirements.

However, numbers can only go so far to measure and determine the impacts of these investments. Since it is difficult to quantify all the co-benefits of every project, there must be an emphasis on community engagement processes to ensure the communities most impacted have an influence on how investments are made. States must balance larger infrastructure needs with democratic inclusive governance structures, allowing communities to self-determine how some of the revenue is used to meet localized needs.



## IX. CONCLUSION

Based on data released by state agencies, California Climate Investments appear to be remarkably successful to date, in terms of the cost-benefit of GHG reductions and the improvement in health outcomes for the population. While the costs of implementing projects are higher than the value of GHG reductions (counted at a relatively modest benefit per ton of reduction), the value of lives saved and gains in health are substantially greater than the implementing costs. Combined, GHG reductions and health benefits are 4.8 times the costs of all projects to date. For transportation programs, which often require higher investments, these benefits are 3.6 times greater than the costs of projects. These numbers do not count other co-benefits from the projects, such as local jobs, local sustainable development, and improved transportation access and affordability.

These results indicate that California's cap-and-trade system is highly successful, both in reducing the severe planetary dangers of climate change and in aiding the health and economy of its own population. It would appear that continuing to decrease the level of allowed emissions, as California plans to do, thereby generating greater revenues for investment, will continue to bring extensive benefits both in-state and worldwide.

Also important to California's programs are the gains to disadvantaged or low-income communities and

**These results indicate that California's cap-and-trade system is highly successful, both in reducing the severe planetary dangers of climate change and in aiding the health and economy of its own population.**

low-income households, which constitute about half the state's population. State agencies estimate that more than half of implemented cap-and-trade revenue has funded projects that provide benefits to Priority Populations (PP's), through intensive efforts at targeting funds. However, current California practices are insufficient to properly classify benefits to priority populations from multi-census tract transportation projects. As a result, we suspect that priority populations receive a smaller proportion of California Climate Investments than CARB currently claims.

For other states that wish to invest large sums of money from cap-and-trade or carbon fee/tax forms of carbon pricing, California's model will be important to watch carefully, both in the efficient use of funds to cut GHGs and bring about co-benefits, and in establishing the proper investment processes to ensure meaningful and substantial benefits to the communities and households that need it most.

<sup>55</sup> | Transportation and Climate Initiative, 2019. "Webinar: Draft Memorandum of Understanding & 2019 Cap-and-Invest Modeling Results", slides 39 to 40.

<sup>56</sup> | Conversation with Bailey Smith of California Air Resources Board, August 6, 2019.



X. REFERENCES

**“2016 REVISED VALUE OF A STATISTICAL LIFE GUIDANCE.”** United States Department of Transportation, 8 Aug., 2016. <https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20a%20Statistical%20Life%20Guidance.pdf>

**“2017 ANNUAL REPORT TO THE LEGISLATURE ON CALIFORNIA CLIMATE INVESTMENTS USING CAP-AND-TRADE AUCTION PROCEEDS.”** California Climate Investments, California Air Resources Board, Mar. 2017, [https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/cci\\_annual\\_report\\_2017.pdf](https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf)

**“2019 ANNUAL REPORT TO THE LEGISLATURE ON CALIFORNIA CLIMATE INVESTMENTS USING CAP-AND-TRADE AUCTION PROCEEDS.”** California Climate Investments, California Air Resources Board, Mar. 2019, [https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/2019\\_cci\\_annual\\_report.pdf](https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/2019_cci_annual_report.pdf).

**AB 1550, GOMEZ. CALIFORNIA STATE LEGISLATURE,** 14 Sept., 2016. [https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill\\_id=201520160AB1550](https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB1550)

Balbus, John M., et al. **“A WEDGE-BASED APPROACH TO ESTIMATING HEALTH CO-BENEFITS OF CLIMATE CHANGE MITIGATION ACTIVITIES IN THE UNITED STATES.”** Climatic Change, Jan. 2015, pp. 199–210., doi:10.2172/1241151.

**CALIFORNIA CAP-AND-TRADE PROGRAM, SUMMARY OF PROCEEDS TO CALIFORNIA AND COSIGNING ENTITIES.** California Air Resources Board, Sept. 2019, [https://ww3.arb.ca.gov/cc/capandtrade/auction/proceeds\\_summary.pdf](https://ww3.arb.ca.gov/cc/capandtrade/auction/proceeds_summary.pdf).

**CALIFORNIA CAP-AND-TRADE PROGRAM SUMMARY OF CALIFORNIA-QUEBEC JOINT AUCTION SETTLEMENT PRICES AND RESULTS,** California Air Resources Board, Nov. 2019, [https://ww3.arb.ca.gov/cc/capandtrade/auction/results\\_summary.pdf](https://ww3.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf)

**“CALIFORNIA CLIMATE INVESTMENTS: INVESTMENT TARGETS FOR ...”** California Climate Investments,

**CALIFORNIA AIR RESOURCES BOARD,** Dec. 2018, [https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/priority\\_targets\\_fy1819.pdf](https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/priority_targets_fy1819.pdf).

**CALIFORNIA GREENHOUSE GAS EMISSIONS INVENTORY: 2000 - 2017.** California Air Resources Board, 2018, [https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000\\_2017/ghg\\_inventory\\_trends\\_00-17.pdf](https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2017/ghg_inventory_trends_00-17.pdf).

**CALIFORNIA CLEAN VEHICLE REBATE PROJECT,** Center for Sustainable Energy, 2019, <https://cleanvehiclerebate.org/eng>.

**CCI CO-BENEFIT ASSESSMENT METHODOLOGIES,** California Air Resources Board, <https://ww2.arb.ca.gov/resources/documents/cci-methodologies>.

**CCI QUANTIFICATION, BENEFITS, AND REPORTING MATERIALS,** California Air Resources Board, 2019, <https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials>.

**DESIGNATION OF DISADVANTAGED COMMUNITIES PURSUANT TO SENATE BILL 535 (DE LEON).** California Environmental Protection Agency, Apr. 2017, <https://calepa.ca.gov/wp-content/uploads/sites/6/2017/04/SB-535-Designation-Final.pdf>.

European Commission Joint Research Centre. **“REDUCING METHANE EMISSIONS CAN PLAY A KEY ROLE IN REDUCING OZONE WORLDWIDE.”** ScienceDaily. ScienceDaily, 30 October 2018. <[www.sciencedaily.com/releases/2018/10/181030134330.htm](http://www.sciencedaily.com/releases/2018/10/181030134330.htm)>.

**“EXECUTIVE ORDER B-16-2012.”** Governor Edmund G Brown Jr, State of California, 23 Mar. 2012, <https://www.ca.gov/archive/gov39/2012/03/23/news17472/index.html>.

**“EXECUTIVE ORDER 13783.”** President Donald J Trump. 28 Mar. 2017, <https://www.whitehouse.gov/presidential-actions/presidential-executive-order-promoting-energy-independence-economic-growth/>.

**“FUNDING GUIDELINES FOR AGENCIES THAT ADMINISTER CALIFORNIA CLIMATE INVESTMENTS.”** Priority Population Investments, California Air Resources Board, 21 Dec. 2015, <https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/arb-funding-guidelines-for-ca-climate-investments.pdf>.

**“GLOBAL BURDEN OF DISEASE 2010 STUDY PUBLISHED.”** The Partnership for Maternal, Newborn and Child Health, WHO. Dec. 2012, [https://www.who.int/pmnch/media/news/2012/who\\_burdenofdisease/en/](https://www.who.int/pmnch/media/news/2012/who_burdenofdisease/en/)

**“GOOD FOR THE ENVIRONMENT.”** California High-Speed Rail Authority, 2019, [https://www.hsr.ca.gov/docs/communication/info\\_center/factsheets/Environmental\\_Factsheet.pdf](https://www.hsr.ca.gov/docs/communication/info_center/factsheets/Environmental_Factsheet.pdf).

Hamilton, Kirk, et al. **“MULTIPLE BENEFITS FROM CLIMATE CHANGE MITIGATION: ASSESSING THE EVIDENCE.”** Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, Nov. 2017, [www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2017/11/Multiple-benefits-from-climate-action\\_Hamilton-et-al-1.pdf](http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2017/11/Multiple-benefits-from-climate-action_Hamilton-et-al-1.pdf).

**“HEALTH AND ENVIRONMENTAL EFFECTS OF PARTICULATE MATTER (PM).”** EPA, Environmental Protection Agency, 20 June 2018, <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>.

Howard, Peter and Derek Sylvan. **“THE ECONOMIC CLIMATE: ESTABLISHING EXPERT CONSENSUS ON THE ECONOMICS OF CLIMATE CHANGE.”** Institute for Policy Integrity, New York University School of Law, Nov. 2015, <https://policyintegrity.org/files/publications/EconomicClimateConsensus.pdf>.

**“HOW BENMAP-CE ESTIMATES THE HEALTH AND ECONOMIC EFFECTS OF AIR POLLUTION.”** EPA, Environmental Protection Agency, 2 Jan. 2018, <https://www.epa.gov/benmap/how-benmap-ce-estimates-health-and-economic-effects-air-pollution>.

**IDENTIFICATION OF LOW-INCOME COMMUNITIES UNDER AB 1550 ...** California Air Resources Board, 14 Feb. 2017, [https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/kml/ab1550\\_maps\\_documentation.pdf](https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/kml/ab1550_maps_documentation.pdf).

**“REGULATORY IMPACT ANALYSIS FOR THE PROPOSED EMISSION GUIDELINES FOR GREENHOUSE GAS EMISSIONS FROM EXISTING ELECTRIC UTILITY GENERATING UNITS; REVISIONS TO EMISSION GUIDELINE IMPLEMENTING REGULATIONS; REVISIONS TO NEW SOURCE REVIEW PROGRAM.”** EPA, Environmental Protection Agency, Aug. 2018, [https://www.epa.gov/sites/production/files/2018-08/documents/utilities\\_ria\\_proposed\\_ace\\_2018-08.pdf](https://www.epa.gov/sites/production/files/2018-08/documents/utilities_ria_proposed_ace_2018-08.pdf)

Rennert, Kevin, and Cora Kingdon. **SOCIAL COST OF CARBON 101. RESOURCES FOR THE FUTURE,** 1 Aug. 2019, <https://www.rff.org/publications/explainers/social-cost-carbon-101/>.

Ricke, K., Drouet, L., Caldeira, K. et al. **COUNTRY-LEVEL SOCIAL COST OF CARBON.** Nature Climate Change 8, 895–900 (2018) doi:10.1038/s41558-018-0282-y

**SB 535, DE LEÓN.** California State Legislature, 30 Sept. 2012, [https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill\\_id=201120120SB535](https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201120120SB535).

Serrano, Kim. **“GREENHOUSE GAS REDUCTION FUND INVESTMENTS IN AND AROUND ...”** Community Resilience, University of California Irvine, 2018, <https://communityresilience.uci.edu/wp-content/uploads/2018/02/UCI-OC-GGRF-Report-FINAL-1.pdf>.

Stiglitz, Joseph E, and Nicholas Stern. **“REPORT OF THE HIGH-LEVEL COMMISSION ON CARBON PRICES.”** Carbon Pricing Leadership Coalition, World Bank, 29 May 2017, [https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing\\_FullReport.pdf](https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing_FullReport.pdf).



**TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS. INTERAGENCY WORKING GROUP ON SOCIAL COST OF GREENHOUSE GASES,** Aug. 2016, [https://www.epa.gov/sites/production/files/2016-12/documents/sc\\_co2\\_tsd\\_august\\_2016.pdf](https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf).

Thompson, Tammy M., et al. **“A SYSTEMS APPROACH TO EVALUATING THE AIR QUALITY CO-BENEFITS OF US CARBON POLICIES.”** *Nature Climate Change*, vol. 4, no. 10, 2014, pp. 917–923., doi:10.1038/nclimate2342.

**TRANSIT AND INTERCITY RAIL CAPITAL PROGRAM (TIRCP)** | Caltrans, California Department of Transportation, 2019, <https://dot.ca.gov/programs/rail-and-mass-transportation/transit-and-intercity-rail-capital-program>.

**“USERS MANUAL APPENDICES.”** Environmental Benefits Mapping and Analysis Program, United States Environmental Protection Agency, Sept. 2008, [https://www.epa.gov/sites/production/files/2015-07/documents/dec2009\\_benmapappendicessept08.pdf](https://www.epa.gov/sites/production/files/2015-07/documents/dec2009_benmapappendicessept08.pdf).

Vandyck, Toon, et al. **“AIR QUALITY CO-BENEFITS FOR HUMAN HEALTH AND AGRICULTURE COUNTERBALANCE COSTS TO MEET PARIS AGREEMENT PLEDGES.”** *Nature Communications*, vol. 9, no. 1, 2018, doi:10.1038/s41467-018-06885-9.

**“WEBINAR: DRAFT MEMORANDUM OF UNDERSTANDING AND 2019 CAP-AND-INVEST MODELING RESULTS.”** Transportation and Climate Initiative, Dec. 2019, slides 39–40, [https://www.transportationandclimate.org/sites/default/files/TCI%20Public%20Webinar%20Slides\\_20191217.pdf](https://www.transportationandclimate.org/sites/default/files/TCI%20Public%20Webinar%20Slides_20191217.pdf)

West, J. Jason, et al. **“CO-BENEFITS OF MITIGATING GLOBAL GREENHOUSE GAS EMISSIONS FOR FUTURE AIR QUALITY AND HUMAN HEALTH.”** *Nature Climate Change*, vol. 3, no. 10, 2013, pp. 885–889., doi:10.1038/nclimate2009.

Wolfe, Philip, et al. **“MONETIZED HEALTH BENEFITS ATTRIBUTABLE TO MOBILE SOURCE EMISSION**

**REDUCTIONS ACROSS THE UNITED STATES IN 2025.”** *Science of The Total Environment*, vol. 650, 2019, pp. 2490–2498., doi:10.1016/j.scitotenv.2018.09.273.

Xu, Ruoying, and Bill Eisenstein. **“ACCELERATED IMPLEMENTATION OF TECHNOLOGY.”** CCI Co-Benefit Assessment Methodologies, California Air Resources Board, 2017, [https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/ucb\\_lit\\_rev\\_on\\_accelerated\\_implementation\\_technology.pdf?\\_ga=2.119025920.86983697.1579126862-2103291742.1562773235](https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/ucb_lit_rev_on_accelerated_implementation_technology.pdf?_ga=2.119025920.86983697.1579126862-2103291742.1562773235).

Xu, Ruoying, and Bill Eisenstein. **“ANTI-DISPLACEMENT.”** CCI Co-Benefit Assessment Methodologies, California Air Resources Board, 2017, [https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/ucb\\_lit\\_review\\_anti\\_displacement.pdf?\\_ga=2.110754956.86983697.1579126862-2103291742.1562773235](https://ww3.arb.ca.gov/cc/capandtrade/auctionproceeds/ucb_lit_review_anti_displacement.pdf?_ga=2.110754956.86983697.1579126862-2103291742.1562773235).

Zapata, Christina, et al. **“PM2.5 CO-BENEFITS OF CLIMATE CHANGE LEGISLATION PART 1: CALIFORNIA’S AB 32.”** *Climatic Change*, vol. 117, no. 1–2, May 2012, pp. 377–397, doi:10.1007/s10584-012-0545-y.