California Climate Challenge Methodology

General Assumptions	
Cost of Electricity in 2030	17.5¢ per kilowatt-hour (for estimating cost savings from measures that reduce electricity consumption). Source: E3, "California Pathways: GHG Scenario Results," April 6, 2015.
Greenhouse gas emissions from grid electricity in 2030	530 lbs. CO_2 per megawatt-hour for a 33% Renewable Portfolio Standard (for estimating greenhouse gas reductions from measures that reduce grid electricity consumption). Source: E3, "California Pathways: GHG Scenario Results," April 6, 2015.
Baseline fuel economy of average automobile in 2030	34.5 miles per gallon (for estimating savings from improved fuel economy or from switching to electric vehicles). Source: J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015).

Measure	Measure Description	Comments/Methodology
Semi-TruckFuel Efficiency	Increase fuel efficiency of new heavy-duty semi trucks by 60%.	Methodology: Benefit estimates are from J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015) Cost estimates are based on truck fleet size projections from CARB's EMFAC2014 vehicle emissions and travel model and cost estimates in EPA's Regulatory Impact Analysis (RIA) for its recently proposed heavy-duty truck fuel economy standards. The Carbon Challenge measure is more stringent than assumed in EPA's RIA, so projected costs were scaled up accordingly. Costs for higher fuel economy include higher purchase costs up front as well as higher annual maintenance costs. Purchase costs were annualized based on the assumption of a 15-year payback period at 5% interest. Net costs of the measure include offsetting savings due to lower fuel costs.
Pay-As-You Drive Insurance	Create a system of pay-as-you-drive car insurance, which charges rates based on how much, when, and what vehicle you drive.	Methodology: Estimates for this measure are based on the Brookings Institution report *Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity* (July 2008) and Greenblatt (2015).
Congestion Charges	Charge (higher) tolls during peak periods on congested highways and arterials in order to reduce congestion.	Methodology: Assumptions regarding congestion charges and their effects on driving are based on reports of actual experience with congestion charges in various urbanized areas and the Texas Transportation Institute's 2015 Urban Mobility Scorecard on congestion in urban areas.

Measure	Measure Description	Comments/Methodology
Parking Prices	Increase on-street parking fees by $1.00 an hour in urban areas.	Methodology: Estimates are based on a review of the literature done by CARB on the VMT effects of parking pricing and modeling of future parking programs by Blue Sky Consulting Group. Additional sources include the following: T. Stecker, "Reducing Parking Spaces Helps Cities Cut Auto Emissions: A New Study Shows Economic and Policy Changes That Limit Parking Have Significantly Reduced Miles Driven in 10 European Cities," *Scientific American* (January 24, 2011); M. Kodransky and H. Gabrielle, "Europe's Parking U-Turn: From Accommodation to Regulation," ITDP (July 2014); D. Shoup, "Cruising for Parking," *Access* (Spring 2007).
High-Speed Rail	Build a high-speed rail network that links California's major cities.	Methodology: Estimates are based on the California High Speed Rail Authority's cost and ridership estimates detailed in the CHSRA's March 2015 project update and Greenblatt (2015).
Employer-based Trip Reduction	Require large employers to provide bus services or carpool vans to employees.	Methodology: Estimates are based on the impact and costs of the Los Angeles Metro Vanpool Program by Blue Sky Consulting Group, including federal spending and contract costs, number of boardings/trips, number of routes/vans, and average trip length for the program from 2007 to 2011.
Transit Services	Increase subsidies to municipal and regional transit systems that provide bus, rail, and ferry services by 15 percent.	Methodology: Estimates of the effect of increased transit investment are based on C. Rodier, "A Review of the International Modeling Literature: Transit, Land Use and Auto Pricing Strategies to Reduce Vehicle Miles Traveled and Greenhouse Gas Emissions," Institute of Transportation Studies, UC Davis (2009), combined with modeling of SB 375's impact of regional plan transit investments by Blue Sky Consulting Group. The cost is based on the 4 largest California regional transportation plans' investments in transit with the assumption that SB 375 is associated with a 15% increase in investment. Regional plans included are SANDAG, SCAG, MTC, and SACOG. The historical effect of transit and proximity to transit is based on research conducted by PPIC.
Telecommuting	Create a California Telework Resource Center to provide consulting services and resources to employers to begin or expand telecommuting programs.	Methodology: Estimates of the effects of telecommuting on trip reductions are from a review of the literature conducted by CARB combined with Cambridge Systematics, "Congestion Mitigation Commission Technical Analysis: Telecommuting Incentives," prepared for the New York City Department of Transportation (December 10, 2007). The cost is based on the 2015 budget and number of firms served in 2014 by a Telework consulting program in Connecticut, and modeled for California by Blue Sky Consulting Group.

Measure	Measure Description	Comments/Methodology
Bicycling	Double the amount of bike lanes in California's cities in order to increase the number of bicycle commuters.	Methodology: Estimates of the effects of bike lanes on the number of bicycle commuters are based on a review of the literature and modeling of a California program by Blue Sky Consulting Group. Specifically, our model assumes that doubling the amount of bike lanes per square mile in urban areas would cause a 30% increase in bicycle commuting. In addition, we assume California cities currently average two miles of bike lanes per square mile (based on the 2014 Benchmarking Report for Bicycling and Walking in the United States). The Los Angeles 2010 Bicycle Plan indicates that eight miles per square mile is the saturation point at which an urban area can realize the full 10% reduction in VMT based on the density of bike lanes in bike-friendly cities like Davis, CA. In calculating the cost to build a mile of bike lane infrastructure, San Francisco was considered to represent the most expensive third of the state's urban area while Los Angeles represented the remaining 2/3.
Commercial Solar	Provide a tax incentive for commercial buildings to install solar systems.	Methodology: Assumes (1) average installed cost for solar panels declines by 33% between 2015 and 2030, from $4.59 to $3.32 per watt for commercial systems; (2) average commercial space consumes 12.7 kWh/square foot/year (Greenblatt 2015); (3) solar is installed on 1% of pre-existing commercial square footage and 50% of new commercial square footage each year and displaces 50% of grid electricity use; (4) the state subsidy is sufficient to reduce electricity costs by 10% when compared with grid electricity; reported cost represents debt service in 2030 on the up-front cost of the state subsidy, amortized over 25 years at a 5% interest rate.
A Million More Solar Roofs	Double the Million Solar Roofs program to subsidize installation of another million solar roofs on residential buildings.	Methodology: Assumes (1) average installed cost for solar panels declines by 33% between 2015 and 2030, from $5.35 to $3.86 per watt for residential systems; (2) average pre-existing household consumes 6976 kWh/year (Greenblatt 2015); (3) solar PV systems displace 70% of grid electricity use; (4) the state subsidy is sufficient to reduce electricity costs by 10% when compared with grid electricity; reported cost represents debt service in 2030 on the up front cost of the state subsidy, amortized over 25 years at a 5% interest rate.
Energy Retrofits for Commercial Buildings	Provide incentives to retrofit existing commercial buildings for lower energy use.	The measure would upgrade existing commercial buildings to use one-third less energy, with 20% of buildings assumed to participate by 2030. The stock of commercial buildings and their energy use is estimated in Greenblatt (2015). We assumed retrofits would cost $12 per square foot. The cost is the estimated annualized cost of the government subsidy, assuming the cost is amortized over 30 years at 5% interest.

Measure	Measure Description	Comments/Methodology
Home Energy Efficiency	Provide incentives to reduce energy use by 50% in one million older homes by installing state-of-the-art insulation, windows, and energy efficiency technologies.	Methodology: Estimated primarily based on Lawrence Berkeley Lab's "Home Energy Save" online calculator using default assumptions for a pre-WWII 1800 square-foot home. The cost for window replacement was assumed to be $10,000 (roughly the cost to replace all the windows in a typical home with vinyl Energy Star windows). Total retrofit cost was $18,000 per home. The government subsidy was assumed to cover 35% of the cost of the retrofit.
Time-of-Day Electricity Pricing	Instead of paying a single price for electricity regardless of the time of day, households and businesses would be charged higher rates during periods of high demand (for example, summer afternoons) and lower rates during periods of low demand (for example, nights and weekends).	Methodology: Assumes a 5.7% reduction in total electricity usage, based on data from a number of pilot programs and data on electricity usage in California. Results assume that the overall cost of electricity stays the same. Savings are due to lower total electricity usage induced by time-of-day pricing. However, there might be offsetting costs of buying more efficient appliances and equipment and retiring existing equipment before the end of its nominal useful life. We did not attempt to analyze these second-order impacts and they are not included in the cost estimate.
Green Cement	Require cement plants in California to produce a new cement mixture that reduces carbon emissions	The researchers that developed the new cement mixture at Ecole Polytechnique Federal de Lausanne (EPFL) estimated that producing it reduces greenhouse gas emissions by 30 percent compared to the process of making conventional Portland cement. Current practices of California cement producers are discussed in a CPUC document, "Cement Industry Standard Practice to Add a Percentage of Limestone during Grinding," January 10, 2013. Blue Sky Consulting Group modeled the amount of cement produced in California based on data from the USGS annual publications of Mineral Commodity Summaries.
Land-Use Mix	Require new residential housing developments to be located near neighborhood centers that include amenities such as grocery stores, restaurants, parks and libraries.	Methodology: Estimates of the effects of mixed-use development are based on a 2014 study commissioned by CARB, D. Salon, "Quantifying the Effect of Local Government Actions on VMT" and from a meta-analysis conducted by R. Ewing and R. Cervero, "Travel and the Built Environment," *Journal of the American Planning Association* vol. 76, Issue 3 (2010), which estimated that doubling density is associated with a 4% decrease in VMT, combined with modeling of a California program by Blue Sky Consulting Group.

Measure	Measure Description	Comments/Methodology
Growth Boundary	Adopt an "Urban Growth Boundary" beyond which future development would be prohibited, thereby increasing the height and density of buildings within the boundary.	Methodology: Estimates of the effects of increased residential and job density are from R. Ewing and R. Cervero, "Travel and the Built Environment," *Journal of the American Planning Association* vol. 76, Issue 3 (2010), combined with modeling of a California program by Blue Sky Consulting Group using county population and density data from the California Department of Finance and Vehicle Miles Traveled projections from a study commissioned by CARB, J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015).
Transit-Oriented Development	Exempt developers from California Environmental Quality Act (CEQA) regulations if they construct mixed-use buildings within a half mile of a major transit stop or well-served transit corridor.	Methodology: The policy is assumed to be implemented in 2015 and to result in 35,000 additional units of transit-oriented development housing by 2030. People who move into these developments are assumed to reduce their annual VMT by 3,500 miles per year (about 19% relative to household average VMT) based on estimates in California Housing Partnership Corporation Working Paper, "Building and Preserving Affordable Homes Near Transit," (2013).
Subdivision Density	Create a revenue neutral, sliding scale density development fee in which developers pay to build lower density single-family residential subdivisions and get a rebate to build dense or multi-family developments.	Methodology: The policy is assumed to be implemented in 2015 and about 1.7 million units are assumed to be constructed and occupied by 2030 (based on estimates in J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015)). Greenblatt also provides baseline annual household VMT. The effect of density on VMT reduction is based on a 2014 review of the literature by CARB: "Impacts of Residential Density on Passenger Vehicle Use and Greenhouse Gas Emissions."
Green Vehicle Fleets	Require state and local governments to purchase only electric vehicles (unless public safety or other obstacles prevent such a purchase).	Methodology: The state government fleet size was estimated by CARB. The local government fleet size was estimated by scaling up fleet data for a few representative California local governments. Electric automobiles were assumed to cost $5,000 more than a comparable gasoline/hybrid automobile. Projected fuel economy and electricity usage for automobiles in 2030 is from Greenblatt (2015).

Measure	Measure Description	Comments/Methodology
Energy Efficient Government Buildings	Require all state and local governments to reduce energy use by one-third in existing government buildings.	Methodology: Since data are not readily available on the energy usage or energy savings available from upgrading many state and local government buildings, we assumed these buildings use energy at the average rate for commercial buildings in California (as reported in Greenblatt (2015)). We assumed retrofits would cost $12 per square foot and would be paid through a 30-year loan at 5% interest. The net cost in 2030 is the annual debt service on the energy upgrades minus the annual savings in energy costs.
Green Governme nt Buildings.	Require all state and local governments to progressively improve new government building efficiency between 2016 and 2030.	Methodology: As a baseline, we assumed future new government buildings would use energy at the same rate projected in Greenblatt (2015) for new commercial buildings. We assumed this measure would reduce energy use by nearly 55% below this baseline (equivalent to measure S2.7 in Greenblatt 2015) and that the reductions would cost $15 per square foot. The costs were assumed to be paid through a 30-year loan at 5% interest. The net cost in 2030 is the annual debt service on the energy upgrades minus the annual savings in energy costs.
More Stringent Cap-and-Trade Target	California already has a cap-and-trade program. This measure would lower the overall emissions cap.	Methodology: Assumes an average cost of $45/ton for reducing emissions in 2030, based on modeling projections in S. Borenstein, et al., “Report of the Market Simulation Group on Competitive Supply/Demand Balance in the California Allowance Market and the Potential for Market Manipulation” (2014).
Carbon Tax	Institute a carbon tax on the energy used by commercial and industrial users.	Methodology: Economic theory suggests that, given similar conditions and program structure, a carbon tax and cap-and-trade should produce similar results. Thus, given the same cost per ton, a carbon tax and cap-and-trade are assumed to result in similar emission reductions.
Expand Low-Carbon Fuel Standard	Increase existing Low-Carbon Fuel Standard from a 10% reduction by 2020 to a 30% reduction by 2030	Methodology: Meeting the current LCFS by 2020 is projected to cost somewhere between 6¢ and 19¢ per gallon (ICF International, *California’s Low Carbon Fuel Standard: Compliance Outlook & Economic Impact* (April 2014)). We assumed compliance with the more stringent LCFS by 2030 would cost 30¢ per gallon.
Renewable Energy	Increase electricity generation from renewables (e.g., wind, solar, biomass, and geothermal) from 33% up to 50% of total electricity generation.	Methodology: The impact was obtained from an ARB commissioned model by J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015). The difference in cost between RPS 33% in 2030 and RPS 50% in 2030 was estimated using Greenblatt's estimates for electricity demand and grid composition in 2030 for RPS 33% and 50% and the levelized costs of each power source, as estimated in the California Energy Commission reports "Estimated Cost of new renewable and fossil generation in California" and "Comparative costs of California central station electricity generation."

Measure	Measure Description	Comments/Methodology
Build a Nuclear Power Plant	Build a new nuclear power plant with the same capacity of the decommissioned SONGS plant	Methodology: The estimated impact was obtained from a CARB sponsored model by J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015). Since nuclear plants provide base load power, the estimates assume fossil fuel power would replace it. The cost is estimated as the difference between the levelized cost of nuclear power and the levelized cost of power from fossil fuels. These costs were obtained from the California Energy Commission reports "Comparative Costs of California Central Station Electricity Generation." The composition of fossil fuels in the California grid was obtained from Greenblatt (2015). The U.S. Energy Information Administration published the amount of power capacity of the decommissioned SONGS plant.
Relicense a Nuclear Power Plant	Relicense Diablo Canyon Power Plant	Methodology: The estimated impact was obtained from an CARB-sponsored study, J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015). The cost estimate for relicensing Diablo annualizes the costs for obtaining federal and state approvals related to license renewal, the cost of the seismic studies underway, fuel costs for operating the plant, other operations and maintenance costs, and waste management obtained from the California Public Utilities Commission and the Nuclear Energy Institute. The difference between the cost of relicensing Diablo to the cost of replacing Diablo with power from the grid resulted in net savings.
Phase-out Imported Coal Power	California will no longer purchase coal-powered electricity from power plants outside the state	Methodology: This measure is based on SB 1368. The estimated impact is from a CARB-sponsored study, J. B. Greenblatt, "Modeling California policy impacts on greenhouse gas emissions," (2015). Consistent with Greenblatt (2015), the cost assumes the 3.9 GWh of coal-powered electricity would be replaced by natural gas combined cycle power plants. The cost is calculated as the difference in levelized costs of coal and natural gas obtained from U.S. Energy Information Administration, "Annual Energy Outlook 2015" and California Energy Commission, "Comparative Costs of California Central Station Electricity Generation".

Measure	Measure Description	Comments/Methodology
More Trees	Plant 15 million trees in urban areas by 2030	Methodology: Estimates of the effects of tree planting are based on a technical analysis of the costs and benefits of tree planting in New York City to the New York Department of Parks and Recreation, "New York City, New York Municipal Forest Resource Analysis," extrapolated to reflect statewide results in California. Specifically we assume that 15 million trees would be planted statewide from 2015 to 2030, that trees will be planted in urban areas in close enough proximity to buildings so as to affect the amount of annual heating and cooling those building require, that the trees planted will absorb the same amount of CO2 and provide the same energy-saving and environmental benefits each year. Tree planting is assumed to cost $16 per new tree and $27 per year for maintenance. Also assumes a benefit of .12 metric tons of CO2 equivalent per year per tree. These values are weighted averages from the studies reviewed. Further assumes that full benefit is achieved in 2030, though most types of trees would not be fully grown at this point.
Waste Diversion	Divert 80% of waste by recycling and composting	Methodology: This measure is based on AB 341, a state policy goal to divert 75% of waste by 2020. Blue Sky Consulting Group's estimate of the impact is based on Calrecycle's definition of AB 341's goal, "California's New Goal: 75% Recycling" and uses Calrecycle's "Waste Characterization Study" and ARB's estimates of recycling and composting GHG reduction factors in "Method for Estimating Greenhouse Gas Emission Reductions from Recycling" and "Method for Estimating Greenhouse Gas Emission Reduction sfrom Compost from Commercial Organic Waste". The cost estimate is based on Calrecycle's "Cost Study on Commercial
Garbage Incinerators	Convert organic waste to electricity through Waste-to-Energy (WTE) garbage incinerators rather than Landfill-Gas-to-Energy (LFTGE) facilities	Methodology: The estimates of impact and cost assume that all California landfills are capturing emissions by 2030. The projected amount of organic waste in 2030 is based on Calrecycle's estimate of 10.7 lbs of waste generation per resident per day and the percent of organic waste from Calrecycle's "State of Disposal in California" multiplied by the California Department of Finance's population projection for 2030. The difference in life cycle green house gas emissions of converting organic waste to electricity in WTEs and LFTGEs is from a study cited by the EPA by Kaplan, DeCarolis, and Thorneloe "Is It Better to Burn or Bury Waste for Clean Electricity Generation?" Environ. Sci. Technol.2009, 43 (6). The levelized costs of WTE and LFGTE electricity generation was obtained from Chandel, Kwok, Jackson, and Pratson, "The potential of weaste-to-energy in reducing GHG emissions," Carbon Management, 2012, 3(2).

CONTACT

Please contact Next 10 at
stephanie@next10.org or call 415-957-0202 Ext. 14
with questions on our methodology