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ORIGINAL RESEARCH REPORT

# Chapter 7. Paths to Carbon Neutrality: Lessons from California

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California is one of the least greenhouse-gas intensive states in the United States, and one of the most energy efficient economies in the world. Its success is partly an accident of geography, due to a temperate climate, and its service-based economy with little emissions-intensive industry. But California's governors, state legislators, and local agencies have also shown a willingness to enact climate legislation and implement mitigation policies, far ahead of the federal government and most other states. In part, climate action in California is rooted in the legacy of the air quality and energy efficiency programs from the 1970s and 1980s, which bequeathed state agencies with a depth of technical, regulatory and legal expertise. However, California has also legitimized climate mitigation as a matter of state action, and demonstrates high public accountability and enlists powerful coalitions by providing substantial and enduring incentives. This article discusses the range of mitigation policies, from cap-and-trade to vehicle efficiency and green building standards, that California has implemented, and the political coalition that has enabled their introduction. It also highlights challenges, particularly the difficulty in passing down mandates and incentives for emissions reduction to local government agencies, which retain a monopoly in land-use planning.

## California in the World: The Significance of Subnational Governance

California is one of the least greenhouse-gas intensive states in the United States. On a per-capita basis, only New York and Vermont rank lower, and the average Californian emits just 53 percent of the national average amount of greenhouse gases (GHG) [1]. California's large metropolitan regions also score well compared to their counterparts elsewhere. In popular perception, Los Angeles might be the poster-child for unsustainable excess. When measured by household GHG emissions per capita, however, the region is one of the greenest in the nation. San Diego, San Francisco and San Jose claim the top three spots in one metropolitan-level ranking, while LA comes in at number five, after Providence, Rhode Island [2].

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California is also a major world energy user. It has the 36th largest population in the world and ranks 20th among all countries in total GHG emissions from energy consumption [3]. However, just as California is among the greenest states in the United States, it is one of the most energy efficient economies in the world. Its emissions per capita are almost half that of the U.S. as a whole, and it is the second-to-least carbon intense (emissions per dollar of GDP) economy in the world, bested only by France [3]. California also has the second highest percentage of its electricity coming from renewable sources (not including large hydropower), at 23 percent, behind only Germany with 27 percent [3].

California's effort over the last decade to curb greenhouse gas emissions and combat climate change has catapulted it into the national and international spotlight. As the nation's leading state in many economic sectors, including agriculture, clean energy technology, and entertainment, and as the eighth largest economy in the world, California has the potential to influence climate policy worldwide and to show how to reduce emissions while sustaining strong economic growth.

### *California's Story*

California's success is partly an accident of geography. The largest cities lie near the coast where, for most of the year, homes achieve a pleasant temperature with neither air conditioning nor heating. About 40 percent

of the state's electricity comes from low-carbon sources such as renewables, hydro and nuclear – the result of deliberate policy, but also the product of federal subsidies for dams, and the lack of large coal deposits in the state. Most of the remainder of the electricity is generated from natural gas.

Low emissions are also a product of a service-based economy with little heavy industry. California ranks in the lowest five states in terms of the emissions intensiveness of the economy [1, 4], although this is partially offset by "embedded" emissions in imported products, which perhaps misleadingly, are not captured in the state's emissions inventory.

The nature of California's economy means that political support is easier to gather for wide-ranging climate change policy. In districts with low per-capita emissions, politicians are more likely to support climate legislation [5]. A reduction in power generation from coal, for example, will affect mining employment in neighboring states, but cost few jobs in California. Fossil fuel extraction and automobile manufacturing are only minor players in California's economy. In contrast, sectors that would be harmed by climate change, such as agriculture and tourism, or would benefit from efforts to reduce emissions, such as renewable energy technology, have a much larger presence on the west coast.

Thus, California governors and legislators have shown a willingness to enact climate legislation, far ahead of the federal government and most other states. For example, California's precedent-setting Global Warming Solutions Act was signed into law by Republican Governor Arnold Schwarzenegger, who continues to support regulations to reduce GHG emissions. Governor Jerry Brown, a Democrat and vocal advocate for state leadership on GHG reductions, recently cited the ongoing drought and extended fire season in calls for more stringent, national climate measures [6].

The political attitudes that favor climate change action in the state legislature and Governor's office also permeate through many of the state's counties, cities, water and transit districts, and other local and regional agencies. As discussed below, many climate policies, from green buildings to transit-oriented development, are difficult for the state to implement directly, and fall within the purview of local government. Many local officials, such as former San Francisco mayor Gavin Newsom, have sought to portray themselves as leaders on climate policy – in part, in an effort to pressure the federal government into action. San Francisco is rated the most progressive large city in the country, and Oakland the fourth [7].

The legacy of the air quality and energy efficiency programs from the 1970s and 1980s has also played a part. California regulators have been accustomed to taking action on air quality and other environmental issues, which in other states might be left to the federal government. The state's Air Resources Board (CARB), which has assumed the primary role in California's climate efforts, already had a depth of technical, regulatory and legal expertise that positioned it well to respond to climate change policy imperatives.

### *Lessons from California*

California's story provides lessons for other states and international leaders at a time when subnational governments are gaining importance in the global climate change conversation. California has embraced this subnational emphasis and is using its position to motivate other governments to follow in its footsteps. Regions from New York to Shenzhen, China have looked to California for lessons in developing greenhouse gas reduction programs [8, 9]. California Governor Jerry Brown has spoken at pivotal international climate change events, including the UN Climate Summit in New York in 2014 and a conference hosted by Pope Francis at the Vatican in 2015 [8, 10]. California was one of the creators of and founding signatories to the Subnational Global Climate Leadership Memorandum of Understanding, "Under 2 MOU," an agreement between twenty-one states and regions from countries across the globe to reduce their greenhouse gas emissions 80–95 percent by 2050, with the goal of keeping global warming to within two degrees Celsius [11]. Though the MOU is not a binding treaty, it does express the parties' intention to coordinate and cooperate as they each pursue individual strategies to reduce emissions [12]. The MOU is also a call to action in the lead up to the United Nations Framework Convention on Climate Change (UNFCCC) Convention of the Parties in Paris. The ambitious goals set in the MOU are designed not only to reduce the emissions of its signatories, but also to encourage other global leaders to make similar commitments [13].

The next few years are crucial if we are to avoid the worst effects of climate change. Some of those effects are already occurring, including in California [14, 15]. The following sections discuss the progress that California has made in climate policy and the key lessons that other governments can learn from its experience.

## California's Air Quality Policies Paved way for Curbing Greenhouse Gases

California began its GHG emissions reduction efforts with the planet's first greenhouse gas standards for automobiles. The state then passed landmark legislation known as AB 32, the Global Warming Solutions Act, which committed the state to reducing its GHG emissions to 1990 levels by 2020 [16]. The Act gave CARB, the state's air pollution agency, significant authority to determine how to meet the 2020 goal [16]. CARB has responded with a suite of measures, including an economy wide cap-and-trade program, a Low Carbon Fuel Standard, renewable portfolio standards, and transit and land use programs to encourage more effective development. These polices are influencing other states, the U.S. government and governments around the world in designing effective climate policy [16]. They also stem directly out of the leadership the state has demonstrated in regulating air pollution.

California's leadership in regulating harmful air pollutants dates back much further than the modern focus on climate change. Since the 1960s, California has provided leadership in describing the mechanisms of air pollution as well as adopting – and enforcing – regulatory controls. California created the first laws limiting noxious

emissions from vehicles in 1961, and developed its own administrative capacities by establishing CARB and several large, regional air quality districts by the end of the decade [16]. Because of the state's leadership efforts and because Los Angeles faced particularly severe air pollution, when Congress enacted the Clean Air Act (CAA) in 1963, it exempted California from the prohibition banning states from regulating auto emissions [16]. Congress allowed California to create emissions standards for automobiles as long as they were stricter than the federal standards, and permitted other states to "opt in" to California's standards in place of the less stringent federal regulations [16]. The exemption not only permitted California to experiment with stricter emissions standards than the federal government was willing to enact, but it also identified California as a model for other states to emulate.

The 1970's through the 1990's were a time of continuous back-and-forth between CARB and the federal Environmental Protection Agency (EPA). California would first tighten its pollution standards, and a few years later the EPA would nationalize the same standard. In 1988, the state legislature established ambitious vehicle pollution reduction goals to be met by 2000, prompting CARB to completely overhaul its regulatory strategy [16]. Instead of creating an emissions standard that each individual car had to meet, CARB created standards for the average emissions of a fleet, allowing manufacturers to customize a mix of vehicles falling into four broad categories that together would meet the fleet-wide standard [16]. Collectively, these standards are known as the LEV (for Low Emission Vehicle) program and formed the basis for the approach CARB took in regulation greenhouse gas emissions from vehicles.

The first phase of the LEV program was extremely successful, and CARB built on that success by enacting LEV II in 1998. By that time, EPA had created a voluntary National LEV program with standards almost equivalent to California's LEV program. The state LEV program reduced smog-producing pollution from cars by 99 percent. The national standard decreased tailpipe smog emissions by 95 percent. These reductions yielded tangible improvements that people could see and smell every day and inspired trust in CARB from the public and political leaders [17].

### *Air Quality Regulation in California*

California uses a wide variety of environmental policy tools to improve air quality, some of them with great results, and these may prove highly effective in mitigating climate change. Many of the activities that cause air pollution also contribute GHGs that result in climate change. As a result, that reducing GHGs not only improves public health [18], but can also be done using tried-and-true policy tools that have long been successfully implemented to combat air pollution.

The command and control approach to air quality regulation that California first employed seems classic and perhaps even old school today: emissions limits, like auto tailpipe standards, dictated acceptable pollution releases in grams per mile. Other strategies involved outright bans – such as lead in gasoline, first limited by the Air Board in 1976, in advance of the federal EPA.

The so-called end-of-pipe regulation approach offers a powerful promise and depends on a delicate political compromise: regulators impose tough emissions levels and/or require specific pollution control technologies. In return, regulators allow manufacturers and facility operators to continue using their core technologies and raw materials. That means controlling auto emissions rather than phasing out gasoline use, for example. Old cars, manufacturing plants and power stations (so-called existing sources) get more lenient treatment than new sources based on the proven idea that building pollution controls into a new facility or car is always cheaper than retrofitting one that already exists. As long as the old, dirtier cars and facilities eventually get retired or scrapped, air and water quality will get better. Regulators usually phase in their technological requirements pretty slowly so that industries can time and plan their investments with enough time and certainty to avoid costly surprises.

Prompted by disastrously poor air in large urban areas like Los Angeles, California has often acted earlier or more aggressively (sometimes both) than the federal government or other states. Indeed, California adopted tailpipe standards for automobiles, controlling hydrocarbons (HC) and carbon monoxide (CO), in 1965, a full decade before the federal standards went into effect under the US Clean Air Act of 1970 [19].

After the US Clean Air Act Amendments of 1970 were passed, the federal government asserted primacy over the task of setting clean air standards, so California's role shifted from "first-mover" to vigorously prodding the federal government further. Section 209 of the 1970 Clean Air Act allowed states with especially poor air quality (with many so-called "nonattainment" areas) to petition the EPA for permission to adopt regulations that strayed from federal guidelines, as long as these were as stringent as the EPA standards. Section 177 allowed other states to adopt California's standards, which ten states have done. These "waiver requests" were often prompted by states seeking tougher standards. Since 1968, the US EPA has granted California 50 waivers and issued only five denials [20]. Perhaps the most noteworthy instance of California's aggressive stance came during the 1980s, when the US Congress adopted California's new mobile source emissions in its 1990 Clean Air Act Amendments. Today, the CARB bundles regulatory controls on smog-causing pollutants and greenhouse gas emissions from mobile sources into a single, coordinated package of standards that the agency calls its "Advanced Clean Car Program." The coordinated rules will apply to auto model years 2017–25.

When first employed, California's end-of-pipe air quality standards removed a lot of pollution before it reached ambient air. In 1970, before the federal Clean Air Act was implemented, officials in the Los Angeles basin issued many smog alerts (when ozone concentrations reached 0.20 ppm), warning residents to limit their physical exertion and sometimes even to stay indoors. Air quality staff recorded a maximum one-hour ozone concentration

of 0.58 ppm in 1970, nearly five times higher than the 0.12 ppm health-based standard that would be adopted a year later [21]. As late as 1975, the South Coast Air Quality Management District (SCAQMD) issued smog alerts on 118 days. By 1990, there were only 42 alerts and none by 2000.

Despite enormous population growth, from around 10 million people in 1970 to around 17 million people in 2015, air quality in the greater Los Angeles area has improved markedly. Air quality started getting better in the 1980s and generally improved steadily every year since. Recent studies examining trends between 1994 and 2011 found average declines in $NO_2$ between 28 percent and 53 percent throughout the basin, and $PM_{2.5}$ declines between 13 percent and 54 percent. Ozone concentrations have decreased most in parts of the basin that had once been among the most polluted [22]. Regulation was not responsible for all of these air quality improvements, since they coincided with the closure of many stationary sources in California (aluminum smelters, shipyards, wood finishers) and the conversion from fuel oil to natural gas in many industrial and utility boilers.

California also bundled air quality and energy planning by adopting ambitious efficiency requirements starting in the 1970s. Through uniform building codes, appliance standards and power plant requirements, the state steadily cranked down its per capita energy consumption and associated air emissions. While it's exceedingly difficult to show exactly how any particular environmental or energy policy affected pollution or consumption levels, many of California's trends are very encouraging.

Today, California ranks 50$^{th}$ in per capita electricity consumption. The US per capita annual residential electricity consumption in 2011 was 4,566 kWh; California was 2,346. The national average is almost twice that of California; a remarkable statistic, even accounting for California's mild climate [23] – Californians use less air conditioning than most other southern and western states. Most (59 percent in 2009) homes in California are heated with natural gas, a far more efficient form of home heating than electricity, and Californians also heat their water mostly with natural gas [24]. Fully 14 percent of homes were not even heated in 2009. The state ranked 30$^{th}$ in its average annual per capita residential natural gas use in 2011 [23]. Building and appliance codes adopted by the California Energy Commission (CEC) and California Public Utilities Commission (CPUC) since 1975 have steadily driven down natural gas consumption [25].

### *Market Incentives for Environmental Policy*

The early 1990s saw widespread adoption of new environmental policy tools, notably ones that took advantage of economic incentives rather than classic regulation. At the federal level, Congress used cap-and-trade (also called "tradable permits") to curb acid rain damage, which had been caused by the hundreds of Midwestern power plants that were burning sulfur-containing coal to produce electricity. The Acid Rain Program is widely credited with reducing SOx and NOx emissions far more and at much less cost than had been achieved by pre-existing command-and-control standards, although more needs to be done in order for the acid-sensitive ecosystems in Appalachia and the Northeast to fully recover [26].

In California, the SCAQMD rolled out the Regional Clean Air Incentives Market (RECLAIM) in 1994. Initially covering 392 facilities that collectively accounted for 65 percent of the region's NOx emissions, RECLAIM replaced about 40 command-and-control regulations with a mandatory tradable permits system. Although the RECLAIM program had a rocky debut, a recent study found that RECLAIM facilities decreased their emissions by about 20 percent more than similar sources that remained subject to command-and-control regulations [27]. The same study did not find disproportionate pollution reductions (or increases) in neighborhoods with different demographic characteristics. Thus, while RECLAIM has been challenged on environmental justice grounds (as has AB 32), no inequitable impact has been definitively demonstrated [27].

This history of ambitious, independent air pollution regulation allowed CARB to build expertise in how to make air pollution control effective [17]. The state's cooperative relationship with federal air quality regulation, where EPA and CARB work together and learn from each other, has made California unique among states when it comes to environmental policy. California's air quality has improved and today's pollution control costs less than it used to; this is an undeniable achievement, particularly in light of tremendous population and resource consumption growth. Not only has it reduced air pollution within its borders, its actions led to similar progress across the country. The state is now regarded as a national, and indeed global, leader on air pollution policy. That said, it is absolutely critical to note that air quality in many parts of California remains unacceptably poor. The Los Angeles Basin is still out of attainment for ozone and NOx and will likely remain so for years to come. California's Central Valley, the nation's most important vegetable-producing region, suffers acutely from persistent air pollution (especially particulate matter) exacerbated by drought, wildfire and heat waves.

## Climate Change Mitigation

When the environmental and policy communities' attention shifted in the late 1990s to climate change and the greenhouse gases that cause it, California already had years of experience regulating air pollutants from mobile sources, a robust administrative structure, the trust of political leadership, and an expert staff to tackle the challenge. It was well positioned to pioneer constraints on greenhouse gases from automobiles and to pursue ambitious economy-wide targets.

In 2005, Governor Schwarzenegger set the first and most ambitious state greenhouse gas emissions reduction target, issuing an Executive Order that called for a return to 2000 levels of GHG emissions by 2010, to 1990 levels by 2020, and to 80 percent below 1990 levels by 2050 [28]. The 2050 target is widely acknowledged as the reduction needed worldwide to avoid the worst impacts of climate change. One year later, the state legislature also took action and passed AB 32, the Global Warming

Solutions Act. AB 32 codified the goal of reducing emissions to 1990 levels by 2020 and directed CARB to develop a strategy, called a "Scoping Plan," to identify and implement measures to meet that target. In 2015, Governor Brown added another milestone on the path to 2050. He issued an Executive Order establishing the goal of a 40 percent reduction in GHG emissions below 1990 levels by 2030 [29]. California's climate change policy is noteworthy for the consistent political support it has received despite changes in political leadership, economic conditions, and national and international politics.

### *Regulation of GHGs from the Transportation Sector*

In California, the transportation sector generates 37 percent of the state's total greenhouse gas emissions [30]. This reality, combined with the state's record of success in reducing vehicle air pollution, made transportation the natural starting point of the state's climate change strategy. In 2002, the state legislature passed the first law in the country targeting GHG emissions from motor vehicles. AB 1493, commonly referred to as the Pavley standards for its author, then-Assembly member (and subsequently Senator) Fran Pavley directed CARB to set standards that "achieve the maximum feasible and cost-effective reductions" in GHG emissions from light-duty vehicles [31]. After a lengthy delay by EPA in allowing the regulations under the CAA, CARB issued regulations in 2009 requiring a 17 percent reduction in GHG emissions from light-duty vehicles by 2020, and a 25 percent reduction by 2030 [31]. In 2010, the federal government followed California's lead in regulating GHG emissions from cars, enacting essentially the same emissions standards for model year 2012–2016 light-duty vehicles [32]. California was thus the first state to enact meaningful GHG reduction requirements and the model for one of the first major federal greenhouse gas reduction initiatives.

At the same time, CARB also updated its Zero-Emission Vehicle (ZEV) program. Zero-emission vehicles include plug-in hybrid, battery electric and fuel cell vehicles. The ZEV program was originally part of California's strategy to regulate smog. The first goals required manufacturers to make 2 percent of their fleet ZEVs by 1998 and 10 percent by 2003. After several years of little progress, CARB concluded it had been overly optimistic about how quickly the battery technology would advance to make the cars economically competitive, and the targets were extended and revised several times [33]. After the state embraced large-scale, long-term greenhouse gas emission reduction targets, however, the ZEV program became an important part of meeting those goals. In order to achieve the 80 percent reduction below 1990 emissions levels by 2050, CARB estimates that about 87 percent of the light-duty vehicles in use (on the road) in 2050 will need to be ZEVs, which means that almost 100 percent of new car sales in 2040 must be ZEVs [31]. In light of this formidable task, CARB amended the ZEV regulations, increasing the standard for the first time [34]. In 2012, CARB integrated the ZEV program into its new comprehensive Advanced Clean Cars Program, discussed in detail below. These transportation programs are also critical to helping reach the goal announced by Governor Brown in his 2015 inaugural address of cutting the state's petroleum consumption by cars and trucks in half by 2030 [35].

After the passage of AB 32, the implementation of the Pavley greenhouse gas regulations, and their subsequent adoption by the federal government, California again ramped up the climate change focus of its vehicle regulations. In order to meet AB 32's emissions reduction goal, CARB's Scoping Plan called for a reduction in emissions from passenger vehicles by an additional 3.8 million metric tons of carbon dioxide equivalent (MMTCO2) beyond the reductions that would result from the Pavley regulations covering 2009–2016 [36]. Working with EPA and the National Highway and Traffic Safety Administration (NHTSA), CARB created the Advanced Clean Cars Program, a suite of regulations that together would accelerate commercialization of clean car technology and reduce both smog-causing pollutants and greenhouse gases.

The Advanced Clean Cars Program (ACC) combines the regulations of tailpipe emissions and the ZEV program, and includes recharging and fueling infrastructure goals, creating a comprehensive set of incentives in favor of cleaner vehicles. The LEV III program will continue to limit emissions of smog-causing pollutants, and will cover not only passenger cars but also light-duty trucks and medium-duty passenger vehicles (small SUVs) [31]. After the Pavley GHG regulations expire in 2016, CARB will impose separate standards for the major GHGs, reducing emissions by 34 percent by model year 2025 and aligning its regulations with federal standards [31]. The ACC also strengthens the ZEV program by requiring that 15 percent of new cars sold in California be ZEV [36]. Demonstrating again California's leadership on climate change, ten other states have enacted similar ZEV programs, covering about a quarter of the entire U.S. vehicle market [36]. Finally, the ACC aims to ensure that the fueling infrastructure for advanced vehicles (electric charging stations and hydrogen fuel stations) is sufficient to meet demand [31].

Shortly after enacting AB 32, California Governor Schwarzenegger issued an executive order directing CARB to set standards reducing the carbon intensity of transportation fuels [37]. CARB's Low-Carbon Fuel Standard (LCFS) came into effect in 2011 [38]. The regulations assign a carbon intensity to every fuel sold in California based on a life-cycle assessment [38]. Fuel suppliers must meet the cap for average carbon intensity across all fuels that they supply, and the cap decreases each year, resulting in a 10 percent reduction in fuel carbon intensity by 2020 [36]. This innovative policy is already influencing other states. Oregon has enacted a similar law, and Washington is considering doing the same [38].

### *Sustainable Communities*

The final piece in a comprehensive approach to decreasing transportation emissions is to reduce the amount that people drive. California has taken major, though as yet unproven, steps to reduce reliance on private vehicle use.

In 2008, California passed SB 375, which aims to reduce climate emissions from transportation by encouraging land use development that makes communities more

integrated, accessible, and equitable. SB 375 directs CARB to establish GHG emissions reduction targets for each region with a Metropolitan Planning Organization (MPO) [39]. The targets apply only to the passenger car and light truck sector and are to be achieved by 2020 and 2035 [39]. MPOs then must create Sustainable Community Strategies (SCS) describing policies and projects that will achieve the targeted reductions [36]. Federal law already requires that MPOs prepare a Regional Transportation Plan, and the goal is for agencies to merge these planning processes. Although local governments maintain authority to make all local land use and planning decisions, SB 375 incentivizes these bodies to follow the SCS by allowing projects that comply with the SCS to bypass major environmental review processes and by limiting eligibility for federal funds to projects listed in the SCS (Adams et al. 2009). CARB issued the 2020 and 2035 regional emissions reduction goals in 2011, and all MPOs have finalized their first SCS [40].

A major goal of SB 375 is to increase the variety of transportation options available to commuters, including public transit options, such as trains and buses, as well as active transportation, including walking and cycling. SB 375 encourages development around public transit hubs and dense, walkable neighborhoods. California is also constructing the nation's first high-speed rail system, starting with a line providing service between San Francisco and Los Angeles [36]. The cap-and-trade system established by AB 32 generates funds that the legislature reinvests in programs that reduce GHG emissions, such as expanding and improving public transportation services [41]. One aim of these community planning projects funded by cap-and-trade revenue is to benefit disadvantaged communities by providing better access to jobs and services and creating more affordable transportation options. The overall effect of these programs on total vehicle miles travelled, regional GHG emissions, and community equity remains to be seen, and the lack of enforcement mechanisms and the dependence on local government cooperation may limit the bill's impact [42].

### *Freight transportation*

Although passenger cars and trucks make up the majority of GHG emissions in the transportation sector, freight transportation is another significant source. In California, freight transportation is responsible for 6 percent of the state's total GHG emissions and 45 percent of the nitrogen oxides that form ozone [43]. It's also indirectly the source of one-third of jobs in the state [44]. Accordingly, CARB identified the creation of a Sustainable Freight Initiative as a major element of its climate change strategy [36]. In 2015, CARB published a discussion document detailing the environmental and health risks posed by air pollution from the freight system and the possible strategies for reducing those harmful emissions [43]. Governor Brown issued an Executive Order in July 2015 directing multiple state agencies, including CARB and the Energy Commission, to create an action plan within a year that establishes targets for freight efficiency and competitiveness and for a transition to zero-emission technologies. The plan must also identify policies that will achieve those targets. Further, the Executive Order requires the same group of agencies to prepare a pilot project in a major trade corridor featuring advanced technologies, alternative fuels and fuel infrastructure, and economic development [44].

### *Clean Energy Technologies*

California is working hard to reduce its reliance on petroleum, and gasoline consumption declined almost 10 percent from 2006 to 2013 despite a growing population [4]. However, the economic competitiveness of advanced technology cars must improve if California is to meet the Governor's goal of having 1.5 million zero emission vehicles on the road by 2025 [45]. California already provides funding to assist citizens in purchasing clean cars through rebates and vouchers and is home to 150,000 electric vehicles, more than any other state [46]. The legislature appropriated $200 million of the proceeds from the cap-and-trade market to low-carbon transportation development projects, and the Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program invests $100 million per year in alternative fuels, fueling infrastructure, and workforce development [36]. Other policies needed to smooth the transition to a largely advanced technology fleet include electricity rates that encourage vehicle electrification but also incentivize off-peak charging, permitting procedures that facilitate fueling infrastructure development, and electric grid upgrades to support more demand [36].

Although California is a national and world leader in terms of its efforts in and progress toward reducing GHG emissions, it continues to develop and implement energy systems to ensure increasing sustainability. California began requiring a certain percentage of retail electricity sales to come from renewable sources even before it began regulating greenhouse gas emissions. The state's first renewable portfolio standard, issued by the state legislature in 2002, set a goal of getting 20 percent of electricity from renewable energy sources by 2017 [47]. Governor Schwarzenegger increased the goal in 2008 by Executive Order, to 33 percent by 2020 [48]. The legislature codified that goal in 2011, and has just enacted a longer-term goal of 50 percent renewable electricity by 2030 [48].

California is also planning for improvements to the electricity system to facilitate increasing renewable resource use. Upgrading the electrical grid to account for fundamental differences between renewable sources and traditional fossil fuel sources is essential for a large-scale transition to renewable energy sources. The California Public Utilities Commission has initiated new rules focused on improving demand response, and in 2013 it directed investor-owned utilities to obtain 1,325 megawatts of energy storage by 2024 [36].

Reducing energy consumption through efficiency measures has been another longstanding state priority, with programs addressing energy usage from new and existing buildings, appliances, and the generation and transmission process. California is finding innovative and creative ways to stimulate energy efficiency improvements in the building sector. The state has long been a leader in efficiency

standards for new construction, but 55 percent of existing residential buildings and 45 percent of existing nonresidential buildings were constructed before California began issuing those standards [36]. In 2009 the legislature directed the Energy Commission to collaborate with the California Public Utilities Commission (CPUC) and community stakeholders to create a comprehensive program for improving the energy efficiency of existing buildings [49]. The Energy Commission released the final Existing Buildings Energy Efficiency Action Plan in 2015 [49]. In 2008 the CPUC established a goal that all new residential construction in California be zero net energy by 2020, and that all new commercial construction be zero net energy by 2030 [50]. To help stimulate demand for efficiency technologies, Governor Brown issued an Executive Order in 2012 that required state agencies to reduce their electricity purchases by 20 percent by 2018 [51]. The same year, voters approved a ballot proposition entitled the California Clean Energy Jobs Act, which closes a corporate tax loophole and channels the generated funds into energy efficiency and renewable energy generation projects at school facilities [52]. Finally, the recently enacted law SB 350 requires building energy efficiency to double by 2030 [48].

California is also working to improve the efficiency of appliances. The Energy Commission continues to develop efficiency standards for appliances not covered by federal law, adopting standards for televisions in 2009 and battery-chargers in 2012 (the first state to do so) [36]. The Energy Commission is also examining the nexus between water and energy usage, adding new standards for water-using appliances, such as sprinklers and irrigation systems, toilets, faucets, and showerheads [53].

## The Politics of Air Quality and Cap-and-Trade

California's emissions allowance trading system, also called a cap-and-trade system, is perhaps the highest profile element of the state's climate change strategy. The program, which launched in 2013, applies to electricity utilities (both generators and importers), to large industrial facilities, and (as of 2015) to fuel distributors [36]. The program now covers 85 percent of emissions in California, making it the most comprehensive cap-and-trade market in the world [17].

The cap and trade system provides for the government (in this case CARB) to issue a set number of emission "allowances," equal to one metric ton of carbon dioxide equivalent, that add up to the identified allowed emissions for the market, with the number of allowances (or "cap") declining each year [17]. Entities regulated by the cap-and-trade program must report their emissions and hold sufficient allowances for them. Entities that reduce their emissions enough to have extra allowances may then sell those allowances on the established market to entities that expect to exceed their allowed emissions. The program also provides for offset credits, through which entities can meet up to a set percentage of their emissions reductions through projects outside of the cap-and-trade system. The idea of offset credits in cap-and-trade policy is controversial, mainly because of the difficulty in quantifying and verifying the claimed emissions reductions. To date, the California system accepts offsets from four specific types of projects: forestry, urban forestry, manure digesters, and destruction of ozone-depleting substances [36].

Cap-and-trade programs can distribute allowances either through an auction (which sets the price for each allowance), for free, or by some mix of the two. California distributes its allowances through a mix of public auctions and free allocations [17]. The proceeds generated by the auction of allowances fund other projects designed to reduce greenhouse gas emissions [36].

### *Environmental Justice under Cap-and-Trade*

Such market-based policy tools sometimes draw criticism from environmentalists, who claim that these programs amount to selling the right to pollute, or other activists, who assert that cap-and-trade programs concentrate pollution in communities of color and poorer neighborhoods. In 2012, the Legislature thus passed SB 535, which requires that 25 percent of cap-and-trade auction revenues be invested in projects that benefit disadvantaged communities, and at least 10 percent of the funds go toward projects located in those communities [54].

In late 2014, the California Environmental Protection Agency (CalEPA) issued its list of disadvantaged communities that would qualify for the requirements under SB 535 [55]. These communities were identified from a quantitative ranking based on the location's socioeconomic characteristics and environmental vulnerabilities (air pollution, proximity to hazardous sites, industry, etc.) [56]. For the 2014–2015 budget, the legislature appropriated $125 million to develop affordable housing near transit, $50 million for improving and expanding rail and bus services and facilities that serve disadvantaged communities, and $75 million for weatherization and renewable energy installation in single and multi-family low-income housing [57]. The actual proceeds from the auctions in 2014–2015 far exceeded the budgeted appropriations, so the proposed allocations for the 2015–2016 fiscal year were to significantly increase these numbers [58]. Funding from the auction revenue has greatly increased the total public investment in these programs, doubling some of them [58]. The program is still new, and the CalEPA and the legislature continue to seek input from the public and improve implementation [58].

### *Cap-and-trade vs carbon taxes*

California's cap-and-trade system is the centerpiece of its climate policy efforts. But would a carbon tax be a more efficient alternative? British Columbia's revenue neutral carbon tax has been widely hailed as a model for others to follow, while cap-and-trade programs such as the European Emissions Trading Scheme have been plagued by price volatility.

In a world with no uncertainty, cap-and-trade and carbon taxes could be designed to have identical effects. By setting the stringency of the cap, a government determines both the amount of emission reductions, and implicitly, the price that polluters pay to emit a ton of

$CO_2$ – i.e., the price of a cap-and-trade allowance. By setting the level of the tax, the government determines an explicit price, and an implicit amount of emission reductions. A tax generates revenue for the government, but so does the auctioning of carbon allowances. In both cases, a monitoring and enforcement system is needed to track emissions, and to collect revenue or surrendered permits.

In an uncertain world, however, the two policies will differ [59]. Under a carbon tax, the price of polluting is fixed, but economic growth and technological change means that the actual level of emissions is hard to predict. A leap forward in solar technology might lead to much more mitigation than expected from a carbon tax. Under cap-and-trade, meanwhile, the level of emissions is fixed, but the price of allowances can be volatile. Europe found its cap-and-trade scheme undermined by the global recession. The price to pollute fell by about 40% to less than €10 as firms needed fewer allowances [60] – giving less incentive to invest in long-term mitigation.

California's cap-and-trade program, however, mitigates the risks of uncertainty through a price floor and a partial price ceiling (formally known as the "allowance reserve"). In effect, if allowance prices fall too low or too high, the program converts into a carbon tax. California gets the best features of a tax and cap-and-trade.

### *Regional and Global Significance*

One particular challenge for the California cap-and-trade system is its interaction with the larger Western electricity grid, in which California is just one participant [61]. Because California is currently the only state in the Western grid with a cap-and-trade system in place, there is a concern that utilities with California compliance obligations will import electricity from less carbon-intensive sources, but total emissions will not decrease. This is one form of leakage, and it was a major concern in designing the California program. CARB has issued complex regulations to prevent leakage [62].

California's cap-and-trade program was designed to attract partners in other states and jurisdictions, both in order to alleviate leakage concerns and to expand market participation and influence. In 2014, the Canadian province of Quebec became the first jurisdiction to link its cap-and-trade system with California's. Regulated entities in each region can trade emissions allowances through a common auction platform [36]. The first joint auction occurred in the last quarter of 2014 and is considered a success [63]. All of the allowance offered for auction sold at above the minimum bid price, and future allowances for 2017 also sold out, showing market participants' confidence in the programs' durability [63]. This international carbon market partnership may attract other U.S. states and other jurisdictions to join. The federal government's new Clean Power Plan, requiring existing power plants to reduce their greenhouse gas emissions, may also attract states in the western region to link with California's cap-and-trade program. If it does, the problems of potential leakage will be reduced.

### *Trading in the regulatory mix*

Like any recent new policy, cap-and-trade sits on top of existing command-and-control regulation. As such, cap-and-trade, on it own, cannot do all the work of reducing California's GHG emissions. Even within California's landmark climate change policies, market incentives coexist with traditional command-and-control. While AB 32 relies on cap-and-trade, an earlier bill and its amendments, AB 1493 (passed in 2002 and known as the Pavley Bill), reduces GHGs from automobiles using efficiency standards. As discussed above, AB 1493 is expected to have reduced GHG emissions from autos by about 30 percent by 2016 [64]. The Pavley bill is significant, because Californians, like most Americans, continue driving more each year. Between 1980 and 2013, Californians went from driving 156 billion miles to 329 billion miles [30], about a two-fold increase. GHG emissions are not available for the 1970s–90s, but almost a decade and a half of efforts have already paid off in reduced CO2. Specifically, California's vehicle miles traveled increased from 306 billion miles in 2000 to 329 billion miles in 2013, about a 7 percent increase, but GHG emissions from the transportation sector *dropped* by about 4 percent in the same period [30, 57] and gasoline consumption has fallen faster than the US as a whole [65]. It is also significant to note that California's vehicle miles traveled have barely changed since 2004, despite an approximately 8.5 percent growth in the state's population [66].

Californians are generally supportive of air pollution control measures as well as standards that improve the efficiencies of their appliances, automobiles and homes. Voters in California have also consistently supported climate change mitigation policies. Whether voters in other states and countries will align their support for air quality improvements with climate change policies remains to be seen. As a general rule, policymakers enjoy much more support for environmental regulations designed to improve human health in the near-term than policies pursued on behalf of nonhuman nature (e.g., acid rain) or resource efficiencies (e.g., water and energy conservation). In the case of air quality, no one disputes the importance of clean air; rather, fierce battles occur over the cost of new regulations and sometimes the efficacy of new standards. In this way, climate policies that draw on the same policy toolkit as antipollution regulations will probably not benefit from human health constituents in the same way. As a political matter, therefore, disputing the scientific merits of combating climate change will likely become less and less viable over time; however, battle lines will be drawn over the pace and cost of climate policies.

The breadth of actions that California has taken to reduce its emissions and advance the technologies that will help others do the same is unprecedented for a U.S. state and is indeed one of the most ambitious climate programs in the world. Decades of successful air pollution policies have given California the capacity and the will to translate this policy expertise to the climate change realm. As compared with more traditional air pollution, however, California cannot address climate change on its own. It must use its reputation as an environmental leader to

urge others to recognize the need to reduce greenhouse gas emissions immediately.

## Innovations in Land Use and Transportation Planning

Transportation emissions not only account for 37 percent of California's GHG emissions, but they are also currently the fastest-growing source of these pollutants [30]. The California Air Resources Board (CARB), charged with implementing AB 32, regards technological changes to improve energy efficiency and air quality control as the most efficient means of reducing GHG emissions. In addition to the stringent fuel economy and low carbon fuel standards discussed above, however, CARB has committed to reducing Californians' demand for driving by changing the built environment to encourage active transportation and transit in the interest of achieving the state's long-term climate goals.

California was the first state to mandate regional targets for reducing GHG emissions through coordinated land use and transportation planning. Since the 2008 passage of SB 375, California has sought to contribute to the state's GHG emissions reductions goals via more efficient development patterns. Land use planning to facilitate transportation-oriented development, investments in public transportation, carpooling programs, and active transportation combined with increased costs of driving can bring significant reductions in GHG emissions [42, 67, 68].

### *Regional Planning to Reduce Sprawl*

While California is the most populous state in the United States and one of the world's largest economies, many issues related to economic and population growth occur at the regional level—from "mega regions" such as the Los Angeles metropolitan area to smaller regions such as the Central Coast. California's regions are vulnerable to social, political, environmental, and economic fluctuations that often exceed the problem-solving capacity of traditional governing institutions at the state and local levels.

In particular, urban growth has intensified conflicts between regional transportation policies and local government land use practices. Transportation planning is conducted through councils, or associations, of government, which rely on member cooperation and influence to achieve policy consensus. Land use regulation and planning are reserved for local governments. In addition, a wide array of federal, state, and sub-state agencies implement laws to improve air and water quality, and to evaluate environmental impacts from any proposed projects. Collaborative regional planning represents a promising response to this crisis of governance [69].

Increasingly, this comprehensive and inclusive planning model seeks to achieve efficient and sustainable land use, transportation and transit networks, and economic development to accommodate population growth that may exceed the governance capacities of cities and counties. Smart growth, an approach to urban planning that concentrates growth in compact, walkable urban centers, promises to reduce automobile use and the low-density "sprawl" that has come to dominate much of the California landscape. The benefits of smart growth include: lower per capita consumption of land; more accessible and diverse transportation options, with lower attendant costs; more efficient provision of utilities and public services; and often also a greater sense of community [70, 71]. Yet its primary appeal in the context of SB 375 is its potential to reduce GHG emissions.

SB 375 requires each Metropolitan Planning Organization (MPO) to develop and implement a Sustainable Communities Strategy (SCS) as part of its Regional Transportation Plan (RTP), which regulates transportation financing, and Regional Housing Needs Allocation (RHNA), which sets housing goals and allocations. A SCS is an element of the RTP, and is intended to build on California's existing framework of regional planning by integrating land use and transportation planning to reduce GHG emissions from transportation and achieve CARB emissions reduction targets. These emissions targets are established in collaboration with MPOs. In practice, current targets for 2020 and 2035 were developed by a Regional Targets Advisory Committee (RTAC) composed of MPO representatives and local government officials, as well as other stakeholders, including selected members of developers, affordable housing, and environmental organizations.

Addition of the SCS requirement represents a modification of MPOs' responsibility for incorporating land use and development considerations into RTPs. It is akin to existing requirements that RTPs comply with federal air quality standards. If an MPO is not able to achieve its emissions reductions goals, it must submit an alternative planning strategy (APS) that explains how the target might be achieved with additional rules and/or resources.

SB 375 builds on the blueprint process that many of the states MPOs use to achieve the efficient and sustainable placement of land use activities, transportation and other public infrastructure, and housing and other development to accommodate population growth beyond the governance capacities of cities and counties [69]. Blueprint planning relies on outreach to local officials and community engagement to identify long-range regional development goals and build popular support for achieving them. Their success is attributable, in part, to the institutionalization of regional governance following the passage of the federal Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, which tied federal funding for transportation to MPOs [72]. Passage of SB 45 in 1997 supported the transition to regional governance by authorizing regional agencies to administer state and federal investment funds.

### *The Politics of Land Use and Transportation Planning*

Land use and transportation planning under the auspices of SB 375 is the result of an "impossible coalition" that included environmentalists, homebuilders and other developers, business owners and organizations, affordable housing advocates, and representatives of local governments, agencies, and supporters [73]. The broad scope of the bill makes it appealing to climate activists, environmentalists seeking to preserve open space, urbanists, public health advocates who see the benefits of active

transportation, policy-makers focused on housing and jobs, and businesses that might be able to take advantage of the streamlining of environmental impact analysis discussed below. Still, prospects for SB 375 are compromised by its dependence on intergovernmental collaboration in the absence of sustained sources of institutional and financial support.

Although SB 375 provides a clear regulatory focus—GHG emissions—for the regional-local planning processes that must yield compliance, it is much more difficult to regulate GHG equitably than it has been to regulate criteria pollutants. Carbon dioxide and other GHG are emitted broadly as opposed to being associated with an identifiable set of operations or technologies, making it difficult to assign responsibility and justify sanctions. GHG are also sources of a global pollution problem, while the mitigation strategies associated with SB 375 will be costly for regions and localities, attendant air quality and public health improvements notwithstanding.

Those who crafted SB 375 might also be congratulated for preserving local planning authority, though the assignment of responsibility for GHG emissions reductions to MPOs still supports a longer-term transition to planning at the regional level. MPOs are responsible for ensuring outcomes—GHG emissions reductions targets—but possess little direct authority over planning to manage economic growth, environmental protection, and social equity simultaneously. Still, local governments do face a set of incentives and constraints designed to make it cost-effective for them to comply with the regional SCS.

Streamlining the California Environmental Quality Act (CEQA) is the primary direct incentive provided by SB 375. CEQA is the law that requires state and local agencies to identify environmental impacts associated with proposed developments and take appropriate steps to mitigate any damages. The time and expense associated with the environmental impact assessment process can be a formidable barrier to development. SB 375 exempts some projects, such as high-density housing and urban infill that are likely to encourage transit use and active transportation as alternatives to driving.

This incentive is accompanied by potentially significant financial and institutional constraints on local planners. MPOs may fund only those projects that are consistent with the SCS included in the regional land use and transportation plan, making it prohibitively expensive to build resource-intensive structures at a distance from city centers. In addition, existing mandates to amend local housing elements to accommodate projected demands for housing per the RHNA must be consistent with the SCS. Tomorrow's housing will be increasingly dense and, when possible, located close to transit stops and centers.

This situation threatens to antagonize pre-existing, or incite new, tensions between regional governance organizations and local governments and agencies over planning priorities; however, the pace and effect of regional governance remains stymied by budgetary limits on funding for transit and redevelopment, statutory impediments, such as Prop 13, to compact housing and related sources of revenue, and lack of popular support for infill and infrastructure expenditures in some locales. The current political context makes "wait and see" a viable response to the progress of SB 375. A more progressive tack would be to mobilize popular support and leadership at all levels of governance for stronger implementation on a shorter timescale.

## Central Role of Cities

Legislation and regulations in Sacramento have been the most high-profile elements of California's climate policy. However, many of the actual policies and projects that reduce emissions are the purview of local governments. While the state has authority over the fuel economy of new cars, the amount of driving is chiefly influenced by land-use and transportation decisions by cities and counties. Bicycle lanes, zoning regulations on parking and density, and parking pricing are all municipal decisions. Local agencies also manage recycling and waste reduction programs, which can decrease methane emissions from landfills. And while State regulations mandate minimum energy efficiency levels for new buildings, many cities require developers to achieve more stringent targets, and extend requirements to existing buildings as well as new construction.

### *Climate action planning in California cities*

California cities have shown particularly strong climate change commitments, which are often packaged under the umbrella of a Climate Action Plan, Sustainability Plan or similar green initiative. More than 70 percent of local governments in California are engaged or are planning to engage in climate policy efforts [74, 75], and California cities are more than twice as likely to have a climate plan compared to cities elsewhere in the country [76].

Some of the policies implemented by local governments are explicitly designed with climate policy in mind. Property Assessed Clean Energy (PACE) programs, which allow homeowners to fund the installation of solar or energy efficiency projects through an annual assessment on their property tax bills, first emerged as a strategy in Berkeley's Climate Action Plan [77].

Often, however, the policies with the greatest potential to reduce greenhouse gas emissions are those that many cities were already pursuing even before climate change became a central concern. This is particularly true in the case of transportation, which accounts for 37 percent of emissions in California [30], and upwards of 50 percent in many cities in the state. Public transit improvements such as Bus Rapid Transit, or increased residential densities around transit stations, are primarily motivated by concerns to reduce traffic congestion and air pollution, provide housing choices, or improve the quality of life of city residents. Such policies might be listed in a city's climate plan, but the climate impacts are almost incidental in comparison to the co-benefits, i.e. the local environmental gains.

The co-benefits of greenhouse gas reduction help explain why many cities have enthusiastically embraced the climate policy agenda. If climate change is the only motivation, city action seems irrational – an individual city

must bear the cost of reducing emissions, but the benefit is dissipated globally. Free riding is the rational approach. However, a primary motivation for cities appears to be co-benefits such as energy savings, water conservation, cleaner air, reduced traffic, and the creation of green jobs [78, 79, 80]. Another goal may be political – mayors and council members can use climate change as a platform to gain wider visibility and political advancement, and also exert pressure on the state and federal governments to take stronger action to reduce emissions [76]. Indeed, local climate plans seem to largely repackage the extensive efforts that cities were undertaking for other reasons, rather than having a causal role in spurring new climate policy implementation [81].

Recognizing the motivations for city climate policy contributes to understanding the limitations of action at the municipal scale, and also how these limitations might be addressed. First, local political preferences are a key driver of climate policy, and environmental policy more generally. It is no surprise that San Francisco and Berkeley, known for their progressive politics, were among the first cities to adopt a climate action plan. In general, affluent, liberal, coastal cities are more likely to adopt a plan to reduce emissions, and to implement specific measures such as public transport improvements and energy-efficiency building regulations [75, 82, 83]. Their residents are also more likely to engage in sustainable travel [84]. This situation does not mean that climate policy is completely absent from conservative cities, but rather that it is less prevalent and tends to emphasize the local economic benefits of promoting green jobs [74].

Second, some of the most effective greenhouse gas reduction measures can be controversial even in environmentally progressive cities – particularly those that relate to transportation and new development. In San Francisco, efforts to price parking and reallocate scarce street space from the car towards transit and bicycles have faced fierce political resistance [85]. Some of the cities that have the most ambitious climate policies, meanwhile, also have "slow growth" policies that restrict new development, in turn pushing development into more peripheral areas where the car is the only transportation option. Liberal cities in California such as Berkeley and Santa Monica issue fewer housing permits than comparable cities in the same metropolitan area [86]. There are few signs to date that climate change concerns can help change these dynamics, unless incentives are provided at the state level.

Third, the fiscal realities in many California cities constrain the possibilities for local action. Most obviously, there is limited funding for greenhouse gas reduction measures, whether energy efficiency retrofits or pedestrian improvements. However, another constraint is the dependence of California cities on sales tax revenue, given the limits on property taxation under Proposition 13. Cities compete with each other to attract auto malls, big-box stores and other sales tax generators, making it hard to restrict such automobile-oriented development or engage in coordinated planning [87].

Taking advantage of the enormous potential of local government climate policy therefore needs a shift in incentives. In his previous post as attorney general, Governor Jerry Brown used the threat of legal action to encourage cities to develop climate plans [74]. As yet, there are few incentives for cities to aggressively implement those plans, and to undertake even deeper greenhouse gas reductions. But embryonic funding and incentive programs give a sense of what is possible. One model is provided by Senate Bill 375, discussed above. Ultimately, implementation relies on the commitment of cities, but that commitment will be hard to obtain without mandates and substantial funding from regions and the state. The substantial cobenefits of reducing greenhouse gas emissions mean that the self-interest of cities can take climate policy a long way, but not to its full potential.

## Conclusion

Political success in environmental policy, like any other issue area, depends on crafting strong, stable coalitions around well-designed programs that can be built upon. Getting the incentives right helps enormously: imposing concentrated, very visible costs on powerful, well-organized interests *today* in the hopes of securing diffuse, uncertain benefits tomorrow is not a winning strategy. The most vulnerable environmental policies suffer from such political realities; protecting obscure endangered species comes to mind. In the case of climate policy, the benefits (avoiding the worst climate change) may be diffuse, but they are easily understood in human terms. Thus, early support for a wide-ranging effort like curbing GHGs can be gained by providing powerful incentives rather than by initially imposing heavy costs.

To avoid galvanizing opposition or the risk that policies produce only modest results, policies aimed at high-profile sectors (e.g., utilities) can provide early and very impactful successes. California's Electricity Rate Adjustment Mechanism (ERAM, adopted by the CPUC in 1982) is a good example. It decoupled rates from energy production, allowing utilities to recover costs from energy saving programs as well as energy production [88]. Before ERAM, giant electric power utilities believed that tremendous growth in electricity demand was inevitable and that profits could only follow energy sales. After ERAM, California's public utilities became much greener, since they could make money conserving electricity as well as selling it, and often enough, more cost-effectively.

How broad should energy and climate policies be? Very specific programs targeted narrowly at firms and households – think rebates, subsidies and renewable energy standards – often secure earlier and more lasting support than broad systemic policies like a carbon tax or urban planning reform [88].

Good policy designs provide for their own evolution and even replacement, if necessary. First, they rely on high-quality information so that policymakers can reliably detect success and failure (and at a sufficiently fine-grained level). Second, they reward continual improvements in performance. Efficiency rebates and standards work this way as each successive wave of efficiencies reward end users with further savings. Third, when a standard or regulation has wrung all the environmental improvement it can from

a particular source, it should be possible to replace it with new approaches [89]. These points essentially describe the arc of policies aimed at the environmental effects of gasoline-powered automobiles. Earlier measures targeted air emissions (HC, CO, NOx). These were controlled by the catalytic converter (an equipment standard) and reformulated gasoline (i.e., a materials standard that required removing lead). Fuel efficiency standards followed and continue to this day, as did rebates for hybrid vehicles. But there's only so much GHG reduction one can wring, in the near term, from a 3,000–5,000 pound car burning gasoline. So the next step in the mobile source policy is to motivate complete replacements for gasoline (e.g., electric, hydrogen).

Several contemporary trends that characterize the politics of policymaking could undermine climate policy efforts, whether in California or elsewhere. To varying degrees depending on location, policymakers must contend with anti-government sentiments, very fragmented political power and public preferences for third-party or private provision of public goods and services [90]. A natural reaction to these forces is to pursue indirect and relatively less visible programs, which will not draw too much opposition. Paradoxically, as Salamon [90] puts it, "policymakers seem to be under increasing pressures to select those tools of public action that are the most difficult to manage and the hardest to keep focused on their public objectives." California succeeds in avoiding this paradox as it addresses climate policy only to the extent that it legitimizes climate mitigation as a matter of state action, demonstrates high public accountability and enlists powerful coalitions by providing substantial and enduring incentives.

## Competing Interests

The authors have no competing interests to declare.

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