CLIMATE CHANGE SOLUTIONS

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(Editor)

BENDING THE CURVE

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About the Cover

The Age of Humans and Climate Disruption We are living in the age of humans, and there is no denying that the technologies innovated by *Homo sapiens* have turned us into a major geologic force. The resulting modification of the land, the oceans, and the atmosphere has poisoned our bodies, imperiled our environment, and disrupted the planet's climate. The composite image on the cover acknowledges the inextricable link that humans have with our planet. To solve the imminent problem of climate disruption, human beings have to realize that we all belong to the same *Homo sapiens* species. We must work together for the common good since the problems we face require global solutions. Think local, to protect your family and community, but act global. This is the spirit of the book you are about to read. It describes how the climate change problem can still be solved.

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CONTENTS

CHAPTER 9

Lessons from California

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CHAPTER CONTENTS

Learning Objectives

1. Understand the historical foundation for California's climate policy. You will learn how local concerns—primarily air pollution in Southern California, but also public opposition to nuclear energy—built the institutional structures, technical capacity, and legal framework that the state later employed to tackle greenhouse gas emissions. You will also learn how a combination of public, legislative, and business support has maintained and extended California's climate policies.
2. Understand and identify the policy tools used to achieve cleaner air and a more energy-efficient economy. You will learn about the mix of regulatory, incentive-based, and market approaches that California has developed to reduce emissions and improve energy efficiency. You will also learn how the state has built on experience from elsewhere—for example, through designing a cap-and-trade system to avoid the problems experienced in Europe—and how it has responded to concerns about the equity and environmental justice impacts of climate policy tools.
3. Critically analyze the progress that California has made and the work that remains to be done. You will learn about the degree to which California has achieved its near-term objectives and the challenges that lie ahead as the state looks toward its goals for 2040 and beyond. You will be able to analyze why progress in some sectors has been rapid and identify the barriers that have hampered progress in other areas—particularly land use policies to reduce vehicle travel. You will also learn about the influence of California's policies beyond its boundaries and about how the state has served as a climate policy laboratory.

Overview

This chapter introduces the steps that one climate change leader, California, has taken to reduce its greenhouse gas (GHG) emissions across a wide range of economic activities. Given the magnitude of the climate change challenge, it's easy to conclude that brand-new or as-yet-undiscovered mitigation and adaptation policies will be needed. But California's experience shows that decades-old policies and programs designed to improve air quality and energy efficiency, as well as spur large-scale use of renewable power sources, can all be used to combat climate change. So, climate change policies are neither unknown nor untried; indeed, many of the required policies simply build on existing efforts that are widespread and well understood.

The chapter begins with some history, discussing how very poor air quality, especially in the Los Angeles basin, spurred activists, scientists, and policymakers to act. The chapter then focuses on California's innovative climate policies. We do not aim to provide a comprehensive guide to all of the state's efforts. Rather, we selectively review some of the most innovative and far-reaching policies, and chart the steady ratcheting up of its targets for greenhouse gas reductions and renewable energy. The first law explicitly requiring greenhouse gas reductions—anywhere in the country—targeted cars and other light-duty vehicles. The resulting regulations were adopted by 14 other states, accounting for almost 40% of US new vehicle sales. Later, the federal government worked with California to develop even more aggressive regulations. Thus, vehicle GHG emission standards were an early example of how California's policies could spur climate action beyond its boundaries.

Subsequent laws went beyond the transportation sector to require economy-wide greenhouse gas reductions. Most notably, Assembly Bill 32 (AB 32), the California Global Warming Solutions Act of 2006, set a target of reducing greenhouse gas emissions to 1990 levels by 2020, which in practice meant a reduction of 25% to 30% below business-as-usual emissions. A statewide vote highlighted the depth of California voters' support for climate policy; a ballot measure that would have effectively repealed AB 32 lost by more than 2 million votes.

Section 9.3 analyzes one of the centerpieces of California's plan to achieve the AB 32 target—cap and trade, which sets a limit on emissions and allows firms to trade emission allowances in order to reduce overall mitigation costs. California's experience with cap and trade has generally been a success. Emissions have fallen while the state's economy has prospered, and auctions of emissions permits have generated more than $10 billion for the state's Greenhouse Gas Reduction Fund.

Despite the high-profile nature of cap and trade, California has also relied on more traditional "command and control" regulations and performance standards, as well as other types of market instruments, to achieve its goals. The energy sector is a case in point. The state has continued to expand requirements for utilities to generate a certain portion of their electricity from renewables—by 2045, electricity must be 100% carbon free—and set energy efficiency standards. These energy gains have resulted in a state whose carbon footprint, in tons of CO_2 equivalent per capita, is much lower than that of the rest of the US, but still higher than the world average.

Section 9.5 discusses one area where the state's climate policies have had more limited results—encouraging more transit-oriented land use patterns that reduce vehicle travel and emissions from the transportation sector. The state has no authority over local land use decisions—that is, what gets built where. These decisions are jealously guarded by cities and counties as their own prerogative and determine whether and how far California residents have to drive.

In the final section, we'll go beyond AB 32, discussing how the state's targets have gradually increased in ambition. A 2016 law (SB 32) enshrines a target of reducing GHG emissions 40% below 1990 levels by 2030, and a subsequent executive order from the governor sets an even more ambitious goal of carbon neutrality by 2045. A key conclusion is that the politics of the state are favorable to climate policy. The lack of coal reserves and limited heavy industry, together with a business community that benefits from clean energy and environmental protection, have ensured that climate mitigation rests on a broad base of support.

9.1 Air Quality as the Genesis for Climate Policy

Urban smog in the Los Angeles basin is legendary. On many days, downtown skyscrapers and even the Hollywood sign blur into a dirty haze (Figure 9.1.1). Geography plays an important role; the San Gabriel Mountains create what is known as an inversion layer of warm air that traps the smog-laden cooler air below and prevents air pollution from dispersing. However, the region's air quality problems are rooted in the sheer number of cars and industrial pollution sources.

Southern California smog paradoxically laid the foundation for California's ambitious climate policy agenda and helped the state become one of the most energy efficient and least polluting in the country. The severity of air pollution forced a response that led to the creation of the institutional and legal framework that would later be harnessed in the fight against climate change.

A Dutch-American chemist, Arie Haagen-Smit, was the first to demonstrate, in the 1940s and 1950s, that Southern California smog was being caused by tailpipe emissions and smokestack gases. In 1968, Haagen-Smit became the first chair of the California Air Resources Board (CARB), a state agency that was created to help Californians address the problem of air pollution. Over the years, CARB developed and enforced air quality regulations, often acting earlier or more aggressively (sometimes both) than the federal government and other states. Indeed, California's tailpipe standards for automobiles, controlling hydrocarbons and carbon monoxide (CO), took effect in 1966—2 years before the first federal standards.

In the 1970s and earlier, officials in the Los Angeles basin issued many smog alerts when ozone concentrations reached 0.20 parts per million (ppm), warning residents to limit their physical exertion and sometimes even to stay indoors. Air quality staff recorded a maximum 1-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 later

FIGURE 9.1.1 **Smog in downtown Los Angeles, circa 1995. California's experience since the 1940s in combating air pollution laid the groundwork for climate policy.** Reproduced with permission from the Dorothy Peyton Gray Transportation Library and Archive at the Los Angeles County Metropolitan Transportation Authority.

that decade. As late as 1975, the South Coast Air Quality Management District issued smog alerts on 118 days. But air quality started getting better in the 1980s and has improved steadily ever since. By 1990, there were only 42 alerts, and there were none by 2000. These marked improvements came despite enormous population growth in the greater Los Angeles area, from around 10 million people in 1970 to around 17 million people in 2015.

One regulatory approach used by CARB and its federal counterparts in the 1970s and 1980s is known as **command and control**—the government commands firms and individuals to behave in a certain way, or to adopt a certain technology, and controls or monitors compliance. For example, bans on lead in gasoline, first implemented by CARB in 1992, 3 years in advance of the federal government, fall into this category. A closely related approach is called **performance standards**—the

government sets a limit on how much pollution can be produced for a given amount of activity but does not specify the precise technologies that must be used to achieve the standard. Auto tailpipe standards that dictate acceptable pollution releases in grams per mile are a good example of the performance standard approach that California has used.

Over the same period, California's environmental policy began to address broader questions of energy, normally using the same framework of command and control and performance standards. 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 precisely how any particular environmental or energy policy affected pollution or consumption levels, many of California's trends (discussed in Section 9.4) are very encouraging.

9.2 California's Climate Legislation

California's recent wave of legislative efforts on climate change, summarized in Table 9.2.1, was built on the air quality and energy efficiency regulation described in the previous section and can be traced back to 2000. In a piece of legislation authored by state senator Byron Sher, California created the California Climate Action Registry to enable major sources of greenhouse gases to report their emissions and gain credit for "early action" to reduce CO_2 and other greenhouse gases. These efforts to collect baseline data helped build technical expertise, as California's regulators partnered with other regions, cities, states, and countries around the world to pool information and refine the methodologies for counting greenhouse gases.

Cleaner cars

The first major step toward regulating emissions, rather than just counting carbon, came in 2002, with the passage of a bill (AB 1493) from assembly member Fran Pavley to regulate the climate impact of motor vehicles. At the time, advocacy group Environmental Defense called it "the most important climate bill passed anywhere in the U.S. in the past two decades." Prior to the "Pavley bill," as it came to be known, emissions regulations for cars and light trucks had been limited to the pollutants that affect local air quality, such as carbon monoxide, oxides of nitrogen, and hydrocarbons. Carbon dioxide was not considered a "pollutant."

Car and light truck emissions are regulated by the Environmental Protection Agency (EPA). Because of long-standing smog in Southern California, however, California has a unique position under the federal Clean Air Act and can set its own, more stringent standards subject to a "waiver" from the EPA. Other states can follow California's stricter standards or default to the EPA rules. It was California's special status that the Pavley bill made use of, in order to add greenhouse gases to

TABLE 9.2.1 Major climate policy legislation in California

Year Enacted	*Bill*	*Key Provisions*
2000	SB 1771	Established the California Climate Action Registry to enable polluters to report their emissions
2002	AB 1493 (Pavley bill)	Required CARB to adopt regulations that achieve the "maximum feasible and cost-effective reduction of greenhouse gas emissions" from cars and light trucks
2002	SB 1078	Required 20% of retail electricity sales to come from renewables by 2017 (Renewables Portfolio Standard)
2006	AB 32 (California Global Warming Solutions Act of 2006)	Set target of reducing greenhouse gas emissions to 1990 levels by 2020, required CARB to develop a plan to achieve that target, and authorized the use of cap and trade
2008	SB 375 (Sustainable Communities and Climate Protection Act of 2008)	Required CARB to develop regional targets for greenhouse gas emissions and required regional agencies to develop integrated land use and transportation plans to achieve those targets
2011	SB 2-IX	Increased Renewables Portfolio Standard to 33% by 2020
2012	SB 535	Required at least 25% of cap-and-trade revenue in the Greenhouse Gas Reduction Fund to be spent on projects that benefit disadvantaged communities
2015	SB 350 (Clean Energy and Pollution Reduction Act of 2015)	Increased Renewables Portfolio Standard to 50% by 2030
2016	SB 32	Set target of reducing greenhouse gas emissions to 40% below 1990 levels by 2030
2016	AB 197	Required CARB to prioritize regulations that result in direct emission reductions (implicitly, command and control)
2017	AB 398	Extended cap-and-trade program through 2030
2017	AB 617	Required CARB to monitor and address local air pollution in the worst-affected communities, addressing some environmental justice concerns from cap and trade
2018	SB 100	Increased Renewables Portfolio Standard to 60% by 2030 and set goal of zero-carbon retail electricity by 2045

SOURCE: Adapted from California Air Resources Board. California Climate Change Legislation. https://www.climatechange.ca.gov/state/legislation.html.

the list of regulated pollutants. The Bush administration first delayed and then rejected California's waiver request, which would have allowed the new standards to take effect, but the waiver was quickly approved in 2009 once the Obama administration took office. Thus, while California continued to be at the forefront of national climate policy efforts, it could be most effective when its policies had the support of—or at least no opposition from—the federal government.

In what would become a common refrain for California's climate legislation, the Pavley bill did not set specific mandates for emission reductions. Instead, it required CARB to "develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of GHG emissions from motor vehicles." Under the subsequent regulations, CARB required manufacturers to reduce per-mile emissions by about 30% by 2016, and by about 45% by 2020. Most of this reduction was to be achieved through improved fuel economy—for example, using turbochargers and more efficient transmissions in new cars—but the targets could also be satisfied through reductions in hydrofluorocarbon (HFC) emissions from air conditioners. HFCs are an important short-lived climate pollutant, as discussed in Chapter 15.

While the direct effect of the bill was limited to vehicles sold in California, 14 other states, accounting for almost 40% of US new vehicle sales, followed suit and adopted the Pavley standards, and several more were poised to do so. More importantly, the Obama administration later used them as the basis for even more aggressive federal regulations—negotiated together with California. Thus, California's law ended up influencing greenhouse gas limits for new vehicles for the entire United States. Without California's initiative, which demonstrated how ambitious reductions were technologically possible at a reasonable cost, federal regulation may well have been more limited.

Assembly Bill 32

While the Pavley standards were confined to the transportation sector, economy-wide greenhouse gas reduction goals followed soon after. An executive order from Governor Arnold Schwarzenegger set targets of returning to 2000 levels by 2010, to 1990 levels by 2020, and to 80% below 1990 levels by 2050—some of the most ambitious goals in the

FIGURE 9.2.1 Fran Pavley. As a state assembly member and senator, Fran Pavley authored several key pieces of climate legislation. Photograph by Jonathan Van Dyke, UCLA. Used by permission.

country. "I say the debate is over. We know the science. We see the threat, and we know the time for action is now," said the governor when signing the executive order.

Subsequent legislation gave the 2020 target the force of law and provided the mechanisms to achieve the emission reduction goal. Co-authored by Fran Pavley and Assembly Speaker Fabian Núñez, Assembly Bill 32 (AB 32), named the California Global Warming Solutions Act of 2006, was the centerpiece of the state's early climate change legislative efforts.

AB 32 is a short and simple bill, coming in at just 13 pages. (For comparison, the Waxman-Markey bill to introduce a federal cap-and-trade system, which passed the US House of Representatives but failed in the Senate, ran to more than 1,400 pages.) The main requirement of AB 32 was simply to return California's greenhouse gas emissions to 1990 levels by 2020, which in practice meant a reduction of 25% to 30% below business-as-usual emissions. The bill said very little about how to do that and did not even specify what "1990 levels" meant in terms of the number of tons of CO_2. The bill authorized, but did not mandate,

Box 9.2.1 Promoting Low-Carbon Fuels

The Low Carbon Fuel Standard (LCFS) is a good example of one of the hybrid policies pursued by CARB to achieve the AB 32 goal. Here, *hybrid* means that the LCFS combines regulations with market mechanisms to achieve its goal of reducing the carbon intensity of transportation fuels.

The initial LCFS regulation, adopted by CARB in 2009, required a 10% reduction in the greenhouse gas intensity of transport fuels by 2020. In 2018, the program was extended with a target of a 20% reduction by 2030. These targets are the heart of the regulatory portion of the standard.

The market mechanisms allow the targets to be met at lower cost and with increased flexibility. Oil companies that find it difficult or expensive to reduce carbon intensity can purchase credits from other fuel suppliers, such as electric utilities or biofuel producers.

The LCFS factors in the full life cycle emissions of different fuels. Those include emissions from oil extraction and refining, from combustion (burning) of the fuel in a motor vehicle, and from growing the raw materials for biofuels. For example, oil from the Canadian tar sands has a higher carbon intensity than conventional crude oil, while biofuels such as ethanol tend to have a lower carbon intensity, as does electricity.

a "market-based compliance mechanism" (that is, cap and trade) and more generally did not concern itself with the details of how to reduce greenhouse gas emissions.

Instead, the bill gave CARB responsibility for determining the 1990 baseline and developing a strategy to achieve the emission reduction target. The bill set a series of interim deadlines and specified objectives such as cost-effectiveness, technological feasibility, and equity. However, it said nothing about the types of regulations and other policies that should be implemented to meet the emissions goal.

CARB's blueprint to achieve the AB 32 goal is detailed in the Climate Change Scoping Plan, adopted in December 2008 after extensive technical analysis and public process and updated in 2014 and again in 2017. The first Scoping Plan set out both previously approved and new measures to reduce emissions by 174 million metric tons of CO_2 equivalent

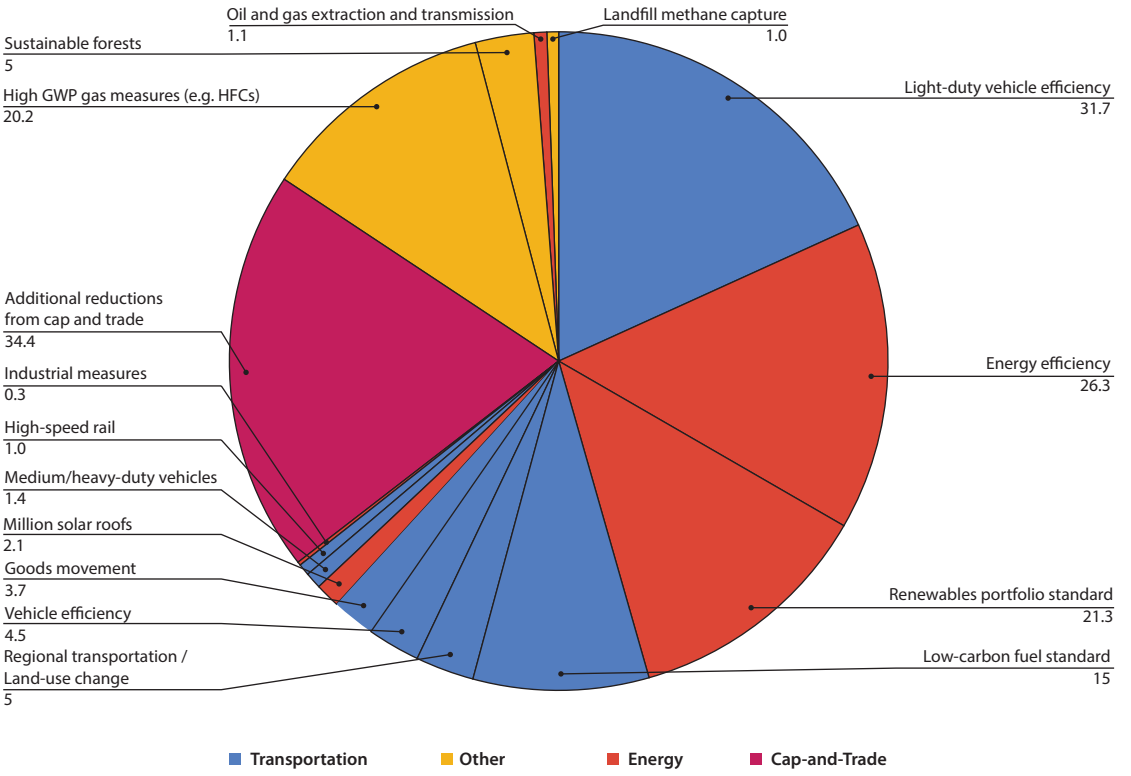


FIGURE 9.2.2 Planned sources of emission reductions in California's first Climate Change Scoping Plan. The reductions are those counted toward the 2020 target. Values indicate MMT CO_2e. Data from California Air Resources Board 2008.

(MMT CO_2e). The largest cuts (Figure 9.2.2) were to be achieved through the Pavley vehicle emissions standards; a new Low Carbon Fuel Standard (Box 9.2.1); energy efficiency regulations; requirements for 33% of electricity to come from renewable sources (the Renewables Portfolio Standard, or RPS, discussed in Section 9.4); and cap and trade, which is discussed in Section 9.3.

Leaving the details of how to achieve the AB 32 goal to a technocratic process within an existing regulatory agency brought many advantages. To some extent, it depoliticized decisions over specific emission reduction measures—in stark contrast to the federal Waxman-Markey proposal, which included intricate side deals negotiated with seemingly every affected industry. AB 32 allowed lawmakers to focus on the overall goal rather than the details of how it would be achieved. And it took

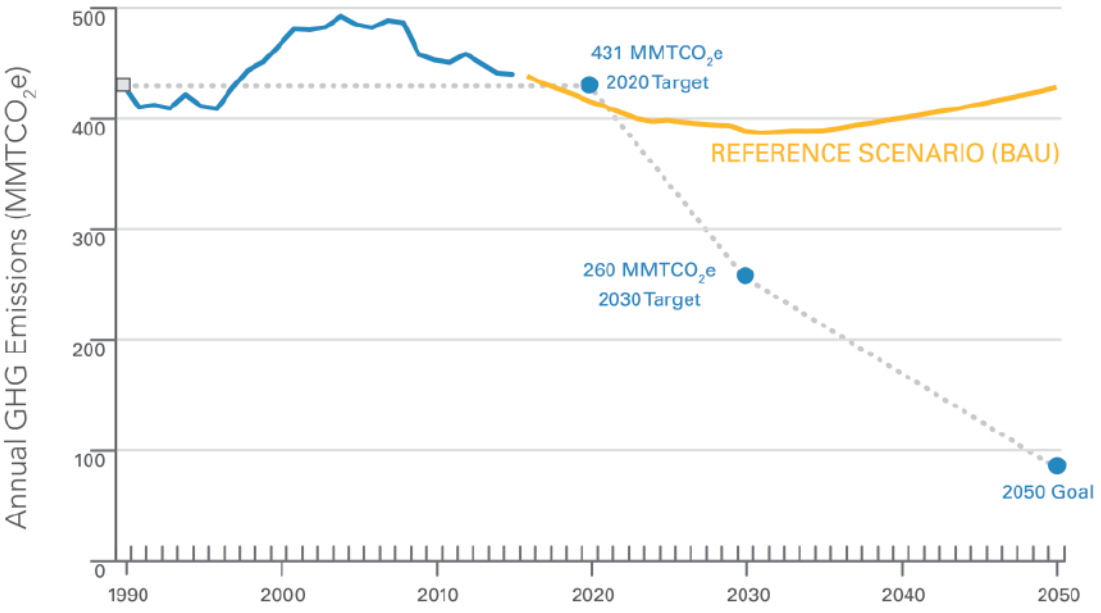


FIGURE 9.2.3 **California emissions trends and targets.** Reproduced with permission from the California Air Resources Board.

advantage of the institutional capacity of CARB, which as discussed in Section 9.1, had grown into one of the country's most technically adept regulators since the 1970s.

The successors to AB 32

More recent legislation has built on the foundation of AB 32. In particular, SB 32, enacted in 2016, ambitiously and vastly extends the state's targets beyond the 2020 horizon of AB 32, to enshrine a target of reducing emissions to 40% below 1990 levels by 2030. To the extent that AB 32 picked the low-hanging fruit, SB 32 represents an even greater commitment by the state. Most radically, outgoing Governor Jerry Brown issued an executive order in 2018 committing California to attain total, economy-wide carbon neutrality by 2045 and to achieve and maintain "net negative emissions" thereafter.

More-specific laws have also taken aim at specific sectors or focused on specific policies. The Sustainable Communities and Climate Protection Act of 2008 (SB 375) targets emission reductions from integrated

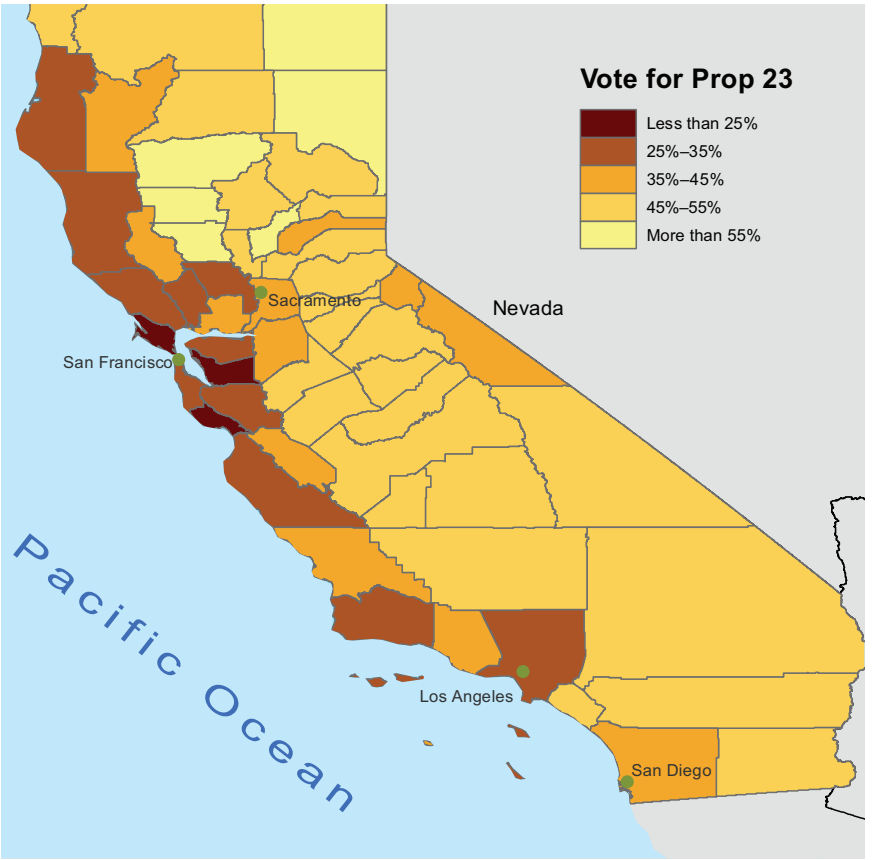


FIGURE 9.2.4 Voting patterns to suspend AB 32. The colors indicate the percentage in each county voting "Yes" on Proposition 23, which would have suspended and effectively repealed AB 32. Note that the support for suspension was strongest in the more remote northern and mountainous counties and was weakest on the coast, including in cities such as San Francisco and Los Angeles. Data from California Secretary of State. Map by Jesus Contreras, UC Santa Cruz.

transportation and land use planning; this effort is discussed in detail in Section 9.5. AB 398 extends the cap-and-trade program to 2030, and the accompanying AB 617 seeks to ensure that the benefits are distributed equitably throughout California (Section 9.3). Meanwhile, requirements for renewable energy have been ratcheting up (Section 9.4).

Thus, in the last two decades California's climate goals have become more ambitious. Not only have the targets been extended and deepened, but they go far beyond aspirational rhetoric and are accompanied

FIGURE 9.2.5 Anti–Proposition 23 campaign rally. The "No" campaign against AB 32 suspension focused on the fact that the initiative was backed by out-of-state oil companies such as Valero. This rally took place at UC Santa Barbara. Photograph by Ron V. Ocampo, The Bottom Line. Used by permission.

by extensive analysis and an effective implementation mechanism. The AB 32 target for 2020 seems likely to be achieved. By 2016, emissions had already fallen to below the required level (Figure 9.2.3), and so, provided that emissions do not tick up between 2017 and 2020, California will attain this major landmark.

California's steadily increasing commitments may seem inexorable, given the progressive political climate in the state and strong support from successive governors, the legislature, and the voters. Both AB 32 and the earlier Pavley clean-cars legislation were passed by a Democratic-controlled legislature, with support and leadership from Democratic and Republican governors, Gray Davis and Arnold Schwarzenegger. However, they did not become law in a political vacuum or in the absence of political opposition. The car industry vocally opposed the Pavley bill to limit emissions from motor vehicles, on the

grounds that it was a "veiled attack on California's family vehicles," such as SUVs and pickup trucks. AB 32 itself was the subject of a referendum (Proposition 23) in 2010, which would have effectively repealed the law by suspending its provisions until the statewide unemployment rate fell to 5.5% for a full year. (Rarely has statewide unemployment fallen that low for that long; at the time of the campaign, it was about 12%. Thus, "suspension" would have meant effective repeal.)

The Proposition 23 campaign, however, ended up highlighting the depth of California voters' support for climate policy and its air quality co-benefits. The anti–AB 32 measure lost by more than 2.2 million votes, with 38% in favor and 62% against (Figure 9.2.4). Campaign contributions from some mainly out-of-state oil companies were outweighed by pro–climate policy donations from individuals, nonprofit organizations, and labor unions. Many key organizations, including electric utilities, the California Chamber of Commerce, and oil companies such as Chevron, remained neutral or were opposed to the repeal measure. Partly, this broad support reflects California's low-carbon economy; indeed, "green jobs" were a key message of the "No on Proposition 23" campaign. But the referendum also reflected the political interests of many businesses, whose leaders evidently decided that energy conservation, low-carbon fuels, and CO_2 mitigation are the route to a profitable future.

9.3 The Cap-and-Trade Experiment

Cap and trade is one of the highest-profile features of California's emission reduction efforts. In the 2008 Scoping Plan, it accounted for 34.4 of the 174 MMT CO_2e of estimated reductions. These reductions would come about as cap and trade put a price on carbon, giving firms and individuals the financial incentive to reduce emissions. Just as importantly, cap and trade provided assurance that the AB 32 target would be met, assuming that the system functioned as intended. Should one of the other measures in the Scoping Plan fall short of expectations, cap and trade would soak up the shortfall.

During the debates over AB 32, cap and trade was a point of contention. From an economic point of view, cap and trade allows a given emission target to be achieved in the most efficient way possible (Chapters 11 and 12 for a more in-depth analysis). However, California was emerging from a bruising experience with a cap-and-trade program for a different pollutant—the RECLAIM program for nitrogen oxides in Southern California, which was partially suspended after permit prices rose from about $2,000 to more than $120,000 per ton during California's electricity crisis. Another set of concerns related to environmental justice. Because cap and trade does not specify where and how emissions will be reduced, it is possible for an inequitable outcome to occur, with middle-class, majority-white, higher-income communities benefiting the most.

Design of cap and trade in California

The compromise was for AB 32 to authorize, but not require, CARB to implement "market-based compliance mechanisms"—in other words, cap and trade. CARB ultimately opted to use this authority, and the detailed system design was informed by a market advisory committee of prominent academics, state and local officials, and other parties. However, most of the emission reductions in the Scoping Plan were to

be achieved through more-traditional command-and-control regulatory measures rather than the cap-and-trade system—effectively mandating many of the reductions that would have occurred anyway through the market-based approach of cap and trade. This hybrid system—part market based, part regulatory—may have reflected a lack of confidence in cap and trade, the political realities, and/or CARB's traditional regulatory expertise. In 2016, new legislation (AB 197) reaffirmed the role of command and control in California's climate policy.

When launched in 2013, the cap-and-trade system covered large electric power plants and industrial facilities. In 2015, it was extended to apply to fuel distributors, meaning that the heating and transportation sectors would be covered as well and that the program would encompass nearly 85% of California's emissions. Cap and trade for transportation does not mean that individual drivers need to buy and sell carbon allowances. Rather, this task is handled by fuel distributors, and the cost is passed on at the pump. In practice, cap and trade has added about 14 cents to a gallon of gasoline, providing a small incentive for drivers to choose more fuel-efficient cars and to drive less.

The *cap* in cap and trade refers to the limited number of emission allowances that are issued. One allowance gives the right to emit 1 ton of CO_2, and a polluter subject to the cap must purchase or otherwise obtain enough allowances to cover its emissions. The number of allowances issued by CARB each year is planned to gradually fall to 334 million in 2020—achieving the 2020 emissions goal, provided that sufficient emission reductions are also achieved by "non-capped" polluters, that is, those that remain outside the cap-and-trade system. These non-capped pollution sources include hydrofluorocarbons and other "super pollutants" (Chapter 15), emissions from agriculture and land use change, and methane emissions from the decomposition of organic waste in landfills.

CARB's decisions regarding the distribution of emission allowances internalized the lessons learned from problems with previous cap-and-trade programs, such as the European Union Emissions Trading Scheme (EU ETS) and the RECLAIM program for nitrogen oxides in Southern California. In particular, two innovations aimed to avoid the price volatility

experienced in Europe (where the prices of allowances have on occasion fallen to near zero) and in Southern California's RECLAIM program:

- An auction **reserve price**—this is the minimum price at which CARB will sell allowances. It started at $10 in November 2012 and rises each year at 5% plus inflation. The reserve price ensures that cap and trade will always provide a financial incentive to reduce emissions, and it avoids the risk that the price will fall to zero.
- An **allowance reserve** or "safety valve"—this is an extra pool of allowances that CARB only issues if the price rises above a given level.

Together, the reserve price and the allowance reserve make the price of carbon more predictable, enabling firms to plan their investments with greater confidence.

California's cap-and-trade experience

In general, California's experience with cap and trade has been a success and has avoided many of the pitfalls of trading programs in Europe and the northeastern US (Chapter 12). Emissions have fallen while the state's economy has prospered. The auction price has normally been slightly above the reserve price, and statewide emissions have declined along with the cap. Several major criticisms, however, remain.

One concern relates to the **reshuffling** of electricity contracts. That is, California's electric utilities have swapped out purchases of out-of-state coal-generated electricity in favor of cleaner sources elsewhere on the western electricity grid, which extends far beyond the state's borders. However, some of these coal-fired power stations have continued to sell electricity to consumers in other states, swapping out contracts in the opposite direction. Thus, while California reports lower emissions, the net reduction—considering emissions in other western states—is more limited. Coal plants simply sell their power to customers in Nevada, Arizona, or New Mexico instead.

Another concern for cap-and-trade integrity is **carbon offsets**. An offset is a certified emission reduction from a project that is not subject to the cap-and-trade program. In California, offsets allowed by CARB mainly come from forestry and agriculture, such as projects to reduce

methane emissions from flooded rice fields. Polluters can use an offset credit in place of an emission allowance. If all offsets were "real" and "additional," there would be no cause for concern, but in practice many offset projects may have been undertaken anyway.

A third potential challenge is the volume of allowances that firms have accumulated. More than 200 million allowances have been **banked**, or held by polluters for future use or sale. Such banking means that emissions are lower in the short term, but this practice may threaten the state's ability to achieve longer-term reductions.

A broader criticism of the cap-and-trade program relates to equity and environmental justice. As noted above, while cap and trade provides a price signal to reduce emissions and it limits overall emission levels, it does not prescribe *where* those reductions take place. In the first 3 years of California's trading program, some polluters increased emissions, while others reduced emissions. Those that increased emissions tended be located in places with more people of color, lower-income people, and other marginalized groups (although this analysis excludes emissions from transportation, which account for the majority of local air pollution impacts). This would not be a problem if the pollution were confined to CO_2 alone—while a major cause of climate change, CO_2 does not have any direct adverse health impacts. However, factories, power stations, and other sources of CO_2 also tend to emit other pollutants, such as sulfur dioxide and particulate matter, that do have health consequences for people nearby. At least in its early years, cap and trade seems to have done little to realize the hopes of improved air quality in the state's most vulnerable communities. Many of the co-pollutant reductions occurred out of state, as California's electric utilities reduced their purchases of imported coal-generated power, while in-state emissions saw more-limited changes and even increased in some places.

The equity situation may improve as the cap declines and polluters in all parts of the state begin to reduce their emissions. However, a more direct approach to address environmental justice concerns is to strengthen even further the regulation of local air pollution (where location matters) separately from greenhouse gas emissions (where the global concentration matters, not the location of the source). Indeed,

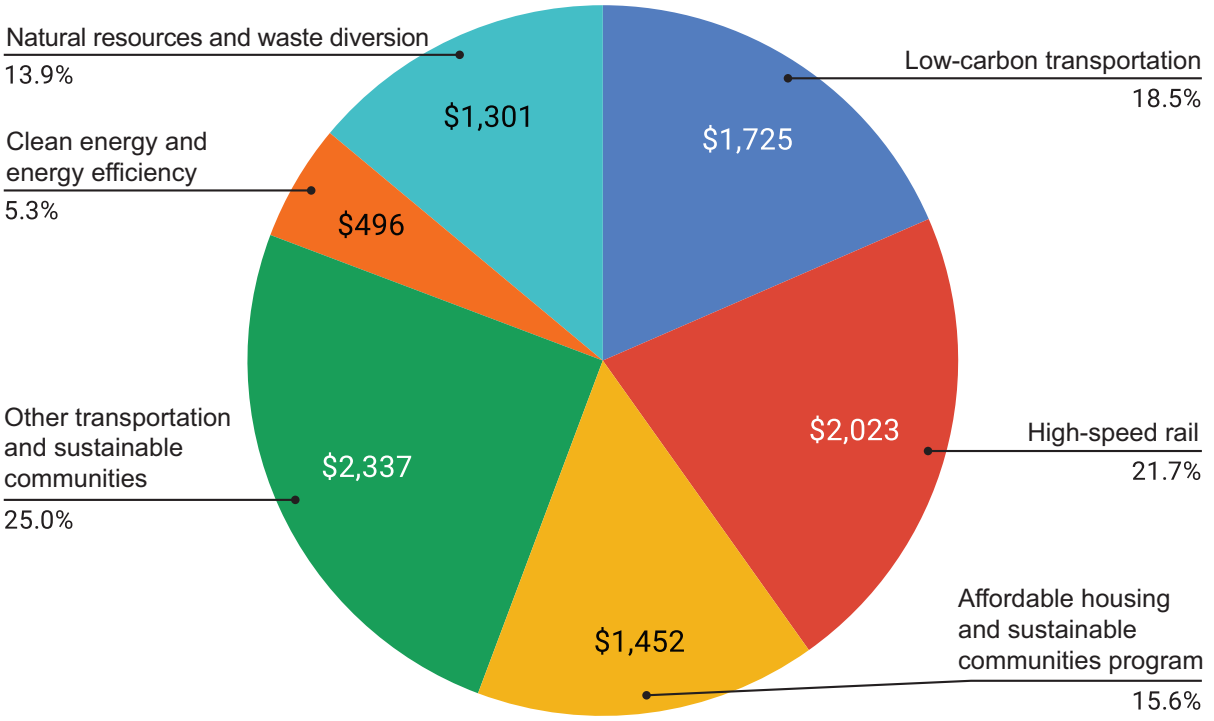


FIGURE 9.3.1 Use of revenues from cap and trade. Figures show appropriations from the Greenhouse Gas Reduction Fund ($ million) through fiscal year 2018–2019. Data from California Air Resources Board.

this direct approach was the tenor of the state legislature in Assembly Bill 617 (AB 617) in 2017, which was enacted as a parallel measure to the extension of the cap-and-trade system. AB 617 requires CARB and its local counterparts to implement additional air quality monitoring in heavily polluted communities, to accelerate the introduction of pollution control technologies, and to develop a statewide strategy to reduce local air pollution in the worst-affected communities.

Another positive contribution to equity—and to other state goals—comes from the revenue generated by auctioning a portion of the emission allowances. Through early 2019, the auctions have generated $10.3 billion for the state's Greenhouse Gas Reduction Fund. By law, at least 35% must be spent on projects that benefit and are located within (or, in a few cases, within a half mile of) low-income neighborhoods and disadvantaged communities that are disproportionately affected by pollution. Figure 9.3.1 shows how the money raised to date has been used. Some

projects focus on general emission reductions—for example, high-speed rail, encouraging housing close to public transit, water efficiency, and manure management. However, other projects specifically target low-income communities, such as the Low-Income Weatherization Program that funds energy-efficient appliances, new windows, water heaters, and other improvements that both reduce emissions and reduce household energy bills.

9.4 Energy

Many of California's climate policy efforts have been economy-wide—that is, they aim to reduce greenhouse gas emissions in many different sectors, such as industry, electricity generation, and transportation. However, legislators have also pursued more-focused efforts aimed at increasing energy efficiency and the use of renewable energy in the state. These efforts, which have led to California's having one of the least-carbon-intensive electricity supplies in the United States (Figure 9.4.1), date back to the 1970s, before climate change became a major issue. Instead, the original motivations included the oil crisis and fears over nuclear power.

To understand California's energy policy history, you have to understand the state's geography, its development history, and a little bit of its political culture. First, let's think about the geography. California is a large state in terms of land area—a state that's as big as many countries around the world. It has no coal, which has significantly influenced its energy pathway. Otherwise, however, it has an abundance of energy resources. It has a lot of oil, especially down in Southern California. It has a little bit of geothermal. Unlike the other western states or Appalachia, California has a large volume of water runoff from the Sierra Nevada, which has been tapped for hydroelectric potential. There's a lot of wind power, especially around Altamont Pass, near San Francisco, and down south in the Tehachapi Mountains, just north of Los Angeles. And California receives many hours of sunshine, with concomitant potential for solar power.

But renewable energy was not on the minds of energy planners around the middle of the twentieth century, when California's population and economy were rapidly growing. At the time, the assumption was that electricity generation capacity had to keep pace with population and economic growth—they were **coupled** together. Nuclear power was seen as the best way to scale up the supply to meet the

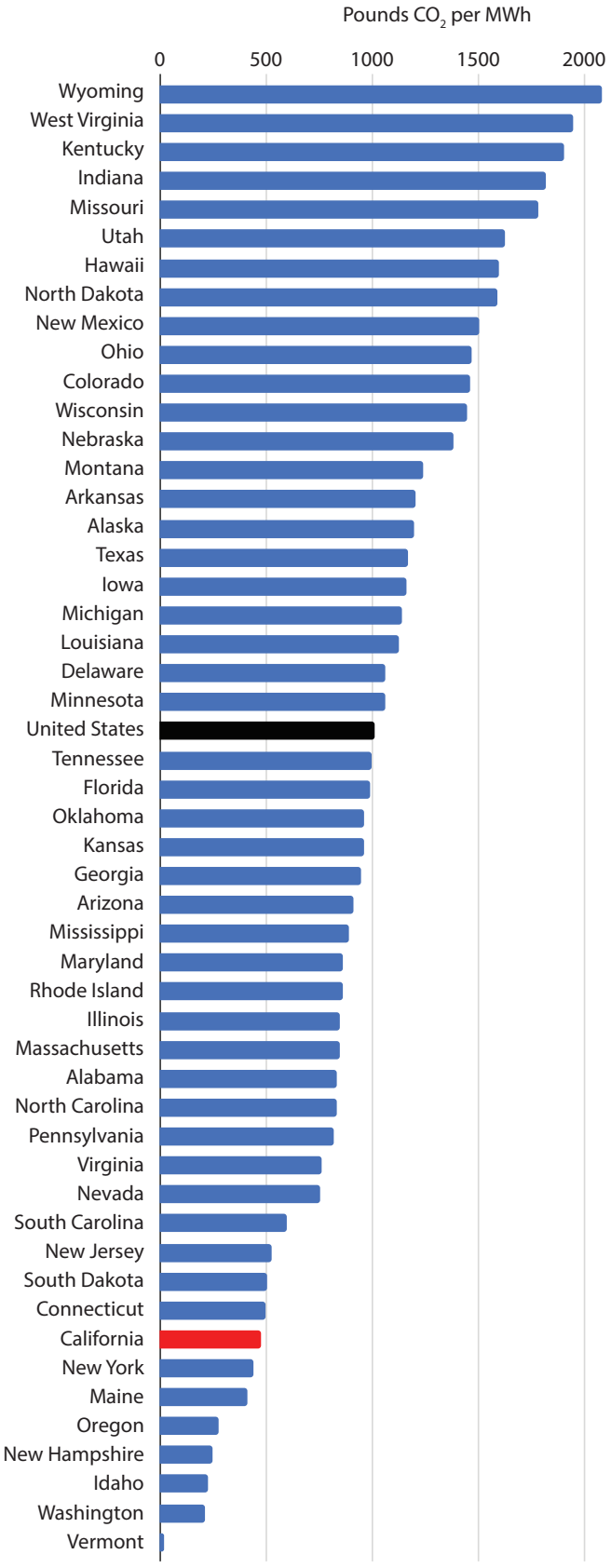


FIGURE 9.4.1 Electric power carbon intensity, by state, 2017. California has the eighth-least-carbon-intensive state power generation mix in the US. Most of the states that are less carbon intensive have much smaller populations and rely on hydroelectric or nuclear power. Data from US Energy Information Administration.

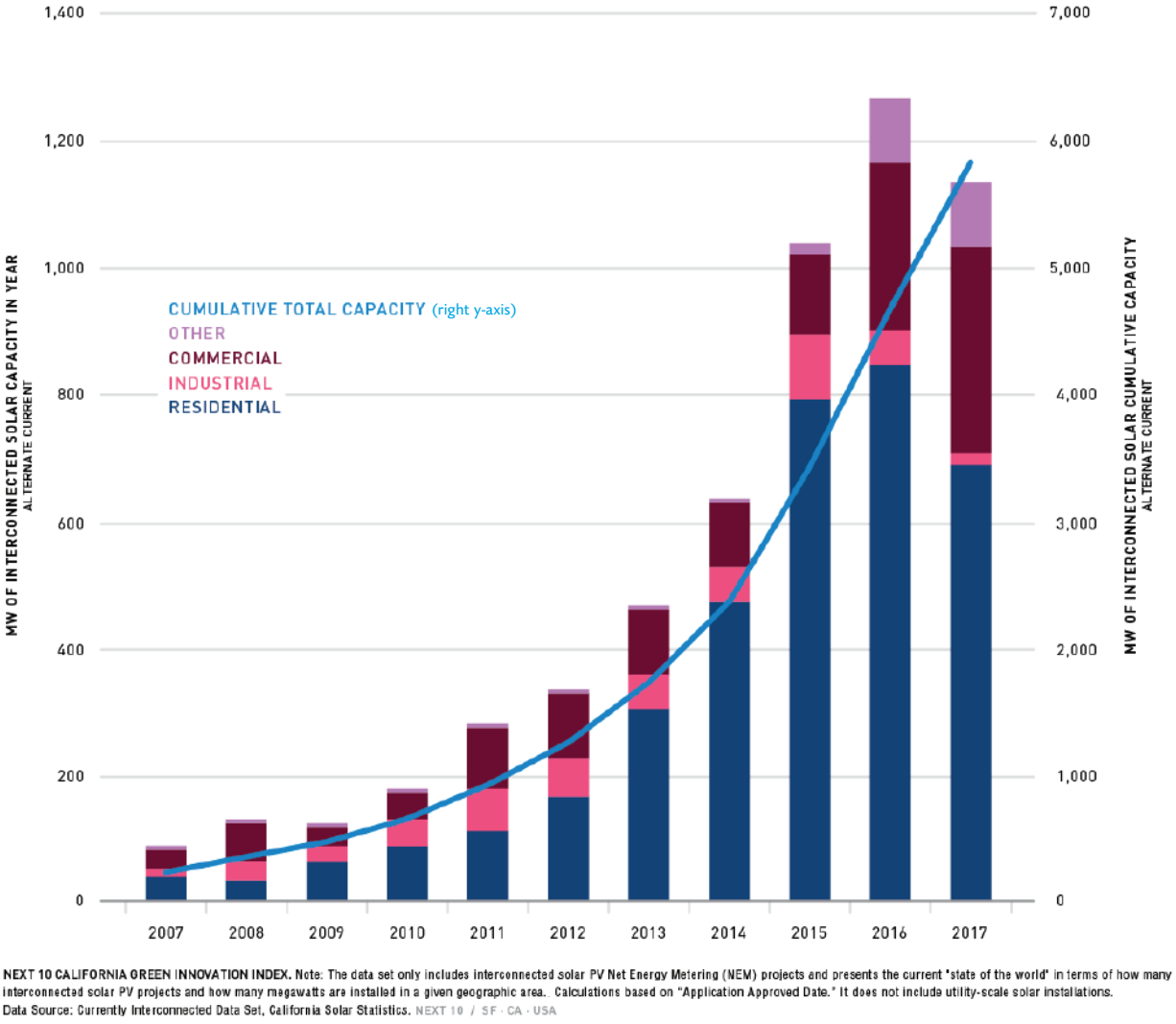
forecast demand; a series of planned nuclear plants on the coast from Southern California all the way up to the north would cool their reactors with the abundant waters of the Pacific. However, public opposition—partly due to the risks posed by earthquakes, and partly because of consciousness around the disposal of radioactive waste—frightened the public, prompting many to say, well, we don't want nuclear either. In 1976, state legislators placed a moratorium on new plants, pending a permanent solution to nuclear waste.

Energy planners were then faced with the dilemma of how to increase generation capacity without relying on nuclear, coal, or oil. Nuclear had been ruled out because of safety and waste concerns; the state had few reserves of coal; and oil, which in any case is a poor fuel for producing electricity, was in question following the embargo of 1973. Moreover, plentiful supplies of natural gas were not yet available in California.

In response, the legislature passed the Warren-Alquist Act in 1974 to create the California Energy Commission (CEC). While this might seem like a trivial move—yet another bureaucracy—the CEC created the framework to plan for energy in a comprehensive manner. The CEC preceded the federal Department of Energy (which was founded in 1977) and had the money and staff to plan in a systematic way, rather than lurching from one project to another.

Renewable energy was one area of policy that the CEC pushed forward, with large-scale wind energy projects as the initial focus. Subsequently, the state's Renewables Portfolio Standard (RPS) required utilities to source a certain proportion of retail sales of electricity from renewables. The first RPS, in 2002, was set at 20% by 2017. Over the years, the targets have ratcheted up, with a 2018 law setting an RPS of 60% by 2030 (Table 9.2.1). The same law sets a goal of carbon-free electricity by 2045, although the *carbon-free* definition encompasses several sources that do not qualify as "renewable" under the RPS, such as nuclear and large hydroelectric dams.

The state is already much of the way toward the 2030 and 2045 goals. On a sunny day—not too hot, not too cool—in March of 2017, 40% of the state's electricity was being generated by **utility-scale solar**, that is, large installations such as solar farms in the desert. Adding in



NEXT 10 CALIFORNIA GREEN INNOVATION INDEX. Note: The data set only includes interconnected solar PV Net Energy Metering (NEM) projects and presents the current "state of the world" in terms of how many interconnected solar PV projects and how many megawatts are installed in a given geographic area. Calculations based on "Application Approved Date." It does not include utility-scale solar installations.
Data Source: Currently Interconnected Data Set, California Solar Statistics. NEXT 10 / SF · CA · USA

FIGURE 9.4.2 Interconnected solar in California. Through 2016, solar energy grew almost exponentially. In 2017, capacity reached almost 6,000 megawatts (MW), up from 228 MW just 10 years earlier. Residential rooftops account for most of the capacity. Reproduced with permission from Next 10.

the solar panels that are dotting thousands and thousands of rooftops throughout California, that number came to about 50%. Figure 9.4.2 charts the dramatic growth in solar capacity, and Figure 9.4.3 illustrates the evolution of energy policy in California over the last 50 years.

Local governments, meanwhile, have been pushing forward with

FIGURE 9.4.3 Rancho Seco. The decommissioned Rancho Seco nuclear power plant in Sacramento County now hosts a solar farm and is under contract to the Golden 1 Center, the home of the Sacramento Kings. At full build-out, the facility will provide up to 100 MW of power, taking advantage of the transmission lines and other infrastructure built for the nuclear plant. Photograph by Hajhouse from Wikimedia Commons.

even more ambitious plans for renewable energy. **Community choice aggregation** (CCA) allows cities and counties to make energy supply decisions for their communities, taking over from investor-owned utilities. CCA programs have been launched in San Francisco, Los Angeles, and many other parts of the state and have normally aimed for higher shares of renewable power than the state-mandated minimums. Collectively, CCA programs are likely to mean that the targets in the state's RPS are exceeded by 9% in 2025, equivalent to 1–2 MMT CO_2e.

Less visible than wind turbines or solar panels, but just as effective in reducing carbon emissions, have been the CEC's efforts to promote energy efficiency. Partly, the CEC acted through direct regulation, setting efficiency standards for refrigerators and, later on, for such varied appliances as swimming pool heaters, furnaces, and computers. But the CEC and its partner agency, the Public Utilities Commission, also worked to transform the motives of utilities. Before, the more electricity they sold, the more money utilities made. They had a vested interest in encouraging profligacy. Under the state's new model, utilities were rewarded for weatherizing residences and commercial facilities and for promoting more-efficient heating and cooling equipment. In effect, utilities were allowed to charge ratepayers for not just megawatt hours, but **negawatts**, or negative watts—the energy savings from efficiency. This model of **decoupling** their profits from growth in energy consumption transformed the utilities overnight. Overnight, they became indifferent to sales—it was just as profitable for them to weatherize homes as to build new power plants.

Today, California ranks fiftieth among US states in per capita electricity consumption. The US per capita annual residential electricity consumption in 2011 was 4,566 kilowatt hours (kWh); California's was 2,346. Taking all consumption together (residential and commercial), the US per capita electricity consumption in 2016 was 11,634 kWh, but California's was only 6,536 kWh. Whether measuring just residential or all end use, the national average is almost twice that of California; a remarkable statistic, even accounting for California's mild climate—Californians use less air conditioning than residents of most other southern and western states. Most (64% in 2017) 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. Fully 14% of homes were not even heated in 2009. The state ranked thirtieth in its average annual per capita residential natural gas use in 2011.

9.5 The Land Use Problem

Shortly after AB 32 was passed, there was a growing realization that CARB had few tools to bring about emission reductions from regional land use planning and transit-oriented development patterns that reduce vehicle travel. Such plans would encourage denser, mixed-use development in urban centers and in other places well served by public transit, in contrast to the sprawl that has characterized much postwar development in California.

However, in considering land use planning, CARB ran up against the limits to its regulatory authority. While CARB had achieved success through command-and-control policies and performance standards such as the Pavley clean car standards, and through market-based approaches such as cap and trade, it had no authority over local land use decisions, which are jealously guarded by local governments—that is, cities and counties—as their own prerogative. And in contrast to out-of-state car manufacturers and oil companies, which had little clout with decisionmakers, local governments wielded substantial influence in the state legislature. Given that transportation accounts for more than 40% of California's greenhouse gas emissions, not including a further 7% from petroleum refining and hydrogen production, this was a major gap in the state's climate policy arsenal.

The legislative compromise was for CARB to set regional targets for emission reductions from the transportation sector but to avoid imposing any mandates on local governments. Senate Bill 375 (SB 375), the Sustainable Communities and Climate Protection Act of 2008, makes the state's 18 metropolitan planning organizations (MPOs)—regional agencies that plan for freeways and public transit expansions and make other large-scale transportation spending decisions—responsible for developing plans to meet these targets. Each MPO was asked to develop a sustainable communities strategy to demonstrate the combination of land use patterns and transportation policies that would allow it to meet

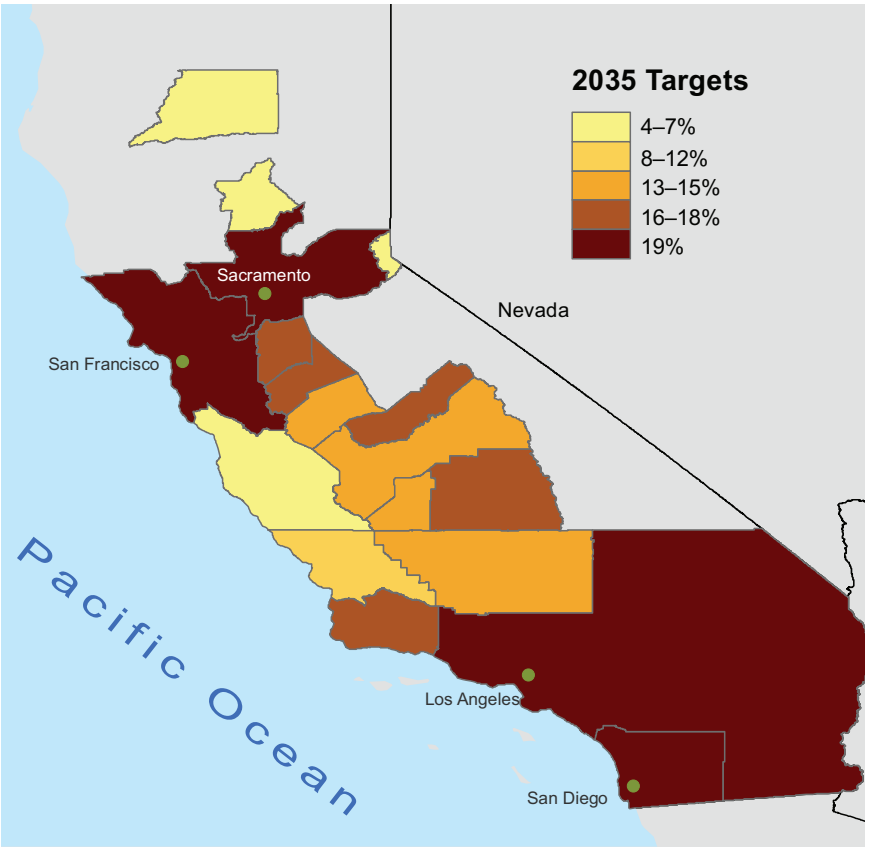


FIGURE 9.5.1 Regional greenhouse gas reduction targets. Targets refer to the reduction in per capita passenger vehicle emissions between 2005 and 2035, as adopted in 2018. The four largest regions (Southern California, San Francisco Bay Area, San Diego, and Sacramento) each have a 19% reduction target. Smaller regions have reduction targets ranging from 4% to 17%. Data from California Air Resources Board 2019. Map by Jesus Contreras, UC Santa Cruz.

its regional target. When it was passed, SB 375 was billed by Governor Schwarzenegger as the "nation's first law to control greenhouse gas emissions by curbing sprawl."

The process of setting the targets involved detailed modeling work and a negotiation between CARB and each metropolitan region. Some regions went beyond CARB's initial proposal, while other regions were more recalcitrant. The most recent (2018) round of targets call for reductions in per capita passenger vehicle emissions of 3% to 15% between 2005 and 2020, and 4% to 19% between 2005 and 2035. The

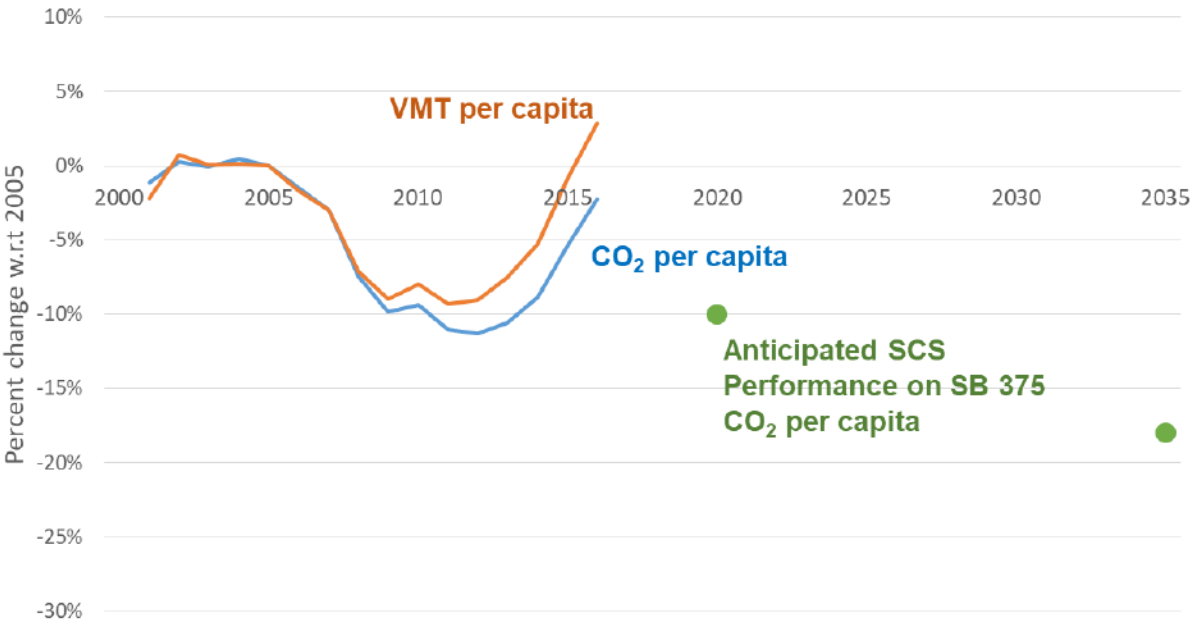


FIGURE 9.5.2 **Vehicle travel and CO_2 trends in California. The orange line indicates vehicle miles traveled per person, and the blue line shows emissions from gasoline-fueled vehicles in California. The green dots indicate the modeled outcomes from the regional sustainable communities strategies, which, if current trends continue, will not be achieved.** Reproduced with permission from California Air Resources Board 2018.

more limited reductions apply to smaller regions such as Monterey Bay and Shasta, while the most ambitious apply to the four largest metropolitan areas (Figure 9.5.1).

So far, SB 375 has led to incremental progress, but it is far from a revolution that is overturning entrenched patterns of urban sprawl. On the positive side, each region has developed a sustainable communities strategy that, according to its modeling, will meet its target. The law has changed the way that planning is done in many regions, leading to a greater emphasis on climate change and integration of transportation and land use planning efforts. And some regions have responded enthusiastically. In the San Francisco Bay Area, for example, regional agencies introduced a new grant program that rewards cities for building housing close to transit and implementing affordable housing policies.

Overall, however, Californians have increased their driving, meaning that fuel-efficiency gains from the Pavley clean car standards have been

outweighed by a greater number of miles driven (Figure 9.5.2). Transit ridership has declined in major metropolitan areas, and the proportion of funding dedicated to highways has changed little. There has been no dramatic shift in funding priorities toward public transportation, walking, and cycling. Overall, CARB's 2018 progress report finds that "California is not on track to meet greenhouse gas reductions expected under SB 375." The modeled reductions have yet to materialize in practice.

At root, SB 375 does not provide a way to coerce or incentivize recalcitrant cities into curbing car use through increasing densities and reducing parking next to transit. Cities still have incentives to be **free riders.** That is, city governments want tax revenue from car-oriented shopping centers and low-density, high-end housing within their own borders while relying on their neighboring cities to provide space for new housing next to transit. In contrast to the strong regulatory power that CARB wields in many other domains and the clear price signal provided by cap and trade, land use planning shows the limits of the state's climate policy power.

9.6 Conclusions and Outlook

California is one of the country's climate mitigation success stories. By many measures, it ranks among the least greenhouse-gas-intensive states in the US. On a per capita basis, only New York and Vermont rank lower, and the average Californian emits just 53% of the national average amount of greenhouse gases. California's large metropolitan regions also score well compared with their counterparts elsewhere. In popular perception, Los Angeles might be the poster child for unsustainable excess. But when measured by household greenhouse gas emissions per capita, 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.

Most impressively, California's greenhouse gas reductions have not come at the expense of its economy. Figure 9.6.1 shows that the state's per capita GDP (roughly equivalent to average income) has grown even while emissions per capita have fallen. Indeed, some of the strongest supporters of AB 32 and other climate legislation have been clean energy firms and other businesses that see environmental protection as beneficial for the economy rather than a drag on performance.

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% of the state's electricity comes from low-carbon sources such as renewables, hydro, and nuclear—that is in part 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 among the lowest five states in terms of the emissions intensiveness of the economy, although this is

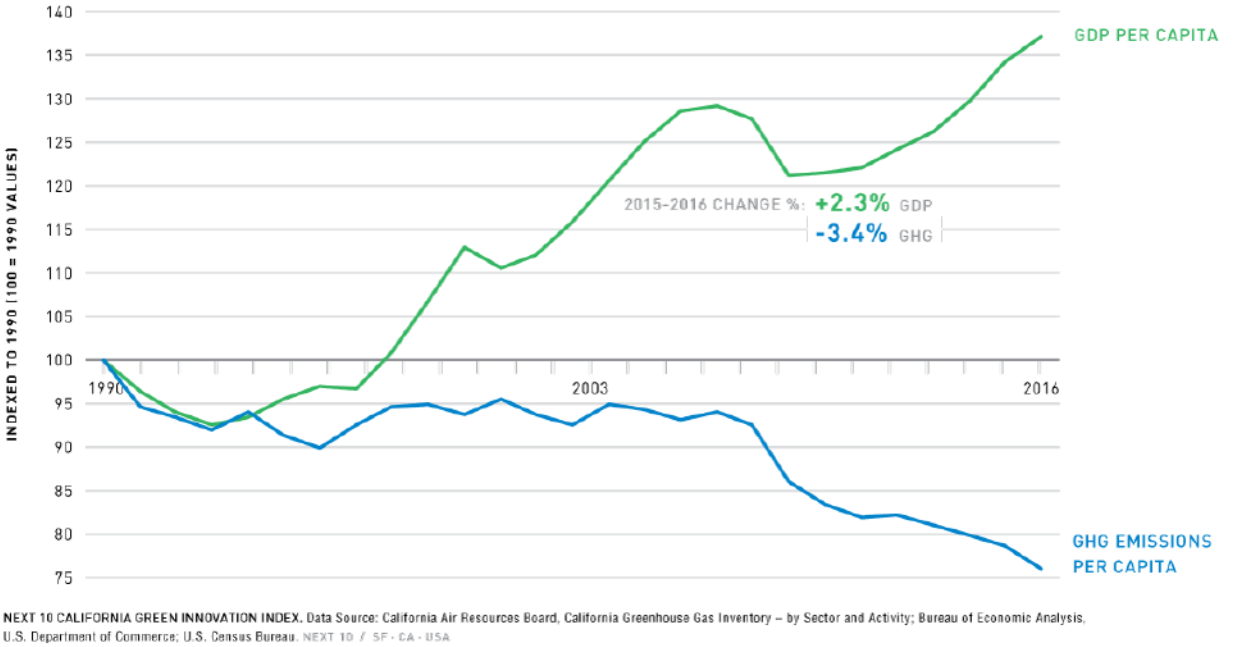


FIGURE 9.6.1 Greenhouse gas emissions and economic growth. Between 1990 and 2016, California's economy grew while greenhouse gas emissions declined in per capita terms, indicating that climate mitigation does not have to be at the expense of economic growth. Reproduced with permission from Next 10.

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. 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 that would benefit from efforts to reduce emissions, such as renewable energy technology, have a much larger presence on the West Coast. One of the main economic powerhouses of the state, the technology industry and associated venture capitalists centered in Silicon Valley, also tends to be a strong supporter of GHG mitigation. Energy costs for their

California operations are minimal (most server farms and data centers are located elsewhere), and many firms invest in innovations to improve energy efficiency or otherwise reduce emissions. Thus, California governors and legislators have shown a willingness to enact climate legislation far ahead of the federal government and most other states.

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. Many officials, such as former San Francisco mayor and now California governor 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.

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, renewable energy supply, and other environmental issues, which in other states might be left to the federal government. 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.

What lies next for California? While the state is likely to achieve its 2020 goals, the 2040 target (a 40% reduction below 1990 levels) is much more ambitious, and the goal of carbon neutrality by 2045 even more so. Many of the low-hanging fruits (such as switching away from out-of-state coal generation) have already been picked. One key challenge is the number of "banked" allowances (Section 9.3) that may reduce the effectiveness of cap and trade in the future. Another is the stubborn resistance of the transportation sector, where vehicle travel has ticked up in recent years and local governments have been reluctant to implement the land use changes called for in regional plans. And a third is the federal government. While the Obama administration was largely supportive, the Trump administration has signaled that it will throw up roadblocks to the state's policies—for example, by threatening to revoke the waiver that California needs to enforce its more stringent clean car standards.

If California were an independent country, it would rank as the world's fifth-largest economy. This means that the action that California takes to reduce emissions is intrinsically important in terms of atmospheric carbon concentrations. Fundamentally, however, California's success should be measured not just by its ability to reduce in-state greenhouse gases, but also by its influence on energy efficiency and climate policy beyond the state's boundaries, in what is often called the "California effect." The Pavley clean car standards were adopted by 14 other states, accounting for almost 40% of US new vehicle sales, and ultimately by the federal government. Its cap-and-trade system has been joined by the Canadian province of Quebec, with the two governments holding joint auctions (although earlier plans for Ontario and several US states to join never materialized). And California's energy efficiency standards for everything from refrigerators to buildings have influenced policy elsewhere. Providing a laboratory to test and demonstrate the economic and technological feasibility of deep reductions in greenhouse gas emissions may be the state's most significant contribution to confronting global climate change.

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