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California's Climate Policy for Transportation and Electric-Drive Vehicles

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Abstract

California has been a leader in advancing policy solutions to environmental challenges. Many of those policy innovations have spread worldwide. Now it is doing the same for greenhouse gas (GHG) emissions associated with transportation. It is adopting policies, regulations, and incentives that provide a durable framework for transforming vehicles, fuels, and mobility. The greatest effects are on vehicles. The GHG performance standards and zero emission vehicle rules adopted by the California Air Resources Board in January 2012 will lead to a transformation of vehicle technology. This paper elaborates on California's policy and regulatory approach to reducing GHG emissions (and oil use) in the transportation sector, focusing on light duty vehicles.

Keywords: climate, policy, California

1 Introduction

California pioneered car-centric cities and lifestyles like nowhere else. By 1930, one of every five California residents owned a car, a level not reached in western Europe until the 1970s, 40 years later. With motorization came high oil use, smog, and greenhouse gas emissions. The downside of cars became apparent by the mid 20th century, when brown smog started to blanket Los Angeles, heightening Californians' awareness of the health, economic, and aesthetic downsides of the car-dependent lifestyle.

Now, as part of a larger effort to address climate change, California is pioneering policies to reduce vehicle use and their greenhouse gas emissions. And whereas most of the international discussion of climate solutions has focused on electricity and coal, in California greater emphasis has been given to transportation, where three-quarters of all oil consumed and 40% of all greenhouse gases emitted are for the movement of goods and people. Because cars, oil, and environmental leadership are intertwined, any strategy to reduce oil consumption and greenhouse gas emissions must target transportation, especially in California.

A key agent in the design and implementation of climate policy is the California Air Resources Board (CARB), the agency most responsible for California's leadership in air pollution regulation and policy. Since its establishment in 1967 by Governor Ronald Reagan, CARB has been highly effective at regulating conventional air pollutants. Its clean air policies were imitated in Washington, DC and around the world, leading to the commercialization of catalytic converters, reformulated gasoline, zero emission vehicles, and many other technology innovations. As Daniel Yergin notes *in The Quest: Energy, Security, and the Remaking of the Modern World*, CARB became the "de facto national authority."[1] Now its mission is evolving and

spreading as it extends this leadership to climate policy and regulation.

The agency oversees a budget of $300 million and a staff of 1,000 employees, and is governed by an 11-member board serving at the pleasure of the governor. The Board, with broad-ranging regulatory authority granted by the Legislature, operates in an independent manner through formal notice-and-comment rulemaking. Its decision- making is highly transparent, taking place in public at monthly board meetings, usually attended by hundreds of people and broadcast live over the World Wide Web.

The California Air Resources Board has adopted a far reaching set of climate rules and policies that reach into virtually every economic activity of the state, surpassing Europe in crafting the most comprehensive approach to climate policy in the world. Although the European Union adopted a carbon cap-and-trade program before California and has more aggressive greenhouse gas standards for vehicles, California has adopted a broader web of policies that range from energy efficiency standards for appliances and buildings, to reduced use of global warming gases by industry, to reduction of methane gases on farms.

Two political circumstances favor California's climate policy leadership.

First, CARB has unique authority and political flexibility. Because California suffered unusually severe air quality problems as early as the 1940s and adopted requirements for vehicles and fuels before Congress was moved to act, the U.S. Congress in 1970 preserved the state's authority over vehicle emissions, as long as its rules were at least as strong as the federal ones. California has continued in a leadership role for over 40 years, launching many of the world's first emission controls on vehicles and first requirements for cleaner (reformulated) gasoline and zero-emission vehicles. Since the 1977 amendments to the US Clean Air Act, other states have enjoyed the option of following the more stringent California standards instead of the federal standards. The California Legislature took advantage of this authority in 2002 when it directed CARB to adopt limits on vehicular emissions of greenhouse gases, acknowledging these emissions as a form of air pollution.[2]

Second, California has been able to act in advance of the national government because it has more political space to maneuver. The Detroit car companies have relatively small investments in California and coal companies are absent. California is home to leading research universities, innovators and entrepreneurs, as well as a diverse resource base of solar, wind, ocean, and geothermal energy resources. The state is also home to the largest venture capital industry in the world, which favors clean energy policy. California politicians feel freer to pursue aggressive energy and climate policies than their counterparts in many other states.

While California's climate law (AB32) does not require equal reductions in emissions across all sectors of the economy, dramatic changes will be needed in the transportation sector if large reductions are to be achieved. Such changes in behavior and technology are not implausible. Researchers and companies have made rapid technological progress in recent years in improving conventional and advanced technologies. Humans are incredibly inventive and creative. Gasoline-powered cars are expected (as a result of California and US regulation) to more than double their fuel economy between 2010 and 2025, and rapid advances are being made with advanced lithium batteries and vehicular fuel cells.[3] With greater emphasis on energy efficiency and low carbon technologies, dramatic reductions in oil use and greenhouse gas emissions will occur.

In this article we assess the policies adopted by California and their effectiveness in stimulating innovation, encouraging consumer behavior changes, and directing society toward large reductions in oil use and greenhouse gas emissions. Our intent is to document California's policy innovations and explore its role as a model for the rest of the country and the world.

2 Elements of the California Transportation Policy Model

Good policy generally encompasses seven key attributes. It addresses both the short and long term, harnesses market forces, is performance based, equitable (across geographical regions, socioeconomic groups and companies), transparent to all stakeholders, easy to administer, and efficient.[4]

We begin by acknowledging that because climate change is a global problem, the solutions must be global. No single country or state by itself can hope to stabilize the climate. The failure of the international community at past meetings of the United Nations Conference of Parties to adopt climate protocols, financing programs, and mitigation policies is disappointing. But does it

really matter for transportation? We suggest that the absence of international agreements is not a fatal shortcoming. Indeed, there is essentially nothing on the table in international negotiations that affects cars and trucks, and thus little prospect that there will be any agreements in the foreseeable future.[5] Thus, California leadership is not only appropriate, but potentially of great value to the nation and the world.

Another widely held view is that the solution to our energy and climate problems is getting the prices right—sending the correct price signals to industry and consumers. But, in fact, the transport sector's behavior is highly inelastic—unresponsive—to fuel prices, at least in the range that is politically acceptable.[6] As we will see, California's initiatives are based on a broader set of policy instruments, with only minor dependence on market instruments, again defying conventional wisdom but in a way that likely will prove most effective at reducing emissions and energy use.

Europe provides an example of why pure market instruments (ie, taxes) are inadequate; it has gasoline taxes over $4 per gallon, and still finds the need to adopt aggressive performance standards for cars to reduce greenhouse gas and oil use. Europe's high fuel taxes certainly have an effect—vehicles are smaller, engines are less powerful, and people drive less—but the resulting reductions in fuel use and greenhouse gases still fall far short of the climate goals of the European Union (and California). Large carbon (and fuel) taxes are efficient in an economic sense, but because consumer purchase behavior is relatively insensitive to fuel prices, the effect on vehicles, fuels, and driving are modest. The European experience suggests that *huge* taxes would be needed to motivate significant changes in investments and consumer behavior. Economic research supports this finding[7] (despite anecdotal media stories suggesting the contrary). Even small taxes have proven unacceptable to politicians and voters. Moreover, the effectiveness of taxes and other market instruments in reducing oil use and emissions are inhibited by a long list of market failures and market conditions—including market power of the OPEC cartel, technology lock-in, and the principal agent problem (for example, apartment dwellers and users of company cars have no incentive to reduce energy use when they do not directly pay for the cost). As a result, it is clear that a variety of policies are needed to overcome these various market failures and barriers, as well as the inelastic responses of vehicle owners.

It's not that getting the prices right and adopting international climate agreements and carbon taxes are irrelevant and unimportant. They are clearly important. But much progress can, and probably will, be made within the transport sector in the next decade without them.

3 Transformation of Transport

California is far from perfect, in so many ways. It has the most car-dependent and oil-intensive transportation system of any major economy, and its state government is often derided as dysfunctional. But it does provide a broad policy framework that can be used to orchestrate the transformation of transportation.

California's legislative and regulatory basis for this task is tied to greenhouse gases and climate change because, in part, California is precluded by federal law from regulating energy use of vehicles.. This legal distinction is not important with current petroleum-powered vehicles because greenhouse gas emissions and oil use are exactly correlated. This distinction is also not important in reducing vehicle use, because less vehicle use has the same effects on greenhouse gases as oil use. With alternative fuels, however, the legal distinction becomes more significant, as all alternatives reduce oil use but some are more carbon intensive than others.

The shift to Canadian oil sands, for instance, reduces the use of conventional petroleum and enhances energy security, like other alternative fuels—but the high carbon intensity of those oil sand fuels exacerbates climate change. For nearly all other elements of the California Climate Policy Model, energy security and climate goals are well aligned. In the case of oil sands and some other fuels, they are not, leading to political tensions with oil company suppliers and energy security advocates .

To describe and critique this policy model, we simplify the complexity of the transportation system into a three legged stool, with each leg representing a critical area of transformation: vehicles, fuels, and mobility. The three legs are addressed in descending order of importance, measured in terms of effectiveness in reducing emissions. The "weak" third leg, mobility—the users—can be measured as vehicle miles traveled (VMT).

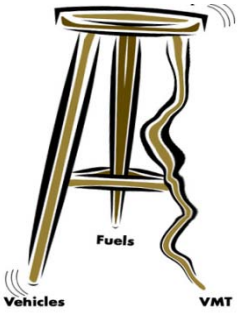

Figure 1. The Transportation System as a Three-Legged Stool

The California policy model is a complex mix of rules, incentives, and market instruments. Economists would describe this approach as second best, since it does not rely on pure market instruments. As suggested above, we disagree with this view. Here is how the model works.

4 The First Leg: Vehicles

American vehicles stand apart from those of other major industrialized countries. They are much larger and more powerful, and therefore consume much more oil and emit far more greenhouse gases. Yet our fuel economy standards remained stagnant for 30 years, until 2010, while Japan, Europe, and even China adopted increasingly aggressive standards to reduce oil use and greenhouse gases.

California played a leadership role in breaking the paralysis. In 2002, California passed the so-called Pavley law that required a sharp reduction in vehicle greenhouse gas emissions—about 40% by 2016. The car companies filed lawsuits against California and states that followed California's lead. When those lawsuits failed, the Bush Administration refused to grant a waiver to California to proceed, even though waivers were granted routinely for previous vehicle emissions regulations by California. In 2009, President Obama not only agreed to grant a waiver, but committed the entire country to the aggressive California standards.

And then in July 2011, at the request of President Obama, the US Department of Transportation, US Environmental Protection Agency, and the California Air Resources Board announced an agreement with the major automakers to sharply reduce fuel consumption and greenhouse gas emissions another 4-5% per year from 2017 to 2025. California, by threatening to adopt its own more stringent rules if the federal government and automakers did not agree to large reductions, was recognized as playing an instrumental role,.

These regulations are central to California's greenhouse gas reduction efforts. They are expected to elicit larger reductions than any other policy or rule, including carbon cap and trade. The reductions are also expected to be the most cost-effective, with consumers actually earning back two to three times more from fuel savings over the life of their vehicle than they would be paying for the added cost of the efficiency improvements (after discounting future fuel cost savings).[8]

The federal government has recently asserted leadership in supporting the commercialization of electric vehicles, with the Obama Administration offering tax credits of $7,500 per car and billions of dollars to electric vehicles and battery manufacturers. And the federal government adopted vehicle greenhouse gas standards in 2009 that provide strong incentives to automakers to sell electric vehicles.

But California has a much longer policy commitment to electric vehicles. In 1990, the state adopted a zero emission vehicle (ZEV) requirement, requiring the seven largest automotive companies in California to "make available for sale" an increasing number of vehicles with zero tailpipe emissions. The initial sales requirement was 2 percent of car sales in 1998 (representing about 20,000 vehicles at the time), increasing to 5 percent in 2001 and 10 percent in 2003.

The intent was to accelerate the commercialization of electric and other advanced technology, including hydrogen fuel cells, but batteries and fuel cells did not advance as fast as regulators hoped. The zero emission vehicle rule, after surviving industry litigation along with multiple adjustments to reflect uneven progress of hybrids, fuel cell and battery technologies, now bears little resemblance to the original. While some consider the ZEV mandate a policy failure, others credit it with launching a revolution in clean automotive technology.[9]

The actual numbers of vehicles sold to consumers as a result of the ZEV program fall well short of what CARB originally expected. Only a few thousand electric vehicles were sold in the US in the first decade of this century, most of them by start-ups such as Tesla.[10] But 2011 appears to have been a breakthrough, because for the first time major automakers made firm commercial commitments to the technology. Nissan began selling its all-electric Leaf and General Motors its

Volt plug-in hybrid electric vehicle, the very first commitment of major car companies to plug-in vehicle production in over a century. Sales of the two vehicle models amounted to less than 20,000 worldwide in 2011 (about half in California), but both companies are expanding factory capacity in anticipation of each selling much larger volumes in 2012, and virtually all major car companies have plans to sell plug-in vehicles in the next couple of years.

In addition to the ZEV mandate, California has enacted various other incentives in recent years to support the introduction of fuel-efficient and low-greenhouse gas vehicles, including allowing access to carpool lanes and providing rebates to buyers of electric vehicles.

Was the zero emission vehicle mandate the most effective policy to launch the electric vehicle revolution? Could other policies have accomplished the same at less cost with less conflict? Who knows? What's certain is the ZEV program accelerated worldwide investment in electric-drive vehicle technology. The benefits of those accelerated investments continue to sprout throughout the automotive world. And California policy was the catalyst.

5 The Second Leg: Fuels

California has been even more innovative about replacing petroleum fuels with low carbon alternatives. In some ways, the federal government has been a leader: Its Renewable Fuel Standard (RFS) requires the production of 36 billion gallons of biofuels by 2022. But this requirement has serious shortcomings. The RFS biofuels mandate has led to the production of more than 12 billion gallons per year of corn-based ethanol, but almost no low-carbon, non-food based biofuels. Corn ethanol is roughly similar to gasoline in terms of lifecycle carbon emissions. Worse, the Environmental Protection Agency has repeatedly given waivers to oil companies to defer investments in lower-carbon advanced biofuels.

California has pioneered a regulation that provides a durable framework for the transition to low-carbon fuel alternatives. Its Low Carbon Fuel Standard (LCFS), adopted in 2009, applies to all fuel alternatives, unlike the biofuels-only Renewable Fuel Standard. It also allows oil companies to trade credits among themselves and with other suppliers of low-carbon fuel alternatives (such as electric utilities) and, unlike the federal Renewable Fuel Standard, it provides incentives to make each step in the energy pathway, from the growing of biomass to the processing of oil sands in Canada, more efficient and less carbon-intensive. The LCFS is superior in stimulating innovation, harnessing market forces, and providing a framework for all alternatives to compete.

British Columbia and the European Union, among others, are adopting versions of California's LCFS, and many states are in advanced stages of review and design.

Because the Low Carbon Fuel Standard is novel, casts a wide net, and requires major investments in low-carbon alternative fuels, it has been controversial. Economists argue that a carbon tax would be more economically efficient. Energy security advocates and producers of high-carbon petroleum, such as the Canadian oil sands, argue that it will discourage investments in unconventional energy sources and technologies that could extend the world's supply of oil. Many correctly argue that the imposition of the LCFS in one state will encourage shuffling of high-carbon ethanol and petroleum to regions that don't discourage those fuels. And corn ethanol producers and others argue about the details of lifecycle emissions assumptions. Another concern is that administering this seemingly simple rule requires vast amounts of technical information.

The Low Carbon Fuel Standard is a powerful policy instrument. Oil company executives acknowledge privately that it has already motivated their companies to reduce the carbon footprint of their investments and to reassess their long term commitment to high carbon fuels, such as oil sands. But to minimize fuel shuffling and thereby realize the full benefits of an LCFS policy, more governments must adopt similar policies. Greater benefits would also be realized, as with low-carbon vehicles, if additional complementary policies were adopted to target the many market failures and market conditions that inhibit the transition to low-carbon fuels. The case of hydrogen, among the most promising low-carbon transport fuels of the future, illustrates the challenge. Oil companies are unwilling to commit to building hydrogen stations until the demand is apparent in the form of vehicles sold, while car companies assert they can't take the multi-year risk of building hydrogen fuel cell cars unless they are confident the stations will be there. It is a classic chicken-and-egg dilemma. As this article goes to press, California is considering a requirement that oil companies build a certain number of hydrogen stations in accordance with

the number of hydrogen-powered fuel cell vehicles that sold by automakers.

6 The Third Leg: Mobility

The third leg of the stool—the wobbly, uncertain one—is vehicle users. Greenhouse gas emissions will be reduced if people drive less. The strategies to induce this greater good are complex and difficult to implement, however. They include reducing urban sprawl, enhancing public transportation, and raising the price of travel (and parking) to incorporate externalities of carbon emissions, pollution, and energy security.

Less demanding user-related strategies involve educating the public. They include better driving habits, called eco-driving, whereby jack-rabbit stops and high-speed driving are discouraged, and where tires are well inflated and unneeded racks that increase wind resistance are taken off vehicles. And then there are infrastructure challenges: Better management of roads to reduce energy wasted in stop-and-go traffic, and better information to drivers so that they find their destinations and parking spots more quickly, are still other user-based strategies to reduce greenhouse gas emissions.

In the drawing, this third leg is bent and shaky because efforts to reduce vehicle use in California and the rest of the nation have largely failed.[11] Indeed, vehicle use during the last 40 years has increased substantially, despite a series of US government initiatives dating back to the mid 1970s—including "Transportation System Management," "Transportation Control Measures," and "Transportation Demand Management," as well as construction of hundreds of miles of carpool lanes and increasing subsidies for public transportation. The number of vehicles per licensed driver is 1.15; public transport accounts for less than 3% of passenger miles; carpooling has shrunk; and vehicle miles per capita has steadily increased. Cars have become ever more central to daily life. The school bus is a thing of the past in most California communities.

Reversing this trend, while providing a high level of accessibility to work, school, health and other services, is a daunting challenge. It requires a vast swath of changes related to imposition and disbursement of sales and property taxes, land use zoning, transportation funding formulas, parking supply, innovative mobility services (such as demand-responsive transit and smart car sharing), pricing of vehicle use, and much more.

California pioneered car-dependent cities and living and took it to an extreme, creating a highly expensive and resource-intensive transportation system. We've over-indulged, and are experiencing the consequences. And although most of the world followed our car-dependent path (but later and slower), other countries and regions have been far more innovative and determined at restraining vehicle use. The good news is that—perhaps because California has gone so far to the extreme—the state is now showing policy leadership in reversing the pattern.

In 2008, California passed the Sustainable Communities law, known as SB375, to reduce land use sprawl and vehicle use. It led to the creation of a new policy framework for cities to guide the transition to a less resource-intensive and car-intensive future. It provides a more robust and performance-based approach than previous efforts to reduce vehicle use.

In implementing the law, the California Air Resources Board established distinct targets for each metropolitan area in the state. Those targets range from 6 to 8% reduction in greenhouse gases per capita by 2020 for major metropolitan areas and 13 to 16% in 2035. The targets are applied to regional associations of governments (known as Metropolitan Planning Organizations), who pass on the targets and responsibilities to individual cities and counties within their region. The local governments can meet the targets with any tools at hand, including pricing of vehicle use and parking, better land use management and public transportation, and better management of traffic.

The attraction of the Sustainable Communities targets is that they are performance-based and don't dictate to local governments how they should comply. Cities can be innovative in ways that are locally most compelling.

The downside of SB375 is that it imposes no penalties for non-compliance and, so far, gives only weak incentives and rewards. This lack of teeth in the law is reasonable, considering the financial trouble most cities are in. The challenge is to provide incentives that are compelling enough for cities to assert themselves. Two options under consideration are diversion of cap and trade revenues to cities who comply with reduction targets, and restructuring of transport funding formulas to reward the cities that comply. In what now seems perverse, current transportation funding formulas are largely tied to population and vehicle

use; more vehicles earn cities more money. It should be just the opposite.

One lesson learned during the early implementation of the program and the development of the greenhouse gas targets was helpful. Local politicians and transportation managers came to support the targets when they realized that strategies to achieve them are the same strategies they were already pursuing for other reasons, such as infrastructure cost reduction, livability, and public health. In fact, having a formal policy framework aided their efforts to govern their cities.

7 What about Carbon Cap and Trade?

California adopted a carbon cap and trade rule as the capstone of its plan for meeting the goals of the overarching climate law (known as AB32, the Global Warming Solutions Act of 2006). California is not the first to do so; the European Union preceded us by a few years, and northeast and mid-Atlantic states began a carbon cap-and-trade program for their electric utilities in 2008. But California's program is broader than the European program because it caps transport fuels, and broader than the eastern utilities program because it includes all large industrial and electricity generation facilities.

Yet perhaps surprisingly, California's carbon cap and trade rule will not have much impact on transportation. A cap-and-trade program—whereby factories, oil refineries, cement producers, electricity generating facilities, and other large greenhouse gas sources are assigned shrinking carbon caps—is important in injecting a carbon price into the economy. A carbon price results from carbon trades. If companies cannot shrink their emissions, or choose not to, they can purchase "allowances" from companies that are over-performing. With carbon trading, a market is created for carbon reductions, with carbon gaining a market value. If everyone is successful in reducing their emissions and few need to buy allowances from others, the carbon price will be low. If they are not successful, prices will be high. When carbon has a market value, polluters know exactly how much it costs them to pollute, and can make economically rational decisions about how to reduce their greenhouse gas emissions.

The shortcoming of the cap-and-trade program is that, while valuable in creating a price for carbon, it is not central to reducing transportation emissions. The California cap-and-trade program is relevant to transportation in that it covers oil refineries and, in 2015, the carbon content of the fuels themselves. The program is designed with floor and ceiling prices of $10 and $70 per ton of carbon through 2020. While $70 is likely to motivate large changes in electricity generation, the effect will be far less for transportation. Consider that $70 per ton equates to about $0.70 per gallon of gasoline. A $0.70 price increase is unlikely to motivate oil companies to switch to alternative fuels, or to induce consumers to significantly reduce their oil consumption.[12] Therefore, the impact of cap and trade on transportation will be minimal—because of inelastic responses by both fuel suppliers and consumers. It is nevertheless a crucial step in placing an explicit price on carbon.

8 Assessing the Policy Framework

California has put in place a comprehensive and largely coherent set of policies to reduce greenhouse gases and oil use. This set of policies and regulations is unique in the world, in that it is an integrated approach to reducing greenhouse gases and oil use in transportation.

While it includes a carbon cap and trade policy that injects a price of carbon into the economy, more important is the mix of policy instruments that target specific vehicle, fuel, and mobility activities. Most of these policies are regulatory, though they are largely performance-based, and many have a pricing component to them, such as the Low Carbon Fuel Standard and its credit trading component.

In summary, this California model has the benefit of minimal cost burdens on taxpayers, extensive use of performance-based standards, and some harnessing of market forces. Most important of all, it has survived political challenge in the form of a statewide election at a time of severe recession and 12% unemployment, where voters defeated an initiative measure to suspend implementation of the program by the widest margin of any issue on the ballot (61% to 38%, in November 2010).

The defects of the California model are both theoretical and practical. One concern is that many of the policies shield consumers from price increases. When we don't feel it (directly) in our wallets, why change anything? One future policy response might be to impose a system of "feebates" for vehicles, whereby car buyers pay an

additional fee for vehicles that consume more oil and produce more greenhouse gases, and pay a lower price for those that consume and emit less. A feebate reconciles regulations with market signals. Another way to create more transparency and boost the effectiveness of the price signal might be to convert the carbon cap imposed on fuels into a fee or carbon tax.

Another major weakness is the absence of policies addressing most air, maritime, and freight activities, leaving significant chunks of the economy untouched by carbon policy. Unless the US government is willing to act, these significant sources will only continue to grow.

Still another weakness is emissions leakage and fuel shuffling—whereby fuel suppliers send their "good" fuel to California and their high-carbon fuel elsewhere. This shuffling is a particular challenge for California and other sub-national governments, whether the policies are based on market or regulatory instruments.

In a broad sense, perhaps the biggest challenge to California is the complex interplay of the many regulations and incentives, and the involvement by various governmental bodies. It's can seem positively dizzying. For example, large-scale adoption of electric vehicles depends on whether the design of the cap-and-trade program by the California Air Resources Board and Public Utilities Commission encourages electricity generation that replaces high-carbon petroleum in the transportation sector. The Public Utilities Commission also enacts rules regarding who can or cannot sell electricity to vehicles. Meanwhile, the federal government and CARB determine how much credit EVs receive as part of vehicle performance standards. Are full upstream emissions from utilities considered, even though they are not with petroleum-fueled vehicles? And should automakers be given more or less credit for electric vehicles relative to fuel cell vehicles in the ZEV mandate? It is important to make sure that the many rules are aligned and send consistent signals. It's a challenging task, exacerbated by the involvement by numerous government agencies and legislative bodies.

9 Conclusions

California pioneered the extraordinarily expensive and resource intensive car-dependent transportation system that has been imitated around the world. But it is not a sustainable model for California or anywhere else. The challenge is to redirect and transform transportation.

California has crafted a mix of regulations, incentives and market instruments that together comprise a sophisticated, comprehensive, and largely coherent policy model to guide the transformation. We are clearly not alone. Many countries are enacting policies and programs to reduce greenhouse gas emissions from transportation and other sources. But California is unique in the comprehensiveness of its climate policies addressing transportation. The European Union was a leader in adopting (voluntary) carbon dioxide standards for vehicles in 1998 and launched a cap-and-trade program for major stationary sources in 2005. Both preceded California. But California's 2006 global warming law (AB32), which is the empowering law for many of the policies described in this paper, is broader, requiring reductions across the entire economy. California also adopted mandatory vehicle greenhouse gas standards before Europe, and adopted a low carbon fuel standard which is being imitated in Europe, but more slowly and in a more limited way.

California has also created a policy program that addresses vehicle usage, via SB375, while Europe still has not devised a coherent policy or strategy for addressing the road transport sector—though, for historical reasons, most European cities are far more innovative and effective at reducing sprawl and vehicle use. To Europe's credit, it is also pursuing broad policies to reduce greenhouse gas emissions from ocean shipping and aviation, which California is not—largely because as a state within a nation, California has limited jurisdiction over inter-state and international trade.

Economists would argue that California's approach is second best, since it does not rely principally on market instruments. While it is true that California is not relying principally on a simple carbon tax (or even cap-and-trade program), we argue that such a tax-based approach is not politically possible in the current climate, nor is it capable of gaining more than a small fraction of the reductions that are being called for. Even Europe, with its large fuel taxes, feels the need to also enact very aggressive regulatory requirements. Moreover, many market failures and market conditions undermine the effect of carbon and fuel taxes.[13] Targeted incentives and rules are needed to address the myriad market failures and market barriers hindering the transformation of the transportation system. Do the

complications of this broad mix of instruments offset their attractiveness? With wise oversight, we think not. The California model may not be elegant, but it is not second best.

One might argue that California has no business pioneering climate policy, that it contributes a small part of the world's total greenhouse gas emissions and that this global problem should be left to global agreements. While it is true that California contributes only about 2% of the world's total greenhouse gas emissions, there are few entities with larger shares. More importantly, while it is clear that top-down approaches contained in international treaties and even national rules will be required to achieve substantial climate change mitigation, a bottom-up approach is also needed, one that more directly engages individuals and businesses. California is providing the bottom-up model for others to follow.[14]

Acknowledgments

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References

[1] Daniel Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World*, The Penguin Press, 2011, p. 691. As described later, CARB's authority emerged from the state's early and effective commitment to air pollution reduction.

[2] In 2002, the legislature passed, and Governor Davis signed, AB1493, known as the Pavley Act. CARB adopted implementing regulations in 2004, but they were blocked until 2009 by lawsuits, as described later.

[3] See D. Sperling and Deborah Gordon, *Two Billion Cars*, Oxford University Press, 2009; A. Schäfer, JB Heywood, HD Jacoby, A. Waitz, *Transportation in a Climate-Constrained World*, MIT Press, 2009; and a series of reports from the National Academies, including *Real Prospects for Energy Efficiency in the United States*, National Academy Press, 2009; *Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs, and Environmental Impacts* (2009); *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*, National Academy Press (2004).

[4] For overview of policy options and strategies to reduce greenhouse gas emissions from transportation, see National Research Council, *Policy Options for Reducing Energy Use and Greenhouse Gas Emissions from U.S. Transportation*. Transportation Research Board of the National Academies, Special Report 307, Washington, DC, 2011.

[5] The two transportation activities where international agreements are needed are maritime and air transport, though these activities represent a small share of total transport emissions and energy use.

[6] Hughes, Jonathan, Chris Knittel, and D. Sperling (2008), "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," *Energy Journal*, 29:1, 113-134; and Small, K. A. and Van Dender, K. (2007). "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect." *Energy Journal* 28:1: 25-51.

[7] Holland, S., Hughes, J., Knittel, C., 2009. Greenhouse gas reductions under low carbon fuel standards? *American Economic Journal: Economic Policy* 1(1), 106–146.

[8] US Environmental Protection Agency, US Department of Transportation, and California Air Resources Board, *Interim Joint Technical Assessment Report: Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2017-2025*, September 2010. The auto industry challenged these cost findings as too optimistic, but in the end all automakers except Volkswagen and Daimler agreed to support the aggressive standards proposed for 2017 to 2025.

[9] For the skeptical view, see L. Dixon, I. Porche, and J. Kulick, *Driving Emissions to Zero: Are the Benefits of California's Zero Emission Vehicle Program Worth the Costs?* (Santa Monica, CA: Rand, 2002). For a positive view, see A. Burke, K. Kurani, and E. J. Kenney, *Study of the Secondary Benefits of the ZEV Mandate*, Institute of Transportation Studies, University of California at Davis, Report UCD-ITS-RR-00–07 (2000). For the historical origins, see Gustavo Collantes and Daniel Sperling, "The Origin of California's Zero Emission Vehicle Mandate," *Transportation Research* A ,42 (2008) 1302–1313.

[10] ZEV sales in the ten other states that have adopted California's ZEV program all count toward meeting California ZEV requirement. In recent years, over half the ZEV sales in the US were physically in California.

[11] For an overview of the challenges of reducing greenhouse gas emissions through land use changes, see National Research Council, *Driving*

and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions. Transportation Research Board of the National Academies, Special Report 298, Washington, DC, 2009.

[12] This inelastic behavior is illustrated as follows. The $0.70 surcharge would represent about a 20% increase in price (for gasoline selling at $3.50 per gallon. Research reported earlier suggests that consumers have a price elasticity of about 0.10 in the short term to perhaps 0.50 in the long term. What this means is that with a price of $70 per ton of carbon, consumers would reduce their consumption by 2% (0.1 x 20%) in the short term and 10% (0.5 x 20%) in the long term.

[13] Christian Flachsland, Steffen Brunner, Ottmar Edenhofer, Felix Creutzig, "Climate policies for road transport revisited (II): Closing the policy gap with cap-and-trade", *Energy Policy*, Volume 39, Issue 4, April 2011, pp. 2100-2110 .

[14] The top-down approach is championed in D. G. Victor, J. C. House, and S. Joy, "A Madisonian Approach to Climate Policy," *Science* 309 (2005): 1820–21. The bottom-up approach is articulated in Nic Lutsey and Daniel Sperling, "America's Bottom-Up Climate Change Mitigation Policy," *Energy Policy* 36 (2008): 673–85.

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