Automaker Carbon Burdens in California

ENVIRONMENTAL DEFENSE
finding the ways that work

Automaker Carbon Burdens in California

AUTHORS
John DeCicco
Kate Larsen
with Energy and Transportation Technologies, LLC

ENVIRONMENTAL DEFENSE
finding the ways that work

Acknowledgments
The authors are grateful for the analytical work on the project by Feng An and Huiming Gong of Energy and Transportation Technologies, LLC; editorial assistance by Freda Fung, Robyn Scrafford and Allison Cobb; and comments by anonymous reviewers. This effort was supported in part by the Energy Foundation.

Cover: Getty Images.

Our mission
Environmental Defense is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

The complete report is available online at www.environmentaldefense.org.

Contents

Executive summary

Climate disruption poses grave risks to the people of California. Destabilized by uncontrolled increases in greenhouse gas pollution, the changing climate is likely to bring more frequent, deadly heat waves; extensive loss of snow pack from the state's mountains; impacts on water supply; loss of forests at higher elevations; and a domino effect of other disruptive changes to California's landscapes and habitats that scientists have barely begun to identify.

The driving force behind these dangers of global warming are greenhouse gases from the burning of fossil fuels. The single largest portion of the state's greenhouse gas (GHG) pollution is emitted by the cars Californians drive and on which its citizens now so depend for transportation. Yet it is this same extensiveness of automobile use that gives California the leverage to lead the way in reducing the risks of climate disruption, not only in the state, but nationwide and globally as well. A key way to cut greenhouse gas pollution from automobiles is using improved technology to redesign cars, vans, SUVs, and pickups so that they have lower emission rates, without changing size, safety, performance, or any other aspects of their functionality. The engineering and design skills needed to exploit this technological opportunity reside in the hands of the auto industry.

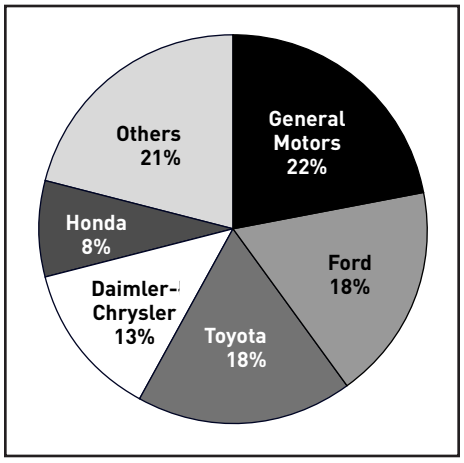
The dominant greenhouse gas pollutant from cars is carbon dioxide (CO_2), and so a useful starting point for evaluating both the opportunity to cut climate-disrupting pollution—and the responsibility for doing so—is to develop a picture of where California's car market stands in terms of CO_2 emissions. A method for painting this picture is with the concept of the "carbon burden" resulting from the sales of a group of vehicles. In short, the carbon burden represents the expected annual average quantity of CO_2 pollution emitted over the lifetime of the vehicles. Measured in tons of carbon-equivalent emissions, the carbon burden metric provides a yardstick to evaluate how California's auto sector GHG pollution breaks down by car company and by market segment. By assembling the best available data from state, federal, and automotive trade sources, this report characterizes the carbon burdens of the California car market in model year 2002, the most recent year for which reasonably complete data are available.

The carbon burden imposed by an automaker's sales is calculated as the product of sales volume, the fleet-average CO_2 emission rate of the vehicles sold, and the expected annual miles of driving over the life of the vehicles. Thus, carbon burden is proportional to market share as well as to how "carbon polluting" the vehicles are on average. While sales volume, by either company or vehicle type, represents success in the market, it also represents both the capability and responsibility for reducing cutting pollution. Figure ES-1 shows a breakdown of model year 2002 new fleet carbon burdens by automaker.

General Motors, by dint of its leading market share, had the largest carbon burden, amounting to 640,000 metric tons of carbon per year for its new car and light truck sales in California. This value corresponds to 22% of the overall new light-duty vehicle carbon burden, higher than GM's sales market share of 20% because the company's vehicles are more GHG-polluting than average. In

FIGURE ES-1

New fleet carbon burdens for major automakers in California, 2002

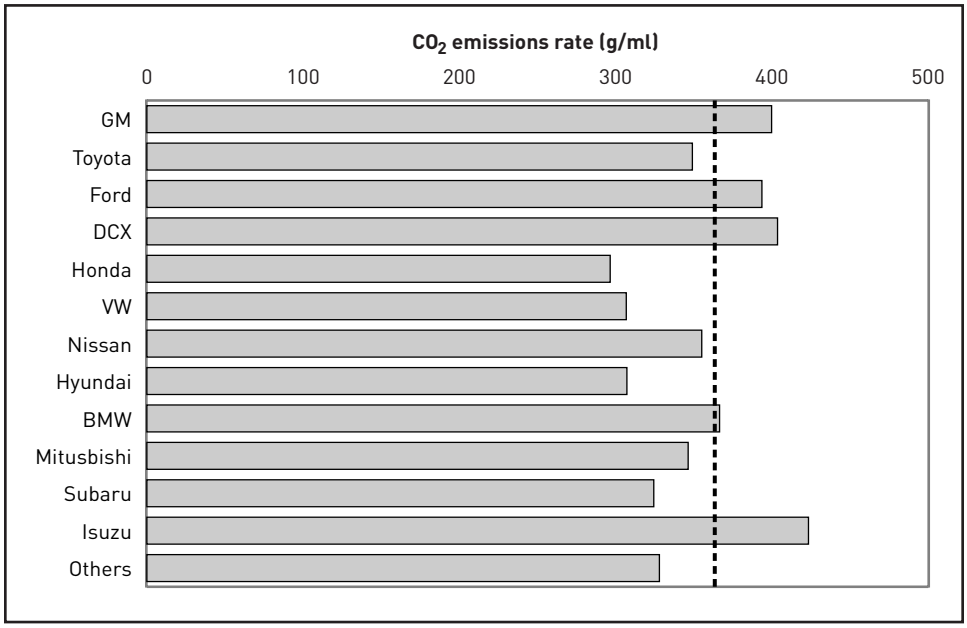


the number two position was Ford Motor Company, but not because it was number two in California market share. Toyota outsold Ford in California during model year 2002, but Ford's truck-heavy sales mix pushed its CO_2 emission rate to a level 8% higher than the average, while Toyota's was lower than average. As a result, Ford's new fleet carbon burden was slightly higher than Toyota's, even though they both round to 18% as shown in Figure ES-1.

Figure ES-2 illustrates new light-duty fleet average CO_2 emission rates by automaker. The model year 2002 average was 364 grams per mile (g/mi). Toyota's level was 4% lower than average, counter-balancing its number two market share position to edge it down to its third place position in terms of carbon burden. With their full-line fleets emphasizing trucks, the Big 3's CO_2 emission rates ranged 8%-11% higher than the market average. Honda's was lowest, at 19% below the market average. Collectively, the top five automakers in the California market (the firms broken out in Figure ES-1) account for 77% of sales and 79% of the new fleet carbon burden. The total California new fleet carbon burden, corresponding to the whole pie of Figure ES-1, was 3 million metric tons and accounted for 13% of

FIGURE ES-2

New fleet average CO_2 emissions rates by automaker in California, 2002



Bars show each firm's combined new car and light truck fleet average CO_2 emissions rate in grams per mile. Dashed line is the estimated 2002 market average of 364 grams per mile.

the carbon burden from model year 2002 car and light truck sales nationwide.

Among the top 12 automakers shown in Figure ES-2, Isuzu had the highest fleet average CO_2 emission rate because its sales (about 1% of the market) were all light trucks. Among the top five, DaimlerChrysler (DCX) had the highest CO_2 emission rate and Honda had the lowest; Honda's was also the lowest of any company overall. These patterns are similar to those seen in national data and largely reflect each company's sales mix. For the 2002 model year in California, vehicles classified as cars and those classified as light trucks comprised 53% and 47% of sales, respectively, but with their 38% higher CO_2 emission rate, light trucks accounted for 55% of the total new fleet carbon burden, compared to 45% for cars. The light truck category's carbon burden share breaks down in turn as 27% from SUVs, 20% from pickups, and 7% from vans.

The differences in carbon burdens and CO_2 emission rates among firms reflect their relative accountability for reducing GHG pollution. An important opportunity for achieving such reduction is the redesign of vehicles through the use of improved technology. Just as technology enabled major reductions of smog-forming tailpipe emissions for all types of vehicles, so too can improved technologies enable all automakers to cut GHG pollution regardless of their sales mix. Nevertheless, because pollution control is a public good, public policy is needed to guide the industry to improve their vehicles for lower CO_2 emissions, in the same way that government policies were needed to cut conventional air pollution. California led the way for air quality improvement over the past generation, including a path breaking emphasis on control of auto tailpipe emissions. With the 2002 passage of Assembly Bill 1493 calling for reductions of GHG emissions from passenger vehicles, the state is again leading the way toward an effective national policy for addressing global warming pollution from automobiles.

Clearly, in terms of automakers' interests, reducing the emission rates of their products is preferable to reducing sales or market share. Such an approach is consistent with the opportunity to cost-effectively reduce CO_2 pollution through technology improvement. In reporting on the carbon burdens associated with each company's new vehicle sales in California, this analysis emphasizes the role of the auto industry in using its engineering skills to provide consumers with cars and light trucks that emit less CO_2 pollution. By cooperating with the state's policy makers in implementing California's law to cut GHG emissions from motor vehicles, automakers can reduce their carbon burdens. Only then will these firms become part of the solution to one of the world's most serious problems, namely, the risks of global climate disruption, and thereby truly demonstrate the commitment to environmental protection that all of them profess.

Introduction

It's hard to imagine life in California without the automobile. American car culture was nurtured in California, home of the drive-thru, the motel and now to a governor who is known as the champion of both the GM Hummer and the Toyota Prius. California has grown up around the automobile, with its myriad highways, suburbs and far off vacation destinations, leaving remarkably few options for public transportation and other alternatives to driving. In 2002 there were over 24 million passenger vehicles on the road in California—that's two cars for every three people.[1] And the amount of driving continues to grow. Californians have come not only to depend on the convenience and mobility their cars afford them, but also to relish the symbolism of freedom and adventure that the automobile has come to embody.

While few dispute the benefits provided by the automobile, car use has its downsides, especially when automakers have failed to improve a key aspect of their product, namely, the amount of global warming pollution that cars produce. This form of pollution—greenhouse gas (GHG) emissions—causes one of the most severe impacts of auto use in California, climate change. Rising levels of greenhouse gases, mainly produced from the burning of fossil fuels, are raising global temperatures and disrupting climatic systems across the globe.

A landmark study on the impacts of climate change on California, authored by 19 leading experts from a number of universities and research institutions, including Stanford University, University of California at Berkeley, Scripps Institution of Oceanography and Lawrence Berkeley National Laboratory, was recently published in the Proceedings of the National Academy of Sciences.[2] The study found that climate change is likely to result in increasingly severe water shortages, longer and more intense heat waves, increased smog formation in urban areas and the central valley, property damage from storm surges and rising sea levels, an increase in frequency and damage from wildfires, and severely reduced snow pack in the Sierras. Rising GHG pollution levels are also likely to negatively impact many important sectors of the California

Impacts of climate change on California

A new analysis published in the Proceedings of the National Academy of Sciences[2] compared the risks to California from different levels of greenhouse gas emissions. It found that greater rises in emissions lead to increased climate-related risks and that the extent of future disruptions depends on how well emissions are controlled over the first few decades of the 21st century.

The study examines conditions likely to occur by the year 2100 compared to baseline conditions of the past four decades. If emissions are largely uncontrolled, heat waves in Los Angeles will be 6–8 times more frequent, with heat-related mortality increasing five to seven times; alpine and subalpine forests will be reduced by 75%–90%; and snow pack will decline 73%–90%. Along with the projected declines in winter precipitation, the resulting impacts on streamflow would also fundamentally disrupt California's water system.

economy, including agriculture, recreation (skiing, boating, fishing, river rafting), housing and other construction, electricity generation (from reduced hydroelectric power generation and increased air conditioning loads), and much more.

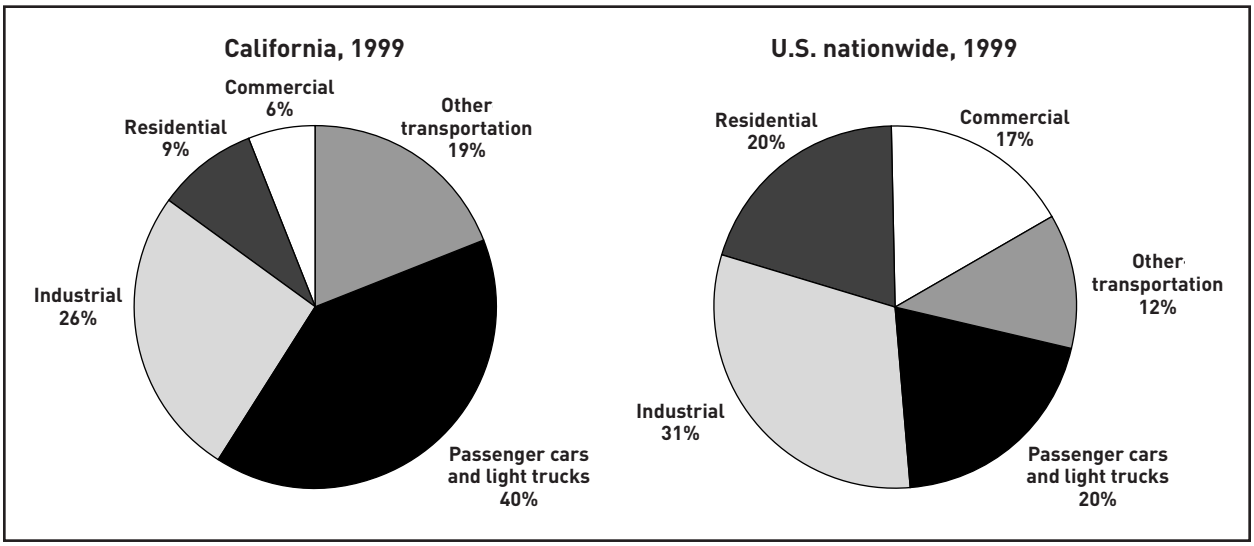
The carbon burden from cars

A way to characterize the global warming impact of products and activities that emit greenhouse gases is through the concept of their carbon burden. Carbon dioxide (CO_2) is the dominant greenhouse gas that causes climate change, so the quantity of carbon is the yardstick that climate scientists use to measure the global warming pollution impacts of various sources. Combustion of fossil fuels—oil, coal, and natural gas—is the main source of human-produced CO_2 emissions. Oil—mainly used for transportation—accounts for the largest share of the fossil carbon burden both in the United States and globally. Within California, the auto-oil share of the carbon burden is even greater than the national or global averages.

As shown in Figure 1, the transportation sector accounts for 32% of CO_2 emissions in the United States, but nearly 60% of CO_2 emissions in California.[3] And automobiles (cars plus light trucks such as pickups, vans and SUVs) account for as much as 65% of California greenhouse gas emissions from the transportation sector. Thus, personal vehicles cause approximately 40% of the total California carbon burden. In addition to CO_2, other greenhouse gases emitted by cars include halocarbons (used as the refrigerants in auto air conditioners), plus methane and nitrous oxide in the exhaust. Although these other greenhouse gases have a greater unit global warming impact than CO_2, they are emitted in much smaller quantities. Thus, CO_2 accounts for an estimated 94% of direct, carbon-equivalent GHG emissions from the average car or light truck in California.

In addition to GHGs emitted directly by a car, global warming pollution is emitted indirectly. But looking over the entire life of a vehicle (its "life-cycle," from manufacturing through

FIGURE 1
CO_2 emissions by sector



Source: Based on statistics from California Energy Commission and U.S. Department of Energy

scrappage), by far the largest portion of GHG emissions is that associated with a vehicle's fuel use. The direct emissions, noted earlier, that occur at the tailpipe and result from fuel combustion, account for 68% of an average vehicle's lifecycle CO_2 emissions. Another 21% are linked to fuel consumption but occur before use, largely at petroleum refineries but also during extracting and transporting crude oil and distributing gasoline. The remaining 11% of an automobile's CO_2 emissions occur during manufacturing, counting the energy used to make steel and other materials, plus that used in assembling the car and its parts.[4] Although the carbon burden as tallied in this report includes only the direct tailpipe CO_2 emissions, cutting these emissions reduces proportionately many of the upstream emissions (including those of greenhouse gases other than CO_2).

Despite the steady progress in reducing smog and soot pollution from California cars and light trucks, GHG emissions from the state's fleet continue to grow without restraint. Emissions of CO_2 from passenger vehicles rose 9.4% between 1990 and 1999, almost three times the rate of growth in total GHG emissions for the state.[5] Reducing these emissions presents a challenge to the auto and oil industries as well as car users.

The CO_2 emitted by a motor vehicle is the product of three factors: the amount of driving, the vehicle's fuel consumption rate and the carbon intensity of the fuel consumed. The fuel consumption rate (e.g., the number of gallons needed to drive 100 miles) is the inverse of fuel economy (miles per gallon, or mpg). Carbon intensity is how much CO_2 is emitted per unit of fuel consumed. For gasoline, this amounts to 19.6 pounds per gallon.[6] The amount of driving depends on the nature of the transportation system, land use patterns, and the availability and cost of alternative travel choices. Fuel intensity depends on the type of fuel and is linked to the infrastructure of global energy supply. Although each of these three factors is important, redesign of cars through technology improvement is a critical opportunity to reduce greenhouse gas emissions. Because cars last 12–15 years, the stock of light-duty vehicles in use turns over relatively quickly, compared to the rates of change of land use and major elements of infrastructure that influence the amount of driving or enable a significant change in the source of fuel.

Methodology

The methodology for auto sector carbon burdens analysis is described in Environmental Defense's 2002 *Automakers' Corporate Carbon Burdens* report, which performed the first such analysis for the overall U.S. car and light truck market. Readers can reference that report[7] for details on how the basic analysis is performed. Similar assumptions are used in this report except where otherwise noted. For example, this report uses the 19.6 lb/gal noted above, a California-specific value for the gasoline carbon intensity (or CO_2 emissions factor) that is slightly higher than the 19.4 lb/gal used for the national analysis.

Data sources

Characterizing automotive CO_2 emissions by manufacturer and vehicle type requires detailed data on CO_2 emission rates by make and model. More than 200 different nameplates (branded makes and models) are offered in today's car market. Counting variations of body style, engine, and drive type — all of which affect a vehicle's CO_2 emission rate — there are over 900 different configurations to track. CO_2 emissions have not been traditionally tracked in the car market, and even though California tracks vehicles for certifying compliance with the state's Low Emissions Vehicle (LEV) program, the engine-test-group listing used for the LEV program is not complete enough for developing a full picture of CO_2 emissions. Therefore, it was necessary to combine data from several sources to assemble a database suitable for a detailed carbon burdens analysis. We developed a database for model year (MY) 2002, the most recent year for which reasonably complete data could be obtained and also the year that the California Air Resources Board (CARB) is using as a baseline for regulations to implement AB 1493, the legislation requiring reduction of GHG emissions from passenger vehicles starting in MY2009.

CARB supplied us with a database for California light-duty vehicle sales for ten months, from January to October 2002, tabulating data for six automakers: General Motors, Toyota, Ford, DaimlerChrysler, Honda, and Nissan. Sales figures for these firms were generated by CARB's contractor by decoding a California state registration database.[8] Because the registration database does not have emission rates matched to vehicle models, CARB relied on EPA's and NHTSA's national databases to calculate CO_2 emission rates for vehicles sold in California. The CARB database provides the foundation for developing a CO_2 emission baseline for the California new light-duty vehicle fleet in model year 2002. We also used CARB's LEV certification data further supplemented by federal data from NHTSA and EPA, and we drew on data from *Automotive News* to cross-check and correct some sales estimates.

Developing a composite data set

To carry out our analysis we needed to address the following two shortcomings of the database provided by CARB:

1. Because the database covers only a ten-month period, adjustment was needed to develop annual estimates.

2. Because the database covers only six automakers, supplemental data were needed to fill in the remainder of the

fleet. The combined database we developed indicates that these "Big Six" manufacturers (General Motors, Toyota, Ford, DaimlerChrysler, Honda and Nissan) account for 81% of total California vehicle sales. Nationwide, these same six firms account for about 90% of total market sales.

To solve the above two shortcomings, we made the following estimates:

1. For estimating annual vehicle sales, we adjusted the annual vehicle sales by simply multiplying the first ten-months sales figures by 1.2. This approach assumes that the vehicle monthly sales in the last two months of 2002 would be same as the average monthly rate of the first ten months.

2. For estimating non-Big-Six vehicle sales, we used MY2001 data from CARB's vehicle emissions certification data set for non-CO_2 emissions. These data are based on automakers submissions of vehicle and engine specifications and are coded by engine family, but were not designed for CO_2 analysis and so cannot be used as the foundation data set for carbon burdens analysis.

3. For estimating missing CO_2 emission rates, we used MY2002 national average CO_2 emission rates from our national carbon burdens database (derived from NHTSA and EPA data) to estimate the emission rates for the non-Big-Six vehicle models.

These efforts yielded a composite data set covering all light vehicle models sold in California, providing both sales and CO_2 emission rates.[9] This composite database indicates that in MY2002, VW out-sold Nissan in California; the next ranked firms in terms of sales were Hyundai, BMW, and Mitsubishi. In this sense, the California market appears to be better characterized as having a "Big Five" (GM, Toyota, Ford, DaimlerChrysler and Honda), each having a market share of at least 10%, plus a next-tier five (VW, Nissan, Hyundai, BMW and Mitsubishi), each having market shares of 3%-5%. The remaining firms had market shares of around 1% or lower. We tabulated CO_2 emissions and carbon burdens for the top 12 automakers, covering 96% of the California market in MY2002.

In reviewing CARB's 2001 certification database, we uncovered problems with the sales figures for Isuzu, Suzuki, and Mitsubishi.[10] To develop better sales estimates, we turned to the *Automotive News* Market Data Book 2001, which listed MY2000 California new vehicle registrations by major manufacturer.[11] This source indicates that California accounted for about 13% of Isuzu's nationwide sales and 14% of Mitsubishi's. We assumed these same California fractions for these firms in MY2002, and used it to estimate corrected California sales estimates for their vehicles. A similar problem also occurred with the Suzuki sales, but *Automotive News* did not break out Suzuki figures, so we assumed it had a 13% California sales fraction; Suzuki is tallied within the "Others" category in our charts.

California fleet characterization

It is useful to be able to characterize auto sector CO_2 emissions in California by major market segment (type of vehicle) and by automaker. Such results are of interest for designing and evaluating regulatory measures, incentive programs and other approaches for managing automobile fuel use and CO_2 emissions within the state.

Enumeration by vehicle type

Table 1 provides summary statistics from our composite database by vehicle type (car, pickup, SUV or van). It shows sales tallies and market share along with estimated average fuel economy and CO_2 emission rates. From these values, we calculated annualized average fuel use for each type of vehicle (in 1000s of barrels per day) and the annualized carbon burden (million metric tons per year on a carbon mass basis).

The passenger car category was the largest, accounting for 53% of sales. This level is slightly higher than the national car share of 51% in MY2002. Because cars sold in California in MY2002 have an estimated average CO_2 emission rate of 310 g/mi, 15% lower than the overall light-duty vehicle average of 364 g/mi, they represent only a 45% share of total new fleet carbon burden.

With a 24% market share, SUVs comprised the second largest segment in terms of California sales. This share rank is somewhat less than the nationwide SUV market share of 27% in MY2002. Although we did not attempt to assemble multi-year trend data for California, the national sales trend has shown ongoing increases in SUV share, with a marked increase even recently from their 19% share in MY2000. New California SUVs had an average CO_2 emission rate of 423 g/mi, which is 16% higher than the light-duty fleet average. Thus, they held a disproportionately higher carbon burden share, accounting for 27% of the new fleet total. Pickups were third in terms of California market share, at 17%, and had the highest average CO_2 emission rate of 443 g/mi (22% above average), implying a 20% carbon burden share. For vans (mostly minivans), the sales share and carbon burden share were 6.6% and 7.1% respectively.

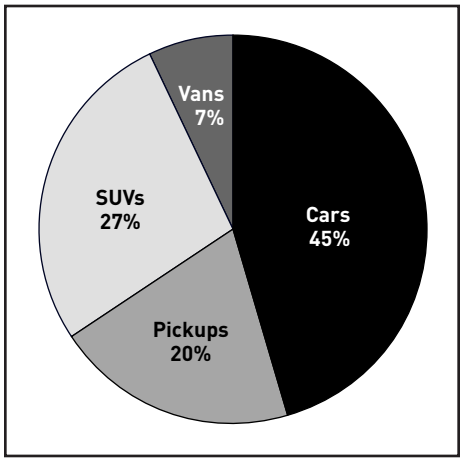
Table 1 shows that for MY2002, new car sales were roughly 1.12 million and

TABLE 1
Sales and carbon burden related statistics by vehicle type in California new passenger vehicle market, 2002

	Cars	Pickups	SUVs	Vans	Total
Sales (1000s)	1,121	353	498	139	2,111
Market share (%)	53%	17%	24%	7%	100%
Fuel economy (mpg)	28.8	20.1	21.0	22.6	24.4
Average CO_2 (g/mi)	310	443	423	394	364
Fuel use (10^3 bbl/day)	35.9	16.2	21.8	5.7	79.5
Carbon burden (MTc/yr)	1.34	0.60	0.81	0.21	2.96
Fuel/carbon share (%)	45%	20%	27%	7%	100%

FIGURE 2

New fleet carbon burdens by vehicle type in California, 2002



new light truck sales (sum of pickups, SUVs, and vans) were just under a million (990,000), and total new light-duty vehicle sales were roughly 2.11 million. The California new light-duty fleet total carbon burden is approximately 3 million metric tons per year (MMTc/yr). Thus, in market terms, cars and light trucks accounted for 53% and 47% of sales respectively. But with their 38% higher CO_2 emission rate, light trucks accounted for 55% of the new fleet carbon burden in MY2002. The 3 MMTc/yr imposed by new light vehicle sales in California represents 13% of the estimated model year 2002 carbon burden of new car and light truck sales nationwide.[12]

Figure 2 summarizes carbon burden contributions by vehicle type, broken down into cars, pickups, SUVs and vans. Cars, with 45% of the carbon burden, contribute carbon emissions of around 1.3 MMTc/yr. SUVs, with a 27% of the total carbon burden, have the second largest contribution of 0.8 MMTc/yr. Pickups contribute 20% of total vehicle carbon emissions with approximately 0.6 MMTc/yr. Finally, vans contribute about 0.2 MMTc/yr, or about 7% of the total carbon burden.

Enumeration by Automaker

Table 2 gives MY2002 new vehicle sales figures and carbon burdens in California

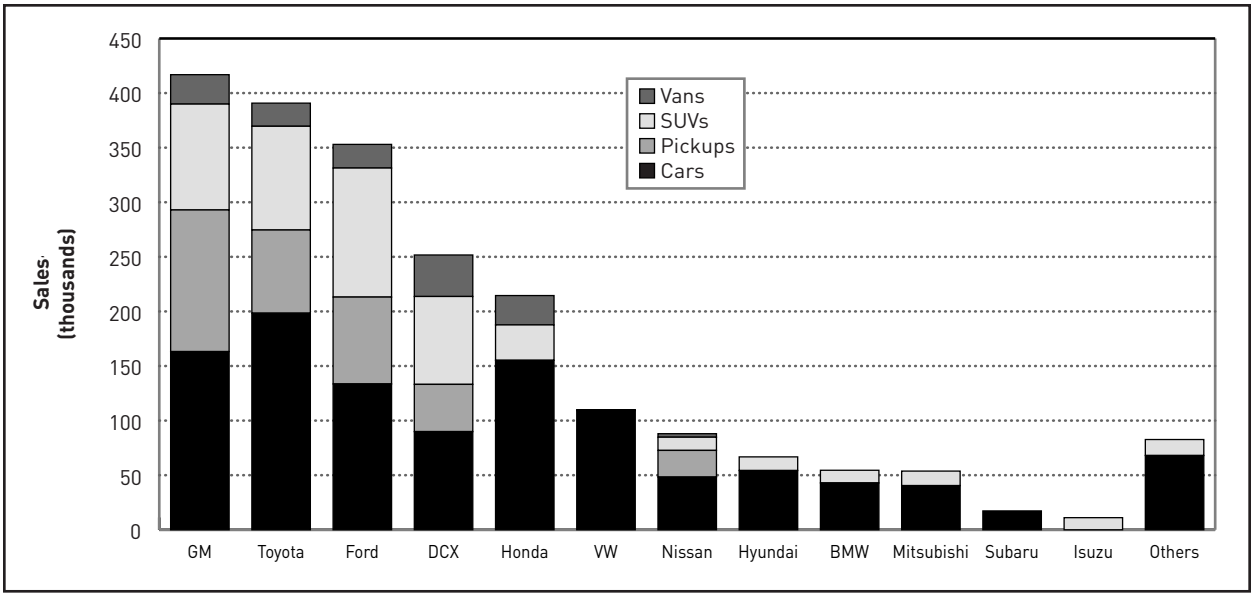
TABLE 2

New fleet sales and carbon burdens by automaker in California, 2002

	Total 2002 Sales	Carbon burden (MMTc/yr)	SHARES Sales	Carbon
GM	416,855	0.642	20%	21.7%
Toyota	390,787	0.525	19%	17.7%
Ford	353,002	0.535	17%	18.1%
DCX	251,696	0.391	12%	13.2%
Honda	214,542	0.245	10%	8.3%
VW	110,023	0.130	5%	4.4%
Nissan	88,007	0.120	4%	4.1%
Hyundai	66,769	0.079	3%	2.7%
BMW	54,510	0.077	3%	2.6%
Mitsubishi	53,751	0.072	3%	2.4%
Subaru	17,265	0.022	1%	0.7%
Isuzu	11,083	0.018	1%	0.6%
Others	82,663	0.104	4%	3.5%
Total	**2,110,953**	**2.960**	**100%**	**100%**

FIGURE 3

New fleet sales by automaker and vehicle type in California, 2002



by automaker. Figure 3 illustrates the MY2002 sales ranks for major automakers in California broken down by vehicle type. General Motors was the market leader in California, but Toyota and Ford were close behind, outselling DaimlerChrysler (DCX), and Honda was in fifth place. These Big Five automakers all had MY2002 California market shares of at least 10%. Collectively, the California Big Five accounted for 77% of total MY2002 light-duty vehicle sales in the state, with about 66% of the car market and 90% of the light truck market. The next seven firms (VW, Nissan, Hyundai, BMW, Mitsubishi, Subaru, and Isuzu) had market shares of 1%–5% each. The remaining automakers had market shares of less than 1% and are grouped into the "Other" category.

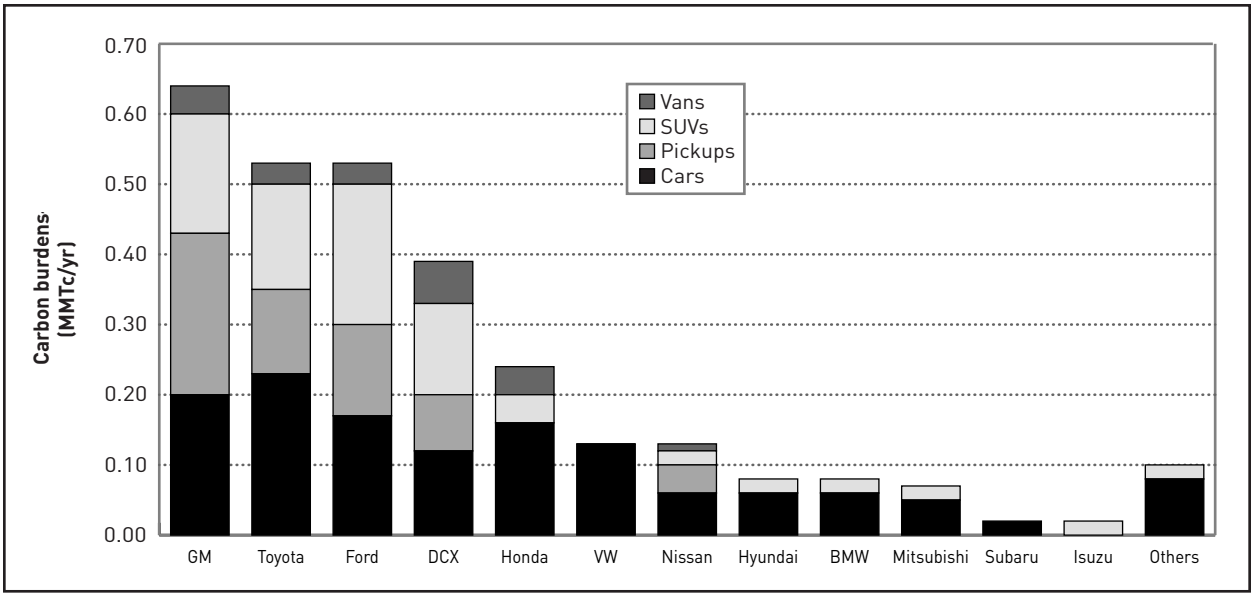
The bars in Figure 3 reveal the composition of each automaker's sales by vehicle type (car, SUV, pickup and van). Sales from Honda, VW, Hyundai, BMW, Mitsubishi, Subaru, and the other automakers are mostly dominated by cars, although Nissan's popular compact pickup truck gives that segment a notable place in Nissan's mix. General Motors, DaimlerChrysler, Ford, and Isuzu sales are dominated by trucks. With its combined Chevy and GMC brands, GM has a major presence in the pickup truck market. Ford also sells many pickups, but its mix is relatively more dependent on SUVs. Truck sales of other Big Five firms are also SUV-dominated; Honda does not sell pickups, and 72% of its sales were still models classified as cars in MY2002. As noted, the remaining automakers mostly have car-dominated fleets.

CARBON BURDEN ESTIMATES

New fleet carbon burdens (by firm or market segment) are calculated as the product of sales and average CO_2 emission rate. Table 2 and Figure 4 illustrate the MY2002 carbon contributions for major automakers in California. The bars in Figure 4 also break down carbon burdens by vehicle type. General Motors, of course, still ranks number one in terms of carbon burden with 0.64 MMTc/yr. However, Ford edges out Toyota as the number two

FIGURE 4

New fleet carbon burdens by automaker and vehicle type in California, 2002



carbon contributor because its fleet average CO_2 emission rate is higher than average (CO_2 emission rates are discussed in more detail below).

These differences in ranking are apparent when comparing Figure 4 with Figure 3; a direct comparison of sales and carbon burden shares can also be seen in Table 2. Only the first four automakers have a carbon share above 10%, and collectively, they accounted for 71% of total MY2002 light vehicle carbon burden in California. Although Honda's sales share was 10%, its carbon burden share was 8% because of the lower-than-average emission rate of their largely car-based fleet. The disproportionate contribution of light trucks, particularly pickups and SUVs, can also be seen when comparing Figure 4 with Figure 3. Because Toyota's products of each vehicle type have lower than average CO_2 emission rates, and because its fleet mix is still less truck dependent than Ford's, its carbon burden reaches a level just below that of Ford even though it led Ford by 2 points of market share. The carbon burden shares of Ford and Toyota both round to 18%, however, as shown earlier in Figure ES-1.

CO_2 EMISSION RATES

Table 3 lists CO_2 emission rates (in g/mi) of cars, trucks and total light-duty

TABLE 3

Average CO_2 emission rates of cars, light trucks, and all new light duty vehicles (LDVs) by automaker in California, 2002

	Cars	Trucks	LDVs
GM	316	454	400
Toyota	298	402	349
Ford	329	433	394
DCX	350	434	404
Honda	275	354	297
VW	306	427	307
Nissan	297	425	355
Hyundai	294	365	307
BMW	343	452	367
Mitsubishi	320	427	346
Subaru	324	-	324
Isuzu	-	423	423
Others	313	398	328
Total	**310**	**426**	**364**

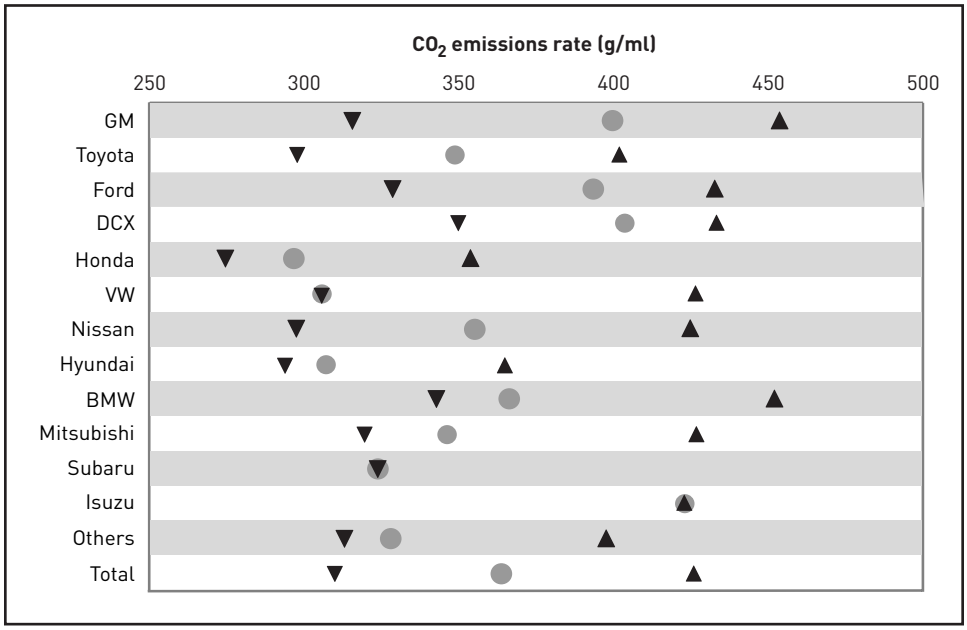
vehicles by automaker in California in MY2002. The numbers in this table are illustrated in Figure 5, where the leftmost triangle represents the class average CO_2 emission rate for cars, the rightmost triangle represents the class average CO_2 emission rate for trucks, and the circle represents the firm's overall light-duty fleet average (all averages are sales-weighted). Honda has the lowest average CO_2 emission rate of 297 g/mi and is the only firm with a fleet average emission rate below 300 g/mi. At the other end of the spectrum, General Motors, DaimlerChrysler, and Isuzu have fleet average CO_2 emission rates at or above 400 g/mi.

Fleet-composition impacts are one of the factors in a firm's overall carbon burden. These impacts are illustrated by the position of the circle (a firm's overall fleet average CO_2 emission rate) relative to the triangles giving the firm's average car and light truck emission rates. Firms whose fleets are mainly comprised of cars have the fleet-average circle closer to the leftmost triangle. This variation is most pronounced for VW, which sold very few light trucks compared to its car sales. A similar pattern can be seen for Honda, Hyundai, BMW, and Mitsubishi because of their car-dominated fleets. Conversely, the fleet-average circle is closer to the rightmost triangle for firms whose fleets are composed primarily of light trucks. Such is the case for each of the Big 3 automakers to varying degrees. In MY2002, Subaru's light vehicle sales consisted of only passenger cars, and Isuzu's passenger vehicle sales consisted of only light trucks, so their graphs collapse to a single point.

The symbols in Figure 5 also show the disparities between CO_2 emission rates of cars and trucks, represented by the distance between the triangles, which indicates how much higher a

FIGURE 5

New car, light truck, and overall fleet average CO_2 emission rates by automaker in California, 2002



For each automaker, the lower triangle (▼) is car average, upper triangle (▲) is light truck average, and circle (●) is overall (combined fleet) average.

firm's average light truck CO_2 emission rate is compared to its car CO_2 emission rate. For the overall California market in MY2002, the average light truck CO_2 emission rate of 426 g/mi was 38% higher than the new car average of 310 g/mi, similar to the 40% difference seen in federal data. The largest percentage disparities in CO_2 emission rate between cars and light trucks are for GM (44%) and Nissan (43%). DaimlerChrysler shows a small disparity (its light trucks emitting 24% more CO_2 than cars) largely because its cars have the highest average CO_2 emission rate (350 g/mi) among the top 12 firms.

The highest light truck class-average CO_2 emission rates belong to GM and BMW, both of which exceed 450 g/mi. The lowest class-average car CO_2 emission rate is that of Honda at 275 g/mi. The highest class-average CO_2 emission rate (GM trucks at 454 g/mi) is about 65% higher than the lowest emission rate (Honda cars at 275 g/mi). Among the Big Five, DaimlerChrysler had the highest overall fleet average (404 g/mi). Although Toyota offered a fairly full range of light trucks by MY2002, its truck fleet average (402 g/mi) was similar in level to the Big 3's overall (combined car and light truck) fleet average CO_2 emission rate. Honda's light trucks (of a much more restricted range of models than any of the Big 3's) had an average CO_2 emission rate only somewhat higher than that of DaimlerChrysler's cars, even though that company does offer small cars.

Reducing automotive carbon burdens

Although greenhouse gas pollution from motor vehicles can be reduced through many strategies related to automobile use, as well as to sustainable transportation more broadly, an important opportunity lies in redesigning vehicles for lower CO_2 emission rates. This strategy entails application of the ongoing technological progress in automotive engineering.

The historical progress in cutting conventional motor vehicle air pollution presages the power of technology for improving cars and light trucks so that they emit fewer climate-threatening greenhouse gases. California led the way in cutting smog-forming pollution from all types of passenger vehicles.[13] And it did so without inhibiting vehicle choice, as clearly seen in the wide range of models now available—all of which are much cleaner than even small cars of a generation ago. Innovative engineering can again be used to cut GHG pollution from small sports cars to large SUVs and everything in between.

The ability to exploit these technological advances rests in automakers' hands. The very same engineering and design skills they apply to improve vehicles in other ways can also be harnessed to cut the carbon burdens now imposed by their products. However, the competitive nature of the car market along with the fact that global warming is a "tragedy of the commons" means that government policy is essential for enabling the industry to address this public concern, a problem that far transcends the capabilities of individual car buyers. The firms that manufacture motor vehicles rank among the world's largest; they command extensive resources, both human talent and capital, which they continually invest to improve their products and expand their success in the market. Cutting automotive carbon burdens is a challenge that the automotive industry is well equipped to handle.

California has been the historical leader in establishing regulatory incentives for industry to find innovative solutions to fight air pollution. The state's pollution control programs became a model for national motor vehicle standards, and its Low Emissions Vehicle (LEV) program has been an outstanding success, cost-effectively reducing smog-forming criteria pollutants by over 75% from cars and light trucks. California has again stepped up to take the lead in addressing the threats to the state posed by global warming pollution. In 2002, the state legislature passed Assembly Bill 1493, which requires the California Air Resources Board (CARB) to adopt regulations that achieve the maximum feasible and cost-effective reduction of greenhouse gases from passenger vehicles. The regulations, scheduled to be adopted by January 1, 2006, will apply to model year 2009 vehicles and beyond.

CARB's regulatory proposal,[14] modeled after the LEV program, calls for reductions in four greenhouse gases: carbon dioxide, hydrofluorocarbons, nitrous oxide and methane. The proposed regulations require automakers to phase in cuts over eight years, achieving reductions on the order of 30% across the new vehicle fleet by 2016. Considering the wide range of technology existing today and projected to be available within that time frame,[15] this proposal is a readily achievable, conservative requirement.[16]

One condition of AB 1493 is that the GHG reductions be achieved in a manner that is cost-effective to consumers. Although technologies to cut GHG

pollution might add to the cost of a vehicle, any sticker price increase would be more than offset by the savings drivers see at the pump from reduced operating costs. With today's high gasoline prices ($2.00/gal), the average driver will save an estimated $1,200 over the first eight years of vehicle ownership. Thus, while the policy rationale for addressing global warming pollution is the same as that successfully used for addressing soot and smog, an added benefit is the fact that the design improvements that cut global warming pollution from cars will also save consumers money. This is a valuable bonus given the recent persistence of high fuel prices, exceeding the basic cost-effectiveness requirements of AB 1493 by a wide margin. In fact, a recent Public Policy Institute of California poll[17] showed that 81% of Californians, including 77% of SUV drivers, support the AB 1493 regulations and would like automakers to offer less polluting vehicles. There is little doubt that the improved vehicles of all types would find ready acceptance by California drivers.

California's historical technology-forcing regulations, such as the LEV program, have produced better automotive technologies, including ever-improving catalytic converters and electronic engine controls, that spread to vehicles nationwide and subsequently to other countries. As automakers begin to comply with California's GHG emissions standards, they will find that demand exists across the world for their new, low-GHG, clean technologies. The result will be a major step for protecting not only California, but the nation and the world, from the worst risks of global climate disruption.

Notes

[1] California Department of Transportation, California Motor Vehicle Stock, Travel, and Fuel Forecast 2001; U.S. Census, 2000.

[2] Hayhoe et al. (2004), Emissions pathways, climate change, and impacts on California, Proceedings of the National Academy of Sciences (PNAS) 101(34): 12422-27, August 24, 2004.

[3] California Energy Commission (CEC), Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999, Sacramento, November 2002.

[4] Less than 1% of an automobile's lifecycle energy consumption and CO_2 emissions occur during "end-of-life" processing (scrappage, etc.), but the end-of-life impacts can be much larger for other pollutants, such as mercury and other toxic materials (Keoleian, G., K. Kar, M.M. Manion, and J.W. Bulkley, *Industrial Ecology of the Automobile: A Lifecycle Perspective,* Warrendale, PA: Society of Automotive Engineers, 1997).

[5] California Energy Commission, 2002. Inventory of California Greenhouse Gas Emissions and Sinks: 1990–1999.

[6] Based on a value of 8.9 $kgCO_2$/gal, as used by CARB for its analyses.

[7] http://www.environmentaldefense.org/documents/2220_AutomakersCorporateCarbonBurdens.pdf

[8] Note that all of the data discussed here are highly aggregate, representing sums of California sales for a given model, and so reveal no information about vehicle registrations at the level of individual car owners.

[9] Note that for non-Big Six automakers, we applied MY2002 CO_2 emission rates, but estimate sales figures based on MY2001 projection.

[10] For these automakers, the data set indicated sales volumes that were too high, in some cases closer to total U.S. sales of the firm; we assume data errors and developed replacement estimates as described in the text.

[11] Unfortunately, 2000 was the last year for which the *Automotive News* Market Data Book published a breakdown of new car registrations by make and state, so we were not able to obtain a similar breakdown for 2002, which would have been a useful cross-check for the data obtained from CARB.

[12] Based on comparison to the 22.4 MMTc/yr carbon burden estimate for MY2002 derived from Environmental Defense's national automotive carbon burdens data base.

[13] See CARB's webpage on "Clearing California Skies" (www.arb.ca.gov/videos/clskies.htm), May 2004.

[14] California Environmental Protection Agency, Air Resources Board, "Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles," August 6, 2004.

[15] S. Vicuna, *Exploring Greenhouse Gas Reduction Options for Automobiles: A Report on the International Vehicle Technology Symposium,* Environmental Defense, April 2004.

[16] See "Comments on the proposed adoption of regulations by the California Air Resources Board to control greenhouse gas emissions from motor vehicles," Environmental Defense, September 13, 2004.

[17] Public Policy Institute of California, Special Survey on Californians and the Environment, July 2004 (www.ppic.org).

ENVIRONMENTAL DEFENSE

finding the ways that work

National Headquarters
257 Park Avenue South
New York, NY 10010
212-505-2100

1875 Connecticut Avenue, NW
Washington, DC 20009
202-387-3500

5655 College Avenue
Oakland, CA 94618
510-658-8008

2334 North Broadway
Boulder, CO 80304
303-440-4901

2500 Blue Ridge Road
Raleigh, NC 27607
919-881-2601

44 East Avenue
Austin, TX 78701
512-478-5161

18 Tremont Street
Boston, MA 02108
617-723-5111

Project Office
3250 Wilshire Boulevard
Los Angeles, CA 90010
213-386-5501