Pollution Lineup

An Environmental Ranking of Automakers

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Executive Summary

Despite three decades of emissions regulations, cars and light trucks (a category that includes sport utility vehicles, minivans, and pickups) still threaten Americans' health and the environment. Automakers are trying to distinguish themselves as environmentally responsible companies through both advertising and voluntary actions such as lowering pollution from their vehicles, increasing recycled materials content, or selling advanced technology vehicles. At the same time, almost all automakers are trying to sell more sport utility vehicles (SUVs) and other light trucks, which are allowed to pollute more than passenger cars.

Determining which automakers are truly environmental leaders requires an objective comparison of the pollution performance of their products. This study compares automakers' new passenger vehicles based on smog-forming and global warming emissions. We evaluated vehicles sold in 1998 (the most recent year for which complete data are available) using information from the Environmental Protection Agency, the California Air Resources Board, and the National Highway and Transportation Safety Administration. Our study also indicates the most important steps automakers and policymakers can take to reduce the environmental impacts of new automobiles.

Figure ES-1

Automaker Pollution Rankings for Average New Vehicle Smog-Forming and Global Warming Emissions

Rank	Pollution Performance	Automaker[a]
1	Worst	Isuzu
2		Daimler Chrysler[b]
3		Ford[c]
4		General Motors
5	Poor	BMW ↖ industry average
6		Mitsubishi
7		Nissan
8		Toyota
9		Volkswagen
10		Subaru
11	Better	Honda

a. Automakers with annual sales greater than 100,000 vehicles.

b. Daimler Chrysler includes Chrysler and Mercedes vehicles.

c. Ford includes Mazda and Volvo.

Key Results

This study demonstrates that pollution from automakers' new vehicles varies significantly (see Figure ES-1). Causes of these differences are outlined below.

Light Trucks Damage the Big 3's Rankings. The "Big 3" (DaimlerChrysler, Ford, and General Motors) account for 85 percent of light truck sales in the United States, which puts them into our "worst polluters" category. Although recently adopted regulations will require light trucks to meet the same tailpipe standards as cars, nearly a decade will pass before they are completely phased in. In addition, the Corporate Average Fuel Economy (CAFE) standards allow light trucks to consume one-third more gasoline than cars. Fuel economy is directly related to emissions of carbon dioxide (CO_2), the primary global warming gas, and fuel-inefficient trucks emit more CO_2 than cars. Technologies can make light trucks as clean and fuel-efficient as cars today, but unless the Big 3 build them into vehicles soon, they will continue to lag behind the average pollution performance of the industry (see Table ES-1).

Sales of Fuel-Efficient, Low-Emissions Vehicles Secure Honda's Ranking. Honda's vehicles achieve the lowest emissions of both smog-forming and global warming gases. Honda was the first automaker to sell a

Table ES-1

Average Smog-Forming and Global Warming Emissions by Automaker (grams per mile)[a]

Automaker	Smog-Forming Emissions[b] (NO_x + HC)			CO_2 emissions[c] (CO_2-equivalent gases)		
	Overall	Cars	Trucks	**Overall**	Cars	Trucks
Isuzu	**0.99**	n/a[d]	0.99	**599**	n/a	599
DaimlerChrysler[e]	**0.86**	0.61	0.99	**570**	453	624
Ford	**0.82**	0.61	1.00	**558**	465	637
General Motors	**0.78**	0.63	0.99	**521**	460	607
BMW	**0.62**	0.62	n/a	**504**	504	n/a
Mitsubishi	**0.70**	0.42	0.95	**456**	431	569
Nissan	**0.66**	0.60	0.79	**473**	422	577
Toyota	**0.65**	0.55	0.83	**464**	420	545
Volkswagen	**0.66**	0.66	n/a	**446**	446	n/a
Subaru	**0.59**	0.59	n/a	**464**	464	n/a
Honda	**0.45**	0.43	0.61	**409**	402	473

a. This table provides detailed results from our study on the relative pollution from automakers' cars and trucks, for both smog-forming and global warming emissions.

b. Nitrogen oxides (NO_x) and hydrocarbons (HC) are the two major smog-forming pollutants from motor vehicles.

c. Calculated based on fuel economy values (see appendix). Fuel economy is directly related to emissions of carbon dioxide—vehicles that use more gasoline emit more global warming gases.

d. Indicates the automaker does not sell this type of vehicle.

e. DaimlerChrysler includes Chrysler and Mercedes vehicles. Ford includes Mazda and Volvo.

significant portion of its vehicles as low-emission vehicles (LEVs)—a standard that is 57 percent more stringent than the current national requirement. Honda also leads the nation in fuel efficiency, with cars averaging the industry best at 31.8 miles per gallon. Finally, Honda benefits from selling a relatively small fraction of light trucks (10 percent of its sales), and those trucks are among the cleanest and most fuel-efficient in the industry.

The Auto Industry Is Backsliding on Global Warming. Historic fuel-economy data reveals a disturbing trend—every automaker's average new vehicles emit more global warming gases today than ten years ago, with the exception of BMW.[1] In 1999, US fuel economy overall dropped to its lowest value in 20 years. Two decades of fuel-saving technologies that could have helped curb CO_2 emissions have instead gone into increasing vehicle weight and performance.

The Big 3 Account for Most Global-Warming Emissions from New Vehicles. The Big 3 sell the dirtiest vehicles and capture the vast majority of US passenger vehicle sales, making them the worst polluters by any measure. Together, Daimler Chrysler, Ford, and General Motors' vehicles are the source of 76 percent of the CO_2 emitted by vehicles sold in 1998. Immediate action by these automakers to raise the fuel economy of their light trucks would significantly reduce global warming emissions from new automobiles.

Key Recommendations

What Automakers Can Do. "Green" competition will never fully replace the need for public policies, but it can help accelerate the introduction of cleaner technologies. Automakers wishing to distinguish themselves as environmental leaders must make their light trucks meet the same emissions and fuel economy standards as cars within the next five years or sooner. If Ford had taken these steps, it would have been the second-cleanest automaker in our rankings.

Environmentally concerned automakers must lower the total pollution from their new vehicles each year. Introducing cleaner gasoline vehicles ahead of mandates will help. Cooperating with policymakers to develop stronger fuel economy standards is essential. Finally, automakers must begin selling advanced technology vehicles, which hold the promise to eliminate automobiles from the pollution picture.

Policymakers Must Act Now. Regulators have taken steps to slowly close tailpipe pollution loopholes for light trucks, but they continue to disregard fuel-saving technologies for trucks by retaining the CAFE loophole. Holding light trucks to the same fuel economy standards as cars is the most effective step we can take to cut global warming emissions. The CAFE loophole alone allowed an extra 237 million tons of CO_2 to enter our atmosphere last year.

[1] For vehicles sold from 1989 to 1998. Although BMW's fuel economy increased from 1989 to 1998, the company fails to meet CAFE standards almost every year. In 1998 its CAFE was almost 8 percent below the legal requirement.

Pollution Lineup

An Environmental Ranking of Automakers

In 1999, automakers sold a record 17 million cars, sport utility vehicles, pickups, and minivans in the United States. Collectively, the five biggest manufacturers earned a staggering 25 billion dollars (Moneycentral 2000).[1] Unfortunately, good news for automakers has not been good news for the environment. Over 92 million Americans breathe unhealthy air (based on EPA 1998c),[2] and emissions of auto-generated global warming gases continue to grow to record levels. In addition, booming sales of higher polluting and fuel-inefficient light trucks (a category including sport utility vehicles (SUVs), minivans, and pickups) are confounding efforts to reduce the environmental impacts of driving.

With mounting public concern for the environment, automakers are realizing that a positive or "green" environmental image can help distinguish their products in a competitive global marketplace (Van Amburg and Gage 1999). But while automakers are trying to reconstitute their image from polluters to environmentally responsible corporations, no one has yet done an objective evaluation of their efforts. This report helps separate the "hype from the hardware" by ranking major automobile manufacturers based on the overall pollution performance of their new cars and light trucks. Our ranking will help automakers go beyond corporate policy statements by providing guidance on the most meaningful steps they can take to reduce the pollution impacts of their products.

Automakers and the Environment

Despite significant strides in reducing tailpipe pollution, automobiles still pose a serious threat to American's health and environment. Regulators are only slowly closing air pollution loopholes, and no action to raise fuel economy standards is in sight. In the meantime, automakers' aggressive pursuit of increased SUV and pickup sales comes at the expense of public health and the environment, since these vehicles are legally allowed to pollute more than cars. This trend in particular throws into question the auto industry's commitment to becoming more responsible for the pollution emitted by its products.

Pollution Problems Today. Motor vehicles are responsible for 30 percent of the primary smog-forming emissions nationwide (EPA 1998b).[3] Smog, a combination of ground-level ozone and particulate matter, causes a variety of health and environmental problems (see box, p. 2). Motor vehicles are the largest source of air toxics, chemicals that can cause cancer (EPA 1998a). And existing limits on tailpipe pollution neglect fine particles, which have been associated with an increased risk of premature death (EPA 1996; ATS 1996). Finally, toxic leaks from underground storage tanks and runoff from roads and highways cause considerable water pollution.

Passenger vehicles[4] are also major emitters of carbon dioxide (CO_2), the primary global warming gas.

[1] Calculated as net income (or profit) for General Motors, Ford, DaimlerChrysler, Toyota, and Honda.

[2] Based on 1990 census population data for non-attainment areas for one-hour ozone (includes San Francisco and moderate through extreme areas).

[3] As measured by the combined hydrocarbon and nitrogen oxide emissions.

[4] In this report, we use "passenger vehicles" to refer to both cars and light trucks less than 8,500 pounds gross vehicle weight.

Types and Health Effects of Air Pollution

Ozone is the primary ingredient in the smog engulfing major cities. Tailpipe emissions of **Nitrogen oxides** (NO_x) and **hydrocarbons** (HC) play a major role in the formation of ground-level ozone. These two pollutants are products of most combustion, but motor vehicles are the source of about one-third of the total nitrogen oxides and hydrocarbons emitted nationwide.

Ozone causes a variety of short-term health effects in the lungs, including irritation of the respiratory system, reduction of lung function, asthma aggravation, as well as inflammation and damage to the lining of the lung. These effects may cease when ozone levels fall, but repeated short-term damage from ozone exposure may permanently injure the lung.

Particulate Matter is a second major component of the haze obscuring visibility in our cities, rural communities, and scenic parks. Fine particulate matter is emitted directly from cars and trucks, but is also formed in the atmosphere through chemical transformation of other pollutants emitted by vehicles.

Particulate matter can increase the number and severity of asthma attacks and cause or aggravate bronchitis and other lung diseases. Health studies also link particle exposure to the premature death of people who already have heart and lung disease, especially the elderly.

With each passing year, the scientific consensus continues to grow that not only is the earth's surface temperature increasing due to human activity, but the consequences for our health, environment, and economy will be serious (Goetze and Farnsworth 1998). Automobiles alone emit 20 percent of US CO_2 emissions. Transportation as a whole is the fastest-growing sector of carbon dioxide emissions (Alson 1998). As of 1996, carbon dioxide emissions from US cars and light trucks *alone* exceeded the total emissions of all but three other countries in the world (based on Marland et al. 1996).[5]

Finally, passenger vehicles burn 40 percent of the oil consumed in the United States. Rising car and light truck fuel use is the main reason for rising oil imports. Americans send more than $100,000 a minute overseas to pay for foreign oil, adding to our trade deficit, costing jobs, and putting the entire economy at risk from significant price shocks.

Pollution Trends. Over the past three decades, stringent tailpipe standards have forced automakers to clean up smog-forming and other harmful pollutants from their vehicles. Catalytic converters, exhaust gas recirculation, and electronically controlled fuel injection are common pollution-control technologies in modern automobiles. Despite these improvements, total emissions of nitrogen oxides from the on-road fleet of passenger vehicles have not changed since 1970 (EPA 1998d). This is because Americans now drive more than 2.5 trillion miles per year, up from 1 trillion in 1970 (EPA 1998e). Passenger vehicle pollution standards recently adopted by California and federal regulators will reduce smog, but will not be sufficient to ensure that all Americans breathe healthy air in the twenty-first century. In particular, new scientific studies documenting the serious health effects from fine particles are not yet reflected in air pollution standards.

The situation is even worse when it comes to global warming. Emissions of carbon dioxide (CO_2) from cars and light trucks have risen 50 percent over the past three decades (based on Davis 1998 and EIA 1999) and continue to rise. Automotive impacts on global warming are directly related to fuel economy: lower fuel economy means higher CO_2 emissions. But fuel economy standards have been stagnant for the past decade and include a loophole permitting SUVs and other light trucks to consume one-third more gasoline per mile than cars. Along with stagnant CAFE standards, high sales of light trucks (about half of new vehicle sales) is expected to drop the overall fuel economy of new autos to 23.8 miles per gallon for 1999—the lowest value in nearly *20 years* (Heavenrich and Hellman 1999). This need not have happened. Two decades of fuel-saving design improvements that could have slowed growth in global warming emissions have instead been used to increase vehicle horsepower and mass.

The "Greening" of the Auto Industry? Automakers recognize a growing environmental consciousness amongst consumers, and many are capitalizing on this concern by marketing themselves as environmentally responsible. Ford, Honda, and Toyota have been among the most aggressive in advertising their corporate commitment to the environment. For example, Ford chairman William Clay Ford Jr. stated that one of his chief goals is to make Ford the most environmentally

[5] Based on passenger vehicles accounting for 20 percent of total US CO_2 emissions. China, Russia, and Japan have higher total emissions.

friendly automaker. Mr. Ford vowed to instill a new "environmental ethic" in the company and stated his belief that there is "no conflict between doing the right thing and the [financial] bottom line" (Nauss 1998).

Honda and Toyota also endeavor to project green images. One Honda advertisement proclaims, "We've always been committed to balancing your desires for fun and performance with society's need for cleaner air and improved fuel economy." (Newsweek 1999). At the 2000 Detroit Auto Show, Toyota President Fuji Cho said, "We can no longer afford to ignore the signs of global warming. Environmentally friendly cars will soon cease to be an option. They will become a necessity." (UPI 2000). Such statements may mislead the public into believing that automakers are making pollution reductions a high priority. But a look at actual trends tells a very different story.

Light Truck Pollution Loopholes Create Barriers to a Greener Auto Industry. Despite "green" advertising most automakers are pursuing increased sales of light trucks. Although allowed higher emissions of smog-forming and global warming gases by law, SUVs, pickups, and minivans do not have to be highly polluting and fuel-inefficient. Proven, cost-effective technologies can make light trucks as clean and fuel-efficient as cars. For example, a recent study demonstrated that a Ford Explorer could be constructed to meet the same fuel economy and tailpipe standards as cars for an additional $715. Furthermore, the extra purchase cost would be more than offset by almost $5,000 in fuel savings over the vehicle's lifetime (Mark 1999).

Unfortunately, automakers today are capitalizing on the light truck pollution loopholes, putting off investments in fuel- and smog-saving technologies in favor of larger short-term profits. Ford reportedly earns up to $15,000 for each Lincoln Navigator it sells, and the *one plant* producing Ford Expeditions, Lincoln Navigators, and heavy-duty pickup trucks profited more than all but 54 *companies* worldwide in 1997 (Bradsher 1999).

With such large potential profits, other automakers are pursuing increased sales of SUVs and pickups. Even companies that have been leaders in marketing advanced technology vehicles appear to be leading the pursuit of increased profits from light trucks. General Motors and Honda are each investing $400 million to boost their production of light trucks (Nauss 1999; White 1999). In 1999, Toyota began selling its first full-sized pickup, the Tundra, and is targeting sales of 100,000 units annually (Kisiel 1999). And in 2000, Toyota will begin selling the Sequoia, another full-sized SUV. In the near-term, the benefits of low-volume advanced technology vehicle sales will be outweighed by the pollution liabilities of high sales of SUVs, pickups, and minivans.

An automaker that is truly committed to the environment must take concrete steps to reduce the average pollution from its products as well as pollution from its overall sales fleet. The vehicles sold in 1998 alone will release almost 95 million tons of carbon dioxide annually—almost twice the emissions from the entire country of Switzerland—and will last between 10 and 15 years. Every year that automakers hold off investing in pollution-control technologies confounds future efforts to reduce smog and slow global warming. Environmental stewardship entails using the best available technologies today and moving aggressively forward to commercialize new and cleaner technologies for tomorrow.

Some companies have voluntarily begun cutting pollution from their vehicles. Ford, Honda, and Subaru are all producing some of the vehicles in their nationwide sales fleets to meet California's low-emission vehicle (LEV) pollution standards ahead of requirements.[6] Our ranking is intended to disentangle the actual environmental benefits of these voluntary actions and to help generate and guide additional, meaningful green actions.

Calculating the Pollution Ranking

Our analysis is based on a combined ranking for both smog-forming and global warming emissions, focusing on emissions created during vehicle use. Pollution from manufacturing and disposing of vehicles is also important, but data on these impacts are neither universally nor uniformly reported (Keoleian et al. 1997).

While some automakers tout particular environmental aspects of their products, such as the high recycled content of their vehicles, rarely do they provide the whole story.[7] Tailpipe pollution alone accounts for the majority of automobile pollution impact. About 89 percent of the criteria air pollution, weighted by health damage, occurs during vehicle usage (DeCicco and

[6] See appendix for a detailed discussion of nationwide and California exhaust emissions regulations.

[7] A notable exception is Volvo's recent environmental declarations for several of its models. It has released diagrams showing relative improvements for various environmental impacts. In addition, Volvo forthrightly indicates where more improvement is needed (for example, in reducing global warming emissions).

Thomas 1999).[8] Nearly 90 percent of the energy use—and essentially the same share of global warming emissions—occurs when a car is driven, while only about 10 percent occurs during manufacturing and disposal (DeLucchi 1991). Including manufacturing, disposal, and other sources of pollution is unlikely to significantly change the automakers rankings.

In addition, data for exhaust pollution are the most complete and detailed information. As more complete data become available, we recommend moving towards a full lifecycle method of estimating pollution. For this study, however, examining each automaker's products in terms of smog-forming and global warming exhaust emissions provides the best measure of the automaker's overall environmental performance.

Fleet Average Smog-Forming Emissions. Nitrogen oxides and hydrocarbons are the two major pollutants from automobiles that contribute to smog, or urban ozone. Today, passenger vehicles meet an array of pollution standards depending on vehicle type (car or one of four classes of light trucks) and where they are certified for sale (California or nationwide). (See appendix for details.) Full-size SUVs and pickups are allowed to emit three times more smog-forming pollution than passenger cars in California and five times more nationwide. New pollution standards requiring SUVs to meet the same emission standards as cars will not be fully phased in for another seven to nine years.[9]

We calculated average tailpipe emissions standards of nitrogen oxides plus hydrocarbons using data on sales and emission standards for individual engine families provided by the Environmental Protection Agency (EPA 1999a; EPA 1999b) and the California Air Resources Board (CARB 1999). These data allowed us to calculate grams-per-mile emissions for the entire fleet as well as for cars and trucks separately.

For reasons discussed above, we ignored smog-forming emissions associated with vehicle manufacturing and disposal. We also did not include two other sources of smog-forming pollution, as follows:

- **Evaporative emissions.** Vehicles emit hydrocarbons through the engine and refueling system, even when they are not in operation. Evaporative emission standards are the same for cars and light trucks regardless of size, so including them would not have greatly changed our relative ranking.[10]
- **Upstream emissions.** These include emissions from extraction, refining, and delivery of gasoline. Including upstream emissions would not change our ranking since they are usually assumed to be proportional to gasoline consumption. Adding upstream emissions would be equivalent to placing greater weighting on fleet average fuel economy but also would not change our overall ranking.

Fleet Average Global Warming Emissions. Carbon dioxide is the major emission from autos associated with global warming.[11] Carbon dioxide emissions are inversely proportional to fuel economy: gas guzzlers create more global warming pollution than fuel-efficient vehicles. These emissions are kept in check by the federal government's Corporate Average Fuel Economy (CAFE) standards, which dictate that each automaker's fleet of new cars must achieve an average of 27.5 miles per gallon. The CAFE standard for light trucks is only 20.7 miles per gallon, allowing the average light truck sold to emit one-third more carbon dioxide than the average car sold.

To determine average CO_2 emissions, we first calculated each manufacturer's CAFE (NHTSA 1999), then converted fuel economy to global warming emissions. Our conversion factor was based on CO_2-equivalent emissions and included upstream emissions because reliable estimates were available (see appendix for details, factor based on Delucchi 1997). Our conversion implies that the average vehicle on the road today emits 8 tons of global warming gases annually.[12]

[8] That is not to say pollution impacts from manufacturing and disposal are not important, especially their impacts on local communities.

[9] California's new emission standards (called the "LEV II" emission program) begin to take effect in 2004, the same year that new nationwide tailpipe standards (called the "Tier 2" tailpipe standards) begin. However, the biggest, most polluting SUVs and light trucks will not be required to meet car standards until 2007 in California and 2009 nationwide. For a detailed explanation of past and future tailpipe standards see the Union of Concerned Scientists' website at *www.ucsusa.org/transportation.*

[10] Light trucks with gas tanks larger than 34 gallons are subject to less stringent standards. We have no way of determining which vehicles have large tanks. However, they are most likely too small a percentage of total truck sales to influence the ranking.

[11] Small emissions of nitrous oxide and methane from vehicles also contribute to global warming. We included them and present the results as carbon dioxide–equivalent emissions.

[12] Based on the average light-duty vehicle achieving 20 miles per gallon and travelling 11,400 miles per year.

Ranking Based on Average Combined Emissions. Our ranking is based on a combined global warming and smog-forming emissions score. In order to combine the two, which differ by orders of magnitude on a gram-per-mile basis, we first standardized the values (see appendix for method). We averaged the results by giving smog-forming and global warming emissions equal weighting, then ranked the results.

Calculating Total Global Warming Emissions. To calculate a manufacturer's total global-warming emissions, we simply multiplied its average vehicle carbon dioxide-equivalent emissions by its total vehicle sales in 1998.

How the Automakers Line Up

Our study reveals a number of things about the comparative pollution performance of the major automakers. The key results are

- Average vehicle pollution differs significantly among automakers.
- Light truck sales significantly degrade the average pollution performance of the three largest manufacturers (DaimlerChrysler, Ford, and General Motors, known as the "Big 3").
- Sales of the most fuel-efficient and lowest smog-forming emitting cars, coupled with low sales of light trucks gave Honda the best average score.
- Over the past decade, almost every automaker's fleet average global warming emissions have risen.
- Actions by the Big 3 have enormous environmental consequences because they account for almost three-quarters of the global warming emissions from automobiles.

Automakers Differ Significantly in Pollution Performance. All automakers are not alike when it comes to the environment (see Figure 1). Isuzu, which sells only light trucks, has the dirtiest average new vehicles. Honda comes out the best—with the lowest combined emissions of smog-forming and global warming gases. But perhaps most significantly from a total pollution standpoint, the top-selling US automakers—Daimler Chrysler, Ford, and General Motors—are *worse than the industry average* for both emissions. As discussed below, these three manufacturers collectively account for 72 percent of domestic vehicle sales, and their products have a major impact on air quality and global warming.

Figure 1

Automaker Pollution Rankings for Average New Vehicle Smog-Forming and Global Warming Emissions

Rank	Pollution Performance	Automaker[a]
1	Worst	Isuzu
2		Daimler Chrysler[b]
3		Ford[c]
4		General Motors
5	Poor	BMW ↖ industry average
6		Mitsubishi
7		Nissan
8		Toyota
9		Volkswagen
10		Subaru
11	Better	Honda

a. Automakers with annual sales greater than 100,000 vehicles.
b. Daimler Chrysler includes Chrysler and Mercedes vehicles.
c. Ford includes Mazda and Volvo.

To provide more insight into the results of our ranking, Tables 1 and 2 detail the results by vehicle category and emission. The tables show that Honda has significantly lower average emissions than any other automaker for both smog-forming and global warming gases. Conversely, Isuzu, DaimlerChrysler, Ford, and General Motors' vehicles are the highest emitters for pollutants.

SUVs and Light Trucks Degrade Big 3 Automakers' Environmental Performance. The main factor driving the inferior pollution performance of the Big 3 automakers (DaimlerChrysler, Ford, and General Motors) is their large sales volumes of highly polluting and fuel-inefficient light trucks. The first two columns of Tables 1 and 2 clearly show the disparity between the pollution performance of cars and light trucks in general. The worst four polluters are severely affected by a high proportion of light truck sales, which account for an average of 65 percent of sales for these automakers compared with an average of 15 percent for the other automakers (see appendix). These four automakers' light trucks also emit more pollution than other

Table 1

Average New Vehicle Smog-Forming Exhaust Emissions[a] (grams per mile)

Automaker	Cars	Trucks	Overall
Isuzu	n/a	0.99	0.99
DaimlerChrysler[b]	0.61	0.99	0.86
Ford[c]	0.61	1.00	0.82
General Motors	0.63	0.99	0.78
Mitsubishi	0.42	0.95	0.70
Nissan	0.60	0.79	0.66
Volkswagen	0.66	n/a	0.66
Toyota	0.55	0.83	0.65
BMW	0.62	n/a	0.62
Subaru	0.59	n/a	0.59
Honda	0.43	0.61	0.45

a. *Sales-weighted average of 50,000-mile exhaust emissions standards of nitrogen oxides plus hydrocarbons, based on model year 1998 vehicles. Evaporative emissions not included.*
b. *DaimlerChrysler includes Chrysler and Mercedes Benz.*
c. *Ford includes Volvo.*

Table 2

Average New Vehicle Global Warming Emissions[a] (grams per mile)

Automaker	Cars	Trucks	Overall
Isuzu	n/a	599	599
DaimlerChrysler[b]	453	624	570
Ford[c]	465	637	558
General Motors	460	607	521
BMW	504	n/a	504
Nissan	422	577	473
Subaru	464	n/a	464
Toyota	420	545	464
Mitsubishi	431	569	456
Volkswagen	446	n/a	446
Honda	402	473	409

a. *CO_2-equivalent emissions of global warming gases from average model year 1998 vehicles. Includes upstream emissions.*
b. *DaimlerChrysler includes Chrysler and Mercedes Benz.*
c. *Ford includes Volvo.*

Source: NHTSA 1999; CO_2 emissions factor based on Delucchi 1997.

manufacturer's trucks. Consequently, the "worst four" retain that status even in a separate evaluation of emissions from light trucks.

Sales of Fuel-Efficient, Low-Emission Vehicles Improve Honda's Ranking. Honda ranks the best for combined pollution performance for a few reasons. First, like many foreign manufacturers, Honda sells a much lower proportion of light trucks than the worst four manufacturers (10 percent of its sales). Second, its cars and light trucks, separately, are the lowest polluting for each vehicle type. In addition, Honda was the first automaker to sell a significant fraction of its vehicles as low-emissions vehicles nationwide. The company certified nearly all of its Accords and many Civics to nationwide LEV standards, making its tailpipes cleaner than was legally required in 1998. Finally, Honda maintained relatively high fuel economy by using more efficient technologies, with its cars reaching 31.8 miles per gallon on average (see appendix for fuel economy results by automaker). These factors secured Honda's place as the lowest overall polluter.

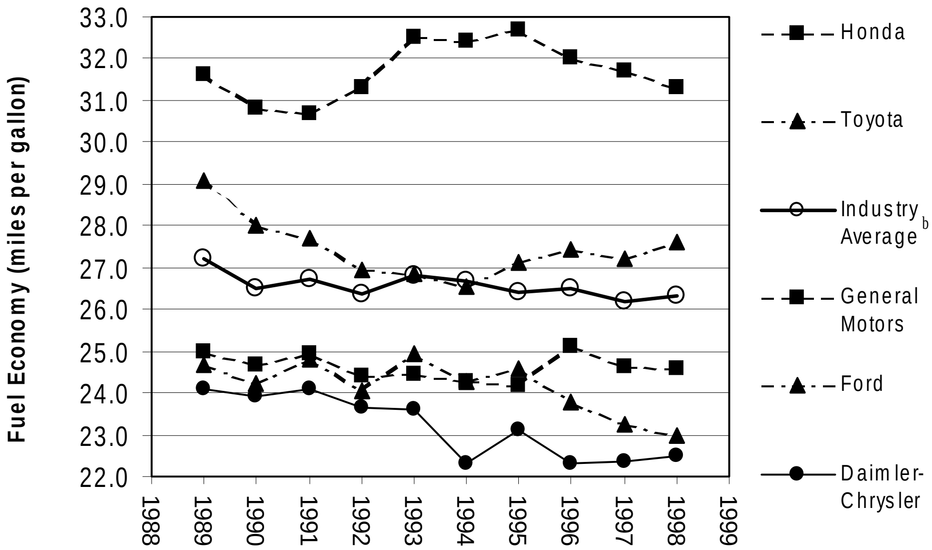
Unfortunately, Honda may be jeopardizing its good environmental standing as it increases the power and weight of its vehicles and seeks to increase its sales of light trucks. In 1998 (the year of our analysis), Honda's Odyssey minivan was classified as a midsize station wagon meeting passenger car tailpipe standards, despite Honda's legal right to classify it as a light truck.[13] But in 1999, Honda upsized the Odyssey, shifting it into a higher-polluting truck category. The switch from a passenger car meeting federal emission standards to a truck meeting California's low-emission vehicle standards left the Odyssey's smog-forming pollution virtually unchanged. However, making the minivan larger and heavier caused a drop in fuel economy which corresponds to about a 10 percent increase in global warming emissions.[14] Honda's overall fuel economy has been declining in recent years (as has that of most other automakers), with the average fuel economy of

[13] Since Honda certified the Odyssey as a truck in 1999, we assume it also could legally have been classified as a truck in 1998.

[14] Based on fuel economy data indicating the Odyssey achieved 23.7 mpg (combined city/highway) for model year 1998 and 21.5 mpg (combined city/highway) for model year 2000.

Figure 2

10-Year Fuel Economy Trend[a] for 5 Largest Automakers



a. Fuel economy is for test values and is not adjusted to reflect in-use degradation.
b. Straight harmonic average of industry CAFE. This is not *the sales-weighted CAFE, which would reflect the US fleet.*

Source: NHTSA 1999.

its vehicles slipping about 4 percent between 1995 and 1998. This trend may continue when Honda introduces a larger and more powerful SUV into its lineup next year.

The Auto Industry Is Backsliding on Global Warming. Our 1998 ranking is a snapshot in time and does not depict historical trends of declining smog-forming but increasing global warming emissions. We could not examine changes in smog-forming emissions for individual automakers due to a lack of reliable data. However, a rough calculation based on overall sales shares of cars and light trucks suggests that over the past decade smog-forming pollution from the new vehicle sales fleet has been roughly halved (Mark 1999).

Since reliable data were available, we could examine ten-year trends in CO_2 emissions by automaker. This reveals that the average new-vehicle fuel economy of almost every major automaker fell during the past ten years (see Figure 2 and Table 3). This corresponds to an increase in average CO_2 emissions for each automaker, but Subaru, Isuzu, Ford, and DaimlerChrysler exhibited the largest *percent* increase in global warming emissions between 1989 and 1998.

In addition to each individual automaker's fuel economy languishing, the US fleet fuel economy has also suffered. Due to a decade of stagnant CAFE standards, both the average car and the average light truck emit as much global warming gases as they did ten years ago. But increased sales of light trucks have resulted in a lower overall average fuel economy, with preliminary data indicating that average US fuel economy in 1999 will reach its lowest value since 1980 (Heavenrich and Hellman 1999). Table 3 indicates that per-mile emissions of CO_2 were more than 4 percent higher for 1998 versus 1989. When adding in the fact that the number of miles driven increases each year, it is easy to see why global warming emissions from automobiles have been on the rise, and why Americans are paying more at the pump.

Even as improved technologies have entered the market over the past two decades, automakers have used them to increase vehicle weight and performance rather than fuel economy. Thus, not only have they failed to take steps that could cut global warming emissions, they have pushed the design of their products in directions that run counter to better environmental protection.

The Big 3 Account for Most Global Warming Emissions. Total carbon dioxide emissions from the Big 3 automakers stand high above all other manufacturers, individually and collectively (see Figure 3). Together, the Big 3 (DaimlerChrysler, Ford, and General Motors) account for almost three-quarters of the global warming emissions from model year 1998 automobiles. This is primarily due to the fact that they sell the most vehicles and less because they have the least fuel-efficient vehicles, but it points to the immense impact their decisions have on the environment.

General Motors sold approximately 4.2 million vehicles in 1998 that averaged 24.6 mpg. These vehicles alone generate 27.6 million tons of CO_2-equivalent emissions each year, placing a larger "carbon burden" on the environment than any other automaker's 1998 vehicles. In fact, the 1998 annual burden generated by the Big 3 automakers is approximately 72 million tons—slightly more than the combined annual CO_2 emissions of the entire state of Michigan's electric utilities. If these three manufacturers had produced light trucks meeting the same mile-per-gallon standards as cars in 1998, the

Table 3

10-Year Change in Fuel Economy and CO_2 Emissions[a]

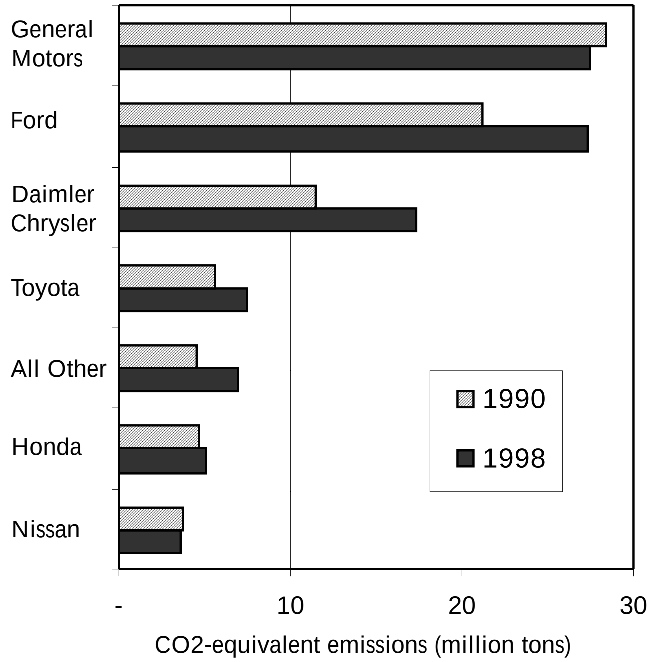
Automaker	Average yearly change in CAFE	Total change in CAFE (mpg)	Increase in new vehicle CO_2 emissions
BMW	1.6%	3.2	-12.6%
DaimlerChrysler	-0.7%	-1.6	7.2%
Ford	-0.8%	-1.7	7.4%
General Motors	-0.2%	-0.4	1.7%
Honda	-0.1%	-0.3	0.9%
Isuzu	-0.8%	-1.8	8.6%
Mitsubishi	-0.2%	-0.5	1.8%
Nissan	-0.5%	-1.4	5.2%
Subaru	-1.5%	-4.2	15.1%
Toyota	-0.6%	-1.5	5.3%
Volkswagen	-0.4%	-1.4	4.7%
Industry Average[b]	-0.36%	-0.9	3.4%
US Fleet[c]	-0.44%	-1.0	4.1%

a. Model years 1989 to 1998.
b. Straight harmonic average of industry CAFE.
c. Sales weighted harmonic average of all manufacturers' CAFE values.

Source: NHTSA 1999 and emissions factor based on Delucchi 1997.

Figure 3.

Annual Global Warming Emissions from New Vehicles, 1990 and 1998



average fuel economy of a new car sold in the United States would have been 13 percent higher, avoiding almost 11 million tons of carbon dioxide emissions every year.

Blueprint for Improving Automakers' Pollution Performance

The pollution disparity among automakers demonstrates that some are doing more for the environment than others. High emissions from SUVs and other light trucks are a major reason for the poor rankings of the worst polluters. But there is no reason for these automakers to lag behind; existing, inexpensive technologies can make trucks as clean and fuel-efficient as cars as well as improve all vehicles. By implementing these technologies in their fleets, automakers could provide immediate benefits for health and the environment. However, automakers clearly need strong incentives to take such steps. Policymakers must provide regulatory guidance and nurture markets for clean and efficient vehicles, and consumers can demonstrate a market value for greener products by making environmental performance a priority when purchasing a new vehicle.

Automakers as Environmental Stewards. Automakers wishing to foster a corporate environmental ethic must start by considering the modest short-term costs of improving their environmental performance as a long-term investment in becoming environmental stewards. They must also embrace a cooperative approach to developing new environmental standards and policies. This especially applies to developing timely increases in fuel economy standards.

But the transformation into true environmental stewards entails making substantial and steady reductions in pollution by lowering the *total* smog-forming and global warming emissions from their new vehicle fleets every year. An important first step would be to commit to making their average light truck as fuel efficient and clean as cars within the next five years or sooner.

Automakers must also step up efforts to use state-of-the-art clean production processes, to design for reuse and materials recycling, and to increase the recycled content of their products. Finally, truly environmentally concerned automakers must move quickly to introduce advanced technologies such as lightweight materials, electric drivetrains, and fuel cells. Zero and near-zero emission vehicles are ultimately needed to minimize the pollution impact of automobiles.

Impact of Voluntary Actions on Pollution Ranking. By taking some of the steps outlined above, automakers can improve in our ranking and distinguish themselves as leaders on environmental action. Companies such as Ford, Honda, and Subaru have already begun this process by voluntarily committing to make all or some of their vehicles meet lower emission tailpipe standards than required.

In Honda's case, its voluntary effort to reduce smog-forming pollutants helped it secure the "lowest polluter" position in our 1998 ranking. Since Ford's low-emission truck program did not start until the 1999 model year, it did not impact our current 1998-based ranking. We evaluate below the impacts Ford's 1999 commitments would have had on its ranking and further examine what efforts it could undertake to improve. We also examine what Toyota, a company that is not as saddled by light truck pollution as Ford, could do to improve its ranking.

Of course, stricter tailpipe standards are set to begin phasing in soon. To stay ahead of the curve on reducing smog-forming pollutants, automakers must move beyond current standards and introduce vehicles that meet even tougher standards, such as the ones EPA announced last year. However, the greatest immediate opportunity for green leadership is to make substantial improvements to vehicle fuel economy, specifically the fuel economy of light trucks.

Options for Ford. Ford's voluntary efforts are an excellent example of an automaker struggling with a highly publicized mandate from its new chairman, William Ford Jr., to be an environmental leader. For Ford (as well as the three other companies that top our "worst polluters" list) leadership requires addressing the pollution liability of its light truck fleet. Ford has taken a commendable first step toward reducing pollution from its trucks, announcing in 1998 that its SUVs, minivans, and pickup trucks would meet LEV standards for light trucks. While low-emission trucks are still dirtier than low-emission cars,[15] a LEV truck does meet a standard about 50 percent cleaner than is required by law. In addition, Ford has recently stated that it will improve the fuel economy of each new vehicle it designs 5 percent over the model it replaces. This corresponds to a 1 to 1.5 mile per gallon improvement for most vehicles, but the entire process will take roughly eight years (DeCicco and Ross 1993).

While Ford's current voluntary commitments are a good first step, they would do little to improve its current ranking. If it had already acted on the above commitments in 1998, Ford would have improved only one position, even if we make the generous assumption that its entire fleet was 5 percent more fuel-efficient in 1999. The overall improvement would be slight because of the poor fuel economy of Ford's light trucks—the lowest in the industry at a meager 20.1 miles per gallon—and its high sales of trucks, which account for 54 percent of Ford's vehicle sales.

For Ford to have made substantial strides, it would have had to raise the fuel economy of its light truck fleet to 27.5 mpg (equivalent to cars) and certify all of its vehicles to low-emission vehicle standards. These actions would have allowed it to reach the second-cleanest position in our ranking.

Options for Toyota. Toyota is currently the fourth cleanest automaker, so becoming an environmental leader is less of a challenge than for Ford. Toyota could have reached the second best position if it had certified its trucks to LEV standards and boosted the fuel economy of its trucks from an average 23.5 mpg to a car-equivalent 27.5 mpg. Based on 1998 figures, Toyota could have overtaken Honda as the lowest polluter if it had certified all of its vehicles to LEV standards and improved its light truck fuel economy.

Light trucks currently account for 36 percent of Toyota's new vehicle sales, with the majority falling into the two least-polluting categories. Nonetheless, the company has shown great interest in selling more higher-polluting full-sized pickup and SUV classes, demonstrated by its introduction of the Tundra and Sequoia full-sized trucks. Higher truck sales will jeopardize Toyota's environmental ranking and make it difficult to improve its pollution performance. If Toyota does sell more trucks, it will be vital for the automaker to both certify its light trucks to low-emission passenger car standards and improve the fuel economy of its light trucks in order to prevent backsliding in our ranking.

Key Roles for Policymakers. Stated commitments to reduce pollution by some automakers is a welcome change. But if history is any lesson, the auto industry as a whole will not embrace meaningful environmental initiatives without government requirements. It is doubtful that all automakers will recognize the urgent need to clean up their products. Furthermore, those that do

[15] "Low-emissions trucks" are allowed to emit up to three times more pollution than "low-emissions cars" under the California or national LEV exhaust emission programs.

recognize the need to act quickly may not take action ahead of the industry (such as investing in cleaner technologies or not pursuing popular market trends) because it could be economically disadvantageous. Strong public policies are necessary to ensure that all automakers keep pace with advances in pollution-control technologies and apply new technologies throughout their vehicle fleet.

Closing CAFE Loopholes and Strengthening the Standards. Raising CAFE standards, specifically through closing the loopholes for trucks, is the single most effective action policymakers can take to decrease global warming emissions from cars and trucks. Policymakers should act immediately and increase the CAFE standards for light trucks to car-equivalent 27.5 mpg within 5 years. Subsequently, policymakers must continue increasing combined car and light truck fleet fuel economy at a rate of 1.5 mpg per year. Improving CAFE standards is critical and effective because those regulations act as the determining factor for inducing fuel efficiency improvements in vehicles nationwide.

Government Research and Development Programs. Government research and development programs play a vital role in spurring the technological advancements that will improve vehicle fuel efficiency. Unfortunately, the government's programs are focused on strategies with limited future potential.

The main venue for research and development of high efficiency, advanced technology vehicles is the government/industry-sponsored Partnership for a New Generation of Vehicles (PNGV). Unfortunately, the PNGV program is focused primarily on improving vehicle efficiency and undervalues the importance of reducing the health risks associated with criteria and toxic pollutants from motor vehicles. The PNGV program should refocus its goals, placing a greater emphasis on simultaneously reducing health-harming emissions while increasing vehicle efficiency. In addition, this program should follow through on its stated goals to introduce high efficiency technologies into the market today and not be used as a reason to stall incremental CAFE increases (or other programs) that would achieve this goal.

Towards a Green Vehicle Market. New technologies promise great opportunities for reducing emissions from the transportation sector. However, a comprehensive strategy for mitigating global warming and smog-forming gases must address market limitations to the widespread use of cleaner, more efficient technologies. Government can provide key support to correct market deficiencies and help consumers make good purchasing decisions. In addition to strengthening CAFE standards and investing more effectively in research and development, government should

- Expand the "gas-guzzler" tax to a federal fee and rebate (feebate) system. This would motivate sales of cleaner and more efficient vehicles in all class sizes.
- Create state or federal incentives programs for clean and efficient vehicles such as tax credits or lower vehicle fees. This would encourage consumers to place a higher emphasis on pollution as an aspect of vehicle quality.
- Create green labeling and other information programs, such as easy-to-understand smog and global warming pollution labeling. This would help consumers quickly identify cleaner and more efficient vehicles in different size classes.
- Sponsor green fleet programs in which government and private purchasers commit to buying the cleanest, most efficient vehicles that meet the fleet's needs. This would create markets and speed the widespread commercialization of advanced technology vehicles.

These price-incentive, information, and market-creation programs support strong standards on the demand side—offering a "pull" for advanced technologies emerging from research and development programs.

The Role of Consumers. Consumers also have a part to play in improving automakers' environmental performance, in two ways.

Consumers are an important part of the democratic process. They can provide key support for raising light truck CAFE standards by telling their representatives that they support tougher pollution policies. The UCS website at *www.ucsusa.org* provides current information on specific actions consumers can take.

Consumers can send a strong, direct signal to automakers that there is a market value for greener vehicles by purchasing the cleanest, most fuel-efficient vehicle that meets their driving needs. The American Council for an Energy Efficient Environment's *Green Book: The Environmental Guide to Cars and Trucks* (DeCicco et al. 2000) rates individual cars and trucks based on their pollution performance. Finally, even consumers who are not currently looking for a new automobile can send a signal to the automakers that they want cleaner options the next time they do purchase a car, by signing onto the clean car pledge sponsored by UCS. This pledge can be accessed online at *www.cleancarpledge.org*.

Summary

Environmental concerns will undoubtedly play a large role in shaping the auto industry in the twenty-first century, and many automakers are already paying more attention to environmental issues. Honda has introduced a hybrid vehicle for sale in the United States this year, and Toyota will soon follow suit. Ford is reducing smog-forming emissions from its trucks by certifying them as low-emission vehicles and also recently announced plans to sell hybrid vehicles. Nonetheless, our study shows that these actions are not enough—most automakers need to do more to be environmental *leaders*, and they all must take additional steps quickly to become environmental stewards. This is particularly true for automakers that sell primarily SUVs, minivans, and pickups or that hope to sell more in the future.

Economic constraints make it difficult for any one automaker to introduce clean and fuel-efficient technologies ahead of the rest of the industry. And although the industry may have difficulty endorsing specific public policies, they are essential to ensure that all automakers invest in cleaner technologies. The process of setting standards will be more constructive if environmentalists, regulators, and automakers can work together to reduce the environmental impacts of driving. Specifically, automakers concerned about the environment should work cooperatively with environmental groups to determine the most effective steps for cleaning up their products.

Every automaker has the potential to become the environmental leader of tomorrow by implementing existing, inexpensive technologies. The question now becomes one of who has the vision to step up to the challenge.

Appendix

Detailed Methods and Results

Automakers Evaluated

For this study, we evaluated automakers with sales greater than 100,000 vehicles nationwide in 1998. When calculating the industry averages, however, we included two additional manufacturers, Hyundai and Kia, which had sales of approximately 90,000 and 72,000 vehicles, respectively. By including these two manufacturers, our analysis captured 99.5 percent of new US vehicle sales for model year 1998.

Our results represent companies based on recent industry consolidation. DaimlerChrysler sales include both Chrysler and Mercedes Benz, and Ford data include Mazda and Volvo. We chose to consolidate the results in order to make it easier to identify independent companies today, even though these automakers had not merged in 1998. The overall results for Chrysler and Ford did not change significantly by including the smaller companies, because those sales were minor compared with the larger company's sales.

Smog-Forming Emissions

Emissions Standards. Cars and light trucks are subject to an array of emission standards based on the vehicle type and where they are certified for sale.

Vehicle Types. Cars are one vehicle type. Minivans, pickups, and sport utility vehicles are all considered "light trucks," a term that actually represents *four* different vehicle types. These four vehicle types are referred to as "LDT1" through "LDT4," and are assigned based on the gross vehicle weight of the truck.[1] In California, the two heaviest types are actually considered "medium-duty" trucks ("MDV2" and "MDV3s"[2]), which roughly correspond to the federal "LDT3" and "LDT4" classifications, respectively.

Exhaust Emissions Programs. Depending on where they are designated for sale, vehicles are certified under a nationwide or California emissions program. Vehicles sold nationwide are subject to the "Tier 1" emission standards. Vehicles sold in California and some northeastern states[3] meet a more stringent set of emissions standards under the low-emission vehicle (LEV) program.

The LEV program includes several emissions categories for each type of vehicle, which vary in stringency. These include transitional low-emissions vehicles (TLEVs), low-emission vehicles (LEVs), ultra low-emission vehicles (ULEVs), super-ultra low-emission vehicles (SULEVs), and zero emission vehicles (ZEVs).[4]

Table 4 lists emission standards at 50,000 miles for nitrogen oxides (NO_x) and hydrocarbons (HC) based on vehicle type and emissions category.

Calculating Automakers' Average Smog-Forming Emissions. Calculating automakers' average smog-forming emission standard required knowing total US sales of vehicles certified to each different emission standard (i.e., each vehicle type and emissions category). Using data from the Environmental Protection Agency and California Air Resources Board we calculated the sales-weighted average emission standards for nitrogen oxides plus hydrocarbons for each automaker.

[1] Gross vehicle weight refers to the maximum weight of the vehicle when it is fully loaded. This value is specified by the manufacturer.

[2] An additional "MDV1" category exists, but no vehicles are certified to this standard.

[3] In 1998, vehicles sold in Maine, Massachusetts, New York, and Vermont also met California's low-emission vehicle program standards.

[4] Our analysis did not indicate any ZEV sales in 1998, because they were such a small fraction of total sales.

Table 4

50,000-Mile Emission Standards for Nitrogen Oxides and Hydrocarbons by Vehicle Type and Emission Category

Vehicle Type	Emission Category	NO_x	HC	Total NO_x +HC[a]
LDV/ PC	TIER 1	0.4	0.25[b]	0.650
	TLEV	0.4	0.125	0.525
	LEV	0.2	0.075	0.275
	ULEV	0.2	0.040	0.240
LDT1	TIER 1	0.4	0.25[b]	0.650
	TLEV	0.4	0.125	0.525
	LEV	0.2	0.075	0.275
	ULEV	0.2	0.040	0.240
LDT2	TIER 1	0.7	0.32[b]	1.020
	TLEV	0.7	0.160	0.860
	LEV	0.4	0.100	0.500
	ULEV	0.4	0.050	0.450
LDT3/ MDV2	TIER 1	0.7	0.32[b]	1.020
	LEV	0.4	0.160	0.560
	ULEV	0.4	0.100	0.500
	SULEV	0.2	0.050	0.250
LDT4/ MDV3	TIER 1	1.1	0.39[b]	1.490
	LEV	0.6	0.195	0.795
	ULEV	0.6	0.117	0.717
	SULEV	0.3	0.059	0.359

a. *These values were used to calculate manufacturers' relative smog-forming pollution.*
b. *Measured as nonmethane hydrocarbons (NMHC). California hydrocarbon standards are measured as nonmethane organic gases (NMOG). We considered the two equivalent for this study.*

Source: EPA 2000.

EPA Data. Two data sets were provided by the EPA. The first lists nationwide (50-state) sales by engine family reported by each automaker for 1998 (EPA 1999a). These are the same data that are used to calculate manufacturer's final Corporate Average Fuel Economy (CAFE) values each year. The second lists vehicle type and emission category by engine family for each automaker (EPA 1999b).

The EPA maintains a database, accessible through its Internet site, called the Certification and Fuel Economy Information System (CFEIS).[5] The CFEIS files contain information about every make and model of vehicle offered for sale in the United Sates, including engine family codes, emissions certification test levels, and emission certification standards, but excluding sales information. Unfortunately, the CFEIS database for model year 1998 was missing information for over half of the engine families reported for sale because of computer problems encountered while the EPA was updating the system. The EPA provided us the second data set upon request because of the gaps in the CFEIS system. In future years, however, interested parties should be able to use the CFEIS system to calculate automaker pollution rankings.

California Data. The California Air Resources Board sets the LEV program exhaust emission standards and monitors manufacturers' compliance independently of the EPA. CARB provided us with production numbers and vehicle type and emission category by engine family for vehicles sold in California (CARB 1999). The engine family codes in the EPA data sets are inclusive of California's.

Manufacturers report production numbers of California-bound vehicles, rather than actual sales, to CARB. These values are assumed sufficiently accurate to calculate manufacturers' hydrocarbon averages under the LEV program, and we assumed them accurate for our purposes. Using production numbers could slightly overestimate manufacturer's LEV-certified vehicles, since fewer—but not more—could be sold in California than were produced as LEVs.

In the second EPA data set, many individual engine families are listed as meeting both federal and California LEV program standards. However, sales were reported by engine family without indicating breakdown by standard. For these vehicles, we assumed that LEV program vehicles were captured by the CARB data and that the remaining vehicles met the federal standards. Thus, we subtracted California sales from the 50-state sales provided by the EPA for each individual engine family and treated them separately when calculating automakers' average emissions standards.

Northeast LEV Programs. Data for vehicles sold under LEV programs in the Northeast (Maine, Massachusetts, New York, and Vermont) were not available, so our rankings are based solely on California's data. However, our data indicated that most automakers had sales of LEVs and TLEVs outside of California, and that those sales are on par with what would be expected for sales in the Northeast based on new vehicle registration data (Ward's 1999; Table 5). Therefore, we assume our analysis sufficiently captured vehicles sold

[5] Available online at *www.epa.gov/OMSWWW/cfeis.htm.*

Table 5

New Vehicle Registrations and Sales for California and Northeast LEV States[a]

	Percent of US Registrations[b]		Percent of US Sales[c]	
Automaker	California	Northeast	California	non-California LEVs[d]
BMW	n/a[e]	n/a	33	--[f]
Chrysler	7	7	11	8
Ford	10	7	11	9
General Motors	8	6	8	7
Honda	17	11	15	44
Isuzu	n/a	n/a	13	--
Mitsubishi	11	9	11	11
Nissan	12	12	20	6
Subaru	n/a	n/a	3	41
Toyota	19	9	18	12
Volkswagen	n/a	n/a	15	--

a. *States that adopted California's LEV program in 1998 were Maine, Massachusetts, New York, and Vermont.*
b. *Source: Ward's 1999.*
c. *Sources: CARB 1999; EPA 1999a; EPA 1999b.*
d. *Low-emission and transitional low-emission vehicles sold nationwide outside of California. We assume these represent Northeast LEVs. Total vehicle sales in Northeast LEV states would actually be higher since some federal Tier 1 vehicles could be sold under the LEV program in 1998, just as California sales do include federal Tier 1 vehicles.*
e. *Registrations for smaller manufacturers not indicated.*
f. *EPA data do not indicate any sales of LEVs outside of California.*

under the Northeast LEV programs for most automakers. We analyzed the potential impacts on the rankings of automakers for which there were no non-California LEV or TLEV sales. We found that Nissan's ranking may change one position but results for all other automakers would likely remain the same.

Our analysis undercredits sales of LEVs and TLEVs for BMW, Isuzu, and Volkswagen, and possibly for Nissan. (The percent of non-California sales of LEVs and TLEVs were about half of the percent of Northeast registrations for Nissan; thus we could be undercounting its Northeast LEV program sales.) We analyzed the potential impacts on our rankings by assuming that Northeast LEV program sales and average emissions were equal to California's. Concerning sales, this assumption would likely overestimate Northeast LEV sales (based on a comparison of California and Northeast registrations). Manufacturers' average emissions would be approximately equal under the all LEV programs unless there are major differences in the mix of vehicles (i.e., cars versus light trucks) sold in California versus the Northeast. However, BMW and Volkswagen sell only cars, Isuzu sells only trucks, and registration data indicated that Nissan's car and light truck sales were about the same in the Northeast and in California.

Under the above assumption, Isuzu and Volkswagen's ranks would be the same. Nissan would move up one position, and BMW would move up two positions. However, under this scenario BMW's California and Northeast LEV sales would account for over 65 percent of its US sales, which seems unrealistically high. A more feasible explanation may be that California represents an unusually large portion of BMW's US sales. If California and Northeast LEV vehicles together accounted for 50 percent of BMW's US sales, its rank would remain the same (fifth out of 11). Therefore, we conclude that omitting Northeast LEV sales might change Nissan's ranking by one position, but most likely would not affect other automakers' positions.

Choice of 50,000-Mile Emission Standards. Based on the vehicle type and emissions category indicated by the CARB and EPA data, we assigned the appropriate 50,000-mile smog-forming emission standards to each engine family (see Table 4 above for standards). We chose 50,000-mile standards as a good estimation of average lifetime emissions for the purpose of ranking the automakers. Two important issues to consider when choosing the appropriate emissions factor are (1) certification test values versus in-use emissions and (2) the behavior of the gap between in-use emissions and certification standards.

Considerable evidence and modeling indicates that modern vehicles emit two to three times more HC and NO_x than the emission standards because of malfunctioning, degradation, and off-cycle emissions (Hwang 1997; Ross et al. 1995). This gap between in-use emissions and standards may be dropping as emissions-control systems become more durable and as the Supplemental Federal Test Procedure is introduced to capture offcycle driving events. On the other hand, the few vehicles of each make and model subject to emissions testing emit substantially less than the emission standard.[6] Manufacturers design vehicles with this "headroom" to account for variability in in-use

[6] Only a few of each vehicle make and model are subject to emissions certification testing. The results are entered into the CFEIS database.

emissions among mass-produced vehicles. Given these countervailing factors—(a) the tendency for vehicles to emit more than the standard under real-world driving conditions and (b) the low test values relative to the standard—we feel that certification standards are the most accurate means for comparing relative smog-forming emissions from manufacturers' vehicles.

The second issue we considered was the *behavior* of the gap between in-use emissions and standards. It is unclear whether the gap is constant for all types of vehicles or if it varies by vehicle type or emissions category (for example, the ratio of in-use emissions to the standards is higher for vehicles subject to more stringent standards). In the first case, our ranking would not be affected, since it essentially adds a constant factor to every automaker's smog-forming emissions standards. The second case could affect our results if the magnitude of the differences among emissions types became so small as to render the different vehicle classifications useless. However, we believe that LEV vehicles do in fact emit significantly less pollution than TLEVs, TLEVs less than Tier 1s, etc. Thus, we are confident that emissions standards are the most accurate means for determining automakers' relative pollution.

Equation for Emissions Calculation. After assigning the correct emissions factors based on EPA and CARB data, we calculated the average smog-forming emissions standard as shown in Equation 1. The results of our calculations are presented in Table 1 in the body of the report. Table 6 lists detailed sales by each automaker and vehicle type.

Equation 1

Calculation of Average Smog-Forming Emissions Standard

Where i = any engine family for each manufacturer, 1 through n,

the average smog-forming emission standard (smog) for each automaker is:

$$\text{Smog (g/mi)} = \frac{\sum_{i=1-n} \left[\text{CA Sales}_i \times \text{CA Smog Factor}_i + \text{49-State Sales}_i \times \text{49-State Smog Factor}_i \right]}{\sum_{i=1-n} \text{50-State Sales}_i}$$

Table 6

Automakers' Sales by Vehicle Type

Automaker	Vehicle Type[a]	Percent of Sales
BMW	PC	100.0
DaimlerChrysler	PC	33.8
	LDT1	3.6
	LDT2	43.9
	LDT3	14.1
	LDT4	4.6
Ford	PC	46.1
	LDT1	8.9
	LDT2	31.8
	LDT3	3.5
	LDT4	9.7
General Motors	PC	59.4
	LDT1	6.3
	LDT2	17.5
	LDT3	13.4
	LDT4	3.4
Honda	PC	90.3
	LDT1	9.7
Isuzu	LDT1	4.8
	LDT2	95.2
Mitsubishi	PC	73.7
	LDT2	26.3
Nissan	PC	67.7
	LDT1	11.0
	LDT2	21.2
Subaru	PC	100.0
Toyota	PC	64.5
	LDT1	15.9
	LDT2	18.4
	LDT4	1.2
Volkswagen	PC	100.0

a. California MDV2 vehicles are included as LDT3s. California MDV3 vehicles are included as LDT4s.

Sources: CARB 1999; EPA 1999a; EPA 1999b.

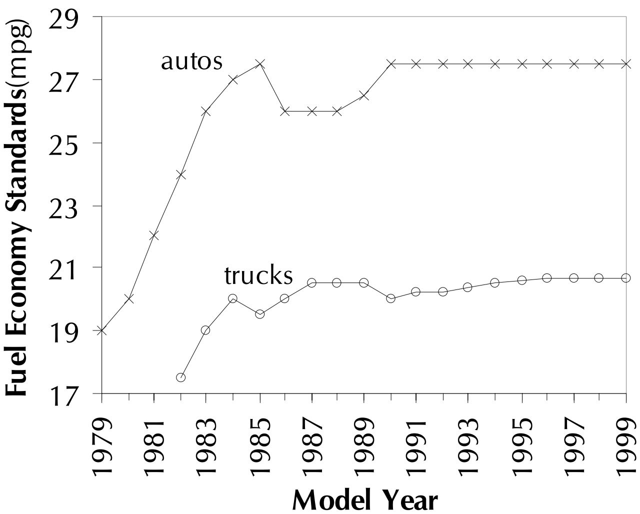
Global Warming Emissions

Carbon dioxide is the main global warming gas emitted by cars and trucks. Carbon dioxide emissions are inversely proportional to fuel economy—automobiles with low miles per gallon emit more CO_2.

CAFE Standards. As with smog-forming emissions, the Corporate Average Fuel Economy (CAFE) standards treat cars and light trucks differently. Under CAFE standards, the mix of cars a manufacturer sells must meet an average of 27.5 miles per gallon on average, while that standard is only 20.7 miles per gallon on average for trucks. This light truck loophole has been in place since the inception of the CAFE standards (see Figure 4).

Figure 4

The Gap in Fuel Economy Standards for Cars and Light Trucks



Source: NHTSA 1999.

Calculating Automakers' Average CO_2-Equivalent Emissions. Calculating average CO_2-equivalent emissions required knowing each automaker's CAFE for 1998. We turned to the "Summary of Fuel Economy Performance," a biannual report of the National Highway and Traffic Safety Administration (NHTSA 1999). This report lists CAFE and total sales for each manufacturer's domestic cars, import cars, and light trucks. We calculated total fleet CAFE using a harmonic average, as shown in Equation 2.[7]

Our CAFE results were not adjusted to reflect real-world emissions. Adjusting the CAFE values would increase the values listed in Table 2 but would not significantly change our rankings. In fact, the spread might increase between the worst polluters and the rest, because there is some evidence that light trucks have worse in-use fuel economy than cars, compared with the EPA test cycles (Mintz et al. 1993). Table 7 lists CAFE by automaker for cars, trucks, and the overall fleet. These values were converted into CO_2-equivalent emissions as described below.

The CAFE values for 1998 listed in the 1999 report did not all reflect the most recent data. We assumed, however, that the CAFE values and NHTSA total sales (and hence the percentage of light trucks) were correct for the purposes of calculating the total average fuel economy by manufacturer. For all but one

Equation 2.

Calculation of CAFE for Each Automaker

Where

- V = sales volume
- DC = domestic cars
- IC = import cars
- LT = light trucks
- TOT = total

$$\text{Fleet CAFE} = \left[\frac{(V_{DC}/V_{TOT})}{CAFE_{DC}} + \frac{(V_{IC}/V_{TOT})}{CAFE_{IC}} + \frac{(V_{LT}/V_{TOT})}{CAFE_{LT}} \right]^{-1}$$

Table 7

Average Vehicle Fuel Economy by Automaker (miles per gallon)

Automaker	Car CAFE	Truck CAFE	Fleet CAFE
Isuzu	n/a	21.4	21.4
DaimlerChrysler	28.3	20.5	22.5
Ford	27.6	20.1	23.0
General Motors	27.8	21.1	24.6
BMW	25.4	n/a	25.4
Nissan	30.4	22.2	27.1
Subaru	27.6	n/a	27.6
Toyota	30.5	23.5	27.6
Mitsubishi	29.7	22.5	28.1
Volkswagen	28.7	n/a	28.7
Honda	31.8	27.1	31.3
Industry Average[a]	29.1	22.4	26.3
US Fleet[b]	28.5	20.9	24.6

a. *Harmonic average of CAFE values for largest 13 manufacturers.*

b. *Sales-weighted (harmonic) average of all vehicles sold in the United States.*

Source: NHTSA 1999.

[7] For consolidated manufacturers, we computed the sales-weighted harmonic CAFE based on all relevant vehicles.

manufacturer, the percent sales of light trucks differed by less than 1 percent from the EPA sales data. Mitsubishi was the only manufacturer for which the two data sets were significantly different: the EPA data indicate that Mitsubishi's light trucks accounted for 26 percent of sales, while that figure was only 18 percent in the NHTSA data. However, this difference was insignificant to the overall results.

Converting Fuel Economy to Carbon Dioxide Emissions. While CO_2 is the major global warming gas emitted by autos, other global warming gases are released during the combustion, refining, and distribution of gasoline. Nitrous oxides are the second largest emission (in CO_2-equivalents), but carbon monoxide, hydrocarbons, methane, and nitrogen oxides also contribute to global warming. Our analysis considers the full fuel-cycle emissions of global warming pollution adjusted as CO_2-equivalent emissions.

The CO_2 directly released by burning gasoline amounts to 8.0 kg per gallon, but the global warming impacts of associated combustion products raises the effect to 10.5 kg of CO_2-equivalent emissions. Upstream emissions associated with refining and distributing gasoline create an additional 2.31 kilograms of CO_2-equivalent gases. This amounts to a total of 12.81 kilograms of global warming gases per gallon of fuel used (based on Delucchi 1997). Dividing our CO_2-equivalent emissions factor by each manufacturer's CAFE yielded grams-per-mile emissions of global warming pollution.

Total Global Warming Emissions by Automaker. Total global warming pollution by automaker was determined by multiplying CO_2-equivalent emissions by total vehicle sales and the average number of miles traveled each year. We assumed that an average vehicle travels 11,400 miles annually (Davis, 1998).

Combined Rankings

Our final rankings are based on a combined score for both smog-forming and global warming emissions. Average grams-per-mile global warming emissions are roughly 500 to 1000 times those of smog-forming emissions. Thus, we needed to standardize the values in order to rank automakers based on a combined score for both pollutants. We assumed each set of emissions fit a bell curve, much like class grades. We chose this method rather than normalizing each emission to a "baseline" value (such as the best in the industry, the best vehicle offered for sale that year, or even lower emissions from advanced technology vehicles), because we wished to objectively compare automakers environmental performance relative to each other. For this analysis, our purpose was not to measure how automakers are faring relative to longer-term goals for reducing vehicle pollution.

Standardizing the Emissions Values. To standardize our values, we first calculated the industry average and standard deviation for the two sets of emissions (smog-forming and global warming) separately. We then assigned each grams-per-mile emission its standard-normal equivalent, based on the industry mean and standard deviation (Equation 3). This yielded two independent, unitless standard-normal distributions, each with a mean of zero and standard deviation of one. We then averaged the two standardized values, yielding a third normal distribution with a mean of zero and a standard deviation of one. We ranked these results from highest to lowest (most to least polluting).

Equation 3

Standardization of Smog-Forming and Carbon Dioxide Emissions

Where

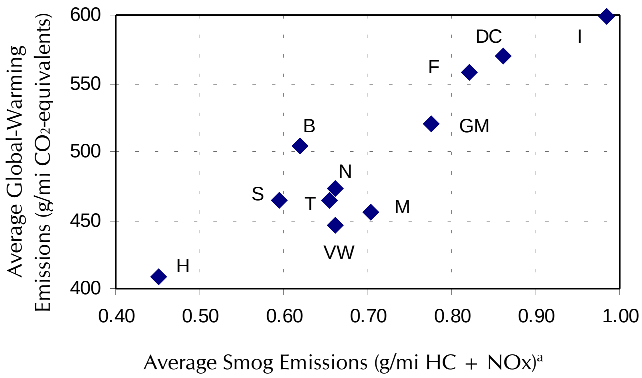
- x = each automaker's smog (or global warming) emissions
- i = each automaker, 1 through 13
- $\bar{x}$ = average (mean) of smog (or global warming) emissions
- s = standard deviation of all smog (or global warming) emissions
- Z = the standard normal distribution, with mean = 0 and standard deviation = 1
- z_i = resulting standard normal variable for each smog (or global warming) emission

For $Z \sim [0,1]$: $$z_i = \frac{(x_i - \bar{x})}{s}$$

Raw Versus Standardized Results. The raw results of our analysis are shown in Figure 5. Average smog-forming emissions are plotted against the CO_2-equivalent emissions by manufacturer. Figure 6 shows the same plot for the standardized values. In both figures, the abbreviations represent each automaker and the numbers indicate their position in our ranking (1 = worst polluter). A comparison of the two figures shows that we did not introduce bias by applying the standard-normal distributions.

Figure 5

Raw Results of Automaker Ranking Analysis

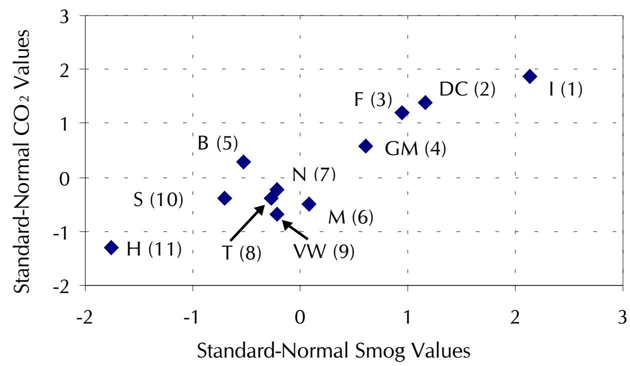


a. Average of 50,000-mile emission standards

b. I = Isuzu, DC = DaimlerChrysler, F = Ford, GM = General Motors, B = BMW, N = Nissan, M = Mitsubishi, T = Toyota, S = Subaru, VW = Volkswagen, H = Honda

Figure 6

Standardized Results of Automaker Ranking Analysis



a. I = Isuzu, DC = DaimlerChrysler, F = Ford, GM = General Motors, B = BMW, N = Nissan, M = Mitsubishi, T = Toyota, S = Subaru, VW = Volkswagen, H = Honda.

b. Numbers indicate position in ranking.

c. The location of the industry mean is at (0,0) on the plot. One unit on each axis represents one standard-deviation for the group data.

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