Executive Summary

To reduce transportation-related emissions—responsible for nearly 40 percent of the United States' total global warming pollution—we need more efficient vehicles, fewer miles driven, and lower-carbon fuels (i.e., fuels that generate significantly less heat-trapping gases per unit of energy delivered than today's petroleum-based gasoline and diesel). Hydrogen, electricity, and biofuels (fuels produced from plants) all have the potential—if produced in a sustainable manner—to not only reduce transportation-related emissions but also promote economic and energy security by curbing our country's growing oil dependence.

Biofuels can quickly become a staple of a low-carbon fuel diet because they integrate well with our existing fuel distribution infrastructure and offer potentially abundant domestic supplies with significant opportunities for growth. But not all biofuels are the same. There is a wide range in the estimated heat-trapping emissions and other environmental impacts from each biofuel over its life cycle (i.e., from farm to finished fuel to use in the vehicle), depending on the feedstock, production process, and model inputs and assumptions. There are also concerns about emissions and impacts from land conversion and land use associated with biofuel production.

New rules are being developed that will require fuel providers to account for and reduce the heat-trapping emissions associated with the production and use of transportation fuels. For example, both the U.S. Congress and Environmental Protection Agency (EPA) are considering strategies to promote low-carbon and renewable transportation fuels (including biofuels). California, the nation's largest market for transportation fuel, is developing a Low Carbon Fuel Standard that will require fuel providers to demonstrate reductions in global warming pollution per unit of energy delivered, regardless of fuel source. More state, regional, and federal rules will undoubtedly follow.

The purposes of this report are two-fold:

1. To ensure that we "count carbs" accurately, by explaining why we need a comprehensive accounting system for carbon emissions—one that measures global warming emissions over a transportation fuel's entire life cycle. An effective accounting system will not only need to be robust enough to encompass the fuel life cycle, but also address uncertainties and allow for changes over time as better assessment tools and methods become available.

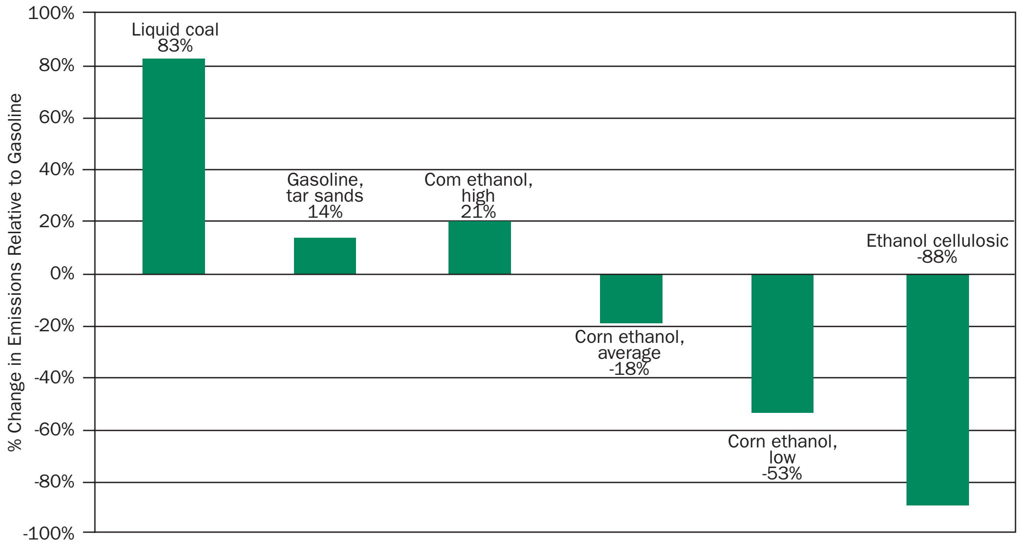
2. To "make carbs count" by describing performance-based policies that will reward low-carbon transportation fuels for their performance and help them compete against highly polluting fuels such as liquid coal (gasoline or diesel made from coal). For example, low-carbon fuel standards require a reduction in the average amount of global warming pollution per gallon of fuel.

A market for low-carbon fuels can produce a rare convergence of business, agricultural, and environmental interests that, if pursued wisely, could represent a "win-win-win" opportunity. But the promise of a lower-carbon transportation future can only be realized through federal and state policies that "count carbs and make carbs count."

COUNTING CARBS

To fully assess the global warming impact of transportation fuels, we must measure their full life cycle emissions per unit of energy delivered. This poses an analytical challenge for a number of reasons. For

FIGURE ES-1 **Life Cycle Global Warming Pollution Relative to Gasoline**



NOTE: These values do not include all potential sources of global warming pollution, particularly the effect of direct or indirect land use changes. Actual global warming emissions may be higher than these estimates.

SOURCES: Gasoline estimate is from Wang (2006). Liquid coal estimate is from Williams (2005). Gasoline from tar sands estimate is from Moorhouse (2006). High corn ethanol estimate is based on ethanol used in California but produced in a Midwest coal-fired dry mill (Unnasch et al. 2007). Current industry average for corn ethanol is from Farrell et al. (2006a). Low corn ethanol estimate is based on ethanol produced in a biomass-fired wet mill (Turner et al. 2007). Cellulosic ethanol estimate is based on switchgrass (Farrell et al. 2006a).

example, plants capture carbon dioxide (CO_2, a potent heat-trapping gas) from the atmosphere during photosynthesis, but the impact of this carbon capture on biofuel emissions varies by feedstock. The global warming pollution produced by farming varies depending on the farming equipment, fertilizers, tillage practices, and perhaps most important, whether forests and grassland are converted into cropland. Even the refining process used to convert biomass into biofuels produces varying amounts of heat-trapping emissions.

Figure ES-1 illustrates how emissions may vary depending on the feedstock and refining process. Liquid coal, for example, can increase emissions more than 80 percent compared with gasoline. Gasoline produced from tar sands can increase emissions about 14 percent. Corn ethanol, depending on how it is processed, can produce higher emissions than gasoline or cut emissions more than 50 percent. Cellulosic ethanol, which is made from woody plants, may be able to reduce emissions more than 85 percent.

Life cycle analysis tools such as the U.S. Department of Energy's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model (Wang 2006) have been critical in building understanding of the full impact of transportation fuels. But there is currently no scientific consensus on a single analytical approach, particularly for biofuels. Key areas of debate include the impact of land use changes, fertilizer use and emissions, coproducts, process emissions, and uncertainties or poor data (Farrell and Sperling 2007a).

While life cycle models typically estimate that today's average corn ethanol cuts global warming pollution about 20 percent compared with gasoline, some researchers estimate that it may actually ***increase*** global warming pollution (Patzek 2007). Similarly, biodiesel is generally credited with a 50 percent reduction in global warming pollution (Hill et al. 2006), but there is also research indicating that it may increase emissions as well (Delucchi, unpublished, in Farrell and Sperling 2007a). In addition, biofuel production could exacerbate deforestation, generating more global warming pollution and a host of concerns about the industry's sustainability.

The key to improving our understanding and quantification of life cycle emissions is to hold transportation fuel providers responsible for their global warming pollution. Our current system provides no incentive for fuel providers to accurately measure or minimize their carbon emissions. In contrast, a system that requires providers to account for their emissions would spur increased research into life cycle analysis and provide a public process for evaluating the benefits and limitations of different analytical methods. By developing emissions standards that are periodically updated using the best data available, the market can steer fuel production toward lower-carbon pathways.

MAKING CARBS COUNT

Without a framework in place to lower the carbon intensity of our transportation fuels, we risk losing a precious opportunity to cut our global warming pollution substantially. We therefore need smart fuel policies such as California's Low Carbon Fuel Standard, which is slated to take effect as early as 2010. This standard does not "pick winners" by focusing on specific fuels, but instead relies on performance criteria that require each gallon of fuel (on an energy-equivalent basis) to meet a standard for global warming pollution that becomes more strict over time. The standard encompasses the fuel's entire life cycle, promoting carbon reduction along every link in the fuel supply chain.

Low-carbon fuel standards would also create market certainty for cleaner fuels and complement existing vehicle standards by ensuring the fuel industry does its part—along with automakers and consumers—to reduce transportation-related emissions. Other states considering such regulations include Arizona, Minnesota, New Mexico, Oregon, and Washington.

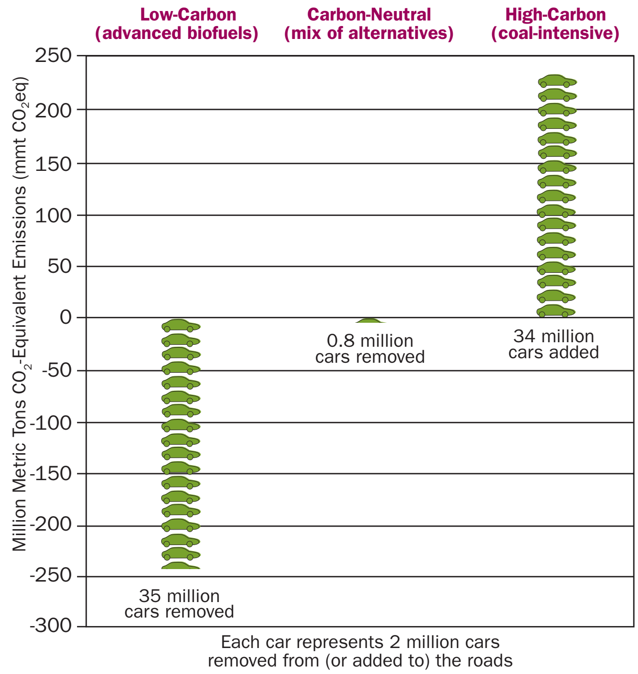
At the national level, efforts are under way to incorporate heat-trapping emissions requirements into the current Renewable Fuel Standard, and several bills have been introduced in Congress that would establish a separate low-carbon fuel standard. The Bush administration is also preparing rules for reducing gasoline use that would include a low-carbon fuel component.

THE BENEFITS OF A LOW-CARBON DIET

The stakes are extremely high when it comes to determining the mix of transportation fuels we will use to reduce our heat-trapping emissions. This becomes clear when comparing three scenarios designed by the Union of Concerned Scientists to displace 37 billion gallons of gasoline (Figure ES-2).

We evaluated each fuel's life cycle emissions and included all heat-trapping gases on a CO_2-equivalent (CO_2eq) basis (i.e., the amount of CO_2 that would have the same global warming potential as another gas). For the purposes of this analysis, we made the following assumptions: compared with today's gasoline, conventional biofuels would reduce global

FIGURE ES-2 **Global Warming Pollution from Three Alternative Fuel Scenarios**



NOTES: Each scenario assumes that 37 billion gallons of gasoline are displaced by alternative fuels and that conventional biofuels meet 25 percent of the demand for alternative fuels. In the low-carbon scenario, advanced biofuels meet the remaining 75 percent of demand. In the carbon-neutral scenario, the remaining demand is split equally between low- and high-carbon fuels. In the high-carbon scenario, liquid coal meets the remaining 75 percent. We assumed conventional biofuels reduce global warming pollution by 20% relative to gasoline, advanced biofuels reduce global warming pollution by 70%, and high-carbon liquid coal increases global warming pollution by 80%.

warming pollution by 20 percent; advanced low-carbon biofuels would reduce emissions by 70 percent; and high-carbon liquid coal would increase emissions by 80 percent.

Our scenarios also assume that one-quarter of the total demand for alternative fuels will be met with conventional biofuels, while the share provided by liquid coal and advanced biofuels varies. This produced the following key findings (Figure ES-2):

- In the high-carbon scenario (in which liquid coal meets 75 percent of the demand for alternative fuels), global warming pollution would *increase* by 233 million metric tons (mmt) CO_2eq—the same impact as adding approximately 34 million cars to the road (about two year's worth of new vehicle sales at today's rate).

- In the carbon-neutral scenario (in which liquid coal and advanced biofuels each meet 37.5 percent of the demand for alternative fuels), emissions are reduced by just 5 mmt CO_2eq—the same impact as removing 0.8 million cars from the road.

- The low-carbon scenario (in which liquid coal does not gain a foothold and advanced biofuels meet three-quarters of the demand for alternative fuels) will only be possible if policies that require a reduction in global warming pollution from transportation fuels are put in place. In this scenario, global warming pollution would be reduced by more than 244 mmt CO_2eq—the same impact as removing approximately 35 million cars from the road.

Focusing on low-carbon fuels may be good not only for public health and the environment, but also for business. Demand for lower-carbon fuels can create new opportunities for the agriculture and forestry sectors (which can provide a diverse array of energy crops) and for renewable fuel producers (who can lead the transition to cleaner resources and away from high-carbon alternatives such as liquid fuels from tar sands, oil shale, and coal). The domestic economy should also benefit from expanded consumer choice and new job opportunities for scientists, engineers, construction workers, and the many others who would help develop and deploy low-carbon fuel technologies throughout the United States.

THE OTHER KEYS TO A LOW-CARBON DIET

A system that only accounts for carbon emissions is not enough to ensure sustainable fuel production due to the fact that petroleum and alternative fuels can both do serious harm to the environment. Locating and extracting oil, for example, can disrupt and contaminate underground aquifers and cause land subsidence and damage to wildlife and ecosystems. As oil becomes more expensive, the pressure to drill in sensitive areas such as Alaska's Arctic National Wildlife Refuge intensifies. Liquid coal production would expand the especially destructive practice of mountaintop removal mining. And if done wrong, biomass production could destroy habitats, worsen water or air quality, raise food prices, and even jeopardize the long-term viability of the biomass resource itself.

A low-carbon fuel standard that accounts for all of the global warming pollution produced over a fuel's entire life cycle would help prevent some—but not all—of these harmful impacts. For example, a full accounting of the global warming pollution generated when virgin lands are converted into coal mines or agricultural lands would help advance broader objectives such as biodiversity and the preservation of open space. Accounting for heat-trapping nitrous oxide emissions from the fertilizers used to grow biofuel feedstocks would encourage reduced fertilizer use, which in turn would help protect water and air quality. Nevertheless, standards designed to reduce a fuel's global warming pollution will not address all of the fuel's potentially harmful impacts—especially social issues such as food access and pricing.

The most comprehensive low-carbon fuel policies will therefore provide adequate safeguards for ensuring that fuels are produced in a sustainable manner. While there is no international consensus on a single accounting system that would certify biofuel production as "sustainable," efforts are under way (both in Europe and the United States) to develop consistent metrics. Marrying a low-carbon fuel standard with environmental protections will give us a head start on the road to cleaner and more sustainable transportation fuels.