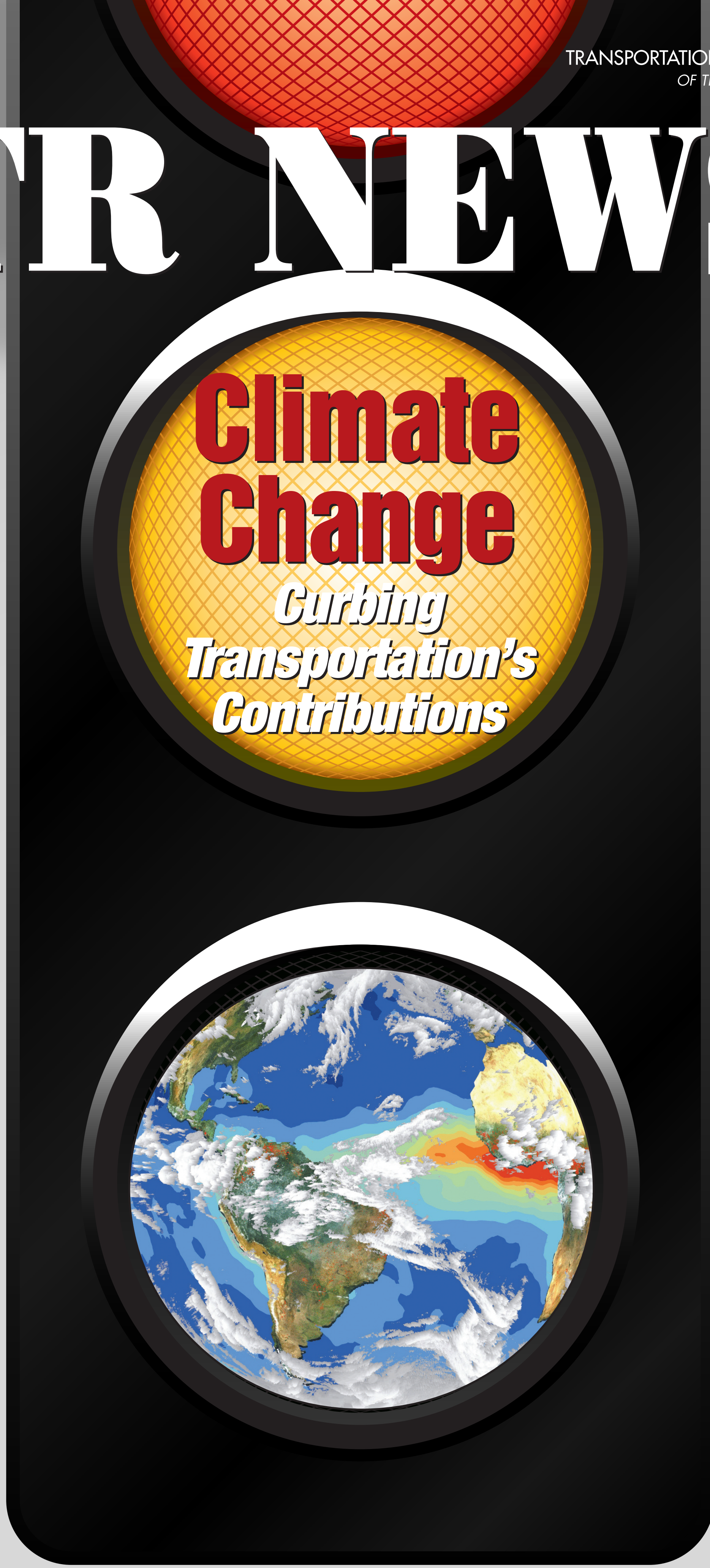
MAY–JUNE 2010
NUMBER 268

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TR NEWS



Climate Change

Curbing Transportation's Contributions

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

National Academy of Sciences
National Academy of Engineering
Institute of Medicine
National Research Council

The **Transportation Research Board** is one of six major divisions of the National Research Council, which serves as an independent adviser to the federal government and others on scientific and technical questions of national importance, and which is jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities.

www.TRB.org

Policies to Promote Low-Carbon Transportation Fuels

What Works?

DANIEL SPERLING

The author, a member of the TRB Executive Committee, is Founding Director, Institute of Transportation Studies, and Professor of Engineering and Environmental Science and Policy, University of California, Davis.

Three basic approaches are available to reduce transportation's greenhouse gas (GHG) emissions from petroleum-based fuels:

- Improve vehicle and engine efficiency;
- Reduce the amount of vehicle or engine use—that is, the vehicle miles traveled; and
- Reduce the carbon content of the energy used for transportation.

The three options are interrelated, but the focus here is on reducing the carbon content of fuels and on the policies that are needed.

In the United States, two newly implemented programs are promoting the replacement of petroleum-based fuels with biomass-based and other alternative fuels that tend to yield lower GHG emissions. California has adopted a low-carbon fuel standard, which requires a reduction in GHG emissions from transportation fuels by gradually introducing lower-carbon fuels, including biofuels, electricity, natural gas, and hydrogen. The U.S. Environmental Protection Agency (EPA) has established the more limited renewable fuel standard (RFS), which requires replacing petroleum-based fuel with biofuels made from renewable materials.

The Energy Independence and Security Act of 2007 increased the RFS fuel requirements and set GHG performance thresholds—the first time that GHG emissions performance has been applied in a regulatory context for a nationwide program. Both the California and EPA programs apply mainly to cars and trucks.

PHOTO: NREL

California's low-carbon fuel standard calls for the gradual introduction of lower-carbon fuels, such as fuel made from biomass such as algae.

Fundamentals of Effective Programs

Policies and programs that aim to motivate industry to pursue innovations are more likely to be successful if they are flexible, performance-based, and inclusive. Federal fuel economy standards for cars and light trucks, for example, allow industry to determine the best way to achieve the targets, which stimulates innovation. Experiences with fuel economy standards and other programs suggest several principles for policies that promote low-carbon transportation fuels.

PHOTO: NREL

All emissions associated with the production of a biofuel should be counted in determining its greenhouse gas output—the energy expended in acquiring, growing, harvesting, and processing the material.

Don't try to pick winners.
Programs are more successful if they focus on the goal and not on the specific means to achieve it. If the goal is to lower GHG emissions from fuels, then setting GHG performance standards for transportation fuels motivates companies to find the best approach. Although mandating the use of specific fuels such as natural gas or ethanol may reduce GHG emissions, the market generally will achieve that goal at lower cost if allowed the flexibility to choose from the mix of possible fuels. The market can adapt quickly to changes in technology, allowing the introduction of new fuel pathways with greater emissions reduction or lower cost or both.

Photo: NREL

The use of feedstock like corn for ethanol production affects the agriculture market and food prices. The promotion of low-emissions fuels must take these and other related consequences into account.

A hand-operated petroleum fuel pump in Leo, Burkina Faso. Reduced consumption in the United States may reduce prices worldwide, leading to greater consumption overseas.

Assess the full GHG life cycle.
To reduce GHG emissions, all emissions associated with the production, distribution, and use of the fuel must be considered. This well-to-wheel or source-to-wheel life-cycle assessment would include all direct emissions, such as those associated with acquiring, growing, and harvesting the feedstock for biofuels; transporting the feedstock to the fuel processing facility; turning the feedstock into an acceptable fuel; delivering the fuel to the point of retail sale; and burning the fuel.

The life-cycle analyses also should consider the indirect impacts, which can be large. For biomass-based fuels, for example, indirect emissions are associated with diverting land from food and other uses to energy production; in the case of corn ethanol, additional land is drawn into production to replace the corn diverted to energy use. These effects are controversial, because they never have been included in policies or regulations, and because the underlying science is still evolving.

The indirect land use effects can be large for food-based feedstocks, which are land-intensive, but small for cellulosic materials, and zero for waste materials. California's low-carbon fuel standard and EPA's RFS regulation both take indirect land use changes into account.

Be aware of positive and negative side effects.
Policies and programs promoting fuels with lower GHG emissions may have other consequences, beneficial or harmful. For example, how are food prices affected by the diversion of food and animal feed, such as corn and soybeans, to biofuel production?

Photo: Stefan Dressler

How much does greater reliance on biofuels from feedstock grown in the United States reduce expenditures on imported oil and increase farm incomes and jobs? Some so-called side effects—for example, the energy security benefits of reducing dependence on petroleum—may be chief reasons for implementing the policies.

Don't be naïve about real-world responses.
Responses may occur outside the jurisdiction of the entity that establishes a low-carbon fuel program. One response, termed "leakage," occurs when fuel suppliers shift their fuels to avoid compliance with the low-carbon fuel standards in California or the federal biofuel mandate. For instance, a high-carbon source of transportation fuel, made from oil sands or liquefied coal, can be shipped to states or countries with no regulations to reduce the carbon content of fuels. Because GHG buildup is a global problem, the benefits of reduction will be lost if the leakage response becomes rampant. The leakage problem would diminish as more states and nations adopt low-carbon fuel policies.

Because reduced consumption in California or the United States may reduce world oil prices, another response could be increased consumption of gasoline and diesel fuels in places without low-carbon fuel policies and biofuel mandates. This "rebound" effect may be small, but nonetheless could offset some of the GHG emissions reductions that the program achieves.

Recognize infrastructure and economic barriers.
Infrastructure can be slow to change and thus act as a barrier to the widespread introduction of new fuels. For example, ethanol is now used as a blend stock with gasoline. With ethanol use increasing, gasoline in the United States is likely to reach the 10 percent blending limit for vehicles by 2015.

Two options could expand the use of ethanol. One is to increase the blending limit—but manufacturers of cars and light trucks and of off-road equipment, such as lawnmowers, oppose this, because of concerns about damage to the engines. The second option is to expand the use of flexible-fueled vehicles, which can use ethanol in concentrations of up to 85 percent in gasoline (E85). Yet the number of filling stations now offering E85 is limited; the cost of adding a pump and storage tank for E85 can run $100,000 and more.

EPA estimates that the number of E85 retail facilities may need to expand from approximately 2,000 to between 12,000 and 24,000 nationwide by 2022, if most of the required 36 billion gallons of biofuel are sold as ethanol, and the blend limit is not raised.

PHOTO: WIKIMEDIA COMMONS

A gas station along the Tarim Desert Highway in China. As more nations adopt low-carbon fuel policies, the problem of fuel suppliers turning to markets with lower emissions standards will decrease.

The number of flexible-fueled vehicles on the road capable of using E85 also would need to expand dramatically.

Performance Standard or Mandate?

Both the California low-carbon fuel standard and EPA's RFS regulation are designed to accelerate the use of lower-carbon fuels, but the two programs pursue the goal in different ways.

California's regulations require a gradual reduction in the carbon intensity of the fuel marketed in the state. The regulations lower the average GHG emissions per unit of energy consumed, by establishing a GHG life-cycle emission performance for transportation fuels—not only for biofuels but for alternatives such as natural gas. Fuel suppliers can market any mix of fuel types, as long as the mix meets the GHG performance standard set by California.

In comparison, the national RFS program requires that certain volumes of certain types of biofuels meet specific GHG performance thresholds. The program mandates increased volumes of cellulosic biofuel; of the 36 billion gallons required in 2022, 16 billion gallons must be produced from cellulosic feedstock. The cellulosic fuels, moreover, must reduce GHG emissions by at least 60 percent compared with gasoline or diesel.

The RFS mandate provides an incentive for developing cellulosic biofuels, even if these may not be the lowest-cost transportation fuels in the near term. Yet treating all cellulosic biofuels the same, as long as the 60 percent performance threshold is met, gives producers less incentive to continue improving the GHG performance. Biofuels from waste materials, for example, can have near-zero life-cycle emissions, but the EPA program gives them no special advantage.

How do the two measures address infrastructure needs? Both count on the fuel industry to assemble the necessary fuel supply infrastructure in a timely way. For biofuels, this is not a great problem—ethanol can be transported readily by rail; petroleum-like biofuels by pipeline; and both can be sold at fuel stations with few additional costs—with the exception of E85.

Electricity, natural gas, and hydrogen raise greater infrastructure problems. Expensive new retail fueling stations are needed for each, and electric vehicles require expensive retrofitting of most houses. California is exploring incentives for energy suppliers to overcome this energy infrastructure challenge.

Neither program attempts to implement measures to control the potentially important impacts of leakage and rebound, except to encourage others to adopt similar programs. Studies are under way to estimate the magnitude of the leakage and rebound effects and determine how to mitigate them.

Challenges for the Transition

How and when low-carbon energy alternatives such as cellulosic biofuels and electric and fuel-cell vehicles will succeed in the marketplace remain unclear, even under aggressive low-carbon fuel policies. The adoption of the low-carbon fuel standard, the RFS, and any other policy approach to introduce low-carbon fuels faces many political, administrative, and scientific challenges.

Scientific uncertainty about the indirect effects of changes in land use encourages lawsuits from those who are placed at a disadvantage by the rules; this creates uncertainty for fuel suppliers who are trying to decide whether and when to make the large investments for low-carbon fuels. The difficulty of addressing other environmental and resource impacts of fuels, from biodiversity to water use, creates additional challenges.

Finally, regulators and policymakers face exceptional challenges in responding to the uncertain and potentially high cost of compliance and to the variety of impacts across regions, companies, and population areas. Embedded in these challenges are the broader questions of avoiding climate change and improving energy security—and the relative importance assigned to each.

The low-carbon fuel standard and RFS programs are important steps forward. Continued progress will require the concerted efforts of scientists, investors, producers, and elected officials to ensure that wise choices are made in the transition to a different transportation energy future.

PHOTO: NREL

Hemicellulose fibers undergoing biofuel conversion pretreatment. The California renewable fuel standards provide incentives for the production of cellulosic biofuels.