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Low Carbon Fuel Standards

The most direct and effective policy for transitioning to low-carbon alternative transportation fuels is to spur innovation with a comprehensive performance standard for upstream fuel producers.

When it comes to energy security and climate change concerns, transportation is the principal culprit. It consumes half the oil used in the world and accounts for almost one-fourth of all greenhouse gas (GHG) emissions. In the United States, it plays an even larger role, consuming two-thirds of the oil and causing about one-third of the GHG emissions. Vehicles, planes, and ships remain almost entirely dependent on petroleum. Efforts to replace petroleum—usually for energy security reasons but also to reduce local air pollution—have recurred through history, with little success.

The United States and the world have caromed from one alternative to another, some gaining more attention than others, but each one faltering. These included methanol, compressed and liquefied natural gas, battery electric vehicles, coal liquids, and hydrogen. In the United States, the fuel du jour four years ago was hydrogen; two years ago it was corn ethanol; now it is electricity for use in plug-in hybrid electric vehicles. Worldwide, the only non-petroleum fuels that have gained significant market share are sugar ethanol in Brazil and corn ethanol in the United States. With the exception of sugar ethanol in Brazil, petroleum's dominance has never been seriously threatened anywhere since taking root nearly a century ago.

The fuel du jour phenomenon has much to do with oil market failures, overblown promises, the power of incumbents, and the short attention spans of government, the mass media, and the public. Alternatives emerge when oil prices are high but whither when prices fall. They emerge when public attention is focused on the environmental shortcomings of petroleum fuels but dissipate when oil and auto companies marshal their considerable resources to improve their environmental performance. When President George H. W. Bush advocated methanol fuel in 1989 as a way of reducing vehicular pollution, oil companies responded with cleaner-burning reformulated gasoline and then with cleaner diesel fuel. And when state air regulators in California and federal officials in Washington adopted aggressive emission standards for gasoline and diesel engines, vehicle manufacturers diverted resources to improve engine combustion and emission-control technologies.

The fuel du jour phenomenon also has much to do with the ad hoc approach of governments to petroleum substitution. The federal government provided loan and purchase guarantees for coal and oil shale "synfuels" in the early 1980s when oil prices were high, passed a law in 1988 offering fuel-economy credits for flexible-fuel cars, launched the Advanced Battery Consortium and the Partnership for a New Generation of Vehicles in the early 1990s to accelerate development of advanced vehicles, promoted hydrogen cars in the early years of this decade, provided tens of billions of dollars in federal and state subsidies for corn ethanol, and now is providing incentives for plug-in hybrids.

State governments also pursued a variety of options, including California's purchases of methanol cars in the 1980s and imposition of a zero-emission vehicle requirement in 1990. These many alternative-fuel initiatives failed to move the country away from petroleum-based transportation. The explanation has much to do with government prescribing specific solutions and not anticipating shifts in fuel markets. More durable policies are needed that do not depend on government picking winners. The needed policies should be performance-based, stimulate innovation, and reduce consumer and industry risk and uncertainty. A more coherent and effective approach is needed to orchestrate the transition away from oil.

Policy strategy

The path to reducing oil dependence and decarbonizing transportation involves three related initiatives: improving vehicle efficiency, reducing vehicle use, and decarbonizing fuels. Here we focus on decarbonizing fuels, which has the additional benefit of reducing oil use.

To succeed, any policy approach must adhere to three principles: It must inspire industry to pursue innovation aggressively; it must be flexible and performance-based so that industry, not government, picks the winners; and it should take into account all GHG emissions associated with the production, distribution, and use of the fuel, from the source to the vehicle.

We believe that the low carbon fuel standard (LCFS) approach that is being implemented in California provides a model for a national policy that can have a significant near-term effect on carbon emissions and petroleum use. The LCFS is a performance standard that is based on the total amount of carbon emitted per unit of fuel energy. Critically, the standard includes all the carbon emitted in the production, transportation, and use of the fuel. Although upstream emissions account for only about 20% of total GHG emissions from petroleum, they represent almost the total lifecycle emissions for fuels such as biofuels, electricity, and hydrogen. Upstream emissions from extraction, production, and refining also comprise a large percentage of total emissions for the very heavy oils and tar sands that oil companies are using to supplement dwindling sources of conventional crude oil. The LCFS is the first major public initiative to codify lifecycle concepts into law, an innovation that must increasingly be part of emission-reduction policies if we are to control the total carbon concentration in the atmosphere.

To simplify implementation, the LCFS focuses as far upstream as possible, on the relatively small number of oil refiners and importers. Each company is assigned a maximum level of GHG emissions per unit of fuel energy it produces. The level declines each year to put the country on a path to reducing total emissions. To maximize flexibility and innovation, the LCFS allows for the trading of emission credits among fuel suppliers. Oil refiners could, for instance, sell biofuels or buy credits from biofuel producers, or they could buy credits from an electric utility that sells power to electric vehicles. Those companies that are most innovative and best able to produce low-cost, low-carbon alternative fuels would thrive. The result is that overall emissions are lowered at the lowest cost for everyone.

A clear advantage of this approach is that it does not have to be revised every time a new alternative appears. Any cost-effective energy source that moves vehicles with lower GHG emissions can benefit from the LCFS. The combination of regulatory and market mechanisms makes the LCFS more politically acceptable and more durable than a strictly regulatory approach.

The California Air Resources Board adopted the LCFS in concept in June 2007 and began a rulemaking process, with the final rule scheduled for adoption in March 2009

EDWARD BURTYNSKY, *Oil Sands #2*, Fort McMurray, Alberta, 2007.

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GEORGE OSODI, *Oil Pipelines, Warri*, 2006.

and implementation in January 2010. California's LCFS proposal calls for at least a 10% reduction in emissions per unit of energy by 2020.

The European Union has in parallel unveiled a proposal similar to the LCFS in California, and the Canadian provinces of British Columbia and Ontario as well as several states in the Northeast are considering similar approaches. The proposed 2007 Lieberman-Warner Climate Security Act (S. 2191) included an LCFS program.

Why not a renewable fuel standard?

To appreciate the wisdom of the LCFS approach, compare it to the alternatives. Congress adopted a renewable fuels standard (RFS) in 2005 and strengthened it in December 2007 as part of the Energy Independence and Security Act (EISA). It requires that 36 billion gallons of biofuels be sold annually by 2022, of which 21 billion gallons must be "advanced" biofuels and the other 15 billion gallons can be corn ethanol. The advanced biofuels are required to achieve at least 50% reduction from baseline lifecycle GHG emissions, with a subcategory required to meet a 60% reduction target. These reduction targets are based on lifecycle emissions, including emissions from indirect land use. Although the RFS is a step in the right direction, the RFS volumetric mandate has three shortcomings. First, it targets only biofuels and not other alternatives. Second, setting the target of 50 and 60% GHG reductions is an admirable but clumsy approach. It forces biofuels into a small number of fixed categories and thereby stifles innovation. Third, it exempts existing and planned corn ethanol production plants from the GHG requirements, essentially endorsing a massive expansion of corn ethanol. This rapid expansion of corn ethanol not only stresses food markets and requires massive amounts of water, but also pulls large quantities of land into corn production. The ultimate effect of increasing corn ethanol production will be diversion of prairie lands, pastures, rainforests, and other lands into intensive agricultural production, likely resulting in higher overall GHG emissions than from an equivalent amount of gasoline and diesel fuels.

Other strategies that have won attention are a carbon tax and a cap and trade program. Economists argue that carbon taxes would be the more economically efficient way to introduce low-carbon alternative fuels. Former Federal Reserve chairman Alan Greenspan, car companies, and economists on the left and the right all have supported carbon and fuel taxes as the principal cure for both oil insecurity and climate change. But carbon taxes have shortcomings. Not only do they attract political opposition and public ire, they are of limited effectiveness. Taxing energy sources according to how much carbon dioxide (CO_2) they admit certainly sounds sensible and straightforward, but this strategy is not effective in all situations. A carbon tax could work well with electricity generation because electricity suppliers can choose among a wide variety of commercially available low-carbon energy sources, such as nuclear power, wind energy, natural gas, or even coal with carbon capture and sequestration. A tax of as little as $25 per ton of CO_2 would increase the retail price of electricity made from coal by 17%, which would be enough to motivate electricity producers to seek lower-carbon alternatives. The result would be innovation, change, and decarbonization. Carbon taxes promise to be effective in transforming the electricity industry.

But transportation is a different story. Producers and consumers would barely respond to even a $50-a-ton tax, which is well above what U.S. politicians have been considering. Oil producers wouldn't respond because they have become almost completely dependent on petroleum to supply transportation fuels and can't easily or quickly find or develop low-carbon alternatives. Equally important, a transition away from oil depends on automakers and drivers also changing their behavior. A carbon tax of $50 per ton would raise the price of gasoline by only about 45 cents a gallon. This wouldn't induce drivers to switch to low-carbon alternative fuels. In fact, it would barely reduce their consumption, especially when price swings of more than this amount have become a routine occurrence.

Carbon cap and trade programs suffer the same shortcomings as carbon taxes. This policy, as usually conceived, involves placing a cap on the CO_2 emissions of large industrial sources and granting or selling emission allowances to individual companies for use in meeting their capped requirements. Emission allowances, once awarded, can be bought and sold. In the transportation sector, the cap would be placed on oil refineries and would require them to reduce CO_2 emissions associated with the fuels. The refineries would be able to trade credits among themselves and with others. As the cap is tightened over time, pressure would build to improve the efficiency of refineries and introduce low-carbon fuels. Refiners are likely to increase the prices of gasoline and diesel fuel to subsidize low-carbon fuels, creating a market signal for consumers to drive less and for the auto companies to offer more energy-efficient vehicles. But unless the cap was very stringent, this signal would be relatively weak for the transportation sector.

Economists might characterize the LCFS approach as second best because it is not as efficient as a carbon tax or a cap and trade program. But given the huge barriers to alternative fuels and the limited impact of increased taxes and prices on transportation fuel demand, the LCFS is the most practical way to begin the transition to alternative fuels. Some day, when advanced biofuels and electric and hydrogen vehicles are commercially viable options, cap and trade and carbon taxes will become an effective policy with the transport sector. But until then, more direct forcing mechanisms, such as a LCFS for refiners, are needed to stimulate innovation and overcome the many barriers to change.

George Osodi, *Ogoni Oil Spill*, 2005.

The LCFS cannot stand alone, however. It must be coupled with other policies, including efficiency and GHG gas emission standards for new cars, infrastructure to support alternative fuel penetration, and incentives to reduce driving and promote transportation alternatives. That is California's approach, and it would also be an effective national policy in the United States and elsewhere.

Designing an LCFS

In the California case, the proposed 10% reduction in life-cycle GHG emissions by 2020 is imposed on all transport fuel providers, including refiners, blenders, producers, and importers. Aviation and certain maritime fuels are excluded because California either does not have authority over them or including these fuels presents logistical challenges.

There are several ways that regulated parties can comply with the LCFS. In the California model, three compliance strategies are available. First, refiners can blend low-GHG fuels such as biofuels made from cellulose or wastes into gasoline and diesel. Second, refiners can buy low-GHG

George Osodi, *Fish Pond Oil Pollution*, 2004.

fuels such as natural gas, biofuels, electricity, and hydrogen. Third, they can buy credits from other refiners or use banked credits from previous years. In the EU's design, producers may also gain credit by improving energy efficiency at oil refineries or by reducing upstream CO2 emissions from petroleum and natural gas production, for instance by eliminating flaring.

LCFS is simple in concept, but implementation involves many details. The LCFS requires a system to record and verify the GHG emissions for each step of fuel production and distribution. California is using a "default and opt-in" approach, borrowed from a voluntary system developed in the United Kingdom, whereby fuels are assigned a conservative default value. In other words, the regulations estimate the carbon emissions associated with each fuel. The fuel producer can accept that estimate or provide evidence that its production system results in significantly lower emissions. This places the burden of measuring and certifying GHG emissions on the oil distributors, biofuel producers, and electricity generators.

A major challenge for the LCFS is avoidance of "shuffling" or "leakage." Companies will seek the easiest way of responding to the new LCFS requirements. That might involve shuffling production and sales in ways that meet the requirements of the LCFS but do not actually result in any net change. For instance, a producer of low-GHG cellulosic biofuels in Iowa could divert its fuel to California markets and send its high-carbon corn ethanol elsewhere. The same could happen with gasoline made from tar sands and conventional oil. Environmental regulators will need to account for this shuffling in their rule making. This problem is mitigated and eventually disappears as more states and nations adopt the same regulatory standards and requirements.

Perhaps the most controversial and challenging issue is indirect land-use changes. When biofuel production increases, land is diverted from agriculture to energy production. The displaced agricultural production is replaced elsewhere, bringing new land into intensive agricultural pro-

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EDWARD BURTYNSKY, *SOCAR Oil Fields #1a* (detail of diptych), Baku, Azerbaijan, 2006.

duction. By definition, this newly farmed land was previously used for less-intensive purposes. It might have been pasture, wetlands, or perhaps even rainforest. Because these lands sequester a vast amount of carbon in the form of underground and aboveground roots and vegetation—effectively storing more than twice the carbon contained in the entire atmosphere—any change in land use can have a large effect on carbon releases.

If biofuel production does not result in land-use changes—for instance when fuel is made from crop and forestry residues—then the indirect land-use effects are small or even zero. But if rainforests are destroyed or vegetation burned, then the carbon releases are huge. In the more extreme cases, these land-use shifts can result in each new gallon of biofuel releasing several times as much carbon as the petroleum diesel fuel it is replacing. In the case of corn ethanol, preliminary analyses suggest that ramping up to meet federal RFS targets will add about 40% more GHG emissions per unit of energy. Cellulosic fuels would have a much smaller effect, and waste biomass, such as crop and forestry residues and urban waste, would have no effect.

The problem is that scientific studies have not yet adequately quantified the indirect land-use effect. One could ignore the carbon and other GHG releases associated with land diversion in calculating lifecycle GHG emissions, but doing so imputes a value of zero to this effect. That is clearly wrong and inappropriate. The prudent approach for regulators is to use the available science to assign an initial conservative value and then provide a mechanism to update these assigned values as the science improves. Meanwhile, companies are advised to focus on biofuels with low GHG emissions and minimal indirect land-use effects, fuels created from wastes and residues or from degraded land, or biofuels produced from algae and renewable hydrocarbons. These feedstock materials and lands, not intensively farmed food crops, should be the heart of a future biofuels industry.

A broader concern is the environmental and social sustainability of biofuels. Many biofuel programs, such as those in the Netherlands, UK, and Germany, have or are adopting sustainability standards for biofuels. These sustainability standards typically address issues of biodiversity, soil, air, and water quality, as well as social and economic conditions of local communities and workers. They require reporting and documentation but lack real enforcement teeth. And none address effects on land and food prices and the market-mediated diversion of land to less sustainable uses. The effectiveness of these standards remains uncertain. New and better approaches are needed.

Those more concerned with energy security than with climate change might be skeptical of the LCFS. They might fear that the LCFS disadvantages high-carbon alternatives such as tar sands and coal liquids. That concern is valid, but disadvantaging does not mean banning. Tar sands and coal liquids could still be introduced on a large scale with an LCFS. That would require producers of high-carbon alternatives to be more energy efficient and to reduce carbon emissions associated with production and refining. They could do so by using low-carbon energy sources for processing energy and could capture and sequester carbon emissions. They could also opt for ways of converting tar sands and coal resources into fuels that facilitate carbon capture and sequestration. For instance, gasifying the coal to acquire hydrogen allows for the capture of almost all the carbon, because none remains in the fuel itself. In this way, coal could be essentially a zero-carbon option.

In a larger sense, the LCFS encourages energy producers to focus on efficiency and methods for reducing carbon. It stimulates innovation in ways that are in the public interest. Even with an LCFS policy in place, a region or nation might still produce significant quantities of fossil alternatives but those fuels would be lower carbon than otherwise, and they would be balanced by increasing quantities of other non-fossil fuels.

Going global

The principle of performance-based standards lends itself to adoption of a national or even international LCFS. The California program is being designed to be compatible with a broader program. Indeed, it will be much more effective if the United States and other countries also adopt it. Although some countries have already adopted volumetric biofuel requirements, these could be readily converted into an LCFS. It would require converting the volumetric requirements into GHG requirements. In the United States that would not be difficult because GHG requirements are already imposed on each category of required biofuels. For the EU programs, efforts are under way to complement their biofuel directive with an LCFS-like fuel-quality directive that would require a 10% reduction in GHG intensity by 2020 for transport fuels.

An important innovation of the California LCFS is its embrace of all transportation fuels. The U.S. and European RFS programs include only biofuels, including biogas. Although it is desirable to cast the net as wide as possible, there is no reason why all states and nations must target the same fuels. Indeed, the northeastern U.S. states are exploring the inclusion of heating oil in their LCFS.

Broader-based LCFS programs are attractive for three reasons. First, it would be easier to include fuels used in international transport modes, especially fuels used in jets and ships. Second, a broader LCFS would facilitate standardization of measurement protocol. At present, California is working with fuel-exporting nations to develop common methods for specifying GHG emissions of fuels produced in those countries. The fuels of most relevance at this time are ethanol and biodiesel from Brazil, but tar sands from Canada will also be of interest. Third, the broader the pool, the greater the options available to regulated entities, and more choice means lower overall cost, because there will be a greater chance of finding low-cost options to meet the targets.

The ad hoc policy approach to alternative fuels has largely failed. A more durable and comprehensive approach is needed that encourages innovation and lets industry pick winners. The LCFS does that. It provides a single GHG performance standard for all transport-fuel providers, and it uses credit trading to ensure that the transition is accomplished in an economically efficient manner.

Although one might prefer more theoretically elegant policies such as carbon taxes and cap and trade, those instruments are not likely to be effective in the foreseeable future with transport fuels. They would not be sufficient to induce large investments in electric vehicles, plug-in hybrids, hydrogen fuel cell vehicles, and advanced biofuels.

The LCFS is amenable to some variation across states and nations, but standardization of the measurement protocol is necessary for the LCFS performance standard to be implemented and enforced fairly and reliably. The LCFS not only encourages investments in low-carbon fuels, but it also accommodates high-carbon fossil fuels, with strong incentives to produce them more energy efficiently and with low-carbon energy inputs. The enormity of the threat of global climate change demands a policy response that encompasses all viable options.

Recommended reading

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