Ethanol can replace gasoline with big energy savings

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Don Prestella, fleet operations supervisor at Lawrence Berkeley National Laboratory, fills a lab vehicle tank with ethanol-based E-85 after LBNL became the first ethanol dispensing station in Northern California in July 2004. (Photo courtesy LBNL)

Putting ethanol instead of gasoline in your tank saves oil and is probably no worse for the environment than burning gasoline, according to a new analysis by researchers at the University of California, Berkeley. The researchers note, however, that new technologies now in development promise to make ethanol a truly "green" fuel with significantly less environmental impact than gasoline.

The analysis, appearing in this week's issue of *Science*, attempts to settle the ongoing debate over whether ethanol is a good substitute for gasoline and thus can help lessen the country's reliance on foreign oil and support farmers in the bargain. The UC Berkeley study weighs these arguments against other studies claiming that it takes more energy to grow the corn to make ethanol than we get out of ethanol when we burn it.

Dan Kammen and Alex Farrell of the Energy and Resources Group at UC Berkeley, with their students Rich Plevin, Brian Turner and Andy Jones along with Michael O'Hare, a professor in the Goldman School of Public Policy, deconstructed six separate high-profile studies of ethanol. They assessed the studies' assumptions and then reanalyzed each after correcting errors, inconsistencies and outdated information regarding the amount of energy used to grow corn and make ethanol, and the energy output in the form of fuel and corn byproducts.

Once these changes were made in the six studies, each yielded the same conclusion about energy: Producing ethanol from corn uses much less petroleum than producing gasoline. However, the UC Berkeley researchers point out that there is still great uncertainty about greenhouse gas emissions and that other environmental effects like soil erosion are not yet quantified.

The UC Berkeley team has made its model, the Energy and Resources Group Biofuels Meta Model (EBAMM), available to the public on its Web site: rael.berkeley.edu/~EBAMM

"It is better to use various inputs to grow corn and make ethanol and use that in your cars than it is to use the gasoline and fossil fuels directly," said Kammen, who is co-director of the Berkeley Institute of the Environment and UC Berkeley's Class of 1935 Distinguished Chair of Energy.

Despite the uncertainty, it appears that ethanol made from corn is a little better - maybe 10 or 15 percent - than gasoline in terms of greenhouse gas production, he said.

"The people who are saying ethanol is bad are just plain wrong," he said. "But it isn't a huge victory - you wouldn't go out and rebuild our economy around corn-based ethanol."

The transition would be worth it, the authors point

out, if the ethanol is produced not from corn but from woody, fibrous plants: cellulose.

"Ethanol can be, if it's made the right way with cellulosic technology, a really good fuel for the United States," said Farrell, an assistant professor of energy and resources. "At the moment, cellulosic technology is just too expensive. If that changes - and the technology is developing rapidly - then we might see cellulosic technology enter the commercial market within five years."

Cellulosic technology refers to the use of bacteria to convert the hard, fibrous content of plants - cellulose and lignin - into starches that can be fermented by other bacteria to produce ethanol. Farrell said that two good sources of fibrous plant material are switchgrass and willow trees, though any material, from farm waste to specially grown crops or trees, would work. One estimate is that there are a billion tons of currently unused waste available for ethanol production in the United States.

"There is a lot for potential for this technology to really help meet national energy goals," he said. "However, there are still unknowns associated with the long-term sustainability of ethanol as a fuel, especially at the global scale. Making smart land use choices will be key."

Farrell, Kammen and their colleagues will publish their study in the Jan. 27 issue of Science. In addition, Kammen will discuss the report on Jan. 26 at 11 a.m. EST at the 6th National Conference on Science, Policy and the Environment, which is being held at the Ronald Reagan Building and International Trade Center in Washington, D.C. Farrell also will discuss the study at a 4 p.m. seminar on Feb. 3 at UC Berkeley's Institute of Transportation Studies.

In 2004, ethanol blended into gasoline comprised only 2 percent of all fuel sold in the United States. But auto manufacturers are able to make cars that run on 85 percent ethanol, and nearly 5 million such "flex-fuel" vehicles are now on the road. Kammen noted that almost all light trucks now sold have flex-fuel capability, though frequently unadvertised. Converting a car into a flex-fuel vehicle able to burn E85, as the 85/15 ethanol/gas mix is called, costs about $100. More flex-fuel vehicles than diesel vehicles are on the road today in California.

"Converting to fuel ethanol will not require a big change in the economy. We are already ethanol-ready. If ethanol were available on the supply side, the demand is there," Kammen said.

Californians may be voting this November on a state proposition requiring that all new cars sold in California be flex-fuel ready. Kammen said that once this happens, California is poised to move toward the situation in Brazil, where many cars burn pure ethanol and ethanol made from sugar cane supplies half the fuel needs for cars and trucks.

Knowledgeable venture capitalists already are putting money behind ethanol and cellulosic technology, as witnessed by recent investments by Microsoft Corp. chairman Bill Gates and strong interest by Sun Microsystems co-founder Vinod Khosla.

"The investment by Gates is an example of the excitement and seriousness the venture capital community sees in cellulosic technology, which they see as now ready to go prime time," he said. "Our assessment in the paper is that it is a very strong winner and that the effort needed to go the last 10 percent of the way to get cellulosic on board is actually very small."

Kammen estimates that ethanol could replace 20 to 30 percent of fuel usage in this country with little effort in just a few years. In the long term, the United States may be able to match Sweden, which recently committed to an oil-free future based on ethanol from forests and solar energy. Kammen last year published a paper, also in Science, arguing that even Africa could exploit its biomass to build a biofuel industry that could meet energy needs for the poor and develop a sustainable local fuel supply, a future much better than using fossil fuels.

The goal of the UC Berkeley analysis was to understand how six studies of fuel ethanol could

come to such different conclusions about the overall energy balance in its production and use. Farrell, Kammen and their UC Berkeley colleagues dissected each study and recreated its analysis in a spreadsheet where they could be compared side-by-side. The team said it found numerous "errors, inconsistencies and omissions" among the studies, such as not considering the value of co-products of ethanol production - dried distillers grains, corn gluten feed and corn oil - that boost the net energy gain from ethanol production. Other studies overestimated the energy used by farm machinery.

On the other side, some studies ignored the use of crushed limestone on corn fields, which can be a significant energy input because of the need to pulverize the rock. Farrell noted that some numbers needed for the analysis, such as the amount of limestone applied, are just not known reliably. On the other hand, some of the studies used outdated data when more recent numbers were available, making ethanol look worse.

"The assumptions made by some of the authors were not based on the best data, or were just a little bit too convenient, and had a strong impact on the results," Kammen said.

Farrell, Kammen and their colleagues considered not only the energy balance of corn ethanol production, but also the effect on the environment through production of greenhouse gases. While corn ethanol came out marginally better than gasoline in terms of greenhouse gas production, Farrell noted that corn production has other negative environmental impacts associated with fertilizer, pesticide and herbicide use. These need to be taken into account when considering the balance between corn ethanol and gasoline, though emerging cellulosic technologies using waste would push the equation more toward ethanol.

"Two things are going to push the commercialization of cellulosic technology," Farrell said. "One is driving the cost down, which is mainly research and development; the other is that environmental concerns are increasingly entering into commercial calculations about biofuels."

Source: University of California - Berkeley