

Producing Ethanol for Low-Carbon Fuel Markets

By Richard Plevin and Steffen Mueller

All ethanol is not created equal. Even with corn-based ethanol, a variety of production processes and energy sources is used in biorefineries, with widely differing greenhouse gas balances. Price volatility in the natural gas markets has led many ethanol producers to consider alternative thermal energy sources, including agricultural residues, distillers grains and syrup, biogas, manure, wood chips and coal. Despite a wide range of climate benefits, domestic bio-fuels policies have treated ethanol largely as a homogenous product, but not for long.

New Fuels Regulations

On Jan. 9, a new regime was ushered in when California Gov. Arnold Schwarzenegger signed an executive order requiring that state agencies develop a "low-carbon fuel standard" to reduce the carbon intensity of transportation fuels by at least 10 percent by 2020. Within weeks, European Union regulators and the Canadian province of British Columbia

proposed a similar standard. Other states are reportedly considering similar measures.

Although the details are still being worked out, the low-carbon fuel standard is likely to use a lifecycle approach and judge each fuel production pathway on its own merits. This will likely involve differentiating ethanol production on a facility-by-facility basis. Carbon regulations will increase the demand for—and relative value of—biofuels offering the greatest greenhouse gas reductions (GHG) relative to gasoline.

Figure 1 shows the range of lifecycle GHG emissions per megajoule of ethanol produced with different energy sources in new dry-grind facilities. Producing ethanol with coal results in a fuel that is just as hard on the climate as gasoline.

Blending climate-friendly grades of ethanol with gasoline may be a primary strategy for reducing the carbon intensity of transport fuels. Without significant adjustments to current operating practices, ethanol produced by coal-fired plants will be of little value to refineries and blenders seeking to lower the carbon intensity of their petroleum-based fuels.

The Way Forward

Existing corn-based ethanol plants have several options for improving their GHG profiles. These include selling wet cake to avoid the GHG emissions and cost of drying distillers grains, like Pacific Ethanol is doing with its 35 MMgy facility in Madera, Calif. Existing plants could also implement a no-cook fermentation system, which avoids energy use for heating and subsequently cooking the mash.

Other plants could integrate with a cattle feedlot similar to what E³ BioFuels has done in Nebraska. E³'s energy needs are met with biomethane from digested manure and thin stilage. Panda Ethanol Inc. plans to gasify cattle manure for process heat at its Hereford, Texas, facility that is currently

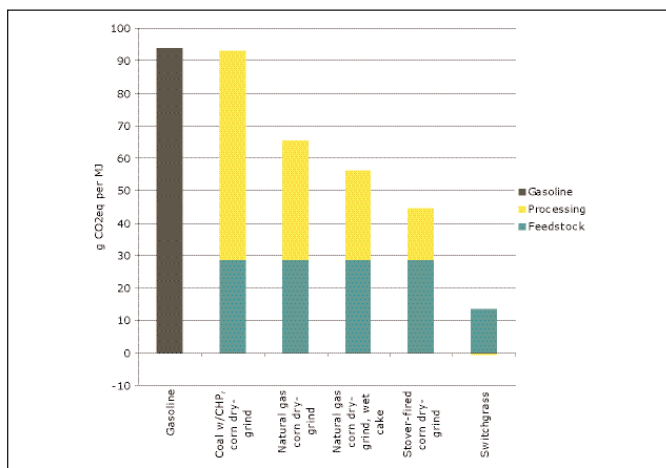


Figure 1. Well-to-tank greenhouse gas emissions for various ethanol pathways compared with emissions (including combustion) of conventional gasoline

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under construction.

Existing producers could also gasify wood waste or combust syrup, like Central Minnesota Ethanol Co-op and Corn Plus, respectively. These producers have reduced their exposure to natural gas price volatility while lowering the carbon intensity of their product. Under low-carbon fuel standards, the plants will be rewarded by the market.

Retrofitting a natural gas dry-grind plant to use a range of biomass feedstocks may be an option for many existing plants. For example, the Chippewa Valley Ethanol Company (CVEC) plans to bring its 75-ton-per-day biomass gasification system on line in the fall of 2007. According to CVEC General Manager Bill Lee, the total capital costs for a gasification system installed at a 40 MMgy dry-grind plant is about \$18 million.

Coal-fired plants can also utilize biomass, either by co-firing the two fuels or by switching to biomass. Co-firing biomass in coal-fired fluidized bed boilers has shown significant promise in large-scale demonstration projects. This practice could allow facilities to approximate the GHG impact of current natural-gas-fired plants.

Under low-carbon fuel standards, the market will demand these adjustments from existing coal-fired ethanol plants. Of course, if the plants are closer to the coal than to biomass sources, their options may be limited.

Carbon sequestration may eventually provide another option for coal-fired ethanol plants to adjust to low-carbon fuel standards.

In the near term, the most readily available biomass source for producers in the Corn Belt is stover. For any quantity of corn, only about 25 percent of the stover is required to provide enough thermal energy to convert the

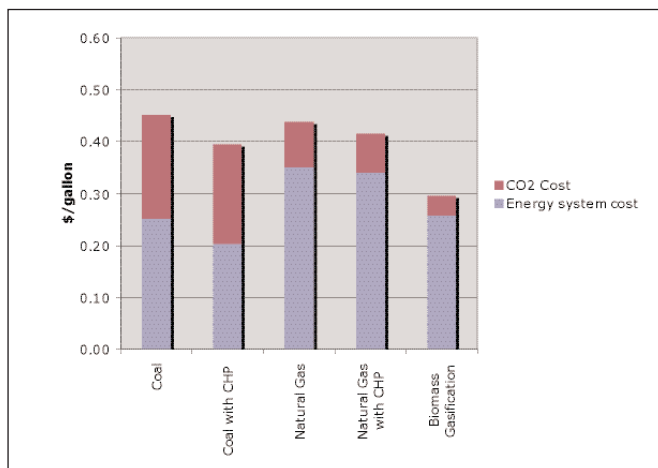


Figure 2a. Cost of ethanol facility energy system with a \$37 per metric ton price for carbon-dioxide equivalent emissions.

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corn to ethanol, an amount that is likely to be harvestable in a sustainable way under conservation tillage. Researchers are actively pursuing improved methods for collecting and storing stover, including pre-processing it in the field (e.g., pelletization) to reduce transport costs and increase storability.

Comparing the Alternatives

We analyzed the production costs of the energy systems in five dry-grind configurations using coal, natural gas and biomass as energy sources. Our analysis includes the fixed and variable costs for equipment, personnel, permits and fuel. In our base case, we assume \$64 per ton of delivered coal, \$0.078 per kilowatt-hour (kwh) of electricity, \$8.46 per MMBtu of natural gas and \$50 per ton of delivered biomass. We considered a range of fuel prices.

Since it is difficult to predict the economic impact of a low-carbon fuel standard on the price of ethanol, we also considered the price per metric ton of carbon dioxide that would balance out the costs of competing systems. For the biomass system, we modeled the cost of retrofitting a natural-gas-fired plant into a biomass gasifier that generates "producer gas" used in lieu of purchasing natural gas, based on engineering estimates provided by Frontline BioEnergy.

Coal-fired plants are the cheapest when carbon dioxide emissions have no cost, as shown by the blue bars in Figures 2a and 2b. However, under GHG regulations, natural gas with combined heat and power (CHP) offers significant benefits, especially in the Midwest where the electric grid is dominated by coal. Producing electricity in a natural gas CHP system offers significant GHG reductions. Natural gas is

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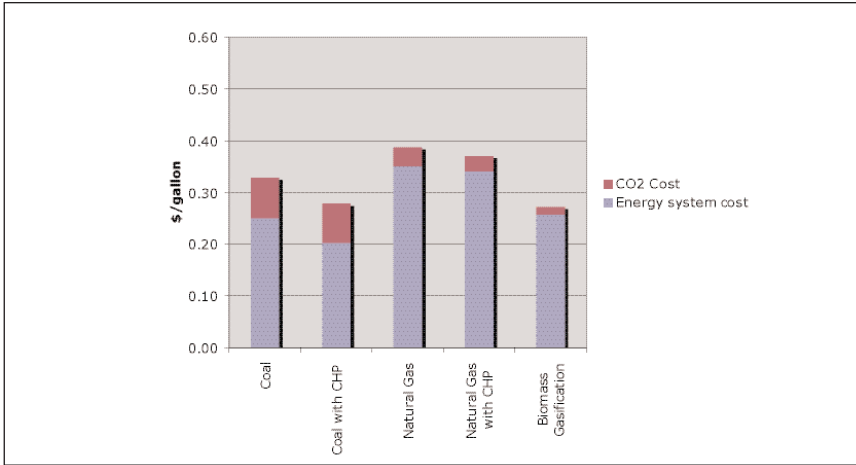


Figure 2b. Biomass gasification is cheaper than natural gas even without paying for carbon dioxide, and cheaper than coal CHP with a price of carbon dioxide as low as \$13 per ton, assuming \$50 per ton for biomass.

much less carbon-dioxide-intensive than coal, and on-site power generation avoids transmission and distribution losses. Most significantly, utilizing the waste heat through CHP further boosts efficiency. In markets with average-to-high electricity costs, the natural gas CHP system isn't only lower in GHG emissions, it's cheaper per gallon of ethanol produced.

Figure 2a shows that a price of \$37 per metric ton of carbon dioxide erases the cost benefits of using coal over natural gas in both CHP and non-CHP configurations. This carbon dioxide price is within the price range seen in the European emissions trading system. The lowest GHG emissions are achieved using biomass for process heat. Assuming access to sufficient biomass resources (often a logistical problem), the biomass gasification system would be cheaper than running a natural gas system. At \$13 per metric ton of carbon dioxide, it becomes cheaper than coal with CHP (Figure 2b).

However, these cost calculations don't tell us how prices will vary in a market that values ethanol for its carbon intensity. Under a national low-carbon fuel standard, coal-fired ethanol will have no value as a means of lowering carbon emissions. This

puts it at a distinct disadvantage.

In a GHG-conscious market, corn-based ethanol will eventually face stiff competition from cellulosic and sugarcane-based ethanol, both of which have better GHG profiles than even the best corn-based ethanol. However, until cellulosic ethanol becomes widely available, the easiest way for petroleum refiners and blenders to reduce their carbon intensity will be to blend gasoline with the greatest possible quantities of the lowest GHG-intensity corn-based ethanol available.

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