Inducing More Efficient Biofuel Production

As Congress encourages the local production of bio-fuels in order to displace petroleum-based gasoline, it also should ensure that the energy islands serving ethanol and biodiesel production facilities – the steam and electricity production facilities – are optimally built to meet the nation's long-term fossil energy and environmental goals. Inducing the industry to optimize the energy island can increase the net fossil savings per gallon of biofuel by 25 percent to 310 percent compared to the lowest-first-cost approach. Furthermore, the more efficient approaches make it easier to convert the ethanol or biodiesel plant in the future to a cellulosic feedstock. Maximizing the efficiency and recycling the waste heat of these bio-fuel production plants will enhance energy independence, increase base load production of clean electricity, improve biofuel's net fossil energy savings and reduce the emissions of pollutants and greenhouse gases.

Energy options are numerous for bio-fuel facilities. Unfortunately, the default case that minimizes initial capital costs is also the least efficient and fails to capture other benefits. This note explains the energy choices and suggests ways that policy could induce increased fossil efficiency of bio-fuel production. The following example focuses on ethanol but is relevant for all biofuel production.

Energy Supply Choices

A typical ethanol plant is designed to produce about 55 million gallons of per year, and will require a continuous and significant stream of steam, plus about 5 megawatts of electricity. The required steam and electrical energy can be supplied in several ways, which differ in capital cost and energy efficiency.

The basic ethanol plant, which does not dry the resulting distiller grains but sells them for local livestock feed, will cost roughly $85 million, plus an additional $5 million for natural gas boilers that produce only the required steam and do not combine the generation of heat and power. In this case, all electricity is provided by the grid, with an average delivered fossil efficiency of only 33 percent. The ethanol plant will require about 35,000 British thermal units (Btus) of fossil energy per gallon of ethanol, and experts estimate the corn crop will require 25,000 Btu's per gallon, for a total fossil fuel use of 60,000 Btus per gallon of ethanol. Since the ethanol has 76,000 Btu's of energy value, (lower heating value or LHV), the lowest first-cost ethanol plant saves 16,000 Btu's of fossil energy per gallon of ethanol.

For an extra $2.0 million, the ethanol plant could combine the generation of heat and power by installing higher-pressure boilers and a back-pressure steam turbine to generate most of the plant's electric requirements. This CHP approach has incremental electric efficiencies of over 80 percent, versus the 33 percent for grid power, and it reduces the ethanol plant's fossil use by 4,000 Btu's per gallon of ethanol. This approach raises the net fossil savings by 25 percent, from 16,000 to 20,000 Btus per gallon of ethanol.

To achieve more than a 300-percent increase in fossil savings per gallon of ethanol, the plant could construct a 50-megawatt combined-cycle gas turbine facility, sized to perfectly match the ethanol plant's steam requirements. This approach requires roughly $50 million of capital, but will produce 50 megawatts of electric power at 85-percent net efficiency, displacing 2.5 billion Btu's per year and completely offsetting the ethanol plant's fossil energy. In this case, the net plant fossil savings per gallon of ethanol grows to 51,000 Btus, a 310-percent improvement over the fossil energy efficiency of the lowest-first-cost ethanol production plant.

The ethanol energy plant could burn biomass or some other form of non-fossil fuel, also with a combined-heat-and-power plant. This case is difficult to generalize because each fuel is different and requires unique technical approaches, but all biomass fuel options would reduce the burning of fossil fuels and would further benefit from combining heat and power generation. Each biomass option requires significant added capital and would not typically be funded by ethanol plant developers.

The construction of numerous 50-megawatt CHP plants at ethanol plants would help meet the nation's growing electricity needs. Such efficient facilities – since they are located near the power demand – also would avoid the costs of new transmission lines, reduce line losses, cut emissions of criteria pollutants and greenhouse gases, and reduce the grid's vulnerability to extreme weather and terrorism.

How Congress Can Induce More Efficiency at Ethanol and Biodiesel Production Facilities

Lawmakers can induce the building of high-efficiency bio-fuel plants by offering a production credit of 1.5 cents per kilowatt-hour (kWh) for electricity those facilities generate.

This production credit, more specifically, shall be paid for each kilowatt-hour produced sequentially with the ethanol or biodiesel plant's thermal energy, with these limitations:

1. In the case of high-pressure steam boilers, a credit shall be given for all net kilowatt-hours produced by a backpressure steam turbine strictly from the reduction of the boiler pressure to the required pressure for the ethanol or biodiesel plant. No power produced by condensing the steam shall qualify. In the event that the ethanol or biodiesel power plant is served by a combination extraction-and-condensing turbine, the power eligible for the production credit from the backpressure turbine shall be determined by a third-party expert familiar with the actual turbine generator set and calculated to determine the power that the pressure reduction created. This credit shall be available regardless of the fuel burned by the boiler to produce the high-pressure steam.
2. In the case of prime movers – such as combustion turbines, reciprocating engines, or fuel cells – that produce electricity and then capture the waste thermal energy for the ethanol or biodiesel plant's requirements, all of the power plant's net kWh shall be eligible for the credit, providing that the plant recovers most of its exhaust energy to produce the ethanol or biodiesel plant's steam at pressures at least three times the required pressure of the ethanol or biodiesel plant and that none of the resulting steam

is used in a condensing turbine. Kilowatt-hours from a plant that employs any of these prime movers shall be required to pass an additional test, namely that the total net electric energy from the plant – plus the boiler fuel that would have been burned to produce the same amount of steam – is equal to at least 80 percent of the potential energy in the fuel the power plant burns, measured in lower heating value. In other words, eligible power will be at least 80-percent efficient, or roughly 240 percent more efficient than the average delivered electricity in the U.S.

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