Corn-Based Ethanol Does Indeed Achieve Energy Benefits

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Prof. David Pimentel's 1998 assessment of corn ethanol concluded that corn ethanol achieved a negative energy balance (which is usually defined as the energy in a product minus energy used to produce the product). Unfortunately, his assessment lacked timeliness in that it relied on data appropriate to conditions of the 1970s and early1980s, but clearly not the 1990s. Prof. Pimentel failed to take into account technology improvements over the last twenty years and their impacts on energy requirements of corn farming and ethanol production.

Technological advancements have undoubtedly helped increase productivity and product performance and reduce input energy requirement in almost every U.S. economic sector. Those of us who have been analyzing transportation-related technologies have noted the dramatic reductions in per-vehicle emissions and increases in fuel economy and vehicle performance because of vehicle technology advancements. We have found, through our analyses, that corn farming and ethanol production are no exception, benefiting significantly from technological advancements. Failure to consider this, as Prof. Pimentel's assessment did, inevitably reaches erroneous conclusions.

Problems with Prof. Pimentel's assessment are found in three key areas: energy use of corn farming, energy use of ethanol production, and failure to credit co-products from ethanol plants. With respect to the first two areas, Prof. Pimentel in his 1998 assessment used data from his 1991 and 1992 publications, despite the fact that a 1995 thorough study on the topic by the U.S. Department of Agriculture (USDA) was readily available. Further, since that time we have conducted our own study of the subject, and the USDA is currently updating its estimates. We anticipate that these studies will support our prior assumptions that progress continues to be made. The farming sector is not technologically mature, as Prof. Pimentel contends. In fact, we found that best practices in corn farming and ethanol production provide reason to believe that the improvements in energy efficiency that we identified are likely to continue.

We conducted a series of detailed analyses on energy and emission impacts of corn ethanol from 1997 through 1999. During our analyses, we researched improvements in energy intensity of corn farming and ethanol production by studying publicly available data and by contacting USDA, experts in the Midwestern farming and meat production communities, and ethanol plant designers and operators. Our research showed that corn productivity (defined as corn yield per unit of chemical input) increased by 30% between the early 1970s and mid-1990s. We also found that energy intensity of ethanol production (defined as energy use in ethanol plants per unit of ethanol produced) decreased by about 40% between the mid-1980s and late 1990s. The table below presents our results, together with Prof. Pimentel's values.

Energy Inputs for a Gallon of Ethanol

Item	Argonne	Pimentel
Corn Farming	26,700	55,300
Ethanol Production	44,300	74,300
Co-Product Credit	-15,400	0
Total	55,600	129,600
Net Energy Balance	20,400	-53,600

In the table, the value for corn farming in our analyses included energy use of powering farming machinery (tillage, irrigation, harvesting, and product drying), energy embedded in fertilizer and pesticides (production, transportation, and application), and energy use for transporting corn to ethanol plants. The value for ethanol production included energy use in ethanol plants and for transporting ethanol from plants to refueling stations.

The most contentious issue on corn ethanol perhaps is how to deal with co-products from ethanol plants. Dry milling ethanol plants produce distillers' grains and solubles together with ethanol, while wet milling plants produce corn gluten feed, corn gluten meal, corn oil, and other high-value products together with ethanol. These products are currently sold in the marketplace as animal feeds and for other uses (e.g., corn oil for cooking). While there are several ways of estimating energy and emission credits of co-products, most analysts now agree that the so-called displacement method should be used to estimate the credits. This assigns a co-product credit based on the input energy requirement of the feed product or good that the ethanol co-product displaces. With the method, we have estimated an energy credit of 15,440 Btu per gallon of ethanol. In contrast, Prof. Pimentel failed to allow any credits for co-products.

It is worth noting that the displacement method gives the least energy and emission credits to ethanol co-products. If other methods are to be used, co-product credits will be higher than that presented in the table. One of us contends that the dollar valuation of products sold should be used to allocate emissions to products produced.

We note that Prof. Pimentel fallaciously sets up a "strawman" – an assumption that those analyzing corn ethanol intend for it to entirely replace gasoline fuel. By doing so, he creates a hypothetical arbitrary situation where the quantities of co-products produced are so large as that the market obviously would not be able to absorb the quantities and therefore that co-products become onerous waste products. The situation that our study team analyzed carefully considered the reasonableness of the size of the market that could be served by ethanol production while retaining a market for co-products and avoiding excessive displacement of valuable cropland. In particular, we assumed a scenario of increasing corn ethanol production from the current level of 1.5 billion gallons a year to a level of 3 billion gallons a year by 2010. For this situation, which is the only reasonable one to consider, a co-product credit is appropriate.

Also, our analyses, and most other studies, did not credit ethanol with an octane boosting effect, which does exist when ethanol is blended in small percentages in gasoline, the dominant use of ethanol at this time. Had this effect been included for the case of use of ethanol in “low level” ethanol/gasoline blends, our benefits estimates would have been larger.

In summary, with up-to-date information on corn farming and ethanol production and treating ethanol co-products fairly, we have concluded that corn-based ethanol now has a positive energy balance of about 20,000 Btu per gallon. Our analyses have also concluded that corn ethanol achieves modest to moderate reductions in greenhouse gas emissions, relative to petroleum-based gasoline. Our analyses are documented in several publications available on request. Needless to say, we do not contend that our estimates are valid for the case in which one assumes that corn-ethanol completely replaces gasoline; such an analysis is an unrealistic academic exercise with little value for public policy debate related to continuation or moderate expansion of present corn ethanol production.

Admittedly, our studies are quite limited in the sense that they focus on energy and greenhouse gas emissions impacts of corn ethanol production. We have not explicitly addressed issues of cost effectiveness, water pollution, soil erosion, and ethical and moral issues associated with use of cropland for fuel production, while Prof. Pimentel does tackle them. However, we do implicitly acknowledge that such limits to the use of corn ethanol do exist, by refusing in our analysis to examine cases of excessively rapid expansion of corn ethanol output. The cases that we did examine were tied closely to our estimates of rates of productivity increase, such that little expansion of use of cropland was required to meet our projected expansions of ethanol production.