A Rebuttal to "Ethanol Fuels: Energy, Economics and Environmental Impacts" by D. Pimentel

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Since 1995, four different research groups have reported that ethanol from corn exhibits a favorable energy balance. Dr. David Pimentel takes a different position. In his recent article published in this Journal, "Ethanol Fuels: Energy, Economics and Environmental Impact", Dr. Pimentel reported that it takes 1.7 times the energy to produce a gallon of ethanol compared to its energy content. He thus concludes that ethanol produced from corn is not renewable. In this note, we compare and critically evaluate Pimentel's analysis based upon one we are presently developing.

Ethanol and Corn Use:

In 2010, the US will consume about 158 billion gallons of gasoline. Pimentel ridiculously calculates that there is barely sufficient land in the US to supply our entire fuel needs with ethanol from corn. USDA has estimated that about 7 billion gallons of ethanol could be produced from agricultural products in the near future without disrupting food markets. Assuming that was achieved in 2010, ethanol would make up about 4.4% of the gasoline volume.

According to the 2001 USDA Corn Baseline, corn production should increase by 1 billion bushels to 11.2 billion in 2010. Currently, about 58% of corn is used for domestic livestock feed, 11% for food and industrial uses not including ethanol, and 22% is exported. Today, only about 7% of US corn is used for ethanol.

Corn Production:

Much of the discrepancy between Pimentel's study and other recent analyses may be traced to his use of very out-of-date information. USDA reports that the inputs of energy, predominantly fuels and electricity have declined 15% since 1980 while farm output has increased by 33%.

Since 1980, an annual average of 53,200,000 acres ? 2,176,000 have been harvested for grain corn in a 9-state area where ethanol is produced. The 3-year average yield in bushels per acre rose from 109 for 1980-1982 to 140 in 1998-2000. It is hard to envision that corn production is not sustainable in light of these dramatic gains in yield. While yield has increased, the three-year average N, P, K fertilizer inputs have declined from 1.13, 0.44, 0.53 pounds per bushel in 1991-93 to 0.93, 0.34, 0.42 pounds per bushel in 1998-2000. At the same time, herbicide and insecticide use has declined from 0.029 to 0.018 pounds of active ingredient per bushel.

Ethanol Co-products:

Essentially all new ethanol production is based on dry-mill technology. Dry mills produce a co-product called dried distillers grains (DDGS) that amounts to about 1/3 of the input corn weight and contains essentially all of the oil, protein and micronutrients in the original corn. Data from a number of feeding studies clearly demonstrates that DDGS is directly substituted for whole corn or soybean meal in the animal diet.

Use of Ethanol as a Fuel:

Table 1 provides a comparison of key assumptions. Both analyses are based on net or lower heating value. Primary energy relates to the direct input such as diesel fuel for tractors. We also include energy for extraction, refining and transportation of the primary energy sources (total basis). Pimentel assumes an energy input associated with labor and equipment manufacture. Energy in machinery and labor are very small. For ethanol manufacture, Pimentel estimates this might be 3% of the total energy input. Pimentel has estimated the energy consumption for corn farming based upon yields and fertilizer inputs consistent with the early 1990's. Our fertilizer energy input is based upon 1987 and 2000 US industry energy input surveys. Pimentel used the results of a UN FAO analysis of the world fertilizer industry. Pimentel calculated that the energy input for irrigation amounted to almost 30% of the total energy in corn. Based upon the 1997 USDA NASS Farm and Ranch Irrigation study, we found that his estimate is an order of magnitude high. Pimentel reported that the energy used to manufacture ethanol is 70,000 BTU/gal, characteristic of 1979 technology. In 2000, the industry average dry mill consumed 49,252 total (45,173 primary) BTU/gallon. Pimentel assumed an ethanol yield of 2.5 gallons per bushel of corn. The 2000 dry-mill industry average was 2.68. Pimentel ignores any value to the co-products. In our analysis, we assign a credit for DDGS production since its use reduces the quantity of corn fed to livestock.

Table 2 compares the Pimentel energy balance with the one developed by us. The energy balance reported by us is net positive by about 30%.

Discussion:

By using old data and questionable assumptions, Pimentel draws the wrong conclusion about corn agriculture, and the use of ethanol as it relates to sustainability and domestic energy policy. Even if ethanol energetics were not favorable, there is an argument to be made in favor of ethanol. We estimate that on an energy basis, only 0.13 BTU of petroleum are used to produce a BTU of ethanol. Since the root of our short-term energy problem is related to liquid fuels, ethanol should be viewed as an extremely effective way to convert natural gas and coal into liquid fuel energy. Since corn-based ethanol has a positive energy balance, it necessarily has a positive impact on climate change.

The details of this analysis are available by E-Mail at mgrabosk@mines.edu.

Table 1
Comparison of Key Assumptions

	Pimentel	This Work
Machinery	Yes	No
Corn Yield	127	140
N fertilizer	33,484	22,567
N-rate	1.02	0.96
Irrigation	$4.935*10^6$	$0.422*10^6$
Manufacture	69,330	49,252
Ethanol	2.5	2.68
Co-product	No	Yes

Table 2
Comparison of Energy Balances
Per gallon basis, LHV

	Pimentel	This Study
Ethanol fuel	76,000	76,000
Corn	55,800	20,546
Manufacture	74,925	50,747
Co-products	0	(12,351)
Inputs	130,725	58,942
Net Energy	(54,725)	17,058