THE NET ENERGY VALUE OF CORN ETHANOL:

IS IT POSITIVE OR NEGATIVE?

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INTRODUCTION

The net energy value (NEV) of ethanol is the difference between the energy content of ethanol and the energy used in producing and distributing it.

Despite the advent of a national ethanol mandate, ethanol's "real" NEV remains a controversial and, from an analytical standpoint, unresolved issue. Ethanol proponents, most notably the U.S. Department of Agriculture, assert that corn ethanol has a positive NEV (i.e., ethanol provides more energy than is used to produce it). Others, most notably Professors David Pimentel and Tad Patzek, assert that corn ethanol has a negative NEV (i.e., ethanol provides less energy than is used to produce it).

RECENT ESTIMATES OF ETHANOL'S NEV

Table 1 shows three recent estimates, *as published*, of ethanol's NEV.

Table 1: Published Estimates of Corn Ethanol's NEV

Source	Date	Estimated NEV			Ref.
U.S. Department of Agriculture	Jul-02	21,205	BTU/gal	HHV	(1)
U.S. Department of Agriculture	Oct-04	30,528	BTU/gal	LHV	(2)
Pimentel and Patzek	Mar-05	-1,467	Kcal/liter	LHV	(3)

References

1 *The Energy Balance of Corn Ethanol: An Update*
H. Shappouri, J. A. Duffield, and M. Wang
U.S. Department of Agriculture

2 *The 2001 Net Energy Balance of Corn Ethanol*
H. Shappouri, J. A. Duffield, A. McAloon, and M. Wang
U.S. Department of Agriculture, Report No: AER-814

3 *Ethanol Production Using Corn, Switchgrass, and Wood;. .*
D. Pimentel and T. W. Patzek
Natural Resources Research, Vol. 14, No. 1

As Table 1 indicates, these estimates are hard to compare, in large part because of differences in units of measure, scope, and technical premises (e.g., HHV vs. LHV). Similarly, the analyses underlying these estimates are hard to evaluate.

COMPARISON OF THE RECENT NEV ESTIMATES

To facilitate discussion and further analysis of ethanol's NEV, MathPro Inc. has prepared a side-by-side comparison, on a consistent basis, of the three estimates of corn ethanol's NEV shown above, shown in **Table 2 (next page)**. The table shows the detailed accounting of energy inputs for each estimate, adjusted to place the estimates on a consistent basis:

- All energy inputs to ethanol production are expressed in BTU/gallon of ethanol.
- Ethanol's energy content and all energy inputs are expressed as lower heating values (LHV), (as opposed to the higher heating values (HHV) used in the 2002 USDA estimate).

The USDA estimates are weighted averages of estimates for wet-mill and dry-mill ethanol plants, based on survey data of different vintages. They reflect the assumptions that: ". . . fertilizers are produced by modern processing plants, corn is converted in modern processing facilities, farmers achieve normal corn yields, and energy credits are allocated to [ethanol] co-products."

The Pimentel-Patzek estimate applies to dry-mill plants and reflects ". . .average corn yield using average production technology. . .," ethanol production in a ". . . modern ethanol plant," and energy credits allocated to co-products.

The 2004 USDA estimate is similar to the 2002 estimate, *except* in the method used to estimate the energy credits allocated to ethanol co-products. In the 2002 USDA estimate (and the Pimentel-Patzek estimate), the co-product energy credit is the estimated energy used in producing animal feed (e.g., soybean meal) that can be displaced by ethanol's co-products (e.g., distillers dry grains with solubles). This is the accepted method of handling co-product energy credits. By contrast, the co-product energy credit in the 2004 USDA estimate is the result of an unexplained calculation procedure having nothing to with feed substitution.

As Table 2 indicates, the NEV estimates reflect sharp differences in four energy use categories:

- *Energy used in corn production*: The USDA estimates (20.2 K BTU/gal in 2002 and 18.7 BTU/gal in 2004) are about half of Pimentel-Patzek's (37.9 K BTU/gal).
- *Energy used in corn transport*: The USDA estimates (2.1 K BTU/gal in 2002 and 2004) are less than half of Pimentel-Patzek's (4.8 K BTU/gal).
- *Energy used in ethanol production*: Both USDA estimates (46.7 K BTU/gal in 2002 and 49.7 BTU/gal in 2004) are significantly less than that of Pimentel-Patzek (56.4 K BTU/gal).
- *Co-product energy credit*: The 2002 USDA estimate (-13.5 K BTU/gal) is twice that of Pimentel-Patzek (-6.7 K BTU/gal). The 2004 USDA estimate (-26.3 K BTU/gal) is twice the 2002 USDA estimate and four times the Pimentel-Patzek estimate.

In addition, the NEV estimates reflect differences in energy accounting frameworks. The Pimentel-Patzek estimate includes energy embodied in (1) farm machinery and irrigation used in corn production and (2) process water and process equipment used in ethanol production. The USDA estimates include none of these line items.

Table 2: Side-by-Side Comparison of Published Estimates of Corn Ethanol's NEV (BTU/gal ethanol, LHV)

		Adjusted Estimate		
	Note	USDA 2002	USDA 2004	Pimentel and Patzek
Energy Use by Category				
Corn Production		20,243	18,713	37,890
Seed		91	227	2,428
Fertilizer	a	8,172	10,177	15,333
Energy	b	10,401	6,474	6,733
Chemicals	c	1,427	1,106	4,202
Custom work/labor		1,265	594	2,157
Input hauling		249	76	789
Farm machinery	c	-	-	4,753
Irrigation		-	51	1,494
Corn Transport	e	2,121	2,120	4,837
Ethanol Production		46,662	49,733	56,441
Thermal energy		42,521		38,383
Electricity		4,141		15,188
Process water		-		2,389
Equipment	f	-		481
Co-product energy credit	g	(13,471)	(26,251)	(6,685)
Ethanol Distribution	h	1,488	1,487	-
Energy Accounting				
Total Energy Input to Ethanol		57,043	45,802	92,482
Energy Content of Ethanol		76,330	76,330	76,330
Net Energy Value of Ethanol				
BTU/gal		**19,287**	**30,528**	**-16,152**
% of ethanol energy content		**25%**	**40%**	**-21%**

Notes

a Energy used in producing nitrogen, phosphorus, potassium, and lime fertilizers
b Diesel fuel, gasoline, LPG, natural gas, and electricity used in corn production
c Energy used in producing herbicides and pesticides
d Energy embodied in farm machinery and equipment used in corn production
e Energy used in transporting corn from farm to ethanol plant
f Energy embodied in equipment used in ethanol production
g Share of total energy input allocated to co-products of corn-ethanol
h Energy used in transporting ethanol from plant to blending site
i USDA estimates are for weighted average of wet-mill and dry-mill ethanol plants
j Pimentel & Patzek estimate is for dry-mill ethanol plants

RESOLVING THE ISSUE OF CORN ETHANOL'S NEV

The controversy surrounding ethanol's NEV will continue as long as published estimates of corn ethanol's NEV differ widely, as these three do, and pressure to increase national ethanol use continues. A sound and widely accepted estimate of ethanol's NEV would serve the national interest.

Any future effort to develop such an estimate should focus on all of the analytical issues described here. The energy used in corn production, corn transport, and ethanol production are matters of agricultural economics. Estimating the co-product energy credit requires a comprehensive NEV analysis of the animal feeds (e.g., soybean meal) displaced by ethanol co-products, using established principles of net energy analysis. Defining the appropriate energy accounting framework likewise involves the principles of net energy analysis. None of these analytical issues are matters of refining or energy economics.