

# R-Squared

Telling It Like It Is

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## **How Reliable are Those USDA Ethanol Studies?**

### **Introduction**

The pro-ethanol contingent is quick to point to certain studies published by the USDA to support the claim that the energy balance of grain-ethanol is positive. Many anti-ethanol advocates will point to studies by Professors Pimentel and Patzek (1) to support claims that the energy balance is negative. Say what you will about the Pimentel and Patzek studies, but they have one thing going for them that that USDA studies do not: They have been published in [peer-reviewed](#) journals. Why does this matter? Peer reviewed papers have been examined by reviewers familiar with the subject matter (but who are not colleagues of the authors) who are looking for deficiencies or gross errors. Peer review is no guarantee that errors won't slip through, but it is a check on papers that establishes that they have met certain scholarly guidelines. Peer review can be a pretty rough ordeal, but does a pretty good job of weeding out poor arguments.

Now, having said that, I will acknowledge that some of the criticisms of the data that Pimentel used may be legitimate. So, the purpose here is not to defend Pimentel's work, but instead to take a rigorous look at the USDA studies. In 2002, the pro-ethanol USDA released a paper by Shapouri, Duffield, and Wang in which they claimed that the energy balance of corn-ethanol was 1.34 (2). In other words, for every 1 BTU you input into the process, you got 1.34 BTUs back out. I analyzed these arguments in an earlier essay, and showed that proper accounting shows that the energy balance is actually 1.27 (using their assumptions, and as long as co-product credits are included) over an average of the 9-highest corn-producing states. Extrapolating this energy balance outside this area is inappropriate. Even within these 9 states, Nebraska, which must irrigate its corn, used substantially more BTUs to produce the corn. The energy balance for Nebraska – assuming for a moment that all of their other assumptions were correct - is 1.21 based on the data in the 2002 paper.

### **Incorrect Assumptions in the 2002 Report**

However, all of their assumptions were not correct. In a 2004 update (3), they note that the estimate of the energy required to produce a pound of nitrogen fertilizer was much too low in the 2002 report. They reported 18,392 BTU/lb in their 2002 report. For the 2004 report, Shapouri consulted a fertilizer manufacturer, and was told that the actual number is about 24,500 BTU/lb. So, Shapouri underestimated this energy input by 25%.

In addition, they also acknowledged that they underestimated the amount of energy used to produce seed corn. They had estimated in 2002 that it took 1.5 times the amount of energy for normal corn, but actually found out that the true number is 4.7 times the amount of energy for normal corn. So, they underestimated this energy input by almost 70%.

They did not include any secondary energy inputs (such as the energy to actually produce an ethanol plant) in either their 2002 or 2004 paper, saying the data is "old and outdated". So, here is an energy input that they simply ignored.

They report higher yields in the 2004 report (weighted avg. of 139.3 bushels per acre for in the 2004 report versus 121.9 in the 2002 report). However, some states saw very little change in their yields between the two reports. Nebraska, for example, increased from 130 bushels per acre to 133.7, a gain of less than 3%.

### **Analysis of the 2004 Report**

Again, they only focused on the 9-highest corn producing states. Nebraska again provides a perfect example of how the energy balance tends to get much worse as you move away from the best corn-producing areas. The energy input for Nebraska is almost 20,000 BTU/bushel higher than for the 9-state weighted average, primarily due to their need to irrigate. So, their energy balance will be much worse than the average number that was ultimately calculated.

Overall, they lowered their estimate for the total energy input into the corn-growing process from 57,476 BTUs/bushel to 49,753 BTUs/bushel. However, Nebraska came in at almost 69,000 BTUs/bushel.

The most amazing thing, though, is that they reported an overall energy balance of corn ethanol of 1.67 in the 2004 report, versus 1.34 (their number) in the 2002 report. Why the huge change? Did the process improve by that much? No, they are just employing ever more sophisticated sleight of hand. What they did is to allocate the energy used in the process to by-products and ethanol separately. This is a valid way of accounting for the energy, if it is done correctly. However, the way they did it looks highly suspicious. It would be quite easy to over-allocate energy to the by-products (especially if one had an agenda), making the ethanol portion show less energy than it actually used. This appears to be exactly what they did.

In 2002, their calculation resulted in 81% of the energy allocation going to ethanol. In 2004, they only allocate 64% of the total energy to ethanol production (Tables 3 and 4), dramatically "improving" the energy balance. They have acknowledged that they changed their accounting methods from their 2002 report, now using an Aspen model to allocate energy. I have plenty of experience with Aspen models, and I can say that it is imperative that you validate your assumptions. If you do not - and I can see no indication that they did - it is nothing more than garbage-in, garbage-out.

Here is an example of how invalid assumptions can lead to an invalid answer. They calculated that the total energy cost for the ethanol conversion step was 49,733 BTUs/gallon, but then allocated almost 20,000 BTUs of that to the by-products! Hello? The only reason you do a distillation is to purify the ethanol. That step has to be completely allocated to ethanol. By allocating some of these inputs to by-products, the impression is left that it took less energy to purify the ethanol than it actually did.

What is stated explicitly is that, ignoring co-product credits, they have energy inputs of 72,052 BTUs to produce 76,375 BTUs of ethanol, for an EROI of 1.06. They are allocating credits based on an Aspen model which is not publicly available, so it is impossible to check their assumptions. I can say that based on the way they have allocated some of the conversion energy to the co-products, that they have made invalid assumptions.

But, we can take the co-product value they reported in 2002 and estimate a more valid EROI. In 2002 they estimated co-product value at 14,372 BTU/gallon of ethanol. If we add that to the BTUs of the ethanol they produced, we get  $(76,375 + 14,372)$  BTUs out, or 90,747 out. Given their input of 72,052 BTUs, then their EROI with co-products is  $90,747/72,052$ , or 1.26. That is a terrible EROI, and is even worse than what they calculated in 2002. This is not entirely surprising given that they admit that they significantly underestimated certain inputs (and left secondary inputs completely out of the equation). The 1.67 number is a fantasy based on

very selective accounting.

## Summary

Given the selective accounting employed in the USDA papers (both 2002 and 2004), it is doubtful that it would have passed peer-review without substantial modification. While I have my reservations about the data used by Pimentel, the USDA work is very shoddy in comparison. It has all the ear-marks of an agency attempting to push a political agenda. Certain data were selectively omitted from the energy calculation. The reported EROI of 1.67, parroted by the pro-ethanol contingent, completely breaks down under close examination. It is simply inaccurate and irresponsible to claim this EROI given the factors examined in this essay.

## References

1. Pimentel, D., and Tad Patzek (2005). *Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower*. Natural Resources Research 14, 1 (March): 65-76.
2. Shapouri, H., J.A. Duffield, and M. Wang. 2002. *The Energy Balance of Corn Ethanol: An Update*. AER-814. Washington, D.C.: USDA Office of the Chief Economist.
3. Shapouri, H., J.A. Duffield, and M. Wang. 2004. *The 2001 Net Energy Balance of Corn Ethanol*. Washington, D.C.: USDA Office of the Chief Economist.  
*posted by Robert Rapier at [5:40 PM](#)*

## About Me

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I am a chemical engineer in the energy business. I am concerned about the impact of Peak Oil on society, and I am passionate about alternative energy and sustainability. However, I think grain-based ethanol is mostly a boondoggle, and I have testified against an ethanol mandate at the Montana state legislature. I have research experience with cellulosic ethanol, butanol production, and gas-to-liquids (GTL). I am also an advocate for improving science education in the U.S.

<http://i-r-squared.blogspot.com/2006/03/how-reliable-are-those-usda-ethanol.html>