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Supplementary Material

Summary of Review Reports: Pimentel *et al.* Biofuel Impacts on World Food Supply: Use of Fossil Fuel, Land and Water Resources. *Energies* 2008, *1*, 41-78.

Energies Editorial Office

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This summary aims to solve the controversy about the publication of a paper published in *Energies* by Pimentel *et al.* recently [1]. In total 10 review reports have been collected from peers, whereas three reports have been received from referees selected and invited by the *Energies* Editorial Office, and where seven review reports have been collected and sent to the *Energies* Editorial Office by Dr. Bruce Dale. The reviews are listed in its original state, and have only been edited for the paragraph formatting to fit the *Energies* journal style.

Review Reports Collected by the Energies Editorial Office (Received: 1, 2 and 4 August 2008)

Review A

Subject: Biofuel Impacts on World Food Supply: Use of Fossil fuel, Land and Water Resources Pimentel (and colleagues) is an amazing machine for generating massive numbers of good and sometimes very good papers on what I perceive as the main issues of the day. Not everyone accepts his "limits to growth" perspective, and many believe his analyses are at least partially flawed, but we must give him a lot of credit for approaching important issues quantitatively and putting his numbers and their sources out there so if you disagree you can have explicit numbers to argue with. There are some problems with many of these papers.

1) Pimentel tends to quote himself as if he alone were the only source of the numbers where in fact there are often other numbers, sometimes resulting in rather different conclusions. Now my personal sense is that Pimentel's numbers are usually reasonably (but not perfectly) defensible. But I think he does himself a disservice by not quoting these other analysts. It really does not make any difference whether EROI from corn is 0.8 to 1 or 1.6:1 as any of them are ridiculous to

use as a fuel (oil is still say 15-20:1) and his case does not require only his numbers, although it is perfectly permissible for him to say he prefers his own numbers. But scientific honesty demands you quote other such analyses.

2) Pimentel often uses normative words (better) than non normative words (larger). HE wears his prejudices on his shoulder. Again I think this is not necessary: let his facts speak for themselves.
3) Pimentel's writing style is sort of throw it out with lots of analyses and let the reader organize the information. It is not poorly organized, but there is not much flow, and I think it can be made more readable. As it is it is rather pell mell and unstructured. I think he can make it more of a story with a little work. I am going to go back in and see if I can make a suggestion or two.
4) I would like to see him use EROI rather than the ratio he does, and he might quote Cleveland et al 1984 and Hall et al 1986 as sources of the concept (or also his original corn work. Since we are interested in output relative to the input I feel it is much more useful than the opposite ratio he uses.

But overall this paper does a great service by putting all this information in one place and showing the very serious limitations of using biomass for fuel. I am very enthusiastic about its publication.

Review B

This is a monster attempt at quantifying and articulating a controversial and urgent subject. The paper is clearly written by different authors as it doesn't flow particularly well, but the general facts presented (with exceptions noted below) are sound, especially as the authors utilize wider boundary analysis than biofuel proponent studies. There are many adjective qualifiers in the text that connote good or bad that can be removed. The entire text could use a good editing. The section on oil and gas peaking is outright incorrect –there are many other sources to use other than personal correspondence with Walter Youngquist, who while a pioneer in the field, holds one viewpoint of many on when oil peaks. This is not the papers main point so the language there should be softened so as not to detract from the biofuel research. It is significant enough to know oil is peaking in the next decade. The authors also point to a 48% energy balance for corn ethanol compared to most other analyses showing 10-70% positive energy balance. While it seems that this is due to using more inclusive inputs (wider boundaries) it is not explicitly stated 'why' the big difference. Also, energy quality is not mentioned. In theory, it would be possible, even desirable to follow an energy breakeven technology to upgrade abundant low grade energy into something of value to society, in this case liquid fuels. (but due to negative externalities of corn, ethanol is NOT one of these examples – but energy break even concept is red herring) Below are some more specific suggestions/comments. As I mentioned – an impartial editor should go through the whole thing. In sum though, a great contribution. Pg 3 "This is the equivalent of an average of 3,800 kcal per day, whereas the average male should be eating only 2,400 kcal and female 2,000 kcal per day" The word 'should' is unscientific. Change to 'only requires' or some such. Pg 4 "However, world irrigation has declined about 10% during the past 10 years (Postel, 1997)" Is this the 10 years prior to 1997? If so that should me made clear, especially as the next sentence asserts that it is of 'critical importance'. If not it should be updated. Next sentence is also unclear. "17% of the crops that are irrigated provide 40% of the world food supply" Does this mean

17% of only the irrigated crops provide 40% or 17% of all crops are irrigated and these provide 40%? Pg 4 “Reports agree that the world reached peak oil and natural gas availability in 2007.” Absolutely false. First of all we won’t know we’ve reached peak until many years past the actual peak. Secondly, January 2008 we hit an all time high in crude oil production. Most experts expect a peak between 2005 and 2040. There is no evidence of a 2007 peak as yet. On natural gas, world production is not expected to peak until well after 2020. This sentence needs to be defended or removed. Pg 6 “In the U.S., natural gas supplies are already in short supply: it is projected that the U.S. will deplete its natural gas resources in about 20 years (Youngquist and Duncan, 2003).” The last 2 years we have had a glut of natgas. New horizontal drilling in Haynesville Shale project 2.5+ trillion cubic feet in 2010 (after which a rapid decline). There is a long term NG problem in North America but the way this is worded is specious and misleading. Pg 8 The first few paragraphs refer to ‘calculations’ –where are the calculations (also it seems this page all of a sudden written by different author – doesn’t flow with preceding pages) Pg 8 “absolutely not feasible to use ethanol as a replacement for U.S. oil.” Should read “U.S oil consumption.

Review C

This is a comprehensive, coherently organized and well-written report on biofuel impacts. The title is a little misleading, as the article is more about the problems and limits of biofuels themselves, in addition to their inability to solve the world’s food problems. If the authors want to retain this theme, then the conclusion needs rewriting. It seems, though, that the article is ultimately about the ill-advised rush into biofuels, given all their negative externalities and inability to solve the energy crisis anyway. P4 “..world irrigation has declined…” – what is the measure here? P12 3rd substantive sentence is missing a verb or something… P14 1st sentence of 1st complete para – syntax is awkward. And in fact the whole para is awkward, with short sentences not well linked, and the final sentence lacking resolution to the para… The same is true for the following paragraph, which needs better phrasing and linking.

Review Reports Collected by Dr. Bruce Dale (Received: 27 August 2008)

Review D

I do not have time to fully review every part of this paper since seems to be written to cover a very broad area of topics within the subject field, and it would take weeks to cover all that material. Consequently, I have focused on selected areas relating to plant science, crop production, and commercial biofuels.

In general I did not follow the intent of this proposed paper. There is clearly no scientific hypothesis being tested. There is no original data, for example, from actual ethanol production situations. Clearly, it does not fit the style of a review paper since it is very one-sided: The data is second hand and selected to fit a particular assertion, although in many cases the data does not even justify the assertion being made. There are no comparative tables using peer-reviewed, or actual data for current situations.

If the objective was to state that biofuels cannot replace all liquid transport fuels then this is already well-known and is not an innovative insight.[McLaren, J. (2008). The Economic Realities, Sustainable Opportunities, and Technical Promises of Biofuels. AgBioForum, 11.]
If the intent was to demonstrate that there are too many people in the world, then the points made could support this. However, I would submit that we moved forward from Malthusian approaches many years ago, largely based on the application of new technologies to crop production. Decreasing human population is not a practical option.

ADDRESSING GENERAL POINT MADE BY THE AUTHORS

The authors are out of touch with the current situation and do not seem to understand the industry nor the forces involved. For example, use of old thinking and/or statistics with a projection of these to the future requires that the technology applications of recent years be ignored (as the authors have done here).

The World food will run out assertion….

The title starts with “Biofuel Impacts on World Food Supply” yet the paper does not address this in any meaningful way. Today, biofuels have almost no impact on world food supply. First, the volume of biofuels produced compared to global food production is very small (<4%), and within the noise level for measuring total food production. The following table shows the FAO statistics for world food production in the crop groups that are currently used for biofuel production. Data is in metric tonnes (MT). Two years are shown to avoid a spike year. The global total volume for these groups in 2007 was 3226MM MT.

Production Quantity

	year						
country		item	2006			2007		
	World +	Cereals,Total +	2228039021	tonnes	A	2340724678	tonnes	A
	World +	Oilcrops Primary +	145784722	tonnes	A	144713549	tonnes	A
	World +	Roots and Tubers,Total +	727739266	tonnes	A	742055948	tonnes	A

A = May include official, semi-official or estimated data

FAOSTAT | © FAO Statistics Division 2008 | 18 August 2008

In 2007, the global production of biuofuels was ~14B gal (12B gal EtOH and ~2B gal biodiesel). Typically, 1 MT will produce 110 gallons. Therefore the amount of global relevant food crop volume used for biofuels in 2007 was 3.9%. Conclusion: the “Biofuel Impacts on World Food Supply” is insignificant.

It is well-recognized in the industry that in the longer-term, it is possible that at some future point there will be some conflicts between food and fuel from agriculturally productive land but, as shown above, that has not happened to any significant extent to-date.

Within the US, for example, corn ethanol has expanded due to the presence of available corn (note that even today we still export 2.5 B bu of corn, enough to make another 7B gallons of ethanol if we chose to do that). In the case of biodiesel from vegetable oil, the edible demand has been greater than the value for biodiesel. Consequently, we see that biodiesel in the form of fatty acid methyl esters is very limited (only 450MM gal), and is based on locally excess, used oil, or oil that is no longer suitable.

It is also recognized that while some fossil fuels (natural gas, coal) have a longer life-term, based on available reserves, crude oil has a relatively short future. An alternative to current liquid transport fuels is required. Since crude oil is on the verge of running out then there will be no conflict with using more of it in the future – it is self-correcting issue.

The "using corn for ethanol somehow causes malnutrition" assertion…

That "Nearly 60% of humans in the world are currently malnourished, so the need for grains and other basic foods is critical" may be true but it has very little to do with biofuels. First, how can a 3.9% change in utilization result in a 60% impact on human malnutrition. Secondly, malnutrition is not the same as lack of nutrition. In many cases, there is not a shortage of starch – but malnutrition is typically due to a lack of protein and/or appropriate vitamins in the diet. To imply that corn ethanol is responsible for such a situation is a complete misjudgment. First, yellow dent corn (as is grown in the US) is not a major food, but rather a feed. Secondly, making ethanol uses the starch and leaves the protein to be returned to feed system, in a more condensed form. [Schlicher, M. (2008). Biofuels in the US: Today and in the Future. AgBioForum, 11]

The authors quote state that "reports that using food grains to produce biofuels is already causing food shortages for the poor of the world". As already described, corn is not a food grain and the protein is upgraded after making EtOH. The major food grains are typically wheat and rice – these crops are not used for making biofuels. In a very few cases, the residue after processing these crops is used for making EtOH but this is on a small scale and uses parts that are not used for food.

The food price increase is due to ethanol assertion…

The authors state that "Using corn for ethanol increases the price of U.S. beef, chicken, pork, eggs, breads, cereals, and milk from 10% to 30%" Neither simple logic, calculation, nor the studies done support this assertion. Overall, the impact of corn ethanol on food prices may have been in the ~3% range: although the recent drop in corn price has lowered that considerably.

In reality, several factors impact commodity prices and trade -- food prices are impacted by several factors that are not related to the basic feedstock. On average, only about 19 percent of the price of food can be attributed to ingredients. Marketing and transportation costs make up a much higher portion of total costs: the increase in the price of energy and gasoline had a large impact on food prices.

The Center for Agricultural and Rural Development (CARD) at Iowa State University repeated the study that it had done earlier in 2007 and reached the same conclusions -- a 30 percent increase in corn prices would increase consumer food prices by only about 1.1 percent. [Emerging Biofuels: Outlook of Effects on U.S. Grain, Oilseed, and Livestock Markets. Simla Tokgoz, Amani Elobeid, Jacinto

Fabiosa, Dermot J. Hayes, Bruce A. Babcock, Tun-Hsiang (Edward) Yu, Fengxia Dong, Chad E. Hart, and John C. Beghin. Report 07-SR 101. July 2007]

The USDA have published information showing that price increases were due to a combination of several factors and not just to biofuels production. See http://www.ers.usda.gov/Publications/WRS0801/

The corn energy balance situation….

This has been already debated for several years. The majority of studies disagree with Pimentel analyses that use out-dated numbers and practices. Actually, the energy debate is irrelevant since the Second Law of Thermodynamics always wins, but for those who believe that is not true, there are ~14 studies with a positive energy balance outcome.

SOME SPECIFIC POINTS MADE BY THE AUTHORS

Yield

The authors state that corn yields are decreasing. While year-to-year variability still exists, corn yields are following an increasing trend – possibly due to new technology applications. [McLaren, J. (2005). Crop biotechnology provides an opportunity to develop a sustainable future. Trends in Biotech, 23, 339-342]. The biotechnology traits (drought tolerance, agronomic efficiency, fertilizer use, etc.) that are in the pipeline for commercial development have the potential to double the unit yields.

Soil erosion/conservation

While soil erosion was a problem in the mid-1900's, new technologies have changed the landscape. Soil conservation has been a growing trend in US agriculture, with about 25% of crops being grown under no-till.

See National Resources Conservation Service: http://www.nrcs.usda.gov/

The authors state "When conservation technologies, like organic agriculture, are employed, increased yields may result because water, nutrients…"

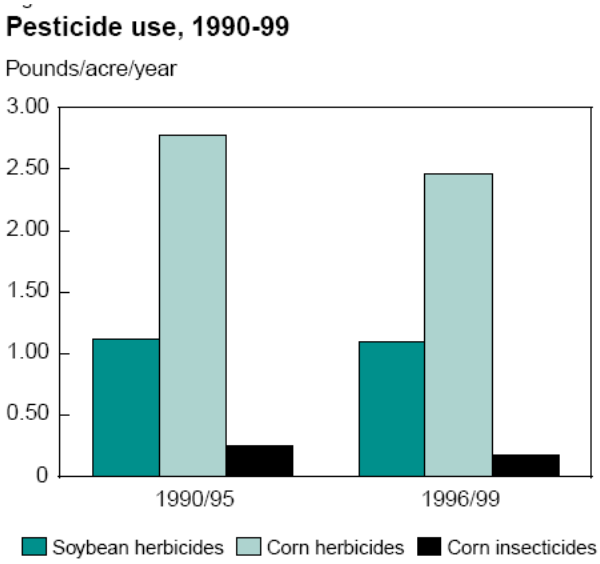
Organic farming does not produce obvious advantages, especially on a large-scale. There is even a danger of less food production and less healthy food production. To suggest otherwise is irresponsible and may lead to major food shortages. [Goklany I., Office of Policy Analysis, U.S. Department of the Interior. (2002). The Ins and Outs of Organic Farming. Science, 298, 1889 – 1890]

The level of farm output in 2004 was 167 percent above its level in 1948 for an average annual rate of growth of 1.74 percent. Input use actually declined in aggregate (labor has been departing the sector and land use has declined slightly, while capital influx has been modest), so the positive growth in farm sector output is wholly due to productivity growth. This contrasts with a 3.7-percent annual output increase in the private nonfarm sector, with productivity growth accounting for a little more than a third of the economic growth. [http://www.ers.usda.gov/Data/AgProductivity/] Note that this level of productivity improvement was achieved by changing form organic type practices to modern

technologies, that produce more healthier food in a more sustainable manner – otherwise we might not be here today.

Insecticides

The authors state that "Corn production uses more insecticides than any other crop grown" and quote data from several years ago. This level of knowledge is out-dated and shows a lack of understanding of modern crop production. The adoption of the biotech genes for the control of European corn borer and corn root-worm have had a major impact on insecticide use. Yet, the authors fail to mention any of these or similar recent improvements. The following chart shows the decrease in corn pesticide use:



Sources: Fernandez-Cornejo (2000) based on USDA data (USDA, 1991, 1992, 1993, 1994, 1995, 1996, 1997c, 1998b, 1999a, 2000a).

Ethanol use

The authors focus a large number of negative comments on corn ethanol. Presumably, this is because corn ethanol is a commercial product today. The fact that current ethanol is used as an oxygentate [~95% of EtOH is used as E10 or less] to replace MTBE is ignored. The US E10 market alone is 15B gal EtOH. Therefore, as an oxygentate ethanol is making a large contribution to the US liquid fuel market – that $20B has been invested and that petroleum companies are using the product is confirmation.

Corn ethanol has a limited volume in the future – this is known. That a product cannot take 100% market share is not a reason to stop using it, especially when there is a need for the features that it delivers to the consumer. Other feedstock are being explored via research but none are yet ready as commercial alternatives to corn for the oxygenate ethanol required.

The authors also state the more research is needed in alternative renewable energy; but no specific are given as to what is intended here. Several types of possible future fuel sources are being

researched. Cumulative contributions from several types may be a possible solution. However, we should also consider the possibility no renewable liquid transport fuels will emerge to cover 100% of the market. That research is required on several fronts is already known and is underway.

APPENDIX

USDA Report with recent data on corn production and use.

August 14, 2008

Numbers Show How Livestock Benefits From Ethanol (8-14-08)

When the U.S. Department of Agriculture came out with corn production numbers Tuesday that were revised upward to a bountiful 12.3 billion bushels, two areas of corn demand also saw an increase – the amount projected for ethanol use was increased by 150 million bushels to 4.1 billion bushels, and the corn for livestock feed was boosted 100 million bushels to 5.3 billion.

Although the USDA estimates that more corn will go into livestock feed than any other use, these figures leave out another important statistic, according the National Corn Growers Association – the amount of livestock feed that will be produced from the same corn that goes into ethanol.

In fact, if the USDA projection holds true, then there will be an additional equivalent of 1 billion bushels of livestock feed derived from the corn for ethanol, in the form of distiller grains (25.3 million metric tons), corn gluten feed (2.6 million metric tons) and corn gluten meal (500,000 metric tons).

“Critics lament how much corn goes into ethanol but often ignore the coproducts and calculate too high a figure,” said NCGA President Ron Litterer. “Distillers grains offer a high-protein feed for livestock and help us meet all needs.”

While the industry is evolving and becoming more efficient, each bushel of corn, Litterer notes, can produce approximately 2.8 gallons of ethanol, in one of two different ways.

- In the dry milling process, each bushel of corn produces 17.5 pounds of distillers dried grains with solubles in addition to the ethanol. A high-protein livestock feed, corn distillers grains contain all the nutrients from the incoming corn minus the starch.
- In the wet milling process, 13.5 pounds of gluten feed are produced from each bushel of corn used. Corn gluten feed is rich in highly digestible fiber and is processed as either dry pellets or wet feed. These feeds are widely used for dairy and beef cattle, poultry, swine and pets. This process also results in 2.6 pounds of gluten meal, a high-protein concentrate that is excellent cattle feed providing a high level of rumen bypass protein. Finally, this process also results in 1.5 pounds of corn oil from each bushel used.

“When you take into account the use of coproducts, and shift a billion bushels of corn from the ethanol to the feed category, you get a better sense of where the corn is really going,” Litterer added. “Actual ethanol production – as projected by the USDA for 2008 –

will consume approximately 22 percent of the total 2008-09 corn supply of 13.9 billion bushels."

Review E

The potential value of this paper is all but eliminated by its many deficiencies. If it is to be published, it will need extensive revision. Here are some of the general and specific deficiencies that must be addressed in any revision.

General Issues

1. Much of the paper is taken up with calculations of the "net energy" of various fuels (corn ethanol, ethanol from switchgrass, soy biodiesel, palm oil biodiesel, etc.). However, the authors never define explicitly what they mean by "net energy". A specific equation defining exactly how net energy is calculated is needed in any revised manuscript.
2. Based on their previous papers, I believe the authors define net energy as follows: LHV (lower heating value) of one liter of ethanol minus the sum of the LHV of all the fossil fuels (coal, natural gas and petroleum) required to produce that one liter of ethanol.
3. If my understanding of the definition of "net energy" is correct, then the authors should provide a detailed intellectual defense of the rationale for treating one MJ of coal as equal to a MJ of natural gas as equal to a MJ of petroleum (since that is what their calculation of net energy does). It seems obvious that a MJ of coal, natural gas and petroleum are not equivalent in the energy services they deliver. One MJ of coal will simply not deliver the transportation services equivalent to one MJ of petroleum. As a consequence, the market for energy services values one MJ of petroleum as being worth at least 10 MJ of coal when coal is $40 per ton and oil is $120 per barrel. Therefore, how do the authors justify treating one MJ of petroleum as equal to one MJ of coal?
4. The authors do not provide the appropriate comparisons. We do not have a choice between biofuels and some perfect, imaginary fuel. Our choice is between biofuels and petroleum derived fuels. Thus the net energy comparison that is needed is between ethanol and gasoline (since they compete as fuels in spark ignition engines) and between biodiesel and petroleum diesel (since they compete as fuels in compression ignition engines). Any revised manuscript should provide those comparisons.

Specific Issues

1. A recent metaanalysis of ethanol's net energy is not referenced in the present paper (Hammerschlag, et al, attached). Since the metaanalysis is quite unfavorable to Dr. Pimentel's work compared with other net energy studies, it seems only appropriate that that metaanalysis be cited and refuted here.
2. Another prominent recent paper by Farrell, et al (attached), also reached very different conclusions than those of Dr. Pimentel about ethanol's role as a replacement for gasoline. This

paper is cited but not refuted in the present work. Again, is seems only appropriate that any revised paper deal with the criticisms of Dr. Pimentel's work in the Farrell, et al, paper.

3. The data in the Farrell paper can be used to calculate ethanol's net energy (Figure 2) according to what I believe to be Dr. Pimentel's definition of net energy (given above). From that Figure in the Ethanol Today scenario, the net energy of ethanol is +29% while gasoline's net energy is -18%. Any revised paper should address the very different values of net energy obtained via the Farrell data versus those obtained by Dr. Pimentel's work.
4. Specifically, the Supporting Material for the Farrell paper questions much of the data upon which Dr. Pimentel's conclusions are based. Many of those same references are used in the present paper. The revised paper should deal with those criticisms of the Pimentel data.
5. A great many of the references cited in this work are incomplete and cannot be checked to see if the data they supposedly contain do in fact support the papers conclusions. For example, the following references are incomplete since the page from which data are taken is not given:

a. Ali and McBride
b. Arnold and Jongma
c. Barbara
d. Birdsey
e. Blais, et al
f. BP
g. Brees,
h. Briggs
i. Brown
j. And many, many more.

Review F

Land use for food and biofuels is a complex issue of great importance to both the public and the scientific community. A thorough review of the subject is sorely needed in the literature. Unfortunately, this ms. falls far short of the mark. Overall, I feel this review does not reflect the literature available on this topic, nor does it summarize the literature it does cover. Data presented is provided in tables that allow for specific conclusions, but not summary or interpretation of the state of the art on the topic. This ms should not be accepted without major revision. My specific comments are focused on sections 8 and 10, and are listed by page below. Please refer to the marked up pdf for comment placement in the text.

Summary of Comments on Microsoft Word - Energies-12-02-original.doc
Page: 1
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 4:39:42 PM
Cause and effect relationship of statements unclear. What was done in this review to draw these conclusions?
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 4:45:21 PM

biomass energy consumption is still a small proportion of energy use in the majority of countries and energy sectors (eia.doe.gov).
Page: 2
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 4:47:49 PM
some mention of these objectives should be made in the abstract.
Page: 3
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 4:53:14 PM
The word "also" is not needed.
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 4:57:36 PM
More explanation is needed in transitioning between these paragraphs if the goal is to establish a causal relationship.
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 5:19:15 PM
Reference?
Page: 5
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 5:26:38 PM
Table needs more description. what numbers reflect fossil vs. solar energy? What is the accounting method for solar energy use?
Page: 6
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 5:42:19 PM
What of coal?
Page: 7
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 6:15:40 PM
Notwithstanding the release of fossil CO2 to the atmosphere.
Page: 8
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 6:26:05 PM
Some mention of modern wood burning technology e.g.., district heating systems in Scandinavia, would be useful here.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 6:08:51 AM
The more recent USCB 2004 sited for this statistic on previous page would be a preferred reference.
Page: 9
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:16:58 AM
This section would benefit from a more balance and recent review of the literature. Significant omissions have been made in assessing the
European bioenergy research and utilization of wood, the South American experience with sugarcane, and the North American experience with
switchgrass production.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 6:16:10 AM
38% each in cropland and pasture? Statistic does not add up the way it is currently stated.
Author: Emily Heaton Subject: Cross-Out Date: 8/25/2008 6:19:25 AM
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 6:18:58 AM
Would be help to specify liquid biofuels, to agree with earlier statements on wood use in the U.S.
Author: Emily Heaton Subject: Cross-Out Date: 8/25/2008 6:19:41 AM

Page: 12
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 6:36:03 AM
What are the references for gasoline subsidies?
Author: Emily Heaton Subject: Cross-Out Date: 8/25/2008 6:40:15 AM
Page: 13
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 6:49:09 AM
Tilman et al. 2006 make inferences to global abandoned cropland conversion to grassland rather than existing global grassland. This statement
does not really represent the suggestions of Tilman et al. 2006.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 6:52:56 AM
This paragraph confuses annual crop stover removal with perennial grasslands harvested for biofuels. These two systems have dramatically
different soil carbon implications that need to be more clearly distinguished.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:02:46 AM
These estimates do not agree with findings from direct, and much more recent, data on farm scale switchgrass production (Perrin R.K., Vogel
K.P., Schmer M.R. & Mitchell R.B. (2008) Farm-Scale Production Cost of Switchgrass for Biomass. *Bioenergy Research*
Schmer M.R., Vogel K.P., Mitchell R.B. & Perrin R.K. (2008) Net Energy of Cellulosic Ethanol from Switchgrass. *Proceedings*
of the National Academy of Sciences, **105**, 464-469.)
Page: 14
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:06:47 AM
Tilman et al. refers to unmanaged grasslands on unproductive soil. Data from dedicated bioenergy systems indicated far less land is required to
produce equivalent or greater amounts of energy e.g. Heaton E.A., Dohleman F.G. & Long S.P. (2008) Meeting US biofuel goals
with less land: the potential of Miscanthus. *Global Change Biology*, **14**, 2000-2014.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:08:49 AM
This is incorrect; similar amounts of cellulosic material (stalks and leaves) are produced by the corn plant concurrently with grain.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:11:05 AM
Data in this table do not reflect recent and farm scale inputs for switchgrass production in Perrin et al. 2008.
Page: 25
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:22:06 AM
Most of the crops mentioned in this section are grasses. Please use more precise descriptions, particularly in distinguishing annual food crops
and dedicated energy crops.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:21:01 AM
This statement is simply erroneous. Numerous literature sources report high biomass yields from multiple grass species, as well as increases in

soil carbon, organic matter, etc.
Page: 26
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:25:16 AM
This is also true of herbaceous perennial bioenergy crops. Again, more thorough review of the literature should be reflected in statements.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:27:19 AM
Modern biomass utilization technology (cf. Danish literature) differs dramatically from the "fireplace" use described here.
Author: Emily Heaton Subject: Sticky Note Date: 8/25/2008 7:28:35 AM
These findings do not reflect other major contributions on this topic, e.g. the IPCC assessments of biofuel potential.
Page: 33
Author: Emily Heaton Subject: Sticky Note Date: 8/23/2008 5:34:59 PM
Liebman 2008 Reference link not functional.

Review G

The paper as it stands is unacceptable. The topic tackled is undoubtedly of great interest, but to do it justice, three lines of argument would have to be developed:

1) The situation in advanced countries (the US in particular, but also the EU) where food production is close to maximum attainable efficiency, and production of first generation biofuels (particularly bioethanol) is a diversion of land, water and other resources;
2) The situation in developing countries where biofuels are in production – such as in Brazil – where food production is not as close to the efficiency frontier, and where some diversion to energy crops could be satisfied without undue infringement on food production (and where crops might not have much impact on food chains, such as ethanol from sugar cane); and
3) The situation regarding traditional biomass used for cooking and lighting in poverty-stricken countries, where diversion is not the issue and raising agricultural productivity is far and away the principal concern.

These three strands of argument are contained in the text as it stands, but mingled arbitrarily and without any logical separation. The discussion of section 2 on food supply and malnourishment for example mingles assertions that stem from all three sources. Nowhere is the improvement in agricultural productivity associated with the Green Revolution in Mexico et al mentioned. Slowing productivity in the US is asserted as if this applies to the world as a whole – yet the fact is that African countries are producing way below their potential yields because of absence of rational techniques and inputs. Then the malnourishment data are cited, reflecting a huge polarization in the world in terms of incomes and access to agricultural inputs, as if they are a direct result of lowering agricultural yields in the US.

In section 3 on cropland resources, again the assertions are inter-mingled without any clear argument being developed. For example it is asserted ‘By all available measurements the Chinese have

reached the limits of their agricultural system' and '… severe problems [are] looming in the near future'. What is left out here is the extraordinary capacity of China to have raised agricultural yields to the point that it is able to feed itself, with the assistance of some grain imports when necessary. World trade in grains is a good thing surely – and not be viewed as an admission of failure. As for the relevance to biofuel production, nothing is said – and yet again it surely ought to be acknowledged that the Chinese leadership have banned diversion of domestically produced grain to bioethanol production!

In a totally inadequate section 4 on water resources, again the fact that agricultural yields in the US depend on irrigation while in tropical countries monsoonal rains can be utilized is glossed over. The water supply of the US is asserted in one sentence and then another sentence asserting a world situation is made – without any connection. And so on, and so on…

If the authors are prepared to restructure the paper so that it treats the three cases outlined above as separate, and then draw global conclusions based on separate consideration of the three cases, then it could be reconsidered.

Review H

Biofuel Impacts on World Food Supply: Additional Review Comments from Daniel de la Torre Ugarte

Since the mid-seventies global food production have been such as to provide every person with more than a minimally adequate diet; however more than 800 million people are chronically undernourished (Cohen and Reeves). At the same time agricultural prices have fallen dramatically, and remained low for nearly thirty years (FAOSTAT). This hunger situation has prevailed, despite the lower prices for most of the last 30 years, more than 50% below 1960s prices. Which has lead to the consensus that chronic hunger and malnourishment are one piece of a complex intertwined set of social problems. It is linked to poverty; to global economic, political, and social power structures; to modes of development and consumption; and deep-rooted discrimination based on race, ethnicity, gender, and age (Cohen and Reeves).

According to the 2008 World Economic Report (World Bank), the production side of the agricultural and food equation indicates that of the 5.5 billion people on Earth, 2.5 billion are in households directly and indirectly involved in agricultural productive activities; and of this 1.5 billion are small- holders agricultural households. Moreover, 80% of the people suffering chronic hunger and malnutrition live in rural areas, where agriculture is the dominant economic and social activity (World Bank). In the last thirty years not only low agricultural prices, but also stagnant investment have characterized the agricultural sector of developing countries.

While low agricultural prices, have not solved the huger problem, they have contributed to keep the income of 2.5 billion people depressed. In fact many of these same people include the 80% of the chronically undernourished population of the world.

The modest contribution of biofuels to the global energy supply of transportation fuels has put agriculture and food production back at the top of the social, economic, and political global agenda. Regarding agriculture, biofuels has the potential to attract investment into the sector, not only for the

production of feedstock for biofuels, but also for the production of food, feed, and fiber crops. At the current production levels, still biofuels plays a small role in the overall agricultural resource use.

In a nutshell, the potential contribution or role of biofuels in agriculture is to create the economic and social environment for massive investments in the productive capacity of the agricultural sector in developing countries. This same economic an social environment will be required to transform the social and political power structures of the sector so as to ensure a large share of the benefits go to the 2.5 billion people linked to agricultural productive activities.

In this regard the relevant question should not be biofuels or not biofuels? But it should be, how much biofuels? and which biofuels?

Regarding the environmental aspects, one has to begin by acknowledging that while the increased use of fossil fuels in agriculture in the form of nitrogen, mechanization, and chemical utilization has resulted in a significant increased in agricultural productivity, it has also brought serious environmental consequences. Both of these, before biofuels, totally linked to the production of food, feed, and fiber. As an illustration, agriculture and forestry together are second only to the energy sector in the emission of GHG (IPCC). Moreover, of the total GHG emissions from agriculture about half of them are generated in the livestock sector in the form of methane emissions. The contribution of biofuels to this environmental performance is close to none. If one takes the recent work of Searchinger et. al at face value, the total CO2 GHG emissions trigger by the expansion of biofuels amounts to 0.26% of the total GHG emissions of 2004. This contrasts with the 31% of agriculture and forestry combines, or with the 13.5% generated by the production of food, feed, and fiber.

Environmental performance of agriculture and forestry is linked to management practices, technology, and consumption patterns of agriculture and food system. These factors in turn are closely related to market signals and policy instruments driving investment, innovation, and consumption. As it was mentioned earlier, the economic and social environment induced by the production and expansion of biofuels could provide the necessary opportunity to bring investment into agriculture into practices and technologies, with a much more positive environmental performance in the production of food, feed, fiber, and fuel. Also, the new price reality would indicate that it is no longer attractive to pursue a diet heavily dependent on animal protein, which traditionally has been driven by subsidized grain production.

Again, in the presence of all of these facts, the question is not biofuels or not biofuels? But it should be, how much biofuels and which biofuels?

Cohen, Marc J. and Don Reeves. Causes of Hunger. 2020 Vision Brief No. 19. IFPRI, Washington, DC. May 1995.

FAO, FAOSTAT Database. FAO, Rome. 2005

IPCC, Fourth Assessment Report, IPCC (2007)

Review I

While this paper attempts to make substantive contributions to the literature, I believe it is flawed in a number of fundamental ways. First, much of the data used is significantly out of date (relying on the 1997 Ag Census) and the figures used are not well explained (8.1cm of irrigation for corn). Some of the sources are not available and/or peer-reviewed (the Patzek pdf). Finally, some of the conclusions

drawn are incredibly different from other sources (cost of agricultural production) and the inclusion of worker calorie consumption is difficult to justify.

Review J

General comments:

Conservation of our natural and energy resources is important and if we are not truly producing more energy or reducing greenhouse gas emissions with biofuels, that is important and we should move on from considering biofuels as a source of energy and tool to reduce the greenhouse gases associated with energy use. However, although the author's results are very different from the consensus of the scientific community, they do not even acknowledge this discrepancy. They ignore the important papers present in the scientific literature whether it is corn (Farrell et al., 2006, Science; Hill et al., 2006 PNAS) or switchgrass (Schmer et al., 2008, PNAS). These papers have resolved the debate about net energy benefits of biofuels and a consensus within the scientific community has formed around this work. If the authors reject this consensus, they need to include a clear discuss in this paper of why their numbers should be considered over these papers.

Specific comments:

P 14 The authors make this claim…"Some claim that the lignin can be used as a fuel. Clearly, this would not be when dissolved in water. The lignin in the water mixture can be extracted using various energy intensive technologies. Usually less than 25% of the lignin can be extracted from the water mixture (Pimentel and Patzek, 2008)." The use of lignin to power biorefineries is based on proven technology in the paper and pulp industries, it is not theory. P 25 Instead of dealing with the issue directly as it is being proposed, the authors set up "straw men". For example, in an article they cite (Lal and Pimentel, 2007) they argue the negative environmental impacts of "wholesale removal of crop residues…" which no one is proposing, and then in this paper they go on to conclude "Removing crop residues would therefore devastate U.S. agriculture.". Of course, that is why this is not being proposed. Everyone acknowledges that the limit on residue removal should be maintaining enough cover to meet erosion limits and possibly even soil carbon. Scientists are investigating cropping strategies, such as cover crops, to ensure this goal is met. P 25 I am not sure what grass species they are referring to which only lasts 5 years. "These crops are usually grown as perennials and cover the soil all year for about 5 year periods."…or is not productive…"Yet, grass and other such crops are unfortunately not generally productive as biofuel crops." It certainly can't be switchgrass. P 25 The authors present a number of tables in non standard units and often obscure citations instead of peer reviewed literature including links which do not work… Liebman, M. New Cropping Systems for Cellulosic Feedstock Production and Environmental Stewardship. 2008. http://129.186.41.143/20th/home.files/liebman.pdf. (1/31/08). or are wrong....Southwestern University. Biology Research Finds Rising CO2 Levels Could Decrease the Nutritional Value of Major Food Crops. 2008. http://www.blackwellsynergy.com/doi/full10.1111/j.1365-2486.2007.01511.x. (2/15/08). see Taub et al. http://www.blackwell-synergy.com/doi/full/10.1111/j.1365-2486.2007.01511.x. Details

are important in this type of study. P 27 These kinds of statements are not true…"In most cases, more fossil energy is required to produce a unit of biofuel compared with the energy that is produced (Tables 4 – 11)." and "Based on careful up-to-date analysis of all fossil energy inputs, most conversions of biomass into ethanol and biodiesel result in a negative energy return. Four of the negative energy returns are: corn ethanol (minus 48%); switchgrass (minus 68%) soybean biodiesel (minus 63%); and rapeseed (minus 58%)." See peer reviewed literature (Farrell et al., 2006, Science; Hill et al., 2006 PNAS; Schmer et al., 2008, PNAS).

The authors present a very confusing analysis in general, which is not balanced. Instead of dealing with the issue directly, they present "straw men" which can easily be refuted. In other cases they totally ignore the important papers in the literature around which the scientific community has formed consensus. This is an important issue, requiring serious and honest analysis.

Authors Replies to Reviewers (Received: 5 September 2008)

To Referee E:

This reviewer appears to be biased in favor of biofuels (ethanol). I will single out only two points:

1) He says that we reported that 1 MJ of coal is equal to 1 MJ of natural gas or oil. We never said this. We were specific when we reported the energy inputs if it were oil or natural gas. Very little coal is used in biofuel production.
2) This reviewer clearly does not know the recent literature. He suggests Farrell et al (2006) paper should be used as a standard. He is clearly not aware that both Farrell and another of the senior authors (Dan Kammen) of this paper, now reject their initial view that corn ethanol is a winner: Dan Kammen in Time, June 7th (2007) states that "Corn ethanol is clearly flawed". Then A. Farrell (March 22, 2008) reports in "The Case Against Grain-Based Alternative Fuels. Alternative Energy Investors, Take Note" that the biofuel industry is headed in the wrong direction.

I could go on in detail refuting the errors in this review, but these two points clearly point to the flaws in this review.

To Referee G:

This referee does not believe that the production of biofuels is diverting food from the U.S. and EU. However, both the Director General of the UN and the Director General of FAO have stated that using food for biofuels is increasing starvation in the world. The Director General of UN has even stated that this use of food is "Criminal".

We specifically report that it takes about 6 million liters of water to produce 1 hectare of corn. We also reported that about 17% of world agriculture is irrigated and that this irrigated land provides 40% of all world food according to the FAO. Monsoonal rains are a benefit; we never said they were not, but we examine the problems related to water in India.

This referee reports that there are 5.5 billion people on earth. The latest figure is 6.7 billion according to the UN and Population Reference Bureau.

To Referee H:

This referee suggests that we rejected all biofuels. This is clearly incorrect; we were most supportive of the use of wood fuel for cooking and in some cases producing electricity. This reviewer clearly did not read our paper carefully.

To Referee I:

Concerning the use of use of 1997 USDA data for the use of water in irrigation, this is the most recent data available. The reviewer never suggested a more recent source because there is none. We specifically spelled out that 15% of U.S corn is irrigated and we stated that we used this 15% figure to calculate the energy input in corn production. We could not provide any more data.

To Referee J:

1) This reviewer clearly does not know the recent literature. He suggests Farrell et al (2006) paper should be used as a standard. He is clearly not aware that both Farrell and another of the senior authors (Dan Kammen) of this paper, now reject their initial view that corn ethanol is a winner: Dan Kammen in Time, June 7th (2007) states that "Corn ethanol is clearly flawed". Then A. Farrell (March 22, 2008) reports in "The Case Against Grain-Based Alternative Fuels. Alternative Energy Investors, Take Note" that the biofuel industry is headed in the wrong direction.
2) The reviewer also cites Schmer et al. (2008). This paper is seriously flawed because they claim that switchgrass can be effectively converted into ethanol. In fact, they state that they can get a 540% net return on the conversion of switchgrass into ethanol. No one in the world has produced a net return of ethanol in the conversion of cellulosic biomass into ethanol. This is the reason that there is not a single commercial plant in the world producing ethanol from cellulosic biomass.

To Referee A:

We have added a reference to EROI and the citation to Cleveland et al (1984) and Hall et al. (1986).

To Referee B:

The information related to irrigation decline and the reference to Postel has been corrected. The same applies to the fact that 17% of world agriculture is irrigated, and that irrigated portion provides 40% of world food.

The data that we have do not suggest a glut of natural gas:

1) More than half of U.S. nitrogen fertilizer had to be imported and the price of nitrogen fertilizer doubled in price during the past two years.

The reviewer is correct; it should read not just oil, but oil consumption.

To Referee C:

The measure of irrigation here is per capita irrigated land. This was corrected. Verb was added on page 12.

Editor-in-Chief Decision (Received: 5 September 2008)

The documents submitted by Prof. Dale include both complete articles and reviews of the subject article by Pimentel, et al. I have read the materials, though not at the in-depth level that would associate with much more free time.

Many of the criticisms seem valid. Of those that appeared more than once, I especially notice the charge that Pimentel's data is obsolescent and that a significant number of links to the Internet presented do not work. My original review of Pimentel, et al., did not discover these elements, and I am inclined to belief that the reviewers presented by Dale are honorable people and that these criticisms are correct.

There is also the criticism that the paper is poorly organized, and I agree with that in part. The Pimentel, et al. paper could be better organized - no question about that. I also find that the Pimentel paper tends too much toward redundancy.

There is also a strong tendency among Dale's review panel to find that many elements of the Pimentel, et al. presentation are old thoughts, but they also tend to agree that interest is high. OK, What to make of this in relation to the publication? My view is that publication of the Pimentel paper is not at all a bad thing. Here are some "political thoughts".

The biofuels program in the US is controversial. Obviously, supporters have so far won out over detractors, because the programs continue. I believe, however, that it has been clearly shown that there is no chance that the biofuels programs can make a significant dent in present demand for petroleum and its products, (which dontinues to increase) largely because significant cultivable land is not available for biofuels and also because the EROI is not sufficient. (One worthy though very small aspect of the biofuels program involves recovery of fats and oils otherwise wasted, and their conversion to biodiesel; that certainly is good.) Of course, there is also controversy on the actual EROI, but my opinion is that even the values presented by biofuel optimists are insufficient to justify continuation of the operational biofuels program, which in actuality is continues to expand. Well, we may disagree on some of that, and if there were more time on my side, I could present additional data, the other side could present theirs, and so on.

For whatever its worth, note that from 2006 to 2007, US oil consumption increased 0.1 mbpd while ethanol production increased by the same amount. But ethanol production is supposed to decrease petroleum usage. Of course, this is just one year and there are undoubtedly a number of factors simultanueously involved here. Oil consumption in the US diminished a little from 2005 to 2006.

I think that there is a decent solution to this publication problem. As suggested by the publisher(s), Prof. Dale could present his article. In it, I hope that he shows how the obsolescence of the Pimentel data influences the conclusions. Dale and possible coauthors should show, among other things, of course, how new data influence conclusions drawn and he should show that the biofuels program is or can be effective. In addition to matters of his choosing, he might also demonstrate some aspects of the biofuels programs that are counter to my thoughts in preceding and next paragraph.

My thinking, probably opposite to that of Dale and the panel he has assembled, is that the biofuels program is destructive to the extent that it serves as an excuse for not undertaking the truly drastic actions needed to address the interactive fuel decline and global warming problems at the same time. I have been in research all my adult life, but I believe that there is a tendency for research to substitute inappropriately for effective actions. The political and practical issues and their interactions are immensely complex and cannot be developed here. I have explored them in some depth elsewhere, in Chapter 11 of a book edited by Pimentel. My chapter is entitled "Our Food and Fuel Future" and I conclude that the futures are very problematic, in part because the output of political systems, including that in the U.S., focus on the short term, have not adjusted for the immense present powers of science and technology, lack sufficient objective scientific input, and too much reflect the powers of narrow interests bent on personal gain. Not at all new political characteristics, but much more consequential than in the past.

References and Notes

1. Pimentel, D.; Marklein, A.; Toth, M.A.; Karpoff, M.; Paul, G.S.; McCormack, R.; Kyriazis, J.; Krueger, T. Biofuel Impacts on World Food Supply: Use of Fossil Fuel, Land and Water Resources. *Energies* **2008**, *1*, 41-78.