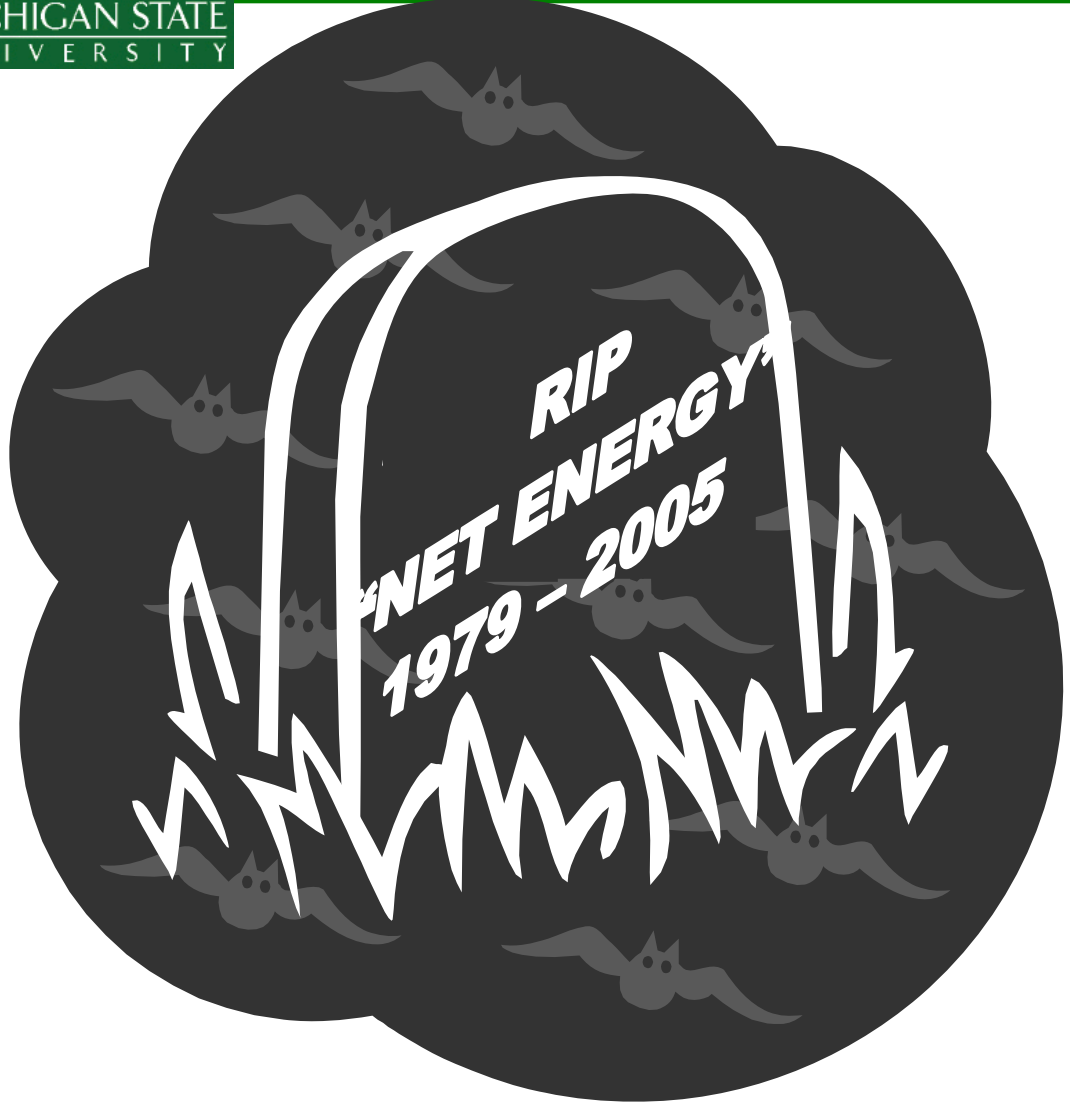
Rebutting Some Ethanol Myths

- Ethanol has a negative “net energy”
  - Gasoline has a worse net energy & besides, the “net energy” discussion is foolish
- People will starve with large scale biofuels
  - It is much more likely that food supplies will *increase* with very large scale biofuels
- We will devastate the environment with large scale biofuels
  - Actually, environmental improvements are both possible and likely



"WE COME TO BURY NET ENERGY, NOT TO PRAISE IT"

Most Recent Pimentel & Patzek Study*- Some Serious Deficiencies and Errors

- Define ethanol's % net energy as:
  - [(Ethanol Heating Value (LHV) – Fossil Energy Inputs) /Ethanol Heating Value (LHV)] x 100
- All BTU are treated as equivalent (1 BTU coal = 1 BTU petroleum = 1 BTU natural gas = 1 BTU electricity = and so on)
- Confuse "fossil fuels" with "liquid fossil fuels"=petroleum
- They calculate net energy for ethanol from:
  - Corn - 29%
  - Switchgrass - 50%
  - Wood - 57%
- They make no comparisons with other liquid fuels
- I calculate net energy for:
  - Gasoline from petroleum - 37% (less than)
  - Electricity from coal - 240%
- **Natural Resources Research, vol. 14, No. 1, March 2005 pgs. 65-76*

Petroleum Refining

Refining input
9.6 BTU

Crude oil

100 BTU

Fuel out **83.5 BTU**
Gasoline, diesel, jet fuel, LPG, residual oil, etc

Other non fuel products

Production & Distribution Input
4.5 BTU

$$\textbf{NET ENERGY} = \frac{83.5\ \text{BTU} - 114.1\ \text{BTU}}{83.5\ \text{BTU}} = \textbf{- 37 \% (vs.-29\%)}$$

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Are All Btu Created Equal: What Does "the Market" Say?

Energy Carrier	Energy Content* (Btu/X)	Typical Market Value ($/X)	Market Value ($/MM Btu)
Coal	20.4 MM Btu/short ton	$40.30/short ton	$2.00
Natural Gas	1,030 Btu/ cubic foot	$7.30 per 1000 cubic foot	$7.10
Petroleum	5.8 MM Btu/barrel	$55 per barrel	$9.50
Electricity	3413 Btu/ Kwhr	$0.082/Kwhr	$24.00
* EIA 2004 pg. 357-386			

Pimentel & Patzek Confound Fossil Fuels & Petroleum Used for Ethanol Production I

Five major Inputs in P&P 2005*	**Total Fossil Energy (kcal x 1000)**	**Petroleum Fraction of Total Fossil**	**Total Petroleum (kcal x 1000)**
Machinery	1,018/ha	~50%	500/ha
Diesel	1,003/ha	~100%	1,003/ha
Nitrogen (Fertilizer)	2,448/ha	~0%	0
Steam	2,546/1000 ℓ	~0%	0
Electricity	1,011/1000 ℓ	~0%	0
Total*	**6,597/1000 ℓ**		**2,123/1000 ℓ**

*Out of 21 different inputs. Adapted from Tables 1 & 2 of Pimentel & Patzek, NRR, 2005.

What Do Others Conclude about Pimentel and Patzek Studies? *

- "Studies** that reported negative net energy incorrectly ignored coproducts and used some obsolete data.
- "All studies (two by P&P and four others) indicated that current corn ethanol technologies are much less petroleum-intensive than gasoline..."
- Fig. 2. Corn ethanol yields (1.1/0.05) = **22x** more liquid fuel than gasoline per unit of petroleum "invested"
- *Farrell, et al, "Ethanol can Contribute to Energy and Environmental Goals" *Science* vol. 311. Jan. 2006 pg. 506-508
- **Refers to T. Patzek. *Crit. Rev. Plant. Sci.* **23,** 219 (2004) & D. Pimentel and T. Patzek. *Nat. Resource Res.* **14,** 65 (2005)

Net Energy *Reductio Ad Absurdum:* the Accounting Analogy

- "Net energy" is an energy accounting tool: a terrible one
- Using the net energy approach of "All BTU are equal" an international company's accountants would calculate:
  - 100 U.S. $ + 100 Euro + 100 Mexican pesos + 100 Japanese yen = $400 U. S.
  - The math is right; the idea is absurd!
- We cannot add up different forms of energy on a straight BTU basis any more than we can add up different currencies on a straight numerical basis
- Different forms of energy have different qualities—just like different currencies do
- So is there a better energy accounting tool?

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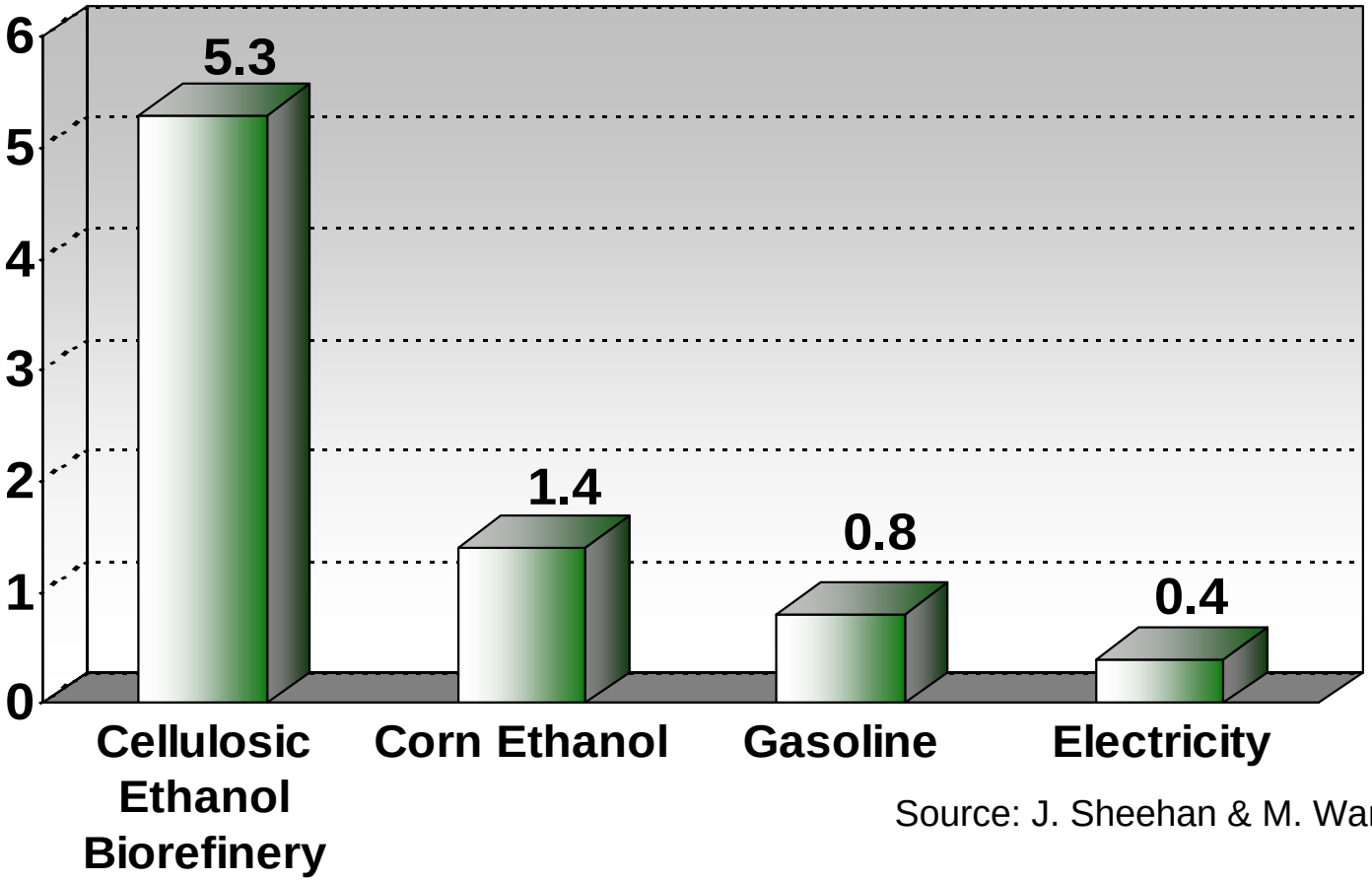
Fossil Energy Replacement Ratio:
the Primary Climate Security Driver

$$\text{Fossil Energy Ratio (FER)} = \frac{\text{Energy Delivered to Customer}}{\text{Fossil Energy Used}}$$



Source: J. Sheehan & M. Wang (2003)

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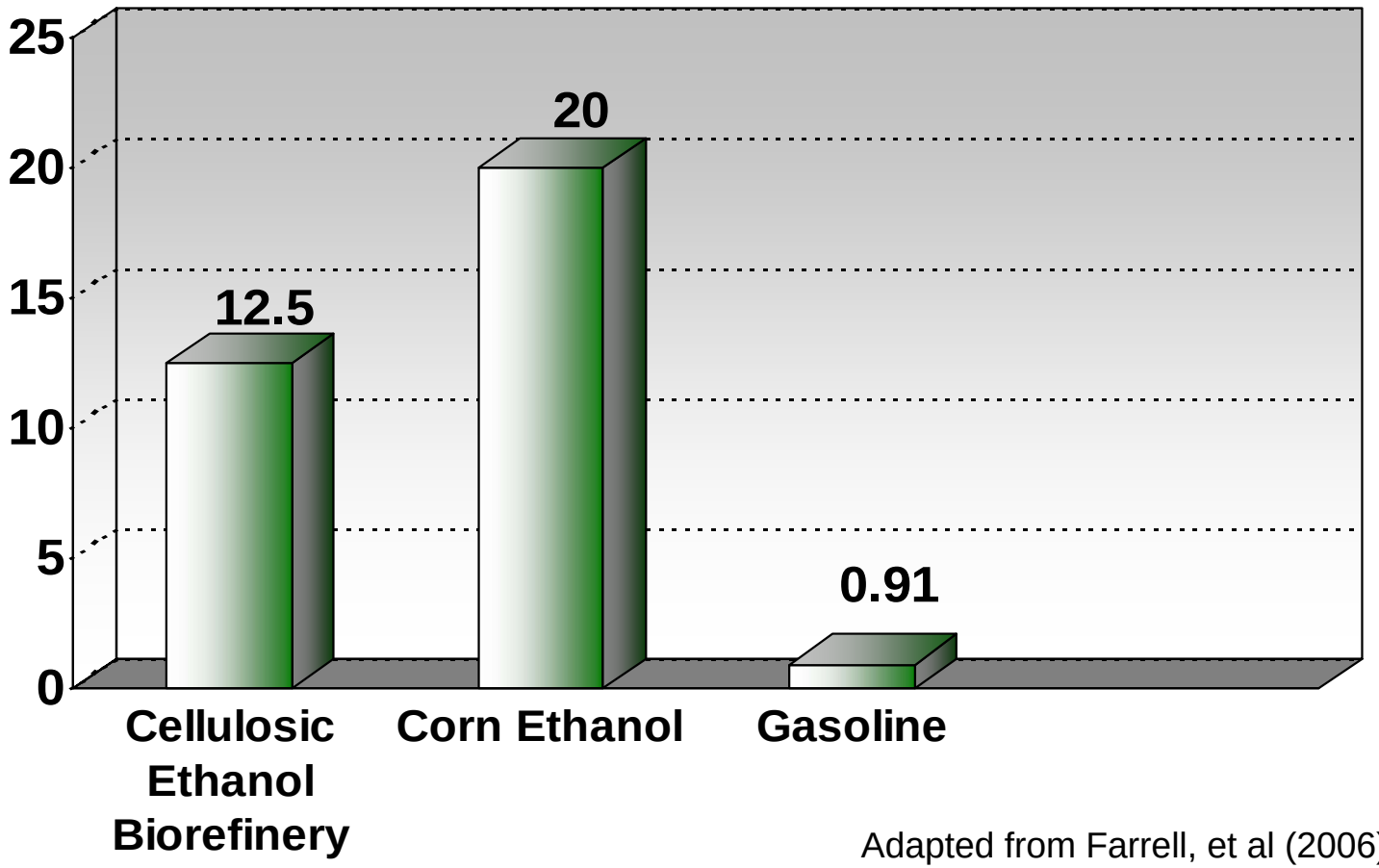
Petroleum Replacement Ratio:
the Primary Energy Security Driver

$$\text{Petroleum Replacement Ratio (PRR)} = \frac{\text{Liquid Fuels Delivered to User}}{\text{Petroleum Energy Used}}$$



Adapted from Farrell, et al (2006)