Valoración Ambiental (energética y eMergética) de los Bioenergéticos

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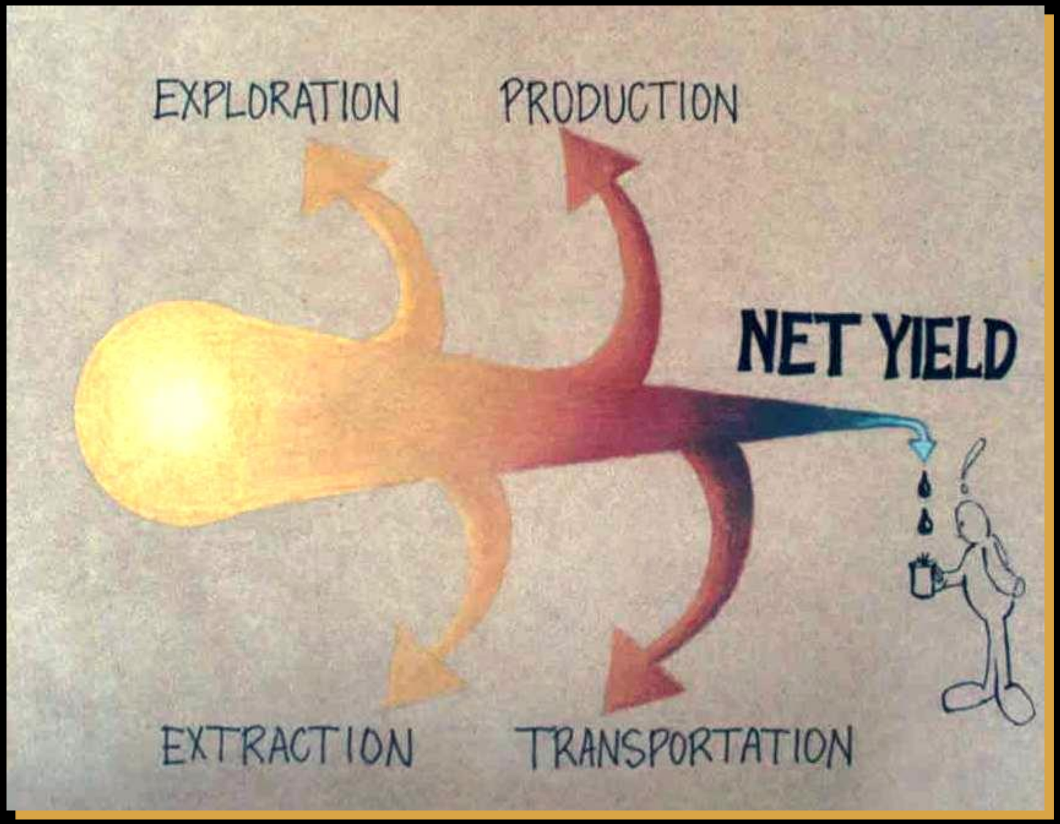
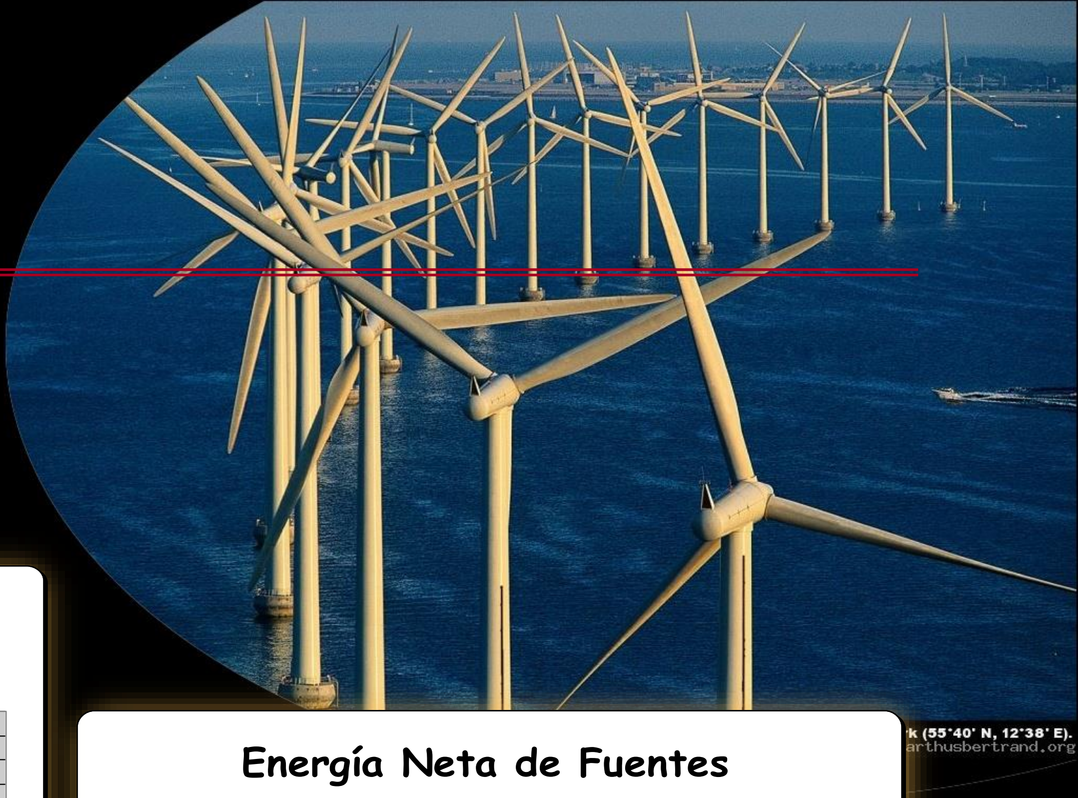
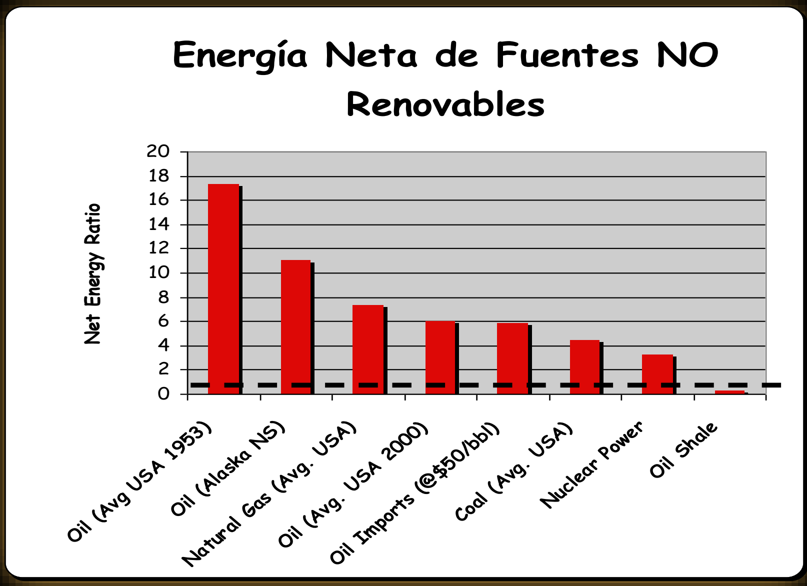
Energía Neta…

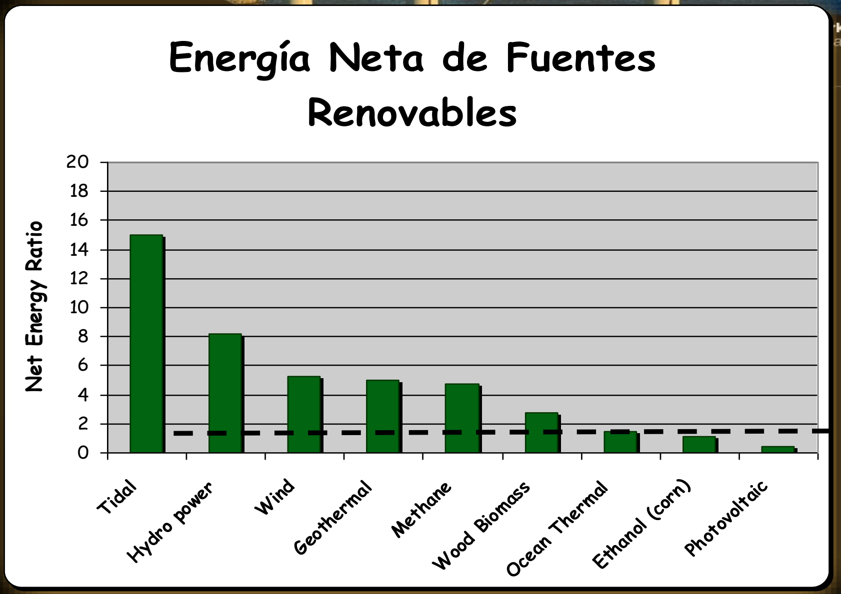


Se define como el cociente de la energía obtenida entre la invertida en el proceso.

Energía Neta…







Energía…

Principales requerimientos de energía para la producción de Maíz

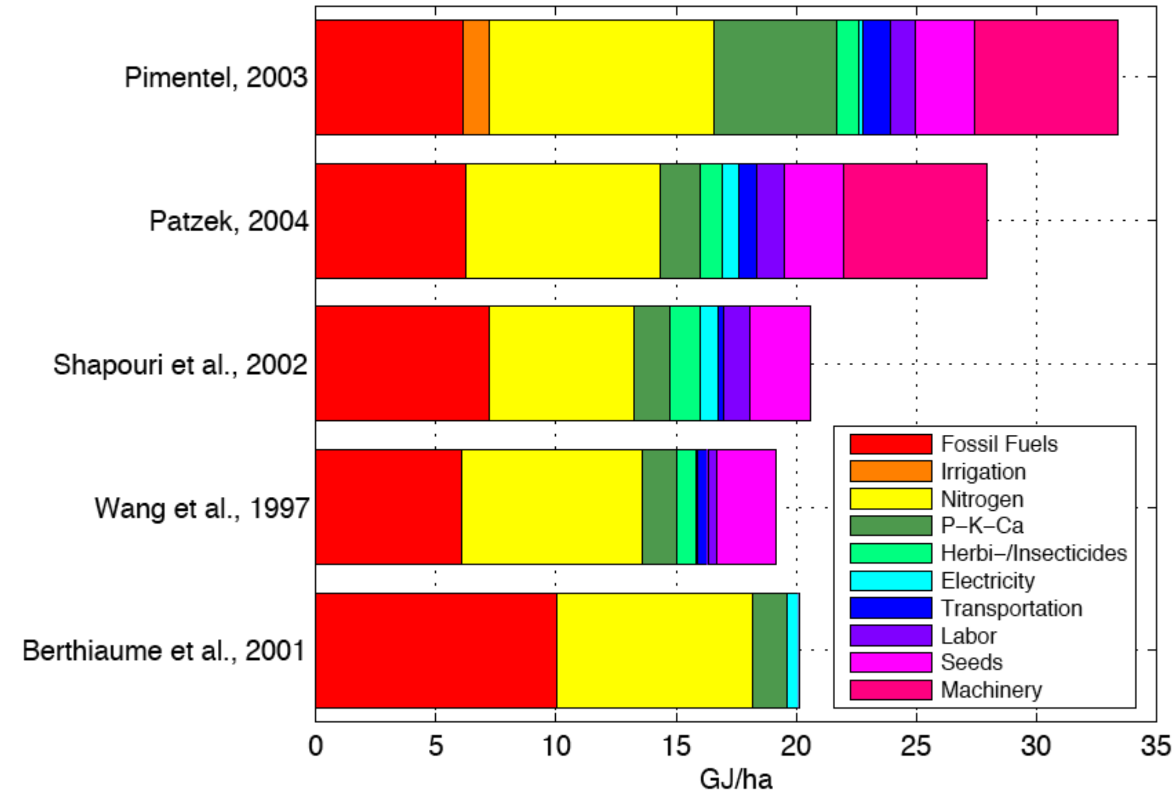


Figure 12: Major fossil energy inputs into corn farming.

Energía…(valoración energética)

Balance total de energía para la producción de etanol derivado del maíz

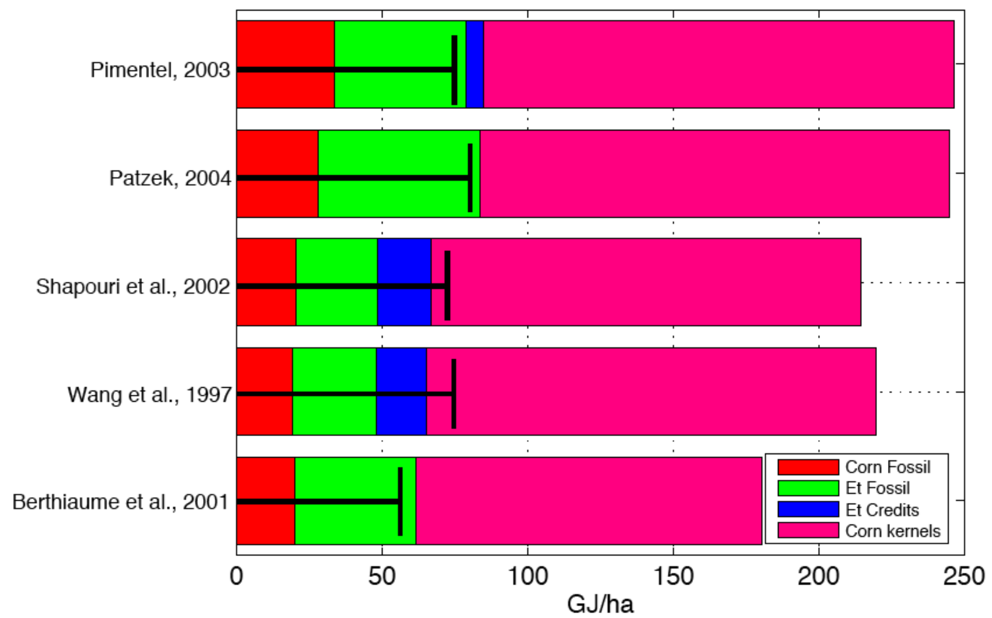
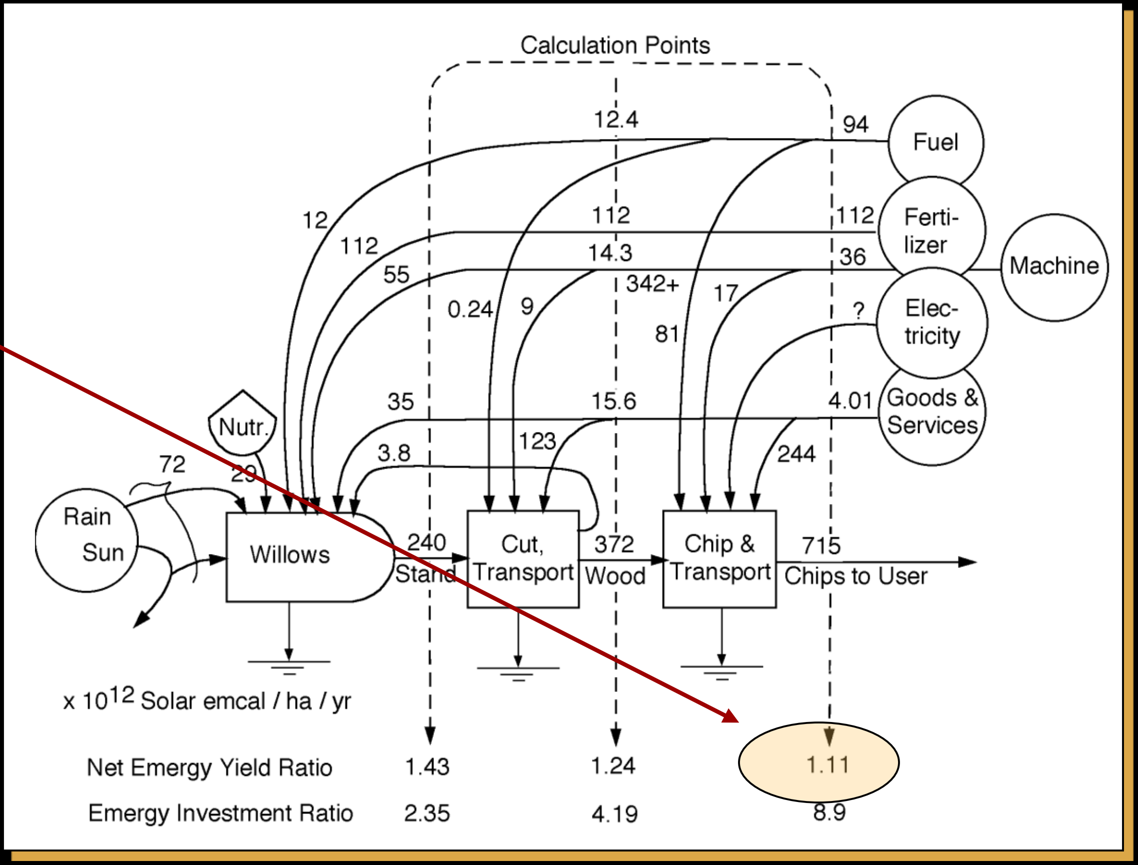


Figure 18: The overall energy balance of ethanol production. The two or three leftmost parts of each bar represent the specific fossil energy used in corn farming and ethanol production. The fossil energy inputs into ethanol production are the sum of the green part and the blue energy credit part for some authors. The rightmost part is the calorific value of corn grain harvested from 1 hectare. The total lengths of the horizontal bars represent all energy inputs into ethanol production. The horizontal lines with the vertical anchors represent the calorific value of ethanol obtained from one hectare of corn. Note that the total energy inputs into ethanol production are equivalent to ∼4–5 metric tonnes of gasoline per hectare. The ethanol's calorific value is equal to 1–1.3 metric tonnes of gasoline.

Energía Neta (valoración eMergética)...

La Energía Neta de la biomasa es apenas de 1/1



Energía…

Ganancia/pérdida en energía fosil para la producción de Etanol derivado del maíz

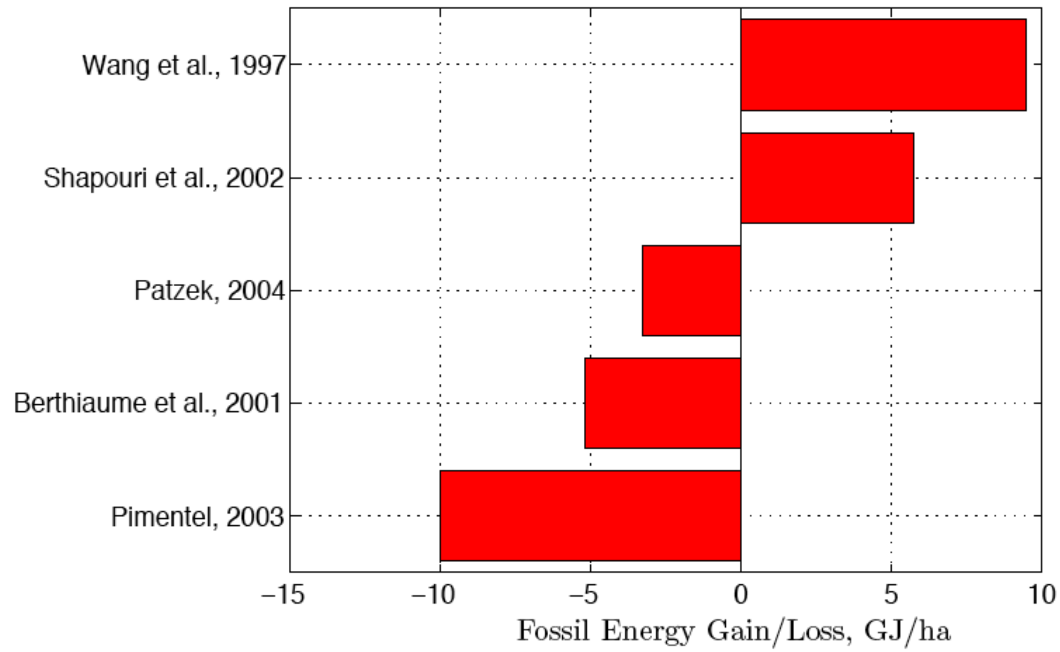


Figure 19: Fossil energy gain/loss in corn ethanol production. Note that the dubious energy credits described in Section 4.4 do not eliminate the use of fossil fuels in the first place, but present alternative useful outcomes of this use.

(Pimentel & Patzek, 2005)

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Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower

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(Pimentel & Patzek, 2005)

Maíz a Etanol…

Table 1. Energy Inputs and Costs of Corn Production Per Hectare in the United States

Inputs	Quantity	kcal × 1000	Costs $
Labor	11.4 hrs[a]	462[b]	148.20[c]
Machinery	55 kg[d]	1,018[e]	103.21[f]
Diesel	88 L[g]	1,003[h]	34.76
Gasoline	40 L[i]	405[j]	20.80
Nitrogen	153 kg[k]	2,448[l]	94.86[m]
Phosphorus	65 kg[n]	270[o]	40.30[p]
Potassium	77 kg[q]	251[r]	23.87[s]
Lime	1,120 kg[t]	315[u]	11.00
Seeds	21 kg[v]	520[w]	74.81[x]
Irrigation	8.1 cm[y]	320[z]	123.00[aa]
Herbicides	6.2 kg[bb]	620[ee]	124.00
Insecticides	2.8 kg[cc]	280[ee]	56.00
Electricity	13.2 kWh[dd]	34[ff]	0.92
Transport	204 kg[gg]	169[hh]	61.20
Total		8,115	$916.93
Corn yield 8,655 kg/ha[ii]		31,158	kcal input: output 1:3.84

Table 2. Inputs Per 1000 l of 99.5% Ethanol Produced From Corn[a]

Inputs	Quantity	kcal × 1000	Dollars $
Corn grain	2,690 kg[b]	2,522[b]	284.25[b]
Corn transport	2,690 kg[b]	322[c]	21.40[d]
Water	40,000 L[e]	90[f]	21.16[g]
Stainless steel	3 kg[i]	12[i]	10.60[d]
Steel	4 kg[i]	12[i]	10.60[d]
Cement	8 kg[i]	8[i]	10.60[d]
Steam	2,546,000 kcal[j]	2,546[j]	21.16[k]
Electricity	392 kWh[j]	1,011[j]	27.44[l]
95% ethanol to 99.5%	9 kcal/L[m]	9[m]	40.00
Sewage effluent	20 kg BOD[n]	69[h]	6.0
Total		6,597	$453.21

5.1 E6/6.6 E6= energía neta
0.77/1

(Pimentel & Patzek, 2005)

Pasto a Etanol…

Table 3. Average Inputs and Energy Inputs Per Hectare Per Year for Switchgrass Production

Input	Quantity	10^3 kcal	Dollars
Labor	5 hr[a]	20[b]	$65[c]
Machinery	30 kg[d]	555	50[a]
Diesel	100 L[e]	1,000	50
Nitrogen	50 kg[e]	800	28[e]
Seeds	1.6 kg[f]	100[a]	3[f]
Herbicides	3 kg[g]	300[h]	30[a]
Total	10,000 kg yield[i] 40 million kcal yield	2,755 input/ output ratio	$230[j] 1:14.4[k]

Table 4. Inputs Per 1000 l of 99.5% Ethanol Produced From U.S. Switchgrass

Inputs	Quantities	kcal × 1000[a]	Costs
Switchgrass	2,500 kg[b]	694[c]	$250[o]
Transport, switchgrass	2,500 kg[d]	300	15
Water	125,000 kg[e]	70[f]	20[m]
Stainless steel	3 kg[g]	45[g]	11[g]
Steel	4 kg[g]	46[g]	11[g]
Cement	8 kg[g]	15[g]	11[g]
Grind switchgrass	2,500 kg	100[h]	8[h]
Sulfuric acid	118 kg[i]	0	83[n]
Steam production	8.1 tons[i]	4,404	36
Electricity	660 kWh[i]	1,703	46
Ethanol conversion to 99.5%	9 kcal/L[j]	9	40
Sewage effluent	20 kg (BOD)[k]	69[l]	6
Total		7,455	$537

5.1 E6/7.5 E6= energía neta
0.68/1

Celulosa a Etanol…

Table 5. Inputs Per 1000 l of 99.5% Ethanol Produced From U.S. wood cellulose

Inputs	Quantities	kcal × 1000[a]	Costs
Wood, harvest (fuel)	2,500 kg[b]	400[c]	$ 250[n]
Machinery	5 kg[m]	100[m]	10[o]
Replace nitrogen	50 kg[c]	800	28[o]
Transport, wood	2,500 kg[d]	300	15
Water	125,000 kg[e]	70[f]	20[o]
Stainless steel	3 kg[g]	45[g]	11[g]
Steel	4 kg[g]	46[g]	11[g]
Cement	8 kg[g]	15[g]	11[g]
Grind wood	2,500 kg	100[h]	8[h]
Sulfuric acid	118 kg[b]	0	83[p]
Steam production	8.1 tons[b]	4,404	36
Electricity	666 kWh[bl]	1,703	46
Ethanol conversion to 99.5%	9 kcal/L[i]	9	40
Sewage effluent	20 kg (BOD)[j]	69[k]	6
Total		8,061	$575

5.1 E6/8.1E6= energía neta
0.63/1

(Pimentel & Patzek, 2005)

Soya a Biodiesel…

Table 6. Energy Inputs and Costs in Soybean Production Per Hectare in the U.S.

Inputs	Quantity	kcal × 1000	Costs $
Labor	7.1 h[a]	284[b]	92.30c
Machinery	20 kg[d]	360[e]	148.00[f]
Diesel	38.8 L[a]	442[g]	20.18
Gasoline	35.7 L[a]	270[h]	13.36
LP gas	3.3 L[a]	25[i]	1.20
Nitrogen	3.7 kg[j]	59[k]	2.29[l]
Phosphorus	37.8 kg[j]	156[m]	23.44[n]
Potassium	14.8 kg[j]	48[o]	4.59[p]
Lime	4800 kg[v]	1,349[d]	110.38[v]
Seeds	69.3 kg[a]	554[q]	48.58[r]
Herbicides	1.3 kg[j]	130[e]	26.00
Electricity	10 kWh[d]	29[s]	0.70
Transport	154 kg[t]	40[u]	46.20
Total		3,746	$537.22
Soybean yield 2,668 kg/ha[w]		9,605	kcal input: output 1:2.56

Table 7. Inputs Per 1,000 kg of Biodiesel Oil From Soybeans

Inputs	Quantity	kcal × 1000	Costs $
Soybeans	5,556 kg[a]	7,800[a]	$1,117.42[a]
Electricity	270 kWh[b]	697[c]	18.90[d]
Steam	1,350,000 kcal[b]	1,350[b]	11.06[e]
Cleanup water	160,000 kcal[b]	160[b]	1.31[e]
Space heat	152,000 kcal[b]	152[b]	1.24[e]
Direct heat	440,000 kcal[b]	440[b]	3.61[e]
Losses	300,000 kcal[b]	300[b]	2.46[e]
Stainless steel	11 kg[f]	158[f]	18.72[g]
Steel	21 kg[f]	246[f]	18.72[g]
Cement	56 kg[f]	106[f]	18.72[g]
Total		11,878	$1,212.16

9.0 E6/11.9E6= energía neta
0.75/1

(Pimentel & Patzek, 2005)

Girasol a Biodiesel...

Table 8. Energy Inputs and Costs in Sunflower Production Per Ha in the U.S.

Inputs	Quantity	kcal × 1000	Costs $
Labor	8.6 h[a]	344[b]	111.80[c]
Machinery	20 kg[d]	360[e]	148.00[f]
Diesel	180 L[a]	1,800[g]	93.62[h]
Nitrogen	110 kg[j]	1,760[k]	68.08[l]
Phosphorus	71 kg[j]	293[m]	44.03[n]
Potassium	100 kg[j]	324[o]	34.11[p]
Lime	1000 kg[j]	281[d]	23.00[v]
Seeds	70 kg[a]	560[q]	49.07[r]
Herbicides	3 kg[j]	300[v]	60.00[i]
Electricity	10 kWh[d]	29[s]	0.70
Transport	270 kg[t]	68[u]	81.00
Total		6,119	$601.61
Sunflower yield 1,500 kg/ha[w]		4,650	kcal input: output 1:0.76

Table 9. Inputs Per 1,000 kg of Biodiesel Oil From Sunflower

Inputs	Quantity	kcal × 1000	Costs $
Sunflower	3,920 kg[a]	15,990[a]	$1.570.20[a]
Electricity	270 kWh[b]	697[c]	18.90[d]
Steam	1,350,000 kcal[b]	1,350[b]	11.06[e]
Cleanup water	160,000 kcal[b]	160[b]	1.31[e]
Space heat	152,000 kcal[b]	152[b]	1.24[e]
Direct heat	440,000 kcal[b]	440[b]	3.61[e]
Losses	300,000 kcal[b]	300[b]	2.46[e]
Stainless steel	11 kg[f]	158[f]	18.72[g]
Steel	21 kg[f]	246[f]	18.72[g]
Cement	56 kg[f]	106[f]	18.72[g]
Total		19,599	$1,662.48

9.0 E6/19.6E6= energía neta
0.46/1

Giampietro, et.al 2003 …

Típicos sistemas agrícolas para producir bioenergía

Table 1. Typical biofuel production systems from agricultural crops.

Indicators of performance	Biodiesel[a]	Ethanol in temperate areas	Ethanol in (sub)tropical areas
Gross energy yield (GJ · ha^{-1} · yr^{-1})	20–40	40–80	80[b]–130[c]
Net energy yield (GJ · ha^{-1} · yr^{-1})	<0–10	<0–30	50[b]–70[c]
Output–input energy ratio	0.6–1.3	0.5–1.7	3.0[b]–2.5[c]
Net to gross ratio (F*/F1)	<0–0.2	<0–0.4	0.66[b]–0.60[c]
Water requirement (t · ha^{-1} · yr^{-1})	4000–7000	4000–8000	10,000[b]–15,000[c]
Energy throughput (net MJ/h)	<0–250	<0–1000	250[b]–1600[c]
Best-performing system	oilseed rape	corn–sorghum	sugarcane
Land requirement (ha/net GJ)	0.100	0.033	0.020[b]–0.014[c]
Water requirement (t/net GJ)	500	170	200[b]–200[c]
Labor requirement (h/net GJ)	4	1	4[b]–0.6[c]

[a]Trans-methylester from oil seeds (sunflower, rapeseed, or soybeans). Sunflower and soybean systems have net energies close to or less than zero.
[b]Low-input production, as in the Brazilian ProAlcohol Project (Giampietro et al. 1997a).
[c]High-input production, as reported in Pimentel et al. (1988).

Giampietro, et.al 2003 ...

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Entonces…

Se requieren estudios específicos para la valoración ambiental de diferentes cultivos en diferentes áreas agroecológicas para determinar la sustentabilidad en la producción de bioenergéticos.

"Gracias."

Hugo Guillén, 2008

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Plática de Bioenergéticos y Energías Renovables