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ECONOMIC VALUE OF BIOMASS IN VARIOUS FORMS AND FUNCTIONS: A NOTE

by

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Many discussions of the potential for expanded use of biomass as an energy source seem to proceed without recognition of the problem of competing uses for biomass and the resources needed to produce biomass. The fact is that biomass can be and is used as food for humans, feed for animals, fiber, chemical feedstock, and fertilizer, as well as for fuel, not to mention the ecosystem functions performed by living plants. Not all of these uses are mutually exclusive--a single crop may provide food, feed, and fertilizer simultaneously, for example, each using a different part of the plant. Nevertheless, society often confronts choices between alternative uses of the same plant material (grain for food versus for feed versus for alcohol production) or between alternative biomass-related uses of the same land (timber production versus pasture versus food crops).

One way to allocate a scarce resource among competing uses is through the operation of the market--that is, according to the relative prices that prospective users are prepared to pay for the resource. As an allocational mechanism, the market has two classes of liabilities: built-in shortcomings, most notably the necessity simply to assume the legitimacy of the prevailing distribution of wealth and income, which underlies the determination of a pattern of relative prices; and shortcomings remediable in principle, such as the effects of monopoly, subsidies, poor information, and externalities. Notwithstanding these liabilities, relative prices provide a useful first-order perspective on the relative attractiveness of alternative uses of biomass or the inputs to biomass production. Determining what choices existing markets would be likely to make is also a necessary prerequisite to determining whether and where the defects in such choices call for deliberate intervention via market-modifying policies.

In this spirit, I have provided in Table 1 a sample of recent (1974-77) prices received by producers of biomass in various forms in the United States. The end-use categories covered are food, feed, fiber, chemical feedstock, and fuel. The columns show: (a) the price of the raw (harvested but unprocessed) biomass, as received by the grower; (b) the price of selected

refined (i.e., processed) forms--defined in the notes--as received by the processor or wholesaler; (c) the equivalent of these prices in dollars per gigajoule of energy contained in the biomass material as sold (1 GJ = 0.95 million Btu); (d) the equivalent of these prices in dollars per hectare per year of production, at yields typical of recent U.S. experience (defined in the notes). All of the numbers have been rounded to two significant figures.

These data must be interpreted cautiously. The following points need particular attention:

1. The price of the refined form is not directly relevant to a grower's incentive to produce a particular kind of biomass, except in cases where growing and processing are combined in a single enterprise. Prices of refined forms and equivalent revenues on a per hectare basis are given here mainly as an indication of what might be considered "indirect" incentives in the form of revenues (and, presumably, employment) that ultimately derive from the availability of the raw biomass.

2. Gross revenue should not be confused with profitability. The most attractive crop economically is the one that yields the greatest return on investment, which depends upon the difference between gross revenue and production costs. Examination of production costs was beyond the scope of this preliminary inquiry.

3. All hectares are not created equal. That is, the characteristics of a piece of land govern what can be grown on it (subject to modification, within limits, by such technologies as irrigation and fertilization). Thus, not all of the kinds of biomass production shown in Table 1 will be real options for a given piece of land.

4. Since no significant market for biomass as feedstock or fuel (except firewood) yet exists in the United States, the price of raw biomass as shown in Table 1 under these uses is the price given higher in the Table for the same material used as food or fiber. The prices of the refined forms for feedstock (methanol from pulpwood, ethanol from sugar cane) are the present producers' prices for these alcohols as made from fossil fuels. The prices of the refined forms for fuel (again, methanol and ethanol) are based on the replacement of gasoline as automobile fuel, using the 1974-77 average wholesale price of gasoline and correcting for energy content.

5. By presenting the prices in Table 1, I make no explicit or implicit claim that the markets that yielded these prices are not distorted by government policies and other factors. As noted above, the prices are presented only as a first-order perspective on relative economic value. Under no circumstances, moreover, can one neglect the circumstance that, all other factors being equal, a large increase in production of any of these biomass forms would tend to depress the price.

With these caveats, one can draw the following conclusions from the information in Table 1:

1. At recent U.S prices, the highest-value forms of raw biomass are some that serve as food or feed. The next ranking category in economic value is fiber.

2. Alcohols producible from biomass are presently worth considerably more as chemical feedstocks than as fuels.

3. The highest-yielding energy crop considered (if yield is measured in gigajoules per hectare-year) is sugar cane. Yet it yields more gross revenue as raw biomass for sugar production than could be obtained for the alcohol refined from it, sold as fuel.

Questions worthy of closer attention include:

1. Would the results obtained here for the U.S. context differ significantly in other parts of the world?

2. Would the results differ if the comparisons were made on the basis of profitability rather than gross revenues?

3. What would be the results of removing identifiable market distortions (subsidies, price supports, energy-price control, etc.)?

Additional questions at a more difficult (and sometimes more philosophical) level include:

4. In national contexts and internationally, what is the potential for energy interests outbidding hungry people for biomass in circumstances where the hungry people are too poor to generate effective market demand? What corrective measures might policymakers wish to consider?

5. Do the environmental externalities of alternative patterns of biomass use differ enough, and are they large enough in absolute magnitude, to alter conclusions about relative attractiveness reached on economic grounds? If so, what policy measures would be responsive to the situation?

Question 4 seems squarely in the province of the Resource Systems Institute, question 5 in that of the Environment and Policy Institute.

Table 1. Economic Value of Biomass in the United States

	Prices of Raw Biomass[a]	Prices of Refined Form[a]	$ per GJ Raw (Refined)[b]	$ per ha.yr. Raw (Refined)[b]
Food				
Wheat[c]	$2.30-4.10/bu	6-11¢/lb	9.40 (15.)	240 (380)
Soybeans[d]	$5.00-7.00/bu	---	18.	420
Corn[e]	$2.00-3.00/bu	---	5.90	560
Rice[f]	7-11¢/lb	---	16.	1000
Peanuts[g]	18-21¢/lb	---	34.	1200
Beet sugar[h]	$21-46/wet ton	17-31¢/lb	10. (32.)	1700 (3600)
Cane sugar[i]	$16-22/wet ton	17-31¢/lb	4.60 (32.)	2100 (5300)
Tobacco[j]	$1.00-1.20/lb	$6.90-9.40/$10^3$ cig	140 (490)	5500 (18,000)
Feed				
Sugar beet pulp[k]	---	$110/te	(8.70)	(360)
Alfalfa[l]	$63/te	---	5.00	3000
Fiber				
Pulpwood[m]	$24-35/cord	$29-360/ton	1.10 (20.)	160 (2700)
Timber[n]	$40-230/$10^3$bd-ft	$140-600/$10^3$bd-ft	6.30 (18.)	560 (1600)
Cotton[o]	43-64¢/lb	$1.40-1.50/$yd^2$	94. (850)	670 (6000)
Feedstock				
Pulpwood[p]	$24-35/cord	$140/te	1.10 (7.10)	160 (520)
Sugar cane[q]	$16-22/wet ton	$260/te	4.60 (9.80)	2100 (3600)
Fuel				
Pulpwood[p]	$24-35/cord	20¢/gal	1.10 (3.00)	160 (220)
Firewood[r]	$65/cord	---	1.90	180
Sugar cane[q]	$16-22/wet ton	26¢/gal	4.60 (3.00)	2100 (1100)

Notes for Table 1

a) Prices are 1974-77 averages for the U.S., as received by producers.

b) Based on arithmetic means of price ranges shown in preceding columns.

c) Yield 30 bu/acre at 60 lb/bu (75% DOM--dry organic matter). Refined form is wheat flour. Ref.: 1, pp. 487, 713.

d) Yield 28 bu/acre at 60 lb/bu (75% DOM). Ref.: 1, p. 713.

e) Yield 90 bu/acre at 56 lb/bu (75% DOM). Ref.: 1, p. 713.

f) Yield 4500 lb/acre (75% DOM). Ref.: 1, p. 713.

g) Yield 2500 lb/acre (75% DOM). Ref.: 1, p. 713.

h) Yield 20 tons/acre (roots at 22% DOM, 15% sugar). Refs.: 1, p. 713; 2, pp. 36, 40.

i) Yield 100 te/ha (millable cane at 27% DOM, 10% sugar). Refs.: 1, p. 713; 2, pp. 4, 18-20.

j) Yield 2000 lb/acre (100% DOM). Ref.: 1, p. 713.

k) Yield 20 t/acre (roots, of which 6.7% is pulp at 75% DOM). Value per hectare-year is for pulp only. Ref.: 2, p. 40.

l) Yield 48 te/ha (75% DOM). Refs.: 2, p. 40; 3, p. 133.

m) Yield 20 m^3/ha (600 kg/m^3, 75% DOM). Refined form is woodpulp. Ref.: 1, p. 737.

n) Yield 10 m^3/ha (600 kg/m^3, 75% DOM). Raw biomass is saw logs, refined form is lumber. Refs.: 1, p. 487; 3, pp. 132, 146.

o) Yield 500 lb/acre (75% DOM). Refined form is cotton cloth (0.3 lb/yd^2). Refs: 1, pp. 487, 713; 4, p. 286.

p) Refined form is methanol. Yield is 0.5 kcal methanol per kcal DOM. Fuel price is as replacement for gasoline at 1974-77 average wholesale price of 40.5¢/gal. (Volumetric energy content of methanol is 0.45 that of gasoline.) Ref: 2, p. 66.

q) Refined form is ethanol. Yield is 75 kg ethanol per te millable cane. Fuel price is as replacement for gasoline (see note p). Volumetric energy content of ethanol is 0.65 that of gasoline. Refs: 1, p. 487; 2, pp. 21, 67, 78, 113.

r) DOM content is 75%. Ref.: 5, p. 632.

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