

## Online Supplemental Note

### 1. Calculation of petroleum equivalent price of biomass feedstock

The petroleum energy equivalent (LHV basis) price of biomass feedstock is calculated as follows:

$$\frac{\$}{\text{tonne dry biomass}} \times \frac{\text{tonne dry biomass}}{\text{GJ}} \times \frac{\text{GJ}}{\text{barrel oil}} = \frac{\$}{\text{barrel oil}}$$

$$\frac{\$50}{\text{tonne dry biomass}} \times \frac{\text{tonne dry biomass}}{17.4 \text{ GJ}} \times \frac{5.8 \text{ GJ}}{\text{barrel oil}} = \frac{\$16.67}{\text{barrel}}$$

### 2. Calculation of land fuel yield.

Fuel yield per unit land area  $Y_{G/L}$  is calculated as follows:

$$Y_{G/L} = Y_{P/F} * P \quad [2]$$

Where  $Y_{P/F}$  is the process yield (GJ/dry ton biomass) and P is the productivity of feedstock production (dry tons/hectare/year).

Table S1. Process yields and crop productivities used in land fuel yield calculation.

	Process Yield, $Y_{P/F}$	Crop Productivity, P	Land Fuel Yield, $Y_{G/L}$
Feedstock	GJ/dry ton	dry ton/hectare/year	GJ/ha/year
Biomass energy crop	10.9 <sup>a</sup>	12.4 <sup>d</sup>	135.2
Corn kernels	9.5 <sup>b</sup>	8.8 <sup>e</sup>	83.6
Soybeans	6.6 <sup>c</sup>	2.8 <sup>f</sup>	18.5

<sup>a</sup>Mature technology biorefinery yielding 105.4 gallons ethanol/dry ton and 17.6 gallons FT diesel/dry ton.<sup>1</sup>

<sup>b</sup>Corn dry mill yielding 2.8 gallons ethanol/bushel.<sup>2</sup>

<sup>c</sup>Biodiesel process yielding 0.2 kg biodiesel/kg soybean.<sup>3</sup>

<sup>d</sup>Based on estimated current yield for switchgrass, assumed to be 5 dry ton/acre/year.<sup>4</sup>

<sup>e</sup>Average corn kernel yield in 2006, 149.1 bushels/acre<sup>5</sup>

<sup>f</sup>Average soybean yield in 2006, 42.7 bushels/acre<sup>5</sup>

### **3. Definition of process scenarios.**

All scenarios are modeled using Aspen Plus simulation software, and process economics evaluated using discounted cash flow profitability analysis. Important aspects of process scenarios include: configuration and integration of process steps (unit operations), feedstock cost and composition, plant scale, assumed technological performance or process steps (e.g. yields and rates of fermentation and hydrolysis), availability of preexisting infrastructure, extent of allowance for costs and risks associated with first-of-a-kind plants, and financial parameters (e.g. rate of return, debt:equity ratio). Variation due to these factors is often due to, and further compounded by, differences in the intended purpose for which designs and cost estimates are made. A design for a first plant based on technology proven today is, for example, entirely different from a design for an  $n^{\text{th}}$  plant based on technology likely to be available soon, which is also entirely different from a production facility based on mature technology that has benefited from both extensive field experience as well as R&D-driven advances. In light of the many factors implicit in cost estimates for bioenergy processes, it is important to clearly define process scenarios, and it is not surprising that cost estimates vary widely among various sources even for apparently similar processes. Table S2 lists parameter values for the current technology scenario (Figures 1, 3, 4), mature technology scenario (Figure 3), and the advanced non-biological steps scenario (scenario 2, Figures 2 & 4).

Table S2. Parameter values for scenarios presented in Figures 1 and 2.

Process Step	Current technology Scenario 1 <sup>a</sup>	Mature technology	Advanced non-biological steps Scenario 2 <sup>a</sup>
Feedstock Rate (dry tons/day)	2,205	5,000	5,000
EtOH Yield (gal/dry ton)	74.5	105.3	82.5
Pretreatment Method	Dilute Acid	AFEX	AFEX
Pretreatment Acid Conc. (wt. %)	1.1	-	-
Pretreatment NH <sub>3</sub> :dry biomass	-	0.3	0.3
Pretreatment Temp (deg C)	190	90	90
Pretreatment Solids (wt. %)	30	50	50
Bioconversion Method	SSF	CBP	SSF
C6 Enzymatic Hydrolysis Yield (%)	80	95	80
C6 Fermentation Yield (%)	90	95	90
C5 Fermentation Yield (%)	90	95	90
Bioconversion Residence Time (days)	7	1.5	7
Enzyme Loading (mg/g cellulose)	15	-	15
Ethanol titer (mass %)	5	5	5

<sup>a</sup>Base-case values are listed, with individual improvements as specified in the text.

Table S3. Financial parameter values.

Parameter	Value
Financing	40% debt/60% equity
Loan Rate	7.5%
Discount Rate	12%
Return on Equity	15%
Plant Economic Life	25 years
General Plant Depreciation	200% DB (MACRS)
General Plant Recovery Period	7 years
Power Plant Depreciation	150% DB (MACRS)
Power Plant Recovery Period	20 years
Federal Tax Rate	39%
Construction Period	2.5 years
1 <sup>st</sup> 6 months expenditures	8%
Next 12 months expenditures	60%
Last 12 months expenditures	32%
Start-Up Time	6 months
Revenues	50%
Variable Costs	75%
Fixed Costs	100%
Resulting capital charge rate	16.7%

## Supplemental Material References

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