Future Predictions of Cellulosic Ethanol Production Costs

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Introduction

Both conventional ethanol and cellulosic ethanol are biofuels, but conventional ethanol is produced using food crops such as corn, wheat, sugarcane and soybeans, and processed either through dry or wet milling.

Cellulosic ethanol is a biofuel produced from agricultural wastes such as corn stover, sugarcane bagasse and also from wood, grasses, or the non-edible parts of plants. It is a type of biofuel produced from lignocelluloses, a structural material that comprises much of the mass of plants.

Conventional Ethanol vs. Cellulosic Ethanol

Cellulosic ethanol overcomes some of the problems presented by the first generation ethanol feedstock such as corn, maize etc.

The following table presents the key differences between conventional (first generation) ethanol and first generation feedstocks such as corn and cellulosic ethanol production.

Conventional and Cellulosic Ethanol – Comparison

Aspect	Conventional Ethanol	Cellulosic Ethanol
Choice of Feedstock	Feedstocks are agriculture plants like corn wheat, soybeans, sugarcane etc	Feedstocks are agricultural plant wastes like corn stover, cereal straws, and sugarcane bagasse, plant wastes from industrial processes like sawdust, paper pulp as well as switchgrass.
Food vs Fuel	Ethanol production carries the risk that food cropping will turn into more lucrative fuel-cropping	Cellulosic ethanol production prevents the danger
Feedstock Availability	The supply of raw material is scarce	The supply of raw material is much higher than that for first generation ethanol
Fertilizer and Water Use	High amounts of fertilizers and water essential for ethanol production	The quantities of fertilizers and waters required are not as high as those for feedstocks for first generation ethanol

Production Process	Corn ethanol extraction from feedstock is simple and economic.	Cellulosic ethanol extraction from feedstock is complex and less economic.(1)

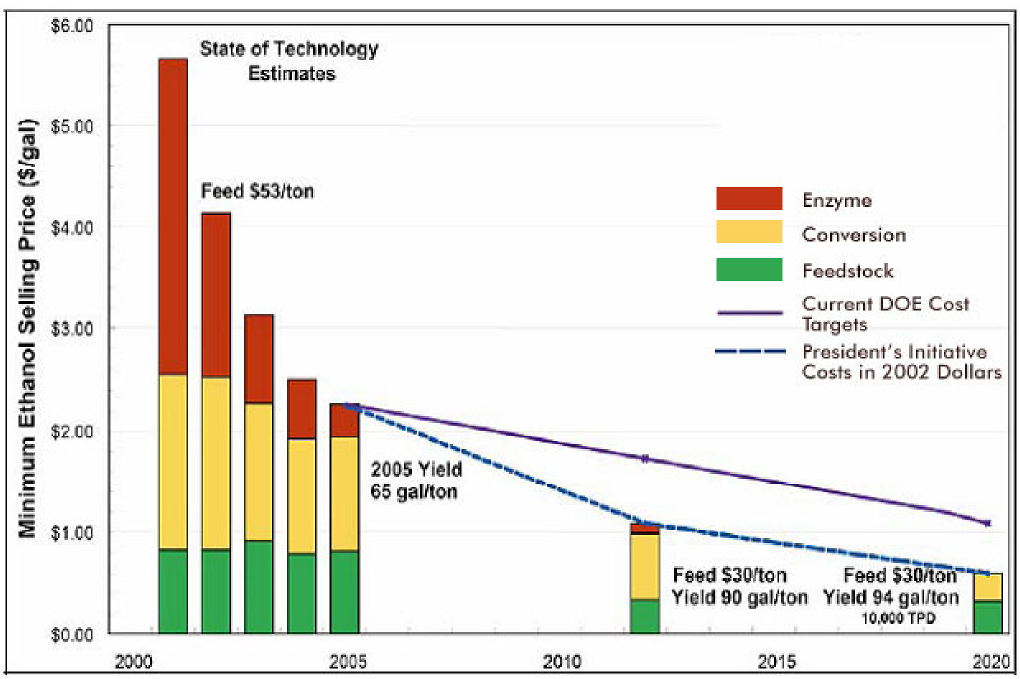
1: The only disadvantage of cellulosic ethanol lies in the difficulty with which it is presently extracted; the feedstock sugars in cellulose and hemicellulose are bound in complex carbohydrates called polysaccharides[1], and separating these complex structures into simple sugars is not easy. This leads to longer process time, and low yield per unit of feedstock, making cellulosic ethanol somewhat less economical to produce than conventional ethanol currently.

Costs - Predictions

NREL

The chart provided below presents data on what the NREL expects the costs of cellulosic ethanol to be in future.

Cost and Cost Targets for Cellulosic Ethanol Production Projected by Analysts at the US NREL Laboratory



Source: http://www.unctad.org/en/docs/ditcted200710_en.pdf

[1] Polysaccharides are polymeric substances composed of monosaccharides as repeating units and joined by glycosidic linkages. They have formed from both hexose and pentose sugars and, thus, have widely varying structures and properties dependent on the component sugars and mode of linkage

It can be observed from the above illustration that significant reductions are expected in all the main three cost contributors – feedstock costs, enzyme costs and conversion costs. Between 2005 and 2012, the NREL expects feedstock costs to decrease by over 40%, conversion costs to decrease by over 40% and enzyme costs to decrease by almost 70%.

IEA

Another set of predictions about cellulosic ethanol costs, this time by the IEA, are provided below. It can be seen that IEA expects percentage cost reductions to be much more modest than the NREL estimated earlier.

IEA 2nd – generation biofuel cost assumptions for 2010 and 2030
(Costs given in terms of gasoline equivalents)

Lignocellulosic Conversion Technology	Assumptions	Production cost-By 2010 USD/lge	By 2030 USD/lge
Biochemical Ethanol	Optimistic	0.80	0.55
	Pessimistic	0.90	0.65
BTL diesel	Optimistic	1.00	0.60
	Pessimistic	1.20	0.70

Lge: Liter gasoline equivalent. Source: IEA

The above table is presented below in terms of US$ per gallon.

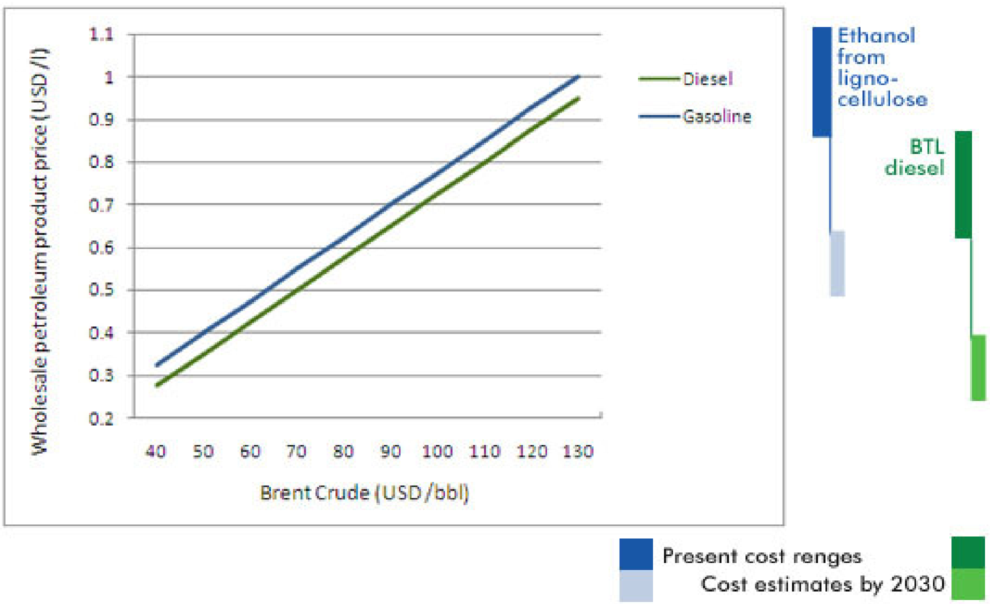
IEA 2nd – generation biofuel cost assumptions for 2010 and 2030

Lignocellulosic Conversion Technology	Assumptions	Production cost-By 2010 US$/gal	By 2030 US$/gal
Biochemical Ethanol	Optimistic	1.87	1.29
	Pessimistic	2.11	1.52
BTL diesel	Optimistic	2.34	1.40
	Pessimistic	2.81	1.64

Notes: 3.79 liter = 1 gallon; 1.63 gallons of ethanol is the equivalent of 1 gallon of gasoline, in terms of calorific value / energy density

Production cost ranges for 2nd generation biofuels compared with wholesale petroleum fuel prices correlated with the crude oil price over a 16 month period, and 2030 projections assuming significant investment in R&D

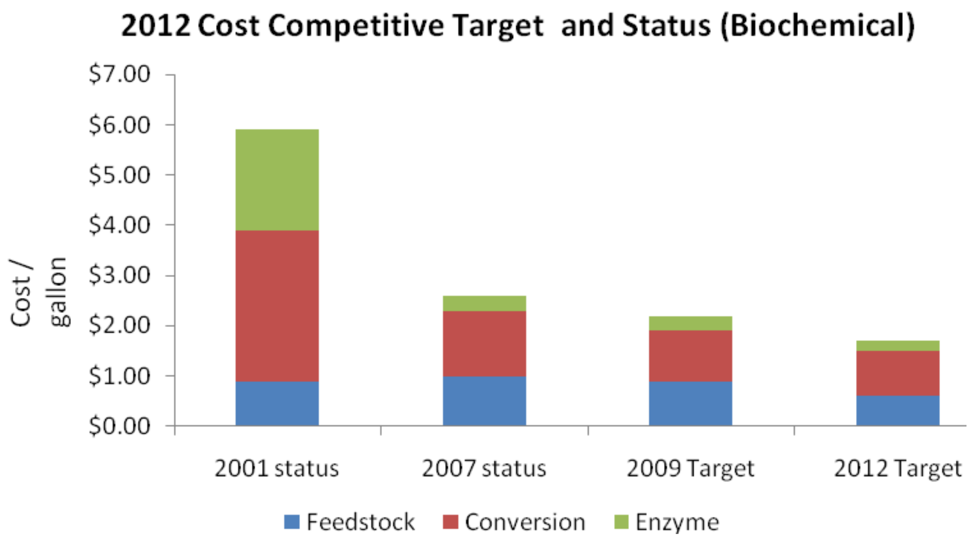
Production Cost Ranges for 2nd Generation Biofuels



Source: Based on IEA World Energy Outlook, 2006, section on biofuels.

The above chart was published in 2006. As it can be seen from the chart above, lignocellulosic ethanol is estimated to become cost competitive with fossil fuels currently at a crude price of about $100 per barrel, and by 2030, it is expected to be competitive at a crude price of $75.

Department of Energy, USA



Source: DOE EERE Office of the Biomass Program, Multi-year Program Plan, Appendix C.

Based on above charts and data, and using other reference sources, we estimate that the following is the likely trend for cellulosic ethanol costs in future.

Future Projections for Cellulosic Ethanol Costs

All cost data in $ / gallon

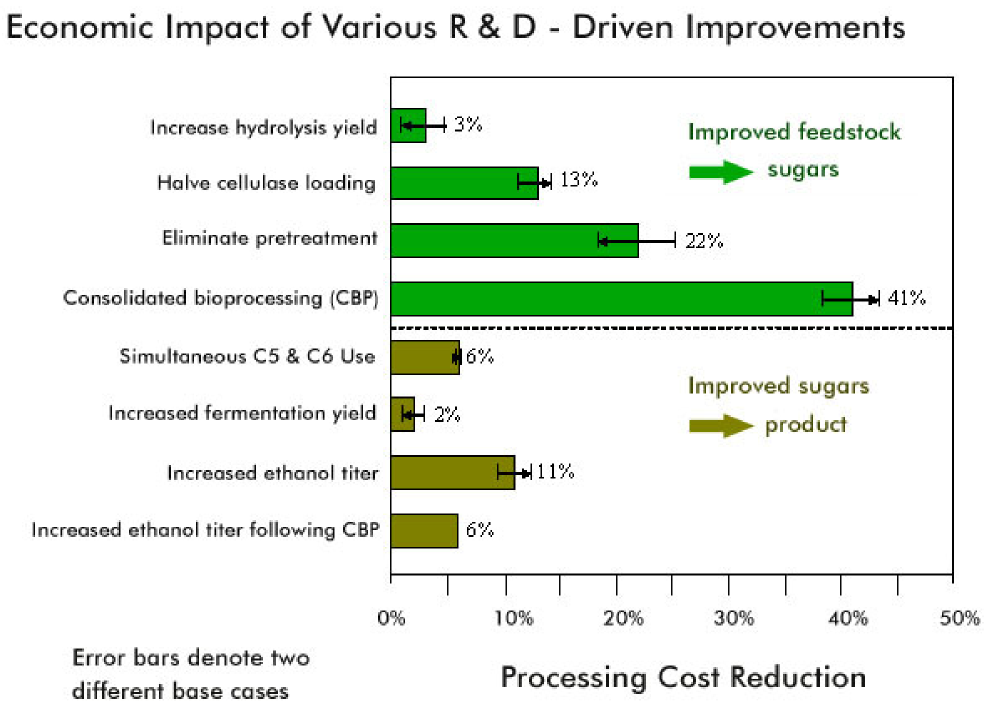
Cost component	2001	2005	2012	2020
Feedstock	0.8	0.8	0.5	0.35
Enzyme	3.2	0.4	0.3	0.1
Conversion	1.7	1.2	0.8	0.6
Total cost per gallon ($)	*5.7*	*2.4*	*1.6*	*1.05*
*Total cost per gallon equivalent of gasoline**	*9.3*	*3.9*	*2.6*	*1.7*

* : 1.63 gallons of ethanol is the equivalent of 1 gallon of gasoline, in terms of calorific value / energy density.

Source: BioZio estimates

Cost Drivers

Potential for Cost Reduction in Cellulosic Ethanol



Source: Laser & Lynd 2007

The chart above provides the likely processing cost reduction benefits that could result from various efficiency efforts. The largest of these reductions are likely to come from concepts such consolidated bioprocessing, efficiencies in (or elimination of) pretreatment methods, and a more optimal utilization of cellulose enzymes. Given that the total processing cost of cellulosic ethanol is about $1.0 per gallon, it is interesting to see that concepts such as CPB could provide cost savings of over 40 cents per gallon! *(Note: The various R&D improvements shown in the chart are not mutually exclusive)*