THE ECONOMIC FEASIBILITY OF ETHANOL PRODUCTION FROM SUGAR IN THE UNITED STATES

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Summary and Conclusions

Ethanol is a high-octane fuel which is used primarily as a gasoline additive and extender. The reduction in use of methyl tertiary butyl ether (MTBE) due to its environmental problems caused by groundwater contamination and surging prices for petroleum-based fuels are dramatically increasing the demand for ethanol and the interest in ethanol production in the United States. Ethanol can be produced from carbohydrates such as sugar, starch, and cellulose by fermentation using yeast or other organisms.

The purpose of this report is to investigate the economic feasibility of producing ethanol from sugar feedstocks in the United States. These sugar feedstocks include: (1) sugarcane juice, (2) sugar beet juice, (3) cane or beet molasses, (4) raw sugar and (5) refined sugar. Estimated costs of producing ethanol from these feedstocks are presented along with a discussion of other factors that may influence the economic feasibility of converting sugar feedstocks into ethanol. Comparisons are made with grain feedstocks, specifically corn.

The United States produced 3.9 billion gallons of ethanol in 2005, up from 3.4 billion gallons in 2004. Currently, corn is the primary feedstock being used in the production process. In 2005, Brazil, produced 4.2 billion gallons of ethanol, up from 4.0 billion gallons in 2004. Production of ethanol in Brazil utilizes sugar and molasses from sugarcane as a primary feedstock and thus demonstrates the technical feasibility of sugar-to-ethanol production. Corn-based ethanol accounts for approximately 97 percent of the total ethanol produced in the United States.

U.S. ethanol conversion rates utilizing corn as the feedstock are estimated at approximately 2.65 gallons of ethanol per bushel for a wet mill process and 2.75 gallons per bushel for a dry mill process. For the 2003-05 period, net feedstock costs for a wet mill plant are estimated at about $0.40 per gallon with total ethanol production costs estimated at $1.03 per gallon. Net feedstock costs for a dry mill plant are estimated at $0.53 per gallon with total ethanol production costs at $1.05 per gallon.

The theoretical yield of ethanol from sucrose is 163 gallons of ethanol per ton of sucrose. Factoring in maximum obtainable yield and realistic plant operations, the expected actual recovery would be about 141 gallons per ton of sucrose. Using 2003-05 U.S. average sugar recovery rates, one ton of sugarcane would be expected to yield 19.5 gallons of ethanol and one ton of sugar beets would be expected to yield 24.8 gallons of ethanol. One ton of molasses, a byproduct of sugarcane and sugar beet processing, would yield about 69.4 gallons of ethanol. Using raw sugar as a feedstock, one ton would yield 135.4 gallons of ethanol while refined sugar would yield 141.0 gallons.

Sugarcane and sugar beet feedstock and processing costs were estimated for the 2003-05 period for the purpose of estimating the cost of producing ethanol using these feedstocks. The cost of converting sugarcane into ethanol was estimated to be approximately $2.40 per gallon based on 2003-04 sugarcane market prices and estimated sugarcane processing costs. Feedstock cost was estimated at $1.48 per gallon of ethanol produced, representing 62 percent of the total ethanol production cost. The cost of converting sugar beets into ethanol was estimated to be approximately $2.35 per gallon based on 2003-04 sugar beet market prices and estimated sugar beet processing costs. Feedstock cost was estimated at $1.58 per gallon of ethanol produced, representing 67 percent of the total ethanol production cost. These estimates may understate the relative profitability of converting sugarcane and sugar beets into ethanol, compared with processing sugarcane into raw sugar and sugar beets into refined sugar, due to price increases for raw and refined sugar in recent months following the hurricanes in Florida and Louisiana in 2005. While sugar production is expected to rebound in 2006/07, U.S. sugar prices will likely remain considerably above forfeiture levels.

Molasses, from either sugarcane or sugar beets, was found to be the most cost competitive feedstock. Estimated ethanol production costs using molasses were approximately $1.27 per gallon with a $0.91 per gallon feedstock cost. Given the market prices of raw cane sugar and wholesale refined beet sugar in the United States, use of raw or refined sugar would be very costly to convert into ethanol. Ethanol production costs were estimated at $3.48 per gallon using raw sugar as a feedstock and were estimated at $3.97 per gallon using refined sugar. For these feedstocks, feedstock costs accounted for more than 80 percent of the total estimated ethanol production cost.

The table below summarizes the estimated ethanol production costs for corn and sugar feedstocks in the United States, as well as sugarcane in Brazil and sugar beets in the European Union (EU). In the United States, corn is the least cost feedstock available for ethanol production. The cost of producing ethanol from sugarcane in Brazil is estimated at about $0.81 per gallon, excluding capital costs. Like corn in the United States, the relatively low feedstock cost of sugarcane in Brazil makes this process economically competitive. The economic feasibility of ethanol production in the EU from sugar beets is highly dependent on the negotiated price for sugar beets.

Summary of estimated ethanol production costs (dollars per gallon) 1/

Cost Item	U.S. Corn wet milling	U.S. Corn dry milling	U.S. Sugar cane	U.S. Sugar beets	U.S. Molasses 3/	U.S. Raw sugar 3/	U.S. Refined sugar 3/	Brazil Sugar Cane 4/	E.U. Sugar Beets 4/
Feedstock costs 2/	0.40	0.53	1.48	1.58	0.91	3.12	3.61	0.30	0.97
Processing costs	0.63	0.52	0.92	0.77	0.36	0.36	0.36	0.51	1.92
Total cost	1.03	1.05	2.40	2.35	1.27	3.48	3.97	0.81	2.89

1/ Excludes capital costs.
2/ Feedstock costs for U.S. corn wet and dry milling are net feedstock costs; feedstock costs for U.S. sugarcane and sugar beets are gross feedstock costs.
3/ Excludes transportation costs.
4/ Average of published estimates.

Estimates of capital expenditure costs to construct facilities to utilize sugarcane or sugar beets to produce ethanol would be expected to be higher than capital costs for corn-based ethanol plants primarily due to higher feedstock preparation costs. A 20 million gallon per year ethanol plant using sugarcane or sugar beets as a feedstock would be expected to have capital expenditure costs in the range of $2.10 to $2.20 per gallon of annual capacity, compared to an estimate of $1.50 per gallon of annual capacity for a corn-based facility. The addition of an ethanol plant onto an existing sugarcane or sugar beet factory, to utilize cane or beet juice or molasses, would have a much lower capital expenditure cost making it more comparable with corn. Economies of size have been shown to exist in corn-based ethanol plants and the same would be expected for sugar-based ethanol plants.

The optimal location of an ethanol processing facility is largely dependent on being in close proximity to its feedstock supply, regardless of which feedstock is being utilized. This has been proven with corn-based ethanol in the United States as well as sugar-based ethanol in Brazil. Corn-based ethanol plants in the United States are located close to large supplies of corn, primarily in the Midwest, to minimize feedstock transportation costs. Ethanol facilities utilizing sugar or molasses would be most economical if located at or near sugarcane or sugar beet processing facilities.

Major conclusions from this study relative to the economic feasibility of using sugar crops as a feedstock for ethanol production in the United States are:

- It is economically feasible to make ethanol from molasses. The cost of that feedstock is low enough to make it competitive with corn. Challenges may involve having a large enough supply of molasses at a given location to minimize transportation costs to justify construction and operation of an economically efficient ethanol production facility.

- The estimated ethanol production costs using sugarcane, sugar beets, raw sugar, and refined sugar as a feedstocks are more than twice the production cost of converting corn into ethanol. While it is more profitable to produce ethanol from corn in the United States, the price of ethanol is determined by the price of gasoline and other factors, rather than the cost of producing ethanol from corn. With recent spot market prices for ethanol near $4 per gallon, it is profitable to produce ethanol from sugarcane and sugar beets, raw sugar, and refined sugar.

- Over the next several months, ethanol prices are expected to moderate as ethanol production expands. Based on current futures prices, the price of ethanol could drop to about $2.40 per gallon by the summer of 2007, making it unprofitable to produce ethanol from raw and refined sugar.

- Producing ethanol from sugar beets and sugarcane is estimated to be profitable at current ethanol spot prices and at about breakeven over the next several months, excluding capital replacement costs, based on current futures prices for ethanol. Over the longer term, the profitability of producing ethanol from sugarcane and sugar beets depends on the prices of these two crops, the costs of conversion, and the price of gasoline. A moderation in the price of gasoline and a return in ethanol prices to their historic relationship with gasoline prices could push the price of ethanol well below breakeven levels for converting sugar beets and sugarcane into ethanol. However, the market for crude oil remains very volatile and highly sensitive to events in the Middle East, making it very difficult to forecast future trends in crude oil and gasoline prices.

- Cellulosic conversion of biomass into ethanol could reduce the cost of converting sugarcane into ethanol in the future. Challenges would include development of high tonnage varieties of sugarcane as well as economical processing costs of cellulose on a commercial scale.

- Currently, no U.S. plants are producing ethanol from sugar feedstocks. As a result, no data exist on the cost of producing ethanol from sugar feedstocks in the United States. Brazil and several other countries are producing ethanol from sugarcane, sugar beets, and molasses, demonstrating that it is economically feasible to convert these feedstocks into ethanol. However, the economics of producing ethanol from sugar feedstocks in these countries is not directly comparable to the economics of producing ethanol from sugar feedstocks in the United States. The prices of sugarcane and sugar beets, sugarcane and sugar beet production costs, ethanol production facility construction and processing costs, and government sugar and ethanol policies and programs vary considerably from country to country. For these reasons, the above cost of production figures for converting sugar feedstocks may be imprecise.

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The Economic Feasibility Of Ethanol Production From Sugar In The United States

Introduction

The Central American—Dominican Republic—United States Free Trade Agreement (CAFTA-DR) focused the attention of many in the U.S. sugar industry on the feasibility of converting sugar into ethanol as a new market opportunity for sugar beet and sugarcane producers, as well as a means to help support sugar prices received by producers by reducing the supply of sugar for food use in the domestic market. The purpose of this report is to investigate the feasibility of producing ethanol from sugar feedstocks in the United States. In the production of ethanol from sugar, five potential feedstocks are examined in this report. These feedstocks include: (1) sugarcane juice, (2) sugar beet juice, (3) cane/beet molasses, (4) raw sugar, and (5) refined sugar. Estimated costs of producing ethanol from these feedstocks are presented along with a discussion of future technologies that may have the potential of reducing the cost of converting sugar feedstocks into ethanol. Comparisons of the cost of producing ethanol from sugar feedstocks are made with grain feedstocks, primarily corn.

Ethanol is a high-octane fuel which is used primarily as a gasoline additive and extender. The only economically feasible fuel oxygenates currently available are ethanol and methyl tertiary butyl ether (MTBE). MTBE has been used since 1979 to replace lead in gasoline as an octane enhancer. Ethanol is replacing the use of MTBE as a fuel additive due to groundwater contamination associated with MTBE use in gasoline. In addition, surging prices for petroleum-based fuel are expanding the demand for ethanol as an energy source. As a result, the demand for ethanol in the United States is projected to increase substantially over the next ten to twenty years (*Annual Energy Outlook*, 2006).

Ethanol can be produced from carbohydrates such as sugar, starch, and cellulose by fermentation using yeast or other organisms. World production of ethanol (all grades) in 2005 was about 12 billion gallons (Renewable Fuels Association). Although many countries produce ethanol from a variety of feedstocks, Brazil and the United States are the major producers of ethanol in the world, each accounting for approximately 35 percent of global production. In 2005, Brazil produced 4.2 billion gallons of ethanol, up from 4 billion gallons in 2004. Production of ethanol in Brazil utilizes sugar and molasses from sugarcane as a primary feedstock. In addition to Brazil, production of ethanol from sugarcane is currently underway in several other countries including Australia, Columbia, India, Peru, Cuba, Ethiopia, Vietnam, and Zimbabwe.

In 1970, approximately 80 percent of the Brazilian sugarcane crop was used to produce sugar for food, while only 20 percent was used to produce ethanol. Ethanol production in Brazil started to increase in the late 1970s and early 1980s. For the 2005/06 sugarcane crop year, it is projected that Brazil will use 53 percent of its sugar to produce ethanol, the highest proportion since 2000/01 when almost 55 percent was converted into fuel (F. O. Licht).

The United States produced 3.9 billion gallons of ethanol in 2005, up from 3.4 billion gallons in 2004. Corn-based ethanol accounts for approximately 97 percent of the total ethanol produced in the United States. Most ethanol in the United States is produced by either a wet milling or dry milling process utilizing shelled corn as the principal feedstock.

The U.S. Ethanol Industry

As of June 2006, there are 101 ethanol plants operating in 21 States with a total production capacity of 4.8 billion gallons per year (Renewable Fuels Association). In addition, 33 ethanol plants are under construction and seven ethanol plants are expanding their existing capacity. By early 2007, total production capacity could increase to 6.7 billion gallons per year.

Fuel ethanol production increased from a few hundred million gallons in 1980 to 3.9 billion gallons in 2005. During the past four years, ethanol production in the United States grew, on average, at a compound rate of 20 percent per year. Almost all of the fuel ethanol produced in the United States utilizes corn as its primary feedstock. A relatively minor quantity of ethanol is produced from other feedstocks including sorghum, cheese whey, and beverage waste.

Table 1 shows the number of ethanol plants currently operating or under construction in each state and production capacity in million gallons per year as of June 2006. With corn being the primary feedstock, current plants are primarily located close to a large, dependable supply of corn and are concentrated in the Midwest. States with a relatively large number of ethanol plants are generally major producers of corn.

Table 1. Location and capacity of current U.S. ethanol plants

State	Number of plants	Current capacity (mil. gal./year)	Under construction (mil. gal./year)
Arizona	1	--	55.0
California	4	32.7	35.0
Colorado	3	83.5	1.5
Georgia	1	0.4	--
Illinois	7	533.0	107.0
Indiana	5	102.0	280.0
Iowa	28	1,176.5	530.0
Kansas	9	205.5	95.0
Kentucky	2	35.7	9.0
Michigan	4	50.0	157.0
Minnesota	17	648.6	58.0
Missouri	4	110.0	45.0
Nebraska	19	623.5	501.0
New Mexico	1	30.0	--
North Dakota	4	163.5	100.0
Ohio	2	3.0	100.0
South Dakota	13	432.0	238.0
Tennessee	1	67.0	--
Texas	1	--	30.0
Wisconsin	6	188.0	40.0
Wyoming	1	5.0	--
Total	1/	4,818.9	2,122.5

1/ 101 current ethanol plants, 33 new plants under construction and 7 expansions of existing plants
Source: Renewable Fuels Association

Growth in the U.S. ethanol industry is directly related to Federal and State policies and regulations. Government incentives, such as motor fuel excise tax credits, small ethanol producer tax credits, import duties on fuel ethanol imports, and others helped increase the production of ethanol during the 1980s. Government regulations, such the Clean Air Act Amendments of 1990, the Energy Policy Act of 1992, and the Energy Conservation Reauthorization Act of 1998, significantly increased the demand for ethanol during the 1990's. In recent years, the phasing out of MTBE, the Farm Security and Rural Investment Act of 2002, and the Energy Policy Act of 2005 along with surging prices for gasoline have sharply expanded the production and use of ethanol. It took 20 years for the ethanol industry to reach 1.6 billion gallons of production in 2000, but it took only five more years for the industry to increase ethanol production to 3.9 billion gallons.

The Energy Policy Act of 2005 established the renewable fuels standard (RFS), which directs that gasoline sold in the U.S. contain specified minimum volumes of renewable fuel. Under the Act, the total volume of renewable fuel to be utilized starts at 4 billion gallons in 2006 and increases to 7.5 billion gallons in 2012. The Energy Policy Act of 2005 also provides for a minimum of 250 million gallons of cellulosic derived ethanol to be included in the RFS by 2013.

Industry projections indicate ethanol production will increase beyond the mandated minimum level of 7.5 billion gallons by 2012. While the ethanol requirement in 2006 is set at 4 billion gallons, ethanol production in 2006 is projected to reach 5 billion gallons. Currently, a large percentage of ethanol is being used to replace the gasoline additive MTBE and ethanol is also used as a gasoline extender and octane enhancer. Prices of crude oil and gasoline increased significantly in 2004 and especially in 2005 and continue to remain strong. Long-term projections by the Department of Energy's Energy Information Agency (EIA) indicate that the price of crude oil will remain high during the next 7 to 10 years, boosting the demand for ethanol above the RFS requirement.

Price Outlook for Ethanol

Ethanol is a gasoline extender and octane enhancer and its value depends on the price of gasoline. In recent years, the price of ethanol in the U.S. has followed the price of gasoline (adjusted for energy content relative to gasoline) plus the 51 cents per gallon Federal excise tax credit. However, spot prices of ethanol have increased much more sharply in recent months than the price of gasoline as U.S. oil refineries replace MTBE, an octane booster that has been found to contaminate groundwater, with ethanol. In addition, the lack of infrastructure for shipping and blending ethanol with gasoline and limited ethanol supplies on the international market have also contributed to the surge in ethanol prices.

The average spot price for ethanol for the month of May 2006 was $2.99 per gallon, compared with $1.32 for the same month last year. Spot ethanol prices increased to over $4 per gallon in June and prices are expected to remain strong through the summer driving season. Ethanol prices are eventually expected to ease as ethanol production expands. More than one billion gallons of new production capacity will be online by the fall of 2006. In addition, more ethanol is expected to be available for export from Brazil and through Caribbean Basin Initiative (CBI) countries. The futures price for ethanol on the Chicago Board of Trade gradually declines from over $3 per gallon for July of this year to about $2.40 per gallon for May of 2007.

As ethanol production expands to fully replace MTBE and assuming production continues to exceed the requirements established in the RFS, the price of ethanol should reflect its value as a gasoline extender and move up and down with the wholesale price of gasoline. The key long term factors affecting the price of gasoline in the U.S. are the price of crude oil and gasoline refining capacity. The world price of crude oil is projected to rise through 2006 and remain steady in 2007 at about $60 per barrel, and then gradually decline to about $45 per barrel by 2010 (2004 dollars) as new supplies enter the market (EIA). Based on this forecast, the prices of gasoline and other refined products could start to decline in 2008, which would likely cause ethanol prices to decline further in 2008. However, the market for crude oil remains very volatile and highly sensitive to events in the Middle East making it very difficult to forecast future trends in crude oil and gasoline prices.

Feedstock Available for Ethanol Production

It is technically feasible to make ethanol from a wide variety of available feedstocks. Fuel ethanol could be made from crops which contain starch such as feed grains, food grains, and tubers, such as potatoes and sweet potatoes. Crops containing sugar, such as sugar beets, sugarcane, and sweet sorghum also could be used for the production of ethanol. In addition, food processing byproducts, such as molasses, cheese whey, and cellulosic materials including grass and wood, as well as agricultural and forestry residues could be processed to ethanol.

Area planted, area harvested for grain, production, and yield per harvested acre for corn, sorghum, barley, and oats (feed grains) are presented in Tables 2-5. Planted acreage to corn, sorghum, barley, and oats declined from 1980 to 2005. Total feedgrain planted acres declined from 121.0 million acres in 1980 to 96.3 million acres in 2005. During the same period, harvested area for grain declined from 101.4 million acres to 85.9 million acres. Unlike the area planted and harvested, production, and yield per harvested acre increased significantly during 1980-2005. Total feedgrain production increased from 198 million metric tons in 1980 to 299 million metric tons in 2005. During this period, the increase in production of corn for grain offset decreases in production of sorghum, barley, and oats.

Corn acreage planted declined from 84.0 million acres in 1980 to less than 70 million acres in the late 1980s then increased to 81.8 million acres in 2005. Area harvested for grain increased slightly from 73.0 million acres in 1980 to 75.1 million acres in 2005. The three-year average corn yield per harvested area increased from 104 bushels in 1980-82 to 150 bushels per acre in 2003-05. Corn yield per harvested acre is directly related to land quality, management, weather, farm input use, and advanced technologies used in corn production. Some of these technologies include genetically modified seed, slow release fertilizer, global positioning systems (GPS), and yield mapping.

In addition to corn, sorghum is also used as feedstock for ethanol production. Sorghum area planted and harvested has declined during the last 25 years. Area planted to sorghum increased from 15.6 million acres in 1980 to 18.3 million acres in 1985. Since then, area planted to sorghum declined steadily to 6.5 million acres in 2005. Yield per acre increased from 46.3

Table 2. U.S. corn acreage, yield and production, 1980-2005

Year	Planted	Harvested	Yield per Acre	Production
	(1,000 acres)	(1,000 acres)	(bushels)	(1,000 bushels)
1980	84,043	72,961	91.0	6,639,396
1981	84,097	74,524	108.9	8,118,650
1982	81,857	72,719	113.2	8,235,101
1983	60,207	51,479	81.1	4,174,251
1984	80,517	71,897	106.7	7,672,130
1985	83,398	75,209	118.0	8,875,453
1986	76,580	68,907	119.4	8,225,764
1987	66,200	59,505	119.8	7,131,300
1988	67,717	58,250	84.6	4,928,681
1989	72,322	64,783	116.3	7,531,953
1990	74,166	66,952	118.5	7,934,028
1991	75,957	68,822	108.6	7,474,765
1992	79,311	72,077	131.5	9,476,698
1993	73,239	62,933	100.7	6,337,730
1994	78,921	72,514	138.6	10,050,520
1995	71,479	65,210	113.5	7,400,051
1996	79,229	72,644	127.1	9,232,557
1997	79,537	72,671	126.7	9,206,832
1998	80,165	72,589	134.4	9,758,685
1999	77,386	70,487	133.8	9,430,612
2000	79,551	72,440	136.9	9,915,051
2001	75,702	68,768	138.2	9,502,580
2002	78,894	69,330	129.3	8,966,787
2003	78,603	70,944	142.2	10,089,222
2004	80,929	73,631	160.4	11,807,086
2005	81,759	75,107	147.9	11,112,072

Source: National Agricultural Statistics Service, U.S. Department of Agriculture.

Table 3. U.S. sorghum acreage, yield and production, 1980-2005

Year	Planted	Harvested	Yield per Acre	Production
	(1,000 acres)	(1,000 acres)	(bushels)	(1,000 bushels)
1980	15,639	12,513	46.3	579,343
1981	15,930	13,677	64.0	875,835
1982	16,028	14,137	59.1	835,083
1983	11,880	10,001	48.7	487,521
1984	17,254	15,355	56.4	866,241
1985	18,285	16,782	66.8	1,120,271
1986	15,339	13,862	67.7	938,869
1987	11,756	10,531	69.4	730,809
1988	10,343	9,042	63.8	576,686
1989	12,642	11,103	55.4	615,420
1990	10,535	9,089	63.1	573,303
1991	11,064	9,870	59.3	584,860
1992	13,177	12,050	72.6	875,022
1993	9,882	8,916	59.9	534,172
1994	9,787	8,882	72.7	645,741
1995	9,429	8,253	55.6	458,648
1996	13,097	11,811	67.3	795,274
1997	10,052	9,158	69.2	633,545
1998	9,626	7,723	67.3	519,933
1999	9,288	8,544	69.7	595,166
2000	9,195	7,726	60.9	470,526
2001	10,248	8,579	59.9	514,040
2002	9,589	7,125	50.6	360,713
2003	9,420	7,798	52.7	411,237
2004	7,486	6,517	69.6	453,654
2005	6,454	5,736	68.7	393,893

Source: National Agricultural Statistics Service, U.S. Department of Agriculture.

bushels per acre in 1980 to approximately 73 bushels in 1992 and 1994 and then declined to 68.7 bushels in 2005. During the past 25 years, sorghum yield per acre increased 14 percent, while corn yield per acre increased more than 75 percent. Sorghum has more tolerance to drought than corn. In addition, less chemicals and fertilizer are used in the production of sorghum. Total production of sorghum increased from 579 million bushels in 1980 to a record high of over one billion bushels in 1985. Sorghum production declined to 394 million bushels in 2005.

There are other feed grains produced in the United States which could be used as a feedstock in the production of ethanol, such as barley and oats, although their conversion rates are less than that for corn or sorghum. U.S. barley planted acreage has declined from over 13 million acres in 1985-86 to less than 4 million in 2005. Oats planted acreage has declined from over 12 million acres in the 1980s to just over 4 million 2005.

Table 4. U.S. barley acreage, yield and production, 1980-2005

Year	Planted (1,000 acres)	Harvested (1,000 acres)	Yield per Acre (bushels)	Production (1,000 bushels)
1980	8,320	7,260	49.7	361,135
1981	9,618	9,038	52.4	473,512
1982	9,549	9,013	57.2	515,935
1983	10,411	9,721	52.3	508,269
1984	11,934	11,218	53.3	598,034
1985	13,139	11,591	50.9	590,213
1986	13,024	11,974	50.8	608,532
1987	10,929	9,957	52.4	521,499
1988	9,831	7,636	38.0	289,994
1989	9,125	8,313	48.6	404,203
1990	8,221	7,529	56.1	422,196
1991	8,941	8,413	55.2	464,326
1992	7,762	7,285	62.5	455,090
1993	7,786	6,753	58.9	398,041
1994	7,159	6,667	56.2	374,862
1995	6,689	6,279	57.2	359,376
1996	7,094	6,707	58.5	392,433
1997	6,706	6,198	58.1	359,878
1998	6,325	5,854	60.1	351,569
1999	4,983	4,573	59.5	271,996
2000	5,801	5,200	61.1	317,804
2001	4,951	4,273	58.1	248,329
2002	5,008	4,123	55.0	226,906
2003	5,348	4,727	58.9	278,283
2004	4,527	4,021	69.6	279,743
2005	3,875	3,269	64.8	211,896

Source: National Agricultural Statistics Service, U.S. Department of Agriculture.

Table 5. U.S. oats acreage, yield and production, 1980-2005

Year	Planted	Harvested	Yield per Acre	Production
	(1,000 acres)	(1,000 acres)	(bushels)	(1,000 bushels)
1980	13,381	8,657	53.0	458,792
1981	13,632	9,407	54.2	509,529
1982	13,951	10,258	57.8	592,630
1983	20,289	9,062	52.6	476,471
1984	12,414	8,163	58.0	473,661
1985	13,235	8,147	63.6	518,490
1986	14,671	6,840	56.3	384,996
1987	17,907	6,888	54.3	373,713
1988	13,907	5,530	39.3	217,375
1989	12,085	6,882	54.3	373,587
1990	10,423	5,947	60.1	357,654
1991	8,653	4,816	50.6	243,851
1992	7,943	4,496	65.4	294,229
1993	7,937	3,803	54.4	206,731
1994	6,637	4,008	57.1	228,844
1995	6,225	2,952	54.6	161,094
1996	4,638	2,655	57.7	153,245
1997	5,068	2,813	59.5	167,246
1998	4,891	2,752	60.2	165,768
1999	4,668	2,445	59.6	145,628
2000	4,473	2,325	64.2	149,165
2001	4,401	1,911	61.5	117,602
2002	4,995	2,058	56.4	116,002
2003	4,597	2,220	65.0	144,383
2004	4,085	1,787	64.7	115,695
2005	4,246	1,823	63.0	114,878

Source: National Agricultural Statistics Service, U.S. Department of Agriculture.

Sugarcane is a tropical crop which is processed into raw sugar and molasses. In the United States, sugarcane is planted and harvested in Hawaii, Florida, Louisiana, and Texas. Sugarcane is a perennial crop that can be harvested 4 to 5 times before reseeding. U.S. sugarcane production is reported on a fiscal year basis, as the harvest season in Florida, Hawaii, and Texas generally runs from October through March. The harvest season in Louisiana, the most northern growing U.S. area, generally runs from late September through late December or early January.

In 2005, total U.S. area in sugarcane was 922,600 acres (Table 6). Harvested area for sugar was 858,200 acres, with the remaining acreage harvested for seed. Total sugarcane production, excluding harvested for seed, was 24.726 million tons, resulting in an average national yield of 28.8 tons of cane per harvested acre. The average recovery rate, pounds of raw sugar produced as a percent of total cane volume, was 12.33 percent. The estimated 2005/06 sugar yield per acre was 3.55 tons of raw sugar per harvested acre. Total sugar production from sugarcane in 2005/06 is estimated at 3.05 million tons, raw value, representing 41 percent of U.S. sugar production.

Florida harvested 376,000 acres of sugarcane for sugar in 2005/06 from a total of 401,000 acres in cultivation (Appendix table 1). This harvested acreage accounted for 44 percent of the total sugarcane acreage harvested in the U.S. and is down from a high of 445,000 acres harvested for sugar in 2001/02. Florida's sugarcane production for 2005/06 is estimated at 11.806 million tons, 48 percent of U.S. sugarcane production. Sugarcane acreage in Florida has remained relatively stable over the past several years with a gradual upward trend in both yield per acre and sugar recovery rate. In both 2004 and 2005, hurricanes reduced harvested acreage and yield per acre in Florida.

Table 6. U.S. sugarcane acreage, yield and production, 1980-2005

Crop Year	Total acreage	Acreage for sugar	Sugarcane yield per acre	Sugarcane production	Recovery rate	Sugar yield per acre
	(1,000 acres)		(tons/acre)	(1,000 tons)	(%)	(tons, raw value)
1980/81	732.7	683.6	37.4	25,582	10.66	3.99
1981/82	755.4	715.6	36.6	26,165	10.83	3.96
1982/83	741.7	700.4	40.6	28,449	10.77	4.37
1983/84	767.7	733.4	37.1	27,201	10.77	4.00
1984/85	747.3	700.7	37.1	26,008	11.56	4.29
1985/86	770.0	722.8	37.2	26,877	11.28	4.20
1986/87	796.2	750.7	38.5	28,936	11.34	4.37
1987/88	823.6	778.3	36.0	28,026	11.71	4.22
1988/89	845.3	793.6	35.9	28,479	11.93	4.28
1989/90	851.9	803.3	34.9	28,069	11.32	3.95
1990/91	794.2	726.4	36.4	26,475	11.91	4.34
1991/92	896.9	849.6	34.1	28,960	11.84	4.04
1992/93	925.2	870.4	33.2	28,873	11.68	3.87
1993/94	948.3	893.3	33.2	29,635	11.76	3.90
1994/95	936.8	881.7	33.3	29,404	12.06	4.02
1995/96	932.3	874.7	33.3	29,137	11.85	3.95
1996/97	888.9	829.5	33.4	27,687	11.76	3.93
1997/98	914.0	860.3	34.9	30,003	12.09	4.22
1998/99	947.1	888.3	36.9	32,743	11.97	4.41
1999/00	993.3	941.4	35.7	33,577	12.27	4.38
2000/01	1023.3	976.7	35.1	34,291	12.10	4.25
2001/02	1027.8	970.3	33.8	32,775	12.14	4.10
2002/03	1023.2	971.9	34.9	33,903	11.67	4.07
2003/04	992.3	930.6	34.3	31,942	12.42	4.26
2004/05	938.2	879.5	31.0	27,243	12.02	3.72
2005/06	922.6	858.2	28.8	24,726	12.33	3.55

Source: Economic Research Service, U.S. Department of Agriculture.

Sugarcane production in Hawaii has been declining over the past 25 years. A large percentage of Hawaiian raw sugar was shipped to California for refining, leaving a relatively small quantity for use in Hawaii. Stagnant demand for sugar in Hawaii, as well as high production and transportation costs of raw sugar from Hawaii to the mainland, has forced some of the state's sugar plantations and sugar mills to go out of business. Increased land values due to commercial and residential development have also contributed to the decline in the state's sugar industry. In 2005, Hawaii harvested 21,700 acres of sugarcane for sugar, down from 97,400 acres in 1980 (Appendix table 2). Sugarcane yields in Hawaii have been high, compared to other states, due to the length of the production cycle before harvest. Since 1980, sugarcane yields per harvested acre have exceeded 80 tons every year except 2000/01. However, because of the declining acreage, Hawaii's 2005/06 sugarcane production only represented 7 percent of U.S. sugarcane production.

Louisiana is the other major sugarcane producing state. In 2005/06, Louisiana harvested 420,000 acres of sugarcane for sugar from 455,000 acres under cultivation (Appendix table 3). This harvested acreage accounted for 49 percent of total U.S. harvested acreage. Sugarcane area under cultivation in Louisiana has exceeded 400,000 acres every year since 1997/98. Yield per acre in 2005/06 was 22.9 tons, down from a record high of 32.7 tons in 1999/2000, as hurricanes in 2005 reduced yield per acre. Louisiana's sugarcane production was 9.618 million tons in 2005/06, accounting for 39 percent of total U.S. production. Sugar recovery rate, normally in the 11.0-12.0 percent range, is estimated at 12.9 percent for 2005/06. Raw sugar yield per acre is estimated to be 2.96 tons per harvested acre.

Texas harvested 40,500 acres of sugarcane for sugar in 2005/06, accounting for 4.7 percent of total U.S. harvested acreage (Appendix table 4). Yields have averaged 39.2 tons of sugarcane over the past five years. The sugarcane yield in 2005/06 was 38.3 tons per acre, resulting in an estimated total production of 1.551 million tons of sugarcane, 6 percent of the U.S. total. Sugar recovery rates have varied over the years. Recovery in 2005/06 was 11.6 percent, resulting in an estimated sugar yield of 4.44 tons of raw sugar per harvested acre.

Sugar beets are an annual crop whose acreage is dependent upon the relative profitability of competing crops as well as the price of sugar. Total U.S. planted area of sugar beets in 2005 was 1.3 million acres (Table 7). This acreage is similar to levels planted in the early 1980s, although total planted acreage has fluctuated in the years since. The average U.S. yield in 2005 was 22.2 tons of beets per harvested acre, yielding a total production of 27.537 million tons, down from a high of 33.420 million tons in 1999. Sugar recovery rates in beets generally average higher than cane. In 2005, the average recovery rate was 15.8 percent. Total U.S. production of beet sugar in 2005/06 was estimated at 4.345 million tons, raw value, accounting for 59 percent of total U.S. sugar production (Table 8).

Table 7. U.S. sugar beet acreage, yield and production, 1980-2005

Crop Year	Planted acreage	Harvested acreage	Sugar beet yield per acre	Sugar beet production	Recovery rate	Sugar yield per acre
	(1,000 acres)		(tons/acre)	(1,000 tons)	(%)	(tons)
1980	1,231	1,190	19.7	23,502	13.8	2.72
1981	1,254	1,228	22.4	27,538	12.0	2.70
1982	1,054	1,027	20.3	20,894	12.9	2.62
1983	1,081	1,056	19.9	20,992	13.5	2.69
1984	1,124	1,096	20.2	22,134	13.2	2.66
1985	1,125	1,102	20.4	22,529	13.3	2.71
1986	1,232	1,191	21.1	25,162	14.5	3.07
1987	1,267	1,252	22.4	28,072	13.6	3.05
1988	1,327	1,301	19.1	24,810	13.7	2.61
1989	1,324	1,295	19.4	25,131	13.8	2.68
1990	1,400	1,377	20.0	27,513	14.0	2.80
1991	1,427	1,387	20.3	28,203	13.6	2.77
1992	1,437	1,412	20.6	29,143	15.1	3.11
1993	1,438	1,409	18.6	26,249	15.6	2.90
1994	1,476	1,443	22.1	31,853	14.1	3.11
1995	1,445	1,420	19.8	28,065	14.0	2.76
1996	1,368	1,323	20.2	26,680	15.0	3.03
1997	1,459	1,428	20.9	29,886	14.7	3.07
1998	1,498	1,451	22.4	32,499	13.6	3.05
1999	1,561	1,527	21.9	33,420	14.8	3.24
2000	1,564	1,373	23.7	32,541	14.4	3.41
2001	1,371	1,243	20.7	25,764	15.2	3.15
2002	1,427	1,361	20.4	27,707	16.1	3.28
2003	1,365	1,348	22.8	30,710	15.3	3.48
2004	1,346	1,307	23.0	30,021	15.4	3.53
2005	1,300	1,243	22.2	27,537	15.8	3.50

Source: Economic Research Service, U.S. Department of Agriculture.

Sugar beets are produced primarily in four regions of the country: the Great Lakes region (Michigan and Ohio), the Upper Midwest region (Minnesota and North Dakota), the Great Plains region (Colorado, Montana, Nebraska, Texas, and Wyoming) and the Far West region (California, Idaho, Oregon, and Washington). Sugar beet acreage in the Great Lakes region has been declining slightly over the past ten years. Planted area in 2005 was 154,000 acres, down

Table 8. U.S. beet and cane production, 1980/81 – 2005/06

Crop Year	Total sugar production			Share of production		
	Beet	Cane	Total	Beet	Cane	Total
	(1,000 tons, raw value)			(Percent)		
1980/81	3,234	2,987	6,221	52.0	48.0	100
1981/82	3,318	2,804	6,122	54.2	45.8	100
1982/83	2,692	3,263	5,955	45.2	54.8	100
1983/84	2,837	3,073	5,910	48.0	52.0	100
1984/85	2,915	3,025	5,940	49.1	50.9	100
1985/86	2,988	3,136	6,124	48.8	51.2	100
1986/87	3,653	3,506	7,159	51.0	49.0	100
1987/88	3,822	3,425	7,247	52.7	47.3	100
1988/89	3,396	3,408	6,804	49.9	50.1	100
1989/90	3,466	3,225	6,691	51.8	48.2	100
1990/91	3,854	3,124	6,978	55.2	44.8	100
1991/92	3,845	3,461	7,306	52.6	47.4	100
1992/93	4,392	3,446	7,838	56.0	44.0	100
1993/94	4,090	3,565	7,655	53.4	46.6	100
1994/95	4,493	3,434	7,927	56.7	43.3	100
1995/96	3,916	3,454	7,370	53.1	46.9	100
1996/97	4,013	3,191	7,204	55.7	44.3	100
1997/98	4,389	3,632	8,021	54.7	45.3	100
1998/99	4,423	3,951	8,374	52.8	47.2	100
1999/00	4,956	4,076	9,032	54.9	45.1	100
2000/01	4,680	4,089	8,769	53.4	46.6	100
2001/02	3,915	3,985	7,900	49.6	50.4	100
2002/03	4,462	3,964	8,426	53.0	47.0	100
2003/04	4,692	3,957	8,649	54.3	45.7	100
2004/05	4,611	3,266	7,876	58.5	41.5	100
2005/06	4,345	3,048	7,393	58.8	41.2	100

Source: Economic Research Service, U.S. Department of Agriculture.

from 212,000 acres planted in 1994 (Appendix table 5). A total of 152,000 acres was harvested in 2005 with an average yield of 21.3 tons of beets per acre. This harvested acreage accounted for 12.2 percent of total U.S. harvested beet acreage. Total sugar beet production is estimated at 3.238 million tons, accounting for 12 percent of total U.S. production. An upward trend in yields in this region has offset the decline in acreage, resulting in a relatively stable level of total sugar beet production.

The Upper Midwest region, although including only the states of Minnesota and North Dakota, is the largest sugar beet producing region in the country. Total production in 2005 is estimated at 13.977 million tons of sugar beets, representing 51 percent of total U.S. production (Appendix table 6). Sugar beet acreage in this region has been increasing over the past several years. In 2005, 746,000 acres were planted to sugar beets, up from 564,000 acres in 1991. Approximately 703,000 acres were harvested with an average yield of 19.9 tons per harvested acre.

Sugar beet acreage in the Great Plains region has declined substantially over the past several years. In 2005, 174,900 acres were planted to sugar beets, down from 292,800 in 1992 (Appendix table 7). Harvested area in 2005 was 165,400 acres, representing 13 percent of the U.S. total. Yields over the past few years have been higher compared to earlier years, averaging over 22 tons per acre for the past three years. However, the decrease in planted acreage over the years has significantly reduced total production. In 2005, the region produced 3.701 million tons of sugar beets, 13 percent of U.S. production. In the early 1990s, this region produced almost 6.0 million tons of beets annually.

The Far West region planted 224,900 acres of sugar beets in 2005, down from 379,900 acres in 1991 (Appendix table 8). Harvested area was 222,500 acres, 18 percent of total U.S. harvested acreage. This region has the highest average sugar beet yields per acre. In 2005, the region's average yield was 29.8 tons of beets per harvested acre, down from a high of 31.3 tons a year earlier. Total estimated production was 6.621 million tons of beets, 24 percent of total U.S. beet production in 2005.

Byproducts of the Ethanol and Sugar Industries

There are two processes currently used to produce ethanol from corn in the United States: wet milling process and dry milling or dry ground process. Dry milling accounts for about 79 percent of ethanol production and wet milling accounts for 21 percent of total ethanol production.

In the wet milling process, corn kernels are fractionated into starch, fiber, corn germ, and protein. Only pure starch is used in the production of ethanol. The wet milling process is very similar to bio-refineries. Various byproducts are produced in the process of producing ethanol, such as corn oil, corn gluten meal, corn gluten feed, and carbon dioxide. In addition, some large wet milling ethanol plants produce vitamins, food and feed additives, aquaculture, and hydroponic production of vegetables. Growth of vegetables in greenhouses is enhanced with excess carbon dioxide produced during the fermentation process.

Corn oil is a premium vegetable oil and is used for human consumption. Due to the high prices of this byproduct, corn oil is not used for the production of biodiesel in the United States. Corn gluten meal contains more than 60 percent protein without fiber and is mostly used in poultry feed rations. Corn gluten feed contains 21 percent protein and is mostly exported to the EU. Carbon dioxide is produced during the fermentation of glucose to alcohol. Some ethanol plants capture raw carbon dioxide to be refined and used in carbonated beverages and dry ice.

The byproducts of the dry milling process are distillers dried grain with solubles (DDGS), condensed syrup, and carbon dioxide. In the conventional dry milling process, corn kernels are ground and water is added, the corn mash is cooked, and enzymes are added to convert starch to glucose. The glucose is converted to alcohol through fermentation. After the alcohol is removed, the liquid passes through a centrifuge and is converted to thin stillage and thick stillage or wet distiller's grains. Wet distillers grains contain 33 percent solids. The wet distillers grains can be fed to dairy and beef cattle, comprising up to 43 and 37 percent of their rations, respectively. The shelf life of wet distiller grains is very short, approximately 4 days. In order to increase the shelf life of wet distiller's grains, water must be removed. Distillers dried grains contain 27 percent protein and 87 percent solids. The thin stillage is evaporated and sprayed over the distillers dried grains to make distillers' dried grains with solubles or sold as condensed syrup as a feed additive.

In new dry milling plants, corn germ and fiber are separated from corn before the starch is converted to glucose in a new process called dry fractionation. Some of the existing ethanol plants separate corn fiber and corn germ as valuable byproducts in addition to distillers dried grains and carbon dioxide. In addition, a few ethanol plants separate corn oil from stillage.

Sugar beet processing plants convert sugar beets directly into refined sugar. The byproducts of sugar beet plants include beet pulp and sugar beet molasses. Beet pulp is used as an animal feed. If sugar beet processing plants are located close to livestock and dairy operations, some of the beet pulp is sold as wet pulp. Sugar beet molasses is used as a livestock feed additive.

Sugarcane mills convert sugarcane to raw sugar, which must then be sent to a refinery for conversion to white refined sugar. The byproducts of sugarcane mills, which convert sugarcane to raw sugar, are cane molasses and bagasse. Sugarcane molasses is used in the production of alcohol beverages, fuel alcohol, and for direct human consumption. Modern sugarcane mills also take advantage of sugarcane bagasse for production of steam and generation of electricity within the plant and sell excess electricity to the regional utility grid.

Sugar, in the form of raw or refined sugar, or as sugar in molasses requires no pre-hydrolysis (unlike corn) prior to fermentation. Consequently, the process of producing ethanol from sugar is simpler than converting corn into ethanol.

Starch and Sugar Content of Grains and Sugar Crops

Corn contains between 70 to 72 percent starch. The starch content of corn depends on cultural practices, climate, soil type, weather, and seed varieties. Within the same corn variety, the percent of starch can vary from year to year. Sorghum has a slightly lower starch content than corn. The starch content of sorghum varies between 68 to 70 percent. There is no difference between the starch in corn and in sorghum.

In contrast to grains which contain starch which must be converted to sugars for fermentation, sugar crops contain sucrose, a form of sugar. The sugar content of sugar beets and sugarcane varies by variety, climate, cultural practices, growth season, and weather. Sugar beets generally contain more sugar (sucrose) than sugarcane. The sucrose content of sugar beets ranges from 16 to 18 percent. In contrast, the sucrose content of sugarcane varies between 10 to 15 percent. The sugar recovery rate for sugarcane produced in Florida has generally been higher than recovery rates in Louisiana and Texas. Sugar recovery rates for both sugar beets and sugarcane are highly dependent on the processing equipment used as well as plant variety, cultural practices, and weather conditions.

Feedstock Production Costs

U.S. average operating costs for corn production increased from $157.54 per acre in 1996 to $191.10 in 2005 (Table 9). During this period, expenses for seed, fertilizer, and fuel increased significantly relative to other farm input expenses. Expenses for seed corn increased from $26.65 per acre in 1996 to $39.05 in 2005. Fertilizer costs declined from $47 per acre in 1996 to $35.49 in 2002 and then increased to $52.37 per acre in 2005. Higher expenses for fertilizer in 2005 are directly related to higher prices for natural gas. Expenditures for fuel and electricity increased from $24.43 per acre in 1996 to $38.57 per acre in 2005. In contrast, expenditures for soil conditioners, chemicals, custom operation, repairs, purchased irrigation water, and interest on operating capital were either unchanged or declined during 1996-2005.

Table 9. U.S. corn production costs, 1996-2005

Item	1996	2002	2003	2004	2005
			(dollars per planted acre)		
Operating costs:					
Seed	26.65	31.84	34.83	36.82	39.05
Fertilizer	47.04	35.49	43.41	46.69	52.37
Soil conditioners	0.16	0.12	0.13	0.14	0.14
Manure	0.60	2.13	2.47	2.63	2.63
Chemicals	27.42	26.11	26.20	26.76	26.84
Custom operations	11.30	10.79	11.17	11.55	11.95
Fuel, lubrication, electricity	24.43	18.93	23.06	29.29	38.57
Repairs	15.78	13.91	14.22	15.35	15.94
Purchases irrigation water	0.30	0.22	0.22	0.24	0.25
Interest on operating capital	3.86	1.17	0.82	1.31	3.36
Total operating costs	157.54	140.71	156.53	170.78	191.10
Allocated overhead costs:					
Hired labor	2.83	3.06	3.14	3.20	3.29
Opportunity cost of unpaid labor	28.99	25.74	26.53	26.98	27.71
Capital recovery of machinery	63.02	55.26	56.67	61.25	63.68
Opportunity cost of land	80.79	87.44	89.20	92.14	94.49
Taxes and insurance	6.98	5.42	5.54	5.58	5.67
General farm overhead	10.38	11.91	12.17	12.41	12.83
Total allocated costs	192.99	188.83	193.25	201.56	207.67
Total production costs	350.53	329.54	349.78	372.34	398.77
Yield (bushels / planted acre)	130	134	149	169	148
Operating cost per bushel	1.21	1.05	1.05	1.01	1.29
Total costs per bushel	2.70	2.46	2.35	2.20	2.70

Source: Economic Research Service, U.S. Department of Agriculture.

Total corn production costs include operating costs as well as charges for paid and unpaid labor, capital recovery of machinery, land charges, taxes, insurance, and general farm overhead. Total costs represent expenses which must be covered for a farm business to remain economically viable over the long run. Total U.S. corn production costs per planted acre averaged an estimated at $398.77 in 2005, up from $350.53 per acre in 1996. With a 2005 average yield of 147.9 bushels per acre, cash operating costs averaged an estimated at $1.29 per bushel, with total production costs estimated to average $2.70 per bushel.

Corn is produced in the Northern Crescent, Northern Great Plains, Heartland, and Prairie Gateway farm production regions. A complete list of U.S. production regions as designated by the Economic Research Service (ERS) of USDA can be viewed on the ERS Farm Resource Region web page http://www.ers.usda.gov/Briefing/ARMS/resourceregions/resourceregions.htm. The Prairie Gateway region, including areas of Texas, Oklahoma, Nebraska, Kansas, Wyoming, and New Mexico, has the highest corn production costs and the Northern Great Plains region, primarily North and South Dakota, has the lowest corn production costs.

Corn production costs by region are not available for 2005. Total operating expenses in the Prairie Gateway region increased from $184.57 per acre in 1996 to $207.31 in 2004, while total operating costs in Northern Great Plains increased from $134.35 per acre in 1996 to $142.48 per acre in 2004. More than 65 percent of corn area in the Prairie Gateway region is irrigated and expenses for fuel and electricity is on average double that of other regions.

Average sorghum operating costs increased from an estimated $75.27 per acre in 1996 to $119.05 per acre in 2005 (Table 10). U.S. sorghum is produced in the Heartland, Prairie Gateway, Northern Great Plains, Mississippi Delta, and Eastern Upland regions. Among sorghum growing regions, Northern Great Plains has the lowest and Eastern Upland region has the highest operating costs.

Table 10. U.S. sorghum production costs, 1996-2005

Item	1996	2002	2003	2004	2005
			(dollars per planted acre)		
Operating costs:					
Seed	6.00	6.63	4.66	5.82	6.17
Fertilizer	17.99	15.10	18.87	22.63	25.23
Chemicals	12.29	11.22	17.32	19.96	20.02
Custom operations	6.23	4.38	9.00	10.38	10.74
Fuel, lubrication, electricity	17.10	24.92	19.88	27.16	35.76
Repairs	13.81	17.48	16.31	18.20	18.90
Purchases irrigation water	0.00	0.00	0.10	0.11	0.11
Interest on operating capital	1.85	0.67	0.45	0.82	2.12
Total operating costs	75.27	80.40	86.39	105.08	119.05
Allocated overhead costs:					
Hired labor	5.41	7.45	4.73	4.95	5/08
Opportunity cost of unpaid labor	18.58	22.98	25.26	28.68	29.46
Capital recovery of machinery	53.49	60.91	53.71	64.68	67.29
Opportunity cost of land	39.20	21.49	34.02	39.48	40.49
Taxes and insurance	4.98	5.04	4.20	4.95	5.03
General farm overhead	3.76	4.39	7.52	8.98	9.28
Total allocated costs	125.42	122.26	129.44	151.72	156.63
Total production costs	200.69	202.66	215.83	256.80	275.68
Yield (bushels / planted acre)	63	33	47	65	69
Operating cost per bushel	1.19	2.44	1.83	1.62	1.73
Total costs per bushel	3.19	6.14	4.59	3.95	4.01

Source: Economic Research Service, U.S. Department of Agriculture.

Total sorghum production costs, including operating costs plus other allocated costs, averaged an estimated at $275.68 per planted acre in 2005, up from $200.69 per acre in 1996. Sorghum production costs per bushel have varied significantly over the past few years due to variations in annual yield. In 2002, sorghum yields averaged 33 bushels per acre, pushing total production costs up to an estimated $6.14 per bushel. In 2005, with an average yield of 68.7 bushels per acre, total sorghum production costs averaged an estimated at $4.01 per bushel and average operating costs were $1.73 per bushel.

Currently, no ethanol is produced in the United States which utilizes sugarcane or sugar beets as the primary feedstock. Therefore, no cost data are available for determining the cost of converting sugarcane and sugar beets into ethanol as is available for corn-based ethanol production. For this report, production and processing costs of sugarcane and sugar beets were updated from published USDA estimates in order to estimate the cost of producing ethanol from sugarcane or sugar beet juice. It was assumed that if ethanol were to be produced from these feedstocks, these crops would be converted to juice, as is currently done in sugar factories, with an additional processing stage to convert the juice to ethanol.

Updated sugarcane production and processing costs per pound of raw sugar produced are presented in Table 11. These values represent updated cost estimates averaged over the 2003-05 period. Production and processing cost data for sugarcane were obtained from USDA for the years 1992-96 and updated for the 2003-05 period. Sugarcane production costs were updated using prices paid indices for agricultural inputs (USDA, *Agricultural Prices*). Sugarcane processing costs were updated using price indices for manufacturing from the Bureau of Labor Statistics, as reported in the *2006 Economic Report of the President.* Processing labor costs were updated using the employment cost index for manufacturing wages and benefits. Other processing costs were updated using price indices for capital equipment, energy, and other intermediate materials and supplies. Annual cost data are included in the appendix to this report. Average costs shown in the table for sugarcane include estimates for Florida, Hawaii, and Louisiana/Texas. The majority of sugarcane produced in the United States is grown in Florida and Louisiana.

Table 11. Estimated average sugarcane production and processing costs for sugar, 2003-05 1/

	U.S.	FL	HA	LA/TX
	(cents per pound of raw sugar)			
Production costs:				
Variable cash costs	10.034	10.990	13.672	8.333
Fixed and other non-cash expenses	5.990	5.431	4.698	6.963
Total production costs	16.024	16.421	18.369	15.296
Processing costs:				
Variable cash expenses	7.103	6.490	11.412	7.109
Fixed cash expenses	0.912	0.742	1.087	1.092
General and administration	0.984	1.086	0.883	0.888
Total processing costs	8.999	8.319	13.382	9.088
Credits:				
Molasses	0.581	0.545	0.483	0.646
Bagasse	0.035	0.029	0.000	0.048
Other	0.088	0.043	0.866	0.000
Total credits	0.703	0.617	1.349	0.694
Total processing costs less credits	8.296	7.702	12.033	8.394
Total production and processing costs	24.320	24.122	30.402	23.690
Total variable costs less credits	16.434	16.862	23.735	14.747

Updated cost estimates indicate that the total cost of producing and processing sugarcane into raw sugar is estimated to average 24.3 cents per pound of raw sugar produced during 2003-05. Variable cash production costs include expenses for seedcane, fertilizer, chemicals, fuel, repairs, and other variable costs. Fixed and other non-cash expenses include general farm overhead, taxes and insurance, operating capital, as well as charges for capital replacement of equipment, nonland capital, land, and unpaid labor. Total production and processing costs for Florida were estimated at 24.1 cents per pound, with variable costs at 16.9 cents per pound. Total costs in Louisiana were estimated at 23.7 cents per pound, with variable costs at 14.7 cents.

The average cost estimates for sugarcane for the period 2003-05 may overstate actual costs since the estimates are based on actual costs for the 1992-96 period updated using price paid indices. As a result, these cost estimates do not take into account changes in productivity. Comparable cost estimates for Louisiana from another study estimated total sugarcane production costs of 20.5 cents per pound and variable costs of 13.2 cents per pound in 2005 (Breaux and Salassi, 2005).

Average sugar beet production and processing costs were developed from published sugar beet production cost estimates for 2003 and 2004, estimates for 2005, and updated sugar beet processing costs from the 1997-98 period using relevant prices paid indices (Table 12). Current average U.S. sugar beet production and processing costs were estimated at 24.3 cents per pound of refined sugar produced, with variable costs at 13.9 cents per pound. The Great Lakes and Red River Valley regions had the lowest estimated total costs at 25.1 and 23.1 cents per pound, respectively. The Great Plains and Northwest regions had slightly higher estimated costs. Variable sugar beet production and processing costs were estimated to range from 13.5 to 14.5 cents per pound.

Table 12. Estimated average sugar beet production and processing costs for sugar, 2003-05

	U.S.	Great Lakes	Red River Valley	Great Plains	Northwest
	(cents per pound of refined sugar)				
Production costs:					
Variable cash costs	5.596	6.050	5.136	6.253	6.275
Fixed and other non-cash expenses	7.539	7.924	6.893	9.190	8.347
Total production costs	13.134	13.974	12.029	15.443	14.623
Processing costs:					
Variable cash expenses	10.779	10.993	10.993	10.460	10.460
Fixed cash expenses	1.060	1.132	1.132	0.955	0.955
General and administration	0.545	0.425	0.425	0.703	0.703
Pulp drying and marketing	1.209	1.158	1.158	1.276	1.276
Total processing costs	13.593	13.707	13.707	13.394	13.394
Credits:					
Dried pulp	1.928	2.051	2.051	1.752	1.752
Molasses	0.388	0.412	0.412	0.350	0.350
Other	0.156	0.166	0.166	0.143	0.143
Total credits	2.472	2.629	2.629	2.246	2.246
Total processing costs less credits	11.121	11.078	11.078	11.149	11.149
Total production and processing costs	24.255	25.051	23.107	26.592	25.771
Total variable costs less credits	13.902	14.414	13.500	14.467	14.490

Ethanol Yields from Alternative Feedstocks

Production of ethanol in the United States is based primarily on grain as a feedstock. In order to maximize profitability, the production of ethanol must use the least expensive feedstock available per gallon of ethanol produced. Up to this point in time, the most profitable U.S. feedstock has been corn. Conversion factors for grains used as potential feedstock for ethanol production are shown in Table 13.

Table 13. Ethanol conversion factors for grain feedstocks per unit of feedstock

Commodity	Ethanol conversion factor
Barley	1.40 gallons per bushel
Corn – wet mill	2.65 gallons per bushel
Corn – dry mill	2.75 gallons per bushel
Grain sorghum	2.70 gallons per bushel
Wheat	2.80 gallons per bushel

Source: USDA

Approximately 2.65 gallons of ethanol can be produced from a bushel of corn in existing wet mill facilities. Corn-based ethanol plants using the dry mill process can produce 2.75 gallons of ethanol per bushel of corn. Ethanol yield per bushel of corn in the United States has increased significantly since 1980. New ethanol plants utilize the latest varieties of enzymes that convert the maximum amount of starch to glucose and high tolerance yeast that converts the maximum amount of glucose to alcohol. During 2003-05, the corn yield per harvested acre averaged 150.2 bushels. Therefore, the ethanol yield in dry mill plants per acre of corn for 2003-05 was approximately 413 gallons.

Ethanol production per bushel of sorghum is slightly lower than from dry mill corn, at approximately 2.7 gallons per bushel. Furthermore, sorghum yield per acre is relatively low compared with corn but sorghum is more resistant to drought than corn. The 2003-05 U.S. sorghum yield averaged 63.7 bushels per acre. Therefore, one acre of sorghum could produce about 172 gallons of ethanol.

The stoichiometric (theoretical) yield of ethanol from sucrose is 163 gallons of ethanol per ton of sucrose (Rein). The maximum obtainable yield under ideal conditions is estimated at 94.5 percent of theoretical yield, or 154 gallons per ton. Laboratory yields have generally averaged in the range of 149 gallons per ton of sucrose. A yield of 95 percent of the yield obtained in the laboratory, or 141 gallons per ton, is considered to be reasonable under normal plant operating conditions (Rein). This represents 86.5 percent of the theoretical ethanol yield. Estimated ethanol conversion yields from sucrose are listed in Appendix A of this report.

Estimated ethanol conversion factors for sugar per unit of feedstock are shown in Table 14 with comparisons to corn. In sugarcane or sugar beet factories, the cane or beet juice could be used to make ethanol rather than sugar and molasses. The 2003-05 average raw sugar recovery factor from sugarcane for the U.S. was 12.26 percent (ERS, USDA). Based on actual raw sugar and molasses production values from sugarcane, approximately 3.0 gallons of sugarcane molasses is produced as a byproduct for every 100 pounds of raw sugar produced (American Sugar Cane League; Louisiana State University Agricultural Center). Sugarcane molasses has been estimated to be 49.2 percent sucrose (Rein). Using these recovery factors, one ton of sugarcane would yield approximately 277 pounds of sucrose. This would be sufficient to produce 19.5 gallons of ethanol.

Table 14. Ethanol conversion factors for sugar feedstocks per unit of feedstock

Commodity	Ethanol conversion factor	
Corn	98.21 gallons per ton	(2.75 gallons per bushel)
Sugarcane 1/	19.50 gallons per ton	
Sugar beets 2/	24.80 gallons per ton	
Molasses 3/	69.40 gallons per ton	
Raw sugar	135.40 gallons per ton	
Refined sugar	141.00 gallons per ton	

1/ Based on 2003-05 U.S. average raw sugar recovery rate of 12.26% per ton of cane and sucrose recovery from cane molasses at 41.6 pounds per ton of sugarcane.
2/ Based on 2003-05 U.S. average refined sugar recovery rate of 15.5% per ton of beets and sucrose recovery from beet molasses at 40.0 pounds per ton of sugar beets.
3/ Based on an average sucrose recovery of 49.2% per gallon of cane molasses.

Sugar recovery is slightly higher in sugar beets compared with sugarcane. The 2003-05 average refined sugar recovery for U.S. sugar beets was 15.5 percent (ERS, USDA). Beet molasses yield is approximately 4 percent by weight per ton of sugar beets with a 50 percent sucrose yield, or roughly 40.0 pounds of sucrose from beet molasses per ton of beets (Holly Hybrids; Southern Minnesota Sugar Cooperative). With this recovery rate, one ton of sugar beets would yield 352 pounds of total sucrose capable of producing 24.8 gallons of ethanol.

Ethanol yields per acre of sugarcane vary depending on the yield per acre of sugarcane and the sugar recovery rate. The 2003-05 average sugarcane yield for Florida was 35.2 tons per acre. Average sugarcane yields in Louisiana and Texas over the same period were 24.3 tons and 38.4 tons per acre, respectively. Sugar recovery rates averaged 12.42 percent in Florida, 11.97 percent in Louisiana, and 10.70 percent in Texas during 2003-05. Using these data, one acre of sugarcane would yield about 695 gallons of ethanol in Florida, 465 gallons in Louisiana, and 665 gallons in Texas.

Sugarcane molasses is approximately 49.2 percent total sugars as sucrose (Rein). Therefore, one ton of molasses would yield 69.4 gallons of ethanol. Raw sugar processed from sugarcane is approximately 96.0 percent total sugars as sucrose. Therefore, one ton of raw sugar would yield 135.4 gallons of ethanol. Refined sugar, either from beets or cane, is approximately 100 percent total sugars as sucrose. Therefore, one ton of refined sugar would yield 141.0 gallons of ethanol.

Using the above sugar to ethanol conversion rates, the quantity of alternative sugar feedstocks required per gallon of ethanol are listed in Table 15. Currently, using corn as the feedstock, the production of one gallon of ethanol would require 0.0101 tons of corn. Using alternative forms of sugar as the primary feedstock, one gallon of ethanol would require 0.051 tons of sugarcane, 0.040 tons of sugar beets, 0.0144 tons of molasses, 0.0074 tons of raw cane sugar, or 0.0071 tons of refined beet sugar.

Table 15. Ethanol conversion factors for sugar feedstocks per gallon of ethanol

Feedstock	Feedstock quantity per gallon of ethanol
Corn	0.0101 tons (0.36 bushels)
Sugarcane	0.051 tons
Sugar beets	0.040 tons
Molasses	0.0144 tons (2.45 gallons)
Raw sugar	0.0074 tons (14.77 pounds)
Refined sugar	0.0071 tons (14.18 pounds)

Net Feedstock Cost per Gallon of Ethanol

Net feedstock cost per gallon of ethanol is equal to the value of the feedstock minus the value of byproducts divided by the number of gallons of ethanol produced per unit of feedstock. The byproducts of corn-ethanol are distillers dried grains and carbon dioxide for the dry milling process and corn gluten feed, corn gluten meal, corn oil, and carbon dioxide for the wet milling process. About 6 pounds of distillers dried grains with solubles (DDGS/13 percent moisture) are produced per gallon of ethanol in the dry milling process. In the wet milling process, 4.9 pounds of corn gluten feed, 0.9 pounds of corn gluten meal, and 0.6 pounds of corn oil are produced per gallon of ethanol.

The byproducts of sugarcane to ethanol are bagasse, vinasse, and carbon dioxide. In modern sugarcane ethanol plants, bagasse is used for production of steam and electricity. Vinasse is the left over liquid after alcohol is removed (stillage). Vinasse contains nutrients such as nitrogen, potash, phosphate, sucrose, and yeast which could be applied to cropland as a fertilizer. Carbon dioxide could be collected for sale to beverage companies.

Byproducts of sugar beet ethanol plants are beet pulp, carbon dioxide, and vinasse. Wet and dry beet pulp is sold as animal feed. Byproducts of raw sugar, refined sugar, and molasses to ethanol are carbon dioxide and stillage containing yeast and sugar.

The estimated 2003-05 average quantities and values of byproducts, gallons of ethanol produced per unit of feedstock, and net feedstock cost per gallon for converting corn and sugar feedstocks into ethanol are presented in Table 16. With an average market price for corn of $2.16 per bushel during 2003-05, the estimated net feedstock cost per gallon of ethanol produced from corn is $0.53 for a dry mill plant and about $0.40 for a wet mill plant, factoring in byproduct revenues. The net feedstock costs for sugar beets, sugarcane, raw sugar, refined sugar, and molasses account for the acquisition cost of the feedstock and do not include credits for beet pulp, bagasse, vinasse, and carbon dioxide produced during the conversion into ethanol. The value of these byproducts is included in the cost of processing sugar feedstocks into ethanol.

Table 16. Net feedstock cost per gallon of ethanol, 2003-05

	Corn Dry Milling	Corn Wet Milling	Sugar beets 1/ 2/	Sugar cane 1/ 2/	Raw Sugar 3/	Refined sugar 4/	Molasses 5/
	(bushel)	(bushel)	(ton)	(ton)	(ton)	(ton)	(ton)
Market price, dollars	2.16	2.16	39.15	28.90	422.00	509.00	63.00
Ethanol byproduct prices:							
DDGS $/ton	92.08						
Corn gluten feed, $/ton		66.30					
Corn gluten meal, $/ton		269.00					
Corn oil, cents/lb		26.00					
Starch (corn) / sucrose, %	72	72	17.6	13.8	96	100	49.2
Gallons of ethanol	2.75	2.65	24.80	19.50	135.40	141.00	69.40
Net feedstock cost, $/gal	0.53	0.40	1.58	1.48	3.12	3.61	0.91

1/ Sugar beet and sugarcane sucrose percent includes sucrose recovery from juice including molasses.
2/ Market prices for sugar beet and sugarcane based on 2003-04 average.
3/ U.S. average raw sugar price.
4/ U.S. average wholesale refined beet sugar price.
5/ Molasses price based on 2003-04 prices in New Orleans, Houston and South Florida.

Of the five sugar feedstocks evaluated in this report, molasses is the most cost competitive with corn. Molasses net feedstock cost is about $0.91 per gallon. Net feedstock costs per gallon of ethanol made from sugar beets and sugarcane were $1.58 and $1.48 per gallon, respectively. These feedstock cost estimates are based on the 2003-05 average sugar recovery rates of 15.5 percent for sugar beets and 12.26 percent for sugarcane and on 2003-04 sugarcane and sugar beet market prices per ton. Valuing raw cane sugar and refined beet sugar at market prices, the estimated feedstock cost of using these materials for conversion to ethanol is estimated at $3.12 and $3.61 per gallon, respectively.

According to a 2003 survey, approximately 61 percent of world ethanol production is being produced from sugar crops (Berg, 2004). Ethanol production using sugar as a feedstock is economically feasible in countries like Brazil due to several factors including the relatively low price of raw sugar on the world market in most years and the use of molasses as a major feedstock. Table 17 presents U.S. and world sugar market prices for the 1991-2005 period. Estimated feedstock cost per gallon of ethanol produced has been estimated at $0.30 per gallon for ethanol made from sugarcane in Brazil, compared with $0.97 per gallon for ethanol made from sugar beets in France (Berg, 2004).

Ignoring the current marketing year, U.S. wholesale refined beet sugar prices have ranged from a low of 21.90 cents per pound ($438 per ton) in 2000 to a high of 28.84 cents per pound ($577 per ton) in 1996 (Table 17). Raw cane sugar prices in the U.S. market have ranged from 18.40 cents per pound ($368 per ton) to 22.76 cents per pound ($455 per ton) during 1991 to 2005. Both the raw cane and refined beet sugar prices have been about double the world price.

Table 17. U.S. and world sugar market prices, 1991-2005

Year 1/	U.S. wholesale refined beet sugar price	U.S. raw cane sugar price	World refined sugar price	World raw sugar price
1991	26.57	21.89	13.71	9.26
1992	25.53	21.39	12.67	9.22
1993	24.45	21.49	12.42	9.58
1994	25.60	22.05	14.62	11.25
1995	25.26	22.76	17.97	13.86
1996	28.84	22.50	17.41	12.40
1997	28.06	22.00	14.48	11.67
1998	25.66	22.09	12.36	10.80
1999	27.02	22.07	9.81	7.05
2000	21.90	18.40	9.10	7.53
2001	22.11	21.07	11.35	9.80
2002	25.49	20.65	10.59	7.58
2003	27.02	21.76	10.06	8.01
2004	23.66	20.54	10.25	7.85
2005	25.63	20.94	12.47	10.46

1/Fiscal year
Source: Economic Research Service, U.S. Department of Agriculture

Processing Costs per Gallon of Ethanol

Processing costs of converting corn and grain sorghum to ethanol are very similar. Currently in the United States, a very small amount of grain sorghum is used in production of ethanol. Ethanol plants have been surveyed by USDA in recent years to obtain data to estimate average ethanol production costs. In late 1999 and early 2000, USDA surveyed 28 ethanol plants, both wet and dry mill, to estimate their 1998 costs of production (Shapouri, Gallagher and Graboski). These ethanol plants processed more than 400 million bushels of corn and sorghum in 1998 to produce more than 1.1 billion gallons of ethanol. The average variable cost of production of ethanol was estimated at 93.9 cents per gallon. The net feedstock cost averaged approximately 53 cents per gallon for dry mill plants and 48 cents per gallon for wet mill plants.

In 2003, USDA surveyed 21 dry mill ethanol plants to estimate their 2002 production costs (Shapouri and Gallagher). These plants produced 550 million gallons of ethanol in 2002. Total production costs, including feedstock costs, averaged 95.7 cents per gallon. Net feedstock costs ranged from 39 to 68 cents per gallon for the plants surveyed.

Ethanol costs of production for the wet milling process were updated from the 1998 estimates to values for 2003-05. Prices paid indices for intermediate materials for energy and other inputs, employment cost index for manufacturing wages, and labor benefits were used to update ethanol production costs for the wet milling process from 1998 to 2003-05. Dry milling ethanol costs of production were updated from 2002 base values to 2003-05 utilizing the above indices used in updating wet mill ethanol costs of production.

Ethanol processing costs per gallon of ethanol produced by the wet milling process increased from $0.46 in 1998 to $0.62 in 2004 and to $0.70 in 2005 (Table 18). Electricity and fuel costs increased from $0.11 per gallon in 1998 to $0.21 cents per gallon in 2005. The net corn cost per gallon of ethanol declined significantly from $0.48 per gallon in 1998 to $0.30 in 2005. Lower prices for corn in 2005, higher prices for corn oil and corn gluten meal increased the value of byproduct credits and lowered the net corn feedstock cost. High costs of energy in 2004 and 2005 were offset by lower prices for corn and higher prices for byproducts.

Ethanol processing costs per gallon for dry mill plants increased from $0.41 per gallon in 2002 to $0.58 per gallon in 2005 (Table 19). Higher natural gas and electricity prices increased the energy expenses used in the production of ethanol from 17 cents per gallon in 2002 to 27 cents per gallon in 2005. Corn prices declined in 2005 due to very large ending stocks. Corn costs per gallon of ethanol declined from $0.89 per gallon in 2004 to $0.71 cents in 2005. The value of byproduct credits declined from 30 cents per gallon in 2003 and 2004 to about 22 cents per gallon in 2005.

Table 18. Ethanol cash operating expenses and net feedstock costs, wet milling process

	1998	2003	2004	2005
	($/gal)	($/gal)	($/gal)	($/gal)
Feedstock costs	0.9065	0.8464	0.8911	0.7122
Byproduct credits	0.4270	0.3969	0.4438	0.4108
Carbon dioxide	0.0000	0.0000	0.0000	0.0000
Net feedstock costs	0.4795	0.4495	0.4473	0.3014
Cash operating expenses:				
Electricity	0.0332	0.0460	0.0506	0.0613
Fuels	0.0785	0.1087	0.1197	0.1449
Waste management	0.0263	0.0274	0.0289	0.0305
Water	0.0130	0.0235	0.0143	0.0151
Enzymes	0.0581	0.0604	0.0639	0.0674
Yeast	0.0269	0.0280	0.0296	0.0312
Chemicals	0.0296	0.0410	0.0451	0.0546
Denaturant	0.0322	0.0446	0.0491	0.0594
Maintenance	0.0478	0.0662	0.0729	0.0882
Labor	0.0763	0.0894	0.0916	0.0929
Administrative costs	0.0378	0.0483	0.0531	0.0553
Other	0.0000	0.0000	0.0000	0.0000
Total	0.4597	0.5735	0.6189	0.7008
Total cash costs and net feedstock costs	0.9392	1.0230	1.0662	1.0022

Table 19. Ethanol cash operating expenses and net feedstock costs, dry milling process

	2002	2003	2004	2005
	($/gal)	($/gal)	($/gal)	($/gal)
Feedstock costs	0.8030	0.8407	0.8852	0.7074
Byproduct credits	0.2520	0.2995	0.3067	0.2166
Carbon dioxide	0.0060	0.0061	0.0065	0.0068
Net feedstock costs	0.5450	0.5351	0.5720	0.4840
Cash operating expenses:				
Electricity	0.0374	0.0436	0.0480	0.0581
Fuels	0.1355	0.1581	0.1740	0.2107
Waste management	0.0059	0.0060	0.0064	0.0067
Water	0.0030	0.0031	0.0032	0.0034
Enzymes	0.0366	0.0373	0.0395	0.0416
Yeast	0.0043	0.0044	0.0046	0.0049
Chemicals	0.0229	0.0267	0.0294	0.0356
Denaturant	0.0348	0.0406	0.0447	0.0541
Maintenance	0.0396	0.0462	0.0509	0.0616
Labor	0.0544	0.0557	0.0570	0.0578
Administrative costs	0.0341	0.0368	0.0405	0.0422
Other	0.0039	0.0040	0.0042	0.0044
Total	0.4124	0.4625	0.5025	0.5811
Total cash costs and net feedstock costs	0.9574	0.9976	1.0745	1.0651

Estimated processing costs for converting sugarcane and sugar beets into ethanol are shown in Tables 20 and 21. These estimates were developed to be comparable with the corn ethanol processing costs presented in the previous tables. The byproduct credits for sugarcane and sugar beets to ethanol include the value of excess bagasse and other byproducts, such as filter cake and dried pulp. The dried pulp credit is based on the market value of beet pulp of $6 per ton. The credits for bagasse and other credits are indexed to 2005 using the producer price index.

Table 20 includes cane transportation expenses, variable processing expenses, general and administrative expenses as well as credits, estimated for the conversion of sugarcane into

Table 20. Estimated U.S. sugarcane processing costs for ethanol

	2003	2004	2005	Average
	Cents per pound of raw sugar equivalent			
Processing costs:				
Cane transportation	1.185	1.288	1.328	1.267
Processing:	2.023	2.195	2.281	2.166
Labor	1.161	1.229	1.225	1.205
Fuel	0.154	0.181	0.219	0.185
Chemicals	0.121	0.134	0.139	0.131
Electricity	0.100	0.119	0.145	0.122
Materials and supplies	0.486	0.533	0.553	0.524
Repairs and maintenance	1.456	1.608	1.675	1.580
Total variable processing costs	4.664	5.092	5.284	5.013
General and administrative:				
Labor	0.366	0.390	0.389	0.381
Nonlabor	0.566	0.612	0.629	0.602
Total general and administrative costs	0.932	1.001	1.018	0.984
Total processing costs	5.596	6.093	6.302	5.997
Credits:				
Bagasse	0.037	0.034	0.033	0.035
Other	0.080	0.093	0.090	0.088
Total credits	0.118	0.127	0.123	0.122
Total processing costs less credits	5.478	5.966	6.179	5.875

ethanol. Due to the lower energy requirements in converting sugarcane into ethanol rather than raw sugar, fuel and electricity costs were reduced by half on a per unit basis. Less thermal and electrical energy are required to convert a ton of sugarcane to ethanol than into sugar and molasses. According to Jose Maria P. Zabaleta, Jr., Regional Director of Bronze Oak Limited, which owned many sugar and ethanol plants in the Philippines, the production of ethanol from sugarcane requires one-half of the energy used in the production of raw sugar. Ethanol processing costs from sugarcane were estimated to average $0.059 per pound of raw sugar equivalent during 2003-05.

Table 21 includes beet acquisition expenses, variable processing expenses, general and administrative expenses as well as credits, estimated for the conversion of sugar beets into ethanol. Due to the lower energy requirements in converting sugar beets into ethanol rather than refined sugar, fuel and electricity costs were reduced by half on a per unit basis. Ethanol processing costs from sugar beets were estimated to average $0.051 per pound of refined sugar equivalent during 2003-05.

Table 21. Estimated U.S. sugar beet processing costs for ethanol

	2003	2004	2005	Average
	Cents per pound of refined sugar equivalent			
Processing costs:				
Beet acquisition	1.312	1.162	1.157	1.210
Processing:	2.897	3.040	3.165	3.034
Labor	1.350	1.374	1.333	1.353
Fuel	0.776	0.849	0.983	0.869
Chemicals	0.261	0.274	0.277	0.271
Electricity	0.154	0.168	0.195	0.172
Materials and supplies	0.356	0.374	0.377	0.369
Repairs and maintenance	1.098	1.154	1.164	1.139
Total variable processing costs	5.308	5.356	5.486	5.383
General and administrative:				
Labor	0.252	0.257	0.249	0.253
Nonlabor	0.281	0.296	0.298	0.292
Total general and administrative costs	0.534	0.553	0.548	0.545
Pulp drying and marketing	1.166	1.226	1.236	1.209
Total processing costs	7.008	7.134	7.270	7.137
Credits:				
Dried pulp	1.973	1.977	1.833	1.928
Other	0.156	0.156	0.156	0.156
Total credits	2.129	2.133	1.990	2.084
Total processing costs less credits	4.879	5.001	5.281	5.053

Average processing and total production costs per gallon of ethanol were estimated for the 2003-05 period for the five sugar crop feedstocks: sugarcane, sugar beets, molasses, raw sugar, and refined sugar. Processing costs per gallon of ethanol, including yeast and denaturant, for converting sugarcane into ethanol were estimated to average $0.92 during 2003-05 (Table 22). Average total ethanol production costs using sugarcane as feedstock were estimated to be approximately $2.40 per gallon, excluding capital expenditure charges. In this scenario, sugarcane would be crushed with the entire juice being utilized to make ethanol. Production of ethanol from sugarcane juice would not involve the crystallization process, as is currently done in raw sugar production, but would involve some added fermentation expense. The average feedstock cost of $1.48 per gallon in 2003-04 represents approximately 62 percent of the total ethanol estimated production cost of converting sugarcane into ethanol during 2003-05.

Average total ethanol production costs in the United States were estimated to be $2.35 per gallon during 2003-05 utilizing sugar beets as the feedstock, excluding capital expenditure charges (Table 23). Processing costs averaged $0.77 per gallon of ethanol, including the cost of yeast and denaturant.

Table 22. Estimated ethanol feedstock and production costs, sugarcane feedstock

	2003	2004	2005	Average
Sucrose recovery rate (%) 1/	14.00	13.62	13.85	13.83
Feedstock required (tons/gal)	0.0507	0.0521	0.0512	0.0513
Feedstock market price ($/ton) 2/	29.50	28.30	28.90	28.90
Feedstock cost ($/gal)	1.50	1.47	1.48	1.48
Processing costs ($/gal) 3/ 4/	0.81	0.88	0.91	0.87
Yeast ($/gal)	0.01	0.01	0.01	0.01
Denaturant ($/gal)	0.04	0.04	0.05	0.04
Total cost ($/gal)	2.36	2.40	2.45	2.40

1/ U.S. average sucrose recovery from sugarcane juice (raw sugar and molasses).
2/ 2003-04 sugarcane market price used as estimate for 2005 sugarcane market price.
3/ Sugarcane processing costs less credits.
4/ Based on a sugarcane conversion rate of 14.77 pounds of raw sugar equivalents per gallon.

Table 23. Estimated ethanol feedstock and production costs, sugar beet feedstock

	2003	2004	2005	Average
Sucrose recovery rate (%) 1/	17.30	17.40	18.10	17.60
Feedstock required (tons/gal)	0.0409	0.0408	0.0392	0.0403
Feedstock market price ($/ton) 2/	41.40	36.90	39.15	39.15
Feedstock cost ($/gal)	1.69	1.51	1.53	1.58
Processing costs ($/gal) 3/ 4/	0.69	0.71	0.75	0.72
Yeast ($/gal)	0.01	0.01	0.01	0.01
Denaturant ($/gal)	0.04	0.04	0.05	0.04
Total cost ($/gal)	2.45	2.27	2.34	2.35

1/ U.S. average sucrose recovery from sugar beet juice (sugar and molasses).
2/ 2003-04 sugar beet market price used as estimate for 2005 sugar beet market price.
3/ Sugar beet processing costs less credits (including beet pulp).
4/ Based on a sugar beet conversion rate of 14.18 pounds of refined sugar equivalents per gallon.

Since no U.S. ethanol is currently produced from sugar beets, estimated ethanol production costs were based upon sugar beet processing costs plus charges for yeast and denaturant expenses. Crystallization expense savings would be somewhat offset by increased fermentation expenses. Using the 2003-04 average sugar beet market price of $39.15 per ton, the feedstock cost would be approximately $1.58 per gallon of ethanol produced, representing approximately 67 percent of total ethanol production costs. In table 23, the beet pulp byproduct credit is applied to processing costs, rather than being deducted from the feedstock cost.

Table 24 presents estimates of U.S. ethanol production costs using molasses, raw sugar, and refined sugar as a feedstock. Processing molasses, and raw and refine sugar into ethanol requires a simple process. Unlike the conversion of corn into ethanol which requires cooking and enzymes to convert starch to glucose, the processing of molasses, and raw and refined sugar only requires yeast to ferment sugar to alcohol and removing water. The energy requirement for this process is much less according to industry experts; about half of the energy used in the production of ethanol from corn. In order to estimate the costs of processing raw and refined sugar and molasses into ethanol, the energy costs for converting corn into ethanol are adjusted and expenses for enzymes are removed.

Table 24. Estimated ethanol feedstock and production costs for molasses, raw sugar and refined sugar feedstock

	Molasses	Raw sugar	Refined sugar
Feedstock required (tons/gallon)	0.0144	0.0074	0.0071
Feedstock price ($/ton)	63.00	422.00	509.00
Feedstock cost ($/gallon)	0.91	3.12	3.61
Ethanol operating costs ($/gal) 1/	0.36	0.36	0.36
Total cost ($/gal)	1.27	3.48	3.97

1/ Based on 2003-05 average ethanol dry mill operating costs with adjusted energy expenses, less enzyme expense.

Feedstock costs were estimated using the quantity of each feedstock needed to produce one gallon of ethanol and the 2003-05 average market prices for molasses, and raw and refined sugar. Production costs of ethanol using these feedstocks were estimated using the 2003-05 average ethanol costs for a dry mill process less enzyme expenses and adjusted for reduced energy costs. Total ethanol production costs were estimated to be $1.27 per gallon using molasses, compared with $3.48 per gallon using raw sugar and $3.97 per gallon using refined beet sugar. Estimated costs for these three feedstocks exclude any transportation costs of moving the feedstock from a supply location to an ethanol facility.

Production of ethanol from molasses would appear to be relatively cost competitive with corn-based ethanol (Table 25). Ethanol could be produced from either sugarcane molasses or sugar beet molasses. Other studies have shown that molasses-based ethanol production is economically feasible in the United States (Rein). Ethanol is currently being produced from cane or beet molasses in several countries including Australia, England, India, and South Africa (Berg, 2001; Leiper).

Table 25. Comparison of estimated ethanol production costs for various feedstocks ($/gal.) 1/

Cost Item	U.S. Corn wet milling	U.S. Corn dry milling	U.S. Sugar cane	U.S. Sugar beets	U.S. Molasses 3/	U.S. Raw sugar 3/	U.S. Refined sugar 3/	Brazil Sugar Cane 4/	E.U. Sugar Beets 4/
Feedstock costs 2/	0.40	0.53	1.48	1.58	0.91	3.12	3.61	0.30	0.97
Processing costs	0.63	0.52	0.92	0.77	0.36	0.36	0.36	0.51	1.92
Total cost	1.03	1.05	2.40	2.35	1.27	3.48	3.97	0.81	2.89

1/ Excludes capital costs.
2/ Feedstock costs for U.S. corn wet and dry milling are net feedstock costs; feedstock costs for U.S. sugarcane and sugar beets are gross feedstock costs.
3/ Excludes transportation costs.
4/ Average of published estimates.

The estimated ethanol production costs using sugarcane and sugar beets as feedstocks are more than double the cost of producing ethanol from corn. However, the price of ethanol is determined by the price of gasoline and other factors rather than the cost of producing ethanol from corn. Based on current and near-by futures prices for ethanol, converting sugarcane and sugar beets to ethanol would appear to be profitable, assuming no recovery of capital costs. Over the next several months, the price of ethanol as indicated by futures prices could fall to about breakeven levels for converting sugarcane and sugar beets into ethanol. Over the longer term, the price of ethanol could fall below breakeven levels as crude oil prices decline from current high levels. However, there exists much uncertainty regarding the direction of crude oil and gasoline prices, which could be a major factor in limiting investment in sugarcane and sugar beet ethanol production facilities.

Ethanol Processing Costs in Other Countries

Ethanol is produced in many countries around the world. Over one-half of world ethanol production uses sugarcane, sugar beets or molasses, as a feedstock, while the remainder is produced from grain feedstocks. Table 26 presents total ethanol production for the ten leading ethanol-producing countries for 2004 and 2005. Brazil and the United States are the dominant producers, each accounting for more than 30 percent of world ethanol production.

Table 26. Leading ethanol producing countries, 2004-2005

	2004			2005	
Country	(mil. gal. per year)	(percent)	Country	(mil. gal. per year)	(percent)
Brazil	3,989	37.0	Brazil	4,227	35.8
United States	3,400	32.8	United States	3,904	33.1
China	964	9.0	China	1,004	8.5
India	462	4.3	India	449	3.8
France	219	2.0	France	240	2.0
Russia	198	1.8	Russia	198	1.7
South Africa	110	1.0	Germany	114	1.0
United Kingdom	106	1.0	South Africa	103	0.9
Saudi Arabia	79	0.7	Spain	93	0.8
Spain	79	0.7	United Kingdom	92	0.8
Others	1,029	9.6	Others	1,366	11.6
Total	10,770	100.0	Total	11,790	100.0

Source: F. O. Licht

Brazil is the world's largest producer of sugarcane and centrifugal sugar and, in 2005, the world's largest producer of ethanol. It is also a leading exporter of raw sugar and fuel ethanol. The oil crisis of the 1970s and the escalating cost of importing foreign oil into Brazil prompted the government to develop programs for promoting the production of sugarcane for the manufacture of fuel alcohol to replace gasoline (Knapp). In November of 1975, Brazil initiated a program, the National Alcohol Program (*Proalcool*), for the purpose of increasing the production of ethanol from sugarcane and to increase the domestic use of ethanol as a substitute for gasoline. Since that time, Brazil has made tremendous productivity gains in both sugar and ethanol production. Because it has the developed infrastructure to produce either sugar or ethanol from sugarcane, it is one of the few countries that can adjust sugar production rapidly to react to changing world sugar market conditions. In 2005, less than half of its sugarcane production was ground for sugar.

Total world sugar production for 2005/06 is projected at 144,151 million metric tons (Table 27). Brazil is the world's largest producer of sugar, accounting for 20 percent of total world production with an estimated 28.700 million metric tons of sugar production. All of Brazil's sugar production is from sugarcane. The European Union, the world's leading sugar beet producer, is ranked second with 21.233 million metric tons of sugar production. The United States is the world's fifth leading sugar producer with an estimated total beet and cane sugar production level of 6.824 million metric tons.

Table 27. Projected world centrifugal sugar production and exports, 2005/06

Rank	Country	Projected 2005/06 production	Percent of total	Country	Projected 2005/06 exports	Percent of total
		(1,000 metric tons, raw value)	(%)			
1	Brazil	28,700	19.9	Brazil	18,250	38.2
2	European Union	21,233	14.7	European Union	7,130	14.9
3	India	18,430	12.8	Australia	4,240	8.9
4	China	10,500	7.3	Thailand	2,700	5.7
5	United States	6,824	4.7	Guatemala	1,391	2.9
6	Mexico	6,000	4.2	South Africa	1,300	2.7
7	Australia	5,200	3.6	Cuba	1,032	2.2
8	Thailand	4,330	3.0	Columbia	970	2.0
9	Pakistan	2,890	2.0	Argentina	530	1.1
10	South Africa	2,665	1.8	Mexico	344	0.7
	Other countries	37,379	25.9	Other countries	9,833	20.6
	World total	144,151	100.0	World total	47,720	100.0

Source: *World Sugar Situation*, Foreign Agricultural Service, U.S. Department of Agriculture.

Brazil is the world's largest exporter of sugar. In 2005/06, Brazil is expected to export 18.250 million metric tons of sugar, accounting for 38.2 percent of total world exports. The European Union is expected to export 7.130 million metric tons, 14.9 percent of total world exports. Other major sugar exporting countries include Australia and Thailand, each accounting for less than 10 percent of world sugar exports.

Brazil produces two types of ethyl alcohol or ethanol from sugarcane: hydrated and anhydrous. Hydrated ethanol (with a 4 percent water addition) is used to power alcohol and "flex fuel" vehicles while anhydrous ethanol is used as a gasoline oxygenate and a substitute for tetraethyl lead and MTBE which is a petroleum derivative (UNICA). Ethanol in Brazil is produced at sugarcane mills with adjoining distillery plants, producing both sugar and ethanol, and at independent distilleries, producing only ethanol. The sugar and ethanol industry in Brazil has invested approximately $40 million per year in research and development since 1979 (UNICA). This research has contributed to the dramatic increase in sugar and ethanol productivity in Brazil over the past thirty or so years. In 1975, sugarcane production in Brazil averaged 16 tons per acre. By 2004, sugarcane yields were averaging over 32 tons per acre. Ethanol production from sugarcane increased from 305 gallons per acre to about 590 gallons per acre over this same period.

The most critical factors that determine the economic feasibility of ethanol production from agricultural product feedstocks are ethanol yields per unit of feedstock and the cost of the feedstock. Figure 1 presents the relationship between estimated ethanol yield per acre for three ethanol feedstocks: France—sugar beets, Brazil—sugarcane and the United States—corn.

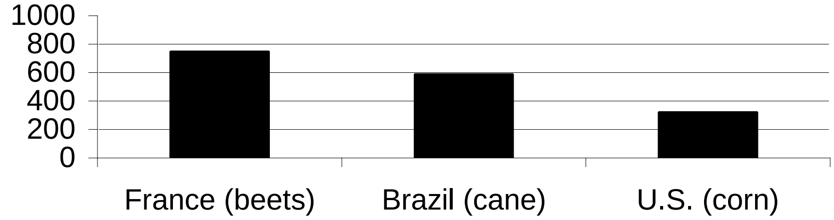
Based on sugar beet yields in France, one acre of sugar beets could produce approximately 750 gallons of ethanol per acre and an acre of sugarcane in Brazil could produce 590 gallons of ethanol per acre. U.S. corn production produces roughly 370 to 430 gallons of ethanol per acre, depending upon corn yields.

When the ethanol yield per ton of feedstock is compared, corn is by far the leader (Figure 2). A ton of U.S. corn can yield approximately 100 gallons of ethanol, compared with 25 gallons from a ton of French sugar beets and 20 gallons from a ton of Brazilian sugarcane. However, it is the cost of producing that feedstock which ultimately determines the relative economic feasibility of various feedstocks. In this regard, Brazil has a significant comparative advantage, with estimated gross feedstock costs of about 30 cents per gallon of ethanol produced (Figure 3), compared to 97 cents per gallon for sugar beets in France and 80-85 cents per gallon for corn in the U.S.

The primary factor influencing the dominance of Brazilian sugarcane for ethanol production has been government policies affecting the production and use of ethanol (Bolling and Suarez). About one-half of the sugarcane produced in Brazil is used for ethanol production, which has no government limits on production. The amount of alcohol blended into gasoline is dictated to the market by law or decree, which directly affects Brazilian producer prices of sugarcane, consumer prices for sugar and ethanol, and sugar quantities both produced and consumed in Brazil, as well as world prices for raw and refined sugar (Schmitz, Seale and Buzzanell).

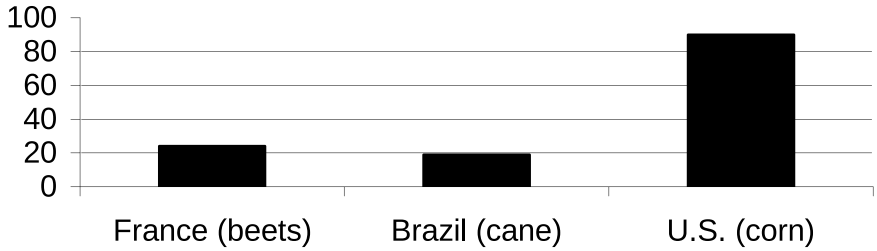
Brazil is the world leader in the production of ethanol from sugarcane. Sugarcane now provides approximately 13 percent of Brazil’s energy, replacing fossil fuels for motor vehicles and bagasse for heat and power (Poppe and Macedo). Ethanol production from sugarcane is very economical in Brazil because of two primary reasons. Brazil dropped support of sugar prices to support the ethanol industry with government established mandates for the blending of ethanol with gasoline. This drastically lowered the cost of the feedstock, sugarcane, and created a demand for and supported the price of ethanol. In addition, Brazil’s vast land area of cultivatable acreage means that land devoted to sugarcane production for ethanol is not in competition with land devoted for food production. As a result, the cost of producing ethanol in Brazil is in the \$0.68 to \$0.95 per gallon range (Coelho; United Nations Environment Programme; International Energy Agency, 2004).

Figure 1 - Ethanol yields per acre (gallons per acre)



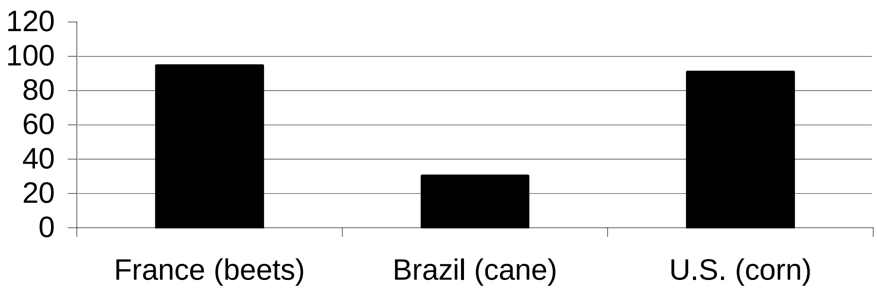
Source: *World Fuel and Ethanol Analysis and Outlook,* F.O. Licht

Figure 2 - Ethanol yields per ton of feedstock (gallons per ton)



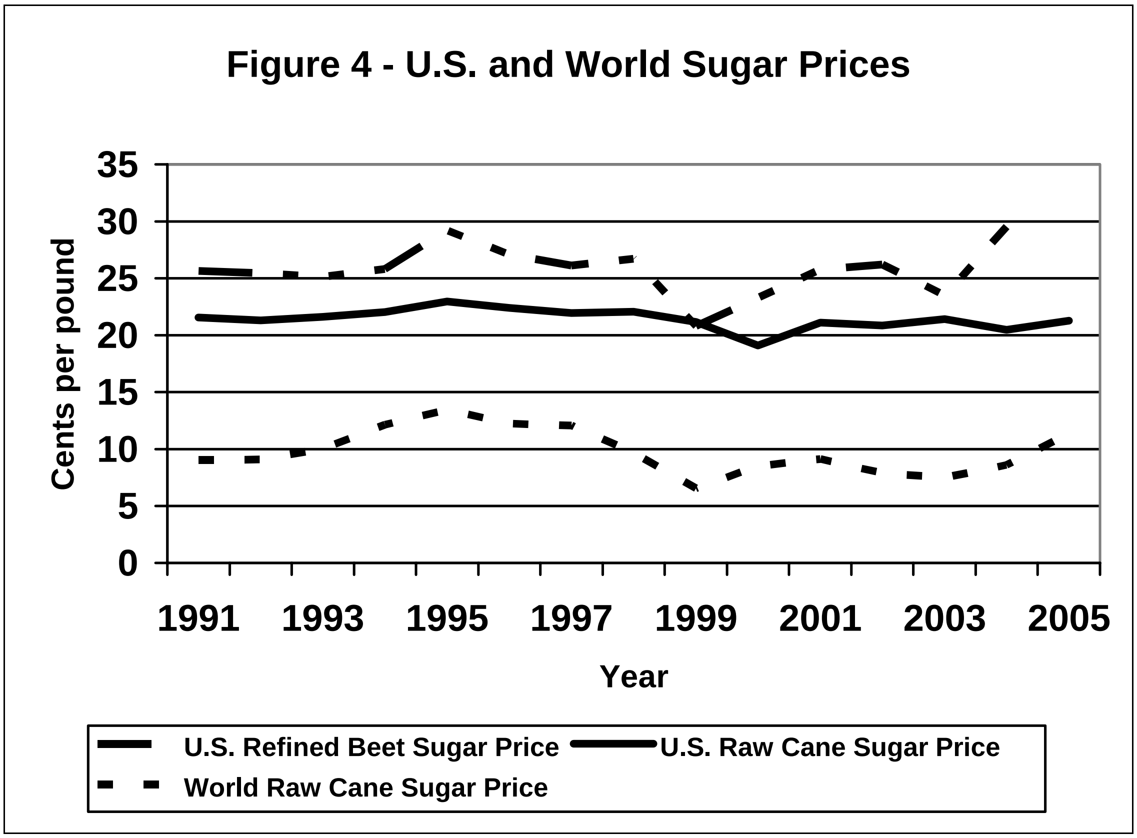
Source: World Fuel and Ethanol Analysis and Outlook,F.O. Licht

Figure 3 - Gross feedstock cost per gallon (cents per gallon of ethanol)



Source: World Fuel and Ethanol Analysis and Outlook,F.O. Licht

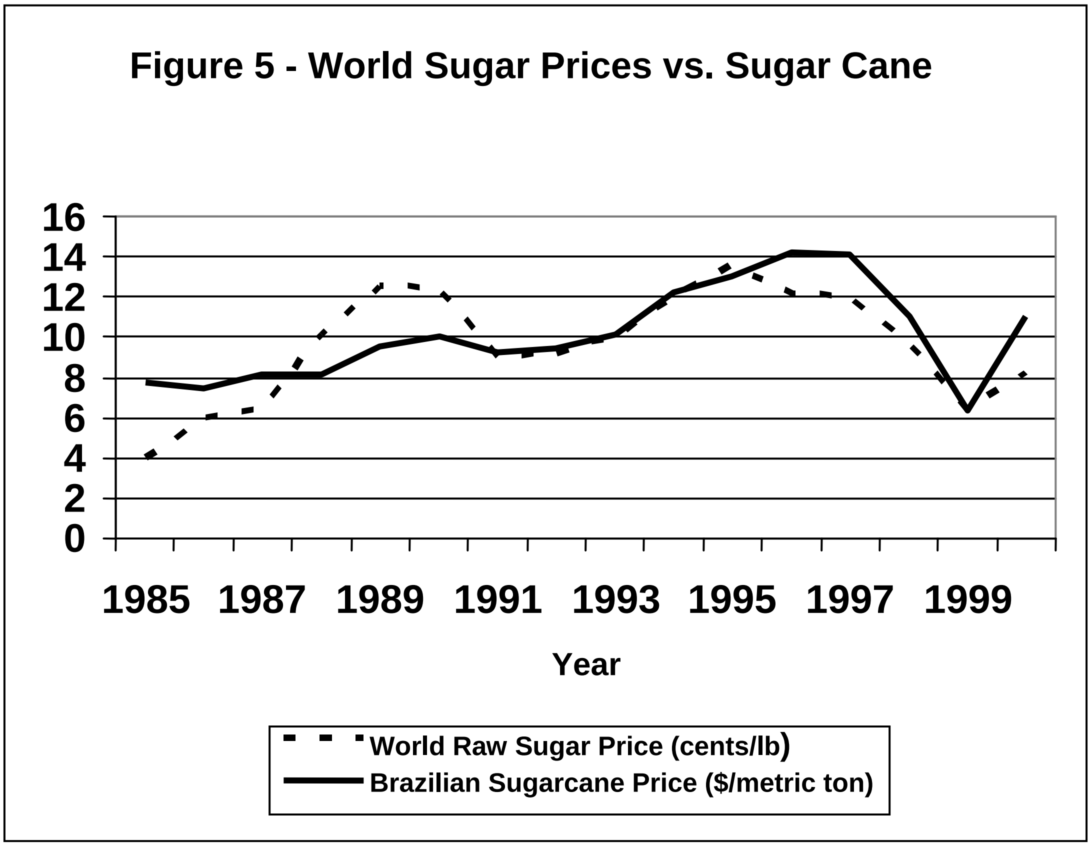
Figures 4 and 5 illustrate the comparative advantage Brazil has in terms of sugar feedstock costs. The world raw cane sugar price is substantially less than the U.S. raw cane sugar price and the U.S. wholesale refined beet sugar price. The sugarcane price per ton paid to Brazilian sugarcane growers closely tracks the world raw sugar price. From 1985 to 2000, the world raw sugar price varied in the 4 to 13 cents per pound range. Over the same period, the sugar cane price paid to growers in Brazil ranged from about $7.00 to $14.00 per ton of cane. These relatively low sugar prices paid to growers in Brazil is largely responsible for their cost advantage on sugar-based ethanol.



Source: Economic Research Service, USDA.

Another factor lowering the cost of ethanol plants in Brazil is the availability of feedstock through much of the year. In Brazil, in the Center South, sugarcane ethanol plants operate 9 months out of the year as the climate permits harvesting over several months. If new sugarcane ethanol plants are built in the sugarcane producing states of Florida, Louisiana, and Texas, these plants would be able to operate 3 to 6 months per year.

A 1994 report by the International Energy Agency (IEA) evaluating the costs and benefits of biofuels included an analysis of producing ethanol in the EU from agricultural feedstocks (International Energy Agency, 1994). Input requirements and production costs were estimated for ethanol production in the EU utilizing corn, wheat, and sugar beets as a feedstock. Results found were similar to relationships presented in this report for the United States. Under current technology, ethanol production in the EU was less expensive using grain as a feedstock rather



Source: Schmitz, Seale and Buzzanell, 2002.

than sugar beets. Total ethanol production costs, in 1991 U.S. dollars, were estimated to range between $1.84 and $2.51 per gallon of ethanol using sugar beets as the feedstock, compared with corn at $1.01 to $1.39 per gallon. More recent studies estimated ethanol production costs in the EU at about $2.89 per gallon using sugar beets as a feedstock (International Energy Agency, 2004). Sugar beets grown for ethanol production in the EU are generally produced outside of the quota and thereby receive a price per ton of beets freely negotiated between farmers and processors rather than receiving the relatively higher B-quota price (Enquidanos et al., 2002).

Capital Expenditure Costs

Although capital expenditure costs for any type of processing facility are dependent upon the circumstances involved with constructing a particular facility in a given location, capital expenditure data from existing ethanol facilities may provide a reasonable range of what the expected capital costs would be for new U.S. facilities utilizing sugar crops as a feedstock. Economies of scale have been shown to exist in construction costs of ethanol plants (Gallagher, Brubaker and Shapouri; Bullock). However, average capital costs for plants of a given size at a particular location is still highly variable due to costs associated with unique circumstances, such as utility access and environmental compliance.

New construction costs for U.S. corn ethanol plants averaged $1.57 per gallon of annual capacity in a recent survey (Shapouri and Gallagher). Capital costs across plants surveyed varied significantly, from $1.05 to $3.00 per gallon of ethanol. Data from Louisiana suggests that a 32 million gallon per year (MGY) ethanol plant, utilizing molasses as a feedstock, could be built for $41 million, or $1.28 per gallon of annual capacity (Rein). Recent data from Brazil indicates that a 45 MGY plant utilizing sugarcane as a feedstock could be built for $60 million, or $1.32 per gallon of capacity (Coelho).

Estimated capital investment costs for two sizes of ethanol plants using alternative sugar feedstocks developed by PRAJ Industries, a major developer of sugar ethanol technology in India, with comparisons to corn, is shown in Table 28 (Urbanchuk). A dry mill plant would require an estimated capital investment of $1.50 per gallon of capacity for a 20 MGY plant. A 40 MGY plant would require an investment of $1.30 per gallon of capacity. With sugarcane or sugar beets as the feedstock, capital investment would be higher than for corn, primarily due to feedstock preparation. A 20 MGY plant utilizing sugarcane or sugar beets would require $2.15 of capital investment per gallon of annual capacity and a 40 MGY plant would require $1.65 per gallon of annual capacity. A new ethanol plant that utilizes cane/beet juice or cane/beet molasses would require capital investment similar to that for corn. Capital investment for the two plant sizes utilizing cane/beet juice as a feed stock are estimated at $1.40 and $1.08 per gallon of annual capacity. Utilizing cane/beet molasses as a feedstock, estimated capital investment is $1.35 and $1.04 per gallon of annual capacity.

Table 28. Estimated capital investment costs for alternative sugar feedstocks

	Plant size (million gallons per year – MGY)	
	20 MGY	40 MGY
Feedstock	($ per gallon of capacity)	($ per gallon of capacity)
Corn	$1.50	$1.30
Sugarcane	$2.10-$2.20	$1.63-$1.68
Sugar beets	$2.10-$2.20	$1.63-$1.68
Cane/beet juice	$1.35-$1.45	$1.05-$1.10
Cane/beet molasses	$1.30-$1.40	$1.03-$1.05

Source: PRAJ Industries

Based on these estimates of capital expenditures, Table 29 presents estimated annual capital investment expense per gallon of annual capacity for ethanol plants using alternative feedstocks. These estimated annual costs represent initial capital investment values financed over a twenty-year period at an annual interest rate of 7.0 percent. Annual capital investment expense for plants utilizing cane/beet juice or molasses are very comparable to values for plants using corn as a feedstock. Ethanol plants that use sugarcane or sugar beets as an ethanol feedstock stock

Table 29. Annual capital investment expense for alternative feedstocks 1/

	Plant size (million gallons per year – MGY)	
	20 MGY	40 MGY
Feedstock	($ per gal. Capacity)	($ per gal. capacity)
Corn	$0.14	$0.12
Sugarcane	$0.20	$0.16
Sugar beets	$0.20	$0.16
Cane/beet juice	$0.13	$0.10
Cane/beet molasses	$0.13	$0.10

1/ Assumes 20 year investment at a 7 percent rate of interest.

would require more capital investment as a result of having equipment to process and prepare the feedstock and, as a result, would have higher annual capital investment expenses.

Capital expenditures for an ethanol plant utilizing sugar crop feedstocks can vary significantly based upon several factors including technology, plant size, and location. It would be expected that capital expenditures would be less for the addition of an ethanol facility adjacent to an existing sugarcane or sugar beet factory than for a stand alone facility.

Potential Location of Sugar Ethanol Plants

The optimal location of an ethanol production facility is largely dependent on being in close proximity to its feedstock supply, regardless of which feedstock is being utilized. The U.S. corn ethanol industry is a good illustration of this relationship. Most of the current ethanol plants in the United States utilizing corn as the feedstock are located within close proximity of major corn producing areas. If sugarcane or sugar beets were to be utilized as a feedstock in producing ethanol, those plants would need to be located close to the location of their feedstock production. This section briefly discusses the current location and processing capacity of sugarcane and sugar beet processors and raw cane refineries in the United States.

Sugar beets are processed directly into white, refined sugar. An annual crop, sugar beets are grown in many of the same states that produce corn. Table 30 presents data on the number of sugar beet factories in each state and daily slicing capacity. In 2005, there were 23 sugar beet factories located in nine states. Fourteen of the 23 factories are located in Idaho, Michigan, Minnesota, and North Dakota. Factories in these states have 71 percent of the total daily sugar beet processing capacity of 163,900 tons of beets. The average daily capacity per factory in 2005 was approximately 7,100 tons.

Table 30. Location and daily capacity of U.S. sugar beet factories, 2005

State	Number of factories	Daily capacity (tons of beets)
California	2	12,600
Colorado	2	10,000
Idaho	3	33,100
Michigan	4	20,900
Minnesota	4	38,600
Montana	2	11,300
Nebraska	1	4,800
North Dakota	3	24,200
Wyoming	2	8,400
Total	23	163,900

Source: U.S. Beet Sugar Association.

Sugarcane is a sub-tropical perennial plant which must be grown in a warmer climate than sugar beets. As a result, sugarcane grown in the United States is produced in the very southern sections of Florida, Louisiana, and Texas and in Hawaii. Mainland sugarcane mills have access to truck, rail, and, in several cases, barge transportation of raw sugar. In 2004, Florida had 6 sugarcane mills with a total daily crushing capacity of 124,300 tons of cane (Table 30). Sugarcane mills in Louisiana are more numerous but generally smaller in size than mills in Florida. Fifteen sugarcane mills were operating in Louisiana in 2004 with a total daily capacity of 175,500 tons. Two or three of these mills have since closed through mergers with existing mills. One mill is located in Texas with a daily capacity of 11,000 tons. Two relatively small mills are located in Hawaii.

Table 31. Location and daily capacity of U.S. sugarcane mills, 2004

State	Number of mills	Daily capacity (tons of cane)
Florida	6	124,300
Hawaii	2	10,500
Louisiana	15	175,500
Texas	1	11,000
Total	24	321,300

Source: *Gilmore Sugar Manual, 2004-2005*.

Raw sugar produced by sugarcane mills must be refined before sale to end users. In 2005, there were five U.S. cane sugar refining companies operating (Table 32). These companies are currently operating eight refineries. The one refinery in California processes raw sugar from Hawaii. All remaining refineries process raw sugar produced on the mainland. Total 24-hour melting capacity of existing cane refineries is 20,350 tons, raw value.

Table 32. Location and melting capacity of U.S. cane sugar refining companies, 2005

Company	Refinery Location	Melting Capacity 1/
American Sugar Refining Co.	Baltimore, MD	3,000
	Chalmette, LA	3,100
	Yonkers, NY	2,000
C & H Sugar Co., Inc.	Crockett, CA	3,400
Florida Crystals Refinery	South Bay, FL	1,100
Imperial Sugar Co.	Port Wentworth, GA	3,150
	Gramercy, LA	2,200
United States Sugar	Clewiston, FL	2,400

1/ 24-hour melting capacity, short tons, raw value
Source: *Sugar Journal*, April 2005

Ethanol - New Technologies in Production and Conversion

This section presents an overview of new technological developments in the production of ethanol feedstocks and the conversion to ethanol. The first section discusses advances in technology in corn-based ethanol production and the second section discusses issues related to sugar production and conversion to ethanol.

Corn. Yields per acre for corn in the United States have increased significantly since 2000. In 2004/05, the U.S. average corn yield increased to a record high of 160.4 bushels per acre. High corn yields in recent years are due primarily to genetically modified seed corn as well as optimum weather for growing corn. In the United States, a large percentage of corn and soybean acreage is now planted with genetically modified varieties. Genetically modified corn protects the plants from insects and diseases and increases the plant's tolerance to herbicides and drought. In addition, advanced technologies in farm management, such as global positioning systems (GPS), adoption of reduced till and no till farming practices, slow release fertilizer, yield mapping, and improved irrigation systems have increased energy efficiency in farming.

Yield mapping using GPS has improved the application rate of nutrients and chemicals per acre for corn and other crops. During harvest, crop yields are measured in each location of the field as well as density of weeds entered into a computer. The yield map is produced based on information stored in the computer. In the following year, the information in the yield map is used to monitor and control fertilizer and herbicide application rates.

New farm machinery and farm equipment have also increased the productivity of the agricultural sector. For example, density of seed per acre can be controlled by a computer connected to the seed planter. Similar technology can be used in application of fertilizers and pesticides. New and modern irrigation systems such as center pivot and drip irrigation significantly reduce water use. In contrast to a gravity system which floods part of a field and can cause soil erosion and crop losses, new irrigation systems provide water and nutrients to the root of the crop instead of watering the whole field.

Although corn ethanol plants in the United States rely on external sources of energy, these ethanol plants are very energy efficient. Ethanol plants purchase natural gas to produce steam required for plant operation and electricity to run pumps, fans, and motors. Due to the high prices of natural gas, new ethanol plants under construction are looking for alternative forms of energy instead of natural gas. Some of the new plants are able to burn coal instead of natural gas for both production of steam and electricity for plant operation and any excess electricity is sold.

There are many energy saving technologies used in corn ethanol plants. Heat exchangers are used widely in ethanol plants to capture excess heat from one process and use it in another process. In conventional ethanol plants, in order to liquefy and saccharify starch to glucose, starch is cooked at 100 to 110 degrees Celsius and then the corn mash is cooled to 36 degrees Celsius and yeast is added to ferment glucose to alcohol. A heat exchanger is used to capture the heat from cooking starch for use in the distillation process.

In the early 1980s, in order to dry alcohol to 99.9 percent, isotropic distillation was used to remove the water. Benzene and cyclohexane (both carcinogenic) were used to remove the water. Today, molecular sieves are used for dehydrating ethanol. Replacing isotropic distillation with molecular sieves eliminates the use of carcinogenic material, eliminates one distillation process, saves as much as $25,000 per installation, and reduces energy costs by up to 20 percent.

Last year, two new energy saving technologies were introduced in the market and used by ethanol plants. One of these new technologies eliminates the cooking process in converting starch to glucose. New enzymes are being developed by enzyme companies that can liquefy and saccharify starch to glucose at 32 degree Celsius. This process is estimated to result in energy savings of about 1,500 to 1,800 BTUs per gallon of ethanol.

Dry fractionation is a process used in dry milling corn-based ethanol. This process separates corn fiber and corn germ from corn kernels before converting corn starch to ethanol. Corn germ contains corn oil. Corn fiber could be used as animal feed, and also could be burned as a source of energy in ethanol plants instead of natural gas. In addition, removing corn fiber and corn germ from corn kernels increases the through put of ethanol plants and reduces energy used per gallon of ethanol. DDGS produced under this process has very low fiber and could be fed to poultry and hogs.

Prior to the 1980s, process automation was not efficient. The systems were bulky and required direct inter-connections with the process with several satellite control rooms for various parts of the process and required sophisticated maintenance by skilled technicians. Distributed control systems (DCS) were introduced in late 1980s, enabling centralized process monitoring and control. This system allowed process instruments, output to pumps and valves, and controller settings to be driven from a computer console located in a central control room.

During the 1990s, these systems grew in capability as computer power increased. This single aspect of production improvement has reduced labor requirements by more than 50 percent over the past 15 years. The advantage of DCS systems include: (1) reduction in manpower by allowing one operator to monitor and control several processes at once and (2) an increase in overall plant efficiency by fine-tuning process parameters using real-time data and sophisticated analysis.

Most of the attention of the research community today is focused the development and implementation of cellulosic biomass ethanol production. Under this process, cellulosic biomass is converted to sugars by hydrolysis and then fermented to produce ethanol. One of the major advantages of this process is that it will dramatically expand the list of feedstocks which could be used in ethanol production. Potential ethanol feedstocks for this process include corn stalks, rice straw, wood chips, and fast-growing trees and grasses.

Sugar. In the United States, sugarcane yield per acre has changed only slightly over the past 25 years. From 1980 to 2005, sugarcane tonnage per acre increased by 13 percent in Florida and 6 percent in Louisiana. In contrast, from 1975 to 2005, sugarcane yields in Brazil about doubled. Genetically modified varieties of sugarcane now are extensively planted in Brazil.

In the Center South region of Brazil, sugarcane yield per acre increased from 55 tons per acre in 1975 to over 90 tons per acre in 2003 with a 14.6 percent sugar content. In addition, sucrose content of sugarcane in Brazil increased by 8 percent during 1975-2000. In contrast, sucrose content of sugarcane did not change significantly in the United States. In the United States, sugarcane and sugar beet yields per acre and sucrose content per ton of cane could be increased if new varieties of sugarcane and sugar beets are developed.

Sugar recovery in sugar beets is higher than in sugarcane due to the higher sucrose content of sugar beets and the process that removes sugar from sugar beets. In all sugar beet plants, the diffusion system (reverse osmosis) is used to remove sugar from sliced sugar beets. In this process, the maximum amount of sugar migrates from sliced beets into water. In contrast, in sugarcane mills, sugarcane is washed with water and then squeezed (ground) through a series of press mills to remove the sugar. In this process, some percentage of sugar is lost in the wash water as well as in filter cake and bagasse. Adopting the diffusion process in existing sugarcane mills in the United States would increase the sugar yield per ton of cane.

Newly developed biotechnology crops such as sugarcane, sugar beets, and corn have new attributes including high yield, high sucrose content, high oil content, or high starch content. Some of the biotechnology crops are commercially available, such as vitamin A rice, high yielding, high sugar content sugarcane and sugar beets, corn with high oil content, corn with high fermentable starch, and corn with alpha amylase enzyme. The major objectives of producing these biotech crops are to increase yield, increase the efficiency of conversion into ethanol and other products, and create high value byproducts.

Sugarcane mills in Brazil, as is the case with dry and wet milling corn ethanol plants in the United States, have become more efficient during the past two decades. Sugarcane mills in Brazil are used for both production of sugar and ethanol. Molasses is diluted with water and added to the sugarcane juice stream for production of more ethanol. Sugarcane plants in Brazil are more efficient and are more capital efficient than U.S. mills. Sugar/ethanol mills in Brazil process cane for a longer time during the year (May-December). In contrast, sugarcane mills in Florida and Texas operate 5-6 months with mills in Louisiana operating only 3-4 months. These sugarcane mills remain unused during the remaining months of the year.

Existing sugarcane mills and sugar beet plants could be modified to produce both sugar and ethanol in the same plants. Rather than build a stand alone plant to convert sugarcane or sugar beets into ethanol, it may be more economical to modify existing plants for the production of ethanol. Less capital investment is required to modify an existing sugarcane or sugar beet mill for production of both sugar and ethanol. The front end of a sugar mill is the same for production of sugar or ethanol. Beet and cane juices are extracted in the first stage of converting sugarcane or sugar beets into either ethanol or raw cane or refined sugar. To make ethanol in existing sugarcane or sugar beet mills, fermenter tanks, as well as distillation columns, molecular sieves, and ethanol storage would need to be added to existing facilities. Since part of the juice stream is diverted to the fermenter for ethanol production, grinding capacity remains the same. It is not necessary to change the boiler system which requires major capital investment.

According to Mr. Zabaleta, cost of production of cane-ethanol could significantly decline if excess bagasse is converted to electricity for sale to the power grid. Bagasse accounts for 27 percent of sugarcane weight and contain 7,000 to 8,000 BTUs of energy per dry pound. Few sugarcane mills in the United States produce electricity as a byproduct of raw sugar production. The remaining sugarcane mills burn bagasse for production of steam in old and inefficient energy boiler systems. In order to take advantage of excess bagasse and sugarcane trash, new cogeneration systems could be added to existing sugar mills to reduce the cost of producing ethanol.

In the United States, renewable electricity made from biomass produced under the close loop system is eligible to receive 1.9 cents per Kwh credit under the 2005 Energy Policy Act of 2005. Renewable electricity made from bagasse could be sold at higher prices to the gird in addition to receiving the 1.9 cents per Kwh incentive.

New technologies in cane and sugar beet production such as precision agriculture, more energy efficient irrigation systems, genetically modified seed with higher yield per acre and with higher sucrose content as well as integrated harvesting and transport systems could be adopted to lower sugarcane and sugar beet production costs. And, advanced processing technologies such as much higher level of industrial automation, new separation process, less labor use, higher sucrose recovery and higher fermentation productivity could be adopted to lower the processing costs of sugarcane and sugar beets into ethanol.

Raw sugar and refined sugar could be converted to ethanol with minimum amount of capital investment. Sugar is converted to syrup by melting sugar in water, using steam. New capital investment for sugar storage and melting tanks would be required if existing corn ethanol plants operators decided to mix beet and cane sugar with corn-glucose. In addition, the computer software used for operating the ethanol plant may need to be modified for use of a mixed stream of sugar and glucose. However, the opportunity cost of raw or refined sugar, as noted earlier in this report, remains a major obstacle for this to be economically feasible.

For crops such as sugarcane in the United States, current research and development into the cellulosic process for producing ethanol production appears to offer some potential. Australia, a major sugarcane producing country is also evaluating the prospects for cellulosic conversion (Bullock). Ethanol can be made from plant cellulose, but it is more difficult than using starch from grains or sugar from sugar beets or sugarcane as the primary feedstock. Current research is underway using sulfuric acid to break down cellulose and hemicellulose into fermentable sugars. The Energy Policy Act of 2005 provides for a minimum of 250 million gallons of cellulosic ethanol in the RFS by 2013.

The Biomass Research Development Act of 2000 established the Biomass Research and Development Initiative. Specific objectives of this initiative are: (1) to develop technologies and processes necessary for abundant commercial production of biobased fuels at prices competitive with fossil fuels, (2) to develop high-value biobased products to enhance the economic viability of biobased fuels and power, and (3) to develop a diversity of sustainable domestic sources of biomass for conversion to biobased fuels and biobased products.

U.S. Sugar Policy and the Market Outlook for Sugar

Domestic prices of sugarcane and sugar beets are supported through non-recourse loans to sugarcane and sugar beet processors. As domestic production of both beet and cane sugar increased during the late 1990s, U.S. sugar import levels were reduced to offset the increase in production, thereby limiting forfeitures and Federal price support outlays. However, during FY 2000, domestic production of beet and cane sugar surged to over 9 million short tons, raw value (Economic Research Service, USDA). Sugar imports could not be reduced below minimum levels established under the Uruguay Round Agreement on Agriculture (URAA) to offset this increase in production causing the stocks-to-use ratio to increase to 22.0 percent at the end of the 1999/2000 marketing year, up from 16.0 percent the year before. Raw sugar prices averaged 18.40 cents per pound during 1999/2000, down from 22.07 cents the prior year and wholesale refined beet sugar prices dropped to 21.90 cents per pound, down from 27.02 cents per pound in 1999/98. Reflecting the low price for sugar, processors forfeited over 1 million tons of sugar to the Commodity Credit Corporation (CCC) under the sugar price support program.

To bring domestic sugar supplies and use into balance and prevent continued forfeitures of sugar to CCC under the price support program, the 2002 Farm Bill authorized marketing allotments on domestic production. The institution of marketing allotments enabled USDA to limit domestic marketings of sugar and maintain prices for sugar at or near the price support level of 18 cents per pound for raw sugar and 22.9 cents per pound for refined sugar with limited forfeitures in 2002/03 and 2003/04.

In 2004/05, U.S. sugar production dropped to 7.9 million tons, down from 8.6 million tons the previous year, as hurricanes reduced sugarcane production in Florida. Sugar production declined further to 7.4 million tons in 2005/06, as hurricanes struck Florida and Louisiana lowering cane production and damaging cane processing facilities in those two States. Imports of raw cane and refined sugar were increased to offset the production shortfalls in 2004/05 and 2005/06.

U.S. prices of refined and raw sugar have increased considerably, even though sugar imports are projected to increase from 2.1 million tons in 2004/05 to nearly 3.2 million tons during the 2005/06 marketing year. In May 2006, the price of refined sugar averaged 35 cents per pound, compared with 25 cents in May 2005, a 40-percent increase, while the price of raw sugar was about 7 percent higher than last year. Domestic prices have increased to attract imports whose value on the world market has also risen due to reduced export prospects for Brazil and the EU. In May 2006, the world price of raw sugar averaged 18 cents per pound, compared with 8.5 cents in May 2005. The prospects for a record sugar harvest in Brazil, the world's largest sugar producer, caused world sugar prices to decline to 16 cents per pound in mid-June 2006.

For the 2006/07 marketing year, U.S. sugar production is forecast to rebound to 8.2 million tons. Even though production is forecast to be the highest since the 2003 crop, sugar use is once again forecast to exceed available sugar supplies, including imports at the minimum level permitted under the URAA minus a shortfall of 50,000 tons. Under this import assumption, the ending stocks-to-use ratio for sugar is projected to fall from 13.2 percent for the current marketing year to 7.7 percent for 2006/07. Given this unusually low stocks-to-use ratio, it is very likely that imports will exceed the minimum level under the URAA and prices for raw and refined sugar well continue to remain well above loan forfeiture levels for the 2006/07 marketing year.

Several significant structural changes could alter the U.S. and world sugar markets. The EU long has been a major supplier of sugar to the world market and a contributor to periods of low world market prices. That could change as the EU implements reforms under the Common Agriculture Policy (CAP). Changes to the EU sugar regime under CAP reform are anticipated to reduce EU's sugar exports by about five million tons each year, resulting in a significant boost in the world price for sugar. In fact, the EU could become a net importer of sugar, since its commitments to import sugar from its traditional suppliers could exceed its permitted subsidized exports.

Another major development in the world sugar market is the growing role of renewable fuels from sugarcane as petroleum prices continue to be record-high. This already is having a perceptible influence on the world sugar market and, as more and more sugar producing countries explore ethanol production, could have a considerable long-term impact. Continuing pressure on world energy prices is expected to divert more sugarcane, chiefly Brazilian, into ethanol production, which would tend to boost world sugar prices. While the world sugar price is expected to remain below the current U.S. domestic support price, increasing demand for ethanol and firmer world prices could reduce the incentive to supply the U.S. market with sugar should U.S. sugar production again be adversely affected by weather or other factors.

With respect to the U.S. sugar market, future trade agreements could to lead to pressure for increased access to the U.S. sugar market. The prosperity of the domestic farm sector and food industry is highly contingent upon gaining greater access to global markets. This has spurred the pursuit of both multilateral and bilateral trade agreements to provide that access. As the U.S. continues to seek expanded opportunities for our farmers and ranchers in international markets through free trade agreements, trading partners in turn will request increased access to the U.S. sugar market, especially as long as our domestic price substantially exceeds the world price.

On January 1, 2008, full implementation of NAFTA eliminates all customs duties for sweetener trade between Mexico and the United States. Relative costs of production, transportation, and other market factors will determine where sugar crops are grown and processed in the United States and Mexico following elimination of customs duties on sweeteners trade between the two countries. If price supports for raw and refined sugar remain at current levels, U.S. prices could attract additional imports from Mexico causing U.S. market prices for sugar to fall. Depending on the volume of imports from Mexico, sugar prices could drop below the forfeiture level raising the cost of the U.S. sugar program. Alternatively, if the cost of producing sugar in the U.S. is less than in Mexico, full implementation of NAFTA could increase U.S. sugar exports to Mexico, which would raise U.S. prices for sugar and other sweeteners.

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Appendix A - Ethanol yields from sucrose:

The stoichiometric (theoretical) yield of ethanol from sucrose:

= 1076 pounds of ethanol / ton of sucrose
= 538 kilograms of ethanol / metric ton of sucrose
= 163 gallons of ethanol / ton of sucrose
= 680 liters of ethanol / metric ton of sucrose

Maximum obtainable yield:

= 154 gallons of ethanol / ton of sucrose
(94.5% of theoretical yield)

Practical ethanol plant operation yield:

= 141 gallons of ethanol / ton of sucrose
(86.6% of theoretical yield)

Ethanol production from feedstocks (using 141 gallons per ton of sucrose conversion factor):

(1) Sugarcane = 12.24% raw sugar recovery rate, plus 41.6 pounds of sucrose from cane molasses
1 ton of sugarcane = 235.0 pounds of sucrose from raw sugar
and 41.6 lbs of sucrose from molasses
= 276.6 pounds (0.1383 tons) sucrose
= 19.5 gallons of ethanol
or 0.051 tons of sugarcane per gallon of ethanol produced

(2) Sugar beets = 15.58% refined sugar recovery rate, plus 40.0 pounds of sucrose from beet molasses
1 ton of sugar beets = 311.6 pounds of sucrose from refined sugar
and 40.0 pounds of sucrose from beet molasses
= 351.6 pounds (0.1758 tons) of sucrose
= 24.8 gallons of ethanol
or 0.040 tons of sugar beets per gallon of ethanol produced

(3) Molasses = 49.2% total sugars as sucrose
1 ton of molasses = 984 pounds (0.492 tons) of sucrose
= 69.4 gallons of ethanol
or 28.8 pounds of molasses per gallon of ethanol produced
or 2.45 gallons of molasses per gallon of ethanol produced
(using a conversion of 1.0 gallon of molasses = 11.74 pounds of weight)

(4) Raw sugar = 96.0% totals sugars as sucrose
1 ton of raw sugar = 1920 pounds (0.96 tons) of sucrose
= 135.4 gallons of ethanol
or 14.77 pounds of raw sugar per gallon of ethanol produced

(5) Refined beet sugar = 100.0% total sugars as sucrose
1 ton of refined sugar = 2000 pounds (1.0 ton) of sucrose
= 141.0 gallons of ethanol
or 14.18 pounds of refined sugar per gallon of ethanol produced

Appendix table 1. Florida sugarcane acreage, yield and production, 1980-2005

Crop Year	Total acreage	Acreage for sugar	Sugarcane yield per acre	Sugarcane production	Recovery rate	Sugar yield per acre
	(1,000 acres)		(tons/acre)	(1,000 tons)	(%)	(tons, raw value)
1980/81	339.2	320.7	31.1	9,985	11.23	3.50
1981/82	348.2	334.4	28.5	9,530	10.10	2.55
1982/83	355.3	341.4	35.4	12,086	10.81	2.76
1983/84	367.9	361.1	31.4	11,330	10.79	5.84
1984/85	387.0	371.9	32.5	12,087	11.68	2.99
1985/86	398.7	383.4	32.9	12,615	11.20	2.92
1986/87	405.0	390.0	33.1	12,916	11.43	3.09
1987/88	417.0	402.0	32.3	12,990	11.68	3.25
1988/89	421.0	404.0	31.6	12,766	12.27	3.04
1989/90	420.0	405.0	31.4	12,717	11.00	3.08
1990/91	434.0	419.0	35.5	14,874	12.14	3.51
1991/92	443.0	428.0	34.9	14,937	12.27	3.62
1992/93	443.0	426.0	33.2	14,143	12.09	3.15
1993/94	444.0	425.0	34.1	14,493	12.22	4.17
1994/95	444.0	423.0	33.6	14,213	12.14	4.08
1995/96	437.0	417.0	34.6	14,428	12.28	4.25
1996/97	438.0	417.0	33.1	13,803	12.17	4.03
1997/98	440.0	421.0	36.9	15,535	12.38	4.57
1998/99	447.0	426.0	40.1	17,083	12.48	5.00
1999/00	460.0	443.0	35.0	15,505	12.68	4.44
2000/01	445.0	436.0	37.5	16,350	12.58	4.72
2001/02	465.0	445.0	35.1	15,620	12.68	4.45
2002/03	461.0	442.0	38.3	16,629	12.58	4.82
2003/04	438.0	419.0	39.3	16,467	13.08	5.14
2004/05	406.0	385.0	34.9	13,437	12.60	4.40
2005/06	401.0	376.0	31.4	11,806	11.59	3..64

Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 2. Hawaii sugarcane acreage, yield and production, 1980-2005

Crop Year	Total acreage	Acreage for sugar	Sugarcane yield per acre	Sugarcane production	Recovery rate	Sugar yield per acre
	(1,000 acres)		(tons/acre)	(1,000 tons)	(%)	(tons, raw value)
1980/81	104.5	97.4	94.6	9,214	11.10	10.50
1981/82	104.8	97.6	90.5	8,831	11.87	10.74
1982/83	94.7	89.3	98.6	8,808	11.16	11.01
1983/84	99.3	92.8	96.2	8,926	11.70	11.25
1984/85	95.2	89.5	94.5	8,454	12.56	11.87
1985/86	89.4	83.0	95.4	7,916	12.78	12.19
1986/87	90.2	83.6	100.2	8,379	12.45	12.48
1987/88	86.5	79.5	100.8	8,014	11.59	11.69
1988/89	86.1	78.9	96.4	7,606	12.20	11.76
1989/90	81.4	74.7	94.8	7,082	12.21	11.58
1990/91	79.0	72.0	90.8	6,538	12.56	11.40
1991/92	74.0	67.4	86.9	5,857	12.36	10.74
1992/93	67.9	61.7	88.0	5,430	11.95	10.52
1993/94	69.9	64.8	85.0	5,508	12.29	10.44
1994/95	69.3	64.3	81.9	5,266	12.47	10.21
1995/96	53.0	48.5	81.5	3,953	12.42	10.12
1996/97	46.0	42.9	82.6	3,544	12.18	10.06
1997/98	34.2	32.0	91.4	2,925	12.41	11.34
1998/99	32.5	30.3	90.0	2,727	12.98	11.68
1999/00	37.3	35.4	81.7	2,892	12.71	10.38
2000/01	32.0	30.2	78.3	2,365	12.73	9.97
2001/02	20.8	19.3	97.3	1,878	13.11	12.76
2002/03	22.7	21.3	99.0	2,109	12.79	12.66
2003/04	21.3	19.9	102.0	2,030	12.86	13.12
2004/05	23.2	21.8	90.8	1,979	13.04	11.83
2005/06	24.2	21.7	80.7	1,751	14.56	11.75

Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 3. Louisiana sugarcane acreage, yield and production, 1980-2005

Crop Year	Total acreage	Acreage for sugar	Sugarcane yield per acre	Sugarcane production	Recovery rate	Sugar yield per acre
	(1,000 acres)		(tons/acre)	(1,000 tons)	(%)	(tons, raw value)
1980/81	254.0	232.0	23.3	5,414	9.07	2.12
1981/82	265.0	247.0	26.9	6,650	10.71	2.88
1982/83	255.0	234.0	27.6	6,450	10.47	2.88
1983/84	265.0	245.0	23.9	5,850	10.31	2.46
1984/85	230.0	205.0	22.0	4,510	10.02	2.20
1985/86	250.0	226.0	24.0	5,430	9.80	2.35
1986/87	270.0	248.0	27.3	6,770	9.91	2.71
1987/88	285.0	263.0	22.7	5,970	12.24	2.78
1988/89	305.0	279.0	25.3	7,050	11.30	2.86
1989/90	315.0	290.0	25.7	7,440	11.34	2.91
1990/91	245.0	201.0	20.6	4,150	10.55	2.18
1991/92	345.0	321.0	22.1	7,090	10.77	2.38
1992/93	375.0	345.0	23.2	8,010	10.93	2.54
1993/94	390.0	360.0	22.8	8,220	10.86	2.48
1994/95	380.0	352.0	24.4	8,589	11.86	2.89
1995/96	400.0	368.0	25.6	9,421	11.22	2.87
1996/97	370.0	335.0	27.9	9,347	11.28	3.15
1997/98	410.0	380.0	28.2	10,716	11.78	3.32
1998/99	435.0	400.0	29.7	11,880	11.17	3.32
1999/00	465.0	435.0	32.7	14,225	11.83	3.87
2000/01	500.0	465.0	29.7	13,811	11.48	3.41
2001/02	495.0	460.0	29.0	13,340	11.84	3.43
2002/03	495.0	465.0	28.3	13,160	10.39	2.94
2003/04	490.0	450.0	26.2	11,790	11.68	3.06
2004/05	465.0	430.0	23.8	10,234	11.30	2.69
2005/06	455.0	420.0	22.9	9,618	12.94	2.96

Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 4. Texas sugarcane acreage, yield and production, 1980-2005

Crop Year	Total acreage	Acreage for sugar	Sugarcane yield per acre	Sugarcane production	Recovery rate	Sugar yield per acre
	(1,000 acres)		(tons/acre)	(1,000 tons)	(%)	(tons, raw value)
1980/81	35.0	33.5	28.9	969	9.60	2.78
1981/82	37.4	36.6	31.5	1,154	9.53	3.01
1982/83	36.7	35.7	31.0	1,105	8.87	2.75
1983/84	35.5	34.5	31.7	1,095	5.48	1.74
1984/85	35.1	34.3	27.9	957	8.46	2.36
1985/86	31.9	30.4	30.1	916	8.30	2.50
1986/87	31.0	29.1	29.9	871	10.445	3.13
1987/88	35.1	33.8	31.1	1,052	10.08	3.14
1988/89	33.2	31.7	33.3	1,057	10.12	3.38
1989/90	35.5	33.6	24.7	830	8.31	2.05
1990/91	36.2	34.4	26.5	913	9.64	2.56
1991/92	34.9	33.2	32.4	1,076	10.16	3.29
1992/93	39.3	37.7	34.2	1,290	10.67	3.65
1993/94	44.4	43.5	32.5	1,414	10.35	3.37
1994/95	43.5	42.4	31.5	1,336	10.78	3.40
1995/96	42.3	41.2	32.4	1,335	10.04	3.25
1996/97	34.9	34.6	28.7	993	9.16	2.63
1997/98	29.8	27.3	30.3	827	9.62	2.91
1998/99	32.6	32.0	32.9	1,053	10.08	3.32
1999/00	31.0	28.0	34.1	955	11.01	3.75
2000/01	46.3	45.5	38.8	1,765	11.68	4.53
2001/02	47.0	46.0	42.1	1,937	8.97	3.78
2002/03	44.5	43.6	39.1	1,705	11.20	4.38
2003/04	43.0	41.7	39.7	1,655	10.58	4.20
2004/05	44.0	42.7	37.3	1,593	9.92	3.70
2005/06	42.4	40.5	38.3	1,551	11.61	4.44

Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 5. Great Lakes sugar beet acreage, yield and production, 1991-2005

Crop Year	Planted acreage	Harvested acreage	Sugar beet yield per acre	Sugar beet production
	(1,000 acres)	(1,000 acres)	(tons/acre)	(1,000 tons)
1991	191.3	184.5	15.6	2,869
1992	200.2	195.5	17.5	3,426
1993	208.1	204.5	16.6	3,391
1994	212.0	203.0	16.2	3,293
1995	206.3	203.3	15.7	3,200
1996	157.9	134.6	15.2	2,049
1997	163.9	160.9	19.0	3,057
1998	178.3	174.1	16.0	2,787
1999	195.8	191.7	18.6	3,567
2000	190.2	166.8	20.5	3,420
2001	180.8	166.6	19.4	3,232
2002	180.9	178.8	18.1	3,241
2003	181.0	179.9	19.2	3,446
2004	166.9	164.7	21.1	3,476
2005	154.0	152.0	21.3	3,238

Great Lakes region includes Michigan and Ohio.
Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 6. Upper Midwest sugar beet acreage, yield and production, 1991-2005

Crop Year	Planted acreage	Harvested Acreage	Sugar beet yield per acre	Sugar beet Production
	(1,000 acres)	(1,000 acres)	(tons/acre)	(1,000 tons)
1991	564.0	556.9	17.5	9,739
1992	567.5	564.7	18.1	10,233
1993	583.8	569.9	14.8	8,456
1994	620.8	612.5	20.8	12,739
1995	634.0	624.2	18.2	11,363
1996	667.6	663.3	18.4	12,184
1997	684.4	673.5	18.5	12,456
1998	723.0	700.6	21.5	15,096
1999	731.6	717.0	20.3	14,585
2000	748.0	662.0	21.7	14,372
2001	729.0	663.0	18.2	12,086
2002	770.0	734.0	18.6	13,653
2003	751.0	742.0	20.5	15,234
2004	742.0	716.0	20.5	14,669
2005	746.0	703.0	19.9	13,977

Upper Midwest region includes Minnesota and North Dakota.
Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 7. Great Plains sugar beet acreage, yield and production, 1991-2005

Crop Year	Planted Acreage	Harvested Acreage	Sugar beet yield per acre	Sugar beet production
	(1,000 acres)	(1,000 acres)	(tons/acre)	(1,000 tons)
1991	289.9	271.5	21.7	5,894
1992	292.8	282.2	20.9	5,888
1993	283.3	277.3	20.4	5,658
1994	269.1	257.1	20.8	5,357
1995	257.6	249.7	18.8	4,694
1996	241.5	230.1	19.9	4,588
1997	276.1	262.5	19.4	5,104
1998	236.3	220.5	21.4	4,729
1999	264.6	253.5	21.3	5,390
2000	271.4	219.7	21.8	4,793
2001	196.0	173.3	21.2	3,671
2002	198.9	173.4	19.1	3,309
2003	160.6	155.1	23.0	3,565
2004	175.9	168.7	22.7	3,831
2005	174.9	165.4	22.4	3,701

Great Plains region includes Colorado, Montana, Nebraska, New Mexico, Texas and Wyoming.
Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 8. Far West sugar beet acreage, yield and production, 1991-2005

Crop Year	Planted Acreage	Harvested Acreage	Sugar beet yield per acre	Sugar beet production
	(1,000 acres)	(1,000 acres)	(tons/acre)	(1,000 tons)
1991	379.9	371.6	25.9	9,624
1992	374.4	367.3	25.9	9,524
1993	360.0	355.2	24.3	8,641
1994	361.7	358.4	27.9	10,012
1995	332.4	328.8	25.3	8,324
1996	301.4	295.3	26.6	7,859
1997	334.9	331.4	28.0	9,269
1998	360.2	355.5	27.8	9,887
1999	368.6	365.1	27.1	9,878
2000	354.6	324.5	30.7	9,956
2001	264.7	240.5	28.2	6,775
2002	277.5	274.5	27.3	7,504
2003	272.8	270.9	31.2	8,465
2004	260.8	257.3	31.3	8,045
2005	224.9	222.5	29.8	6,621

Far West region includes California, Idaho, Oregon and Washington.
Source: Economic Research Service, U.S. Department of Agriculture.

Appendix table 9. Estimated sugarcane processing costs per pound of raw sugar equivalent for ethanol production, U.S. and Florida, 2003-05 1/

	U.S.			Florida		
Item	2003	2004	2005	2003	2004	2005
	(cents per pound of raw sugar equivalent)					
Variable cash expenses:						
Cane transportation	1.185	1.288	1.328	1.215	1.334	1.522
Processing:	2.023	2.195	2.281	1.833	1.973	2.212
Labor	1.161	1.229	1.225	1.247	1.327	1.456
Fuel	0.154	0.181	0.219	0.066	0.075	0.098
Chemicals	0.121	0.134	0.139	0.077	0.084	0.096
Electricity	0.100	0.119	0.145	0.029	0.034	0.044
Materials and supplies	0.486	0.533	0.553	0.413	0.454	0.518
Repairs and maintenance	1.456	1.608	1.675	1.135	1.246	1.422
Total variable expenses	4.664	5.092	5.284	4.183	4.555	5.156
General and administrative:						
Labor	0.366	0.390	0.389	0.325	0.346	0.379
Nonlabor	0.566	0.612	0.629	0.659	0.724	0.826
Total	0.932	1.001	1.018	0.984	1.070	1.205
Total processing costs	5.596	6.093	6.302	5.167	5.625	6.361
Credits:						
Bagasse	0.037	0.034	0.033	0.032	0.029	0.026
Other	0.080	0.093	0.090	0.043	0.043	0.043
Total	0.118	0.127	0.123	0.075	0.072	0.069
Total processing cost less credits	5.478	5.966	6.179	5.092	5.553	6.292

1/ Variable cash, general and administrative expenses less credits with adjusted energy expenses for ethanol production.

Appendix table 10. Estimated sugarcane processing costs per pound of raw sugar equivalent for ethanol production, Hawaii and Louisiana/Texas, 2003-05 1/

	Hawaii.			Louisiana/Texas		
Item	2003	2004	2005	2003	2004	2005
	(cents per pound of raw sugar equivalent)					
Variable cash expenses:						
Cane transportation	0.704	0.707	0.809	1.225	1.346	1.226
Processing:	3.192	3.181	3.701	2.089	2.281	2.102
Labor	1.807	1.758	1.937	0.934	0.994	0.871
Fuel	0.416	0.435	0.572	0.233	0.266	0.278
Chemicals	0.152	0.152	0.175	0.176	0.194	0.176
Electricity	0.351	0.367	0.483	0.157	0.179	0.187
Materials and supplies	0.466	0.468	0.536	0.590	0.648	0.590
Repairs and maintenance	2.168	2.178	2.494	1.782	1.957	1.782
Total variable expenses	6.063	6.066	7.055	5.096	5.584	5.110
General and administrative:						
Labor	0.519	0.505	0.556	0.396	0.422	0.369
Nonlabor	0.339	0.340	0.390	0.476	0.523	0.476
Total	0.857	0.845	0.946	0.872	0.945	0.846
Total processing costs	6.920	6.911	8.001	5.968	6.529	5.956
Credits:						
Bagasse	0.000	0.000	0.000	0.051	0.047	0.046
Other	0.866	0.866	0.866	0.000	0.000	0.000
Total	0.866	0.866	0.866	0.051	0.047	0.046
Total processing cost less credits	6.054	6.045	7.085	5.917	6.482	5.910

1/ Variable cash, general and administrative expenses less credits with adjusted energy expenses for ethanol production.

Appendix table 11. Estimated sugar beet processing costs per pound of refined sugar equivalent for ethanol production, U.S., 2003-05 1/

Item	U.S. 2003	U.S. 2004	U.S. 2005
	(cents per pound of refined sugar equivalent)		
Variable cash expenses:			
Beet acquisition	1.312	1.162	1.157
Processing:			
Labor	1.350	1.374	1.333
Fuel	0.776	0.849	0.983
Chemicals	0.261	0.274	0.277
Electricity	0.154	0.168	0.195
Materials and supplies	0.356	0.374	0.377
Repairs and maintenance	1.098	1.154	1.164
Total variable expenses	5.308	5.356	5.486
General and administrative:			
Labor	0.252	0.257	0.249
Nonlabor	0.281	0.296	0.298
Total	0.534	0.553	0.548
Pulp drying and marketing	1.166	1.226	1.236
Total processing costs	7.008	7.134	7.270
Credits:			
Dried pulp	1.973	1.977	1.833
Other	0.156	0.156	0.156
Total	2.129	2.133	1.990
Total processing cost less credits	4.879	5.001	5.281

1/ Variable cash, general and administrative expenses less credits with adjusted energy expenses for ethanol production.

Appendix table 12. Estimated sugar beet processing costs per pound of refined sugar equivalent for ethanol production, East and West Regions, 2003-05 1/

	East Region 2/			West Region 2/		
Item	2003	2004	2005	2003	2004	2005
	(cents per pound of refined sugar equivalent)					
Variable cash expenses:						
Beet acquisition	1.139	1.009	1.004	1.541	1.365	1.358
Processing:						
Labor	1.294	1.316	1.278	1.423	1.449	1.406
Fuel	0.792	0.867	1.003	0.755	0.826	0.956
Chemicals	0.282	0.296	0.299	0.230	0.241	0.244
Electricity	0.224	0.245	0.283	0.057	0.063	0.072
Materials and supplies	0.473	0.497	0.501	0.199	0.209	0.211
Repairs and maintenance	1.301	1.367	1.379	0.823	0.865	0.872
Total variable expenses	5.504	5.597	5.747	5.028	5.017	5.120
General and administrative:						
Labor	0.257	0.262	0.254	0.244	0.248	0.241
Nonlabor	0.161	0.169	0.171	0.442	0.465	0.469
Total	0.418	0.431	0.425	0.686	0.713	0.710
Pulp drying and marketing	1.117	1.173	1.184	1.231	1.294	1.305
Total processing costs	7.039	7.201	7.356	6.945	7.023	7.134
Credits:						
Dried pulp	2.099	2.103	1.951	1.793	1.797	1.667
Other	0.166	0.166	0.166	0.143	0.143	0.143
Total	2.265	2.269	2.117	1.936	1.940	1.810
Total processing cost less credits	4.774	4.932	5.239	5.009	5.083	5.324

1/ Variable cash, general and administrative expenses less credits with adjusted energy expenses for ethanol production.
2/ East region includes Great Lakes and Red River Valley, West region includes Great Plains and Northwest.

Appendix table 13. Sugarcane production cash costs, Florida, 1992-96 with indexed values for 2003-2005

Item	1992	1993	1994	1995	1996	2003	2004	2005
				(dollars per harvested acre)				
Cash expenses:								
Seed	28.32	27.22	27.77	27.95	27.95	37.43	38.41	40.84
Fertilizer	54.66	51.48	50.97	61.33	57.99	57.53	65.42	75.16
Chemicals	52.93	55.17	57.67	59.10	61.15	62.18	61.67	61.67
Custom operations	89.33	96.16	99.18	106.65	104.81	111.13	112.03	115.65
Fuel and lubrication	21.21	20.81	19.78	21.67	23.79	28.71	33.43	45.94
Repairs	71.39	75.42	76.27	80.12	80.84	85.72	86.42	89.21
Hired labor	373.39	359.80	382.63	406.54	396.76	532.41	545.97	559.53
Purchases irrigation water	6.21	6.34	6.55	6.70	7.07	7.75	8.12	8.67
Miscellaneous	0.51	0.52	0.53	0.56	0.58	0.64	0.67	0.71
Hauling allowance (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total variable cash expenses	697.98	692.92	721.35	770.63	760.95	923.50	952.13	997.37
General farm overhead	87.24	106.01	111.85	114.79	107.45	117.72	123.33	131.74
Taxes and insurance	31.66	36.11	34.47	59.27	59.93	68.49	69.56	67.42
Interest	8.33	8.75	8.64	9.61	9.49	9.13	9.22	9.75
Total fixed cash expenses	127.23	150.87	154.96	183.67	176.86	195.34	202.11	208.91
Total cash expenses	825.21	843.79	876.32	954.31	937.81	1,118.84	1,154.23	1,206.29
Yield (net tons/harvested acre)	33.20	34.10	33.60	34.60	34.00	39.30	35.20	32.30

Source: 1992-96 data from Economic Research Service, USDA

Appendix table 14. Sugarcane production economic costs and returns, Florida, 1992-96 with indexed values for 2003-2005

Item	1992	1993	1994	1995	1996	2003	2204	2005
				(dollars per harvested acre)				
Economic (full ownership) costs:								
Total variable cash expenses	697.98	692.92	721.35	770.63	760.95	923.50	952.13	997.37
General farm overhead	87.24	106.01	111.85	114.79	107.45	117.72	123.33	131.74
Taxes and insurance	31.66	36.11	34.47	59.27	59.93	68.49	69.56	67.42
Capital replacement	44.00	45.13	47.93	50.77	52.88	63.88	68.53	72.34
Operating capital	12.46	10.81	16.81	21.54	19.37	21.22	22.23	23.75
Other nonland capital	10.14	10.37	11.06	12.01	11.86	12.99	13.61	14.54
Land	189.93	176.25	126.05	180.34	183.54	172.07	172.07	179.24
Unpaid labor	1.28	1.23	1.31	1.39	1.36	1.82	1.87	1.92
Total economic costs	1,074.69	1,078.83	1,071.44	1,210.75	1,197.34	1,381.70	1,423.34	1,488.32
Yield (net tons/harvested acre)	33.20	34.10	33.60	34.60	34.00	39.30	35.20	32.30

Source: 1992-96 data from Economic Research Service, USDA

Appendix table 15. Sugarcane production cash costs, Hawaii, 1992-96 with indexed values for 2003-2005

Item	1992	1993	1994	1995	1996	2003	2004	2005
				(dollars per harvested acre)				
Cash expenses:								
Seed	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fertilizer	237.84	230.04	250.84	285.41	294.92	292.56	332.67	382.22
Chemicals	134.36	140.06	146.38	150.01	155.23	157.84	156.54	156.54
Custom operations	58.68	59.40	59.91	62.26	62.57	66.34	66.88	69.04
Fuel and lubrication	91.86	84.65	78.68	83.30	93.51	112.85	131.39	180.57
Repairs	420.72	417.97	413.37	419.62	432.97	459.10	462.83	477.76
Hired labor	1,274.54	1,327.82	1,385.31	1,504.49	1,378.30	1,849.51	1,896.63	1,943.75
Purchases irrigation water	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Miscellaneous	95.85	97.73	99.71	104.39	109.14	119.58	125.27	133.81
Hauling allowance (-)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total variable expenses	2,313.85	2,357.67	2,434.20	2,609.48	2,526.63	3,057.78	3,172.21	3,343.68
General farm overhead	257.69	313.12	330.38	339.08	317.38	347.73	364.29	389.13
Taxes and insurance	42.16	43.26	51.58	49.50	48.28	55.18	56.04	54.31
Interest	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total fixed cash expenses	299.85	356.38	381.97	388.58	365.65	402.91	420.33	443.44
Total cash expenses	2,613.70	2,714.05	2,816.17	2,998.06	2,892.28	3,460.69	3,592.54	3,787.13
Yield (net tons/harvested acre)	88.00	85.00	81.90	81.50	81.90	97.70	87.30	86.90

Source: 1992-96 data from Economic Research Service, USDA

Appendix table 16. Sugarcane production economic costs, Hawaii, 1992-96 with indexed values for 2003-2005

Item	1992	1993	1994	1995	1996	2003	2004	2005
				(dollars per harvested acre)				
Economic (full ownership) costs:								
Total variable cash expenses	2,313.85	2,357.67	2,434.20	2,609.48	2,526.63	3,057.78	3,172.21	3,343.68
General farm overhead	257.69	313.12	330.38	339.08	317.38	347.73	364.29	389.13
Taxes and insurance	42.16	43.26	51.58	49.50	48.28	55.18	56.04	54.31
Capital replacement	159.79	163.91	174.05	184.37	192.06	232.01	248.91	262.74
Operating capital	40.96	36.78	56.72	72.94	64.30	70.45	73.81	78.84
Other nonland capital	90.40	92.48	98.62	107.10	105.74	115.85	121.37	129.65
Land	211.15	203.03	219.27	235.51	241.60	226.50	226.50	235.94
Unpaid labor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total economic costs	3,116.00	3,210.25	3,364.82	3,597.98	3,495.98	4,105.50	4,263.13	4,494.29
Yield (net tons/harvested acre)	88.00	85.00	81.90	81.50	81.90	97.70	87.30	86.90

Source: 1992-96 data from Economic Research Service, USDA

Appendix table 17. Sugarcane production cash costs, Louisiana/Texas, 1992-96 with indexed values for 2003-2005

Item	1992	1993	1994	1995	1996	2003	2004	2005
				(dollars per harvested acre)				
Cash expenses:								
Seed	50.33	50.78	50.04	52.30	54.63	73.16	75.06	79.81
Fertilizer	4.82	42.96	46.68	55.83	53.82	53.39	60.71	69.75
Chemicals	56.86	59.19	61.86	63.42	65.66	66.76	66.21	66.21
Custom operations	9.36	9.52	10.60	11.64	12.20	12.93	13.04	13.46
Fuel and lubrication	23.88	22.12	22.70	25.440	29.73	35.88	41.77	57.41
Repairs	62.14	61.43	67.40	72.59	79.00	83.77	84.45	87.17
Hired labor	113.90	120.85	118.90	119.78	126.81	170.16	174.50	178.83
Purchases irrigation water	3.95	5.13	5.28	5.07	4.92	5.39	5.65	6.03
Miscellaneous	3.18	3.18	3.24	3.41	3.59	3.94	4.13	4.41
Hauling allowance (-)	-18.16	-16.89	-16.30	-17.47	-19.69	-19.90	-17.75	-17.25
Total variable cash expenses	349.26	358.27	370.42	391.98	410.67	485.49	507.76	545.84
General farm overhead	23.48	29.92	31.55	31.94	29.41	32.22	33.75	36.05
Taxes and insurance	30.77	34.90	38.53	37.53	40.51	46.29	47.01	45.57
Interest	16.13	17.24	17.01	18.83	18.48	17.78	17.95	19.00
Total fixed cash expenses	70.38	82.06	87.09	88.31	88.39	96.29	98.72	100.62
Total cash expenses	419.64	440.33	457.51	480.29	499.06	581.77	606.48	646.46
Yield (net tons/harvested acre)	24.13	23.85	21.79	26.28	26.96	27.82	25.56	24.83

Source: 1992-96 data from Economic Research Service, USDA

Appendix table 18. Sugarcane production economic costs, Louisiana/Texas, 1992-96 with indexed values for 2003-2005

Item	1992	1993	1994	1995	1996	2003	2004	2005
				(dollars per harvested acre)				
Economic (full ownership) costs:	349.26	358.27	370.42	391.98	410.67	485.49	507.76	545.84
Total variable expenses	23.48	29.92	31.55	31.94	29.41	32.22	33.75	36.05
General farm overhead	30.77	34.90	38.53	37.53	40.51	46.29	47.01	45.57
Taxes and insurance	80.52	80.82	85.85	91.53	96.07	116.05	124.51	131.42
Capital replacement	6.23	5.59	8.63	10.96	10.45	11.45	11.99	12.81
Operating capital	35.22	35.25	37.60	41.10	40.89	44.80	46.93	50.13
Other nonland capital	105.23	99.27	109.69	119.72	124.27	116.50	116.50	121.36
Land	30.53	32.27	31.68	31.97	33.96	45.57	46.73	47.89
Unpaid labor	661.24	676.29	713.95	756.73	786.22	898.37	935.19	991.08
Total economic costs								
Yield (net tons/harvested acre)	24.13	23.85	21.79	26.28	26.96	27.82	25.56	24.83

Source: 1992-96 data from Economic Research Service, USDA

Appendix table 19. Sugarcane processing costs per pound of 96 degree raw sugar, Florida, 1992-96

Item	1992	1993	1994	1995	1996
	(cents per pound of raw sugar)				
Variable cash expenses:					
Cane transportation	1.164	1.159	1.198	1.252	1.265
Processing:	1.649	1.648	1.662	1.673	1.750
Labor	1.027	1.021	1.034	1.038	1.076
Fuel	0.096	0.095	0.092	0.092	0.113
Chemicals	0.071	0.072	0.075	0.080	0.080
Electricity	0.049	0.051	0.049	0.049	0.051
Materials and supplies	0.406	0.409	0.412	0.415	0.430
Repairs and maintenance	1.099	1.094	1.131	1.177	1.181
Labor benefits	0.455	0.452	0.458	0.460	0.477
Marketing	0.938	0.950	0.963	0.974	1.010
Total variable cash expenses	5.305	5.303	5.412	5.536	5.683
Fixed cash expenses:					
Depreciation	0.398	0.396	0.408	0.403	0.385
Taxes and insurance	0.111	0.111	0.113	0.115	0.121
Interest	0.148	0.129	0.193	0.229	0.210
Total fixed cash expenses	0.657	0.636	0.714	0.747	0.716
General and administrative:					
Labor	0.268	0.266	0.270	0.270	0.280
Nonlabor	0.609	0.627	0.646	0.660	0.686
Total	0.877	0.893	0.915	0.931	0.967
Total processing costs	6.839	6.832	7.041	7.214	7.366
Credits:					
Molasses	0.561	0.514	0.616	0.655	0.701
Bagasse	0.026	0.027	0.026	0.027	0.028
Other	0.038	0.039	0.040	0.043	0.043
Total	0.625	0.580	0.682	0.725	0.772
Recovery per net ton of cane (lbs of raw sugar)	241.8	242.7	242.7	245.4	243.2

Source: Economic Research Service, USDA.

Appendix table 20. Cane sugar production and processing costs per pound of raw sugar, Florida, 1992-96

Item	1992	1993	1994	1995	1996
	(cents per pound of raw sugar)				
Production costs:					
Variable cash expenses	8.695	8.373	8.846	9.076	9.203
Fixed and other noncash expenses	4.693	4.663	4.293	5.183	5.278
Total production costs	13.387	13.036	13.139	14.259	14.480
Processing costs:					
Variable cash expenses	5.305	5.303	5.412	5.536	5.683
Fixed cash expenses	0.657	0.636	0.714	0.747	0.716
General and administrative expenses	0.877	0.893	0.915	0.931	0.967
Total processing costs	6.839	6.832	7.041	7.214	7.366
Credits:					
Molasses	0.561	0.514	0.616	0.655	0.701
Bagasse	0.026	0.027	0.026	0.027	0.028
Other	0.038	0.039	0.040	0.043	0.043
Total	0.625	0.580	0.682	0.725	0.772
Total processing costs less credits	6.214	6.252	6.359	6.489	6.594
Total production and processing costs	19.601	19.288	19.498	20.748	21.074
Total variable costs less credits	13.375	13.096	13.576	13.887	14.114

Source: Economic Research Service, USDA.

Appendix table 21. Sugarcane processing costs per pound of 96 degree raw sugar, Hawaii, 1992-96

Item	1992	1993	1994	1995	1996
		(cents per pound of raw sugar)			
Variable cash expenses:					
Cane transportation	0.682	0.653	0.665	0.700	0.718
Processing:	3.226	3.116	3.124	3.244	3.458
Labor	1.520	1.453	1.467	1.526	1.529
Fuel	0.602	0.576	0.560	0.565	0.705
Chemicals	0.139	0.137	0.141	0.153	0.155
Electricity	0.512	0.509	0.512	0.545	0.595
Materials and supplies	0.453	0.441	0.444	0.455	0.475
Repairs and maintenance	2.109	2.024	2.087	2.223	2.213
Labor benefits	1.250	1.195	1.207	1.255	1.257
Marketing	2.273	2.221	2.249	2.317	2.415
Total variable cash expenses	9.540	9.209	9.332	9.739	10.062
Fixed cash expenses:					
Depreciation	0.981	0.941	0.972	0.975	0.940
Taxes and insurance	0.157	0.156	0.159	0.163	0.174
Interest	0.000	0.000	0.000	0.000	0.000
Total fixed cash expenses	1.138	1.097	1.130	1.138	1.114
General and administrative:					
Labor	0.436	0.417	0.421	0.438	0.439
Nonlabor	0.310	0.308	0.317	0.330	0.346
Total	0.746	0.725	0.738	0.768	0.785
Total processing costs	11.424	11.031	11.200	11.645	11.960
Credits:					
Molasses	0.614	0.537	0.628	0.502	0.454
Bagasse	0.000	0.000	0.000	0.000	0.000
Other	1.292	1.284	1.265	1.030	0.866
Total	1.906	1.821	1.893	1.532	1.320
Recovery per net ton of cane (lbs of raw sugar)	240.1	249.5	249.5	248.0	243.8

Source: Economic Research Service, USDA.

Appendix table 22. Cane sugar production and processing costs per pound of raw sugar, Hawaii, 1992-96

Item	1992	1993	1994	1995	1996
		(cents per pound of raw sugar)			
Production costs:					
Variable cash expenses	10.951	11.117	11.912	12.911	12.654
Fixed and other noncash expenses	3.796	4.020	4.554	4.891	4.855
Total production costs	14.748	15.137	16.467	17.801	17.509
Processing costs:					
Variable cash expenses	9.540	9.209	9.332	9.739	10.062
Fixed cash expenses	1.138	1.097	1.130	1.138	1.114
General and adm.expenses	0.746	0.725	0.738	0.768	0.785
Total processing costs	11.424	11.031	11.200	11.645	11.960
Credits:					
Molasses	0.614	0.537	0.628	0.502	0.454
Bagasse	0.000	0.000	0.000	0.000	0.000
Other	1.292	1.284	1.265	1.030	0.866
Total	1.906	1.821	1.893	1.532	1.320
Total processing costs less credits	9.518	9.210	9.307	10.113	10.639
Total production & processing costs	24.266	24.347	25.774	27.914	28.148
Total variable costs less credits	18.585	18.505	19.351	21.117	21.395

Source: Economic Research Service, USDA.

Appendix table 23. Sugarcane processing costs per pound of 96 degree raw sugar, Louisiana/Texas, 1992-96

Item	1992	1993	1994	1995	1996
	(cents per pound of raw sugar)				
Variable cash expenses:					
Cane transportation	1.147	1.060	1.189	1.254	1.246
Processing:	2.075	1.929	2.104	2.104	2.224
Labor	0.743	0.685	0.765	0.776	0.788
Fuel	0.334	0.307	0.321	0.318	0.393
Chemicals	0.161	0.151	0.167	0.178	0.179
Electricity	0.268	0.253	0.274	0.252	0.264
Materials and supplies	0.569	0.533	0.576	0.579	0.600
Repairs and maintenance	1.689	1.554	1.744	1.823	1.812
Labor benefits	0.540	0.498	0.556	0.565	0.573
Marketing	0.610	0.571	0.625	0.631	0.651
Total variable expenses	6.061	5.612	6.217	6.377	6.506
Fixed cash expenses:					
Depreciation	0.648	0.598	0.663	0.653	0.624
Taxes and insurance	0.296	0.276	0.312	0.313	0.324
Interest	0.117	0.095	0.152	0.180	0.166
Total fixed cash expenses	1.061	0.969	1.127	1.146	1.113
General and administrative:					
Labor	0.315	0.291	0.325	0.329	0.334
Nonlabor	0.432	0.412	0.457	0.466	0.484
Total	0.747	0.703	0.781	0.795	0.818
Total processing costs	7.869	7.284	8.126	8.319	8.438
Credits:					
Molasses	0.688	0.590	0.799	0.904	0.906
Bagasse	0.044	0.043	0.048	0.052	0.050
Other	0.000	0.000	0.000	0.000	0.000
Total	0.732	0.633	0.846	0.956	0.955
Recovery per net ton of cane (lbs of raw sugar)	217.4	235.2	218.9	221.8	219.9

Source: Economic Research Service, USDA.

Appendix table 24. Cane sugar production and processing costs per pound of raw sugar, Louisiana/Texas, 1992-96

Item	1992	1993	1994	1995	1996
	(cents per pound of raw sugar)				
Production costs:					
Variable cash expenses	6.658	6.387	7.764	6.725	6.927
Fixed and other noncash expenses	5.947	5.669	7.201	6.258	6.335
Total production costs	12.605	12.056	14.965	12.982	13.262
Processing costs:					
Variable cash expenses	6.061	5.612	6.217	6.377	6.506
Fixed cash expenses	1.061	0.969	1.127	1.146	1.113
General and adm. expenses	0.747	0.703	0.781	0.795	0.818
Total processing costs	7.869	7.284	8.126	8.319	8.438
Credits:					
Molasses	0.688	0.590	0.799	0.904	0.906
Bagasse	0.044	0.043	0.048	0.052	0.050
Other	0.000	0.000	0.000	0.000	0.000
Total	0.732	0.633	0.846	0.956	0.955
Total processing costs less credits	7.137	6.651	7.280	7.363	7.483
Total production & processing costs	19.742	18.707	22.244	20.345	20.745
Total variable costs less credits	11.987	11.366	13.135	12.146	12.478

Source: Economic Research Service, USDA.

Appendix table 25. Sugarcane estimated processing costs per pound of 96 degree raw sugar, Florida, 2003-05

Item	2003	2004	2005
	(cents per pound of raw sugar)		
Variable cash expenses:			
Cane transportation	1.215	1.334	1.522
Processing:	1.928	2.082	2.354
Labor	1.247	1.327	1.456
Fuel	0.131	0.150	0.197
Chemicals	0.077	0.084	0.096
Electricity	0.059	0.067	0.088
Materials and supplies	0.413	0.454	0.518
Repairs and maintenance	1.135	1.246	1.422
Labor benefits	0.578	0.659	0.743
Marketing	0.970	1.065	1.215
Total variable cash expenses	5.826	6.388	7.256
Fixed cash expenses:			
Depreciation	0.361	0.380	0.421
Taxes and insurance	0.116	0.127	0.145
Interest	0.202	0.222	0.253
Total fixed cash expenses	0.679	0.729	0.819
General and administrative:			
Labor	0.325	0.346	0.379
Nonlabor	0.659	0.724	0.826
Total	.0984	1.070	1.205
Total processing costs	7.490	8.187	9.280
Credits:			
Molasses	0.524	0.534	0.578
Bagasse	0.032	0.029	0.026
Other	0.043	0.043	0.043
Total	0.598	0.606	0.647
Recovery per net ton of cane (lbs of raw sugar)	261.6	252.0	233.0

Appendix table 26. Cane sugar estimated production and processing costs per pound of raw sugar, Florida, 2003-05

Item	2003	2004	2005
	(cents per pound of raw sugar)		
Production costs:			
Variable cash expenses	8.983	10.734	13.253
Fixed and other noncash expenses	4.457	5.312	6.523
Total production costs	13.440	16.046	19.776
Processing costs:			
Variable cash expenses	5.826	6.388	7.256
Fixed cash expenses	0.679	0.729	0.819
General and administrative expenses	0.984	1.070	1.205
Total processing costs	7.490	8.187	9.280
Credits:			
Molasses	0.524	0.534	0.578
Bagasse	0.032	0.029	0.026
Other	0.043	0.043	0.043
Total	0.598	0.606	0.647
Total processing costs less credits	6.891	7.581	8.633
Total production and processing costs	20.331	23.627	28.409
Total variable costs less credits	14.210	16.515	19.861

Appendix table 27. Sugarcane estimated processing costs per pound of 96 degree raw sugar, Hawaii, 2003-05

Item	2003	2004	2005
	(cents per pound of raw sugar)		
Variable cash expenses:			
Cane transportation	0.704	0.707	0.809
Processing:	3.959	3.983	4.756
Labor	1.807	1.758	1.937
Fuel	0.832	0.870	1.144
Chemicals	0.152	0.152	0.175
Electricity	0.702	0.734	0.965
Materials and supplies	0.466	0.468	0.536
Repairs and maintenance	2.168	2.178	2.494
Labor benefits	1.554	1.622	1.836
Marketing	2.366	2.377	2.722
Total variable cash expenses	10.751	10.868	12.617
Fixed cash expenses:			
Depreciation	0.899	0.865	0.961
Taxes and insurance	0.170	0.171	0.196
Interest	0.000	0.000	0.000
Total fixed cash expenses	1.069	1.036	1.157
General and administrative:			
Labor	0.519	0.505	0.556
Nonlabor	0.339	0.340	0.390
Total	0.857	0.845	0.946
Total processing costs	12.677	12.749	14.720
Credits:			
Molasses	0.486	0.462	0.501
Bagasse	0.000	0.000	0.000
Other	0.866	0.866	0.866
Total	1.352	1.328	1.367
Recovery per net ton of cane (lbs of raw sugar)	257.2	270.8	249.4

Appendix table 28. Cane sugar estimated production and processing costs per pound of raw sugar, Hawaii, 2003-05

Item	2003	2004	2005
	(cents per pound of raw sugar)		
Production costs:			
Variable cash expenses	12.169	13.418	15.428
Fixed and other noncash expenses	4.169	4.615	5.309
Total production costs	16.338	18.033	20.737
Processing costs:			
Variable cash expenses	10.751	10.868	12.617
Fixed cash expenses	1.069	1.036	1.157
General and adm.expenses	0.857	0.845	0.946
Total processing costs	12.677	12.749	14.720
Credits:			
Molasses	0.486	0.462	0.501
Bagasse	0.000	0.000	0.000
Other	0.866	0.866	0.866
Total	1.352	1.328	1.367
Total processing costs less credits	11.325	11.421	13.353
Total production & processing costs	27.663	29.454	34.090
Total variable costs less credits	21.567	22.958	26.678

Appendix table 29. Sugarcane estimated processing costs per pound of 96 degree raw sugar, Louisiana/Texas, 2003-05

Item	2003	2004	2005
	(cents per pound of raw sugar)		
Variable cash expenses:			
Cane transportation	1.225	1.346	1.266
Processing:	2.479	2.726	2.567
Labor	0.934	0.994	0.871
Fuel	0.466	0.532	0.556
Chemicals	0.176	0.194	0.176
Electricity	0.313	0.358	0.374
Materials and supplies	0.590	0.648	0.590
Repairs and maintenance	1.782	1.957	1.782
Labor benefits	0.711	0.811	0.730
Marketing	0.640	0.704	0.641
Total variable expenses	6.836	7.544	6.946
Fixed cash expenses:			
Depreciation	0.598	0.630	0.557
Taxes and insurance	0.318	0.350	0.319
Interest	0.163	0.179	0.163
Total fixed cash expenses	1.080	1.159	1.038
General and administrative:			
Labor	0.396	0.422	0.369
Nonlabor	0.476	0.523	0.476
Total	0.872	0.945	0.846
Total processing costs	8.788	9.647	8.830
Credits:			
Molasses	0.663	0.684	0.591
Bagasse	0.051	0.047	0.046
Other	0.000	0.000	0.000
Total	0.715	0.731	0.637
Recovery per net ton of cane (lbs of raw sugar)	231.2	222.6	257.8

Appendix table 30. Cane sugar estimated production and processing costs per pound of raw sugar, Louisiana/Texas, 2003-05

Item	2003	2004	2005
	(cents per pound of raw sugar)		
Production costs:			
Variable cash expenses	7.548	8.924	8.527
Fixed and other noncash expenses	6.419	7.513	6.956
Total production costs	13.967	16.437	15.483
Processing costs:			
Variable cash expenses	6.836	7.544	6.946
Fixed cash expenses	1.080	1.159	1.038
General and adm. expenses	0.872	0.945	0.846
Total processing costs	8.788	9.647	8.830
Credits:			
Molasses	0.663	0.684	0.591
Bagasse	0.051	0.047	0.046
Other	0.000	0.000	0.000
Total	0.715	0.731	0.637
Total processing costs less credits	8.074	8.916	8.193
Total production & processing costs	22.041	25.352	23.676
Total variable costs less credits	13.670	15.736	14.836

Appendix table 31. Sugar beet production cash costs, United States, 2003-04 with indexed values for 2005

Item	2003	2004	2005
	(dollars per planted acre)		
Cash expenses:			
Seed	46.46	50.13	53.30
Fertilizer	57.45	59.23	68.05
Chemicals	96.39	94.73	94.73
Custom operations	34.54	34.89	36.02
Fuel and lubrication	50.53	55.94	76.87
Repairs	47.38	48.25	49.81
Purchases irrigation water	5.06	5.39	5.76
Freight and dirt hauling charges	16.07	16.53	17.66
Miscellaneous	17.48	18.34	19.59
Hauling allowance (-)	7.29	7.46	7.97
Interest on operating capital	1.93	2.97	3.14
Total operating cash expenses	366.00	378.94	416.96
Allocated overhead expenses:			
Hired labor	63.53	66.63	68.29
Opportunity cost of unpaid labor	84.51	88.74	90.94
Capital recovery of machinery	154.50	155.79	164.45
Opportunity cost of land	123.68	124.94	130.15
Taxes and insurance	15.60	15.91	15.42
General farm overhead	35.92	36.68	39.18
Coop share	29.39	30.07	29.73
Total allocated overhead expenses	507.13	518.76	538.15
Total production expenses	873.13	897.70	955.11
Yield (net tons/planted acre)	22.20	22.00	22.30

Source: Economic Research Service, USDA

Appendix table 32. Sugar beet production cash costs, Great Lakes, 2003-04 with indexed values for 2005

Item	2003	2004	2005
		(dollars per planted acre)	
Cash expenses:			
Seed	42.77	46.02	48.93
Fertilizer	80.31	85.65	98.41
Chemicals	74.37	74.13	74.13
Custom operations	30.15	30.86	31.86
Fuel and lubrication	48.14	59.24	81.41
Repairs	56.90	59.99	61.93
Purchases irrigation water	0.00	0.00	0.00
Freight and dirt hauling charges	21.05	21.38	22.84
Miscellaneous	3.34	3.55	3.79
Hauling allowance (-)	0.00	0.00	0.00
Interest on operating capital	1.89	3.01	3.19
Total operating cash expenses	358.92	383.83	426.47
Allocated overhead expenses:			
Hired labor	32.32	31.19	31.96
Opportunity cost of unpaid labor	108.31	104.53	107.13
Capital recovery of machinery	173.35	177.75	187.63
Opportunity cost of land	129.81	131.62	137.10
Taxes and insurance	14.74	15.07	14.61
General farm overhead	29.23	29.88	31.92
Coop share	12.36	12.66	12.51
Total allocated overhead expenses	500.12	502.70	522.85
Total production expenses	859.04	886.53	949.33
Yield (net tons/planted acre)	19.00	20.80	21.40

Source: Economic Research Service, USDA

Appendix table 33. Sugar beet production cash costs, Red River Valley, 2003-04 with indexed values for 2005

Item	2003	2004	2005
		(dollars per planted acre)	
Cash expenses:			
Seed	48.02	51.67	54.94
Fertilizer	36.96	39.10	44.92
Chemicals	109.60	108.30	108.30
Custom operations	24.81	24.73	25.53
Fuel and lubrication	24.40	28.03	38.52
Repairs	38.59	38.93	40.19
Purchases irrigation water	0.06	0.07	0.07
Freight and dirt hauling charges	15.08	15.54	16.60
Miscellaneous	14.39	15.14	16.17
Hauling allowance (-)	10.45	10.45	11.16
Interest on operating capital	1.60	2.46	2.60
Total operating cash expenses	303.06	313.52	336.68
Allocated overhead expenses:			
Hired labor	58.44	61.89	63.43
Opportunity cost of unpaid labor	56.11	59.47	60.95
Capital recovery of machinery	128.54	129.67	136.87
Opportunity cost of land	86.26	87.47	91.11
Taxes and insurance	13.13	13.43	13.02
General farm overhead	29.58	30.24	32.30
Coop share	42.02	43.04	42.53
Total allocated overhead expenses	414.08	425.21	440.21
Total production expenses	717.14	738.73	776.90
Yield (net tons/planted acre)	20.30	19.80	18.80

Source: Economic Research Service, USDA

Appendix table 34. Sugar beet production cash costs, Great Plains, 2003-04 with indexed values for 2005

Item	2003	2004	2005
		(dollars per planted acre)	
Cash expenses:			
Seed	49.74	53.87	57.28
Fertilizer	76.31	78.10	89.73
Chemicals	78.19	77.77	77.77
Custom operations	37.84	40.62	41.93
Fuel and lubrication	50.32	59.59	81.89
Repairs	54.64	56.07	57.88
Purchases irrigation water	9.94	10.20	10.90
Freight and dirt hauling charges	14.81	15.11	16.14
Miscellaneous	19.79	20.51	21.91
Hauling allowance (-)	7.41	7.90	8.44
Interest on operating capital	2.04	3.19	3.38
Total operating cash expenses	386.21	407.13	450.36
Allocated overhead expenses:			
Hired labor	56.50	58.77	60.23
Opportunity cost of unpaid labor	160.43	167.05	171.20
Capital recovery of machinery	173.12	175.40	185.14
Opportunity cost of land	132.97	136.20	141.88
Taxes and insurance	16.90	17.10	16.57
General farm overhead	39.95	40.03	42.76
Coop share	11.75	12.03	11.89
Total allocated overhead expenses	591.62	606.58	629.67
Total production expenses	977.83	1013.71	1080.04
Yield (net tons/planted acre)	22.00	21.60	20.90

Source: Economic Research Service, USDA

Appendix table 35. Sugar beet production cash costs, Northwest, 2003-04 with indexed values for 2005

Item	2003	2004	2005
		(dollars per planted acre)	
Cash expenses:			
Seed	41.83	44.87	47.71
Fertilizer	90.39	88.15	101.28
Chemicals	86.88	81.45	81.45
Custom operations	49.84	49.40	50.99
Fuel and lubrication	131.19	133.17	183.01
Repairs	66.16	67.19	69.36
Purchases irrigation water	17.05	18.34	19.59
Freight and dirt hauling charges	15.43	16.51	17.64
Miscellaneous	30.74	32.18	34.37
Hauling allowance (-)	1.31	1.29	1.38
Interest on operating capital	2.80	4.19	4.43
Total operating cash expenses	531.00	534.16	608.45
Allocated overhead expenses:			
Hired labor	102.65	109.22	111.93
Opportunity cost of unpaid labor	93.42	100.82	103.32
Capital recovery of machinery	220.36	220.63	232.89
Opportunity cost of land	215.02	217.01	226.05
Taxes and insurance	21.96	22.49	21.80
General farm overhead	47.16	48.51	51.82
Coop share	19.04	19.33	19.19
Total allocated overhead expenses	719.61	738.01	767.00
Total production expenses	1250.61	1272.17	1375.45
Yield (net tons/planted acre)	29.30	28.50	28.60

Source: Economic Research Service, USDA

Appendix table 36. Sugar beet processing costs, United States, 1997-98 with projections for 2003-05

Item	1997	1998	2003	2004	2005
	(cents per pound of refined sugar)				
Variable cash expenses:					
Beet acquisition	1.198	1.177	1.312	1.162	1.157
Processing:					
Labor	1.140	1.177	1.350	1.374	1.333
Fuel	1.273	1.144	1.552	1.698	1.966
Chemicals	0.247	0.257	0.261	0.274	0.277
Electricity	0.211	0.227	0.308	0.337	0.390
Materials and supplies	0.334	0.350	0.356	0.374	0.377
Repairs and maintenance	1.049	1.081	1.098	1.154	1.164
Labor benefits	0.737	0.764	0.956	1.044	1.041
Marketing	3.117	3.169	3.221	3.385	3.414
Total variable cash expenses	9.305	9.346	10.415	10.802	11.119
Fixed expenses:					
Depreciation	0.552	0.527	0.523	0.527	0.516
Taxes and insurance	0.120	0.120	0.122	0.128	0.129
Interest	0.412	0.390	0.397	0.417	0.421
Total fixed cash expenses	1.084	1.037	1.042	1.072	1.066
General and administrative:					
Labor	0.211	0.220	0.252	0.257	0.249
Nonlabor	0.279	0.277	0.281	0.296	0.298
Total general and administrative	0.490	0.497	0.534	0.553	0.548
Pulp drying and marketing	1.182	1.147	1.166	1.226	1.236
Total processing costs	12.062	12.028	13.157	13.653	13.969
Credits:					
Dried pulp	1.929	1.978	1.973	1.977	1.833
Molasses	0.487	0.404	0.395	0.393	0.376
Other	0.153	0.160	0.156	0.156	0.156
Total credits	2.568	2.542	2.524	2.526	2.366
Recovery rate per net ton of beets (lbs)	308.0	299.8	306.0	308.0	322.0

Source: 1997-98 data from Economic Research Service, USDA

Appendix table 37. Sugar beet processing costs, Eastern Region, 1997-98 with projections for 2003-05

Item	1997	1998	2003	2004	2005
	(cents per pound of refined sugar)				
Variable cash expenses:					
Beet acquisition	1.036	1.014	1.139	1.009	1.044
Processing:					
Labor	1.101	1.118	1.294	1.316	1.278
Fuel	1.308	1.158	1.584	1.733	2.006
Chemicals	0.272	0.275	0.282	0.296	0.299
Electricity	0.327	0.327	0.448	0.490	0.567
Materials and supplies	0.460	0.461	0.473	0.497	0.501
Repairs and maintenance	1.276	1.269	1.301	1.367	1.379
Labor benefits	0.748	0.759	0.958	1.046	1.043
Marketing	3.028	3.031	3.108	3.266	3.295
Total variable cash expenses	9.556	9.411	10.586	11.020	11.371
Fixed expenses:					
Depreciation	0.748	0.680	0.681	0.686	0.672
Taxes and insurance	0.133	0.131	0.134	0.141	0.142
Interest	0.311	0.294	0.302	0.317	0.320
Total fixed cash expenses	1.192	1.105	1.117	1.144	1.134
General and administrative:					
Labor	0.217	0.222	0.257	0.262	0.254
Nonlabor	0.155	0.157	0.161	0.169	0.171
Total general and administrative	0.372	0.379	0.418	0.431	0.425
Pulp drying and marketing	1.143	1.089	1.117	1.173	1.184
Total processing costs	12.264	11.985	13.238	13.769	14.113
Credits:					
Dried pulp	2.082	2.086	2.099	2.103	1.951
Molasses	0.528	0.425	0.420	0.417	0.399
Other	0.165	0.167	0.166	0.166	0.166
Total credits	2.775	2.678	2.685	2.687	2.516
Recovery rate per net ton of beets (lbs)	308.8	305.8	309.4	311.4	325.6

Source: 1997-98 data from Economic Research Service, USDA

Appendix table 38. Sugar beet processing costs, Western Region, 1997-98 with projections for 2003-05

Item	1997	1998	2003	2004	2005
			(cents per pound of refined sugar)		
Variable cash expenses:					
Beet acquisition	1.380	1.396	1.541	1.365	1.358
Processing:					
Labor	1.182	1.253	1.423	1.449	1.406
Fuel	1.227	1.123	1.510	1.652	1.913
Chemicals	0.218	0.228	0.230	0.241	0.244
Electricity	0.081	0.085	0.114	0.125	0.145
Materials and supplies	0.189	0.197	0.199	0.209	0.211
Repairs and maintenance	0.788	0.817	0.823	0.865	0.872
Labor benefits	0.723	0.766	0.950	1.038	1.034
Marketing4	3.216	3.339	3.364	3.535	3.566
Total variable cash expenses	9.004	9.204	10.154	10.478	10.748
Fixed expenses:					
Depreciation	0.329	0.310	0.305	0.307	0.301
Taxes and insurance	0.101	0.106	0.106	0.112	0.113
Interest	0.527	0.517	0.521	0.548	0.552
Total fixed cash expenses	0.957	0.933	0.932	0.966	0.966
General and administrative:					
Labor	0.202	0.214	0.244	0.248	0.241
Nonlabor	0.420	0.439	0.442	0.465	0.469
Total general and administrative	0.622	0.654	0.686	0.713	0.710
Pulp drying and marketing	1.224	1.222	1.231	1.294	1.305
Total processing costs	11.807	12.012	13.004	13.451	13.728
Credits:					
Dried pulp	1.748	1.814	1.793	1.797	1.667
Molasses	0.443	0.368	0.357	0.355	0.339
Other	0.140	0.146	0.143	0.143	0.143
Total credits	2.331	2.328	2.293	2.295	2.149
Recovery rate per net ton of beets (lbs)	307.2	293.8	302.6	304.6	318.4

Source: 1997-98 data from Economic Research Service, USDA

Appendix table 39. Beet sugar production and processing costs per pound of refined sugar, United States, 2003-2005

Item	2003	2004	2005
	(cents per pound of refined sugar)		
Production costs:			
Variable cash expenses	5.388	5.592	5.807
Fixed and other noncash expenses	7.465	7.656	7.495
Total production costs	12.853	13.248	13.301
Processing costs:			
Variable cash expenses	10.415	10.802	11.119
Fixed cash expenses	1.042	1.072	1.066
General and adm. Expenses	0.534	0.553	0.548
Pulp drying and marketing	1.166	1.226	1.236
Total processing costs	13.157	13.653	13.969
Credits:			
Dried pulp	1.973	1.977	1.833
Molasses	0.395	0.393	0.376
Other	0.156	0.156	0.156
Total	2.524	2.526	2.366
Total processing costs less credits	10.633	11.127	11.603
Total production & processing costs	23.486	24.375	24.905
Total variable costs less credits	13.278	13.869	14.560

Appendix table 40. Beet sugar production and processing costs per pound of refined sugar, Great Lakes and Red River Valley, 2003-2005

	Great Lakes			Red River Valley		
Item	2003	2004	2005	2003	2004	2005
	(cents per pound of refined sugar)					
Production costs:						
Variable cash expenses	6.105	5.925	6.121	4.825	5.084	5.500
Fixed and other noncash expenses	8.507	7.760	7.504	6.592	6.895	7.191
Total production costs	14.612	13.685	13.624	11.417	11.979	12.692
Processing costs:						
Variable cash expenses	10.586	11.020	11.371	10.586	11.020	11.371
Fixed cash expenses	1.117	1.144	1.134	1.117	1.144	1.134
General and adm. Expenses	0.418	0.431	0.425	0.418	0.431	0.425
Pulp drying and marketing	1.117	1.173	1.184	1.117	1.173	1.184
Total processing costs	13.238	13.769	14.113	13.238	13.769	14.113
Credits:						
Dried pulp	2.099	2.103	1.951	2.099	2.103	1.951
Molasses	0.420	0.417	0.399	0.420	0.417	0.399
Other	0.166	0.166	0.166	0.166	0.166	0.166
Total	2.685	2.687	2.516	2.685	2.687	2.516
Total processing costs less credits	10.553	11.082	11.597	10.553	11.082	11.597
Total production & processing costs	25.165	24.767	25.222	21.971	23.062	24.289
Total variable costs less credits	14.007	14.259	14.976	12.726	13.418	14.356

Appendix table 41. Beet sugar production and processing costs per pound of refined sugar, Great Plains and Northwest, 2003-2005

Item	Great Plains 2003	2004	2005	Northwest 2003	2004	2005
	(cents per pound of refined sugar)					
Production costs:						
Variable cash expenses	5.802	6.189	6.768	5.990	6.154	6.682
Fixed and other noncash expenses	8.888	9.221	9.462	8.117	8.503	8.423
Total production costs	14.689	15.410	16.230	14.106	14.657	15.105
Processing costs:						
Variable cash expenses	10.154	10.478	10.748	10.154	10.478	10.748
Fixed cash expenses	0.932	0.966	0.966	0.932	0.966	0.966
General and adm. Expenses	0.686	0.713	0.710	0.686	0.713	0.710
Pulp drying and marketing	1.231	1.294	1.305	1.231	1.294	1.305
Total processing costs	13.004	13.451	13.728	13.004	13.451	13.728
Credits:						
Dried pulp	1.793	1.797	1.667	1.793	1.797	1.667
Molasses	0.357	0.355	0.339	0.357	0.355	0.339
Other	0.143	0.143	0.143	0.143	0.143	0.143
Total	2.293	2.295	2.149	2.293	2.295	2.149
Total processing costs less credits	10.711	11.156	11.579	10.711	11.156	11.579
Total production & processing costs	25.400	26.566	27.810	24.817	25.813	26.684
Total variable costs less credits	13.663	14.372	15.367	13.851	14.337	15.281