FEEDING THE FUTURE:

THE ROLE OF THE U.S. ETHANOL INDUSTRY IN FOOD AND FEED PRODUCTION

SEPTEMBER 2008

RENEWABLE FUELS ASSOCIATION
ONE MASSACHUSETTS AVENUE, NW
WASHINGTON, D.C. 20001
202.289.3835
www.ethanolRFA.org

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Renewable Fuels Association

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The rapid expansion of the U.S. ethanol industry—and the corresponding increase in the amount of grain processed into ethanol—has been well documented and scrutinized in recent years. But what is often overlooked is the simultaneous increase in the amount of animal feed produced by the U.S. ethanol industry. One-third of every bushel of grain that enters the ethanol process is enhanced and returned to the animal feed market, most often in the form of distillers grains, corn gluten feed and corn gluten meal. The remaining two-thirds of the bushel are processed into fuel ethanol and carbon dioxide.

Public discussions and media reports about the grain ethanol industry usually fail to fully appreciate the scale and contribution of today's ethanol feed co-product output. In the past decade, the ethanol industry has quietly quintupled the volume of feed it produces on an annual basis. In the 2007/08 marketing year[1], the U.S. ethanol industry generated approximately 23 million tons of high-quality feed for beef cattle, dairy cows, swine and poultry, making the renewable fuels sector one of the larger feed processing segments in the United States. Grain ethanol co-products, including distillers grains, corn gluten feed and corn gluten meal, are expected to approach 30 million metric tons in 2008/09.

To put these production volumes in context, consider that the amount of feed produced by the ethanol industry in 2007/08 is roughly equivalent to the combined annual amount of total feed consumed by cattle on feed in Texas, Kansas, Nebraska, and Colorado—the nation's four largest feedlot states.[2] Looked at another way, the total combined amount of sorghum, barley, oats, and feed wheat consumed by U.S. livestock and poultry in 2007/08 was 9.2 million metric tons or less than half of ethanol feed co-product output.[3]

Ethanol feed co-product output in 2007/08 was equivalent to 15 percent of U.S. total feed use of corn, effectively reducing the demand for whole corn usage by the livestock and poultry industries. The return of co-products to the feed market has agricultural land use implications as well (i.e. at least one-third of every acre "dedicated" to ethanol production should actually be characterized as producing feed).

Feed co-products represent an increasingly important share of profit opportunities for ethanol producers. The estimated market value of feed co-products from ethanol production in 2007/08 was $3 billion.[4] An estimated additional $1.7 billion was realized through sales of corn oil, a high value co-product of the wet mill ethanol process. In recent years, ethanol co-product feeds have typically been priced at a discount to the feed ingredients they replace, meaning livestock and poultry feeders often take advantage of the value of these products in least-cost ration formulations.

Without a doubt, co-products from grain ethanol production are an increasingly important and valuable component of the biofuels sector and the global feed market. Not only is the U.S. ethanol industry well positioned to provide increasing amounts of renewable fuels in the years ahead, but the sector is also poised to help satisfy growing world demand for food and feed.

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[1] September 1, 2007 through August 31, 2008.

[2] Assumes annual consumption of 3.5 short tons of total feed/head. Cattle on feed in TX, KS, NE, CO totaled 7.3 million as of Aug. 1, 2008.

[3] USDA Feed Outlook. September 16, 2008.

[4] Assumes 07/08 average values per metric ton of $147 for DDG and DDGS, $120 for CGF, $521 for CGM (USDA Feed Grains Database); and $50/metric ton for WDGS.

WHAT TYPES OF FEED DOES THE U.S. ETHANOL INDUSTRY PRODUCE?

Two processes are primarily used to make ethanol in the United States: **dry milling** and **wet milling**. In the **dry milling** process, the entire corn kernel or other starchy grain is ground into flour (or "meal") and processed without separation of the various nutritional component parts of the grain. The meal is slurried with water to form a "mash." Enzymes are added to the mash, which is then processed in a high-temperature cooker, cooled and transferred to fermenters where yeast is added and the conversion of sugar to ethanol begins.

After fermentation, the resulting "beer" is transferred to distillation columns where the ethanol is separated from the remaining "stillage." The stillage is sent through a centrifuge that separates the coarse grain from the solubles. The solubles are then concentrated to about 30 percent solids by evaporation, resulting in **condensed distillers solubles (CDS)** or "syrup." CDS is sometimes sold into the feed market, but more often the residual coarse grain and the CDS are mixed together and dried to produce **distillers dried grains with solubles (DDGS)**. In some cases, the syrup is not reapplied to the residual grains; this product is simply called **distillers dried grains (DDG)**. If the distillers grains are being fed to livestock in close proximity to the ethanol plant, the drying step is avoided and the product is called **wet distillers grains with solubles (WDGS)**. Because of various drying and syrup applications practices, there are several variants of distillers grains (one of which is called **modified wet distillers grains**), but most product is sold as DDGS, DDG, or WDGS.

New and emerging technologies (which are discussed later) allow dry mills the potential to also produce corn germ, corn oil, high-protein DDGS and other value-added products. More than 80 percent of today's ethanol capacity utilizes the dry mill process.

In the **wet milling** process, the grain is soaked or "steeped" in water to facilitate the separation of the grain into its basic nutritional components. After steeping, the corn slurry is processed through a series of grinders to separate the corn germ. **Corn oil** from the germ is either extracted on-site or sold to crushers who extract the corn oil. The remaining fiber, gluten and starch components are further segregated. The steeping liquor is concentrated in an evaporator. This concentrated product, **heavy steep water**, is co-dried with the fiber component and is then sold as **corn gluten feed (CGF)**. Heavy steep water is sometimes sold by itself as a feed ingredient. The gluten component is filtered and dried to produce the **corn gluten meal (CGM)**, a high-protein product used primarily as a feed ingredient in poultry operations. The starch and any remaining water from the mash can then be processed in one of three ways: fermented into ethanol, dried and sold as dried or modified corn starch, or processed into corn syrup. The wet mill fermentation process for ethanol is very similar to the dry mill process described above. Figure 1 shows the wide range of possible feed co-products coming from the ethanol industry.

FIGURE 1. Feed and Food Co-Products from the U.S. Grain Ethanol Industry

Dry Mill Process	Wet Mill Process
Distillers Dried Grains with Solubles (DDGS)	Corn Gluten Feed (CGF)
Distillers Dried Grains (DDG)	Corn Gluten Meal (CGM)
Wet Distillers Grains with Solubles (WDGS)	Heavy Steep Water
Condensed Distillers Solubles (CDS)	Corn Germ Meal
Modified Wet Distillers Grains (MWDG)	Crude Corn Oil
High-Protein (de-germed or de-oiled) DDGS	
Corn Germ Meal	
Crude Corn Oil	

Both the wet and dry mill processes utilize only the starch portion of the corn kernel for ethanol production. The remaining protein, fat, fiber and other nutritional components remain available for use as animal feed. In distillers grains, these remaining nutritional components from the corn kernel are essentially concentrated by a factor of three, meaning typical distillers grains have at least three times as much protein and fat as an equivalent amount of corn. Figure 2 compares the nutritional profile of field corn to the three primary ethanol feed co-products.

FIGURE 2. PROXIMATE NUTRITIONAL ANALYSIS OF NO. 2 YELLOW CORN, DDGS, CGF, CGM

	% Dry Matter	% Protein	% Fat	% Fiber
Corn, Yellow No. 2	85.5	8.3	3.9	1.9
Corn Distillers Dried Grains w/ Solubles	89.3	30.8	11.1	7.4
Corn Gluten Feed	88.0	21.0	2.0	10.0
Corn Gluten Meal, 60%	90.0	60.0	2.0	2.5

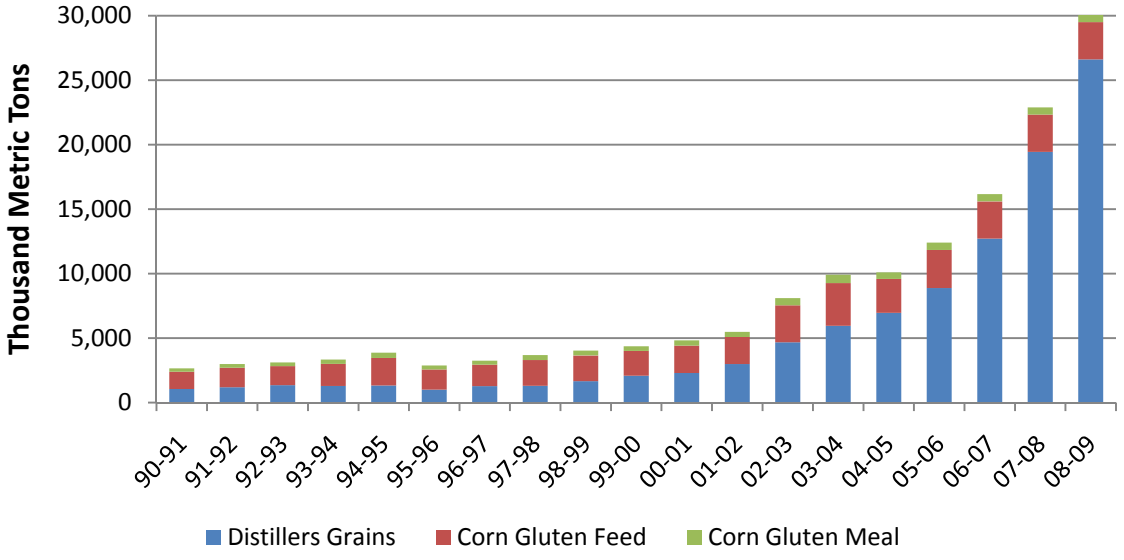
Sources: NRC 1998, White & Johnson (Corn); University of Minnesota (CDDGS); Feedstuffs Reference Issue (CGF and CGM)

HOW MUCH FEED DOES THE U.S. ETHANOL INDUSTRY PRODUCE?

Each 56-pound bushel of corn processed by a dry mill results in the production of approximately 17 pounds of distillers grains and 2.8 gallons of fuel ethanol. Approximately 2.5 billion bushels of corn were processed by dry mills in 2007/08, meaning nearly 19.3 million metric tons of distillers grains were produced. This marks a ten-fold increase in distillers grains production in the last decade.

Wet mill ethanol plants processed about 500 million bushels of corn in 2007/08. Approximately 13 pounds of corn gluten feed and 2.5 pounds of corn gluten meal are produced per bushel of corn processed by a wet mill, meaning the industry produced an estimated 2.9 million metric tons of gluten feed and 600,000 metric tons of gluten meal in 2007/08. Corn gluten feed and meal production has remained relatively constant in the last decade, as the majority of growth in ethanol production has come from dry mills. Figure 3 shows historical distillers grains, corn gluten feed and gluten meal production. In 2007/08, wet mills also produced about 2.6 billion lbs. of corn oil.

FIGURE 3. PRODUCTION OF MAJOR U.S. ETHANOL FEED CO-PRODUCTS



Note: 08-09 is projected based on expected corn use for ethanol

HOW ARE U.S. ETHANOL FEED CO-PRODUCTS USED?

Historically, most of the feed co-products generated by the ethanol industry have been fed to beef cattle and dairy cows. However, in recent years the amount of feed co-products fed to swine and poultry has increased.

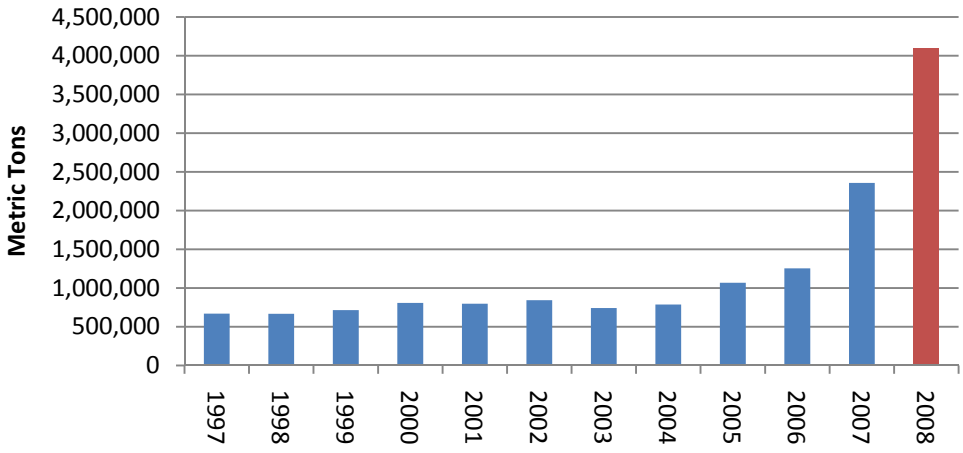
CHS, Inc., a major marketer of feed co-products, estimates the ruminant animal segment (beef and dairy) consumed about 84 percent of distillers grains in 2007, while swine consumed 11 percent and poultry 5 percent.[5] Though poultry and swine still represent a much smaller share of consumption than beef and dairy, usage among these species is increasing. Distillers grains typically replace corn and/or soybean meal in livestock and poultry rations, providing some measure of price relief on the replaced products and allowing the displaced feeds to be used for other applications.

Research indicates distillers grains can account for 40 percent of the daily feed ration for beef cattle, 20 to 25 percent for dairy cows, 20 percent for swine, and 15 percent for poultry.[6] Research is under way at public and private institutions to increase these inclusion levels.

Corn gluten feed is primarily fed to dairy and beef cattle, while corn gluten meal is used to feed a wide variety of species, including poultry and fish. Corn gluten meal, which features a very high concentration of high-quality protein, is often used as an ingredient in pet food as well.

Historically, only small volumes of U.S. distillers grains were exported. But in recent years, distillers grains exports have boomed, reflecting the surge in global demand for energy and protein feeds. Distillers grains exports nearly doubled from 2006 to 2007 and are poised to nearly double again from 2007 to 2008. Figure 4 shows historical distillers grains exports.

FIGURE 4. U.S. DISTILLERS GRAINS EXPORTS



Source: USDA Foreign Agricultural Service (1997-2007); 2008 is projected based on YTD exports

Increases in the amount of distillers grains exports are likely to help offset any marginal decreases in corn exports that may occur because of increased domestic usage in the years ahead. For instance, distillers grains exports in 2007/08 were equivalent to about 100 million bushels of corn and are

[5] RFA. *Changing the Climate: Ethanol Industry Outlook 2008*

[6] See http://www.ddgs.umn.edu/feeding.htm for feed recommendations by species.

expected to be equivalent to approximately 160 million bushels in 2008/09, equal to 8 percent of projected whole corn exports for the marketing year.

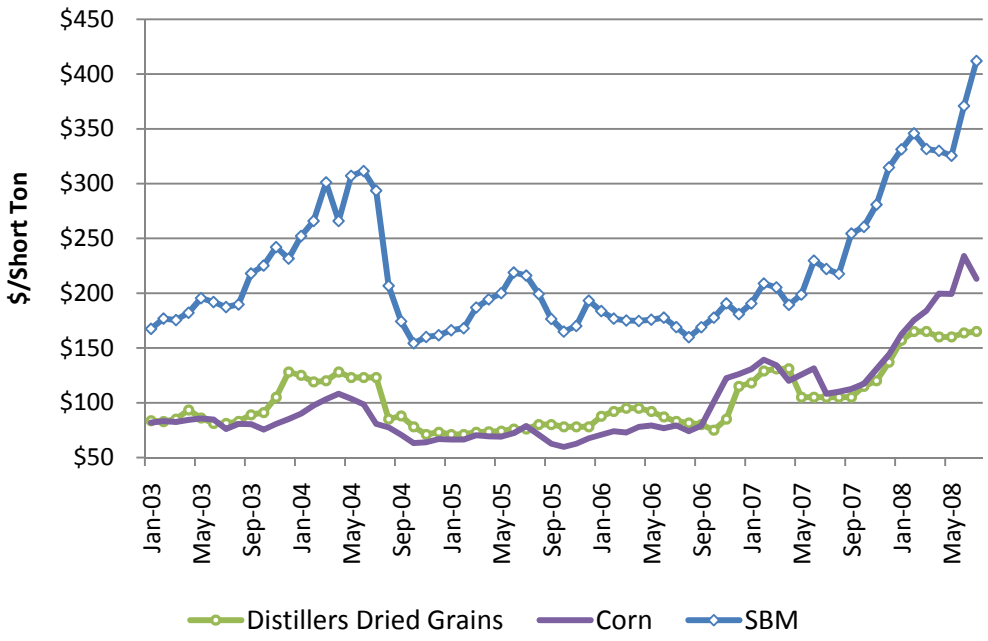
HOW ARE ETHANOL FEED CO-PRODUCTS PRICED RELATIVE TO OTHER FEEDS?

In the past, distillers grains have been priced at a slight premium to corn, but in recent years this trend has changed. Data from USDA indicates that the price of a short ton of DDG in the reference market of Lawrenceburg, Indiana, averaged 115 percent the price of a short ton of corn from January 2003 to December 2005. But in the fall of 2006, as corn prices escalated and more distillers grains became available, the historical price relationship between corn and DDG was inverted and distillers grains have since sold at a considerable discount to corn. Since September 2006, the price of DDG has averaged approximately 90 percent the price of corn, but the price spread between DDG and corn has widened substantially since January 2008. DDG is currently priced at about 75 percent of corn in many markets.

This relative price difference makes distillers grains a good value for livestock and poultry feeders using the co-product as an energy feed. Distillers grains are also a good buy for feeders who use the product primarily to meet protein needs. A ton of DDGS contains approximately 600 pounds of protein, while a ton of high-protein soybean meal contains 960 pounds of protein. Thus, using July 2008 prices, the price per unit of protein was $0.28 per pound in a ton of distillers grains and $0.43 per pound in a ton of soybean meal. Historical prices for corn, DDG, and soybean meal are shown in Figure 5.

Additionally, because of its unique nutritional profile, distillers grains are quite complementary to low-cost feed ingredients like soybean hulls and corn stalks. This allows beef and dairy producers the opportunity to significantly reduce feed costs.

FIGURE 5. CORN, DDG, SOYBEAN MEAL PRICES



Source: USDA. DDG (Lawrenceburg, IN); Corn (Cent. Illinois); SBM (Illinois points)

WHAT IS THE NET IMPACT OF ETHANOL FEED CO-PRODUCTS ON GRAIN MARKETS?

Discussions about the amount of corn used for ethanol often fail to account for the fact 17 pounds of every 56-pound bushel processed return to the animal feed market. Thus, the amount of corn used for ethanol should be looked at in the context of "net usage." The substitution effect of distillers grains allows the displaced corn to be used for other applications, such as exports or ethanol.

The USDA estimates 4.1 billion bushels of corn will be used for ethanol production in 2008/09.[7] However, when the production of distillers grains, corn gluten feed and corn gluten meal are considered, the net usage of corn will be closer to 2.9 billion bushels. This would equate to 22.9 percent of total projected U.S. corn use. Discussions about the ethanol industry's use of the U.S. corn supply often fail to distinguish between "gross" and "net" usage.

Recently, there has been much debate about the land impacts of expanding biofuels production. The debate over agricultural land use often neglects the fact that only two-thirds of every acre of grain "dedicated" to ethanol production is actually used for biofuel production. The remaining one-third of the acre is more accurately characterized as producing livestock feed.

Depending on what assumptions are used about the amount of feed displaced by distillers grains, the land use impact of corn ethanol may be even less than the one-third/two-thirds split. For instance, based on research from the University of Nebraska and other sources, the U.S. Department of Energy's Argonne National Laboratory recently updated its corn ethanol lifecycle assessment assumptions to account for the fact that one unit of distillers grains displaces more than one unit of conventional feed in the average ration. According to Argonne, in average aggregated rations for beef, dairy, and swine, one kilogram of distillers grains displaces .96 kilograms of corn, .29 kilograms of soybean meal, and .03 kilograms of urea.[8]

Another way to examine the land use impacts of ethanol feed co-products is to consider the following example. One acre of corn with a yield of 170 bushels will produce about 810 pounds of protein. One acre of soybeans with a yield of 45 bushels produces about 900 pounds of protein. Since ethanol production utilizes only the starch in the corn kernel, it can be said that one acre of corn produces about 475 gallons of ethanol *and* nearly as much protein as one acre of soybeans. As noted, the protein from that acre of corn remains in the animal feed chain in the form of distillers grains.

WHAT DOES THE FUTURE HOLD FOR ETHANOL FEED CO-PRODUCTS?

Continued expansion of the grain ethanol industry means feed co-product output will continue to grow substantially. Further, a number of new and emerging technologies promise to amplify the ethanol industry's role in producing high-quality feed co-products.

In an attempt to extract more value from the corn kernel, a number of dry mills are installing technology that allows them to separate crude corn oil from the stillage on the back end of the process. This crude corn oil can be sold into the feed market (particularly for poultry), further refined and sold into the human food market, or used as a feedstock for biodiesel. When used as a biodiesel feedstock, corn oil displaces higher value vegetable oils that are typically used in food applications. The feed co-products

[7] USDA. World Agriculture Supply and Demand Estimates. September 12, 2008. **NOTE**: RFA projections suggest USDA is likely overestimating the amount of corn that will be used for ethanol in 2008/09. Gross corn use for ethanol is likely to be closer to 3.8 billion bushels.

[8] Arora et al. *Update of Distillers Grains Displacement Ratios for Corn Ethanol Life-Cycle Analysis*. September 2008.

resulting from oil separation practices typically have lower fat and higher protein content than conventional distillers grains. This form of distillers grains is often called high-protein DDGS.

Dry fractionation is another technology that is emerging in the dry mill ethanol industry. Essentially, this practice allows dry mill ethanol producers to separate the corn germ and other components from the starch on the front end of the ethanol process. The germ can then be processed and sold as feed or as feedstock for further processing for other uses. This separation allows ethanol producers more flexibility in feed manufacturing and potentially provides customers with products that are more tailored to their specific nutritional needs.

Additionally, a number of new and emerging ethanol processing aids are likely to improve the nutritional quality and utility of ethanol co-products. For instance, technologies are under development to reduce the presence of certain minerals in distillers grains, while other processes are being designed to improve the availability of amino acids in the feed. Ultimately, the success of these new technologies will depend on the demands of the ethanol industry's customers in the animal feed market.

Animal scientists and nutritionists continue to study the feeding of ethanol feed co-products to animals. Though beef, dairy, swine and poultry have been the primary consumers of these co-products historically, an increasing amount of research is being conducted that examines the effects of feeding co-products to other species, such as goats, sheep, and fish. The use of ethanol co-products in human food applications is another area of increasing scientific interest.

As innovation in feed co-product technology grows, so too will the volume of co-products available. The 15 billion gallon allotment for corn starch-based ethanol in the Renewable Fuels Standard implies distillers grains production of roughly 36 million metric tons—enough to displace approximately 1.5 billion bushels of corn from feed rations.

While new technologies and practices promise to change the complexion of the ethanol co-products market in the years ahead, one certainty exists about the future of feed co-products: the ethanol industry will continue to take very seriously its role as a producer of safe, quality feed. Not only are U.S. ethanol producers helping to meet future demands for energy, but they are also helping the agriculture industry meet the increasing food and feed needs of a growing world.