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Sourcing Corn for Ethanol: Effects of Increased Local Processing

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Sourcing corn for ethanol: Effects of increased local processing

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Background

Rapid growth of ethanol production continues to generate many questions related to future analysis, shifts in existing businesses and policy development. In Iowa, new dry-grind ethanol processing plant construction is announced frequently, financed by either local or remote investor groups. New dry-grind ethanol plants are also being added to existing wet milling operations. As these markets develop, there will be innovation in contracts, price discovery and market information. There will also be changes to supplier interaction and service aspects as well. One of the growing concerns is the balance of corn supplies between new ethanol demand and existing feed/export demand. The logistics of more or less uniform constant use over the year are also a departure from the shipping-based export chain. Access to approximately one billion bushels of “mobile storage” in trains, barges, export elevators and river elevators is essentially cut off by the need to retain effectively the entire crop within the state, most often very near where it was produced. Processing uses require sufficient local storage to provide a steady flow through the year.

Distillers grains, co-products of dry-grind ethanol production, are rapidly increasing, putting strain on marketing infrastructure and transportation. Depending on the size of local markets for wet distillers grains, plant managers decide how much of the distillers grains to dry, an important decision in terms of operating costs. Expansion of dairy and beef production is encouraged to use a large portion of distillers grains, and inclusion of distillers dried grains (DDG) in swine, poultry feed, pet food and human foods is being studied. As production of DDG increases to rival soybean meal production, shifts in prices and substitutions will occur.

Objectives

The purpose of this study was to create an objective data set describing Iowa’s ethanol processing plants that could be updated as new plants begin production. Processing and storage capacity, corn quality and consumption, and distribution of distillers grains were the main points of interest, but interview data also included plant managers’ opinions about future industry needs in market development, transportation and logistics, and worker training.

Procedure

A survey was conducted through direct interviews with ethanol plant managers to describe how existing plants source and market co-products. Interviews were conducted in late spring and summer 2006 with representatives for 20 ethanol plants within a 200-mile radius of
Ames. Interview data, industry data, and mass balance calculations were used to estimate corn consumption and production amounts for the plants that were not interviewed and for the plants currently being planned or under construction.

Results

Ethanol production and corn consumption (Table 1.)

As of June 2006, 21 dry mill plants and four wet mill plants were producing ethanol in Iowa. Two dry mill plants have or will begin production late in 2006 or early 2007. These plants together are expected to produce nearly 1.5 billion gallons of ethanol, roughly equaling Iowa’s total consumption of gasoline, 1.6 billion gallons. (Norton, 2006). The 23 dry grind plants are expected to use between 506 and 516 million bushels of corn in 2006-2007, the range reflecting the difference between stated production capacity and actual production capacity. Most plants produce at 105% - 110% of rated capacity, according to interview data.

Table 1. Production statistics summary (Iowa ethanol plants)

<table>
<thead>
<tr>
<th>Summary Statistics</th>
<th>n</th>
<th>Ethanol Produced mil gal/yr</th>
<th>Corn Used mil bu/yr</th>
<th>DGS 000 tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Dry-grind Plants</td>
<td>23</td>
<td>1453.0</td>
<td>516.1</td>
<td>4386.6</td>
</tr>
<tr>
<td>Planned Plants, Expansions</td>
<td>48</td>
<td>4311.0</td>
<td>1539.6</td>
<td>13087.0</td>
</tr>
<tr>
<td>Wet Mills</td>
<td>7</td>
<td>1210.0</td>
<td>432.1</td>
<td>3673.2</td>
</tr>
<tr>
<td>Nearby, Iowa Draw*</td>
<td>6</td>
<td>402.0</td>
<td>143.6</td>
<td>1220.4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7376.0</td>
<td>2631.4</td>
<td>25872.1</td>
</tr>
</tbody>
</table>

* Plants in bordering counties of other states with 50% use assigned to Iowa corn.

Plans for 42 new dry-grind plants and six plant expansions have been announced, with expected completion by the end of 2010. This additional capacity will add 4.3 billion gallons of ethanol and use at least 1.5 million bushels of corn. Iowa’s six wet mill plants have added capacity for fuel ethanol production and one new wet mill plant is planned for north-central Iowa. In total, wet mill ethanol production will add 1.2 billion gallons of ethanol production and will use 432 million bushels of corn. Dry grind plants in neighboring states currently draw some of their corn from Iowa farms, estimated at 143 million bushels. In total, fuel ethanol production of 7.3 billion gallons per year in and around Iowa will consume 2.6 billion bushels of corn by 2010. National Agricultural Statistics Service estimates Iowa’s 2006 corn crop at 2.1 billion bushels.

Corn origination practices and storage capacity

Among the 20 ethanol plants interviewed, there is wide variation in how much corn is sold directly to the plant. Corn storage capacity also varies among plants. On average, 62 percent of the corn is purchased directly from farmers. Four ethanol plants own or are partially owned by grain handling companies; in these situations, the ethanol plant acquires 60-95 percent of its corn from local elevators, though each plant maintains storage for at least two days of processing
at the plant. Sixteen of the plants purchase more than 50 percent of the corn directly from farmers. One northwest Iowa plant purchases 100 percent of its corn directly from farmers.

Table 2. Characteristics of dry grind ethanol plants

<table>
<thead>
<tr>
<th></th>
<th>Current capacity (mil gal)</th>
<th>Corn Usage (million bu)</th>
<th>Corn Storage (thousand bu)</th>
<th>Corn Percent (storage/usage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>24.0</td>
<td>8.6</td>
<td>220.0</td>
<td>1.87 %</td>
</tr>
<tr>
<td>Maximum</td>
<td>120.0</td>
<td>42.9</td>
<td>5500.0</td>
<td>59.23 %</td>
</tr>
<tr>
<td>Average</td>
<td>64.6</td>
<td>22.4</td>
<td>1213.9</td>
<td>7.79 %</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>27.6</td>
<td>10.1</td>
<td>1107.9</td>
<td>12.54 %</td>
</tr>
<tr>
<td>Sum</td>
<td>1422.0</td>
<td>516.1</td>
<td>27920.0</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Variation in corn storage capacity among plants depends on production size and whether or not the individual plant depends on a local elevator for corn storage. Table 2 shows the range of processing capacity, corn usage, and corn storage capacity at individual plants. Total storage capacity at all of the plants is 27.9 million bushels, with an average storage capacity of 1.2 million bushels and 24.9 average days of corn storage. However, two plants have three to five times the average capacity (3.0 million bu and 5.5 million bu). The others have a total capacity of 19.4 million bushels, average capacity of 1.0 million bushels, and 14 days of corn storage.

The “Corn Percent” figures shown in Table 2 are the ratios of corn storage capacity to total annual corn usage at individual plants. This ratio ranges from 1.87 percent to 59.23 percent, with an average 7.79 percent. Without the two “high storage capacity” plants included, the average is reduced to 4.38 percent. Higher corn storage capacity would be built for plants with fewer options of local commercial storage. Plants in regions with a high percentage of cash rented farmland should not expect widespread on-farm storage to be built, but instead would rely on local elevators for storage.

Thirteen plants intend to build more storage at their plants, and one manager of an elevator that owns the nearby ethanol plant plans to add more capacity at the elevator. Five plants own or have special arrangements with local elevators for most of their corn storage. Twelve plants rely mainly on farmer deliveries for processing, and they maintain an average on-site storage capacity of 1.0 million bushels, typically in two concrete silos.

Most dry-grind ethanol plants do not receive inbound grain shipments by rail. This would suggest that shipments would need to be carefully scheduled to avoid long delivery lines at the ethanol plant at harvest. Three ethanol plant managers mentioned that they are offering price premium incentives for deliveries at specified times. Figure 1 shows corn ethanol plants (current and planned) in and around Iowa that would draw corn from Iowa farms. Competition will be high in north central and east central Iowa.

Iowa has 1.65 billion bushels of on-farm storage capacity (ProExporter, 2006) and 1.08 billion bushels of commercial grain storage capacity. (Wahl, 2006). Together, Iowa has storage capacity for 2.73 billion bushels include unlicensed temporary space.
Truck/Rail Access

All ethanol plants have truck access for inbound grain and outbound products, and all but one of the plants have rail access for outbound products. Officials from Union Pacific Railroad and Burlington Northern Santa Fe Railroad (BNSF) stated in a Des Moines Register article (May 31, 2006) that ethanol shipments had more than doubled in the past year. Union Pacific is investing in track projects near several Midwest ethanol plants to help speed shipments. BNSF started its “Ethanol Express” program in response to California’s switch from MTBE to ethanol as a gasoline additive, with the intent to run 95-car unit trains to buying stations in Southern California. An Iowa Department of Transportation program has provided funding to seven Iowa ethanol plants for rail connections to main lines. The rapid increase in ethanol rail traffic comes at a time when other industries are also increasing rail shipments due to increased fuel costs. This led to concern by some plant managers about rail availability and the problem of smaller plants filling unit trains. Interview responses showed that an average of 34.7 percent of ethanol produced was shipped by truck and 65.3 percent of ethanol was shipped by rail. (Table 3.)

Table 3. Transportation Patterns of Dry Grind Ethanol Plants

<table>
<thead>
<tr>
<th></th>
<th>Truck</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Range</td>
</tr>
<tr>
<td>Corn (in)</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Ethanol</td>
<td>34.7%</td>
<td>0% - 100%</td>
</tr>
<tr>
<td>DGS</td>
<td>44.4%</td>
<td>7% - 100%</td>
</tr>
</tbody>
</table>
**Corn Quality**

Opinions about corn properties and their effect on the process were reasonably consistent and support higher levels of acceptable quality than are typical in commodity corn markets. At this time, USDA Grade #2 corn is the norm for ethanol processing. High moisture and damage levels are discounted or rejected and the reject levels are lower than those at most elevators buying for the commodity market. Other factors such as protein, oil and starch content might influence the process or yield. Some plants are measuring these factors with near-infrared analyzers in inbound grain. At this time, no plants are paying premiums for corn with desirable levels of protein, oil or starch. Only five plant managers said they were measuring fermentable starch routinely, and none had payment policies based on starch content. Nine plants routinely use protein, starch, and oil measurements in inbound corn to correlate with DGS feed value. Damaged corn, low test weight and the presence of mycotoxins have some influence on the process or end products. Mold damage can have a considerable effect on ethanol yield. Low test weight also is considered to reduce ethanol yield because the kernels are not as densely packed with starch. Distillers grains are used in livestock feed, and different species have varying levels of sensitivity to mold toxins. The levels of fumonisin, vomitoxin, and aflatoxin can triple in the distillers grains, which makes it possible to quickly exceed USDA limits for certain livestock species. New uses in human food and pet foods are being explored, which would require that ingredients meet the general market mycotoxin limits.

The key USDA quality factors that affect some part of the process are:

- **Moisture** – most plants discount above 15 percent with 17 percent moisture as the limit; two plants accept up to 18 percent moisture.
- **Test Weight** – most plants discount below 56 lb/bu; about half of the plants will not accept Test Weight less than 54 lb/bu.
- **Damage** – accepted up to 10 percent, but discounted above five percent.

Mycotoxin levels are tested at 13 plants, usually on a weekly basis on selected loads. Two plant managers stated that they tested all inbound corn for mycotoxins. All managers said they would increase test frequency if there was a suspected problem in the current harvest year.

**Co-Products**

Carbon dioxide (CO₂) is one of the co-products of drymill ethanol production, produced in abundance during the fermentation stage of ethanol production. The carbon dioxide can be compressed and sold to other industries. Carbon dioxide is used to carbonate beverages, to manufacture dry ice, and to flash freeze meat. At present, most plants do not sell the CO₂, but one Iowa plant does sell to a local dry-ice manufacturer, and four other plants are negotiating with potential buyers.

Distillers Grains are the spent corn solids of dry-grind ethanol processing. DGS are a high protein, high fiber feed most suitable for ruminants, primarily dairy and beef cattle. The nutrient percentage levels in distillers grains are roughly three times the levels in whole corn due to concentration during processing. Table 4 shows typical nutrient values of various DGS coproducts.
Table 4. Nutrient Value (dry basis) of Selected Dry Grind Ethanol Coproducts.

<table>
<thead>
<tr>
<th></th>
<th>Distilled Dried Grains Solubles (most common)</th>
<th>Condensed Distillers Solubles</th>
<th>Wet Distillers Grains</th>
<th>Modified Distillers Grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture, %</td>
<td>11</td>
<td>55 - 75</td>
<td>64 - 69</td>
<td>49 - 54</td>
</tr>
<tr>
<td>Protein, %</td>
<td>31</td>
<td>14 - 23</td>
<td>32 - 36</td>
<td>26 - 32</td>
</tr>
<tr>
<td>Fat, %</td>
<td>11</td>
<td>15 - 24</td>
<td>9 - 12</td>
<td>11 - 16</td>
</tr>
<tr>
<td>Fiber, %</td>
<td>7.2</td>
<td>--</td>
<td>--</td>
<td>5 - 15</td>
</tr>
<tr>
<td>ADF, %</td>
<td>12</td>
<td>30 - 50</td>
<td>10 - 12</td>
<td>11 - 18</td>
</tr>
<tr>
<td>NDF, %</td>
<td>45</td>
<td>--</td>
<td>30 - 50</td>
<td>35 - 50</td>
</tr>
<tr>
<td>TDN, %</td>
<td>87</td>
<td>95 - 120</td>
<td>90 - 110</td>
<td>90 - 110</td>
</tr>
<tr>
<td>NEm, mcal/lb</td>
<td>0.99</td>
<td>1.05 - 1.15</td>
<td>0.9 - 1.1</td>
<td>0.9 - 1.1</td>
</tr>
<tr>
<td>NEg, mcal/lb</td>
<td>0.68</td>
<td>0.85 - 0.93</td>
<td>0.7 - 0.8</td>
<td>0.7 - 0.8</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.07</td>
<td>0.03 - 0.17</td>
<td>0.02 - 0.05</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>P, %</td>
<td>0.77</td>
<td>1.3 - 1.5</td>
<td>0.4 - 0.5</td>
<td>0.85 - 1.4</td>
</tr>
<tr>
<td>K, %</td>
<td>1.00</td>
<td>1.75 - 2.25</td>
<td>0.5 - 1</td>
<td>1 - 1.5</td>
</tr>
<tr>
<td>Mg, %</td>
<td>0.30</td>
<td>0.65 - 0.9</td>
<td>0.2 - 0.3</td>
<td>0.3 - 0.5</td>
</tr>
<tr>
<td>Na, %</td>
<td>0.18</td>
<td>0.2 - 0.4</td>
<td>0.1 - 0.2</td>
<td>0.2 - 0.3</td>
</tr>
<tr>
<td>S, %</td>
<td>0.68</td>
<td>0.9 - 1.4</td>
<td>0.4 - 0.6</td>
<td>0.4 - 1.2</td>
</tr>
<tr>
<td>Fe, ppm</td>
<td>127</td>
<td>90 - 120</td>
<td>70 - 180</td>
<td>67 - 130</td>
</tr>
<tr>
<td>Cu, ppm</td>
<td>6</td>
<td>6 - 7</td>
<td>6 - 7</td>
<td>5 - 7</td>
</tr>
<tr>
<td>Zn, ppm</td>
<td>62</td>
<td>100 - 140</td>
<td>40 - 80</td>
<td>62</td>
</tr>
<tr>
<td>Mn, ppm</td>
<td>19</td>
<td>30 - 35</td>
<td>8 - 16</td>
<td>27</td>
</tr>
</tbody>
</table>

Source: Loy (2006)

Currently, distillers grains sales represent about five percent of revenues to ethanol plants; whereas, when ethanol demand and prices were lower, distillers grains represented up to 35 percent of plant revenues. (Ives, 2006). Interviews showed that merchandising efforts were evenly split between in-house marketing personnel and outside brokers. Though long-term booking arrangements with users (3-12 months) were less common than buying on the spot market, merchandisers stated that long term contracts were increasing. One merchandiser stated that hog producers buy short-term (weekly), but that they might become interested in longer term contracts if price and quality were more stable. Feeders say that the variability is mostly in the protein. Many plant managers stated that educational efforts need to be directed toward helping livestock feeders understand how to substitute distillers grain products for other feed ingredients.

Together, Iowa's ethanol plants sold 25 percent of their distillers grains wet at an average moisture content of 56 percent moisture (range 50% - 65%), and 75 percent of the DGS were sold dry at an average 10.3 (range 9% - 13%) percent moisture. This is a larger range than Table...
4 indicates, which means higher variations in “as fed” nutrient levels.

“Wet cake” distillers grains, because of high moisture content, are vulnerable to spoilage within a matter of days or a few weeks, depending on the ambient temperature, so it is important to minimize the transport distance to the user. In contrast, dried distillers grains can be stored for several months and therefore can be shipped long distances. Plants have storage for, on average, 5.1 days of production of wetcake and 8.4 days of production of dried grains. When compared to annual DGS production, Iowa plants had storage capacity for 2.6 percent of annual production. The ratio of storage capacity to annual production is more limiting than that for corn storage.

Iowa’s ethanol plants have enough drying capacity to dry at least 80 percent of the distillers grains they produce. Plant managers stated that, generally, two factors influence how much of the distillers grains they choose to dry; cost of energy (usually natural gas) and available markets. Dried distillers grains can be stored and shipped to distant markets; yet, the most economical product for the ethanol plant to sell is “wet-cake” distillers grains because of the cost savings in not having to dry the product. Managers estimate that 35-40 percent of a plant’s energy costs are associated with drying of distillers grains. Markets for wet-cake are usually within a 50-mile radius of the plant and they are shipped by truck. Cattle feeders are rapidly adopting “wet cake” DGS as the major ingredient in diets Some feeders have found it easier to get calves “on feed” using wet-cake DGS. (Couser, 2006). Figure 2, from the Iowa Beef Center, shows that the closer the cattle to the ethanol plant, the more profitable the feedlot operation.

![Figure 2](image)

Assume: 95% of corn price, $0.10/bushel increase corn price, costs covered, 153 days

Figure 2. Effect of feeding wet cake in beef cattle. Source: Van DerPol, et al (2006)

Ethanol plants are heavily concentrated in the north central and east central parts of the state. In north central Iowa, there is competition among the plants for corn, and competition from swine producers as well. In east central Iowa, there is yet more competition from corn wetmills for the corn and competition with corn gluten meal and corn gluten feed for markets for the co-products. Figure 3 shows the total number of cattle feedlots per county. Though western Iowa has a relatively high concentration of cattle on feed, plant managers stated that there are
not enough local markets for wet-cake distillers grains, so some wet-cake is sold to feedlots in neighboring states.

John Lawrence, director of the Iowa Beef Center, estimates that Iowa has approximately one million cattle on feed at any one time in Iowa. Depending on inclusion rate of distillers grains in the diet, a plant that produces 45 million gallons of ethanol annually can produce enough distillers grains to support 85,000 – 225,000 cattle. As few as four plants or as many as twelve plants could support all of the cattle on feed in Iowa. Though plant managers attributed most of the current use of distillers grains to substitution for other feed ingredients, plant managers in north central and northwest Iowa noted increases in dairy and feedlot cattle. Plant managers in southwest Iowa noted increases in cattle feedlots and cow-calf operations.

**Distillers Grains - Quality issues**

Lack of standardized measurements for the nutrient characteristics in distillers grains is a major problem for users. Even though all plants are using the same feedstock, USDA #2 Yellow Corn, there are operational differences that affect nutrients; for example, high drying temperatures denature proteins and make some nutritionally unavailable.

Industry data collected by Dr. Kenneth Kalscheur at South Dakota State University shows that nutrient composition in DGS from several upper Midwest ethanol plants varied significantly; for example, crude protein ranged from 27 to 35 percent (100 percent dm). (Kalscheur, 2006). Anecdotal reports from feeders agree that protein levels can be extremely variable. The USDA Grain Inspectors, Packers and Stockyards Administration (GIPSA) considered establishing standards for quality in distillers grains as is done for commodity grains, but the industry
persuaded GIPSA officials that standards would not benefit either the buyer or seller. (USDA GIPSA, 2005) Instead, inherent differences among distillers grain products were considered beneficial as long as the sellers could provide an accurate description of nutrient content of their particular product. To insure this, a standardized measurement system is needed.

Another hurdle that needs to be overcome to encourage use of distillers grains is flowability. Shipping long distances by rail and storing in silos and bins causes caking and bridging to occur, which then make the product difficult to load and unload. Severe damage in rail hopper cars occurs when workers pound the outer sides of cars to release the caked DDGS, and workers risk injury and death by climbing inside hopper cars and bins to attempt to release the grains.

Plant managers were asked to suggest potential new uses for distillers grains. The most common responses were to burn distillers grains for fuel to operate the plant or to use as fertilizer. Opportunities to use distillers grains in livestock feed are being explored by public and private research groups, and recommendations are available for inclusion of wet and dry distillers grains in ruminant diets (beef, dairy, and sheep) and for dry distillers grains in swine and poultry diets and in pet foods. Uses in human foods, such as baked products and pasta, are being explored as well. (Rosentrater and Krishnan, 2006)

**Industry challenges**

Plant managers were asked to share concerns and challenges for Iowa’s ethanol industry. The major concern was each plant’s ability to access enough corn to keep it operating at the rated capacity, at minimum. Following closely was the concern over the excess capacity of distillers grains and the need to find new markets. Plant managers thought that educators could be extremely helpful in showing livestock producers how to use distillers grains in feed mixes, and that researchers should try to solve the flowability problems with distillers grains and create a uniform measurement system for nutrient quality. Adequate rail service was another concern that will require cooperation between rail companies and ethanol companies.

More than half of the plant managers stated that the threat of increasing environmental regulations was a concern, both from the standpoint of plant emissions (carbon dioxide and steam) and manure runoff from feedlots. They encouraged Extension personnel to work with feedlot managers to develop ways to mitigate runoff problems, and to explore new uses for carbon dioxide.

Worker training was seen as a major area in which Iowa needs to dedicate resources. Ethanol plants usually seek process engineers to manage general plant operations, but the technical personnel who serve as shift supervisors, quality control managers, corn acquisition personnel, and co-product merchandisers also need general background in life sciences and/or marketing and specific higher level training in their areas of responsibility. “These are good paying jobs, particularly in rural areas,” said one plant manager, “but it is difficult to find one person who has all the background he/she needs for a certain job.” One strategy employed by plant managers is to leverage skills in personnel management with specific scientific/engineering skills across a group of people in the organization, thus creating more of a team approach.

**Summary**

The rapid expansion of Iowa’s ethanol industry has changed corn distribution patterns to support
more local processing. As more corn is used locally in fuel production, less is available for export, feed applications, and other processing. This has led to changes in grain transport, on-farm grain storage, and the function of local grain elevators. This study collected data to indicate the magnitude of current and future impacts of ethanol production on Iowa agricultural logistics.

Interviews with representatives of twenty Iowa ethanol plants revealed information about sourcing corn, processing capacity, corn storage capacity, corn quality specifications, truck and rail access, and co-product storage capacity and marketing. At this time, twenty-three dry grind plants and four wet mills are expected to produce 1.5 billion gallons of ethanol in Iowa in 2006. Forty-two new dry grind plants, one new wet mill plant, and six additions are proposed or under construction. In addition, dry grind plants immediately across Iowa's borders draw corn from Iowa farms. If all proposed facilities are built and operating at capacity by 2010, fuel ethanol production of 7.3 billion gallons per year in and near Iowa will consume 2.6 billion bushels corn. National Agricultural Statistics Service estimates Iowa's 2006 corn crop at 2.1 billion bushels.

Dry-grind ethanol plants also produce distillers grains (DGS) feed co-products. Iowa ethanol plants currently produce about 4.3 million tons of distillers grains. DGS production could grow to 17 million tons if all proposed ethanol plants come online. Distillers grains can significantly substitute for other ingredients in cattle rations (up to 50% of ration), and can also be used in swine and poultry rations at a lower rate (up to 10%). The Iowa Beef Center estimates that as few as four of Iowa's mid-sized ethanol plants could produce enough distillers grains for all the cattle presently in Iowa. Ethanol plants located close to cattle feedlots are able to save energy costs by selling wet distillers grains, but on average only 25% (range 6% - 100%) of DGS is sold wet at an average of 56% moisture (range 50% - 65%). Nearly 60% (range 0% - 93%) of DGS is shipped by rail; this DGS is likely not used in Iowa and certainly is dry.

Ethanol plant managers recognized that new plants and existing livestock markets would compete for corn. Sixty-two percent (range 5% - 100%) of the corn currently used by ethanol plants is purchased directly from farmers. Operators expressed a desire to source corn directly from farmers. However, most had absolute limits (typical 18% moisture, 10% damage) on acceptable quality, unlike the general acceptance policies of traditional elevators. More attention will need to be paid to stored grain quality, over a longer period, than current markets require.

Plants had onsite storage for about 5% (range 2% - 12%) of annual corn use and 2.5% (range 1.6% - 4.7%) of annual DDGS production, which makes consistent logistics a major need. Some expressed concern about adequate rail service for both ethanol and distillers grains. The need for ongoing training for current and future ethanol plant workers was stressed by managers, pointing to Iowa's regents universities, community colleges, and Extension to take this responsibility.

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