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Introduction

Rapid growth in fuel ethanol production in the U.S. will create pressure on infrastructure both in the near term and the longer term. Currently the vast majority of fuel ethanol produced is grain based with corn based feedstocks dwarfing the quantity of all other grain feedstocks. In the future it is expected that biomass based ethanol production will also develop using crop residues and other cellulosic feedstocks including switchgrass, woody plants and woodchip by-products from lumbering activities. Public and private investments are now being made in research and development for both crop residue and other biomass based feedstocks for ethanol production. Several pilot projects for plant scale production are already in progress.

This paper will: (a) Summarize some of the major impacts rapid growth in the corn based ethanol (CE) production is now having on infrastructure in the Midwestern corn producing states. (b) Examine some of the likely infrastructure needs that might be expected to occur as a consequence of the future development of biomass based ethanol (BE) production.

Types of Infrastructure

Business firms, including ethanol plants, are heavily dependent on public and private investments in infrastructure to support their production and distribution activities. Investments in infrastructure are generally large and often involve a large fixed cost component that would be difficult for any individual firm to provide for itself. Infrastructure can be classified into two major categories—Physical Infrastructure and Intangible Infrastructure. Physical infrastructure would include items such as roads and bridges, railroads, pipelines, and public warehousing. In contrast, intangible infrastructure would include such things as uniform grade and quality standards, market price discovery mechanisms, collateral warehouse receipts, regulatory structure and other marketing institutions.

In general physical infrastructure tends to be congestible and subject to capacity constraints. The condition of physical infrastructure also typically deteriorates as a function of use and time. In contrast intangible infrastructure tends to be much less congestible, less likely to deteriorate with use, and less likely to reach capacity constraints. Indeed some types of market institutions actually improve with increased volume and increased number of users. Futures markets for example become more useful and effective as the volumes traded and the number of buyers and sellers increase.

Part I: Growth in Corn Based Ethanol Production and Near Term Effects on Infrastructure

Infrastructure often is taken for granted as small to medium-sized firms make planning decisions. Since the volumes of inputs and outputs used by such firms are often small in relation to market totals, the added demands on existing infrastructure need not be considered. Adequate roads and bridges, unlimited common carrier services from truck, rail, barge, or pipelines, adequate public warehousing services and ready access to utilities such as gas, electric and phone are simply presumed to be available. While this presumption for any one firm is usually justified, such a presumption cannot be made when a large number of other individual firms with a large combined volume are making similar decisions at the same time.

This is the situation that appears to accompany the rapid growth in corn based ethanol production over the past two years and the projected expansions for the next two years. Most of the corn based ethanol production is concentrated in Midwestern states with heavy corn production. Gallagher has compiled a list of 23 states with current fuel ethanol production capacity and projected capacity that is under construction or in the planning stage (Gallagher). Existing capacity in the five states that produce the largest volume of ethanol now exceeds half a billion gallons. Collectively these five states currently have 4.34 billion gallons of annual production capacity (table 1). In the same five states ethanol production capacity that is either now under construction or in the planning stages will add another 4.04 billion gallons of production over the next two years. Iowa leads the nation with 1.6 billion gallons of capacity now producing and an additional 1.94 billion gallons of capacity is either under construction or in the planning stage.

Current marketing patterns for corn in Iowa and the other four states depend upon an existing infrastructure that has been built over a long period. Infrastructure includes assets for inbound truck receiving and outbound truck or rail shipping for whole grains or locally produced feed products. Infrastructure also exists for drying, storage and conditioning of grain either on a farm or at local elevators and subsequent shipping to feed, processing or export users. Finally, an intangible merchandising infrastructure exists to originate grain from farms and ship it to end users both in the state and outside Iowa. The capacity of the existing infrastructure is closely matched with the current volumes of corn and soybeans produced to meet the existing food, feed, processing and the export demands for these grains.

Rapid increases in the production of ethanol will place stress on the physical infrastructure involved in producing and shipping ethanol and co-products. But it also will change the existing grain infrastructure relationships and create some new and different infrastructure requirements. It will require greatly increased investment in the physical infrastructure for grain handling, conditioning and storage. Until this past year, growth in ethanol has occurred at a relatively modest rate. Normal increases in production combined with drawdown of carryover stocks have been able to fill the growth in demand for corn to use as ethanol feedstock. However, planned expansions in ethanol production will demand much faster rates of growth in the corn supply than have occurred thus far. In Iowa some estimates indicate that the current 2.6 billion bushels of corn and soybean produced and stored in Iowa will need to be increased to approximately 4 billion bushels over the next four years (Wisner). This additional growth in ethanol demand will begin to put serious pressure on existing grain infrastructure.

Thus both the infrastructure involved in producing and distributing ethanol and the infrastructure involved in producing the additional grain feedstock will impact the rate at which corn based ethanol production itself can increase.

Crop Production Inputs and Services

Producing more acres of corn will require more production inputs and services. In particular it will be necessary to produce and distribute more seed, crop protection chemicals and fertilizer products for each acre that is switched from soybean to corn.

Seed was available in adequate supply in the spring of 2007 despite increased corn acreage. However, in some cases, it was difficult to get the seed corn varieties with the greatest yield potential and/or biotech technologies that farmers wanted to plant. The seed industry can ramp up production quickly, much of the seed to be planted next spring on an expanded acreage can be grown this summer or in southern hemisphere production areas if the demand is not apparent until the fall. While availability problems may occur in the coming production year for certain types of seed, adjustments are now being made by the seed industry for the coming year and the problem should not be severe.

Corn generally requires more fertilizer and agricultural chemicals than soybean. An increase in corn acreage of 25 percent will require a much larger volume of nitrogen fertilizers to be brought into the state and distributed to producers. Fertilizer distribution logistics have encouraged the building of 8-10 fertilizer receiving and distribution "hub plants" in various parts of Iowa within the past few years. These plants can receive shuttle trains of phosphorous, potassium and some nitrogen products with rapid turnaround times from Canada and the Gulf. Inventories can be moved to other local fertilizer distribution plants or directly to producers by truck. Thus it is possible to quickly increase the quantity of some fertilizer products moving into the state. Domestic production capacity for nitrogen fertilizers has been supplemented by imports over the past five years. This provides some flexibility to accommodate rapid expansion in demand. However the use of imported product has a much longer logistics chain than domestic production. Thus the time between ordering and receiving product will be several weeks longer.

Currently nitrogen fertilizer is applied in both the fall and the spring. Fertilizer distribution plant capacity, application equipment and trained applicator operators are closely adapted to serve the present corn-soybean production levels with a fall and spring season. A significant fraction of the nitrogen used in the fall and spring is in the form of anhydrous ammonia. Anhydrous ammonia is typically shipped by pipeline and is usually somewhat cheaper per unit of actual nitrogen than liquid or dry form nitrogen.

Adequate supplies of nitrogen to accommodate expected rapid increases in the number of corn acres can be obtained quickly. However producers in some areas could find it difficult to obtain all the nitrogen they want in the form of anhydrous ammonia. Rapid expansion in the number of corn acres were accommodated in the spring of 2007 but created the need to use more nitrogen solutions, urea, DAP and MAP—especially in the some regions.

Existing levels of application equipment and the current numbers of trained applicators may need to be increased to accommodate large increases in the number of acres planted to corn in the longer run. This is especially true if adverse weather conditions occur during the spring application season. Capacity is already tight and operators often work long hours. The relatively good weather in the fall of 2006 and in most areas during the spring of 2007 permitted applications on 10-15 percent more acres of corn added this past fall and spring with little disruption. However, these favorable conditions may not exist every year.

Grain Elevator System

The grain elevator system plays a key role in the current origination and marketing patterns for Iowa corn and soybeans. The function of the grain elevator goes beyond the tangible activities of receiving, conditioning, drying, storing and shipping grain. Iowa elevators also serve a critical grain merchandising function. Merchandising involves constantly scanning the market prices offered by grain buyers and users through space and time. The spatial aspect of this activity involves identifying offers to buy at many locations throughout the country, backing out the cost of transportation and offering the best bid to farmers selling grain. Prices are scanned for both the present and future months so a time dimension also is incorporated with the spatial dimension. Simply stated, the merchandising function involves bringing the best price from all the markets the elevator can reach to its customers in the form of a grain bid.

Transportation of Grain into Plants

Thus far, inbound grain transportation to the dry mill ethanol plants has been primarily by truck. Several of the newer plants have the ability to bring in single car or small multi-car shipments by rail, but much of the inbound grain still is delivered in semi-trailers. Grain is sourced from both farmers and elevators. Some plants attempt to buy as much as possible directly from farmers and use elevator grain to fill in the gaps that occur during planting, harvesting and periods when producers are reluctant to sell. Others attempt to establish supply agreements with elevators as a major strategy for obtaining feedstock grain but accept direct shipments from farmers as well. Some in the industry believe it is difficult to economically originate more than 20-30 percent of required grain direct from producers and will become even more difficult as supplies tighten in the future.

Rapid increases in demand for ethanol corn will create a need to increase the number of trucks and the receiving capacity at ethanol plants and elevators. Many producers now own one or more tractor semi-trailer units. These often are powered by used over-the-road tractors coupled with new or used grain trailers purchased primarily for harvest grain hauling. This kind of capacity can be expanded quickly compared to other infrastructure capacities.

Greater tonnage hauled over roads in local areas will create the need for increased investment in local road and bridge infrastructure. This will occur for two reasons. First, there will be more bushels of corn produced and delivered to local elevators as more acres of corn and fewer acres of soybeans are produced. Second, more of those bushels will be delivered back to local ethanol plants by truck rather than shipped out by rail to out-of-state users. While the existing infrastructure in most parts of the state can handle the added volume in the near term, the added traffic is likely to accelerate the need for road and bridge maintenance in the future.

Corn Storage, Drying and Handling

Corn storage is typically in tight supply during harvest when a “normal” size crop is produced. In Iowa the combined “on farm” and “off farm” storage capacity in 2005 was approximately 2.77 billion bushels. This would appear to be more than sufficient to meet the needs for the 2.59 billion bushels harvested in Iowa for the 2005-2006 crop year. However, it has been necessary to make widespread use of ground piles and various types of temporary storage in most of the recent crop years. This disparity occurs in part due to the carryover stocks that were on hand at the beginning of harvest. These stocks have been largely depleted as the growth in ethanol production continues. In this sense the rundown of carryover stocks has served as a “shock absorber” for a storage deficit that would already have occurred had there been no carryover stocks and extra capacity to store them.

In the spring of 2007 there was a significant acreage shift from soybeans to corn to meet the growth in demand for ethanol production, added pressure will be placed on the storage drying and handling infrastructure. An acre of soybeans creates the need for 60 bushels of storage in a good production year. Shifting that acre to corn production will create a need for 180-220 bushels in a good production year—a net increase of 120-160 bushels of storage for each acre shifted. Reductions in carryover stocks have freed up over 1 billion bushels of storage. However, when production increases exceed 1 billion, significant additional investment in grain storage and drying capacity will be necessary to accommodate the larger number of bushels produced.

Projected production levels that incorporate a steady switch of soybean acres to corn acres to obtain the 3.96 billion bushels in Iowa required for the 2010-2011 marketing year imply that storage capacity will need to increase by nearly 1.4 billion bushels. This is more than all commercial storage currently in service in Iowa. Large increases in the storage capacity will need to be made in a very short time frame to accommodate increased production of even half this magnitude.

Ethanol plants typically have storage for only 15-30 days of production and some have less that that. While some plants may decide to add more storage capacity, additional capacity at plants is not likely to fill most of the storage and handling gap. It is more likely that much of this capacity will be built on the farm and at elevators where it can move into a variety of alternative markets in response to market price incentives from all competing uses including out-of-state ethanol production.

While some of this capacity can be obtained through the use of ground piles and other forms of temporary or surge storage capacity, most of it will need to be of a semi-permanent or permanent type where grain quality can be managed. At the present time, it appears most of this capacity will have to be built by producers and elevators. But there is significant risk in building grain storage to handle the expected expansion in ethanol production. Changing basis patterns may not assure there is enough “carry” in the market to pay for new storage. And large expansions in corn storage capacity could become excess capacity if cellulosic crop residue and biomass ethanol feedstocks replace corn feedstocks in the future.

Transportation of Ethanol

Transportation is another potential constraint on the growth in ethanol production. A significant fraction of the initial growth of ethanol production in Iowa has gone to fill demand in Iowa and surrounding states. Projected growth in ethanol production going forward will need to be shipped further unless E-85 demand catches on in Iowa. Prices for ethanol delivered to Iowa terminals have begun to reflect the excess supply at these points.

It is likely much of the planned increase in ethanol production will have to leave the state via rail tank cars since pipeline movement is not a likely possibility—at least in the near future. Rail infrastructure will need to be increased quickly and dramatically. Tank car availability appears to be a serious constraint in the near term. Railroads do not typically supply tank cars for shippers. The vast majority of the U.S. tank car fleet is privately owned or leased from private sources and this is unlikely to change. In 2005, total railroad ownership was 781 cars out of the total tank car fleet of more than 243,000 cars. Plus, railroads prefer not to haul hazardous materials since they are self-insured. They do so only because they are common carriers and are required by law to provide service.

But tank car availability appears to be the major constraint. There are four major tank car manufacturers—GATX, Trinity, Union and AFT. Costs for manufacturing a 30,000-gallon tank car is about $95,000 with escalator clauses for materials and interest. Thus 100 cars would cost $9.5 million. Terms call for 50 percent cash and the remaining 50 percent upon delivery and orders are taken only from entities that provide financial statements showing credit-worthiness. Some car manufacturers are booked for more than two years so an order today will be delivered in the first quarter of 2009.

Most of the tank cars used will be leased by plants rather than owned. Leasing companies currently are raising the monthly lease costs per car and lengthening the lease contract length in response to heavy demand for tank cars. For example, cars that could be leased 2 or 3 years ago for $300 per car per month on a 2-3 year lease must now be leased for $550 per car per year with a 5-6 year lease. This is a $3.96 million commitment for each 100 cars leased (i.e., $550/car x 12 mo. x 100 cars x 6 years) over the life of a six-year lease. To put this in perspective, an ethanol plant with 100 mmg. of capacity would need to lease three unit trains of 100 cars with a capacity of 30,000 gallons per car if about two-thirds the ethanol were shipped by rail and the turnaround time for cars is six weeks. This would require a commitment of $12 million over the life of the lease compared to a $3.24 million commitment two years ago when a three-year lease was available for $300 per car per month. Lease commitments of this kind increase the implicit leverage of the plant and require that a larger amount of equity capital be raised.

The longer turnaround time for tank cars is part of the problem. Turnaround times for grain unit trains to the Gulf or West Coast typically run about two weeks. This reduces the number of cars required and the fixed transportation cost per unit. Turnaround times for ethanol tank cars are not likely to be greatly improved in the near future. At the origination level, most plants are set up to load small multi-car trains. Few plants have the necessary volume or transportation facilities to load unit trains at the present time. When unit trains are used, a number of small multi-car shipments are typically assembled in a yard on the main line into a unit train.

Similar problems exist on the receiving end. Most petroleum refiners and rack distribution terminals are not set up to receive unit train shipments. Unit train shipments typically are disassembled at a destination yard near refiners or terminals and sent to the final destination for blending. Both problems of assembling unit trains and receiving unit trains at the end use point can be addressed and are likely to improve in the future, but it will require some time for the system to develop. In the meantime, longer turnaround times will continue to raise the cost of transportation and aggravate car shortages as the industry continues to grow.

Transportation of DDGS

Moving DDGS also is a potential infrastructure problem. DDGS may be shipped in standard 5,700 cubic feet covered hopper cars that now are used to ship corn and soybeans. Some difficulties have been encountered in removing DDGS from these cars at destination. There is anecdotal evidence cars frequently are damaged in the process of unloading since DDGS does not flow freely from 5,700 cubic feet cars during unloading. Thus some have been reluctant to permit cars they own or control to be used for shipping DDGS.

Two class I railroads have announced in their tariff statements they will not permit railroad-owned hopper cars to be used to haul DDGS. A third class I carrier does not make the explicit statement in its tariff, but as a policy it does not permit shippers to use their cars for DDGS. While all three railroads will haul DDGS on their lines, none will permit cars they own to be used.

As an added complication, the density of DDGS is less than the density of grain so the 5,700 cubic feet cars cannot be loaded to their maximum weight. Although these cars could be used for shipping DDGS as fewer shuttle trains of grain are shipped, there is a weight penalty of more than 10 tons per car. New 6,350 cubic feet cars are becoming available that can haul an additional 11.5 tons of product (143 tons per car versus 131.5 tons per car). The 6,350 cubic feet covered hopper cars have larger hopper gates to permit easier and faster unloading. There are not enough of the larger cars to meet expected increases in DDGS shipments but over time it is expected the 6,350 cubic feet cars will account for a larger fraction of the fleet and become the standard for shipping DDGS.

Conclusions for Corn Based Ethanol

The rapid increases in ethanol production capacity will put heavy pressure on existing grain transportation and storage infrastructure. Prior to 2007 little had been done to add to the existing storage and transportation infrastructure to accommodate the planned expansions in ethanol production capacity. Some capacity is being added in 2007 both at the farm level and the commercial elevator level. Significant additional investment in infrastructure is needed for the planned expansion in CE production capacity to be economically viable. Low margins and higher working capital requirements due to increased grain prices of corn and soybeans will place additional financial pressures on firms in the grain elevator sector. This will make it difficult to expand commercial storage as rapidly as the ethanol production sector is expanding. Lag times to manufacture and to build the infrastructure also are a barrier. Planned increases in production could easily outstrip the capacity to manufacture and build the rail cars, storage facilities and conditioning capacity needed to accommodate the growth in volumes required. If not addressed, these infrastructure limitations can be expected to slow the rate at which ethanol production can grow.

Part II. Development of Bio Based Ethanol Production and Future Infrastructure Issues

The use of more complex cellulose carbohydrates from crop residues and other biomass as ethanol feedstock is anticipated for future ethanol production. Cellulosic ethanol production is in its infancy and at present does not put pressure on existing infrastructure. There is no well developed knowledge base to predict how the industry will develop or for that matter whether it will become a large factor in ethanol production. Many of the processes are still in the bench research phase but some show great promise for commercialization. Several large petroleum companies including BP and ConocoPhillips have made significant investments in private and university research programs. Some attempts have been made to estimate the potential for commercial production of feedstocks that could be used for BE production and to identify regions where that production might occur. A small number of experimental plant scale production facilities have been started.

There are six experimental plants currently slated to receive partial federal support that are now in the planning and construction phase. These plants have various anticipated completion dates that fall between 2009 and 2011 (table 2) (Gallagher). Four of these plants plan to use fermentation as the primary process and two plants to use a combination of gasification and fermentation. Four of the plants plan to use crop residues for at least part of the feedstock they use. Three plan to use wood waste or woodchips and two plan to use yard waste in combination with wood waste. The largest will be a woodchip operation that is expected to produce 40 mgy of ethanol and 9 mgy of methanol annually.

Gallagher has estimated the crop residue supply potential and the potential ethanol production from those residues for 20 states (Gallagher, et al). The five states with the largest volumes of crop residue biomass available for ethanol production are shown in table 3. As would be anticipated many of the states with large grain ethanol production would also have large crop residue potential. However non-crop residue estimates by Gallagher and Shapouri indicate that much of the potential for non-crop residue biomass is in the southeastern region of the U.S. (Gallagher).

Infrastructure for biomass feedstocks differs from the CE infrastructure in several important respects. Since much infrastructure is already in place for the production, transportation, conditioning, storage and shipping of corn, meeting the infrastructure needs is more of a question making adjustments to what is already in place. Certainly there are needs for added capacity at the margin, but the basic system structure for input supply, production, transportation and storage is already in place to move corn to the plant door already exists. On the output side the basic system structure is also in place, but it is less developed and will require more new investment in ethanol storage, transportation and distribution assets.

Physical infrastructure for crop residue BE is for the most part non-existent. Although rudimentary value chains for some crop residues such as corn stover and straw have developed for uses in the livestock industry, these systems are not likely to meet the needs of the emerging cellulosic ethanol production industry. In nearly all cases the corn stover crop residues are collected as a salvage operation after the harvest is complete. In the grain harvest and residue collection process stover is pushed to the ground by harvesting machines and driven over by hauling and harvesting machinery. In the process they become contaminated with soil that can seriously interfere with cellulosic ethanol processing. Even though this contamination could perhaps be reversed by adding cleaning operations at the plant, it is an added cost and may slow and complicate plant operations.

At a very minimum new harvesting and handling practices will be required to prevent or minimize feedstock contamination and it is likely that new or significantly modified harvesting equipment will be necessary. In addition there is currently little or no storage and handling capacity for either crop residues or other biomass products to be used as BE feedstocks. Crop residue feedstocks are similar to the grain feedstocks in that they are harvested once each year and must be stockpiled and stored to meet a continuous demand throughout the year. Unlike grain feedstocks there is no handling and storage system already in place that can be expanded to meet the new demand for ethanol production. A physical system for handling, conditioning and storing crop residues feedstocks will have to be developed more or less from the ground up. Nor is there a large stock of technical information on storage methods and practices and how they relate to physical facilities in terms of cost and performance.

Physical infrastructure needs for non-crop residue biomass is an even greater unknown. Some BE production facilities are likely to be integrated into existing plants for other non-ethanol products (e.g., woodchip processing) where the biomass feedstock is a co-product and therefore already assembled. However; much of the potential for new BE production is likely to involve assembly of raw product that has been produced specifically for ethanol feedstock from the point where it is produced. Unlike corn and crop residue feedstocks, the geographic location of much of the potential biomass production is expected to be located in the south. To some extent the longer growing season there can be expected to reduce the need for the longer term storage that is necessary for grain and crop residue based ethanol production.

Longer (and in some states year around) growing seasons could permit delivery of a much larger fraction of the total biomass produced directly to the BE plant at harvest thereby avoiding storage. This is especially true where the growing season permits multiple harvests over the course of the year. Even where there is only one harvest per year, a longer growing season could permit the purposeful scheduling of that harvest over a much longer time span than is possible for crops and residues in northern parts of the U.S where the harvest is concentrated into one or two months. These kinds of steps could reduce the infrastructure investments and associated operating costs of feedstock storage and quality maintenance.

To the degree that the biomass is cultivated specifically for BE, there would be a need for inputs for production of feedstocks similar to those in the CE regions. The fact that many of these acres would not already be under cultivation will create a new demand for fertilizer, crop protection chemicals and seed that do not currently exist. In addition, there will be added demands for transportation for the feedstocks between point of production and plant. There may also be a need for intermediate assembly stations where the raw BE feedstock is pretreated or partially processed into a more concentrated form of carbohydrate before being shipped to plants for production of fuel grade ethanol.

The impact of BE on rural road, highway and railroad infrastructure is likely to be even greater than the current and anticipated impact of CE. Raw BE feedstocks contain much less concentrated levels of fermentable carbohydrates and therefore require the movement of greater masses of feedstock to produce an equivalent level of ethanol. Thus public and private transportation infrastructure must move more volume of feedstock per gallon ethanol produced. The precise impact will depend on a number of factors including production density of feedstocks near the plant and the amount of preprocessing and shipment of more dense carbohydrate product from the preprocessing point to the BE plant.

Intangible infrastructure is also absent for both crop residue and non-crop residue BE feedstocks. CE plants benefit from a robust set of grain market institutions that has been developed and fine-tuned over the past century. Price information on CE feedstock is available on a daily basis and there is a wealth of crop condition, supply and demand information from a variety of public and private sources. Pre-existing institutions such Uniform Grade and Quality Standards, FGIS, Grain Warehouse Regulations, Collateral Warehouse Receipts, Trade Associations, Non-Recourse Government Commodity Loans, and a set of futures markets that efficiently price grain over time and space are all readily available for CE ethanol feedstock. This infrastructure is already in place, tested and readily accessible to CE ethanol producers. Although it is not highly visible and is frequently taken for granted, it plays a critical role in efficient feedstock pricing, risk management, trading and financing.

Similar institutions for BE feedstocks (either crop residue or other biomass) are at this time largely non-existent. The bulk of the BE marketing infrastructure necessary for efficient commercial transactions will have to be started from scratch.

Pricing infrastructure is one of the most pressing needs. Corn and other grains are traded in large daily volume and openly on well established exchanges with a great deal of confidence on the part of buyers and sellers that the other party will perform. It will be difficult to provide these infrastructure benefits at least initially for crop residue and biomass crops. BE feedstocks will be starting from a relatively small production base with no pricing institutions in place. There are no existing grades and quality standards to underpin transactions over distance and time. Nor are there any trade rules or established patterns for prompt and efficient settlement of trade disputes between buyers and sellers. The absence of these factors does not mean that they will not develop over time or that efficient alternatives will not be developed. But there will be a transition period.

Crop residue and biomass feedstocks are by no means the only commodities that do not have an active cash or futures market. A number of commodities that are routinely produced and priced do not have well established cash or futures markets. These commodities are instead produced under various types of contracts. In some cases there is a close enough relationship between the contracted commodity and a similar commodity that is traded on futures markets so prices in the futures market can be used as a reference price for the contract. And in many cases the relationship is close enough and predictable enough to permit hedging and risk management. However for other commodities with no closely related traded commodities to serve as a reference commodity it is more difficult.

These commodities must be produced under contract and the risk allocated between producer and user. Precedent exists in numerous food crops including some perennial crops such as asparagus and orchard crops. But the fact remains that there are significant transactions costs and costs of gathering market information than for crops where there are no public supply and demand estimates or readily accessed futures markets. As a consequence there are also potentially large differences in bargaining power between producers and users. Marketing and/or bargaining cooperatives are sometimes formed to fill these information and bargaining power gaps.

In addition to the absence of pricing infrastructure there is no regulatory infrastructure to protect those producers who wish to hold inventory after harvest in a public warehouse or handlers warehouse. This kind of infrastructure serves an important role in underpinning warehouse receipts and producer financing by creating a higher and more reliable collateral value for inventory. Nor are there equivalents to the U.S. grain grades and quality standards or Federal Grain Inspection Service. While there are other ways these functions can be provided some kind of commodity grades and standards will be necessary to permit trading. Another possibility would be to have the production of BE feedstocks and the production of ethanol vertically integrated in some fashion so that the responsibility for quality is internalized.

Table 1. States With Greater Than Half a Billion Gallon Corn Based Ethanol (CE) Production and Projected Expansion

State	Existing Capacity (Billion Gallons)	Under Construction or Planned (Billion Gallons)	Projected Total (Billion Gallons)
IA	1.6	1.94	3.62
SD	.64	.71	1.35
IL	.98	.62	1.60
NE	.51	.64	1.15
MN	.61	.13	.74
Total	4.34	4.04	8.46

Source: Renewable Fuels Association

Table 2. Biomass-Fuel Processing Plants: Commercial Facilities in the United States

Location	Process	Fuel Capacity (Mil Gal/Yr)	Primary Input	Yield (Gal/Ton)	Finish Construction
1. Emmetsburg, IA	Fermentation	25	Stover	81-90	End of 2009
2. Colwich, KS	Fermentation	11.4	Stover, straw, switchgrass		End of 2011
3. Shelly, ID	Fermentation	18	Stover, straw, switchgrass	80	End of 2010
4. Soperton, GA	Gasification and fermentation	40 (& 9 MGY methanol)	Woodchips	91	2011
5. Labelle, FL	Gasification & fermentation	20.9 (6,500 KWH electricity)	Citrus peels, yard waste, wood waste		End of 2010
6. San Diego, CA	Fermentation	19	Yard waste, wood waste		End of 2009

Sources: Brasher; Department of Energy Staff; and Des Moines Register Staff (2007)

Table 3. States With Crop Residue Biomass Capable of Producing Greater Than a Billion Gallons of BE Annually

State	Residues [a] (Million Tons)	Ethanol [b] (Billion Gallons)
IL	26.19	2.09
IA	23.75	1.90
ND	15.17	1.21
MN	13.71	1.10
IN	12.62	1.01
Total	91.44	7.31

[a] Gallagher, et al (2003)

[b] Assuming 80 Gallon Ethanol Yield Per Ton of Residue

Table 4. States With Non-Crop Residue Biomass Capable of Producing Greater Than a Billion Gallons of BE Annually

State	Biomass (Million Tons)	Ethanol (Billion Gallons)
AR	25.36	2.03
MS	20.40	1.93
KY	20.33	1.63
AL	19.97	1.60
GA	16.33	1.31
FL	15.75	1.26
Total	118.14	9.76

Source: Gallagher and Shapouri (2007)

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