



Midwestern Ethanol Innovation

Maximizing Process Efficiency and
Carbon Reduction

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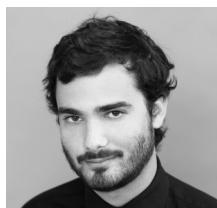
About the Great Plains Institute

As a non-partisan, non-profit organization, the Great Plains Institute takes a pragmatic approach to transforming the way we produce, distribute, and consume energy to be both environmentally and economically sustainable. Through research and analysis, consensus policy development, and technology acceleration, we are leading the transition to clean, efficient and secure energy.

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Introduction

The Great Plains Institute has worked on biofuels policy and technology for over a decade. In recent years our strategy in this area has focused on the following elements:

- Reduce the carbon intensity of existing corn ethanol facilities.
- Commercialize next generation biofuels.
- Commercialize biomaterials as a complementary strategy for next generation biofuels.

In 2011, the Great Plains Institute, in partnership with the Midwestern Governors Association formed an Advanced Transportation Fuels Advisory Group. Information gathered throughout the Advanced Transportation Fuels Advisory Group process demonstrated the need for and provided much of the content of this report.

Intended for members of the renewable fuels industry, policy makers, and anyone who is interested in improving the efficiency and environmental performance of corn ethanol, this white paper provides an overview of efficiency opportunities at each stage of the production process. This paper also provides a high-level menu of innovative practices that ethanol plants can implement to reduce energy use, costs and greenhouse gas emissions.

Key findings from our research:

- There are several strategies available to ethanol producers that can reduce energy use and carbon emissions during the production process.
- While many Midwestern ethanol plants have implemented these strategies, there remains a large opportunity for implementation at a significant number of existing plants.
- Implementing these practices can accelerate the commercialization of additional renewable energy technologies (like anaerobic digestion) and next generation biofuels through bioenergy feedstock establishment and cellulosic bolt-on projects at existing plants.
- Opportunities to implement process improvements will vary from plant-to-plant and a one-size fits all approach may not be effective. Instead, a better approach is to have a menu of options to improve the efficiency of the production system.
- This paper is only a starting place. The industry must invest in further research to determine the costs and benefits of each strategy and to establish best practices for biofuel producers.

Ethanol Today: Production and Innovation

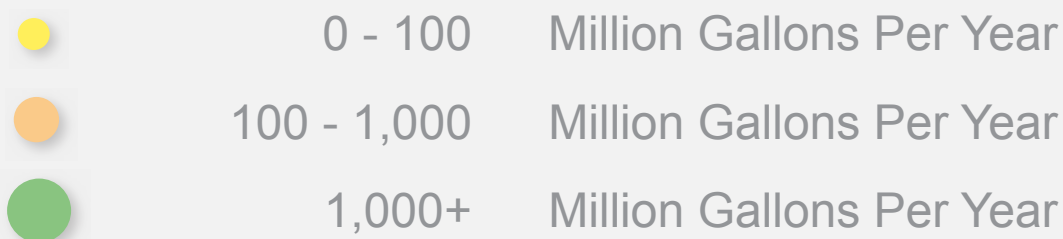
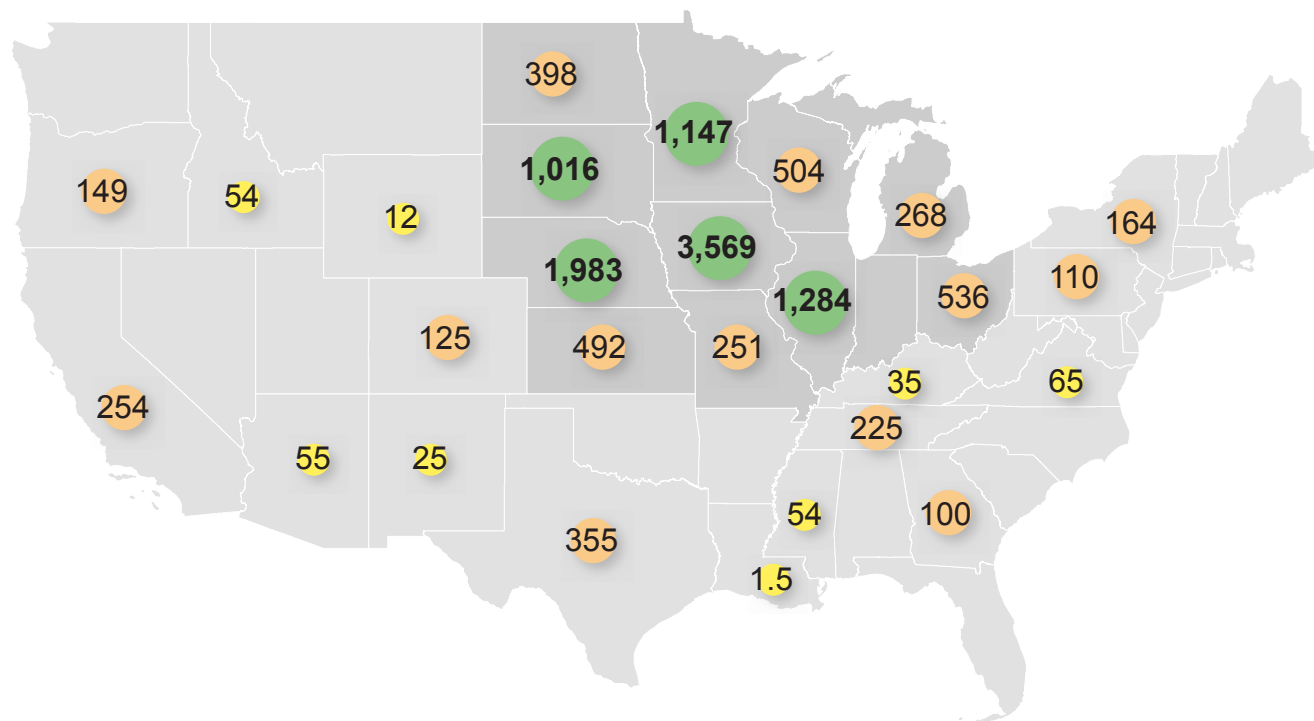
The United States is home to **211 biorefineries** with a production capacity of nearly **15 billion gallons of ethanol per year**. Almost 85 percent of the installed ethanol capacity is in the twelve states that make up the Midwest (*Nebraska Energy Statistics*). There are two different types of production processes used to make corn ethanol: dry milling and wet milling. Approximately 90 percent of current corn ethanol production occurs in dry mill plants (*RFA*). This white paper discusses technology and process improvements for dry mill ethanol plants.

Midwestern corn ethanol producers have been implementing technology and process improvements to reduce energy use and diversify the sources of process fuel. Driven by a combination of economic incentive and environmental stewardship, these changes have improved fuel production efficiency and the overall economics of the production system. They have also reduced greenhouse gas emissions.

Policies such as the Renewable Fuel Standard or California's Low Carbon Fuel Standard (LCFS) now require that biofuel producers measure the greenhouse gas emissions for fuel production on a lifecycle basis. The goal of the LCFS is to reduce the carbon intensity (CI) of transportation fuels by 10 percent over 10 years by either increasing the use of low carbon fuels or by implementing process improvements in existing facilities. A legal challenge to the LCFS is currently pending in California and arguments are scheduled for summer of 2012. Due to a recent court decision, however, implementation of the policy can proceed until the case is resolved. Oregon and Washington are also in the process of designing a low carbon fuels program, as well as a coalition of states in the Northeast and Mid-Atlantic region. Internationally, the Canadian Province of British Columbia has a low carbon fuel policy in place and the European Union's Fuel Quality Directives require reductions in the carbon intensity of transportation fuels. These policies will reward the most innovative producers, thus encouraging investment in new technology and process improvements for biofuel production.

There are opportunities to reduce energy use and decrease carbon emissions at each stage of the ethanol production process. Additional opportunities also exist in the agriculture and feedstock production system. While important, these are not the focus of this paper. Rather, this paper focuses on potential improvements at the biorefinery. Opportunities to implement process improvements will vary from plant-to-plant and a one-size fits all approach may not be effective. Instead, a better approach is to have a menu of options for ethanol producers to improve the efficiency of the production system. The white paper provides an overview of the options on the menu.

Figure 1. Ethanol Production Capacity (2012) - Million Gallons Per Year



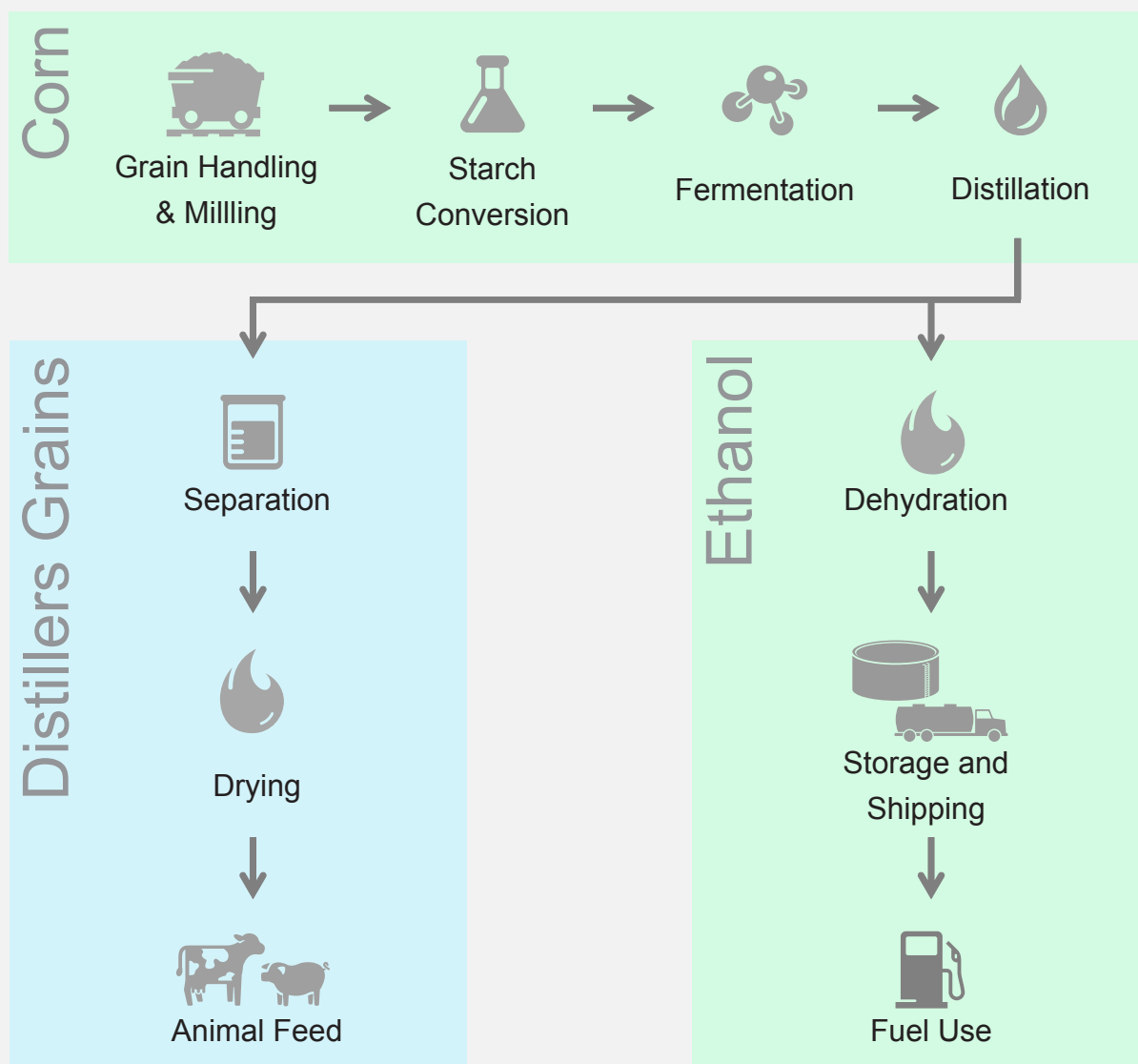
Source: Nebraska Energy Office, April, 2012

This paper provides information about the various process improvements or technology strategies that ethanol plants can implement to reduce energy use, costs and greenhouse gas emissions. It also includes examples of plants throughout the Midwest that have already adopted these technologies and process improvements. Although many ethanol plants in the Midwest have already implemented some of these technologies, a large opportunity for additional implementation still exists. In addition to improving overall energy productivity for ethanol plants, these technologies and process improvements can support the development of additional renewable energy technologies, like anaerobic digestion, and commercialization of next generation biofuel projects, through bioenergy feedstock establishment and cellulosic bolt-on projects.

The Corn Ethanol Production Process

The traditional process for producing ethanol from corn involves a number of steps to process, convert and ferment corn grain into alcohol and other co-products. Figure 2 presents a process flow diagram for a typical dry mill ethanol plant that produces ethanol as well as wet and/or dry distillers grains.

Figure 2. Process flow diagram of a conventional corn ethanol plant



Descriptions of each production stage are listed on pages 5 through 7. The energy use estimates provided for each stage are based on a 40 million gallon per year (MGY) plant.

Grain handling and milling



Corn kernels arriving at a plant must be processed and placed onto the production pathway. Once the kernels are received and handled, Hammermills grind the corn into flour or meal. The electrical energy used at this stage makes up approximately 11 percent of the total electrical demand of the plant (MN TAP).

Starch conversion



A two stage process, starch conversion involves liquefaction and saccharification. During liquefaction, corn meal is mixed with water in a slurry tank, the acidity or pH value is adjusted with ammonia and enzymes are added to digest the corn starch. Steam and heat cook the slurry to the desired temperature for different periods of time.

After liquefaction, the pH and temperature are further adjusted to begin saccharification, a process in which a second enzyme is added to break the starch down into sugars. Once saccharification is complete, the mixture, referred to as mash, is pumped into fermentation tanks. Electrical energy use during the starch conversion process is approximately 4 percent of the plant's total electric use and the steam requirements represent approximately 15 percent of the plant's total thermal demand (MN TAP).

Fermentation



After the mash is produced and cooled, yeast is added to convert the sugars to carbon dioxide (CO_2) and alcohol by fermentation. The mash must be cooled to prevent the yeast from being killed by the heat generated during this phase. Fermentation can take place either continuously or in batches and produces beer, a mixture of water, grain solids and approximately 10 to 15 percent ethanol. CO_2 is also produced during fermentation. Each bushel of corn produces approximately 18 pounds of CO_2 (MN TAP). The fermentation process represents approximately 8 percent of the total electrical load for a facility (MN TAP).

Distillation



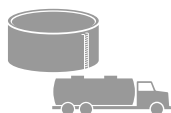
The majority of the water is removed from the beer during distillation. A system of three columns is used to heat the ethanol/water mixture to remove solids and separate the water from the ethanol. Distillation accounts for about 70 percent of the total steam demand for an ethanol plant (MN TAP). In some plants, a closed-loop system recaptures the steam used by some of the equipment for reuse in a boiler.

Dehydration



During dehydration, two molecular sieves pull any remaining water from the ethanol vapor. Once the water is removed, the ethanol vapor is cooled to convert it to liquid form, resulting in pure ethanol fuel. This stage uses about 1 percent of the total steam demand for a plant (MN TAP).

Storage and shipping



Ethanol must be prepared for delivery by adding a small amount of gasoline to denature the product so that it is not purely alcohol. Denatured ethanol is stored on-site until it is ready to be shipped to a terminal for blending. There is no significant energy demand during this stage.

Separation



The solids left over after distillation can be processed and used as animal feed. Stillage from the bottom of the beer column is sent through centrifuges to separate the coarse grains from the solubles. Evaporators are used to remove the remaining water, producing a syrup containing 35 percent solids. The evaporated water is treated with biomethanators for reuse. Syrup is mixed with coarse grains to form wet distiller's grains with solubles (WDGS). WDGS have a 60 percent moisture content and can be used as animal feed for local livestock markets. The separation process uses approximately 30 percent of the total electrical demand for the plant and uses steam recovered from the distillation stage (MN TAP).



Drying

To be used beyond local livestock markets, WDGS are processed through dryers to reduce moisture content to 10 percent. The resulting product is referred to as dried distillers grains with solubles (DDGS). Because drying limits spoilage, reduces odor and increases shelf-life, DDGS can be used in livestock markets internationally or in other areas of the United States. Most ethanol plants use natural gas to fire a grain dryer, which uses 42 percent of the all thermal energy consumed by the facility (MN TAP). This stage uses about 30 percent of the total electrical demand for the plant in order to power fans, mixers and dryers (MN TAP).

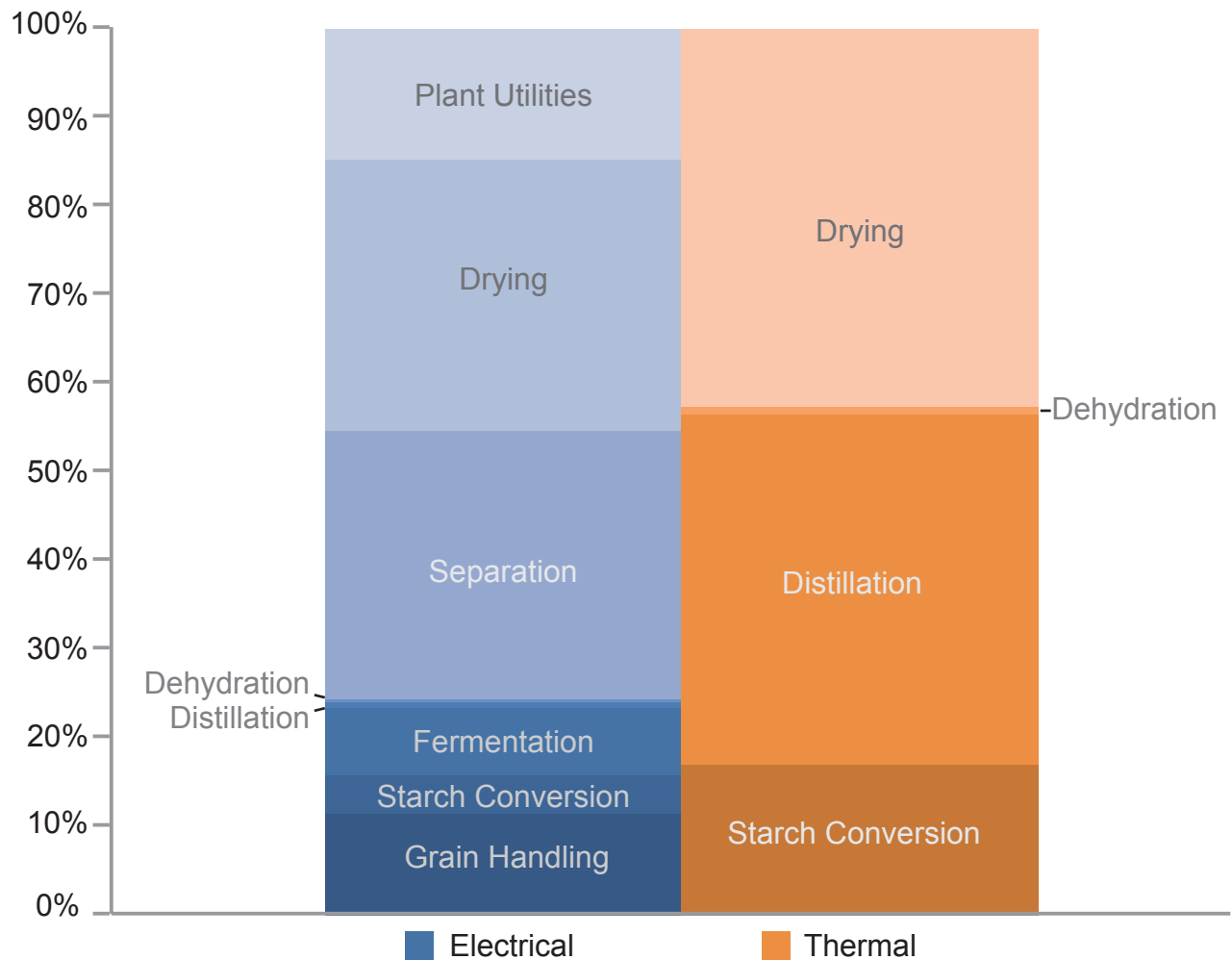


Plant Utilities

In addition to each of the production stages, there are additional electrical loads required to run water pumps, thermal oxidizers, boilers, cooling towers, chillers, air compressors, lighting, water treatment equipment and chemicals. These additional power demands are referred to as plant utilities and represent approximately 15 percent of the total electrical load for a plant (MN TAP).

There are opportunities to improve energy efficiency and reduce carbon emissions at each production stage. Figure 3 shows the share of energy use for each stage and provides valuable context for identifying opportunities for energy reduction. The drying, distillation and starch conversion stages have the largest energy requirements and are often the stages where production efficiencies or alternative process fuel technologies can be integrated. The next section of this whitepaper will go into more detail on technology and process improvements for dry mill corn ethanol production.

Figure 3. Electricity and thermal energy use of ethanol production



	Electrical	Thermal
Grain Handling	11.5%	-
Starch Conversion	4.3%	17.0%
Fermentation	7.6%	0.0%
Distillation	0.6%	39.5%
Dehydration	0.4%	0.8%
Separation	30.3%	-
Drying	30.5%	42.7%
Plant Utilities	14.8%	-

Strategies for Energy Efficiency and Carbon Reduction

Efficiency in the corn ethanol industry

The U.S. ethanol industry has made significant advancements in energy efficiency over the past decade. According to a study completed by the University of Illinois-Chicago, a typical dry mill ethanol plant increased its thermal energy efficiency by 28 percent between 2001 and 2008 (Mueller 2010). In 2001, ethanol plants used an average of 36 thousand BTUs of thermal energy to produce one gallon of gasoline, while in 2008 they used on average less than 26 thousand BTUs per gallon (Mueller 2010). A 32 percent decrease in electricity demand was also documented by the study (Mueller 2010). While these process efficiency improvements demonstrate the gains already made by the industry, there are still a number of opportunities to improve the production efficiency of ethanol by encouraging greater adoption of process improvements and efficient technology. Many of these opportunities are described in the following pages.

This section is organized into four broad categories: water use, industrial energy efficiency, alternative process fuel and co-products. Within each category, descriptions of potential improvement strategies are provided, as well as examples of ethanol plants in the Midwest that have implemented the strategy. The facility examples are intended to be illustrative and are not an exhaustive depiction of innovation throughout the ethanol industry. Where available from previously published literature, information on energy or carbon reduction, costs, and savings is also provided. Ranges are provided for carbon intensity reduction estimates to reflect the fact that actual CI reductions will vary from plant-to-plant.

Water Use

Water is needed during the grain handling, liquefaction, fermentation, separation and drying stages of ethanol production (Wu). Ethanol plants have been improving water efficiency over the last decade. In 2008, the average dry mill ethanol plant used 47 percent less water compared to 2001 (Muller 2010). According to public reports for ethanol plants in Minnesota, water use decreased by 30 percent from 5.8 gallons to 4.1 gallons of water per gallon of ethanol between 1998 and 2006 (MN TAP). POET Biorefining, the nation’s largest ethanol producer, asserts that the typical POET facility uses less than 3 gallons of water per gallon of ethanol. The company has aspirations to reduce average water use to 2.33 gallons of water per gallon of ethanol (POET).

Water efficiency gains can be made by reducing process steam, reducing cooling water use, reusing wastewater in the production process, or increasing water recycling in other process stages (MN TAP 2008). Water recycling can increase both water and energy efficiency, as recycled water requires less energy to be reheated. Below are three examples of Midwestern ethanol plants that have made aggressive efforts to reduce water use through recycling, new technology and process improvements.

Examples	Didion Milling	Wisconsin
	Guardian Energy	Minnesota
	POET Biorefining	South Dakota

Industrial Energy Efficiency

Combined heat and power

Combined heat and power (CHP) captures excess heat from conventional electricity production to be utilized as thermal energy. A single fuel like natural gas, coal or biomass is burned to produce electricity while the thermal energy is transferred for use in another industrial process. Due to their continuous power and steam demand for fuel refining, ethanol plants are a good fit for CHP. Thermal energy is used at ethanol plants for cooking distillation and drying.

Facilities using CHP can increase overall efficiency from 49 percent to 75 percent (EPA 2012). Excess electricity not used at the plant can be sold back to the electric grid. Operating a CHP system at an ethanol plant can also have an impact on greenhouse gas emissions. An ethanol plant using natural gas as a process fuel with CHP offers a 32 percent reduction in GHG emissions compared to gasoline (Wang).

CHP can reduce energy and operating costs. A 50 million gallon per year (MGY) plant that increases natural gas use by 10 percent for CHP can meet approximately 35 to 40 percent of the plant’s electricity needs (Hasselman).

Examples	Adkins Energy	Illinois
	East Kansas Agri-Energy	Kansas
	Otter Creek Ethanol	Iowa
	U.S. Energy Partners and City of Russell	Kansas

20 - 30 g/MJ CO₂e reduction

Source: Kaliyan

\$3.5 million capital cost	↑
\$100 thousand / year O&M cost	↑
\$700 thousand electrical savings	↓
\$300 thousand natural gas savings	↓
\$250 thousand other savings	
Source: Hasselman	

Co-location

An ethanol plant can also co-locate next to a power plant or large industrial facility to gain a source of waste steam. Co-location can eliminate the ethanol plant’s need for a steam boiler and water supplies to generate steam. Unless a new power plant or industrial facility is built next to an existing ethanol plant, this is an opportunity that should be considered during the planning stages of building an ethanol plant.





Examples	Blue Flint Ethanol	North Dakota

Industrial Energy Efficiency




Waste heat recovery

Waste heat recovery captures thermal energy that would otherwise be vented or left unused. Once the thermal energy is captured it can be used to meet thermal or electrical demands for a plant. In general, there are three approaches to waste heat recovery: thermal oxidizer heat recovery, heat exchangers, and the installation of new equipment.

Thermal oxidizer heat recovery captures waste heat from exhaust gases vented through a thermal oxidizer. By capturing the heat and running it through a heat exchanger, plants can reduce burning natural gas to produce heat for other processes in the ethanol production process, resulting in energy savings and decreased fossil energy demand. This process can be used to help meet air emission standards. Biorefineries should be aware that this practice may impact existing air and water permits. A discussion with local regulators is encouraged when considering this process improvement.

Examples	ACE Ethanol	Wisconsin	<div>\$1.5 - \$2.5 million capital cost </div> <div>950 thousand therms of natural gas </div> <div>Source: Hasselman</div>
	The Andersons Marathon Ethanol	Ohio	
	Badger State Ethanol	Wisconsin	
	Chippewa Valley (CVEC)	Minnesota	

Heat exchangers provide the ability to recover heat from processes within the production system. Integration and optimization of heat exchangers in an ethanol plant provide the ability to capture and use thermal energy instead of wasting it and can lower overall thermal energy requirements for a plant.

Examples	Ace Ethanol	Wisconsin	<div>\$23 thousand steam cost </div> <div>4 thousand MMBTU boiler savings </div> <div>16 MWh cooling tower savings </div> <div>Source: Hasselman</div>
	ADM	Iowa, Illinois, Minnesota	

The *installation of new types of equipment*, such as fans, pumps and motors, can reduce energy use and improve process efficiency. Some motors under development can improve overall efficiency by 5 percent and the efficiency of boilers could increase by nearly 15 percent (Mueller 2009).

Examples	Marquis Energy	Illinois and Wisconsin
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Alternative process fuel

Most ethanol plants rely on natural gas and grid electricity to meet their energy needs. Instead of relying on fossil-based source for heat and power, ethanol plants can use alternative forms of fuel to meet process needs. This can reduce a plant's greenhouse gas emissions.

Biomass

Biomass combustion or gasification converts organic material into heat, synthesis gas (syngas), biofuels and chemicals. Biomass combustion has the potential to reduce energy costs and carbon intensity by replacing natural gas. Ethanol plants that combust biomass as process fuel reduce greenhouse gas emissions by 39 to 52 percent (Wang). Biomass gasifiers may require additional energy due to a small efficiency loss in the switch from a natural gas to a biomass fired boiler. Research indicates that an additional 7,500 BTUs is needed per gallon of ethanol to compensate for the efficiency loss. (Mueller 2009).

Incorporating biomass combustion at existing ethanol facilities can also help lead to the commercialization of next generation biofuel projects by establishing a market for cellulosic feedstocks and helping to overcome harvesting, storage and transportation logistics.



Minnesota-based Chippewa Valley Ethanol Company built a full-scale biomass combustion project using wood chips as a fuel source. A corn cob harvesting pilot project was implemented near the plant to work closely with local feedstock providers to supply a source of biomass. Due to the current low price of natural gas, it is not economically feasible for the plant to operate the gasifier at this time. Because biomass has the potential to reduce energy costs and carbon intensity by replacing natural gas, however, the plant is working with local regulators to secure the necessary permits to combust a mix of feedstocks in the future.

Examples

Chippewa Valley Ethanol Company
Corn Plus Ethanol
POET Biorefining

Minnesota
Minnesota
South Dakota

Carbon reduction and capital costs for utilizing biomass feedstocks are listed in Figure 4 on page 14.

Ethanol plants can reduce carbon intensity even further by implementing combined heat and power (CHP) with biomass combustion.

Alternative process fuel

Figure 4. Carbon reductions and cost of utilizing biomass as a process fuel

<i>Fuel Type</i>	<i>Carbon Reduction</i>	<i>Capital Cost</i>
Corn stover	10 - 20 g/MJ	\$34 million
Syrup and stover	1 - 10 g/MJ	\$24 million
Stover + CHP	30 - 40 g/MJ	\$69 million
Syrup and stover + CHP	25 - 30 g/MJ	\$56 million
Stover + CHP + Grid	30 - 40 g/MJ	\$71 million
Syrup and stover + CHP + Grid	40 - 50 g/MJ	\$87 million

Kaliyan et al., 2011

Morey, 2011

CHP: combined heat and power

Grid: selling excess electricity back to the distribution grid

*Carbon reduction measured against a Midwest dry-grind 50 MGY plant with a CI score of 56.4 grams of CO₂ equivalent per megajoule (gCO₂e/MJ, average Midwest corn production and average grid electricity.

Raw starch hydrolysis

Raw starch hydrolysis, or the cold cook process, uses enzymes instead of heat to convert uncooked starch to glucose, essentially eliminating the liquefaction and saccharification steps from the ethanol production process. This reduces the thermal energy demands at the ethanol plant. Raw starch hydrolysis is a proprietary process developed by POET currently used at 24 of the company's 27 biorefineries. This process reduces energy use by an estimated eight to 15 percent and can reduce the need for cooling water. Researchers estimate that using raw starch hydrolysis can reduce thermal energy demand by 5,000 BTUs per gallon (Mueller 2009). Since this is proprietary process, it is unlikely this process would be retrofitted into an existing, non-POET, plant.

Alternative process fuel

Landfill gas recovery

Landfill gas recovery (LFG) captures methane and carbon dioxide from landfill solid waste. Once LFG is captured, it can be converted to produce electricity or refined to replace fossil natural gas. When LFG is combusted to produce electricity, waste heat from the engine can be recovered to help meet thermal needs for the plant. There may be a higher cost associated with transporting captured landfill gas to a local plant.

Examples	Mid-Missouri Energy	Missouri
	POET Biorefining	South Dakota
	Siouxland Ethanol	Nebraska

10-mile pipeline w/LFG system:	
\$6.3 million capital cost	↑
\$410 thousand / year O&M	↑
	Source: EPA
1 - 10 g/MJ CO ₂ e reduction	↓
	Source: CARB

Biogas recovery

Biogas recovery systems use anaerobic digestion, a biological process that breaks down waste biomass in an oxygen free environment. Decomposing material produces biogas: a mixture of methane and carbon dioxide. Collected biogas can be converted to electricity and heat, or processed further as a direct replacement for fossil natural gas. Thin stillage waste from ethanol plants can be processed in an anaerobic digester. A 100 MGY ethanol plant treating thin stillage through anaerobic digestion could produce 970 thousand MMBtu/year of biogas energy (Hasselman). Ethanol plants commonly use biomethanators that capture biogas from non-fermentable contaminants in process water. The collected biogas can be used to offset a small amount of natural gas (MN TAP).

In a closed-loop biogas and ethanol model, a biogas recovery system at a livestock operation can be co-located with an existing ethanol facility to supply alternative process fuel to the ethanol plant. According to research from the University of Nebraska, a closed-loop model could reduce the carbon intensity of ethanol production by 10-20 g/MJ (Liska).

Examples	Adkins Energy	Illinois
	Western Plains Energy	Kansas

10 - 20 g/MJ CO ₂ e reduction	↓
Source: CARB	

\$14 - \$18 million capital cost	↑
\$5.8 - \$9.6 million savings per year	↓
1.5 - 3 year payback	↓
3 GWh / year electrical reduction	↓
607 thousand MMBtu / year thermal energy reduction	↓
Source: Hasselman	

Co-products

Combining distillers grains

Ethanol plants can reduce energy use by combining wet, dry and/or modified distillers grains, depending on local market demands. Selling wet distillers grains to local livestock operations can reduce the amount of distillers grains that need to be dried, therefore reducing thermal energy use. Producing a mixture of wet, dry and modified distillers grains and feeding it to local livestock markets could reduce greenhouse gas emissions by approximately 46 percent (Bremer). This reduction is a result of decreased energy use at the plant and emissions credits for displacing conventional feed.



Examples	Hawkeye Renewables	Iowa
	Louis Dreyfus Commodities	Iowa
	White Energy	Kansas

10 - 20 g/MJ CO ₂ e reduction	↓
Source: Bremer	
Increased transportation costs for grains to livestock market	↑
Reduced thermal energy demand	↓



Corn oil extraction

Corn oil extraction can be performed before or after the ethanol distillation process. Corn oil extracted before distillation can be used as a food grade product. Oil extracted after distillation can be used in the alternative fuel market as a biodiesel feedstock. Although additional energy is required to extract corn oil, the thermal energy required to dry the distillers grain is reduced and heat transfer during the drying process is improved, resulting in a net energy savings. The GreenShift Corporation estimates corn oil extraction can decrease fuel production emissions from seven to 25 percent.

Examples	Little Sioux Corn Processors	Iowa
	Iroquois Bio-Energy	Indiana
	The Andersons Albion Ethanol	Michigan

\$7 - 12 million capital cost	↑
10 - 20 g/MJ CO ₂ e reduction	↓

Co-products

Carbon capture and storage

Carbon capture and storage (CCS) captures carbon dioxide from ethanol fermentation and stores it in underground geologic formations. Several ethanol plants are currently capturing carbon dioxide for food, beverage and industrial markets.

ADM is currently demonstrating this technology at their Illinois Industrial Carbon Capture and Sequestration (ICCS) Project. This commercial-scale project will capture one million tons of CO₂ per year at an ADM ethanol plant. Dehydration and compression equipment will be used to transport the CO₂ which will then be injected for storage in the Mt. Simon Sandstone Formation (NEORI 2012b).

Examples

ADM

Illinois

25-35 g/MJ CO₂e reduction



Source: Kaliyan

CCS with Enhanced Oil Recovery

CCS with Enhanced Oil Recovery (EOR) is a strategy that presents an additional market opportunity for fermentation CO₂ from ethanol plants in parts of the midwest. According to analysis from Advanced Resources International (ARI), the states of Illinois, Indiana, Kansas, Michigan, Nebraska, North Dakota, South Dakota and Ohio all have potential candidate reservoirs for EOR using CO₂ (CO₂-EOR) (ARI 2009). CO₂-EOR is a proven process that can expand domestic oil supplies by injecting CO₂ into already developed oil fields. ARI estimates that an additional 25 - 61 billion barrels of oil could be economically recovered with current technology and that future technology could recover an additional 67 - 137 billion barrels (ARI 2011). Injected CO₂ can help move previously unrecovered oil closer to the surface. Injected CO₂ can be separated from the recovered oil using above-ground equipment and can be re-injected in a closed-loop system to reuse the CO₂ multiple times (NEORI 2012a). Through this closed-loop system, CO₂ is either stored in the geologic formation or recycled back to the injection well for re-use.

Examples

Arkalon Energy

Kansas

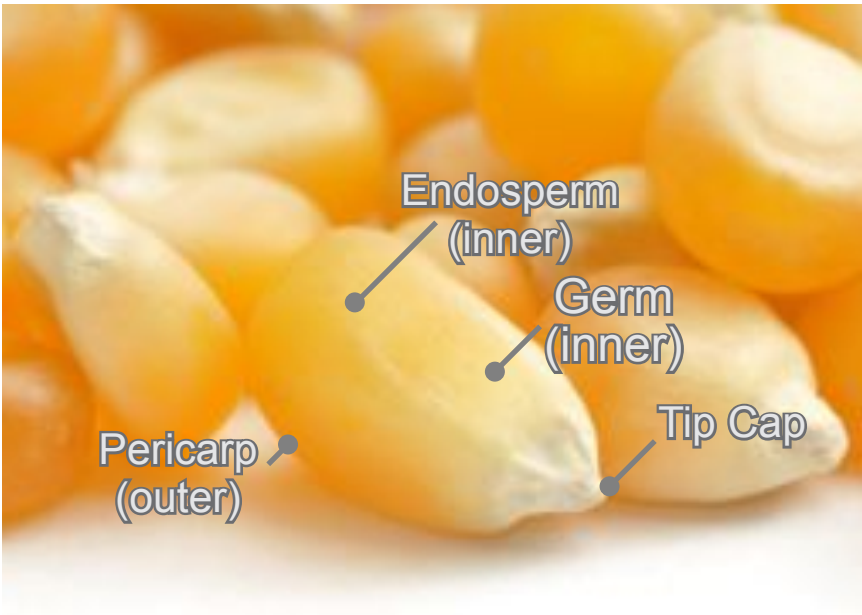
Co-products

Dry mill corn fractionation

Dry mill corn fractionation splits the corn kernel apart into its basic elements: the pericarp, the endosperm, the germ and the tip cap prior to ethanol processing. Fractionation allows an ethanol plant to market multiple co-products such as high protein animal feed, food grade corn oil or a bioenergy feedstock. Fractionation reduces the energy demand for drying, since the germ and the bran are removed before fermentation. It is estimated that fractionation can reduce thermal demand by 31 percent (Mueller 2009).

Examples	Badger State Ethanol	Wisconsin
	Didion Ethanol	Wisconsin
	Illinois River Energy	Illinois

Figure 4. Four main components of a corn kernel



Conclusion

Commercializing next generation biofuels, such as cellulosic ethanol made from agriculture residues and other types of biomass, is an important national priority. But we shouldn't forget the potential that exists to improve the carbon intensity of our existing fleet of corn ethanol plants. With nearly 15 billion gallons of capacity, representing about 10% of the country's gasoline, the potential for improvement is vast. Ethanol producers in the Midwest have made tremendous strides in improving the overall performance of the production system. By adopting innovative technology practices and improving production efficiencies, many ethanol plants have lowered carbon emissions and reduced energy and water use.

Actions taken by individual plants have improved the overall efficiency of the entire industry. Several of the technology practices discussed in this paper will aid in the commercialization of next generation biofuels and can be incorporated at future facilities. Although the industry has made strides to improve production efficiency, there is still additional opportunity to innovate. Individual companies and plants recognize this opportunity and are continuing to make changes to improve the production system.

This paper laid out opportunities and provided general information on estimated carbon reductions, energy savings and implementation cost. However, additional study is needed on the costs, benefits and economic rates of return in order to lead to broader adoption. A robust cost and benefit analysis could provide greater certainty to renewable fuel producers and would be a worthwhile industry investment.

In recent years, policymakers have tended to focus on advanced and cellulosic fuels. While this is very important, this report indicates that additional focus should be given to supporting existing producers. Now that the volumetric excise tax credit for ethanol has expired and does not look likely to be renewed, the time is right for a discussion about new policies that assist the industry in improving their carbon intensity.

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