On March 29, 2007, GS CleanTech Corp. staff completed the installation of its corn oil extraction system at Utica Energy, LLC's 52-million-gallon-per-year ethanol production facility in Oshkosh, Wisconsin, USA. The system will produce more than 1.1 million gallons per year of corn oil (or about 4.2 million liters per year), according to GS CleanTech. Photo courtesy of GS CleanTech Corp.

two fuels from one KERNEL

A new trend in the ethanol industry could alter the food-vs.-fuel-vs.-feed debate by increasing the efficiency of ethanol production. Three companies ——VeraSun Energy Corp., Renessen LLC, and GS CleanTech Corp.——are at the forefront of the movement.

Catherine Watkins

New technology is blurring the line between the ethanol and biodiesel industries as dry-mill ethanol plants add equipment to remove corn oil either before or after the fermentation process. The corn oil can then be used for biodiesel production even as its removal adds value to other by-products of ethanol production.

"There are a number of current and evolving technologies for corn oil extraction," says Mike Bryan, chief executive officer of BBI International, a consultancy based in Salida, Colorado, USA. "The two basic options are front-end removal, which removes the oil before processing the corn, and the back-end process, which removes the corn oil after fermentation and distillation. The front-end extraction process produces a cleaner corn oil and captures 50% more product. However, as one might expect, the cost is at least triple that of back-end extraction processes. So for the ethanol producer, it becomes a matter of analyzing the intended end use and the capital cost required for implementation."

FRONT-END EXTRACTION

Renessen LLC (Bannockburn, Illinois, USA) is innovating on two fronts by developing a new fractionation process as well as breeding new value-added corn varieties. The company, which is a joint venture between Cargill and Monsanto, has constructed a $12-million pilot facility in Eddyville, Iowa, USA, to test its process by

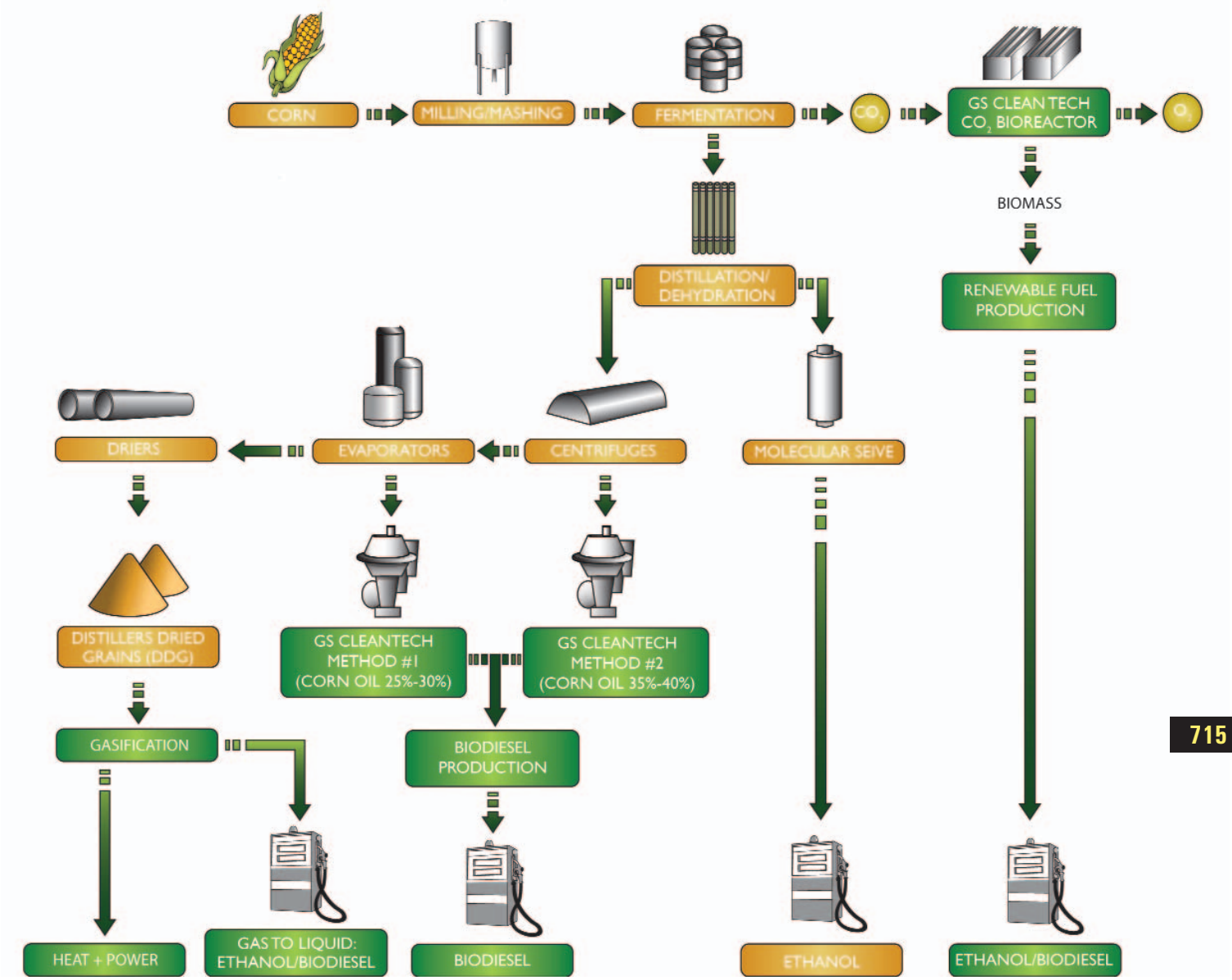

FIG. 1. *GS CleanTech's ethanol program. Adapted from an image courtesy of GS CleanTech Corp.*

simulating a 100-million-gallon-per-year (MMgy) capacity plant (378.5 million liters per year).

The proprietary process—which can be retrofitted to existing plants—boosts efficiency, the company website (netlink: www.renessen.com) says, by extracting nonfermentable parts of the grain before fermentation along with high-value, food-grade corn oil. The process delivers four co-products: corn oil, a swine and poultry feed, a highly fermentable starch, and high-protein, low-oil distillers' dried grains (DDG). The oil is of high enough quality to be used in either food manufacturing or biodiesel production, according to the site. (The company did not respond to requests for an interview.)

The Renessen website also says its system will both reduce and improve the DDG by-product. DDG currently constitute about one-third of every bushel of corn used for ethanol manufacture. They are wet and dense, making transport difficult, and have a high oil content, which limits their use as a feed for ruminants, swine, and poultry. The new system, however, will reduce DDG production by up to 40% and leave them drier, which will lower handling charges. The DDG will also be higher in protein and lower in oil, making them more attractive as a feed, Renessen materials say.

In 2007, the company will test its new conventionally bred MAVERA™ corn in its Eddyville pilot plant. This new variety has almost twice the oil (6.8%) of standard yellow corn No. 2 (3.5%). In 2008, Renessen will begin testing a bioengineered high-oil corn at the Eddyville plant. The bioengineered variety has increased levels of the amino acid lysine, an important element in livestock feed.

BACK-END EXTRACTION

Whereas Renessen is removing corn oil before processing ethanol, VeraSun Energy Corp. (Brookings, South Dakota, USA) will remove corn oil from DDG after ethanol is produced. VeraSun plans to use a proprietary centrifuge technology to extract corn oil from the evaporation area of dry-mill ethanol plants. The company has

Ethanol production primer

Dry-grind ethanol production—which accounted for 82% of U.S. ethanol manufacturing as of January 2007—starts by grinding corn into coarse flour and combining it with water and enzymes. The enzymes begin the conversion process of starch to sugar, creating a mash that is then cooked and sterilized. After cooling, yeast is mixed with the mash to ferment the sugars into ethanol, carbon dioxide, and other metabolites. The fermented mash is then sent to the distillation system to extract the ethanol. The mash is now considered spent mash, which then goes on to either a screen press or centrifuge, where as much liquid as possible is drawn off.

The liquid that is separated either goes back into the cooking system and is sold as livestock feed, or is partially dehydrated into syrup, called condensed distillers' solubles (CDS). The spent grains can also be sold as livestock feed as wet distillers' grains, or they can be dried, in which case they are called distillers' dried grains (DDG). If the syrup is added to the wet distillers' grains and then dried, the resulting product is referred to as distillers' dried grains with solubles (DDGS).

Source: Adapted with permission from materials provided by the National Corn Growers Association at netlink: www. ncga.com/ethanol/coproducts/definition.asp.

contracted with Crown Iron Works (recently purchased by CPM) for the extraction equipment and expects to begin installation by year's end at its Aurora, South Dakota, plant. The construction phase will last one year, a spokesperson said, adding that "once the technology is in place, we will begin extracting oil from dried distillers' grains and selling the oil to the biodiesel market. We will then make the technology available to all our existing facilities." The company at one time announced plans to build a 50 MMgy (189.3 million liters/year) biodiesel plant with corn oil as the primary feedstock, but later thought better of the plan.

"Our research has shown there is better opportunity by selling the oil back to the market," the spokesperson said.

Also working on the recovery of corn oil from the ethanol production process is GS CleanTech Corp., a subsidiary of GreenShift Corp. of New York City, USA. GS CleanTech's process removes the corn oil from a dry-mill ethanol plant's thin stillage, which is the precursor to DDG. The extraction system can be retrofitted to existing plants, and the company offers ethanol producers several options. Plants can purchase the process technology and equipment outright and sell the corn oil at going rates, or GS CleanTech will finance and build a turnkey oil extraction system in exchange for the rights to buy the plant's oil.

In that case, GS CleanTech will sell the corn oil to GS AgriFuels, another GreenShift subsidiary, which is co-locating four corn oil-based biodiesel plants on site

at ethanol plants in the U.S. states of New York, Iowa, Indiana, and Illinois. They will be small-scale modular plants, ranging from 5 to 40 MMgy, and will be integrated with the host ethanol plant.

Ethanol plants that use GS CleanTech's corn oil extraction system save on utility costs, according to Chairman and CEO Kevin Kreisler.

"A 100 MMgy ethanol facility will save about $1 million per year in dryer costs," he says, "and ethanol plants that participate in extraction and host co-located biodiesel production will receive more than $8 million per year (for a 100 MMgy ethanol producer) in additional earnings for no investment."

Overall, GS CleanTech's current corn-oil contracts should produce about 49 MMgy (or about 185.5 million liters) of crude corn oil for conversion into biodiesel fuel once the extraction systems come online during 2007 and 2008, Kreisler says.

This will represent a significant increase in the use of corn oil as a feedstock for biodiesel, which currently comprises a mere 0.159% (2 MMgy) of the total U.S. operational capacity, according to Soyatech LLC's Biofuels Index. Soyatech is a consultancy based in Bar Harbor, Maine, USA.

Conventional ethanol production produces approximately 18 lb (about 8.2 kg) of DDG from a bushel (approximately 56 lb or 25.4 kg) of corn. According to Kreisler, GS CleanTech's patent-pending Corn Oil Extraction System targets the 2 lb (about 0.9 kg) of corn oil in the DDG component, leaving 16 lb (about 7.3 kg) of a more valuable, higher-protein and lower-fat animal feed. The system can extract about 6.5 MMgy of corn oil from a 100 MMgy ethanol producer's stillage, Kreisler notes.

GS CleanTech and its cluster of subsidiaries have also developed a commercial-scale biomass gasification system. By gasifying the remaining 16 lb of DDG created from each bushel of corn processed for ethanol production, or the equivalent amount of locally available biomass, the company says the clean fuel conversion efficiency of ethanol plants can be increased significantly.

Gasification converts carbonaceous materials into synthetic gas, or syngas, which either can be used to generate a renewable source of heat and power with standard generation equipment or can be catalyzed into renewable fuels such as methanol, ethanol, or biomass-derived synthetic diesel using Fischer-Tropsch technology.

The trend toward co-production of corn oil and ethanol in ethanol plants is a classic win-win-win situation: The ethanol producer extracts more profit, DDG buyers receive a product better suited to their needs, and the biodiesel industry has an additional feedstock to help sustain production and, over time, shift the dynamics of the food-vs.-fuel-vs.-feed debate.

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