

**Lifecycle Emissions of POET Biorefining – Emmetsburg**

**Corn Kernel Fiber Cellulosic Ethanol with CA-GREET2.0**

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## **Tier 2 Pathway Lifecycle Emissions of POET Biorefining – Emmetsburg Corn Kernel Fiber Cellulosic Ethanol with CA-GREET2.0**

### **Introduction**

POET Biorefining – Emmetsburg requests approval of a provisional Tier 2 pathway under the California Air Resource Board LCFS program. The pathway request uses corn kernel fiber as a feedstock to produce cellulosic ethanol. The carbon intensity for the fuel production is modeled using CA-GREET2.0. This report analyzes the well-to-tank life cycle carbon intensity of the cellulosic ethanol produced from using corn kernel fiber. All inputs and outputs of the production process are modeled using CA-GREET2.0 and the results are summarized in this report.

The report is organized into the following sections:

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### **Facility Information**

POET Biorefining – Emmetsburg is located at 4724 380th Street, Emmetsburg, IA 50536. The facility produces approximately 65 million gallons of traditional starch and cellulosic ethanol per year from both corn starch and corn kernel fiber. The plant also produces dry distillers grains, wet distillers grain, modified wet distillers grains, and corn oil. Process fuels used in the plant are natural gas and grid electricity. Ethanol produced at the facility is shipped by rail from Emmetsburg, SD to blending terminals in California.

### **POET Overview**

POET, the world's largest biofuels producer, is a leader in biorefining through its efficient, vertically integrated approach to production. The 30-year-old company has a network of 27 production facilities that produces a total of 1.8 billion gallons of ethanol, 10 billion pounds of distiller's grain, and 600 million pounds of corn oil annually. POET, through its joint venture with DSM, also operates a commercial-scale cellulosic ethanol plant in Emmetsburg, Iowa. For more information, visit <http://www.poet.com>.

## **Biofuel Overview**

According to the United States Department of Agriculture, starch-based biofuel reduces greenhouse gas emissions by 43 percent compared to conventional gasoline, would further reduce greenhouse gas emissions by 50 percent by 2022, and has the potential to reduce emissions by as much as 76 percent. Cellulosic biofuel has a greenhouse gas reduction of 75-90 percent over 2005 gasoline baseline.

## **POET Cellulosic Overview**

POET is a world leader in development of cellulosic ethanol technology. The most publicly visible work to date has been “Project LIBERTY” in Emmetsburg, Iowa.

Project LIBERTY is the product of a joint venture between POET, the world’s largest biofuel producer, and DSM, a global science-based company active in health, nutrition and materials. The venture’s first commercial-scale plant has a design-capacity of 20 million gallons per year, later ramping up to 25 million gallons per year. It uses corn cobs, leaves, husk and some stalk harvested by farmers primarily within a 35-mile radius of the facility.

This facility is a commercial plant, used to demonstrate the process to the world. POET-DSM Advanced Biofuels, LLC intends to license the technology to other producers, so that cellulosic biofuel production can spread across the U.S. and around the world.

In 2017, POET-DSM overcame the major hurdles in pretreatment, allowing us to devote resources to aligning downstream processes. Since then we’ve cleared a number of challenges in other areas. We are happy to announce that unit operations are in sync today, and we are focused on bringing all levels up to capacity.

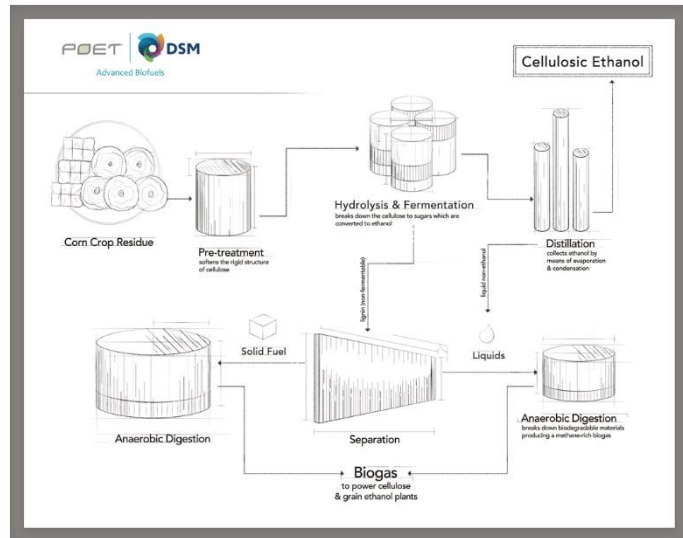
We are also building a first-of-its-kind on-site enzyme manufacturing facility at Project LIBERTY to more efficiently deliver enzymes to the process.

Project LIBERTY is co-located with an existing starch biofuel plant, taking advantage of synergies

- Energy use: The co-product of cellulosic biofuel is energy (steam and biogas). Energy not used in the process is exported to the adjacent starch plant to offset natural gas.
- Feedstock procurement: The same farmers providing grain to the starch biofuel plant also provide the crop residue that feeds Project LIBERTY.
- Infrastructure: Biofuel storage, rail and other existing infrastructure benefit the economics of Project LIBERTY considerably.
- Experience: Team members at the existing starch facility work in conjunction with those in the cellulosic facility, providing extensive experience in most aspects of the process.

Project LIBERTY currently holds an approved pathway that demonstrates a lifecycle analysis of approximately 78% reduction of greenhouse gases when compared to gasoline. These GHG savings are due to a number of factors including

- Production of steam and biogas to offset natural gas use at the facility itself and the adjacent starch facility
- Environmental benefits that are inherent to biofuel over gasoline including reductions in tailpipe emissions
- Utilization of a feedstock that is already being planted, with minimal added fertilizer inputs



In addition to Project LIBERTY, POET has also leveraged its patented raw starch low temperature (i.e. no cook) process (aka BPX Process) to efficiently convert kernel fiber to cellulosic ethanol.

In 2014 the EPA published the final rules regarding additional renewable fuel pathways that had been approved by the Agency under the RFS Program. The new rules qualified corn kernel fiber as a cellulosic feedstock, meaning it meets the 60% green house gas (GHG) reduction and qualifies for the generation of D3 RINs.

The EPA rules governing these new kernel fiber pathways allow for essentially two approaches for kernel fiber conversion:

- 1) Producers of Cellulosic Fuels Derived From Conversion of Feedstocks That Are Predominantly Cellulosic
  - a) “Predominantly Cellulosic” is defined as Feedstock that has an average adjusted cellulosic content of 75%, measured on a dry mass basis; furthermore, this “adjusted cellulosic content” is the percent of organic (nonash) material that is cellulose, hemicellulose, or lignin
- 2) Producers of Cellulosic Fuels Derived From the Simultaneous Conversion of Feedstocks That Are Predominantly Cellulosic and Feedstocks That Are Not Predominantly Cellulosic (aka: in situ process)

The POET BPX Process enables the production of cellulosic ethanol by way of leveraging the native cellulase enzymes in grain to convert the kernel fiber simultaneously with the starch conversion process. In this manner, the POET BPX Process qualifies for the production of cellulosic fuels derived from the simultaneous conversion of feedstocks that are predominantly cellulosic and feedstocks that are not predominantly cellulosic (aka: in situ process).

Producers using the pathway that claims simultaneous conversion of feedstocks that are predominantly cellulosic and feedstocks that are not predominantly cellulosic (aka: the in situ process) are required to quantify the amount of ethanol that is derived specifically from cellulosic content (i.e. kernel fiber) and from starch. To accomplish this, the Producer needs to accurately and precisely measure the amount of cellulosic content and starch present before the conversion process begins and after the conversion process is complete. POET utilizes a third party laboratory to accurately quantify the levels of cellulosic content and starch present before the conversion process begins and after the conversion process is complete, and uses that data to calculate the converted fractions of cellulosic content and starch. The converted fractions for starch and cellulosic content are needed to calculate the percentage of renewable fuel produced that can be considered cellulosic (i.e. derived from cellulosic feedstock). These calculations are prescribed in 40 CFR §80.1426.

Kernel fiber represents the most readily accessible cellulosic biofuel feedstock and holds the potential to provide over 1.8 billion gallons of cellulosic ethanol annually. Because the kernel fiber is a feedstock that is already being delivered commensurate with starch to the existing grain biofuel production facilities, kernel fiber ethanol production also represents the fastest route to commercialization for cellulosic biofuels. Technology development in kernel fiber conversion will be leveraged to continue the development of cellulosic biofuel production across feedstocks that are predominately cellulosic. In essence, kernel fiber cellulosic biofuel production acts as a critical financial and technological stepping-stone to other cellulosic feedstock conversion.

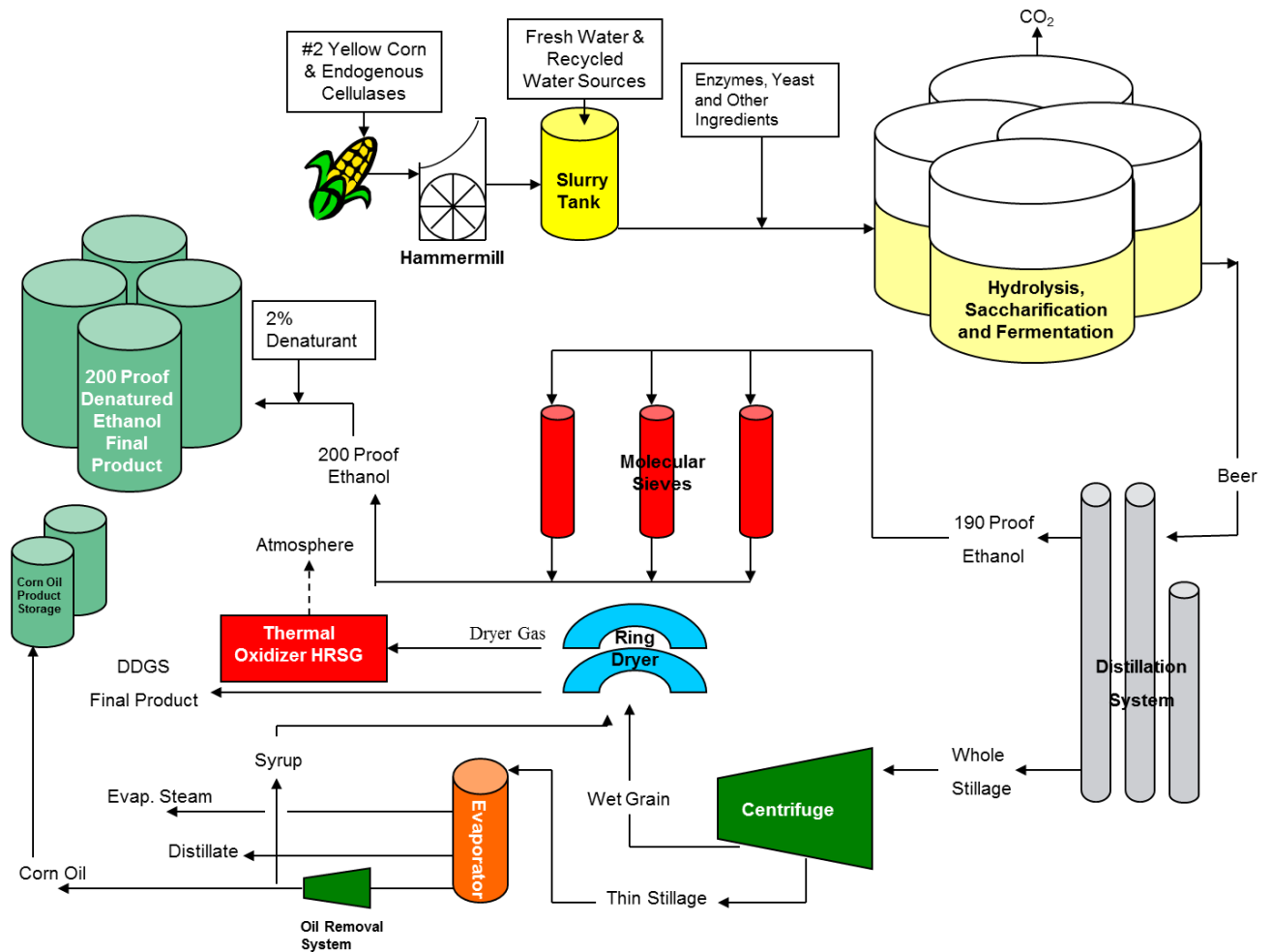
### **BPX Process Overview**

The POET BPX Process is a patented production platform that is deployed at all POET Biorefinery production sites. The BPX Process is a raw starch conversion process that converts native starch in grain without the typical high temperature cooking and gelatinization steps. The BPX Process converts starch in grain without ever exceeding a temperature of 110 degrees F. Conventional ethanol technologies have liquefaction and jet cooking processes that bring typical cook temperatures to 190 to 195 degrees F. The thermal efficiencies of the BPX Process result in less natural gas consumption, leading to an energy savings of 8 to 15 percent, along with the related reduction in greenhouse gas emissions.

Additionally, due to the maintenance of low temperatures under the raw starch hydrolysis process, bioactive molecules native to grain retain their functionality. These bioactive molecules include endogenous enzymes that are leveraged to facilitate the conversion of both starch and fiber. Exogenous cellulases can also be added to further enhance the conversion of kernel fiber.

The BPX process therefore reduces energy costs, significantly decreases plant emissions, releases additional starch content for conversion to ethanol, increases protein content and quality of co-products, improves yield per bushel of corn, and converts kernel fiber using endogenous enzymes.

**Figure 1. Production Process Overview**



**Other POET Sustainability Efforts**

POET facilities are constantly evolving as our researchers and engineers find new ways to improve efficiency and sustainability. Breakthroughs in our laboratories are piloted at the POET Research Center in Scotland, SD and then implemented at commercial plants across our network.

Since 2001, POET has cut energy use by 30%. We have cut energy use in half since the company began in 1987. That has been accomplished in some cases by developing technology – such as BPX – that have been deployed across the POET network. In addition each facility looks for its own opportunities to improve efficiency and sustainability, taking advantage of location, local partnerships, unique markets and other factors.

- POET has received EPA ENERGY STAR awards for the use of Combined Heat & Power at production facilities in Ashton, Laddonia and Macon.

- POET has seven plants that use steam turbines to produce about 1/3 of the power requirement for the facility. Five more plants have steam turbine projects under construction today.
- At POET Biorefining – Emmetsburg, POET has installed two alternative energy sources to displace natural gas usage.
  - A Solid Waste Fuel Boiler burns wood chips from recycled pallets and other wood waste that otherwise would have been destined for landfills. It has the capacity to displace 60 percent of the plant’s natural gas usage.
  - The Sioux Falls Regional Landfill pipes methane gas to the plant. It displaces approximately 10 percent of the plant’s natural gas usage.
- Total Water Recovery technology means POET plants have zero process water discharge. The company is saving more than 1 billion gallons of water per year compared to 2009. POET averages 2.3 gallons of water per gallon of ethanol. In 1987, the first plant POET purchased took in 17 gallons of water per gallon of ethanol.
- POET Biorefining – Caro (Michigan) installed a waste heat recovery system that replaces about 10 percent of the facility’s natural gas needs and reduces water use by 5 percent. It also decreases the plant’s down time for cleaning by almost 50 percent because less live steam is running through the process.

**CA-GREET2.0 Model Inputs**

The input values for the CA-GREET2.0 model are listed below in Table 1.

Table 1. POET-Emmetsburg CA-GREET2.0 Modifications			
CA-GREETv2.0 Worksheet Location	Parameter	CA-GREETv2.0 Default Cell Value	POET-Emmetsburg Pathway Value
T1 Calculator!E9	Fuel production regional electricity mix	N/A	7-MROW Mix
T1 Calculator!E13	Ethanol produced, gal	100,000,000	
T1 Calculator!E22	Natural Gas, Btu/gal	27,296	
T1 Calculator!E26	Electricity (kWh/gal)	0.61	
T1 Calculator!E28	Alpha Amylase (grams/gal)	2.55	
T1 Calculator!E29	Glucos Amylase (grams/gal)	5.48	
T1 Calculator!E31	Yeast (grams/gal)	2.78	
T1 Calculator!E32	Sulfuric acid (H2SO4, (grams/gal)	0	
T1 Calculator!E34	NaOH (grams/gal)	0	
T1 Calculator!E36	Urea (grams/gal)	0	
T1 Calculator!E44	From EtOH Plant to railyard (mi)	50	0
T1 Calculator!E47	From railyard to CA railyard (mi)	1,850	2,017
EtOH!L440	Indirect Land Use, g/MJ	19.8	0

Because all emissions associated with corn farming and transportation and indirect land use have already been applied to the traditional starch ethanol pathway, there are no feedstock related emissions or indirect land use emissions modeled for ethanol produced from corn kernel fiber. Furthermore, because ethanol derived from corn kernel fiber and corn starch are processed simultaneously in an in-situ process, the processing energy is proportionally allocated to all the ethanol produced at the facility.

## CA-GREET2.0 Results

Component	Corn Kernel Fiber
Corn Farming	0.000
Ag Chemical	0.000
Feedstock T&D	0.000
Ethanol Production	
Ethanol T&D	
Co-Product Credit	0.000
Denaturant	
Land Use Change	0.000
Total (Well to Wheel)	35.39

Table 2 provides the resulting carbon intensity for the proposed pathway using the CA-GREET2.0 model.

### Summary

Cellulosic ethanol produced from corn kernel fiber at the POET Biorefining – Emmetsburg Facility has a total well-to-wheels carbon intensity of 35.39 gCO<sub>2</sub>e/MJ.

### References

CARB recently approved two similar pathways for cellulosic ethanol derived from corn kernel fiber. Both application packets are listed below.

Siouxland Energy Cooperative (SEC)

[https://www.arb.ca.gov/fuels/lcfs/fuelpathways/comments/tier2/t2n-1210\\_cover.pdf](https://www.arb.ca.gov/fuels/lcfs/fuelpathways/comments/tier2/t2n-1210_cover.pdf)

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[https://www.arb.ca.gov/fuels/lcfs/fuelpathways/comments/tier2/t2n-1153\\_cover.pdf](https://www.arb.ca.gov/fuels/lcfs/fuelpathways/comments/tier2/t2n-1153_cover.pdf)

### Supporting Data

The modified CA-GREET model can be found in the application packet. Inputs to the model are based on actual invoices and receipts from the time period listed in the provisional pathway. The invoices and receipts are summarized in the energy consumption spreadsheet which are all provided in the application packet.