Final Staff Summary
Method 2B LCFS Application for the
Production of Cellulosic Ethanol from
Corn Stover Residue Feedstock at
POET-DSM Project Liberty, Emmetsburg, IA
(ARB Code: ETHB004)

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Pathway Summary

This staff summary describes a corn stover pathway for cellulosic ethanol produced by POET-DSM at their newly constructed Project Liberty Cellulosic Ethanol Plant in Emmetsburg, Iowa (Project Liberty Plant). The facility is expected to produce over 13 million gallons per year of ethanol using corn stover as feedstock.
The Final Staff Summary addresses the public concerns raised during the public comment period when the pathway was initially posted for public comment.

Corn stover is comprised of the dried leaves, stalks, husk, and cobs left on the ground after the harvest of the primary corn crop. In partnership with local farmers, POET-DSM Project Liberty will collect and bale the corn stover for subsequent transport to the Project Liberty Plant for conversion to ethanol. A polypropylene netting material is used to hold the bales together. The bales are transported to the Project Liberty Plant on tractor-trailers. The carbon intensity (CI) determined for the corn stover pathway includes the GHG emissions impacts associated with the fertilizer/nutrients that must be applied to fields from which corn stover has been removed. This application makes up for the nutrients lost when corn harvesting residues are removed.

Upon arrival at the Project Liberty Plant, the corn stover is shredded and screened to remove the biomass fines, which are used as process fuel for the solid fuels boiler (SFB). The netting material used to wrap the corn stover bales are also separated in the screening process and used as fuel for the SFB. The screened feedstock undergoes an acid pre-treatment process which begins to decompose the cellulosic biomass and primarily produce C5 (xylose) monomer sugars. The remaining biomass is then subjected to enzymatic hydrolysis which produces the C6 (glucose) monomer sugars. This process first involves neutralizing the biomass after acid pre-treatment process with Ammonia, followed by the addition of cellulase enzymes.
The C5 and C6 sugars produced are then fermented into ethanol using yeast.
The fermented beer is then distilled to produce near-pure ethanol at the top of the distillation column, and stillage at the distillation bottoms. The liquid and solids in the stillage are then sent to filter presses to further separate the stillage into filter cake and filtrate. The filter cake is used as process fuel for the SFB, while the filtrate is sent to the wastewater treatment plant where it is anaerobically digested to produce biogas and

sulfur cake. The biogas produced could be used as a process fuel but is considered surplus to the corn stover pathway. Sulfur cake and ash produced by the SFB are sent to landfill for disposal.

The Project Liberty Plant is dependent upon grid-based electricity, as well as fossil-based natural gas from the pipeline. GHG impacts from grid-based energy utilization were assessed for the corn stover pathway. In addition to anhydrous ethanol, Project Liberty produces two valuable co-products; surplus steam from the SFB, and biogas from the wastewater treatment process. Both co-products are exported to the nearby corn-starch plant in Emmetsburg (Emmetsburg), where these co-products are assumed to displace natural-gas based utilization. The GHG emissions associated with the equivalent displacement of natural gas utilization at Emmetsburg accrues as a credit to the Liberty corn stover pathway.

The ethanol produced is denatured and loaded onto rail car tankers destined for California. Once the ethanol arrives in California, it is assumed to be transported in heavy-duty diesel tanker trucks to a bulk terminal 40 miles away where it is blended with CARBOB gasoline to produce reformulated gasoline. Following blending, the reformulated gasoline is distributed to fuel dispensing stations 50 miles away from the blending terminal.

Facility Location and Coordinates

The POET-DSM Project Liberty Cellulosic Ethanol Plant is located in the city of Emmetsburg, Iowa. The geographic coordinates of the centroid of the Project Liberty Plant are 43°05'26" N (latitude), and 94°39'17" W (longitude). The newly constructed Project Liberty Plant is not shown in the satellite view (Figure 1). This is because the date of the image pre-dates the construction of the Project Liberty Plant. The satellite image does however show the corn-starch plant located in the vicinity.

Figure 1
Satellite View of
Unconstructed POET-DSM Project Liberty Cellulosic Ethanol Plant
Emmetsburg, Iowa

Carbon Intensity (CI) of the Liberty Corn Stover Pathway

The inputs POET-DSM used to calculate the Well-to-Wheels (WTW) CI of the Liberty Corn Stover Pathway is described below.

Corn Stover Collection (Harvesting) and Transport

The crop residue used as feedstock for cellulosic ethanol production at the Project Liberty Plant consists of corn stover left on the ground by mechanized harvesting equipment after harvest of the corn crop. It is collected by a 2nd pass baling process in the fields, netted, and then stacked. Only diesel fuel energy is expended in the feedstock collection process.[1]

The applicant has also assessed the GHG emissions associated with the polypropylene (PPE) netting material used to secure the bales. The baled corn stover is then loaded onto tractor trailers and transported to the Project Liberty Plant. The mode of transport was considered to be heavy, heavy-duty diesel truck with a cargo payload of 25 tons, and an estimated average transport distance of 35 miles.

Farming Chemicals

As stated previously, the corn stover feedstock is considered to be a residue of the corn harvesting process. Agricultural phase GHG emissions do not accrue to residues. Removal of the corn stover from the ground however deprives the soil of essential nutrients, including nitrogen (N), potassium (K), and phosphorus (P) present in the corn stover residue. POET-DSM assumes that all N, P, and K nutrients displaced from the fields by corn stover removal would be replenished by application of synthetically produced fertilizer. The net amounts of fertilizer needed to replenish the soil are the quantities stated in Table 1 below:

Table 1
Nutrient Replenishment Rates for Corn Stover and Wheat Straw Removal

NUTRIENT**	CORN STOVER (g / dry ton)
N*	7,140
P as P_2O_5	2,040
K as K_2O	12,240

*Includes an additional 10 percent for loss due to fertilizer volatilization during field application.
** Nutrient rates include an estimated 2 percent dry matter loss during feedstock transportation to the ethanol plant.

[1] The quantity of fuel energy expended during feedstock collection operations was determined to be confidential business information by the applicant.

Process Chemicals and Specialty Enzymes

POET-DSM anticipates using chemicals such as sulfuric acid, caustic (sodium hydroxide), anhydrous ammonia, lime, limestone, as well as cellulase enzymes for pre-treatment and hydrolysis process operations. While their usage rates are considered to be confidential business information, the life cycle impacts of process chemicals and specialty enzyme use for the Liberty corn stover pathway was determined using data available from the CA-GREET 2.0 life cycle analysis model. In addition to chemical and specialty enzyme use, yeast is also used during the sugar-to-ethanol fermentation process. GHG impacts for additional chemicals use were also estimated and assessed for the Liberty corn stover pathway.

Ethanol Production

Ethanol production generates GHG emissions when lignin and other unconverted cellulosic biomass from process yields are combusted to produce steam for process thermal energy requirements. While lignin is a biogenic process fuel, CH_4 and N_2O emissions from combustion of lignin are not considered to be biogenic, and hence contribute to GHG impacts. CH_4 and N_2O GHG impacts from combustion of biomass fines, netting materials, filter cake, and syrup were assessed for the Liberty corn stover pathway. POET-DSM has assumed that combustion of process biomass in the boiler would have a GHG emissions profile similar to the combustion of corn stover.

The Project Liberty Plant is dependent upon grid-based electricity and natural gas for their process operations. GHG impacts from grid-based electrical energy use and natural gas use were assessed for the corn stover pathway.

Ethanol T&D

The ethanol produced at the Project Liberty Plant from the corn stover residue feedstocks is denatured, loaded onto rail car tankers, and transported 1,790 miles to an intermodal rail facility in California. The ethanol is then transferred 40 miles from the rail yard to a bulk terminal by heavy-duty diesel-fueled tanker truck. It is expected that the ethanol will be blended with CARBOB here, and then transported another 50 miles to a fuel dispensing facility also by heavy-duty diesel-fueled tanker trucks.

Co-Product Credit for Export of Surplus Steam and Biogas

POET-DSM has claimed that surplus steam and all biogas produced at the Project Liberty Plant will be exported to the corn-starch plant at Emmetsburg. There, the use of surplus steam and biogas is expected to displace an equivalent amount of fossil-based natural gas used to generate steam and fuel for their process. Transport losses were factored into this energy export, and a co-product credit for surplus steam and biogas export was credited to the Liberty corn stover pathway.

The aggregated inputs discussed above, along with the pathway CI are summarized in Table 2 below:

Table 2
Summary of Disaggregated WTW GHG Emissions for the Liberty Corn Stover Pathway

Pathway Disaggregated Item	Liberty Corn Stover Pathway GHG Emissions (g CO_2e/MJ)
Agricultural Chemicals (Make-up N / P / K Nutrients)	12.81
Corn Stover Collection	4.34
Corn Stover Transport to Project Liberty Plant	2.31
Ethanol Production:	
Cellulosic Chemicals, and Net Wrap Life Cycle Emissions, and Transport	15.50
Natural Gas Use for Process	4.90
Grid-Based Electricity for Process	74.72
Solid Fuels Boiler Biomass and Netting Wrap Combustion Emissions	3.85
Wastewater Treatment Plant Fugitive Methane Emissions	1.63
Boiler Ash and Sulfur Cake Transport to Disposal	1.12
Ethanol Transport & Distribution	2.76
Addition of Denaturant	2.94
Well -to-Tank (WTT) Emissions Before Co-Product Credits	**126.88**
Less Surplus Biogas and Steam Export Co-Product Credits	-105.30
Total Well -to-Tank (WTT)	**21.58**
Carbon in Fuel (Tank-to-Wheels)	-
Indirect Land Use Change Estimates	-
Total Well-to-Wheels (WTW) Estimate	**21.58**

The proposed Lookup Table entry for the POET-DSM Liberty Corn Stover Pathway is presented in Table 3 below:

Table 3
Proposed Lookup Table Entries for Fuel/Feedstocks

Fuel	Pathway Identifier	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)		
			Direct Emissions	Land Use or Other Indirect Effects	Total
Ethanol	ETHB004	2B Application*: Corn Stover residue-based cellulosic ethanol with surplus steam and biogas export co-product credits.	21.58	0.00	21.58

* Specific Conditions Apply.

Applicable Operating Conditions

Operations at the POET-DSM Project Liberty Plant located in the township of Emmetsburg, Iowa will be subject to the following conditions designed to ensure that the CI of the ethanol sold under the Liberty corn stover pathway described in this Final Staff Summary will remain at or below the value appearing in Table 3 above. The conditions must be met for every gallon of ethanol sold by POET-DSM Project Liberty in California. Exceptions are allowable only in the case of brief periods of planned maintenance or unpredictable, unavoidable, and uncontrollable *force majeure* events, or during production ramp up phase to stabilize the ethanol and biomass energy production processes for a period not to exceed six months from the date of final certification of this pathway.

1. POET-DSM shall monitor and record the quantity of cellulosic ethanol produced, and calculate the ethanol yield, as measured on a bone dry ton basis for every batch of corn stover-based feedstock entering the pre-treatment process. The records shall be averaged over 12 months and reported to the Executive Officer of the California Air Resources Board within 30 days after the end of the calendar year, POET-DSM fiscal year, or Project Liberty Plant production year. Subsequent annual records shall be submitted using the same basis.

2. Corn stover removal rates from farms around the Project Liberty Plant shall not exceed **25 percent**.[2] The corn stover removal rates shall also be contingent upon future research results identifying sustainable crop residue removal rates.

[2] Staff notes that this rate was determined to be sustainable harvest rate by the applicant, based on their research studies.

3. POET-DSM shall monitor and notify the Executive Officer of the California Air Resources Board if any of the following changes occur:

    a. The plant either changes one or more of the chemicals or specialty enzymes it uses in its process, or increases the usage rate of the existing chemicals or specialty enzymes beyond the levels specified in the POET-DSM Method 2B LCFS application for the Liberty corn stover pathway.

    b. The transport mode, or distance over which the chemicals or specialty enzymes transported changes.

    The chemical and enzyme usage quantities, and transport distances shall be monitored on an ongoing basis, and any changes from the original application shall be reported to the Executive officer of the California Air Resources Board within 30 days after the end of the calendar year, POET-DSM fiscal year, or Project Liberty Plant production year. The Executive Officer may determine that any changes reported require a CI adjustment.

4. The CI for ethanol produced under the Liberty corn stover pathway includes credits for export of surplus steam and biogas. Only surplus steam and biogas produced from process yields of materials identified in the POET-DSM Method 2B LCFS application for the Liberty corn stover pathway (biomass fines, filter cake, syrup, netting materials, and natural gas utilized as process fuels in the SFB) qualify for the surplus steam and biogas export co-product credits.

    POET-DSM shall submit to the Executive Officer invoices for surplus steam and biogas sales to Emmetsburg after ethanol production at the Project Liberty Plant has stabilized. The invoices shall state the net quantity and energy value of the surplus steam exported (average flow rate in pounds per hour, enthalpy, pressure, and temperature of the steam exported), as well as the net quantity and energy value of the surplus biogas exported to Emmetsburg. These invoices for surplus steam and biogas exports shall be accompanied by copies of an audited[3] production report for ethanol produced at the Project Liberty Plant. Official ethanol production reports shall continue to be submitted on a quarterly basis to the Executive Officer of the California Air Resources Board for a period of two years.

5. POET-DSM shall submit to the Executive Officer copies of receipts for all external (grid-supplied) electricity and natural gas purchases. Receipt submittals shall begin when commercial operations have stabilized at the

[3] The production report must be audited by a certified public accountant, or the accounting firm that prepares POET-DSM's Annual Report to shareholders, or an independent Professional Engineer licensed in the State of Iowa. The audited report must also be attested by the Plant Manager of the Project Liberty Plant.

Project Liberty Plant, and continue until the Executive Officer is in possession of receipts for two years of operations. In addition, POET-DSM shall calculate the CI for the Liberty corn stover pathway every quarter during the two year period, and submit the detailed results to the Executive Officer. These calculations shall be based on actual operational data, and reflect the grid electricity and natural gas purchases for the period. If one or both actual operating pathway CIs are above the certified CI, the Executive Officer may increase the certified CI to better reflect the actual operational CI.

6. Biogas losses from the corn stover pathway shall not exceed 0.5 percent of the total biogas produced and measured by the methane leak detection program instituted at the Project Liberty Plant.

7. The Plant Manager of the Project Liberty Plant must also attest in writing to the veracity of the information presented in the audited reports to the Executive Officer. That attestation shall be in the form of an original signed letter on POET-DSM letterhead.

Staff Analysis and Recommendations

Staff has reviewed POET-DSM's application for certification of ethanol produced from corn stover residue and finds the following:

- Staff has replicated with reasonable accuracy the carbon intensity calculations provided by the applicant. Staff has made this determination based upon the material and energy use information, design considerations, process yields, and other input parameters furnished by the applicant.

- Staff recognizes that the Project Liberty Plant consumes grid-based natural gas and electricity for their process, and uses unconverted cellulosic biomass to produces surplus steam energy. Surplus biogas is additionally produced from the wastewater treatment process at the Project Liberty Plant. Both surplus steam and biogas are exported to Emmetsburg, and factor into the co-product credits for the Liberty corn stover pathway.

- On the basis of these findings, ARB staff recommends that POET-DSM's application for Method 2B LCFS pathway be certified with a CI of 21.58 gCO_2e/MJ of ethanol fuel produced for the Liberty corn stover pathway, subject to the operating conditions set forth in this document.