Ethanol Derived from Corn Kernel Fiber Qualifies for the Renewable Fuel Standard Regulations' D Code 3 under Section 80.1426, Table 1

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EPA has established pathways through which renewable fuels may generate Renewable Identification Numbers (RINs). A volume of fuel must be assigned a pathway in order to qualify under the Renewable Fuel Standard (RFS2) regulations.

Table 1 of Section 80.1426 establishes a D code 3 as a pathway for ethanol produced from cellulosic biomass from "crop residue" through "any" process. However, there has been some discussion regarding the ability of a renewable fuel producer to use D-code 3 for ethanol derived from the cellulosic and hemicellulosic components of corn kernel fiber. This paper explains why the production of ethanol from corn kernel fiber constitutes a renewable fuel and also qualifies for the pathway associated with D-code 3.

Corn kernel fiber is a residue from the processing of whole corn kernels into ethanol or other "useable resources." In the conventional corn starch ethanol process, the fiber contained in the inbound corn kernels is non-fermentable and ends up in distillers grains (which is itself a residue of corn ethanol processing). Only the starch portion of the kernel (~75% of the kernel by mass on a dry basis) is converted to ethanol, while the other residual components (primarily protein, oil and fiber) pass through the process. This is synonymous with bagasse, which is the residue left over after sugarcane milling/sugar extraction, a material that EPA specifically mentions as a "crop residue" from processing.[1]

Background: Cellulosic biofuel is a subcategory of renewable fuel under EPA's Renewable Fuel Standard ("RFS2"). Section 80.1401 of the RFS2 rules defines cellulosic biofuel as:

> Cellulosic biofuel means renewable fuel derived from any cellulose, hemi-cellulose, or lignin that has lifecycle greenhouse gas emissions that are at least 60 percent less than the baseline lifecycle greenhouse gas emissions.

Section 80.1401 defines *renewable fuel* in relevant part as "a fuel ... that is produced from renewable biomass" and defines *renewable biomass* to mean:

> each of the following (including any incidental, de minimis contaminants that are impractical to remove and are related to customary feedstock production and transport): Planted crops and crop residue harvested from existing agricultural land cleared or cultivated prior to December 19, 2007 and that was nonforested and either actively managed or fallow on December 19, 2007.

Section 80.1401 further defines *crop residue* as:

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[1] The fiber typically represents 9% of the mass of the corn kernel on a dry basis. In some cases, the high fiber content found in the residual distillers grains has been a barrier to increased feeding use of DG in some animal diets (particularly poultry). Thus, removing the fiber from DG could result in a higher value residual feed co-product with broader application in the feed market.

> the biomass left over from the harvesting or processing of planted crops from existing agricultural land and any biomass removed from existing agricultural land that facilitates crop management (including biomass removed from such lands in relation to invasive species control or fire management), whether or not the biomass includes any portion of a crop or crop plant.

Section 80.1426(f) states D codes *shall* be used in RINs generated by producers of renewable fuel according to the pathways listed in Table 1 and that "[i]n choosing an appropriate D Code, producers may disregard any incidental de minimis feedstock contaminants." Table 1 of this provision establishes a D-Code 3 as a pathway for ethanol produced from cellulosic biomass from "crop residue" through "any" process.

Thus, ethanol derived from corn kernel fiber would qualify as a cellulosic biofuel if:

1. **it is derived from crop residue,**
2. **the biomass itself is derived from cellulose, hemicellulose, or lignin, and**
3. **lifecycle GHG emissions are at least 60 percent less than baseline emissions from petroleum.**

Moreover, it would qualify for the D Code 3 pathway if it is produced from crop residue through *any process*. As explained below, because corn kernel fiber is a crop residue as defined in the regulations, it may use D code 3 to generate RINs and need not apply for a special pathway designation.

Corn Kernel Fiber is a Crop Residue: Crop residue is defined in the final RFS2 regulations as "the biomass left over from the harvesting *or processing* of planted crops..." 40 CFR § 80.1401 (emphasis added). After initially proposing to only include biomass left over from harvesting, in the final rule EPA noted that it agreed with public comments "encouraging us to expand the definition of crop residue to include the materials left over after the processing of the crop into a useable resource, *such as* husks, seeds, bagasse, and roots." *See* 75 Fed. Reg. 14692 (emphasis added); *see also* RFS2 Summary and Analysis of Comments, 3-48.

Notably, EPA relied upon agricultural/crop residues from sugarcane bagasse and sweet sorghum pulp in its analysis of likely 2022 feedstocks. *See* 75 Fed. Reg. 14754-44. Corn fiber, like bagasse and sweet sorghum pulp, also is derived from the processing of planted crops, and is commonly considered a "crop" or "agricultural" residue. A cursory review of the scientific literature's treatment of "agricultural" or "crop" residues confirms that corn fiber is commonly

understood to be a crop residue. Indeed, corn fiber is often mentioned alongside corn stover, bagasse, and other crop residues as potential feedstocks for cellulosic biofuel production.[2]

EPA did not intend "crop residue" to be limited to specific enumerated examples cited at various points in the preamble. Rather, any crop residue that meets the regulatory definition would qualify. EPA's broad approach to qualifying biomass is demonstrated in its response to comments. There, EPA declined to alter the definition of cellulosic biofuel to include specific examples of crop residues, noting that the existing definition's reference to "any" cellulose, hemicellulose, or lignin made it clear that the crop residues cited by the commenter were included. *See* RFS2 Summary and Analysis of Comments, 3-27.

Corn Kernel Fiber is "Cellulosic Biomass:" Residual corn kernel fiber remaining after fermentation is derived primarily from cellulose, hemicellulose, or lignin, thus qualifying ethanol derived from these corn fiber components as a cellulosic biofuel. There is some residual starch remaining in corn fiber (mass balance analysis showed the ethanol produced via the Quad County Corn Processors [QCCP] corn fiber process came from a ratio of 16.8% starch and 83.2% cellulose).[3] However, section 80.1426(f)(3) of the RFS regulation (*"Renewable fuel that can be described by two or more pathways")* clearly allows for generation of RINs with different D codes when two feedstocks (i.e., corn fiber cellulose/hemicellulose and corn fiber starch) are "used at the same time to produce a single type of renewable fuel" (i.e., ethanol).

Corn Kernel Fiber meets the 60% Lifecycle Requirement Based on Table 1's Plain Language: Having demonstrated that corn fiber is a crop residue and is cellulosic in nature, corn fiber ethanol would qualify as a cellulosic biofuel as long as it meets the statutory minimum 60% lifecycle GHG reduction threshold for cellulosic biofuels.

The only remaining question is whether producers of corn fiber ethanol can avail themselves of an existing RFS2 cellulosic biofuel pathway, or if such producers must petition the agency to formally model a corn fiber ethanol pathway in order to demonstrate that corn fiber ethanol meets the GHG reduction threshold. Quad County Corn Processors (QCCP) has commissioned a GREET analysis of their process to convert the corn fiber found in distiller grains into cellulosic ethanol. The analysis found that the process of converting corn kernel fiber into ethanol actually results in GHG savings of 126% relative to EPA's 2005 petroleum baseline, far surpassing the 60% minimum GHG savings required by the statute for cellulosic biofuels.[4]

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[2] *See, e.g.*, Arantes, Valdeir, and Jack N. Saddler. "Cellulose Accessibility Limits the Effectiveness of Minimum Cellulase Loading on the Efficient Hydrolysis of Pretreated Lignocellulosic Substrates." *Biotechnology for Biofuels* 4.3 (2011): 1-16. "the agricultural residues (corn stover and corn fiber) required significantly lower protein loadings..."; Biswas, Atanu, Badal C. Saha, John W. Lawton, R. L. Shogren, and J. L. Willett. "Process for Obtaining Cellulose Acetate from Agricultural By-products." *Carbohydrate Polymers* 64 (2006): 134-37. "Agricultural residues such as corn fiber, rice hulls and wheat straw can be used as abundant low-cost feedstock for production of fuel ethanol."

[3] Mass balance of QCCP process (based on Midwest Labs analysis) available upon request.

[4] This process is currently being demonstrated at the pilot scale. The results of the QCCP GREET analysis, a summary of which has been provided to EPA by QCCP, show GHG savings far exceeding the minimum statutory requirement for cellulosic ethanol. Consistent with EPA's treatment of corn stover and other agricultural residues, no land use change impacts should be attributed to corn kernel fiber. This is because corn grain is not grown for its fiber content; rather, corn's value and marketable uses derive primarily from its starch, protein and oil content.

In its final RFS2 rule, EPA directly modeled cellulosic ethanol production using both biochemical and thermochemical pathways with corn stover (a crop residue), switchgrass, forestry thinnings, and waste as feedstocks. EPA determined that these feedstocks/pathways exceeded the 60% lifecycle GHG threshold and qualified as cellulosic biofuels. However, EPA recognized that crop residues other than corn stover would likely have similar lifecycle GHG emissions. EPA stated that "our technical judgment indicates other pathways are likely to be similar enough to modeled pathways that we are also assured these similar pathways qualify." See 75 Fed. Reg. 14680.

EPA confirmed the breadth of its view in the preamble to the final rule, stating that it "also received comments encouraging us to expand the definition of crop residue to include materials left over after the processing of the crop into a useable resource, such as husks, seeds, bagasse and roots. EPA agrees with these comments and has altered the final definition to cover such materials. Based on comments received, our final definition of 'crop residue' is the biomass left over from the harvesting or processing of planted crops from existing agricultural land and any biomass removed from existing agricultural land that facilitates crop management (including biomass removed from such lands in relation to invasive species control or fire management), whether or not the biomass includes any portion of a crop or crop plant." 75 Fed. Reg. 14692. Later in the preamble, EPA references sugarcane bagasse and sweet sorghum pulp as examples of "crop residues" resulting from the processing of sugarcane and sweet sorghum, respectively. 75 Fed. Reg. 14754.

Accordingly, EPA extended its formal modeling of corn stover to "all crop residues which provide starch or cellulosic feedstock." 75 Fed. Reg. 14794. EPA appropriately reasoned that such formal modeling for other crop residues was unnecessary because "cellulosic biofuel produced from other agricultural waste will have no land use impact and would be expected to have lifecycle GHG emission impacts similar enough to the modeled corn stover pathway such that they would also comply." 75 Fed. Reg. 14793.

As a result, EPA did not limit Table 1's cellulosic pathway to ethanol from corn stover. Rather, the applicable cellulosic biofuel pathway applies more generally to "cellulosic biomass from agricultural residues..." See Table 1 to §80.1426.[5] As demonstrated above, corn fiber is a "crop residue" and is "cellulosic biomass." Thus, under the plain language of the regulations, ethanol derived from corn fiber is covered under an existing pathway and is eligible to generate cellulosic biofuel RINs with a D code of 3 and does not need to petition for a new pathway under Section 80.1416 of the regulations.

[5] Although EPA uses the term "agricultural residue," in Table 1, this term is undefined in the RFS-II regulations and should be read as interchangeable with the defined term "crop residue."