UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MICHIGAN 48105-2498

DEC 2 2 2014

OFFICE OF
AIR AND RADIATION

Mr. Glenn Johnston
Executive Vice President, Regulatory Affairs
Gevo, Inc.
345 Inverness Drive South, Building C, Suite 310
Englewood, Colorado 80112

Dear Mr. Johnston:

You submitted a petition to the U.S. Environmental Protection Agency on behalf of Gevo, Inc. (Gevo) to approve a pathway for the generation of advanced biofuel (D-code 5) Renewable Identification Numbers (RINs) under the Renewable Fuel Standard (RFS) program for the production of butanol.[1] The butanol is produced through a dry mill process at your production facility located in Luverne, Minnesota using corn starch and/or grain sorghum as feedstocks.

Through the petition process described under 40 CFR 80.1416, Gevo submitted data to the EPA to perform a lifecycle greenhouse gas (GHG) emissions analysis of the fuel produced at the Gevo Luverne facility. This analysis involved a straightforward application of the same methodology and much of the same modeling used for the final rule published on March 26, 2010 (75 FR 14670) (the "March 2010 RFS rule") and the final rule published on December 17, 2012 (77 FR 74592) (the "December 2012 grain sorghum rule"). The difference between this analysis and the analyses completed for the previous rules was the evaluation of more efficient fuel production processes.

The attached document "EPA Response to Gevo, Inc. Request for Fuel Pathway Determination under the RFS Program" describes the data submitted by Gevo, the analysis conducted by the EPA, and our determination of the lifecycle GHG emissions associated with the fuel production pathway described in the Gevo petition.

Gevo's butanol produced from corn starch feedstock appears to already qualify under an existing pathway in Table 1 to 40 CFR 80.1426 for the production of renewable fuel (D-code 6) RINs, assuming Gevo satisfies the pathway specifications and other requirements specified in the Clean Air Act (CAA) and EPA implementing regulations. Based on the attached assessment, we have determined that butanol produced by the Gevo Luverne facility from grain sorghum feedstock can also qualify for D-code 6 RINs, and butanol produced by the Gevo Luverne facility from corn starch and grain

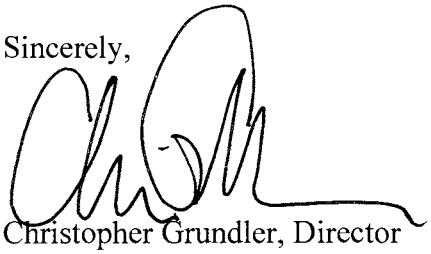
[1] According to your petition, Gevo intends to produce isobutanol, a specific isomer of butanol. This has implications for the lower heating value used in section IV. However, we will refer to the fuel type as "butanol" in this document.

sorghum feedstock can qualify for D-code 5 RINs if the fuel meets the conditions and associated regulatory provisions discussed in the attached document. To qualify for the generation of RINs, the fuel must meet the other definitional and regulatory criteria for renewable fuel (e.g., produced from renewable biomass, and for use as transportation fuel, heating oil or jet fuel) specified in the CAA and EPA implementing regulations.

This approval applies specifically to the Gevo Luverne facility, and to the processes, materials used, fuel produced, and process energy sources as outlined and described in the petition request submitted by Gevo.

The OTAQ Reg: Fuels Programs Registration and OTAQEMTS: OTAQ EMTS Application (OTAQ Reg and EMTS) will be modified to allow Gevo to register and generate D-code 5 RINs for the production of butanol from corn starch using the production process of "Advanced Gevo Luverne Corn Process" and for the production of butanol from grain sorghum using the production process of "Advanced Gevo Luverne Grain Sorghum Process." OTAQ Reg and EMTS will also be modified to allow Gevo to register and generate D-code 6 RINs for the production of butanol from grain sorghum feedstock using a production process of "Renewable Gevo Luverne Grain Sorghum Process."

Sincerely,



Christopher Grundler, Director
Office of Transportation and Air Quality

Enclosure

EPA Response to Gevo, Inc. Request for Fuel Pathway Determination under the RFS Program
Office of Transportation and Air Quality

Summary: Gevo, Inc. (Gevo) submitted a petition (the Gevo petition), dated July 21, 2015, to the Environmental Protection Agency (EPA) seeking approval for the generation of advanced biofuel (D-code 5) Renewable Identification Numbers (RINs) under the Renewable Fuel Standard (RFS) program for butanol produced through a dry mill process[1] at their production facility located in Luverne, MN (the "Gevo Luverne" facility), using only biogas and natural gas for the thermal energy component of energy used for feedstock, fuel and co-product operations, and electricity derived either from the grid or from an on-site combined heat and power process for the non-thermal energy component of energy for feedstock, fuel and co-product operations.[2] The process can produce butanol using corn starch as feedstock (the "Advanced Gevo Luverne Corn Process") and/or it can produce butanol using grain sorghum as feedstock (the "Advanced Gevo Luverne Grain Sorghum Process").

Although Gevo intends to document on an ongoing basis that the butanol it produces at the Gevo Luverne facility meets the appropriate greenhouse gas (GHG) emissions reduction requirements for advanced biofuel, EPA has performed a threshold lifecycle GHG emissions analysis based on the information in the Gevo petition to determine if the butanol produced at the facility may achieve the required GHG reductions, if certain conditions are met. This lifecycle analysis, the results of which are explained in this document, involved a straightforward application of the same methodology and modeling used for the RFS final rule published on March 26, 2010 (75 FR 14670) ("the March 2010 RFS rule") and the final rule published on December 17, 2012 (77 FR 74592) (the "December 2012 grain sorghum rule"). The difference between this analysis and the analyses completed for the previous rules cited above was the evaluation of more efficient fuel production processes, in terms of the amount of feedstocks and amount/type of energy used to produce butanol. Based on the data provided in the Gevo petition, our analysis found that butanol produced through either the Advanced Gevo Luverne Corn Process or the Advanced Gevo Luverne Grain Sorghum Process may be able to qualify as advanced biofuel if it satisfies all of the conditions specified in this document to demonstrate that such butanol meets the minimum 50% lifecycle GHG reduction requirement of the Clean Air Act (CAA).

In this determination EPA is specifying certain conditions designed to ensure that D-code 5 RINs are only assigned to volumes of butanol produced through either the Advanced Gevo Luverne Corn Starch Process or the Advanced Gevo Luverne Grain Sorghum Process if the fuel satisfies the corresponding GHG reduction requirements. EPA is specifying the condition that to generate D-code 5 RINs for corn starch butanol produced through the Advanced Gevo Luverne Corn Process, Gevo

[1] For purposes of this decision document a "dry mill process" is a process as defined in section I.B of this document.
[2] For the purposes of this document, the term "feedstock, fuel and co-product operations" is defined in section IV of this document.

must demonstrate that all corn starch butanol produced during an averaging period (defined as the 365 days prior to the date of RIN generation or the number of days since EPA activated the D-code 5 pathway associated with the Advanced Gevo Luverne Corn Process, whichever is less)[3] meets the 50% GHG reduction requirement. Similarly, EPA is specifying the condition that to generate D-code 5 RINs for grain sorghum butanol produced through the Advanced Gevo Luverne Grain Sorghum Process, Gevo must demonstrate that all grain sorghum butanol produced during a similar averaging period meets the 50% GHG reduction requirement. To make these demonstrations, Gevo must keep records on the feedstocks used and the lifecycle GHG emissions associated with all butanol produced by Gevo Luverne, based on the monitoring requirements, emissions factors and lifecycle analysis methodology and other requirements specified in this document.

If for any reason Gevo is not able to meet the 50% GHG reduction requirement, then they may generate renewable fuel (D-code 6) RINs for the grain sorghum butanol they produce (through the "Renewable Gevo Luverne Grain Sorghum Process") as long as they can demonstrate that all grain sorghum butanol produced during an averaging period meets the 20% GHG reduction requirement.[4]

This document is organized as follows:

- *Section I. Required Information and Criteria for Petition Requests*: Information on the background and purpose of the petition process, the criteria EPA uses to evaluate petitions and the information that is required to be provided under the petition process as outlined in 40 CFR 80.1416.
- *Section II. Available Information*: Background information on Gevo and description of the information Gevo provided and how it complies with the petition requirements outlined in Section I.
- *Section III. Analysis and Discussion*: Description of the lifecycle analysis done for the corn starch butanol and grain sorghum butanol produced through the Gevo Luverne Processes and identifies how the analyses conducted differs from the analyses done for the March 2010 RFS rule. This section also includes explanation of how we have applied the lifecycle results to determine the appropriate D-codes for butanol produced through the Gevo Luverne Processes.
- *Section IV. Conditions and Associated Regulatory Provisions*: Listing of the conditions and associated regulatory provisions that must be satisfied to generate RINs for butanol produced through the Gevo Luverne Processes.

[3] For purposes of this document, the definition of the "averaging time period" is specified in section IV of this document.
[4] In this document we sometimes collectively refer to the Advanced Gevo Luverne Corn Process, the Advanced Gevo Luverne Grain Sorghum Process and the Renewable Gevo Luverne Grain Sorghum Process as the "Gevo Luverne Processes" or to production at the Gevo Luverne facility. Per row O in Table 1 to 40 CFR 80.1426, butanol produced from corn starch already qualifies for D-code 6 RINs as long as the butanol is produced via fermentation in a dry mill using natural gas, biomass or biogas for process energy and the fuel meets other regulatory requirements (e.g., feedstock is renewable biomass and fuel is produced for use as transportation fuel, heating oil or jet fuel).

- *Section V. Public Participation*: Summary of our administrative process to consider the Gevo petition.
- *Section VI. Conclusion*: Summary of our conclusions regarding the Gevo petition, including the D-codes Gevo may use in generating RINs for butanol produced through the Gevo Luverne Processes.

I. Required Information and Criteria for Petition Requests

A. Background and Purpose of Petition Process

As a result of changes to the RFS program in CAA section 211(o), as amended by the Energy Independence and Security Act of 2007 (EISA), EPA adopted new regulations, published at 40 CFR Part 80, Subpart M. The RFS regulations specify the types of renewable fuels eligible to participate in the RFS program and the procedures by which renewable fuel producers and importers may generate RINs for the qualifying renewable fuels they produce through approved fuel pathways.[5]

Pursuant to 40 CFR 80.1426(f)(1):

> *Applicable pathways.* D-codes shall be used in RINs generated by producers or importers of renewable fuel according to the pathways listed in Table 1 to this section, subparagraph 6 of this section, or as approved by the Administrator.

Table 1 to 40 CFR 80.1426 lists the three critical components of a fuel pathway: (1) fuel type; (2) feedstock; and (3) production process. Each specific combination of the three components, or fuel pathway, is assigned a D-code. EPA may also independently approve additional fuel pathways not currently listed in Table 1 for participation in the RFS program, or a third party may petition for EPA to evaluate a new fuel pathway in accordance with 40 CFR 80.1416. In addition, renewable fuel producers identified in 40 CFR 80.1403(c) and (d) that are exempt from the 20% GHG emissions reduction requirement of the CAA may generate D-code 6 RINs pursuant to 40 CFR 80.1426(f)(6) for a specified baseline volume of fuel ("grandfathered fuel"[6]) assuming all other requirements are satisfied.

[5] See EPA's website for information about the RFS regulations and associated rulemakings: https://www.epa.gov/renewable-fuel-standard-program/regulations-and-volume-standards-under-renewable-fuel-standard

[6] "Grandfathered fuel" refers to a baseline volume of renewable fuel produced from facilities that commenced construction before December 19, 2007 and which completed construction within 36 months without an 18 month hiatus in construction and is thereby exempt from the minimum 20% GHG reduction requirement that applies to general renewable fuel. A baseline volume of ethanol from facilities that commenced construction after December 19, 2007, but prior to December 31, 2009, qualifies for the same exemption if construction is completed within 36 months without an 18 months hiatus in construction and the facility is fired with natural gas, biomass, or any combination thereof.

The petition process under 40 CFR 80.1416 allows parties to request that EPA evaluate a new fuel pathway's lifecycle GHG reduction and provide a determination of the D-code for which the new pathway may be eligible.

B. Information to be Provided in Petitions

As specified in 40 CFR 80.1416(b)(1), petitions are to include all of the following information, and should also include, as appropriate, supporting documents such as independent studies, engineering estimates, industry survey data, and reports or other documents supporting any claims:

- The information specified under 40 CFR 80.76 (registration of refiners, importers or oxygenate blenders).
- A technical justification that includes a description of the renewable fuel, feedstock(s), and production process. The justification must include process modeling flow charts.
- A mass balance for the pathway, including feedstocks, fuels produced, co-products, and waste materials production.
- Information on co-products, including their expected use and market value.
- An energy balance for the pathway, including a list of any energy and process heat inputs and outputs used in the pathway, including such sources produced off site or by another entity.
- Any other relevant information, including information pertaining to energy saving technologies or other process improvements.
- Other additional information as requested by the Administrator to complete the lifecycle GHG assessment of the new fuel pathway.

II. Available Information

A. Background on the Petitioner

Gevo submitted a petition requesting approval for their generation of advanced biofuel RINs for butanol produced by a dry mill process from corn starch and/or grain sorghum feedstock at their Luverne, MN facility.[7] A petition is required because the pathways associated with the Gevo Luverne

[7] As requested, this document evaluates pathways for the production of advanced biofuel using the Advanced Gevo Luverne Corn Process or the Advanced Gevo Luverne Grain Sorghum Process. For completeness, this determination also evaluates a pathway for generation of renewable D-code 6 biofuel RINs for butanol produced from sorghum that does not meet the 50% reduction requirement for advanced biofuel but does meet the 20% reduction requirement for non-advanced renewable fuel (the Renewable Gevo Luverne Grain Sorghum Process), since there are currently no pathways in Table 1 to 40 CFR 80.1426 for butanol from grain sorghum.

Processes are not included in Table 1 to 40 CFR 80.1426, and have not otherwise been approved by EPA. In a June 2013 Notice of Proposed Rulemaking (78 FR 36042) (the "Pathways II proposed rule"), EPA proposed a new pathway for advanced butanol from corn starch, based on information provided in an earlier petition from Gevo. However, EPA has not yet taken final action with respect to that proposed pathway. Gevo has since modified their proposed production processes, and the current petition under consideration in this document reflects these modifications. We are addressing all of the comments received on the Pathways II proposed rule that are relevant to Gevo's updated petition in a separate memorandum, attached.

Table 1 to 40 CFR 80.1426 (relevant portions of which are reproduced below) includes a D-code 6 pathway for the production of butanol from corn starch. For corn starch butanol, there are currently no options in Table 1 to 40 CFR 80.1426 for the production of D-code 5 advanced biofuel RINs through the use of a more efficient production process, as Gevo requested in their petition. There are also no pathways in Table 1 to 40 CFR 80.1426 for butanol produced from grain sorghum.

Table 1: Relevant Existing Fuel Pathways from 40 CFR 80.1426

Row	Fuel Type	Feedstock	Production Process Requirements	D-Code
O	Butanol	Corn Starch	Fermentation; dry mill using natural gas, biomass, or biogas for process energy	6

B. Information Submitted by Gevo, Inc.

Gevo provided all of the required information in the petition, including all of the data needed for EPA to perform a threshold determination of the potential for butanol produced through the Advanced Gevo Luverne Processes to satisfy the 50% lifecycle GHG reduction requirement applicable to advanced biofuel if all conditions in this document are satisfied. Gevo included information on their process yield (bushels of feedstock per gallons of fuel) and their energy used. In addition, Gevo's petition included the following certifications for each of their requested pathways:

- Certification that the production process for the requested pathway is a butanol production process where corn and/or sorghum feedstock is ground into a coarse flour, also known as "meal"; the meal is cooked into a hot slurry with the addition of enzymes to produce a mixture commonly known as "mash"; the mash is fermented with the addition of yeast to produce butanol, carbon dioxide and solids from the grain and yeast, known as "fermented mash"; the fermented mash is distilled to produce a mixture of butanol and water, and a residue of non-fermentable solids, also known as "stillage"; the mixture of butanol and water is dehydrated to produce 200-proof butanol; and co-products produced include

distillers grains, but may also include carbon dioxide, solubles syrup and vegetable oil (a "dry mill process").

- Certification that the co-product distillers grains are intended for use as animal feed.
- Certification that the dry mill process for the requested pathway uses one or a combination of the following sources for all of its process energy: electricity from the grid, natural gas or biogas.
- Certification that the butanol production facility uses only corn starch and/or grain sorghum as feedstocks to produce butanol.
- Certification that all of the information provided in the petition is accurate and complete.

C. Information Available Through Existing Modeling

For the pathways addressed in their petition, Gevo would use corn starch, a feedstock that has already been analyzed as part of the March 2010 RFS rule, as noted in Table 1. Gevo may also use grain sorghum, a feedstock that has already been analyzed as part of the December 2012 grain sorghum rule. As a result, no new feedstock modeling was required to evaluate the Gevo petition. Similarly, no new emissions impact modeling of using butanol as a transportation fuel was required as that was already done as part of the March 2010 RFS rule. This petition only requires EPA to evaluate modified fuel production processes.

The same analytical approach that was used to evaluate the lifecycle GHG emissions of the existing corn starch butanol pathway noted above was used to analyze the pathways described in the Gevo petition. The preamble to the March 2010 RFS rule describes the modeling approach used to estimate lifecycle GHG emissions from corn starch butanol. The preamble describes the models and data used as well as the input and output streams from those models to calculate the emissions for each of the lifecycle stages. To modify the corn or sorghum starch analysis to reflect the processes described in the Gevo petition, the only change required was replacing the production process data with the data for the Gevo Luverne facility. This resulted in the following changes to the modeling (described in more detail in the following sections):

- Amounts of corn/sorghum used in the fuel production processes were modified to reflect the Gevo Luverne yields in terms of bushels of feedstock input per gallons of butanol produced; and
- Amounts of energy used by the fuel production processes was changed to reflect data provided in the energy balances for the Gevo Luverne Processes.

This was a straightforward analysis based on existing modeling done for the March 2010 RFS rule and substituting the data for the Gevo Luverne Processes, which only altered the amounts of certain inputs and outputs of the fuel production processes.

III. Analysis and Discussion

A. Lifecycle Analysis

Determining a fuel pathway's compliance with the lifecycle GHG reduction thresholds specified in the CAA for different categories of renewable fuel requires a comprehensive evaluation of the renewable fuel, as compared to the gasoline or diesel fuel that it replaces, on the basis of its lifecycle GHG emissions. As mandated by the CAA, the GHG emissions assessments must evaluate the aggregate quantity of GHG emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes) related to the fuel's full lifecycle, including all stages of fuel and feedstock production, distribution, and use by the ultimate consumer.

In examining the full lifecycle GHG impacts of renewable fuels for the RFS program, EPA considers the following:

- Feedstock production – based on agricultural sector models that include direct and indirect impacts of feedstock production.
- Fuel production – including process energy requirements, impacts of any raw materials used in the process, and benefits from co-products produced.
- Fuel and feedstock distribution – including impacts of transporting feedstock from production to use, and transport of the final fuel to the consumer.
- Use of the fuel – including combustion emissions from use of the fuel in a vehicle.

EPA's evaluation of the lifecycle GHG emissions for the pathways described in the Gevo petition is consistent with the CAA's applicable requirements, including the definition of lifecycle GHG emissions and threshold evaluation requirements. It was based on information provided in the Gevo petition, including mass and energy balance data for the pathways associated with the Gevo Luverne Processes.

The lifecycle GHG emissions of fuel produced through the pathways associated with the Gevo Luverne Processes were determined as follows:

Feedstock production and transport (upstream emissions) – Gevo uses corn starch and/or grain sorghum as feedstocks for the production of butanol. As previously noted, corn starch and grain sorghum are feedstocks already listed in Table 1 to 40 CFR 80.1426 of the RFS regulations. Since corn starch and grain sorghum have already been evaluated by EPA, no new feedstock production modeling was required for EPA to evaluate the Gevo Luverne Processes. Gevo has certified through its petition submissions that it uses dry mill production processes that are consistent with the definition of "dry mill process" specified in section I.B of this decision document. Therefore, the Gevo Luverne Processes are the same type of dry mill processes as that modeled for the March 2010 RFS rule, and

the existing agricultural sector modeling analyses for corn and grain sorghum as feedstocks remain valid for use in estimating the lifecycle impact of renewable fuel produced using the Gevo Luverne Processes.[8]

The Forest and Agricultural Sector Optimization Model (FASOM) and Food and Agricultural Policy Research Institute (FAPRI) models were used to analyze the GHG impacts of the feedstock production portion of the fuel's lifecycle. The same FASOM and FAPRI results representing the emissions from an increase in corn production that were generated as part of the March 2010 RFS rule analysis of the existing corn butanol pathway were used in our analyses of the corn butanol production processes described in the Gevo petition.

In the corn ethanol analysis for the March 2010 RFS rule, we projected approximately 960 million bushels of corn (assuming 56 pounds per bushel at 15.5 percent moisture) used to produce 2.6 billion additional gallons of ethanol compared to a baseline scenario (based on a yield of 2.71 gallons per bushel), and we calculated GHG emissions from feedstock production for that amount of corn. The FASOM and FAPRI agricultural sector GHG results were divided by the total energy value of fuel produced to get emissions per million British thermal units (mmBtu) of ethanol.[9] For the modeled scenario we estimated GHG emissions of 9.73 $kgCO_2e$ per bushel of corn used to make ethanol. This includes the upstream emissions associated with producing the corn feedstock and transporting it to the ethanol production facility, and also includes significant direct and indirect emissions (such as emissions from land use change). In the March 2010 RFS rule, we assumed that the upstream emissions for corn starch butanol would be the same as the upstream emissions for corn starch ethanol per bushel of corn feedstock used, because the same feedstock is used and the same agricultural sector co-product DGS is produced. Therefore, to estimate the lifecycle GHG emissions from the corn feedstock used to make butanol through the Gevo Luverne Processes, the bushels of corn used as feedstock provided in the Gevo petition were multiplied by the emissions factor of 9.73 $kgCO_2e$ per bushel. In the same manner as described in section IV.D of this document, these emissions were then normalized by the mmBtu of butanol produced from the same amount of bushels of corn.

In a similar way, as part of the analysis for the December 2012 grain sorghum rule, we projected approximately 36 million bushels of grain sorghum (assuming 56 pounds per bushel at 13 percent moisture) used to produce 100 million additional gallons of ethanol compared to a baseline scenario (based on a yield of 2.71 gallons per bushel), and we calculated GHG emissions from feedstock production for that amount of sorghum. The FASOM and FAPRI agricultural sector GHG results were divided by the total energy value of fuel produced to get emissions per mmBtu of ethanol.

[8] See the attached memorandum for further discussion on why no new feedstock production modeling was required for EPA to evaluate butanol produced through the Gevo Luverne Processes.

[9] For the purposes of this determination document, Btus are expressed on a lower heating value (LHV) basis, gallons of ethanol and butanol are expressed on an undenatured (neat) basis, bushels of corn are expressed in terms of 15.5% moisture content and bushels of sorghum are expressed in terms of 13% moisture content unless otherwise specified.

For the modeled scenario we estimated GHG emissions of 8.93 $kgCO_2e$ per bushel of grain sorghum used to make ethanol, assuming 100% drying of DGs. This includes the upstream emissions associated with producing the grain sorghum feedstock and transporting it to the ethanol production facility, and also includes significant direct and indirect emissions (such as emissions from land use change). Similar to our decision for corn, we assumed that the upstream emissions for grain sorghum butanol would be the same as the upstream emissions for grain sorghum ethanol on a per bushel of feedstock basis, because the same feedstock is used and the same agricultural sector co-product DGS is produced. Therefore, to estimate the lifecycle GHG emissions from the grain sorghum feedstock used to make butanol through the Gevo Luverne Processes, the bushels of sorghum used as feedstock were multiplied by the emissions factor of 8.93 $kgCO_2e$ per bushel. As described in sections IV.E and IV.F of this document, these emissions were then normalized by the mmBtu of butanol produced from the same amount of bushels of sorghum.

To assess the situation when both corn and sorghum are used in the process, EPA uses a mass-based allocation approach over all butanol gallons to determine the yield of butanol per standard bushel of corn and sorghum. For example, if three hundred bushels of corn and sixty nine bushels of grain sorghum (assuming standard 56 pounds per bushel) were used to produce 1,000 gallons of butanol, EPA would consider approximately 81% of the butanol (810 gallons) to be derived from corn feedstock and the other approximately 19% (190 gallons) to be derived from grain sorghum feedstock. In this example, EPA's analysis would assume both the corn butanol and sorghum butanol yields are 2.71 gallons per bushel.[10] This approach is consistent with EPA's analysis for the March 2010 RFS rule and the December 2012 grain sorghum rule, in which we assumed the average butanol yield for corn starch and grain sorghum is the same at 2.71 gallons per standard bushel.

Fuel production (process emissions) – The fuel production method used by Gevo Luverne involves the production of butanol from corn starch and/or grain sorghum through dry mill processes. However, the Gevo Luverne Processes produce lower GHG emissions compared to the butanol processes analyzed as part of the March 2010 RFS rule as well as the sorghum ethanol processes evaluated as part of the December 2012 grain sorghum rule. The main reason is that the Gevo Luverne Processes utilize biogas and produce excess electricity that is sold to the grid.

To analyze the GHG impacts of the fuel production processes used by Gevo Luverne, EPA utilized the same approach that was used to determine the impacts of processes in the corn starch butanol pathway analyzed in the March 2010 RFS rule, taking into account differences in the types and amounts of energy used. To account for the fact that Gevo Luverne sometimes co-processes corn and grain sorghum, our analysis of the Gevo petition incorporates aspects of the production modeling conducted for the December 2012 grain sorghum rule.

[10] The numbers provided in this example are for illustrative purposes only.

Gevo submitted projected mass and energy balance data for operations at the Gevo Luverne facility, including all of the energy used from the point of delivery of the feedstock through feedstock processing, and fuel and co-product production, to the point of final storage of the end product fuel and co-products at the fuel production facility. This includes the energy used to produce all of the butanol produced by Gevo Luverne (including butanol for which D-code 6 RIN are generated pursuant to the existing corn butanol pathway and fuel for which no RINs are generated).

To allocate the fuel production GHG emissions per gallon of corn or grain sorghum butanol produced through the Gevo Luverne Processes, EPA first determined the amount of energy used to produce corn butanol relative to grain sorghum butanol. Energy used for feedstock, fuel and co-product operations consists of electrical energy in the form of purchases or exports of electricity to the grid and thermal energy in the form of fuels used and combusted on site including fuels used to produce on-site electricity. For the December 2012 grain sorghum rule, EPA found, based on process modeling developed by USDA, that on average a sorghum ethanol plant uses 96.3% of the thermal energy of a corn ethanol plant (3.7% less), and 99.3% of the electrical energy (0.7% less). This is the best information available to EPA on the relative energy requirements for corn and sorghum ethanol processing. We assume that the relative energy requirements for corn and sorghum butanol processing will be the same as those for ethanol processing. Therefore, we applied these efficiency adjustment factors to the data provided in the Gevo petition to determine how much of the electrical and thermal energy to allocate to the corn butanol and grain sorghum butanol produced by Gevo Luverne. Specifically, the total amount of each type of thermal and electrical energy used for butanol feedstock, fuel, and co-product operations at Gevo Luverune was multiplied by the corresponding average GHG emissions factor for that type of energy (see below). Then, the amount of energy used for corn butanol and grain sorghum butanol were assigned based on the relative amounts of corn and grain sorghum feedstock used, and adjustments were made so that each gallon of grain sorghum butanol produced was assigned 3.7% less thermal energy and 0.7% less electrical energy than each gallon of corn butanol.[11]

The lifecycle GHG emissions factors used for process energy were the same emissions factors used in the modeling for the March 2010 RFS rule:

- Natural gas = $6.86*10^{-5}$ $kgCO_2e/Btu$
- Biogas CH_4 = $3.64*10^{-7}$ $kgCO_2e/Btu$
- U.S. average grid electricity = 0.750 $kgCO_2e/kWh$[12]

Fuel distribution and use (downstream emissions) – The fuel type, butanol, and hence the fuel distribution and use for butanol, was already considered as part of the March 2010 RFS rule.

[11] For details on how these calculations were performed see the formulas to calculate GHG_P in section IV of this document.
[12] The grid electricity factor is used to determine emissions from purchased grid electricity and credits associated with exported electricity that was produced on-site. Emissions from production of the on-site electricity are determined based on the on-site fuel use emissions.

Therefore, we applied the existing fuel distribution and use GHG impacts for corn starch butanol to our analysis of both corn starch butanol and grain sorghum butanol produced through the Gevo Luverne Processes. The emissions factor for butanol distribution and use, otherwise known as downstream emissions, is 1.8 $kgCO_2e$ per mmBtu of butanol.

Lifecycle GHG emissions – The lifecycle GHG emissions associated with Gevo Luverne's fuel were then compared to the baseline lifecycle GHG emissions, using the same value for baseline gasoline as in the March 2010 RFS rule analysis. Based on the data submitted by Gevo, our analysis indicates that butanol produced through the Advanced Gevo Luverne Processes would result in at least a 50 percent GHG emissions reduction compared to the baseline lifecycle GHG emissions.

Table 2 below breaks down by stage the lifecycle GHG emissions for corn starch butanol and grain sorghum butanol produced using the Advanced Gevo Luverne Corn Process and the Advanced Gevo Luverne Grain Sorghum Process, compared to such emissions for a corn starch butanol pathway analyzed as part of the March 2010 RFS rule and the 2005 gasoline baseline. The butanol pathways all assume 100% drying of co-product DGs. This table demonstrates the contribution of each stage in the fuel pathway and its relative significance in terms of GHG emissions.

In the table, upstream emissions include the lifecycle GHG emissions associated with producing the feedstock and transporting it to the fuel production facility. Process emissions include the lifecycle GHG emissions associated with the fuel production process, including co-product drying. Downstream emissions include the lifecycle GHG emissions associated with distributing and using the finished fuel. Table 2 provides EPA's mean estimate of GHG emissions for each of these stages of the lifecycle.

Butanol produced through the Gevo Luverne Processes has higher upstream emissions compared to the corn butanol evaluated in the March 2010 RFS rule because of lower overall yield for both corn butanol and sorghum butanol in terms of Btu of fuel produced per bushel of feedstock used. The Gevo Luverne Processes have negative process emissions because of credits associated with exporting to the grid excess electricity produced through a combined heat and power process.[13]

[13] This is because the excess electricity produced at the butanol facility displaces grid electricity and a GHG emissions credit is assumed to reflect the lower GHG emissions associated with electricity produced with biogas at the butanol facility as compared to the GHG emissions of average grid electricity.

Table 2: Lifecycle GHG Emissions for Corn Starch and Grain Sorghum Butanol Produced through the Gevo Luverne Process (kgCO2e/mmBtu)[14]

	Corn Starch Butanol, Natural Gas Fired Dry Mill, 2022 Average Plant	Corn Starch Butanol Produced Through the Advanced Gevo Luverne Corn Process	Grain Sorghum Butanol Produced Through the Advanced Gevo Luverne Grain Sorghum Process	Baseline Lifecycle GHG Emissions for Gasoline
Upstream Emissions	37.5	48.1	43.9	*
Process Emissions	28.4	-1.1	-1.2	19.2
Downstream Emissions	1.8	1.8	1.8	79.0
Lifecycle Emissions	67.7	48.8	44.6	98.2
Percent Reduction	31.1%	50.3%	54.6%	--

* Emissions included in Process Emissions stage.

B. Application of the Criteria for Petition Approval

Based on the information provided in the Gevo petition, the analysis described above, and the requirements specified in section IV limiting RIN generation to butanol for which ongoing monitoring and assessment allow documentation of compliance with appropriate lifecycle GHG reduction requirements, EPA is approving this petition request. Specifically, we have determined that corn butanol produced pursuant to the Advanced Gevo Luverne Corn Process and grain sorghum butanol produced pursuant to the Advanced Gevo Luverne Grain Sorghum Process can satisfy the minimum 50% GHG reduction threshold required in the CAA for advanced biofuel if the butanol is produced in accordance with the fuel yield and energy use information specified in the Gevo petition. As detailed in section IV, EPA is specifying certain conditions that must be satisfied for butanol produced through the approved pathways to be eligible to generate D-code 5 RINs. Where all the conditions are satisfied, EPA is authorizing the generation of D-code 5 RINs for corn butanol produced through the Advanced Gevo Luverne Corn Process and grain sorghum butanol produced through the Advanced Gevo Luverne Grain Sorghum Process, provided that the fuel meets the other criteria for renewable fuel specified in the CAA and EPA implementing regulations.

EPA is also determining that if Gevo Luverne's grain sorghum butanol does not satisfy the minimum 50% GHG reduction threshold requirement specified in section IV, the grain sorghum

[14] Net emissions may not be the sum of the rows due to rounding.

butanol produced may qualify for the generation of D-code 6 RINs if Gevo can demonstrate that the grain sorghum butanol satisfies the 20% GHG reduction threshold required in the CAA for renewable fuel. As detailed in section IV, EPA is specifying certain conditions that must be satisfied for grain sorghum butanol produced through the approved pathway to be eligible to generate D-code 6 RINs. Where all the conditions are satisfied, EPA is authorizing the generation of D-code 6 RINs for grain sorghum butanol produced through the Renewable Gevo Luverne Grain Sorghum Process, provided that the fuel meets the other criteria for renewable fuel specified in the CAA and EPA implementing regulations.

IV. Conditions and Associated Regulatory Provisions

The authority for Gevo to generate RINs for butanol produced pursuant to the Gevo Luverne Processes is expressly conditioned on Gevo satisfying all of the applicable conditions as detailed in this section, in addition to other applicable requirements for renewable fuel producers set forth in the RFS regulations. These conditions are enforceable under the CAA. They are established pursuant to the informal adjudication reflected in this decision document, and also pursuant to regulations cited below and 40 CFR 80.1416(b)(1)(vii), 80.1450(i), and 80.1451(b)(1)(ii)(W). In addition or in the alternative to bringing an enforcement action under the CAA, EPA may revoke this pathway approval if it determines that Gevo has failed to comply with any of the conditions specified herein, or with any applicable regulatory requirements.[15]

The pathway for corn butanol approved in this document is in addition to the existing pathway for corn butanol listed in row O of Table 1 to 40 CFR 80.1426. This document does not impact the ability of Gevo to generate RINs for volumes of fuel produced pursuant to the pathway listed in row O of Table 40 CFR 80.1426.

This section details the registration, compliance monitoring, lifecycle GHG computation, recordkeeping, reporting, attest engagement and other requirements that apply to the butanol pathways associated with the Gevo Luverne Processes and it is organized as follows:

- *Sub-section A*: definitions
- *Sub-section B*: registration requirements
- *Sub-section C*: compliance monitoring
- *Sub-section D*: lifecycle GHG conditions and associated computational requirements
- *Sub-section E*: recordkeeping requirements
- *Sub-section F*: reporting requirements
- *Sub-section G*: additional requirements

[15] As with all pathway determinations, this approval does not convey any property rights of any sort, or any exclusive privilege.

As described in the following sections, one condition for Gevo to generate D-code 5 RINs for corn butanol produced through the Advanced Gevo Luverne Corn Process, D-code 5 RINs for sorghum butanol produced through the Advanced Gevo Luverne Grain Sorghum Process or D-code 6 RINs for sorghum butanol produced through the Renewable Gevo Luverne Grain Sorghum Process is documentation by Gevo that on average, all corn starch and/or grain sorghum butanol produced during a 365-day (or shorter in certain circumstances) averaging period satisfies the lifecycle GHG reduction requirements for the type of RINs generated. The rolling average lifecycle GHG emissions for corn starch and/or grain sorghum butanol are calculated based on the daily data monitored and collected by Gevo and the formulas specified in sections IV.D, IV.E and IV.F and considers all of the GHG emissions associated with butanol produced during the averaging period (including butanol for which D-code 5 or 6 RINs were generated and butanol for which no RINs were generated), which are then apportioned to either corn or grain sorghum butanol based on mass of each feedstock used.[16]

A. Definitions

For the purposes of this petition approval, the following terms are defined as follows:

a. *365-day rolling average lifecycle GHG emissions* means the average lifecycle GHG emissions for the corn starch and/or grain sorghum butanol produced by Gevo Luverne during the averaging time period, calculated as specified in sections IV.D, IV.E and IV.F based on the daily data collected and recorded by Gevo through continuous monitoring.[17]

b. *Averaging time period* means the 365 calendar days prior to the day that Gevo wishes to generate RINs for butanol produced during the averaging period through the Gevo Luverne Processes, or the number of days prior to the day that Gevo wishes to generate RINs for butanol produced through the Gevo Luverne Processes since EPA activated the applicable Gevo Luverne pathway(s),[18] whichever is less.[19] To clarify, Gevo may not generate RINs

[16] For clarification, Gevo's authorization to generate D-code 6 RINs for volumes of corn starch butanol produced through the existing pathway in row O of Table 1 to 40 CFR 80.1416 is not conditional on the 365-day rolling lifecycle GHG emissions for such volumes, or impacted in any way by this determination document.

[17] The EPA has provided spreadsheets on its website to help ethanol producers understand the correct calculation of 365-day rolling average lifecycle GHG emissions. A spreadsheet has been modified for butanol and provided to Gevo. For clarification, if Gevo Luverne uses corn starch and grain sorghum feedstocks, Gevo will calculate two separate 365-day rolling average lifecycle GHG emissions: one for corn butanol and one for grain sorghum butanol. The 365-day rolling average lifecycle GHG emissions shall be calculated for corn butanol as specified in section IV.D, and for grain sorghum butanol as specified in sections IV.E and IV.F.

[18] "Activated" refers to the day that the pathway is allowed to be used in EMTS, i.e., the date of activation of Gevo's registration for one of the new pathways described in this document.

[19] For example, the averaging time period is 365 days long if the applicable Gevo Luverne pathway was activated at least 365 days prior to the day that Gevo wishes to generate RINs through the pathway. If the applicable Gevo Luverne pathway was activated less than 365 days prior to the day that Gevo wishes to generate RINs through the pathway, then the averaging period is shorter than 365 days and begins on the day the pathway was activated.

for butanol produced through the Gevo Luverne Processes on the same day that such butanol is produced.

c. *Continuous monitoring* means the collection and use of measurement data and other information to record the data inputs required to calculate the 365-day rolling average lifecycle GHG emissions, in accordance with the Compliance Monitoring Plan described in section IV.C.

d. *Energy used for feedstock, fuel and co-product operations* means energy used in all buildings or other areas that are used in any part for the storage and/or processing of butanol feedstock, the production and/or storage of butanol intermediates, the production and/or storage of finished butanol fuel or co-products, the production of electricity (whether used on site or exported), and the handling of butanol feedstocks, fuel, co-products and wastes. It includes any energy used offsite for these purposes, including for example energy used offsite to dry the co-product distiller's grains produced by Gevo Luverne before it is sold to the ultimate consumer. It includes thermal energy derived from combusting fossil and other fuels, and non-thermal energy such as electricity.

e. *Period of missing data* includes each day for which Gevo does not have valid data collected through continuous monitoring for any of the daily data inputs required to calculate the 365-day rolling average lifecycle GHG emissions, as specified sections IV.D, IV.E and IV.F.

B. Registration

Gevo Luverne must comply with all registration provisions in 40 CFR Part 80, Subpart M that apply to renewable fuel producers to register for the production of butanol through the Gevo Luverne Processes.

To register for any of the pathways associated with the Gevo Luverne Processes, the description of the Gevo Luverne Processes that is required for registration pursuant to 40 CFR 80.1450(b)(1)(ii) shall include the following:[20]

a. A Compliance Monitoring Plan including technical specifications detailing how Gevo will accurately and reliably measure and record all of the daily data required in sections IV.D, IV.E and IV.F and calculate and record the 365-day rolling average lifecycle GHG emissions. This plan must specify the equipment, procedures and equations that Gevo will follow to accurately and reliably measure and record the standardized volume of butanol at 60 degrees Fahrenheit.

[20] All of the registration materials required by 80.1450(b)(1), including those specifically described in this document, must be reviewed and verified pursuant to the independent third party engineering review required in 80.1450(b)(2).

b. A process flow diagram showing all of the following:

    1. The supply and continuous monitoring of all energy used for feedstock, fuel and co-product operations.

    2. The continuous monitoring of bushels of corn and grain sorghum used in fuel production processes for all of the butanol produced by Gevo Luverne, including butanol for which RINs are generated and butanol for which RINs are not generated.

    3. The continuous monitoring of volume and temperature[21] for all of the butanol produced by Gevo Luverne, including butanol for which RINs are generated and butanol for which RINs are not generated.

    4. Information for each of the continuous monitoring systems (e.g., scales, fuel flow meters and electricity meters) shown in the process flow diagram including the name of the manufacturer, the manufacture date and all relevant serial numbers.

c. A certification signed by a Responsible Corporate Officer containing the following statement: "I hereby certify that: (1) I have reviewed and understand the process flow diagram submitted with this application for registration as required pursuant to section IV.B.b of the petition approval document for the pathways associated with the Gevo Luverne Processes; (2) To the best of my knowledge the process flow diagram is accurate and complete; (3) All monitoring devices specified in the process flow diagram will be calibrated and maintained according to the manufacturer specifications or more frequently (if the manufacturer does not provide calibration or maintenance records then the company shall meet standards for similar monitoring devices); and (4) All of the monitoring devices included in the process flow diagram monitor all of the information specified in sections IV.B.b.1, 2 and 3 of the petition approval document for the applicable pathways associated with the Gevo Luverne Processes."

d. If Gevo wishes to exclude any amount of energy used at the Gevo Luverne facility when calculating the 365-day rolling average lifecycle GHG emissions, the description of the facility's production process must include all of the following:

    1. An explanation of why such energy is not energy used for feedstock, fuel and co-product operations, as defined above.

[21] Temperature readings must take place at the same time the volume is measured.

2. A plan showing how the energy that will not be included in the calculation of the 365-day rolling average lifecycle GHG emissions will be kept completely segregated, separately metered and recorded.[22]

e. If Gevo wishes to take credit for exported electricity in calculating GHG_{PC} pursuant to section IV.D, or GHG_{PGS} pursuant to section IV.E or IV.F, Gevo must include a certification signed by a Responsible Corporate Officer stating that any exported electricity would be the result of combined heat and power technology produced at the Gevo Luverne facility as defined in the RFS regulations at 40 CFR 80.1401.

f. If Gevo intends to process corn starch and grain sorghum feedstocks simultaneously, Gevo must specify in their accepted registration materials the values they will use for the converted fraction (CF) and energy content (E) parameters in the formula to calculate feedstock energy (FE) at 40 CFR 80.1426(f)(3)(vi), and must explain the technical basis for those values.

C. Compliance Monitoring

In order to generate RINs for butanol produced through the Gevo Luverne Processes, Gevo must implement the Compliance Monitoring Plan referenced above, and must use data obtained and recorded in accordance with this plan to calculate the 365-day rolling average lifecycle GHG emissions.

D. Lifecycle GHG Emissions for Butanol Produced Through the Advanced Gevo Luverne Corn Process

Gevo may not generate D-code 5 RINs for corn butanol produced pursuant to the Advanced Gevo Luverne Corn Process unless it can demonstrate through records produced in accordance with 40 CFR 80.1454(b)(3) that are available as of the date of RIN generation and maintained by Gevo for a minimum of five years from the date of RIN generation that all of the corn butanol produced during the averaging period at the Gevo Luverne facility meets all of the following requirements:

[22] Two examples of valid reasons for excluding any amount of energy used at the Gevo Luverne facility or for off-site processing of butanol or co-products from the Gevo Luverne facility when calculating the 365-day rolling average lifecycle GHG emissions include the following: the energy is used in a stand-alone and separately-metered building that is used solely for administrative purposes, and/or the energy is used in a stand-alone and separately-metered tower grain dryer to dry the corn kernel and/or grain sorghum feedstock prior to grinding. The lifecycle GHG emissions from energy used at such a tower grain dryer may be excluded because they have been taken into account in the GHG_{Uc} and GHG_{Ugs} terms of the lifecycle calculations specified in this document; therefore, they do not need to be included in the GHG_{PC} or GHG_{PGS} terms.

a. All of the butanol produced at the Gevo Luverne facility was produced by a dry mill process, using only corn starch, grain sorghum, or a combination of corn starch and grain sorghum as feedstocks during the averaging time period.

b. The corn starch butanol 365-day rolling average lifecycle GHG emissions are calculated using the following formula, and do not exceed 49.10 $kgCO_2e$/mmBtu of butanol:[23]

$$LC_{GHGc} = GHG_{Uc} + GHG_{Pc} + GHG_D$$

Where:

LC_{GHGc} = Lifecycle GHG emissions, in $kgCO_2e$/mmBtu, of the volume of all corn starch butanol produced at the facility during the averaging time period.

GHG_{Uc} = Upstream GHG emissions, in $kgCO_2e$/mmBtu, related to the production and transport of the volume of corn starch feedstock used to produce all corn starch butanol produced at the facility during the averaging time period, calculated per section IV.D.c.

GHG_{Pc} = Process GHG emissions, in $kgCO_2e$/mmBtu, related to the processes used for conversion of corn starch into butanol during the averaging period, including energy used for feedstock, fuel and co-product operations; calculated per section IV.D.d.

GHG_D = Downstream GHG emissions, in $kgCO_2e$/mmBtu, related to the distribution and use of all butanol produced during the averaging period, equal to 1.8 $kgCO_2e$ per mmBtu of butanol as discussed in section III.A.

c. For the purposes of the formula in section IV.D.b, GHG_{Uc} is calculated according to the following formula:

$$GHG_{U_C} = \frac{9.73 * B_C}{V_S * 0.095 * R_C}$$

Where:

9.73 = Upstream emissions factor for corn, in $kgCO_2e$ per bushel, based on the lifecycle GHG modeling done by EPA for the March 2010 RFS rule.

0.095 = Energy content of butanol, in mmBtu/gallon (lower heating value of isobutanol).

B_C = Bushels of corn used by Gevo Luverne as feedstock to produce butanol during the averaging time period in terms of a standard bushel at 15.5% moisture.

[23] The statutory petroleum gasoline baseline estimated for the March 2010 RFS final rule was 98.2 $kgCO_2e$/mmBtu. Fuel meeting the fifty percent lifecycle GHG reduction threshold produces 49.10 $kgCO_2e$/mmBtu or less.

For the purposes of this paragraph, B_C, shall be calculated according to the following formula:

$$B_C = B_{C_m} * \left(\frac{1 - m_c}{1 - 0.155}\right)$$

B_{Cm} = Bushels of corn used by Gevo Luverne as feedstock to produce butanol during the averaging time period based on measurements recorded by Gevo Luverne.

m_c = Average moisture content of corn, in mass percent, for the corn delivered to Gevo Luverne for use as feedstock to produce butanol during the averaging time period. The moisture content tests performed by Gevo shall sample corn that, based on good engineering judgment, is representative of each delivery of corn feedstock to Gevo Luverne. Gevo shall test the moisture content of the corn delivered in each and every truck load, train load, or other delivery of corn to Gevo Luverne, and for any given delivery must measure the corn moisture content no less frequently than once for every 10,000 bushels. For moisture content, Gevo shall use a DICKEY-john GAC 2500UGMA or Perten AM 5200-A moisture meter, as certified by the National Type Evaluation Program, and follow the device's operating instructions, or use alternative test methods as specified by Gevo in their Compliance Monitoring Plan accepted by EPA. Gevo shall calculate the average moisture content as a weighted average, by summing the products of the mass and corresponding moisture content of each corn delivery, and then dividing by the total mass of corn feedstock delivered to Gevo Luverne during the averaging time period.

0.155 = Moisture content of a standard bushel of corn at 56 pounds per bushel.

B_{GS} = Bushels of grain sorghum used by Gevo as feedstock to produce butanol during the averaging time period in terms of a standard bushel at 13% moisture.[24]

For the purposes of this paragraph, B_{GS}, shall be calculated according to the following formula:

$$B_{GS} = B_{GS_m} * \left(\frac{1 - m_{gs}}{1 - 0.13}\right)$$

B_{GSm} = Bushels of grain sorghum used by Gevo as feedstock to produce butanol during the averaging time period based on measurements recorded by Gevo.

m_{gs} = Average moisture content of grain sorghum, in mass percent, for the grain sorghum delivered to Gevo Luverne for use as feedstock to produce butanol during the

[24] As explained in section III, EPA's analysis in this determination considers the amount of grain sorghum used by Gevo Luverne in order to establish the yield of ethanol per bushel of corn feedstock used in the process.

averaging time period. The moisture content tests performed by Gevo shall sample grain sorghum that, based on good engineering judgment, is representative of each delivery of grain sorghum feedstock to Gevo Luverne. Gevo shall test the moisture content of the grain sorghum delivered in each and every truck load, train load, or other delivery of grain sorghum to Gevo Luverne, and for any given delivery must measure the grain sorghum moisture content no less frequently than once for every 10,000 bushels. For moisture content, Gevo shall use a DICKEY-john GAC 2500UGMA or Perten AM 5200-A moisture meter, as certified by the National Type Evaluation Program, and follow the device's operating instructions, or use alternative test methods as specified by Gevo in their Compliance Monitoring Plan accepted by EPA. Gevo shall calculate the average moisture content as a weighted average, by summing the products of the mass and corresponding moisture content of each grain sorghum delivery, and then dividing by the total mass of grain sorghum feedstock delivered to Gevo Luverne during the averaging time period.

0.13 = Moisture content of a standard bushel of grain sorghum at 56 pounds per bushel.

$R_C = \left(\frac{B_C}{B_C + B_{GS}}\right)$ which is the ratio of corn feedstock used, on a mass basis.

V_S = Standardized volume of all butanol produced at the Gevo Luverne facility during the averaging time period (including both corn starch and grain sorghum butanol), in gallons of undenatured butanol. In determining the standardized volume, the actual volumes of butanol shall be adjusted to a standard temperature of 60 degrees Fahrenheit using the formula specified in Gevo's Compliance Monitoring Plan accepted by EPA.

d. For the purposes of the formula in section IV.D.b, GHG_{Pc} is calculated according to the following formula:

$$GHG_{P_C} = \frac{\frac{GHG_{THERM}}{(0.963 * R_{GS}) + R_C} + \frac{GHG_{ELEC}}{(0.993 * R_{GS}) + R_C}}{V_S * 0.095}$$

Where:

GHG_{THERM} = The greenhouse gas emissions, in $kgCO_2e$, associated with the thermal energy component of energy used for feedstock, fuel and co-product operations, as measured by Gevo by continuous monitoring, and calculated according to the following formula:

$$GHG_{THERM} = \sum_{p=1}^{2} \left(PE_p * LHV_{PE,p} * EF_{PE,p}\right)$$

Where:

p = Type of fuel used.

PE_p = a measure of the amount of fuel p used for the thermal energy component of energy used for feedstock, fuel and co-product operations, as follows:

PE_1 = Standard cubic feet (scf) of natural gas used for the thermal energy component of energy used for feedstock, fuel and co-product operations, as measured by Gevo by continuous monitoring.

PE_2 = Standard cubic feet (scf) of biogas CH_4 from landfills, waste treatment plants and/or waste digesters used for the thermal energy component of energy used for feedstock, fuel and co-product operations, as measured by Gevo by continuous monitoring.[25]

$LHV_{PE,p}$ = Lower Heating Value factor for fuel type p, as follows:

$LHV_{PE,1}$ = 983 Btu per scf of natural gas.

$LHV_{PE,2}$ = 983 Btu per scf of biogas CH_4.

$EF_{PE,p}$ = Lifecycle GHG emissions factor for fuel type p, (based on lower heating value) as follows:

$EF_{PE,1}$ = 6.86 * 10^{-5} $kgCO_2e$ per Btu of natural gas.

$EF_{PE,2}$ = 3.64 * 10^{-7} $kgCO_2e$ per Btu of biogas CH_4.

0.963 = Adjustment factor for grain sorghum butanol processing using 3.7% less thermal energy than corn butanol processing.

0.993 = Adjustment factor for grain sorghum butanol processing using 0.7% less electrical energy than corn butanol processing.

$R_{GS} = \left(\frac{B_{GS}}{B_C + B_{GS}}\right)$ which is the ratio of grain sorghum feedstock used, on a mass basis.

GHG_{ELEC} = The greenhouse gas emissions, in $kgCO_2e$, associated with grid electricity used for the electrical energy component of energy used for feedstock, fuel and co-product operations, as measured by Gevo by continuous monitoring, and calculated according to the following formula:

$$GHG_{ELEC} = ELEC * EF_{elec}$$

[25] PE_2 shall only represent the methane present in the biogas used. If the amount of methane present in the biogas is not metered directly, Gevo shall determine it using the monitoring protocols and test procedures specified in the Compliance Monitoring Plan submitted by Gevo as part of their registration materials for the pathways associated with the Gevo Luverne Processes.

Where:

ELEC = kWh of Grid electricity used for the electrical energy component of energy used for feedstock, fuel and co-product operations, as measured by Gevo by continuous monitoring.[26]

EF_{elec} = 0.750 $kgCO_2e$ per kWh of grid electricity, based on the United States grid average.

e. For the purposes of section IV.D, for all corn butanol produced by Gevo during a day where Gevo has missing data on any of the factors described in this section, Gevo shall assess the fuel produced on all such days as having lifecycle GHG emissions of 98.2 kgCO2e per mmBtu,[27] and use this value in their calculation of the 365-day rolling average lifecycle GHG emissions.

E. Lifecycle GHG Emissions for Butanol Produced Through the Advanced Gevo Luverne Grain Sorghum Process

Gevo may not generate D-code 5 RINs for grain sorghum butanol produced pursuant to the Advanced Gevo Luverne Grain Sorghum Process unless it can demonstrate through records produced in accordance with 40 CFR 80.1454(b)(3) that are available as of the date of RIN generation and maintained by Gevo for a minimum of five years from the date of RIN generation that all of the grain sorghum butanol produced during the averaging period at the Gevo Luverne facility meets all of the following requirements:

a. All of the butanol produced at the Gevo Luverne facility was produced by a dry mill process, using only corn starch, grain sorghum, or a combination of corn starch and grain sorghum as feedstocks during the averaging time period.

b. The grain sorghum butanol 365-day rolling average lifecycle GHG emissions are calculated using the following formula, and do not exceed 49.10 $kgCO_2e$/mmBtu of butanol:

$$LC_{GHGGS} = GHG_{UGS} + GHG_{PGS} + GHG_D$$

[26] To account for the fact that during some periods, Gevo Luverne may be exporting excess electricity produced via a combined heating and power process to the grid, and during other periods may use electricity from the grid, Gevo Luverne's grid electricity use, ELEC, shall reflect net grid electricity use, calculated as the amount of electricity purchased from the grid minus electricity exported to the grid, as measured through net metering during the averaging period.

[27] The value of 98.2 kgCO2e/mmBtu was selected because it is the value for baseline lifecycle GHG emissions from gasoline, as evaluated by EPA for the March 2010 RFS rule. We recognize this is a conservative approach for substituting missing data, and we believe a conservative approach is necessary to eliminate any incentive for parties to fail to collect and document accurate data.

Where:

LC_{GHGGS} = Lifecycle GHG emissions, in $kgCO_2e$/mmBtu, of the volume of all grain sorghum butanol produced at the facility during the averaging time period.

GHG_{UGS} = Upstream GHG emissions, in $kgCO_2e$/mmBtu, related to the production and transport of the volume of grain sorghum feedstock used to produce all grain sorghum butanol produced at the facility during the averaging time period, calculated per section IV.E.c.

GHG_{PGS} = Process GHG emissions, in $kgCO_2e$/mmBtu, related to the processes used for conversion of grain sorghum into butanol during the averaging period, including energy used for feedstock, fuel and co-product operations; calculated per section IV.E.d.

GHG_D is defined in section IV.D.b.

c. For the purposes of the formula in section IV.E.b, GHG_{Ugs} is calculated according to the following formula:

$$GHG_{U_{GS}} = \frac{8.93 * B_{GS}}{V_S * 0.095 * R_{GS}}$$

Where:

8.93 = Upstream emissions factor for grain sorghum, in $kgCO_2e$ per bushel, based on the lifecycle GHG modeling done by EPA for the December 2012 grain sorghum rule.

B_{GS}, R_{GS} and V_S are defined in section IV.D.c.

0.095 = Energy content of butanol, in mmBtu/gallon (lower heating value of isobutanol).

d. For the purposes of the formula in section IV.E.b, GHG_{PGS} is calculated according to the following formula:

$$GHG_{P_{GS}} = \frac{\frac{GHG_{THERM}}{(0.963 * R_{GS}) + R_C} * (0.963) + \frac{GHG_{ELEC}}{(0.993 * R_{GS}) + R_C} * (0.993)}{V_S * 0.095}$$

Where the terms are as defined in section IV.D.d

e. For the purposes of Section IV.E, for all grain sorghum butanol produced by Gevo during a day where Gevo has missing data on any of the factors described in this section, Gevo shall assess the fuel produced on all such days as having lifecycle GHG emissions of 98.2 kgCO2e per mmBtu, and use this value in their calculation of the 365-day rolling average lifecycle GHG emissions.

F. Lifecycle GHG Emissions for Butanol Produced Through the Renewable Gevo Luverne Grain Sorghum Process

Gevo may not generate D-code 6 RINs for grain sorghum butanol produced pursuant to the Renewable Gevo Luverne Grain Sorghum Process unless it can demonstrate through records produced in accordance with 40 CFR 80.1454(b)(3) that are available as of the date of RIN generation and maintained by Gevo for a minimum of five years from the date of RIN generation that all of the grain sorghum butanol produced during the averaging period at the Gevo Luverne facility meets all of the following requirements:

a. All of the butanol produced at the Gevo Luverne facility was produced by a dry mill process, using only corn starch, grain sorghum, or a combination of corn starch and grain sorghum as feedstocks during the averaging time period.

b. The grain sorghum butanol 365-day rolling average lifecycle GHG emissions are calculated according to the formula in section IV.E.b, and do not exceed 78.6 kgCO2e/mmBtu of butanol.[28]

c. For the purposes of section IV.F, for all grain sorghum butanol produced by Gevo during a day where Gevo has missing data on any of the factors described in this section, Gevo shall assess the fuel produced on all such days as having lifecycle GHG emissions of 98.2 kgCO2e per mmBtu, and use this value in their calculation of the 365-day rolling average lifecycle GHG emissions.

G. Recordkeeping

In addition to the specific recordkeeping requirements stated at 40 CFR 80.1454(b)(3)(i)-(xii), the following records related to the generation and assignment of RINs must be produced and maintained pursuant to 40 CFR 80.1454(b)(3) when Gevo generates RINs for butanol produced through the Gevo Luverne Processes.

a. Records documenting the data required to calculate lifecycle GHG emissions per the requirements specified in sections IV.D, IV.E and IV.F, and which are collected in accordance with the Compliance Monitoring Plan described in section IV.B.a. This includes comprehensive and reliable information with respect to the amount of feedstock and energy used and the amount of fuel produced, such as meter readings and energy bills

[28] The statutory petroleum gasoline baseline estimated for the March 2010 RFS final rule was 98.2 kgCO_2e/mmBtu. Fuel meeting the twenty percent lifecycle GHG reduction threshold produces 78.6 kgCO_2e/mmBtu or less.

that span the entire averaging time period for each instance that RINs are generated for butanol produced through the Gevo Luverne Processes.

b. Records presenting accurate calculations verifying compliance with the applicable lifecycle GHG reduction requirements on a 365-day rolling average basis in accordance with sections IV.D, IV.E, and IV.F that are prepared on each day that RINs are generated for butanol produced through the Gevo Luverne Processes. The information must include identifiable unique references to all documents and metering data used in the calculations.[29]

H. Reporting

As part of the quarterly RIN generation reports required under 40 CFR 80.1451(b), Gevo shall submit to EPA the information identified in section IV.G.b of this document that was prepared during the relevant quarter.[30]

I. Additional Conditions

The authority for Gevo to generate RINs for butanol produced pursuant to the Gevo Luverne Processes is expressly conditioned on Gevo satisfying all of the following additional conditions.

For any biogas energy used for feedstock, fuel and co-product operations, the biogas shall be from landfills and/or waste digesters,[31] and Gevo must satisfy the requirements specified at 40 CFR 80.1426(f)(12)(i) and/or (ii), as applicable, of the RFS regulations.[32]

Gevo may not generate RINs for butanol produced through the Gevo Luverne Processes if Gevo fails to comply with any of the conditions in this section IV. However, this does not prevent Gevo from generating RINs for fuel produced pursuant to any of the pathways specified in Table 1 to 40 CFR 80.1426, to the extent that Gevo is authorized to do so under applicable regulations.

[29] The EPA has provided spreadsheets on its website to help ethanol producers understand the correct calculation of 365-day rolling average lifecycle GHG emissions. A spreadsheet has been modified for butanol and provided to Gevo. The modified spreadsheet can also be used for recordkeeping.

[30] Since the information prepared pursuant to section IV.G.b must be included in the Gevo quarterly RIN generation reports to EPA, it follows that this information is subject to attest engagement requirements pursuant to 80.1464(b).

[31] For purposes of this condition, biogas from waste digesters includes biogas from municipal wastewater treatment facility digesters, agricultural digesters and separated MSW digesters, and biogas from other waste digesters, and excludes biogas from digesters that process any portion of Gevo Luverne's DGS stream, such as syrup removed from the DGS stream.

[32] For clarity, although 40 CFR 80.1426(f)(12) says "For purposes of Table 1 of this section…" and the Gevo Luverne Processes do not appear in Table 1 to 40 CFR 80.1426, here we are referencing the requirements at 40 CFR 80.1426(f)(12)(i) and/or (ii), as applicable, and making them conditions for Gevo's authority to generate RINs for butanol produced pursuant to the Gevo Luverne Processes.

Per the existing RFS regulations, if Gevo generates D-Code 6 RINs for butanol made from corn starch or grain sorghum feedstock and also generates D-Code 5 RINs for corn starch or grain sorghum butanol, the appropriate subparagraphs of 40 CFR 80.1426(f)(3) shall be used to allocate RINs.

EPA may modify the conditions specified above, as it deems necessary and appropriate to ensure that butanol produced pursuant to the Gevo Luverne Processes achieves the required lifecycle GHG reductions, including to make the conditions align with any future changes to the RFS regulations. If EPA makes any changes to the conditions noted in this document for fuel produced pursuant to the Gevo Luverne Processes, EPA will explain such changes in a public determination letter, similar to this one, and specify in that letter the effective date for any such changes.

V. Public Participation

As part of the March 2010 RFS rule, we took public comment on our lifecycle assessment of the corn starch butanol pathways listed in Table 1 to 40 CFR 80.1426, including all models used and all modeling inputs and evaluative approaches. As part of the December 2012 grain sorghum rule, we took public comment on the grain sorghum ethanol pathway listed in Table 1 to 40 CFR 80.1426. In the March 2010 RFS rule, we also acknowledged that it was unlikely that our final regulations would address all possible qualifying fuel production pathways, and we took comment on allowing the generation of RINs using a temporary D-code in certain circumstances while EPA was evaluating such new pathways and updating its regulations. After considering comments, we finalized the current petition process, where we allow for EPA approval of certain petitions without going through additional notice and public comment if we can do so as a reasonably straightforward extension of prior analyses, whereas notice and public comment would be conducted to respond to petitions requiring significant new analysis and/or modeling. *See* 75 FR 14797 (March 26, 2010).

In the Pathways II proposed rule, EPA proposed a new pathway for advanced butanol from corn starch, based in part on information provided in an earlier petition from Gevo. EPA's proposal included an analysis which showed that fuels produced under these pathways could meet the 50 percent GHG emissions reduction threshold necessary to qualify as advanced biofuel under certain limits on process energy use. In response to the Pathways II proposed rule, EPA received a number of comments supporting our analysis, as well as comments that raised concerns about the analysis. EPA has not yet taken final action with respect to that proposed advanced butanol pathway. Gevo has since modified their proposed production process, and the current petition reflects these modifications. We are addressing all of the comments received on the Pathways II proposed rule that are relevant to Gevo's updated petition in a separate, attached memorandum.

In responding to the petition submitted by Gevo, we have relied on the corn starch butanol modeling that we conducted for the March 2010 RFS rule, and have simply adjusted the analysis to account for the specific production process used by Gevo Luverne. We relied on the same agricultural

sector modeling (FASOM and FAPRI results) that was conducted and commented on as part of the March 2010 RFS rule to represent feedstock production. This also includes use of the same emission factors and types of emission sources that were used in the March 2010 RFS rule analysis. Our analysis of the Gevo petition also relied on certain aspects of the modeling and analysis completed for the December 2012 grain sorghum rule, which sought and addressed public comments through a rulemaking process. Thus, the fundamental analyses relied on for this decision have already been made available for public comment as part of the March 2010 RFS, December 2012 grain sorghum, and Pathways II proposed rules. Our approach today is also consistent with our description of the petition process in the preamble to the March 2010 RFS rule. Our evaluation in response to the petition is a logical extension of analyses already conducted for the March 2010 RFS, December 2012 grain sorghum, and Pathways II proposed rules.

VI. Conclusion

Based on our assessment of the information provided in the Gevo petition, butanol produced from corn starch feedstocks through the Advanced Gevo Luverne Corn Process and butanol produced from grain sorghum feedstocks through the Advanced Gevo Luverne Grain Sorghum Process can, under certain conditions, meet the lifecycle GHG reduction requirements to qualify for D-code 5 RINs. Furthermore, based on our assessment of the information provided in the Gevo petition, butanol produced from grain sorghum feedstocks through the Renewable Gevo Luverne Grain Sorghum Process can, under certain conditions, meet the lifecycle GHG reduction requirements to qualify for D-code 6 RINs. This document specifies the conditions designed to ensure that RINs are generated for butanol produced pursuant to the Gevo Luverne Processes only if the butanol satisfies the required lifecycle GHG reduction requirements specified in the CAA. To qualify for RINs, the fuel must also meet other applicable requirements specified in the CAA and EPA implementing regulations, including being produced from renewable biomass, and for use as transportation fuel, heating oil or jet fuel.

This approval applies specifically to the Gevo Luverne facility and to the processes, materials used, fuel and co-products produced, and energy sources as outlined and described in the Gevo petition. This approval is effective as of signature date. RINs may only be generated for butanol produced pursuant to the Gevo Luverne Processes that is produced after the date of activation of Gevo's registration for these pathways.

The OTAQ Reg: Fuels Programs Registration and OTAQEMTS: OTAQ EMTS Application (OTAQ Reg and EMTS) will be modified to allow Gevo to register and generate D-code 5 RINs for the production of butanol from corn starch feedstocks using a production process of "Advanced Gevo Luverne Corn Process" and the generation of D-code 5 RINs for the production of butanol from grain sorghum feedstocks using a production process of "Advanced Gevo Luverne Grain Sorghum Process." OTAQ Reg and EMTS will also be modified to allow Gevo to register and generate D-code 6 RINs for

the production of butanol from grain sorghum feedstock using a production process of "Renewable Gevo Luverne Grain Sorghum Process." This document has no impact on the ability of Gevo to use OTAQ Reg and EMTS to register and generate D-code 6 RINs for butanol produced using any of the pathways specified in Table 1 to 40 CFR 80.1426.

Response to Comment Memorandum to Accompany EPA Response to Gevo, Inc. Request for Fuel Pathway Determination under the RFS Program

Summary: Gevo petitioned EPA under the RFS program to approve the generation of advanced biofuel (D-code 5) RINs for butanol produced from corn starch and grain sorghum. The company intends to produce butanol through a dry mill process at their production facility in Luverne, MN. The attached document "EPA Response to Gevo, Inc. Request for Fuel Pathway Determination under the RFS Program" (the "Gevo determination") describes the data submitted by Gevo, the analysis conducted by the EPA, and our determination of the lifecycle GHG emissions associated with the fuel production pathways described in the Gevo petition.[1]

In a June 2013 Notice of Proposed Rulemaking (78 FR 36042) (the "Pathways II proposed rule"), EPA proposed a new pathway for advanced butanol from corn starch, based in part on information provided in an earlier petition from Gevo. EPA's proposal included an analysis which showed that fuels produced under this pathway could meet the 50 percent GHG emissions reduction threshold necessary to qualify as advanced biofuel with certain limits on process energy use. In response to the Pathways II proposed rule, EPA received a number of comments supporting our analysis, as well as comments that raised concerns about the analysis. To date, EPA has not acted to finalize the generally applicable proposed advanced butanol pathway. In this document, we are addressing all of the comments received on the butanol proposal that are relevant to the Gevo determination.

Comments on the use of the upstream corn GHG factor

Comments: In the corn ethanol analysis for the final rule published on March 26, 2010 (75 FR 14670) ("the March 2010 RFS rule"), EPA analyzed the GHG impacts associated with the difference between a 13.4 billion gallon baseline ethanol scenario compared to a 15 billion gallon corn ethanol scenario. In this analysis, EPA projected approximately 960 million bushels of corn (assuming 56 pounds per bushel at 15.5 percent moisture) would be used to produce the 2.6 billion additional gallons of ethanol (based on a yield of 2.71 gallons per bushel). The Forest and Agricultural Sector Optimization Model (FASOM) and Food and Agricultural Policy Research Institute (FAPRI) models were used to calculate GHG emissions from feedstock production for that amount of corn. The FASOM and FAPRI agricultural sector GHG results can be divided by the total amount of corn required to get emissions per bushel of corn used for ethanol production. For the modeled scenario we estimated lifecycle GHG emissions of 9.73 $kgCO_2e$ per bushel of corn used for ethanol production. This includes the upstream emissions associated with producing the corn feedstock and transporting it to the ethanol production

[1] Definitions and other terminology used in the Gevo determination document are incorporated by reference into this response to comment document.

facility, and also includes significant direct and indirect emissions (such as emissions from land use change) that occur upstream from the ethanol production. In the Pathways II proposed rule, EPA proposed to use the same upstream GHG factor developed for ethanol for the corn butanol determination.

We received comments indicating that it is not appropriate to use the upstream corn GHG factor from the corn ethanol analysis for corn butanol because the production of corn butanol could expand the use of corn beyond the 15 billion gallons scenario assumed in the March 2010 RFS rule analysis. The commenters suggested that if corn butanol were qualified as an advanced biofuel it would increase the use of corn starch for biofuel. For this reason they suggested it was improper to qualify corn starch-based butanol as an advanced biofuel without doing a new analysis of the land use impacts associated with increased corn starch used for biofuels.

Commenters assumed that the statutory volumes for advanced biofuels would be maintained through 2022, but that cellulosic fuels would only provide a small portion of the advanced mandate. Under these assumptions they determined that between 8 and 15 billion ethanol-equivalent gallons of corn butanol could be used to fill the gap in the advanced mandates. Based on those assumptions, between 3 and 5.5 billion bushels of corn would be needed to produce the additional butanol. They indicated that such an expansion of the use of corn for fuels would have very large negative consequences for competing users of corn and agricultural land and accelerate deforestation globally.

Response: EPA believes it is appropriate to use the upstream GHG values for corn ethanol estimated as part of the March 2010 RFS rule for evaluating the GHG impacts associated with corn butanol production through the Advanced Gevo Luverne Corn Process. This approach is consistent with the conventional corn butanol pathway that was developed as part of the March 2010 RFS rule. For the March 2010 RFS rule we evaluated the lifecycle GHG emissions associated with producing corn starch into butanol. The emissions associated with the production of corn for the butanol pathway was assumed to be the same as for ethanol production and based on the same agricultural sector modeling used in the corn ethanol analysis. However, the results were scaled based on the yield of butanol produced. Corn ethanol was assumed to have a processing yield of 2.71 gal/bu and an energy content of 76,000 Btu/gal which results in an overall energy yield of 206,280 Btu/bu. Corn butanol was assumed to have a slightly lower processing yield of 2.12 gal/bu but a higher energy content of 99,827 Btu/gal for an overall energy yield of 212,153 Btu/bu. Therefore, on a per Btu produced basis corn butanol was found to have slightly lower emissions compared to corn ethanol. Based on this evaluation, in the March 2010 RFS rule EPA approved a pathway for butanol produced from corn starch to qualify for D-code 6 RINs.

EPA does not believe that approving the generation of D-code 5 RINs for corn butanol produced through the Advanced Gevo Luverne Corn Process will materially affect the amount of corn used

for biofuels and modeled as part of the March 2010 RFS rule. The Gevo Luverne facility was originally a corn ethanol plant that has been retrofitted to produce isobutanol. Therefore, it is unlikely that the amount of corn used to produce biofuels will be significantly larger as a result of approving the pathway associated with the Advanced Gevo Luverne Corn Process. Furthermore, this approval is limited to one specific facility, limiting the scope of production and the potential for expansion.

In general we believe it is appropriate to use the upstream GHG emission value for corn modeled as part of the March 2010 RFS rule for our evaluation of butanol produced through the Advanced Gevo Luverne Corn Process as this pathway will not significantly impact the amount of corn starch used for biofuel beyond what would be used in the absence of this determination. EPA intends to further evaluate this issue if multiple butanol facilities are approved in the future.

Although the commenters did not address grain sorghum, we note that, for similar reasons as explained above for corn, we believe it is appropriate to use the upstream GHG emissions value for grain sorghum modeled as part of the final rule published on December 17, 2012 (77 FR 74592) (the "December 2012 grain sorghum rule") for our evaluation of grain sorghum butanol produced through the pathways associated with the Gevo Luverne Processes as these pathways will not significantly impact the amount of grain sorghum used for biofuel beyond what would be used in the absence of this determination.

Comments on postponing analysis of corn butanol as an advanced biofuel

Comments: Some commenters indicated that the volumes modeled in the lifecycle analysis (particularly for indirect land use change emissions) were based on a compliance scenario for 2022, laid out in the March 2010 RFS rule, that does not foresee any corn starch butanol used as an advanced biofuel. They suggest that until EPA provides an updated compliance scenario, it is hard to make reasonable projections about what the land use impacts of bio-butanol qualified as an advanced biofuel will be. Commenters recommended that EPA postpone the consideration of corn starch butanol as an advanced biofuel until EPA has proposed and finalized renewable volume obligations through the year 2022.

Response: EPA does not believe it is appropriate to postpone a determination on butanol produced through the Advanced Gevo Luverne Corn Process until EPA finalizes the renewable volume obligations through 2022. When we analyzed the 2022 compliance scenario in the March 2010 RFS rule (also known as the "Control Case"), we did not claim that these volumes would be the exact mix of fuels that would help to meet the standards. Since March 2010, we have continued to approve new fuel pathways, which provides industry more options for meeting the volume standards. Even if the mix of fuels actually used to meet the standards are different than what was in our Control Case, we still believe our lifecycle GHG analyses for individual fuel pathways are applicable. As described in the previous section, we also believe it is

reasonable to apply the upstream GHG values from corn ethanol to corn butanol, since the upstream impacts are likely to be the same whether the finished fuel is ethanol or butanol, and because approving a pathway for butanol produced through the Advanced Gevo Luverne Corn Process will not significantly impact the amount of corn starch used for biofuel.

Although the commenters did not address grain sorghum, for similar reasons as explained above for corn, we do not believe it is appropriate to postpone a determination on grain sorghum butanol produced through the Gevo Luverne Processes until EPA finalizes the renewable volume obligations through 2022

Comments on the co-product electricity tracking and amount produced

Comments: The Pathways II proposed rule butanol pathway had a provision that specified that in order to qualify for D-code 5 RINs the butanol facility would have to use combined heat and power (CHP) to produce a certain amount of excess electricity for export to the grid, and assigned a co-product GHG credit for this excess electricity production. The onsite emissions associated with electricity production were accounted for in the facility energy use, and the co-product credit for the excess electricity was accounted for by assuming the excess electricity offset average grid electricity production and resulted in associated GHG emissions reductions.

Commenters suggested that if the excess electricity was not tracked properly the GHG reductions would not be as much as indicated. They said for example that ensuring that all fuel produced met the GHG reduction requirements at all times and generated valid RINs would be very sensitive to plant operations and production of fuel.

One commenter was also concerned that such a specification would allow the standard to be met by installing more heat and power capacity than the plant needed, and exporting excess electricity sufficient to meet the standard. They indicated that in such a case the electricity is not really a co-product of the biofuel production but rather, an auxiliary process designed merely to nominally meet the GHG standard (an issue in lifecycle analysis often referred to as "gearing").

Response: Our evaluation of the butanol pathways associated with the Gevo Luverne Processes includes credit associated with exported electricity production; however, it does not rely on the specific electricity export provision that was outlined in the Pathways II proposed rule and therefore does not involve the tracking concerns that commenters raised with that provision. Rather, this decision allows Gevo to generate RINs for butanol produced pursuant to the Gevo Luverne Processes if Gevo satisfies a number of conditions specified in the Gevo determination. The Gevo determination includes the condition that Gevo will have to monitor and keep daily records on all of their feedstock use, energy use, and fuel production volumes, to demonstrate their process efficiency and compliance with the GHG reduction thresholds on an ongoing basis. Thus, Gevo will have to produce and export a quantity of electricity necessary to meet the

applicable lifecycle GHG thresholds. We believe these conditions address the comments on the Pathways II rule associated with concerns regarding proper tracking of exported electricity.

The concerns raised by commenters about gearing are addressed mainly through the provisions for excess electricity stated in the Gevo determination. We specify that if Gevo wishes to take credit for any exported electricity it must be the result of CHP. We also specify in the definition of "energy used for feedstock, fuel and co-product operations" and the conditions regarding calculation of a 365-day rolling average of lifecycle greenhouse gas emissions, that all energy used by Gevo to make electricity, whether used on site or exported, must be counted in the calculation of its 365-day rolling average lifecycle emission.

Furthermore, use of a natural gas-fired turbine to generate electricity would result in roughly the same amount of GHG emissions as the grid average used in EPA's evaluation,[2] so there would be little GHG credit associated with it. Generating electricity from lower GHG-sources, such as landfill biogas, just to reduce the GHG emissions attributed to butanol, and thus qualify the butanol for RINs, is not expected to be cost effective (even with revenue from the sale of electricity). Thus, we believe that the conditions specified in the Gevo determination, together with the expected cost associated with generating electricity from low GHG-sources, sufficiently address or mitigate the concern raised by the commenters on the Pathways II proposed rule regarding EPA's evaluation of excess electricity credits in the lifecycle GHG calculations for butanol.

Comments on the heating value of butanol

Comments: The Pathways II proposed rule pathway for butanol relied on a lower heating value (LHV) for butanol of 99,837 Btu/gal. This value was based on the GREET model,[3] and was also used in the March 2010 RFS rule butanol analysis. However, in the Pathways II proposed rule we specifically solicited comments on the most appropriate LHV energy content assumption to use for butanol. We indicated that differences in the measurement of the energy content of butanol can occur for a number of reasons including variations amongst isomers (t-butanol, n-butanol, isobutanol, and sec-butanol), and differences in testing methodologies. The Pathways II proposed rule sought comment on whether there are any reasons why EPA should change its assumptions and use a different energy content of butanol.

[2] The U.S. grid electricity GHG factor used by EPA includes all sources of electricity production including coal, natural gas, nuclear, and renewables. When the GHG emissions from all these sources are combined and averaged over the total amount of electricity produced it results in a GHG/kWh factor that is roughly equivalent to producing electricity from natural gas.

[3] The GREET value is based on: Guibet, J.-C., 1997, Carburants et Moteurs: Technologies, Energie, Environnement, Publication de l'Institut Franc¸ais du Pe´trole, ISBN 2–7108–0704–1.

We did receive one comment on the appropriate LHV to use including several references that indicated the proposed value may have been high. The commenter referenced values ranging from 93,500 to 96,763 Btu/gal LHV but without specific references to which isomer those values considered or what the exact appropriate value to use would be.

Response: As indicated in the Pathways II proposed rule, one of the biggest factors when determining a heating value for butanol is the variation among the four butanol isomers (t-butanol, n-butanol, isobutanol, and sec-butanol) as they all have slight variation in their LHV. Therefore, we did a further evaluation of heating values associated with the different butanol isomers. This involved considering the enthalpy of combustion of the different isomers,[4] and then adjusting that to a lower heating value. These can then be converted to a per gallon basis using an assumed density.[5] The following table has representative lower heating values for the different butanol isomers developed based on these calculations.

Butanol Isomer	LHV (Btu/gal)
n-Butanol	96,715
Sec-Butanol	95,870
Isobutanol	95,596
Tert-butanol	93,450

These values line up with the range specified by the commenter and also indicate that the LHV used in the Pathways II proposed rule was likely high. The average of these values is 95,408, which can be rounded to 95,000.

Therefore, based on the published data we used a LHV of 95,000 Btu/gal in our evaluation of butanol produced through the Gevo Luverne Processes. Also, as specified in the Gevo determination, Gevo shall also use this LHV in their ongoing calculations of the 365-day rolling average lifecycle GHG emissions associated with the butanol produced by Gevo Luverne. We believe this is a reasonable and conservative approach based on available information.

The LHV of butanol is also important for setting an equivalence value (EV) for the fuel. The EV represents the amount of RINs that can be generated per gallon and is based in part on the heating value of the fuel in relation to the heating value of ethanol. Currently 40 CFR 80.1415 of

[4] See the National Institute of Standards and Technology (NIST) Chemistry WebBook, NIST Standard Reference Database Number 69. http://webbook.nist.gov/chemistry/

[5] See the International Energy Agency's (IEA) transportation related Implementing agreement on Advanced Motor Fuels (AMF). http://www.iea-amf.org/content/fuel_information/butanol/properties

the RFS regulations specifies an EV of 1.3 for butanol. A LHV of 95,000 Btu/gal for butanol will also result in an EV of 1.3 and is therefore consistent with the current regulations.

Comments on the co-product use for biogas reduces DDGS produced and co-product credit

Comments: EPA's lifecycle GHG analysis of butanol for the Pathways II proposed rule included diverting part of the distillers dried grains with solubles (DDGS) co-product stream (the syrup) to an anaerobic digester to create biogas. This biogas was then used as part of the process energy at the butanol plant. The removal of the syrup results in lower quantity of DDGS produced (~10% reduction compared to average ethanol). Commenters claimed this negates our use of the March 2010 RFS rule corn GHG results because they relied on all of the DDGS being used as animal feed. The use of the co-product as animal feed results in less other crop and feed production and reduces overall GHG impacts.

Commenters suggested that the syrup that is removed is a non-negligible component of the DDGS. Therefore, butanol production which does not return the syrup to the feed market, and thus does not displace other feed production to the same extent as ethanol production, results in GHG emissions that are not accounted for under EPA's current LCA.

Response: The analysis for the Gevo determination did not rely on using anaerobic digesters to produce biogas from DDGS syrup. Instead, the analysis was based on using biogas produced at off-site landfills or other waste digesters. Therefore, our assessment of the Gevo processes is based on the assumption that no portion of the DDGS stream gets diverted.

Furthermore, the decision document specifies that any biogas used as energy for feedstock, fuel and co-product operations has to come from landfills or waste digesters, as measured by Gevo by continuous monitoring, and shall not include biogas from digesters that process any portion of Gevo's DGS stream.

Therefore, we believe the comments related to biogas production from syrup derived from DDGS have been addressed through the conditions specified in the Gevo determination.

Comments on statutory restrictions of corn based advanced biofuels

Comments: Commenters suggested that the restriction that can be discerned from the statute that at most 15 billion gallons of conventional renewable fuel would be produced from corn was to limit the exposure of corn markets to competition. They indicate that qualifying corn starch butanol, or indeed any biofuel made from corn starch as opposed to stover, corn oil or other components, would expand the potential draw on corn substantially. They suggest that the decision to open the advanced pool to corn starch-based biofuels merits more careful

consideration, and should be accompanied by analysis of the consequences for food competition, land use change, and other impacts associated with meeting an even larger share of the full 36 billion gallon total mandate from corn.

Response: Section 211(o)(1)(B)(i) of the Clean Air Act (42 U.S.C. 7545(o)) specifies the definition of advanced biofuel as:

The term 'advanced biofuel' means renewable fuel, other than ethanol derived from corn starch, that has lifecycle greenhouse gas emissions, as determined by the Administrator, after notice and opportunity for comment, that are at least 50 percent less than baseline lifecycle greenhouse gas emissions.

Section 211(o)(1)(B)(ii) of the Clean Air Act indicates that the types of fuels eligible for consideration as 'advanced biofuel' may include:

Butanol or other alcohols produced through the conversion of organic matter from renewable biomass.

Based on these statutory provisions EPA does not believe there are any restrictions to butanol produced from corn starch being considered an advanced biofuel under the RFS program as long as the butanol lifecycle GHG emissions are at least 50 percent less than the baseline petroleum fuel lifecycle GHG emissions and the fuel meets other general requirements (e.g., made from renewable biomass and for use as transportation fuel).

Furthermore, as stated earlier, the Gevo determination applies to a single facility and as such we do not believe that this determination will significantly impact the amount of corn starch used for biofuel beyond what would be used regardless of this determination.

Comments on the uncertainty in the lifecycle analysis

Comments: One commenter recommended that EPA not finalize the proposed advanced butanol pathway. The commenter did not believe that the advanced butanol pathway met the 50% lifecycle GHG reduction requirements. This was based in part on the previously mentioned comments, as well as lack of uncertainty analysis and assumptions regarding butanol's lower yield.

Response: This Gevo determination is for a single facility and the authority of Gevo to generate RINs for butanol produced pursuant to the Gevo Luverne Processes is expressly conditioned on Gevo satisfying a number of conditions specified in the Gevo determination, including the condition that Gevo will have to monitor and keep daily records on all of their feedstock use, energy use, and fuel production volumes, to demonstrate their process efficiency and compliance with the GHG reduction thresholds on an ongoing basis. We believe that the conditions specified in the Gevo determination address the concerns raised by this comment.