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ENVIRONMENTAL PROTECTION AGENCY

[EPA-HQ-OAR-2014-0537-; FRL-9921-15-OAR]

Notice of Opportunity to Comment on the Lifecycle Greenhouse Gas Emissions for Renewable Fuels Produced from Biomass Sorghum

AGENCY: Environmental Protection Agency.

ACTION: Notice.

SUMMARY: In this Notice, the Environmental Protection Agency (EPA) is inviting comment on its preliminary analysis of the greenhouse gas (GHG) emissions attributable to the growth and transport of biomass sorghum feedstock for use in making biofuels such as ethanol or diesel. This notice explains EPA's analysis of the growth and transport components of the lifecycle greenhouse gas emissions from biomass sorghum, and describes how EPA may apply this analysis in the future to determine whether biofuels produced from such biomass sorghum meet the necessary GHG reductions required for qualification under the Renewable Fuels Standard (RFS) program. Based on this analysis, we anticipate that biofuels produced from biomass sorghum could qualify for cellulosic biofuel renewable identification numbers (RINs) if certain fuel production process technology conditions are met.

DATES: Comments must be received on or before [**insert date 30 days after publication in the <u>Federal Register</u>**].

ADDRESSES: Submit your comments, identified by Docket ID No. EPA-HQ-OAR-2014-0537, by one of the following methods:

- http://www.regulations.gov. Follow the on-line instructions for submitting comments.

- Email: a-and-r-docket@epa.gov, Attention Air and Radiation Docket ID No. EPA-HQ-OAR-2014-0537.
- Mail: Air and Radiation Docket, Docket No. EPA-HQ-OAR-2014-0537, Environmental Protection Agency, Mail code: 28221T, 1200 Pennsylvania Ave., N.W., Washington, DC 20460.
- Hand Delivery: EPA Docket Center, EPA/DC, EPA WJC West, Room 3334, 1301 Constitution Ave., NW, Washington, DC, 20460, Attention Air and Radiation Docket, ID No. EPA-HQ-OAR-2014-0537. Such deliveries are only accepted during the Docket's normal hours of operation, and special arrangements should be made for deliveries of boxed information.

Instructions: Direct your comments to Docket ID No. EPA-HQ-OAR-2014-0537. EPA's policy is that all comments received will be included in the public docket without change and may be made available online at www.regulations.gov, including any personal information provided, unless the comment includes information claimed to be Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Do not submit information that you consider to be CBI or otherwise protected through www.regulations.gov or e-mail. The www.regulations.gov website is an "anonymous access" system, which means EPA will not know your identity or contact information unless you provide it in the body of your comment. If you send an e-mail comment directly to EPA without going through www.regulations.gov, your e-mail address will be automatically captured and included as part of the comment that is placed in the public docket and made available on the Internet. If you submit an electronic comment, EPA recommends that you include your name and other contact information in the body of your comment and with any disk or CD-ROM you submit. If EPA cannot read your comment due to technical difficulties and cannot contact you for clarification, EPA may not be able to consider your comment. Electronic files should avoid the use of special characters, any form of encryption, and be free of any defects or viruses. For additional information about EPA's public docket visit the EPA Docket Center homepage at http://www.epa.gov/epahome/dockets.htm.

Docket: All documents in the docket are listed in the www.regulations.gov index. Although listed in the index, some information is not publicly available, e.g., CBI or other information for which disclosure is restricted by statute. Certain other material, such as copyrighted material, will be publicly available only in hard copy. Publicly available docket materials are available either electronically in www.regulations.gov or in hard copy at the Air and Radiation Docket, EPA/DC, EPA West, Room 3334, 1301 Constitution Ave., NW, Washington, DC. The Public Reading Room is open from 8:30 a.m. to 4:30 p.m., Monday through Friday, excluding legal holidays. The telephone number for the Public Reading Room is (202) 566-1744, and the telephone number for the Air and Radiation Docket is (202) 566-1742.

FOR FURTHER INFORMATION CONTACT: Jon Monger, Office of Transportation and Air Quality, Mail Code: 6406J, U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue, NW, 20460; telephone number: (202) 564-0628; fax number: (202) 564-1686; email address: *monger.jon@epa.gov*.

SUPPLEMENTARY INFORMATION:

This notice is organized as follows:

I. Introduction

As part of changes to the Renewable Fuel Standard (RFS) program regulations published on March 26, 2010[1] (the "March 2010 rule"), EPA specified the types of renewable fuels eligible to participate in the RFS program through approved fuel pathways. Table 1 to 40 CFR 80.1426 of the RFS regulations lists three critical components of an approved fuel pathway: (1) fuel type; (2) feedstock; and (3) production process. Fuel produced pursuant to each specific combination of the three components, or fuel pathway, is designated in the Table as eligible for purposes of the Act's requirements for greenhouse gas reductions, to qualify as renewable fuel or one of three subsets of renewable fuel (biomass-based diesel, cellulosic biofuel or advanced biofuel). EPA may also independently approve additional fuel pathways not currently listed in Table 1 to §80.1426 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.

EPA's lifecycle analyses are used to assess the overall greenhouse gas impacts of a fuel throughout each stage of its production and use. The results of these analyses, considering uncertainty and the weight of available evidence, are used to determine whether a fuel meets the

[1] See 75 FR 14670.

necessary greenhouse gas reductions required under the Clean Air Act (CAA) for it to be considered renewable fuel or one of the subsets of renewable fuel. Lifecycle analysis includes an assessment of emissions related to the full fuel lifecycle, including feedstock production, feedstock transportation, fuel production, fuel transportation and distribution, and tailpipe emissions. Per the CAA definition of lifecycle GHG emissions, EPA's lifecycle analyses also include an assessment of significant indirect emissions such as emissions from land use changes, agricultural sector impacts, and production of co-products from biofuel production.

Pursuant to 40 CFR 80.1416, EPA received a petition from the National Sorghum Producers (NSP), submitted under a claim of confidential business information (CBI), requesting that EPA evaluate the lifecycle GHG emissions for biofuels produced using a biomass sorghum feedstock, and that EPA provide a determination of the renewable fuel categories, if any, for which such biofuels may be eligible. As an initial step in this process, EPA has conducted a preliminary evaluation of the GHG emissions associated with the growth and transport of biomass sorghum when it is used as a biofuel feedstock, and is seeking public comment on the methodology and results of this preliminary evaluation.

After considering comments received, EPA expects to revise its assessment as appropriate and then use the information to evaluate petitions received pursuant to 40 CFR 80.1416 which propose to use biomass sorghum as a feedstock for the production of biofuel, and which seek an EPA determination regarding whether such biofuels qualify as renewable fuel under the RFS program. In evaluating such petitions, EPA will consider the GHG emissions associated with petitioners' biofuel production processes, as well as emissions associated with the transport and use of the finished biofuel, in addition to the GHG emissions associated with the use and transport of biomass sorghum feedstock in determining whether petitioners' proposed biofuel production pathway satisfies CAA renewable fuel lifecycle GHG reduction requirements.

II. Analysis of Greenhouse Gas Emissions Associated with use of Biomass Sorghum as a Biofuel Feedstock

To evaluate the lifecycle GHG emissions associated with the use of biomass sorghum feedstock to produce biofuels, we used a similar approach to that used for miscanthus in the March 2010 rule, in which GHG emissions associated with the growth and transport of miscanthus was determined by comparing feedstock-related GHG emissions to those of switchgrass. In the March 2010 rule, EPA determined that biofuel made from switchgrass using designated processes meets the GHG emissions reduction threshold for cellulosic fuels. For miscanthus, new agricultural modeling was deemed unnecessary; EPA ultimately determined that miscanthus would have similar lifecycle GHG emissions to switchgrass and therefore that biofuels made from designated processes using miscanthus as a feedstock would have similar lifecycle GHG emissions as similar biofuels made through the same processes with switchgrass. EPA also followed a similar approach in assessing GHG emissions associated with the use of energy cane, giant reed, and napier grass in rules published on March 5, 2013 (the "March 2013 rule")[2] and July 11, 2013 (the "July 2013 rule").[3]

[2] 78 FR 14190.
[3] 78 FR 41703.

As described in detail in the following sections of this notice, EPA believes that new agricultural sector modeling is not needed to analyze biomass sorghum. Instead, we evaluated the agricultural sector GHG emissions impacts of using biomass sorghum by reference to switchgrass. Both biomass sorghum and switchgrass are grasses with high yields and high cellulosic contents. Our preliminary assessment indicates that on a per dry ton of feedstock basis indirect land use emissions would be lower, direct emissions associated with use of farm machinery, fertilizers and pesticides would be lower, and that emissions associated with feedstock transport would be the same as for switchgrass. Therefore, we propose in responding to petitions received pursuant to 40 CFR 80.1416 to assume that on a per dry ton of feedstock basis GHG emissions associated with biomass sorghum production and use are the same as those associated with the production and use of switchgrass for biofuel production. We believe that this is a conservative approach, and we invite comment on it.

A. Feedstock Description, Production, and Distribution

Although all types of cultivated sorghum belong to the species *Sorghum bicolor* (L.) Moench, breeding for different purposes has led to significant variation within this species. Sorghum is native to Africa, but was introduced to the U.S. in the early 17th century. Historically, sorghum has been bred to be used as a grain, a source of sugar, and as animal forage. More recently, it has also been bred to increase biomass. Different types of sorghum have different characteristics and may therefore qualify as different types of renewable fuels under the RFS program, making it important to distinguish among the different types of sorghums.

Grain Sorghum. In the U.S., grain sorghum is commonly used as animal feed similar to feed corn, although in other parts of the world it is used for human consumption. Pathways for ethanol produced from grain sorghum feedstock were approved in a rule published on December 17, 2012 (the "December 2012 RFS rule")[4].

Sweet Sorghum. Sweet sorghum has historically been bred to maximize sugar content, and is crushed to yield a juice that is high in sugars that are easily fermentable. Processing sweet sorghum is similar to processing sugarcane, and the resulting juice can be used to produce sorghum syrup for food consumption or as a biofuel feedstock.

Forage sorghum. Varieties of forage sorghum are typically used for animal grazing. These varieties of sorghum have been bred for optimal nutrition, including high content of digestible nutrients and low lignin content.

Sorghum bred for biomass content. Recently, producers have begun breeding sorghum as a feedstock for biofuel production, beginning with forage sorghum varieties. The goal of these breeding efforts has been to maximize the total biomass yield for use as biofuel feedstock. The resultant sorghum varieties generally have greatly enhanced biomass yields (plants can grow to be over 20 feet tall), longer growing seasons, and lower nitrogen demand because digestibility is not a concern.

Differentiating the types of sorghum for purposes of the lifecycle analysis required under the RFS program is challenging because varieties bred for different purposes all belong to the

[4] See 77 FR 74592.

same species and are often defined based on end-use, rather than based on specific physical characteristics.[5] For purposes of this Notice, EPA considers biomass sorghum to be *Sorghum bicolor* that has been selected or bred to maximize cellulosic content rather than sugar or grain content, and which therefore has at least 75% cellulosic content. EPA also considers hybrids that are crosses of *Sorghum bicolor* and sudangrass[6] to be biomass sorghum if they have 75% cellulosic content, but EPA does not consider hybrids that are crosses of *Sorghum bicolor* and Johnsongrass (*Sorghum halepense*) to be biomass sorghum, even if such hybrids have 75% or higher cellulosic content. This approach is consistent with the NSP petition, which explicitly excluded Johnsongrass due to concerns regarding its potential to behave as an invasive species. See Section II.D. for further discussion of varieties considered biomass sorghum for purposes of this Notice.

1. Crop Yields

For the purposes of analyzing the GHG emissions from biomass sorghum production, EPA examined crop yields and production inputs in relation to switchgrass to assess the relative GHG impacts. For the switchgrass lifecycle analysis, EPA assumed national average yields of approximately 4.5 to 5 dry tons per acre.[7] Based on field trials in nine states under a range of growing conditions, the 2012 average yield of sorghum grown for biomass content is

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[5] E.g. Stefaniak, T.R., J.A. Dahlberg, B.W. Bean, N. Dighe, E.J. Wolfrum, and W.L. Rooney (2012). Variation in biomass composition components among forage, biomass, sorghum-sudangrass and sweet sorghum types. *Crop Science*, 52, 1949-1954.

[6] Sudangrass (*Sorghum* x *drummondii*) is a forage grass which is commonly crossed with *Sorghum bicolor* to produce hybrids. FAO Grassland Species Profile, http://www.fao.org/ag/agp/AGPC/doc/gbase/data/pf000494.HTM. Accessed 15 September, 2014.

[7] Kumar, A. and S. Sokhansanj (2007). "Switchgrass (*Panicum vigratum*, L,) delivery to a biorefinery using integrated biomass supply analysis and logistics (IBSAL) model." Bioresource Technology, 98:1033-1044. A more recent study compiled switchgrass yield data from 45 studies from 1991-2010, and found an average yield of 4.9 dry tons per acre: Maughan, M.W. (2011) "Evaluation of switchgrass, *M. x giganteus*, and sorghum as biomass crops: Effects of environment and field management practices." Ph.D. Dissertation, University of Illinois at Urbana-Champaign.

approximately 11 dry tons per acre,[8] suggesting that biomass sorghum will have significantly higher yields than switchgrass.

Furthermore, EPA's analysis of switchgrass for the RFS rulemaking assumed a 2% annual increase in yield that would result in an average national yield of 6.6 dry tons per acre in 2022.[9] EPA anticipates similar yield improvements for biomass sorghum as for switchgrass since both feedstocks are energy crops in the early stages of development, and improvements in farming practices or new hybrids could increase the yield over time.[10] Given the potential for yield improvements, our analysis assumed an average biomass sorghum yield of 13 dry tons per acre in the southern United States by 2022, which was calculated using a 2% annual increase in yield.

Because of its higher yield, biomass sorghum grown in areas with suitable growing conditions would require approximately 50% less land area compared to switchgrass to produce the same amount of biomass. Even without yield growth assumptions, the current higher crop yield means the land use required for biomass sorghum should be lower than for switchgrass. Therefore less crop area would be converted and displaced through use of biomass sorghum as compared to switchgrass.

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[8] Petition, based on data from 8 sources. A study of the yield of biomass sorghum in Illinois found yields from 10.1-13.4 dry tons/acre: Maughan, M.W. (2011). "Evaluation of switchgrass, *M. x giganteus*, and sorghum as biomass crops: Effects of environment and field management practices." Ph.D. Dissertation, University of Illinois at Urbana-Champaign.

[9] A recently released switchgrass cultivar, "Liberty" has a yield of 8.1 tons/acre in Nebraska (7.3 dry tons/acre, assuming a dry matter content of 90%). As hybrids like this become more commonly used, average national yields will increase; Vogel, K. P., R. B. Mitchell, M. D. Casler and G. Sarath (2014). "Registration of 'Liberty' Switchgrass." Journal of Plant Registrations, 8:242-247.

[10] Progress is being made in developing new biomass sorghum hybrids with higher yields than the parents. Increased used of these hybrids will increase national average yields. Packer, D. J. and W. L. Rooney (2014). "High-parent heteropsis for biomass yield in photoperiod-sensitive sorghum hybrids." Field Crops Research, 167:153-158.

2. Land Use

Biomass sorghum is not currently grown at commercial scale in the United States for the purpose of biofuel production, although approximately 1.4 million acres of forage sorghum were planted in 2012. Biomass sorghum is currently grown in test plots as part of research to develop it as an energy crop, and currently has no other uses. Biomass sorghum can be planted as early as April and can continue growing until the fall.[11] Production is expected to be concentrated in the South Central U.S. in Texas, Oklahoma and Kansas, as well as in Missouri and Arkansas.[12] These areas are similar to the acres where our agricultural sector modeling projected switchgrass would be grown in the March 2010 rule. In addition, modeling results presented in DOE's Billion-Ton Update suggest that biomass sorghum and switchgrass will be grown in similar regions.[13]

In EPA's analysis for the March 2010 rule, switchgrass plantings were projected to primarily displace soybeans and wheat, and to a lesser extent hay, rice, grain sorghum, and cotton in the South Central U.S. Because biomass sorghum is likely to be grown on similar

[11] Blade Energy Crops (2010). "Managing High-Biomass Sorghum as a Dedicated Energy Crop." Available at: www.bladeenergy.com/Bladepdf/Blade_SorghumMgmtGuide2010.pdf.

[12] According to DOE's Billion-Ton Update, "dedicated biomass sorghums grow well throughout the eastern and central United States as far north at 40^{o} latitude." Department of Energy (DOE) (2011). U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry, http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf. DOE's Billion Ton study conducted a technical analysis of the amount of potential biomass that could be produced in the U.S. under a range of different conditions. This study showed that biomass sorghum and switchgrass have the potential to contribute enough biomass to exceed the volumes of cellulosic biofuel required by the CAA. The purpose of EPA's 2010 analysis was to estimate one potential scenario for meeting the biofuel volume requirements in the CAA, not to estimate the maximum potential volumes of biofuels that could be produced in the U.S.

[13] Department of Energy (DOE) (2011). U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry, http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf.

existing agricultural land in the same regions, as explained above, and because biomass sorghum yields are higher than yields of switchgrass (so should displace fewer total acres) EPA concludes that the indirect land use GHG impact for biomass sorghum per gallon should be no greater and likely less than estimated for switchgrass.

In the switchgrass ethanol scenario done for the March 2010 rule, total cropland acres were projected to increase by 4.2 million acres, including an increase of 12.5 million acres of switchgrass and decreases of 4.3 million acres of soybeans, 1.4 million acres of wheat, and 1 million acres of hay, as well as smaller decreases in a variety of other crop acreages. This analysis took into account the economic conditions such as input costs and commodity prices when evaluating the GHG and land use change impacts of switchgrass. Given the higher yields of the biomass sorghum considered here compared to switchgrass, there should be ample land available for production without having any adverse impacts beyond those projected for switchgrass production.

The indirect land use impacts for biomass sorghum are assumed to be similar to or less than those modeled for switchgrass. The justification for this assumption is that both crops are expected to be grown in the South Central U.S. and will likely displace the same types of cropland, but because of higher biomass sorghum yields, fewer total acres will be displaced per gallon of fuel produced.[14] Furthermore, we believe biomass sorghum will have a similar impact on international markets as assumed for switchgrass. Like switchgrass, biomass sorghum is not expected to be traded internationally and its impacts on other crops are expected to be limited.

[14] Department of Energy (DOE) (2011). U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry, http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf.

Accordingly, indirect land use change GHG emissions associated with biomass sorghum would likely be smaller than such emissions for switchgrass. Thus, we believe that our proposal to assume in our lifecycle GHG emissions assessments that indirect land use change GHG emissions from biomass sorghum would be similar to switchgrass represents a conservative approach.

3. Crop Inputs and Feedstock Transport

EPA also assessed the GHG impacts associated with planting, harvesting, and transporting biomass sorghum in comparison to switchgrass. Table 1 below shows the assumed 2022 commercial-scale production inputs for switchgrass modeled for the March 2010 rule and average biomass sorghum production inputs based on U.S. Department of Agriculture (USDA) projections and industry data. Available data gathered by EPA suggest that biomass sorghum requires on average less nitrogen, phosphorous, potassium, and pesticide than switchgrass per dry ton of biomass, but more herbicide and diesel per dry ton of biomass. The inputs were given to EPA from the petitioners based on field trials, verified by the USDA, and documented in peer-reviewed journals where possible. Since biomass sorghum is an annual crop and switchgrass is a perennial, some inputs required for growing biomass sorghum, such as herbicide and diesel, are slightly higher than inputs for switchgrass (see Table 1 below). Applying the GHG emission factors used for the March 2010 rule, biomass sorghum production results in lower GHG emissions per dry ton of biomass produced relative to switchgrass production, as shown in Table 1, below. More information on biomass sorghum inputs is available in the docket.

Table 1—Direct inputs for switchgrass and biomass sorghum[15]

	Switchgrass[16]				Biomass Sorghum[17]			
Category	**Inputs (per dry ton of biomass)**		**Emissions (per dry ton of feedstock)**		**Inputs (per dry ton of biomass)**		**Emissions (per dry ton of feedstock)**	
Yield (Projected)	6.6	dry tons/acre			13	dry ton/acre		
Nitrogen Fertilizer	15.2	lbs/dry ton	25	kg CO_2eq	4.6	lbs/dry ton	8	kg CO_2eq
N_2O	N/A		136	kg CO_2eq	N/A		105	kg CO_2eq
Phosphorus Fertilizer	6.1	lbs/dry ton	3	kg CO_2eq	1.2	lbs/dry ton	0.6	kg CO_2eq
Potassium Fertilizer	6.1	lbs/dry ton	2	kg CO_2eq	0.5	lbs/dry ton	0.2	kg CO_2eq
Herbicide	0.002	lbs/dry ton	0.02	kg CO_2eq	0.4	lbs/dry ton	5	kg CO_2eq
Insecticide	0.02	lbs/dry ton	0.3	kg CO_2eq	0.003	lbs/dry ton	0.05	kg CO_2eq
Lime	0	lbs/dry ton	0	kg CO_2eq	0	lbs/dry ton	0	kg CO_2eq
Diesel	0.4	gal/dry ton	6	kg CO_2eq	0.7	gal/dry ton	9	kg CO_2eq
Electricity (irrigation)	0	kWh/dry ton	0	kg CO_2eq	0.0	kWh/dry ton	0	kg CO_2eq
Total GHG emissions			173	kg CO_2eq			128	kg CO_2eq

The lifecycle GHG emissions associated with distributing biomass sorghum feedstock are expected to be similar to EPA's estimates for switchgrass feedstock. One major difference is that switchgrass has a longer harvest window than biomass sorghum. Biomass sorghum is typically harvested in the fall, whereas switchgrass can be harvested from July to March. This suggests that for fuel production purposes, harvested switchgrass would not need to be stored as long as biomass sorghum because it would be available directly from the field for a longer period of time.[18] However, harvesting switchgrass just once per year, in the fall, can maximize yield and

[15] The IPCC equations for N_2O emissions were updated since our earlier analysis of switchgrass. We use the updated equations here.
[16] Beach, R.H. and B.A. McCarl (2010). U.S. Agricultural and Forestry Impacts of the Energy Independence and Security Act: FASOM Results and Model Description. Docket EPA-HQ-OAR-2005-0161-3178
[17] Input data are from petitioners, peer-reviewed literature, and USDA. Details on the sources of input data can be found in the docket. Emissions are calculated based on the input data and emission factors.
[18] Haque, M. and F. M. Epplin (2012). "Cost to produce switchgrass and cost to produce ethanol from switchgrass for several levels of biorefinery investment cost and biomass to ethanol conversion rates." Biomass and Bioenergy, 46:517-530.

minimize nutrient inputs.[19] Therefore, even though switchgrass could be harvested more often, in practice it may just be harvested once per year in the fall, like biomass sorghum. In addition, the biomass sorghum harvest window can be extended by staggering planting times, using a range of hybrids with different harvesting times, or using multiple cuttings, which would reduce storage needs.[20] When switchgrass and biomass sorghum need to be stored, both can be stored in bales.[21]

Biomass sorghum is expected to achieve higher yields and thus the feedstock distribution radius around a similar sized biofuel production plant, or biomass collection hub, could be lower for biomass sorghum than for switchgrass. Therefore, even though there can be differences in the harvest period of switchgrass and biomass sorghum, our analysis makes the simplifying assumption that both crops require similar transport, loading, unloading, and storage regimes, and have the same GHG emissions for feedstock distribution, on a per dry ton of feedstock basis. Harvesting, storage, and distribution were a small fraction of the total GHG emissions for switchgrass, so we do not believe this simplification substantially affects our lifecycle analysis.

B. Summary of Agricultural Sector Greenhouse Gas Emissions

[19] Mitchell, R. B., and M. R. Schmer (2012). "Switchgrass harvest and storage." *Switchgrass*. A. Monti (ed.), London: Springer-Verlag, 113-127; Garland, C. D., et al (2008). "Growing and harvesting switchgrass for ethanol production in Tennessee." University of Tennessee Agricultural Extension Service.

[20] Turhollow, A. F, E. G. Webb, and M. E. Downing (2010). "Review of sorghum production practices: Applications for Bioenergy." Oak Ridge National Laboratory, Oakridge, TN. Available at: http://info.ornl.gov/sites/publications/files/Pub22854.pdf; Blade Energy Crops (2010). "Managing high-biomass sorghum as a dedicated energy crop." Available at: http://www.bladeenergy.com/Bladepdf/Blade_SorghumMgmtGuide2010.pdf.

[21] Blade Energy Crops (2010). "Managing high-biomass sorghum as a dedicated energy crop." Available at: http://www.bladeenergy.com/Bladepdf/Blade_SorghumMgmtGuide2010.pdf; Sanderson, M. A., R. P. Egg, and A. E. Wiselogel (1997). "Biomass losses during harvest and storage of switchgrass." Biomass and Bioenergy, 12(2):107-114.

Based on our comparison of biomass sorghum to switchgrass, EPA proposes to use, in its future evaluations of petitions proposing to use biomass sorghum as feedstock for biofuel production, an estimate of the GHG emissions associated with the cultivation and transport of biomass sorghum that is the same as that which we have used for switchgrass, on a per dry ton of feedstock basis. EPA solicits comment on this proposed approach.

C. Fuel Production and Distribution

Biomass sorghum is suitable for the same conversion processes as approved cellulosic feedstocks such as switchgrass and corn stover. After reviewing comments received in response to this Notice, we will combine our evaluation of agricultural sector GHG emissions associated with the use of biomass sorghum feedstock with our evaluation of the GHG emissions associated with individual producers' production processes and finished fuels to determine whether the proposed pathways satisfy CAA lifecycle GHG emissions reduction requirements for RFS-qualifying renewable fuels. Based on our evaluation of the lifecycle GHG emissions attributable to the growth and transport of biomass sorghum feedstock, EPA anticipates that fuel produced from biomass sorghum feedstock through the same biochemical or thermochemical process technologies that EPA evaluated for the March 2010 RFS rule for biofuel derived from switchgrass feedstock would qualify for cellulosic biofuel (D-code 3) renewable identification numbers (RINs) or cellulosic diesel (D-code 7) RINs depending on the type of fuel produced.[22]

[22] The biochemical and thermochemical processes that EPA evaluated for the March 2010 RFS rule for biofuel derived from switchgrass feedstock are described in section 2.4.7.4 (Cellulosic Biofuel) of the Regulatory Impact Analysis for the March 2010 RFS rule (EPA-420-R-10-006).

However, EPA will evaluate petitions for fuel produced from biomass sorghum feedstock on a case-by-case basis.[23]

D. Cellulosic Content of Biomass Sorghum

For biomass sorghum-derived biofuels to qualify as cellulosic biofuel under the RFS program, the fuel must achieve a 60% lifecycle GHG reduction as compared to the 2005 baseline fuels, and must also be derived from cellulose, hemicellulose and lignin. This section of the Notice discusses our preliminary analysis of the extent to which fuel made from biomass sorghum may qualify as derived from cellulose, hemicellulose and lignin. For simplicity, these three chemicals are hereafter referred to as "cellulose," and their presence in feedstock as the feedstock's "cellulosic content."

In the rule published on July 18, 2014 (the "July 2014 rule"),[24] EPA determined that fuel generated from feedstocks with an average adjusted cellulosic content[25] of 75% or more is eligible to generate cellulosic biofuel RINs for the entire fuel volume. EPA examined the biochemical composition of different feedstocks commonly understood to be "cellulosic," including corn stover and other crop residues, switchgrass, miscanthus, energy cane, giant reed, napier grass, and various woods and tree branches. Based on this work, EPA found that roughly 75-90% of the organic biomass of these feedstocks was cellulosic, and the balance was

[23] Similarly, EPA anticipates that naphtha produced from biomass sorghum feedstock through any of the gasification and upgrading processes that EPA evaluated in the March 2010 RFS rule (78 FR 14190) for biofuel derived from switchgrass feedstock would likely qualify for cellulosic biofuel (D-code 3) RINs, but EPA intends to evaluate petitions for naphtha produced from biomass sorghum feedstock on a case-by-case basis.
[24] "Regulation of Fuels and Fuel Additives: RFS Pathways II, and Technical Amendments to the RFS Standards and E15 Misfueling Mitigation Requirements." 79 FR 42128
[25] Adjusted cellulosic content is the percent of organic material that is cellulose, hemicellulose, and lignin.

comprised of other constituents, such as starches and sugars.[26] EPA considered in the July 2014 rule the extent to which fuel made from these and other feedstocks with some amount of cellulosic content should be considered "cellulosic biofuel," and determined in the rule that the entire volume of fuel derived from feedstocks with at least 75% adjusted cellulosic content should be considered cellulosic biofuel. Fuel made from feedstocks having less cellulosic content could qualify for the generation of cellulosic biofuel RINs for a portion of the finished fuel.

In the July 2014 rule, EPA described in more detail why we believed that setting the threshold at 75% percent appropriately implements the statutory requirements while not imposing excessive administrative burden on industry. In that rulemaking, EPA also explained that we would apply the 75% threshold to feedstocks that we evaluated in the future, and finalized a definition of energy cane, which can have a wide range of cellulosic contents. Consistent with that rulemaking, we have evaluated the cellulosic content of biomass sorghum. The results of chemical analyses of biomass sorghum and other types of sorghum are shown in Table 2 below and derive from two scientific studies and industry data. One study found that sorghum selected or bred for enhanced biomass content was composed of 61-72% cellulosic materials, with an average of 67% cellulosic material, whereas the other found an average composition of 59% cellulosic material. When these values are adjusted to remove the ash content (which will not yield biofuel),[27] the adjusted cellulosic contents are 75% and 63%,

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[26] See ''Cellulosic Content of Various Feedstocks – 2014 Update.'' Docket EPA–HQ–OAR–2012-0401.

[27] Adjustments are also made to account for percent recoveries less than 100%. If all chemical components of a feedstock are analyzed, the total recovery should equal 100%. However, recoveries may be lower than 100% because of losses during sample processing. For recoveries less than 100%, the percent concentration of each component was adjusted so that the total percent recovery equaled 100%. For more information, see ''Cellulosic Content of Various Feedstocks – 2014 Update.'' Docket EPA–HQ–OAR–2012-0401.

respectively, from the two studies (Table 2). Compared to traditional forage sorghums, one study found sorghums selected or bred for biomass content had greater cellulosic content, whereas the other found they had lower cellulosic content. These differences likely reflect both the natural heterogeneity within crops and the fact that breeders are still experimenting with sorghum to find which varieties are best for biofuel usage, and thus have not yet settled on any particular sets of "ideal" properties or compositions for this crop. Breeding of sorghum to enhance biomass content is in the early stages, and it is likely that in the future, these feedstocks may be bred to contain greater proportions of cellulose, hemicellulose and lignin. Data submitted by NexSteppe and available in the docket indicate that newer hybrids of sorghum do have higher percentages of cellulose, hemicellulose, and lignin, in the range of 75-81%, with a range of 77-89% for the adjusted cellulosic content. Some of the sorghum samples also contained significant proportions of sugar (0.3-19%) and starch (0-12%), as shown in Table 2.

Table 2—Chemical composition of different types of sorghum samples, as determined by two research studies and from industry data. The adjusted cellulosic composition was calculated by adjusting the reported content of cellulose, hemicellulose and lignin for the ash content and for the total yields.

		Chemical Composition (%)							
	Source	Dahlberg et al. (2011)*,[28]			Stefaniak et al. (2012)†,[29]				NexSteppe[30]
	Sorghum variety	High-Yield	Sudan/ Sorghum	Forage	Biomass^	Sudan/ Sorghum	Forage	Sweet	Biomass^
Number of samples		5	4	15	51	6	41	54	7
Sucrose (sugar)	Average	2.9	2.7	1.0	9.0	2.4	1.1	9.8	4.5
	Range	1.6-4.6	0.4-3.5	0.2-1.7	0.3-19	0.4-4.6	0.2-3.0	0.2-23.9	1.2-8.5
Starch	Average	0.8	5.6	18.1	5.6	1.1	1.8	7.3	3.4
	Range	0-4	0-15	0-25.2	0-12.0	0-4.0	0-8.9	0-16.6	0.3-8.1

[28] Dahlberg, J., E. Wolfrum, B. Bean, and W.L. Rooney (2011). Compositional and agronomic evaluation of sorghum biomass as a potential feedstock for renewable fuels. *Journal of Biobased Materials and Bioenergy*. 5, 1-7. Values include additional data provided by J. Dahlberg on October 22, 2013.
[29] Stefaniak, T.R., J.A. Dahlberg, B.W. Bean, N. Dighe, E.J. Wolfrum, and W.L. Rooney (2012). Variation in biomass composition components among forage, biomass, sorghum-sudangrass and sweet sorghum types. *Crop Science*, 52, 1949-1954.
[30] For more information, see "14-10-09 NexSteppe EPA submission.pdf." Docket EPA-HQ-OAR-2014-0537.

Cellulosic Components	Average	66.7	62.0	54.9	59.2	63.9	66.4	58.3	77.5
	Range	61.3-72.3	53.8-67.5	46.8-73.6	-	-	-	-	75.3-80.5
Adjusted Cellulosic Composition	Average	75.4	70.0	60.5	63.2	72.5	70.1	61.8	83.7
	Range	68.9-82.8	61.2-75.8	50.5-84.4	-	-	-	-	77.4-88.6

*This paper analyzed 22 samples of forage sorghum, including some high-yield varieties that could be used for biomass purposes. The four sudan/sorghum varieties include two samples that were also counted in the high-yield category. The remaining varieties fall into the forage sorghum category.
†This study separated 152 samples of sorghum into groups based on end use, with samples being harvested at different growth stages and containing various tissue types depending on how the material would ultimately be used. See the original source for more information about the different classes of sorghum.
^These sources refer to certain hybrids as "biomass" sorghum. However, this does not necessarily mean that these varieties meet EPA's 75% adjusted cellulosic content threshold.

In the July 2014 rule, EPA considered the cellulosic content of energy cane. Like biomass sorghum, cane can be bred for a wide range of cellulosic and sugar contents. In that rule, EPA defined "energy cane" as cultivars containing at least 75% adjusted cellulosic content. EPA also indicated that in the future, feedstocks that could be bred for a wide range of uses and fiber content would have registration requirements similar to energy cane, in order to demonstrate that the adjusted cellulosic content of varieties used is at least 75%. Therefore, for the purposes of the cellulosic content issue, EPA intends to treat biomass sorghum similar to energy cane. For purposes of this Notice, we consider biomass sorghum to include varieties containing at least 75% adjusted cellulosic content. If, as a result of a complete lifecycle assessment in response to individual producer petitions EPA determines that a given fuel product made from biomass sorghum satisfies the 60% lifecycle GHG reduction requirement for cellulosic biofuel, 100% of the fuel in question would qualify for cellulosic biofuel RINs, provided the producer can demonstrate that the varieties they use as a feedstock contain at least 75% adjusted cellulosic content and satisfy all other applicable definitional, registration, recordkeeping, and reporting requirements. We would consider any cultivars with an adjusted cellulosic content less than 75% to be forage sorghum, which we are not addressing in this

Notice. See the discussion regarding energy cane in the July 2014 rule and accompanying memo to the docket[31] for a description of the methodologies and data EPA considers suitable for demonstrating that the average adjusted cellulosic content is at least 75%. We expect that any approved petition for cellulosic biofuel made from biomass sorghum would contain registration requirements comparable to those set forth at 40 CFR 80.1450(b)(1)(xiv).

[31] 79 FR 42128; ‘‘Cellulosic Content of Various Feedstocks – 2014 Update.’’ Docket EPA–HQ–OAR–2012-0401.

III. Summary

EPA invites public comment on its preliminary analysis of GHG emissions associated with the cultivation and transport of biomass sorghum as a feedstock for biofuel production. EPA expects to revise its analysis as appropriate in light of public comments received, and to thereafter use the analysis as part of its evaluation of the lifecycle GHG emissions of biofuel production pathways described in petitions received pursuant to 40 CFR 80.1416 which use biomass sorghum as a feedstock.

Dated: December 17, 2014.

Christopher Grundler,

Director, Office of Transportation and Air Quality

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