Update to Herbaceous and Short Rotation Woody Crops in GREET® Based on the 2016 Billion Ton Study

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1. Background

In July of this year, the U.S. Department of Energy released Volume I of the 2016 Billion-Ton Report (U.S. Department of Energy, 2016). The goal of the study was to determine the amount of biomass that could be available as a feedstock for bioenergy and/or bioproducts in various years, while maintaining adequate production levels of agriculture and forestry crops to supply food, feed, fiber and timber markets. This economic modeling-based analysis investigated numerous feedstocks, including forestry resources, energy crops, agriculture residues, and waste resources. County-level biomass production levels were projected for all feedstocks based on farm resource region production budgets that characterize fuel, fertilizer, and agricultural inputs (U.S. Department of Energy, 2016). The Billion Ton Study Volume 1 also includes county-level yields. Argonne has contributed to Volume 2 of this report, which examines the environmental effects of producing the biomass Volume 1 analyses estimate, and is expected to be released later this year, by evaluating the fossil energy consumption and GHG emissions of the biomass production scenarios. In that analysis, twenty feedstocks were evaluated, some of which are already included in GREET® (biomass sorghum, corn, corn stover, pine, miscanthus, poplar, soybeans, switchgrass, and willow). Feedstocks not currently in GREET include other agriculture residues (barley, oat, sorghum, wheat), energy cane, pine, eucalyptus, and the forestry species including hardwoods (upland and lowland), softwoods (natural and planted), and a mixture of hardwoods and softwoods.

At this time, we have chosen to update the national average energy and fertilizer consumption for several agricultural feedstocks already included in GREET based on the farm resource region budgets used to develop biomass costs in Volume 1 of the Billion Ton Study. Corn grain and stover parameters, recently updated (Wang et al., 2014), were not changed in this year's GREET release. Likewise, soybean farming parameters were not updated but continue to be based on Han et al. (2014). Forestry-derived feedstocks are the subject of ongoing analysis and were not updated at this time. Feedstocks that were updated for the 2016 GREET release include biomass sorghum, miscanthus, poplar, switchgrass, and willow.

2. Data and Methodology

The Billion Ton Study Volume 1 contains many different scenarios to assess the range of biomass that would be produced under different prices for biomass and under different yield increase scenarios for the years 2017, 2030, and 2040. To develop national average fuel, fertilizer, and agricultural chemical intensities for feedstocks in GREET, the BC1 2040 scenario from the Billion-Ton study was used (U.S.

Department of Energy, 2016), which assumes a 1% yield increase for cellulosic feedstocks over time and reflects biomass availability in 2040. The total amount of biomass produced is summarized in Table 1.

Table 1: Total biomass produced for the BC1 2040 scenario (U.S. Department of Energy, 2016)

	Biomass Sorghum	Miscanthus	Poplar	Switchgrass	Willow
Total Biomass Produced					
for BC1 2040	19	160	45	161	25
(million dry tons)					

Inputs to producing switchgrass, miscanthus, biomass sorghum, poplar, and willow include diesel consumed during planting and harvesting, fertilizers and agricultural chemicals. To calculate a national average for these inputs for a given feedstock, the total national consumption of that input across all counties for the feedstock was determined and divided by the total national production of that feedstock. Table 2 presents the national average values of fuel, fertilizer, and agricultural chemicals for the five feedstocks considered. To convert results for biomass sorghum from the dry ton basis on which they were originally calculated, a biomass sorghum moisture content of 75% was used based on communication with authors of Volume I of the Billion-Ton report (Eaton and Turhollow, 2016).

	Biomass Sorghum	Miscanthus	Poplar	Switchgrass	Willow
	Per wet tonne	Per dry ton	Per dry ton	Per dry ton	Per dry ton
Fuel Use (Btu)	60,000	45,000	270,000	59,000	190,000
Nitrogen (g-N)	1,500	4,000	2,000	4,300	1,500
Phosphorus (g-P ₂ O ₅)	580	920	590	2,000	650
Potassium (g-K ₂ O)	770	2,500	520	2,800	1,000
Lime (g-CaCO ₃)	13,000	4,600	23,000	5,100	-
Herbicide (g-herbicide)	23	25	62	47	16
Insecticide (g-insecticide)	-	-	12	-	-

Table 2: Fuel, fertilizer and chemical inputs to the GREET® model based on national level BTS inputs.

Important points to keep in mind regarding these results include that they will vary spatially and that they are based on expected yield increases to 2040. These feedstocks are not produced in large amounts today and so it is appropriate to consider a timeframe in which their production will have matured and they are readily-available feedstocks for the biofuels, biopower, and bioproducts industries.

References:

Eaton, L., Turhollow, A.F., (2016) Personal Communication.

- Han, J., Elgowainy, A., Cai, H., Wang, M., 2014. Update to Soybean Farming and Biodiesel Production in GREET. Available at: https://greet.es.anl.gov/publication-soybean-biodiesel-2014.
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- Wang, Z., Dunn, J.B., Wang, M.Q., 2014. Updates to the Corn Ethanol Pathway and Development of an Integrated Corn and Corn Stover Ethanol Pathway in the GREET Model (No. ANL/ESD-14/11). Argonne National Laboratory.