Bioenergy Feedstock Library Annual Summary Report

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EXECUTIVE SUMMARY

The Bioenergy Feedstock Library (BFL), part of the Biomass Feedstock National User Facility (BFNUF) located at INL, is a physical sample repository and a web-accessible electronic database. The BFL stores physical and chemical characteristics of biomass and waste carbon sources for energy use as well as samples generated from across U.S. Department of Energy (DOE) Bioenergy Technologies Office (BETO) and U.S. Department of Agriculture funded projects. The objective of this Bioenergy Feedstock Library Annual Summary Report for 2023 is to focus on the updates to (1) publicly available analytical data and equipment tracked through the BFNUF, (2) physical samples available for request, (3) sample and data archival progress from recent BETO-funded projects, and (4) publicly available datasets created upon request from BETO, INL projects, or outside entities compared to the 2022 Bioenergy Feedstock Library Annual Summary Report. This report highlights key statistics and available data and information important for INL, BFL users, academics, and industry.

Some key highlights from this report include the following:

- The BFL currently tracks over 110,000 unique samples each with its own barcode. Over 66,000 of these samples and associated data have been made publicly available.

- The BFL hosts nearly 200 unique feedstock types and over 933 unique subtypes (e.g., cultivars and representations of municipal solid fractions).

- Of the publicly available samples, there are over 70 unit operations tracked in the BFL spanning the biomass supply chain and over 24,000 samples representing fractionation, separation, and splitting type unit operations.

- Over 30,000 samples have analytical data in the BFL. Two of the biggest chemical data categories of publicly available data are moisture and fuel properties (i.e., volatiles, fixed carbon, ash, carbon, hydrogen, nitrogen, oxygen, sulfur, and calorimetry), which account for 44% and 15% of the samples with analytical data, respectively.

- The BFL freely provides physical samples to researchers along with any available relevant analytical data, including bulk reference materials and over 4,000 physical samples generated from the Regional Feedstock Partnership (RFP)[1] and Feedstock Conversion Interface Consortium (FCIC).[2]

- More than 1,700 samples generated through BETO's various Funding Opportunity Announcement projects have been archived in the BFL, representing energy crops and municipal solid waste.

- The BFL currently provides 13 datasets containing sample and data summaries from peer-reviewed publications, RFP field studies, and datasets generated in response to BFL user data requests that may be of interest to other researchers.

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[1] Office of Energy Efficiency and Renewable Energy. 2016. "Regional Feedstock Partnership Summary Report: Enabling the Billion-Ton Vision." Bioenergy Technologies Office. Last modified July 11, 2016. https://www.energy.gov/eere/bioenergy/articles/regional-feedstock-partnership-summary-report-enabling-billion-ton-vision.

[2] Office of Energy Efficiency and Renewable Energy. n.d. "Feedstock-Conversion Interface Consortium." Bioenergy Technologies Office. Last modified 2023. https://www.energy.gov/eere/bioenergy/feedstock-conversion-interface-consortium.

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CONTENTS

FIGURES

TABLES

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ACRONYMS

ASEC   Affordable and Sustainable Energy Crops

BETO   Bioenergy Technologies Office

BFL   Bioenergy Feedstock Library

BFNUF   Biomass Feedstock National User Facility

C&D   Construction and demolition

CRP   Conservation Reserve Program

DOE   Department of Energy

FCIC   Feedstock Conversion Interface Consortium

FOA   Funding Opportunity Announcement

INL   Idaho National Laboratory

MSW   Municipal solid waste

RFP   Regional Feedstock Partnership

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Bioenergy Feedstock Library Annual Summary Report

1. INTRODUCTION

The Bioenergy Feedstock Library (BFL), part of the Biomass Feedstock National User Facility (BFNUF) located at INL, is a physical sample repository and a web-accessible electronic database. The BFL stores physical and chemical characteristics of biomass and waste carbon sources for energy use as well as samples generated from across U.S. Department of Energy (DOE) Bioenergy Technologies Office (BETO) funded projects (BFL About Us).

The BFL objective is to provide a sample and data management system to bioenergy researchers and a catalog of physical samples and data for researchers and industry to understand and overcome challenges posed by the variability of the physical and chemical properties of biomass while providing all stakeholders with accessible data for the physical and chemical properties of a wide variety of bioenergy feedstock materials.

1.1 Feedstock Types

The BFL houses information for over 150 unique feedstock types spanning agricultural, forest, waste, and algae resource types and blends of multiple resource types (Figure 1).[3] Comprising approximately 88% of the publicly available samples in the BFL are herbaceous energy crops (such as energycane), agricultural residues (e.g., corn stover), and softwood trees (e.g., pine). Between fiscal year (FY) 2022 and FY 2023, the number of agricultural residue samples increased the most compared to other feedstock types from 14,267 to 24,810.

In addition to the more than 150 feedstock types, the BFL has over 933 unique subtypes. These subtypes are representations of cultivars, varieties, species, and other differentiating factors for multiple feedstock types. These feedstock subtype details are captured in

Figure 1. Number of samples for feedstock resource categories publicly available.

metadata fields, such as cultivar, genotype, and species, that are tracked in the BFL. Table 1 provides a summary of some of the biomass subtypes represented for various publicly available biomass resources. Barley straw and wheat straw samples have some of the largest genetic variability currently in the BFL

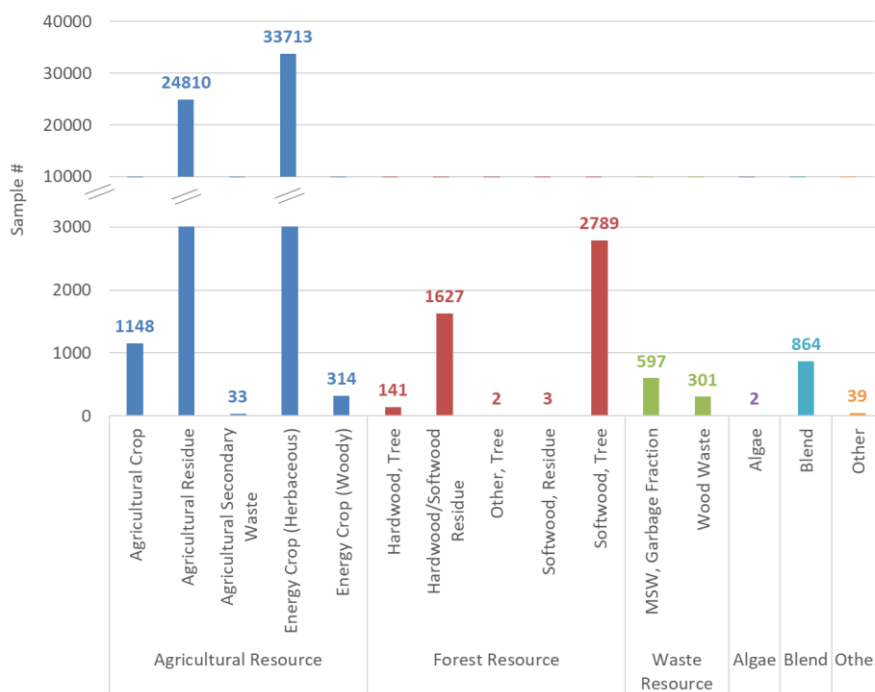[3] The difference between the "trees" and the "residues" in Figure 1 under Forest Resources is the tree typically represents the white wood or whole tree resources while the "residues" typically represent the residue fractions of the tree after logging or thinning.

from BETO-funded projects dating back to the early 2000s. Barley straw has 68 unique cultivar/varieties represented among 242 samples, while wheat straw has 182 cultivar/varieties represented among 2,499 samples. Materials like municipal solid waste (MSW) paper fractions and construction and demolition (C&D) waste also use subtype categories to differentiate waste types. The number of publicly available waste sample types from MSW increased in the BFL between FY 2022 and FY 2023, as seen in Table 1.

Table 1. Summary of feedstock subtypes, including cultivars represented in the BFL for publicly available samples.

Feedstock Types	Subtypes	Sample number
MSW Paper Fraction	8 types (e.g., corrugated cardboard, glossy paper, newspaper)	62
Construction and Demolition (C&D) waste	7 types (i.e., demolition lumber, framing lumber, laminated veneer lumber, oriented strand board, TGI joists, particle board, MDF)	258
Barley Straw	68 unique cultivar/varieties (e.g., Baretta, Cochise, Drummond)	242
Corn Stover/Cob	23 cultivars (e.g., DeKalb 61-69, Legend LR9779RR, Pioneer P0461xr)	3396
Energycane	11 cultivars (e.g., Ho 06-9001, L 99-233, Ho 72-114)	1,372
Grass Clippings/Mixed Lawn Grasses	5 genera (i.e., Cynodon, Poa, Lolium, Festuca, and Zoysia) 4 species (i.e., Bermuda, Kentucky Bluegrass, Ryegrass, Tall Fescue)	271
Hybrid Poplar	2 cultivars (i.e., P. deltoides × P. maximowiczii, P. deltoides × P. nigra hybrid)	185
Mixed Grasses	10 species[a] (e.g., tall fescue, orchardgrass, little bluestem)	5,522
Shrub Willow	35 cultivars (e.g., Onondaga, Fishcreek, 00X-026-082)	1607[b]
Sorghum	3 types (i.e., forage, biomass, sweet) ~14 cultivars (e.g., ES5200, M81E, SugarT)	4616
Switchgrass	6 cultivars (i.e., Alamo, Blackwell, Cave-in-rock, Kanlow, Southlow, Sunburst)	10,371
Wheat/Wheat Straw	182 cultivars/varieties (e.g., Amidon, Briggs, Alturas)	2499

[a] Mixed grass composition within each sample.
[b] Information for shrub willow currently available as a dataset.

1.2 Bioenergy Feedstock Library Overview and Users

The diverse feedstock resources represented in the BFL reflect the evolving bioenergy research priorities of BETO-funded projects over the past decade. The BFL is a living database and is used as the primary sample and data management system for over 100 past and present bioenergy-focused projects. This has resulted in sample information and data management for more than 110,000 bioenergy samples, with approximately 5,000 new samples created each year. Using the BFL database, the data and samples from these projects easily can be made publicly available as projects are completed. To date, information for 66,000 samples has been made publicly accessible compared to FY

Figure 2. Summary of active users represented in the BFL.

2022, where ~52,000 samples and data were publicly accessible. The goal of this project is to continue increasing data and sample accessibility as projects conclude. The BFL provides aggregated data and
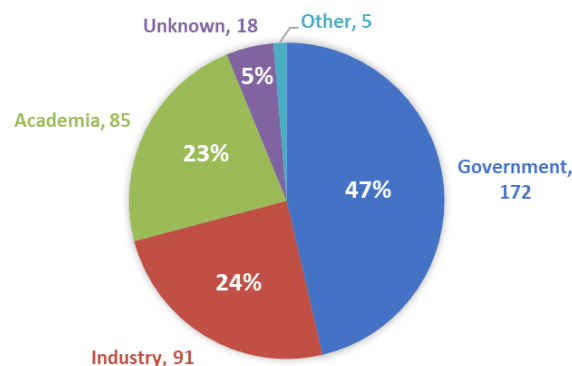
information for public samples through a public-facing web portal without a login. The BFL also allows users to create accounts to access and export more data and sample-specific information. To register for an account, visit the [Registration](#) page. There are 366 active registered users spanning government, industry, and academic institutions in the U.S. and internationally (Figure 2).

1.3 Summary Report Objective

The objective of this 2023 Bioenergy Feedstock Library Annual Summary Report is to focus on the (1) publicly available analytical data and equipment tracked through the BFNUF, (2) physical samples available for request, (3) sample and data archival progress from recent BETO-funded projects, and (4) publicly available datasets created upon request from BETO, INL projects, or outside entities. This report is not intended to be a comprehensive overview of the BFL capabilities but rather to highlight what available data, samples, and information the BFL can provide to INL, BFL users, academics, and industry.

2.   EQUIPMENT AND ANALYTICAL DATA TRACKED

The BFL has tools to store, record, track, and retrieve analytical data and physical samples. Another unique and important feature of the BFL is its ability to track relationships between samples that are represented by unit operations. As material is handled or changes form via a unit operation, new sample identifiers (i.e., globally unique identifiers [GUIDs]) are created in the BFL to represent the newly formed child sample. This hierarchical tracking allows for the capture of information specific to each step in a process. There are approximately 70 unique unit operations tracked in the BFL, spanning feedstock supply and logistics, preprocessing, and conversion process areas. Figure 3 shows the number of publicly available samples for some of the key categories of unit operations. Currently, samples with the highest representation in the BFL are those that have undergone preprocessing unit operations of size reduction through a variety of mills and grinders as well as fractionation using equipment such as air classifiers and screens. The number of samples available for these preprocessing categories compared to last year has increased from 14,760 to 18,797 and 17,968 to 24,093. Additionally, the number of grinders and fractionation equipment represented in the BFL has increased. For many of these size-reduced and fractionated samples, moisture and particle characterization data have been collected and can be found in the BFL.

Figure 3. Equipment examples and number of samples for various unit operation categories represented in the BFL.

Researchers at INL's BFNUF address barriers facing the U.S. bioenergy industry ([BFNUF](#)). Specifically, the BFNUF is focused on these key areas that are critical to producing conversion-ready feedstocks from a variety of biomass and waste carbon sources: advanced feedstock supply logistics, post-harvest quality management, material handling, preprocessing, scale-up and advanced fractionation, and separation

technologies. Beginning in 2020, the BFNUF began a three-year equipment upgrade to expand preprocessing capabilities in size reduction, fractionation, sorting, and conditioning. The equipment upgrade aims to advance this facility to allow researchers to address risks related to material flowability, source variability, equipment performance, and poorly defined feedstock specifications, which have caused production issues for bio-renewable fuels. The BFL, as a key component of the BFNUF, supports the incorporation of the new upgrade preprocessing equipment and unit operations.

The BFL is also used to store analytical data representing the product characteristics of feedstock materials after they have undergone various unit operations. The BFL tracks analytical data for nearly 30,000 samples, of which over 20,000 have been made publicly available, which is an increase of 3,000 samples since FY 2022. The analytical data housed in the BFL are grouped into analysis type categories, as shown in Figure 4. Currently 82% of the available data in these analysis type categories is accounted for by moisture analysis, fuel properties characterization (e.g., volatiles, ash, fixed carbon, total carbon, hydrogen, nitrogen, oxygen, sulfur, and calorific values), and compositional characterization (e.g., carbohydrate, lignin, ash, extractives, and protein contents).
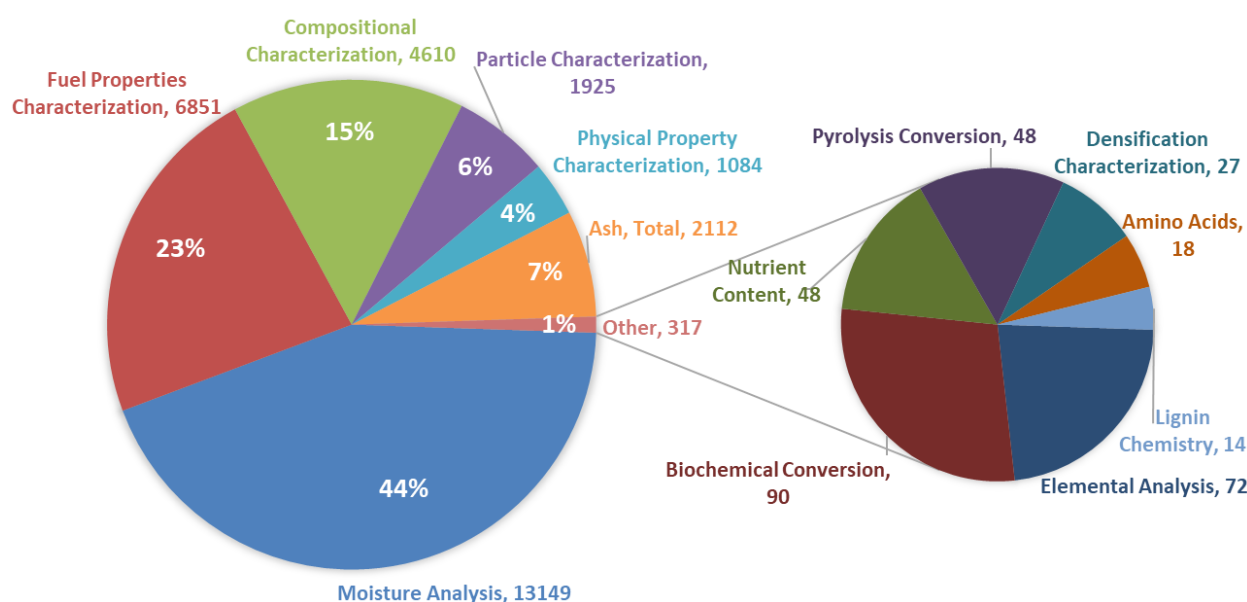
Figure 4. Publicly available analytical data in the BFL.

Like the preprocessing equipment, the BFNUF has recently invested in new analytical characterization instrumentation, including equipment to measure inorganic species and perform particle image analysis. The BFL team is actively working with Bioenergy Feedstock Characterization Laboratory staff (Bioenergy Feedstock Characterization Laboratory) to develop standardized methods for the new analytical equipment from the BFNUF upgrade and to incorporate the resulting methods and data into the BFL.

3.   SAMPLES AVAILABLE FOR REQUEST

The BFL has physical biomass samples available for request. Researchers from government, academia, and industry organizations can contact the BFL Librarian or other BFL team members to inquire about sample availability (BFL Contacts). In addition, requests can be made for samples using the BFL sample request form page (Request Biomass). Samples are archived in the BFL from many BETO-funded projects and are provided based on availability. Three primary sets of biomass samples available publicly include biomass from INL's reference materials, samples generated from the Regional Feedstock Partnership (RFP) field trials, and samples generated from the Feedstock Conversion Interface Consortium project.

3.1 INL Reference Materials

INL's reference materials are industrially relevant, real-world biomass samples available in kilogram quantities with associated characterization data sheets (Figure 5, Biomass Info). The reference materials were originally generated through a BETO-funded project with the intention of creating a sharable feedstock resource. Most of these samples INL processed in bulk, split, and characterized between 2015 and 2016. The reference materials currently available include corn stover, switchgrass, miscanthus, sorghum, wheat straw, and sugarcane bagasse. The BFL aims to identify new reference materials to either refresh feedstock types that are almost depleted or add additional relevant feedstocks (e.g., MSW) as funding permits.

INL Idaho National Laboratory

Switchgrass

REFERENCE MATERIAL

Pedigree

Institution: Oklahoma State University
Location: Garvin County, OK
Cultivar: Alamo

Harvested: 2012
Received at INL: 2013
Sample Preparation: Ground to pass through a 1-inch sieve using a Vermeer BG480 grinder

Composition

Table 1. *Chemical composition^a of Reference Switchgrass (mean of analyses completed 11/2014 & 2/2015)*

%Structural Ash	%Extractable Inorganics	%Structural Protein	%Extractable Protein	%Water Extracted Glucan^b
1.88	2.07	1.51	0.54	2.28
%Water Extracted Xylan^b	**%Water Extractives Others**	**%EtOH Extractives**	**%Lignin**	**%Glucan**
0.09	6.68	2.68	16.24	33.21
%Xylan	**%Galactan**	**%Arabinan^c**	**%Acetate**	**%Total**
21.65	1.43	3.27	3.07	96.60

^{a}Determined using NREL "Summative Mass Closure" LAP (NREL/TP-510-48087)
^{b}Determined by HPLC following an acid hydrolysis of the water extractives
^{c}%Arabinan value includes %mannan, because arabinose and mannose co-elute on the HPLC column
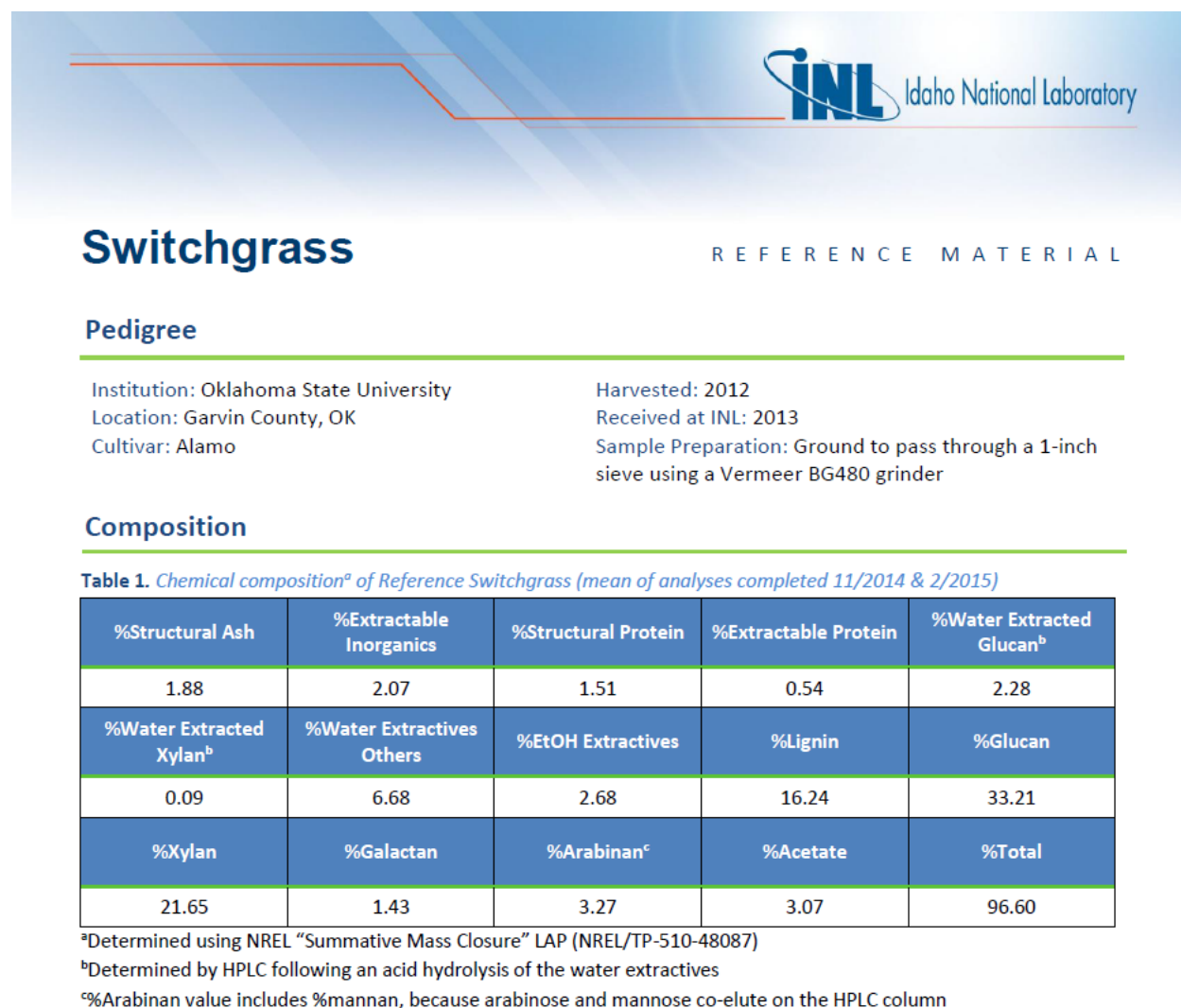
Figure 5. Excerpt from switchgrass reference material data sheet.

3.2 Regional Feedstock Partnership

The Sun Grant RFP's large field trial-based project was developed to fill information gaps and validate biomass yield assumptions from the U.S. DOE Billion-Ton Study.[4,5] The series of field trials included nine
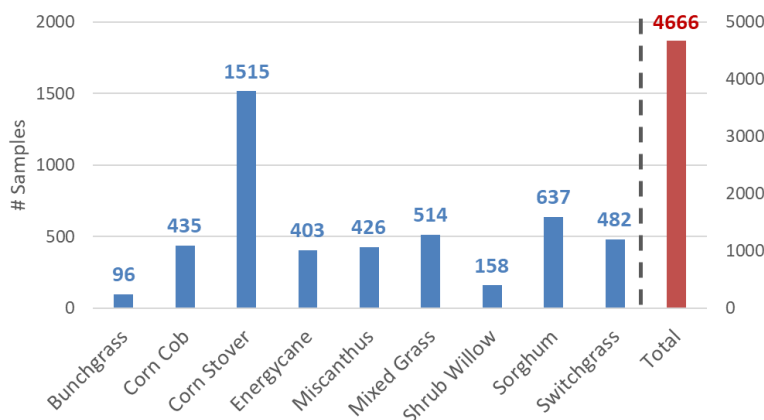

bioenergy feedstocks grown in diverse environments across the United States for five to seven years. The field trials conducted by the RFP led to over 130 scientific publications and were critical in developing both the U.S. Billion-Ton Update report from 2011 and the 2016 Billion-Ton Report.[6,7] The BFL archived samples from these field trials, resulting in over 4,000 biomass samples that have been processed to an approximately 2 mm particle size and are available at quantities under one kilogram (Figure 6). Samples are from a

Figure 6. BFL archived energy crops and agricultural residues from the RFP field trials.

variety of agricultural residues and energy crops, including corn stover, energycane, miscanthus, mixed perennial grasses, shrub willow, sorghum, and switchgrass. Datasets of biomass chemical quality are also available in the BFL for the RFP field trial samples. The links are provided in the DATASETS section of this report. Summaries of the chemical quality data were also published in the Regional Feedstock Partnership Biomass Quality Assessment Final Report.[8]

3.3 Feedstock Conversion Interface Consortium

The Feedstock Conversion Interface Consortium (FCIC) represents a collaborative network of nine U.S. DOE National Laboratories.[9] The FCIC research goals focus on identifying and addressing technical risks faced by integrated biorefineries. Through the FCIC research, large sample sets have been generated representing industrially relevant corn stover and loblolly pine feedstocks (Figure 7). The corn stover samples represent variability across four counties in Iowa and represent ash and harvest moisture levels. Currently, there are approximately 230 samples corn stover samples available from these locations in

[4] Owens, V. N. (2018). Sun Grant/DOE Regional Feedstock Partnership: Final Technical Report. DOE SDSU-85041, South Dakota State University, Brookings, SD, USA. Retrieved from: https://www.osti.gov/servlets/purl/1463330/.

[5] Owens, V. N., D. L. Karlen, and J. A. Lacey, et al. (2016). Regional Feedstock Partnership Report: Enabling the Billion-Ton Vision. INL/EXT-15-37477. U.S. Department of Energy and Idaho National Laboratory, Idaho Falls, ID, USA. Retrieved from: https://www.energy.gov/sites/prod/files/2016/07/f33/regional_feedstock_partnership_summary_report.pdf.

[6] U.S. Department of Energy. (2011). U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R. D. Perlack and B. J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN, USA. Retrieved from: https://www.energy.gov/sites/default/files/2015/01/f19/billion_ton_update_0.pdf.

[7] U.S. Department of Energy. (2016). 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 1: Economic Availability of Feedstocks. M. H. Langholtz, B. J. Stokes, and L. M. Eaton (Leads), ORNL/TM-2016/160. Oak Ridge National Laboratory, Oak Ridge, TN, USA. Retrieved from: http://energy.gov/eere/bioenergy/2016-billion-ton-report.

[8] Emerson, R. M, et al. "Regional Feedstock Partnership Biomass Quality Assessment Final Report." United States. https://doi.org/10.2172/1862678.

[9] Office of Energy Efficiency and Renewable Energy. n.d. "Feedstock-Conversion Interface Consortium." Bioenergy Technologies Office. Last modified 2023. https://www.energy.gov/eere/bioenergy/feedstock-conversion-interface-consortium. https://www.energy.gov/eere/bioenergy/feedstock-conversion-interface-consortium.

formats ranging from unprocessed bale core samples and materials milled to pass a 1-in. screen and 2-mm screen.

The available loblolly pine feedstocks harvested from two states in the Southeast represent "clean" wood samples generated from whole trees, which have their bark removed, and residues representing the tops of harvested trees, including bark, branches, and needles. The 108 loblolly pine formats include samples that have been milled to pass 1/4-in., 3/4-in., and 2-mm screens. More information on the corn stover and loblolly pine, samples can be found in FCIC-related publications.[10,11]

These sample sets have been archived in the BFL and are being made publicly available along with the analytical data and links to associated FCIC publications. As with the reference materials and RFP samples, corn stover and pine samples under one kilogram can be requested by contacting the BFL Librarian or other

Figure 7. FCIC corn stover and loblolly pine samples available for sharing.

BFL team members (BFL Contacts) or be made using the BFL sample request form page (Request Biomass).

4. SAMPLE ARCHIVAL

The BFL aims to make commercially relevant biomass and MSW samples available publicly for research use. To support this objective and to get additional value from DOE BETO-funded bioenergy research, the BFL archives biomass and MSW samples from each of the DOE BETO Renewable Carbon Resources program-funded competitive projects that are required to send samples to the BFL. Each project has its own partnership with the BFL, in which a Sample and Data Management Plan details how samples will be archived, analyzed, and shared; how long samples will be retained; how data will be managed and shared; and necessary dataset disclaimers and other pertinent details. Samples and data will be made available publicly according to each project's plan.

The BFL team has been working with projects funded by the BETO Affordable and Sustainable Energy Crops (ASEC) Funding Opportunity Announcement (FOA),[12] BETO FY 2020 Multi Topic Funding

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[10] A. E. Ray, et al. 2020. Multiscale Characterization of Lignocellulosic Biomass Variability and its Implications to Preprocessing and Conversion: A Case Study for Corn Stover. ACS Sustainable Chemistry & Engineering 8 (8): 3218–3230. https://pubs.acs.org/doi/full/10.1021/acssuschemeng.9b06763.

[11] J. L. Klinger, et al. 2020. Pilot Plant Reliability Metrics for Grinding and Fast Pyrolysis of Woody Residues. ACS Sustainable Chemistry & Engineering 8 (7): 2793–2805. https://pubs.acs.org/doi/full/10.1021/acssuschemeng.9b06718.

[12] Office of Energy Efficiency and Renewable Energy. 2018. "Affordable and Sustainable Energy Crops." Bioenergy Technologies Office. Last accessed October 20, 2023. https://www.energy.gov/eere/bioenergy/affordable-and-sustainable-energy-crops.

Opportunity FOA Topic Area 4,[13] the FY 2021 BETO Feedstocks FOA Topic Area 1,[14] and the FY 2022 BETO Feedstocks FOA Topic Area 1.[15] To date, the BFL has archived switchgrass, miscanthus, sorghum, and energycane for the three ASEC FOA-funded projects:

- University of Illinois-led *Next-Generation Feedstocks for the Emerging Bioeconomy*[16]

- North Carolina State University-led *Next-Generation Miscanthus: Hybrid Performance Evaluation and Enhanced, Sustainable Feedstock Production and Supply in the Southeast U.S. for Biofuels and Bioproducts*[17]

- Texas A&M University-led *Sustainable Herbaceous Energy Crop Production in the Southeast United States.*[18]

These ASEC projects have submitted 1,599 samples for archival, representing energy crops harvested during 2020, 2021, and 2022. Additionally, these projects have worked with the BFL team to develop Sample and Data Management Plans to identify sample and data public release dates beginning in 2023.

The BFL has begun archiving samples for the other active FOA projects as the projects complete their initial verification periods and are given BETO approval to begin work. The BFL has archived hybrid poplar and eastern cottonwood for one of the three projects funded by BETO FY 2020 Multi Topic Funding Opportunity FOA Topic Area 4 and various MSW samples for two of the five projects funded by FY 2021 BETO Feedstocks FOA Topic Area 1. In total, nearly 200 samples have been archived.

5. DATASETS

There are multiple ways to access sample information and data for the various bioenergy resources in the BFL. One mechanism the BFL uses to make data and sample information accessible is through datasets. A dataset is a compilation of meaningful and curated data and sample information, for example, the samples and data associated with a peer-reviewed publication or industrially relevant datasets that have been requested by industry. The current BFL datasets are summarized in Table 2 and can be found in the BFL here: Data Sets. Datasets marked as public do not require a BFL login to access. RFP data, discussed in the "SAMPLES AVAILABLE FOR REQUEST" section, including chemical quality data, have been made available as a dataset for each feedstock type. This includes datasets for energycane, mixed perennial grasses, miscanthus, sorghum, switchgrass, and willow. Data Set 1006, "Image Analysis for Rapid Assessment and Quality-Based Sorting of Corn Stover Data Set," represents supplemental data for a

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[13] Office of Energy Efficiency and Renewable Energy. 2020. "Bioenergy Technologies Office Fiscal Year 2020 Multi-Topic Funding Opportunity Announcement – Project Selections." Bioenergy Technologies Office. Last modified July 31, 2020. https://www.energy.gov/eere/bioenergy/articles/bioenergy-technologies-office-fiscal-year-2020-multi-topic-funding.

[14] Office of Energy Efficiency and Renewable Energy. 2021. "Department of Energy Announces Nearly $34 Million to Advance Waste and Algae Bioenergy Technology." Bioenergy Technologies Office. Last modified July 31, 2020. https://www.energy.gov/eere/bioenergy/articles/department-energy-announces-nearly-34-million-advance-waste-and-algae

[15] Office of Energy Efficiency and Renewable Energy. 2022. "Department of Energy Announces $29.5 Million for Improved Bioenergy Resource Recovery and Conversion Systems." Bioenergy Technologies Office. Last modified August 31, 2022. https://www.energy.gov/eere/bioenergy/articles/department-energy-announces-295-million-improved-bioenergy-resource.

[16] University of Illinois Urabana-Champaign. n.d. "Next-Gen Feedstocks Project." Institute for Sustainability, Energy, and Environment. Last accessed October 30, 2023. https://sustainability.illinois.edu/research/next-generation-feedstocks-for-the-emerging-bioeconomy-project/.

[17] CALS News. 2019. "Fueling the Future: Elephant Grass as Potential Biofuel Material (And More)." Last modified February 12, 2019. https://cals.ncsu.edu/news/fueling-the-future/.

[18] U.S. Department of Agriculture. 2023. "Research Project: Sustainable Herbaceous Energy Crop Production in the Southeast United States." Last modified October 29, 2023. https://www.ars.usda.gov/research/project/?accnNo=437685

publication generated by the FCIC and includes samples similar to the FCIC corn stover samples discussed in the "SAMPLES AVAILABLE FOR REQUEST" section.

Table 2. Datasets available on the BFL.

Dataset Name	Description	Author/Institution
Image Analysis for Rapid Assessment and Quality-Based Sorting of Corn Stover Dataset **Data Set 1006**	Experimental data supporting publication focused on developing a rapid assessment for quality-based sorting of corn stover using images.[19]	Ding, L., Hoover, A.N., Emerson, R.M., Lin, K., Gruber, J.N., Donohoe, B.S., Klinger, J.L., Colby, R.D., Thomas, B.J., Smith, W.A., and Ray, A.E.
Elemental Ash Data - All Biomass Types **Data Set 1007**	This export from the Bioenergy Feedstock Library contains instances of publicly available data for biomass resources with elemental analysis data for all samples available regardless of treatment (e.g., chemical altering preprocessing or pretreatment). Instances of treatments are captured in the metadata and uses the "Include in Research Tools" and "Include in Research Tools Reason" fields in the "Sample Export" tab.	INL – Bioenergy Feedstock Library
Extractives Data - Softwood Biomass **Data Set 1008**	This export from the Bioenergy Feedstock Library contains instances of publicly available data for biomass resources with extractives data for softwood feedstocks.	INL – Bioenergy Feedstock Library
Elemental Ash Data - Softwood Biomass **Data Set 1009**	This export from the Bioenergy Feedstock Library contains instances of publicly available data for softwood resources with elemental data.	INL – Bioenergy Feedstock Library
Fuel Properties Data - All Biomass Types **Data Set 1010**	This export from the Bioenergy Feedstock Library contains instances of publicly available data for biomass resources with analytical data for fuel properties that were considered representative of raw biomass feedstock (e.g., prior to any chemically altering preprocessing or pretreatment).	INL – Bioenergy Feedstock Library
All Analytical Data - All Biomass Types **Data Set 1011**	This export from the Bioenergy Feedstock Library contains instances of publicly available data for all biomass resources with analytical data and resources with carbon data that were considered representative of raw biomass feedstock (e.g., prior to any chemically altering preprocessing or pretreatment).	INL – Bioenergy Feedstock Library
Compositional Analysis and Fuel Properties - All Biomass Types **Data Set 1012**	This export from the Bioenergy Feedstock Library contains instances of publicly available data for all biomass resources that had compositional characterization and/or fuel properties analytical data specifically that were considered representative of raw biomass feedstock (e.g., prior to any chemically altering preprocessing or pretreatment).	INL – Bioenergy Feedstock Library
Regional Feedstock Partnership Miscanthus Data Set	Chemical attribute data available for RFP miscanthus field study samples harvested in 2008–2014 across six established field locations.	Regional Feedstock Partnership and Idaho National Laboratory

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[19] Ding, L, et al. 2022. "Image Analysis for Rapid Assessment and Quality-Based Sorting of Corn Stover." Frontiers in Energy Research (10). https://doi.org/10.3389/fenrg.2022.837698

Data Set 1001	Chemical data included compositional analysis, proximate/ultimate analysis, amino acids analysis, ash speciation analysis, elemental analysis for C and N, and biochemical conversion reactivity analysis.	
Regional Feedstock Partnership Switchgrass Data Set Data Set 1002	Chemical attribute data available for the RFP switchgrass field study samples.	Regional Feedstock Partnership and Idaho National Laboratory
Regional Feedstock Partnership Energycane Data Set Data Set 1013	Chemical attribute data available for the RFP energycane field study samples.	Regional Feedstock Partnership and Idaho National Laboratory
Regional Feedstock Partnership Sorghum Data Set Data Set 1003	Chemical attribute data available for the RFP sorghum field study samples.	Regional Feedstock Partnership and Idaho National Laboratory
Regional Feedstock Partnership Mixed Perennial Grasses Data Set Data Set 1004	Chemical attribute data available for the RFP mixed perennial grasses (Conservation Reserve Program [CRP] land grasses) field study samples.	Regional Feedstock Partnership and Idaho National Laboratory
Regional Feedstock Partnership Willow Data Set Data Set 1005	Chemical attribute data available for the RFP willow field study samples.	Regional Feedstock Partnership and Idaho National Laboratory

6. SUMMARY

Biomass variability in the form of physical or chemical characteristics continues to be a primary challenge to integrated biorefineries achieving continuous operation and meeting yield requirements necessary for commercial-scale biofuels and chemicals. Challenges resulting from biomass variability range from microbial degradation in storage and plugged conversion processing equipment to potential health hazards and incomplete conversion. These challenges increase conversion costs for biofuel and bioenergy producers. There are multiple gaps in understanding biomass variability, including the diverse array of sources impacting the range of variability in biomass properties and how this variability impacts processing. The BFL seeks to address these gaps to decrease and provide as much information as possible to an emerging biorefining industry.

The BFL furthers understanding of biomass variability by providing a centralized, publicly available location that is readily and easily accessible and understandable to bioenergy researchers and industry stakeholders. The BFL is quickly becoming the most comprehensive, actively managed, living database of its kind, which is continuously updated with new samples and data. This database provides tools to store, record, track, retrieve, and analyze data to help researchers and industry overcome challenges posed by biomass variability. Together, BFL and BFNUF researchers provide industry with a resource to address challenges at the interface between feedstocks and conversion. The result is a better understanding of feedstock convertibility and processability.

To access the data effectively in the BFL, registration is required. Registration for the BFL is easy and free. To register for an account, visit the Registration page. For more information regarding the BFL, specific data availability, or other questions please Contact us.