Categorical Exclusion Posting No.: DOE-ID-INL-20-085 R2

Project Title: Biomass Feedstock National User Facility (BFNUF) R2

Project Description and Purpose:

Revision 2:

The Biomass Feedstock National User Facility (BFNUF) offers technology and expertise to help the U.S. bioenergy industry overcome challenges during design, scale up and integration of feedstock preprocessing facilities. Research and Development (R&D) at the BFNUF primarily supports the mission of the Department of Energy's (DOE's) Bioenergy Technologies Offices (BETO) to develop and transform renewable biomass resources into commercially viable, high-performance biofuels, bio-products, and bio-power through targeted research, development, demonstration, and deployment (RDD&D) supported through public and private partnerships. BFNUF also is intended to support the mission objectives of other DOE offices, such as the Advanced Manufacturing Office and the Vehicles Technology Office, other government agencies such as Department of Defense programs for upgrading and utilizing waste materials, and industrial entities. Thus, the operations and activities described in this section are used as required based on customer needs.

This revision is to leverage INL's capabilities to foster mutually beneficial partnerships between BEA and various external non-Federal Sponsors. These partnerships are intended to support and enhance the research efforts of the sponsors and lay the groundwork for future projects.

Additional raw materials to be included are as follows:

- Biomass (e.g., herbaceous and woody materials, microalgae, macroalgae, food and beverage ingredients or waste products, organic sludges)
- Municipal solid waste (e.g., packaging materials, paper, cardboard, plastics, multilayer materials, metals, glass)
- Pulp and paper applications (e.g., cellulose, fibers)
- Consumer and industrial electronics (e.g., computers, monitors, panels, circuit boards, cell phones, tablets)
- Automotive parts
- Chemical and energy production systems (e.g., electrolysis cells, batteries, wind mills, solar cells)
- Primary and secondary sources of raw or processed minerals (e.g., coal, ores, rock, sand, gravel)

All routine scope of works conducted under this agreement are subject to the following provisions:

- The Sponsor will coordinate with BEA in advance of any work to develop a set of processing parameters of interest, along with the number of samples and quantity of material to be processed.
- The Sponsor is responsible for preparing and delivering the samples to INL. All available information regarding sample composition, preparation methods, and relevant safety data must be provided to allow for appropriate safety review by subject matter experts.
- Processed samples will be returned to the Sponsor at their expense. No additional processing or testing will be performed unless otherwise agreed upon in writing.

Work may be conducted under several predefined work scope packages:

1. Size Reduction:

- A target particle size distribution, sample composition, number of samples, and desired throughput will be determined by the Sponsor with INL input to ensure technical feasibility.

- INL may process the samples using preselected comminution equipment, which may include hammermills, knife mills, shredders, crushers, roller mills, cryogenic mills, disk mills, ablation systems, or rotary shear mills.

- Particle size distribution may be adjusted to meet downstream process requirements as specified by the Sponsor.

- INL may provide simple product characterization to potentially include particle size distribution, moisture content, and bulk density measurements, along with performance characteristics including energy consumption. Additional analysis can be performed through the analytical characterization work scope package.

2. Separations:

- The separated fractions, required fraction purities, separated fraction values (product vs. contaminant), number of samples, and desired throughput will be determined by the Sponsor with INL input to ensure technical feasibility.

- INL may process the samples using mechanical or physical separation methods using preselected separation equipment, which may include traditional flat and vibratory screening, air classification, wet and dry density-based separation techniques, robotic or automated sorting, sluice tables, or manual sorting.

- INL may optimize the separation efficiency for targeted material fractions using all possible equipment parameters.

- INL may provide simple product characterization to potentially include sorted fractions mass percentages, moisture content, and bulk density of each separated fraction of interest along with performance characteristics including energy consumption. Additional analysis can be performed through the analytical characterization work scope package.

3. Densification:

- Materials to be densified, the process of interest (e.g., pelleting, briquetting, or cubing), and any additional relevant equipment parameters will be determined between INL and the Sponsor to ensure technical feasibility.

- INL will process the samples using the determined densification method using available densification equipment, which may include pellet mills (multiple scales), briquette press, or cuber.

- INL may produce single pellets under specified conditions (compressive force, temperature, particle size, etc.) to understand relationship between conditions and properties of the resulting pellets.

- INL may optimize the densification performance to increase bulk density, improve mechanical durability, and increased energy density using all possible equipment parameters.

- INL may provide simple product characterization to potentially include moisture content of material, bulk density, unit density, and mechanical durability, along with performance characteristics including energy consumption. Additional analysis can be performed through the analytical characterization work scope package.

4. Extrusion:

- Materials and blends of materials to be extruded, along with any additives or form factors requested will be discussed and determined by the Sponsor with INL input to ensure technical feasibility.

- INL may perform thermomechanical processing of samples using single or co-rotating twin screw extruders. The resulting material will then be post processed according to the application but could include chopping in the pelletizer or spooling onto a spool.

- INL may investigate feedstock processing behavior under varying temperature, pressure, and shear conditions.

- INL may provide extrudate samples with limited product characterization back to Sponsor for use in downstream conversion or material applications. Additional analysis can be performed through the analytical characterization work scope package.

5. Drying and thermal treatment:

- INL may perform moisture reduction through its various drying equipment such as a rotary kiln dryer, a grain dryer, screw presses, or drying ovens. Additionally, a solvent drying technique developed at INL is available for drying based projects.

- A determination of the drying rates, energy consumption, and various other material and processing parameters may be provided.

- Torrefaction may be performed as a thermal treatment to concentrate carbon, reduce chemical variability, improve friability, or release specific chemicals contributing to contamination or downstream chemical incompatibility.

- Integration with various other preprocessing operations may be conducted to optimize overall processing workflow's ability to reduce drying energy expenditure.

6. Conditioning and Pretreatment:

- INL will apply chemical, thermal, and/or mechanical pretreatment methods to enhance material reactivity using liquid steam explosion, a continuous heat and pressure reactor, mixing tanks and pots, Parr reactors, and automated solvent extraction systems.

- Enzymatic, fermentation, washing (water, acid, base, solvent, detergent), steam explosion, and other pretreatment methods will be conducted on samples.

- Dilute-acid, hot water, or alkaline pretreatment followed by enzymatic hydrolysis fermentation, and or size reduction may be performed to analyze conversion potential of feedstocks. Washing using water, acid, base, solvent, or detergent may be employed.

7. Analytical Characterization:

- INL may perform chemical compositional analysis using analytical procedures established by the National Renewable Energy Laboratory and/or NIST to determine the composition and summative mass closure of feedstock materials to characterize all constituents in the sample (e.g., ash, carbohydrates, lignin).

- Thermochemical feedstock properties such as combustion characteristics, energy content, moisture content, and chemical constituents may be determined using proximate, ultimate, and calorific analysis methods based on ASTM standards.

- Screening techniques such as solid state nuclear magnetic resonance spectroscopy, X-ray fluorescence, inductively coupled plasma mass spectroscopy, or inductively coupled plasma optical emission spectroscopy may be used to determine chemical constituents.

- INL may use combustion, pyrolysis, or gasification to evaluate thermochemical conversion potential of feedstocks.

- Various methods and instruments may be used to determine particle size, size distribution, shape, and density. Methods may include a particle image analyzer or size classifier to measure particle features such as geometric mean, diameter length and width, sphericity, and aspect ratio. INL may determine true, envelope and skeletal densities using pycnometry. Gas sorption analysis may determine surface area, pore volume, average pore size, and pore size distribution of microporous and mesoporous solids.

- Rheology of materials may be tested using methods such as 2D and 3D image analysis of size and shape distribution of bulk solids, rheometry to determine flowability, an automated Schulze ring to determine shear, uniaxial compressibility and springback analysis, air permeability analysis, auger feeding tests, and hopper flow tests.

- Time-Domain nuclear magnetic resonance spectroscopy, moisture sorption, and automated water activity measurements may be used to understand water distribution impacting particle rheological behaviors, reactivity, and storage stability.

- Mechanical strength testing using Universal Testing Systems may be performed to characterize materials compressive, flexural, and tensive strength properties.

- Storage simulators may be used to monitor feedstocks under a variety of storage conditions to understand material degradation due to environmental and microbial activity. Evolution of microbial respiration and various other outgassing may be monitored via gas chromatography. Simulation may include exposure to simulated solar irradiance or a variety of water activities.

- Lignin chemistry may be investigated using nuclear magnetic resonance spectroscopy from isolated and purified lignin or from lignin still intact within the cell walls.

- Microscopy and imaging techniques may be used to investigate chemical and physical attributes. INL may use X-ray computed tomography, scanning electron, confocal laser scanning, and/or Fourier-Transform infrared microscopy as well as near infrared, mid infrared, and Raman spectroscopy. These techniques may be used to assist in the development of mechanical and chemical preprocessing and densification options.

8. Analysis and Modeling:

- INL may perform benchmarking Technoeconomic Assessment (TEA) to establish a baseline for the system or technology being evaluated using sponsor supplied or INL generated data. TEA models may be updated with data from experimental runs to serve as a basis for comparison between the baseline and improvements generated from experimental work.

- Life-cycle assessment (LCA) may be conducted in conjunction with the TEA to quantify the GHG Emissions, Energy Use, Water Use associated with the examined industrial processes. LCA results may be generated from each TEA run to provide another dimension for comparison.

- Additional analysis may be completed to examine system performance under variable operating conditions, supply chain design and optimization and/or resource assessments.

9. Wet feedstock processing:

- INL may mechanically dewater or concentrate solids in feedstocks using a screw press, continuous centrifuge, or by using screens. Dewatering may be enhanced through a combination of chemical, enzymatic, thermal, pulsed electrical or mechanical pre-processing.

- Wet samples, such as algae, pulp, or organic materials, may be fractionated into subsamples enriched for specific biological macromolecules (e.g. proteins, lipids and carbohydrates) using physical, chemical, enzymatic or solvent-based approaches.

- Particulates entrained in slurries may be removed using a hydrocyclone. Dissolved solids may be removed by enhancing precipitation through adjustment of pH, electrochemical potential or addition precipitant agent.

- Size reduction of wet materials may be accomplished in a knife mill, PFI mill, attrition mill or disc mill refiner.

- Storage studies may be conducted on wet materials to determine degradation in long-term storage or during logistics operation. Compositional analyses will determine impact to composition. Gas analysis will quantify gaseous fermentation products.

- INL will conduct lipid analysis and report total lipid content as fatty acid methyl esters.

Special Considerations:

- The Sponsor is responsible for all shipping costs associated with the performance of tasks.

- Material review shall be performed according to BEA's Research Management policies and procedures prior to work commencement.
- BEA will make every effort to maximize the success of experimental results but cannot guarantee specific outcomes.
- Additional time and cost may be required if additional testing is needed after executing initial testing.
- Once processing is complete, equipment may be cleaned and/or decontaminated to avoid sample carryover into future experiments.
- Disposition of materials will be the responsibility of the Sponsor if it is outside the normal operating procedures within the BFNUF.

Some additional changes for materials present in the Original ECP and Revision 1 are as follows:

- SF6 (mentioned in the original ECP and Revision 1) has estimated values listed from 10 to 100 L used per year, however, that will now be reduced to 1 to 10 L used per year in this revision.
- Specific pH ranges from the basic and acid solutions used to treat biomass are now denoted as =2 or =12.5.
- In regard to Sergassum spp. (seaweed/biomass in this context) both the arsenic and selenium are inherent in seawater with greatly varying values occasionally measuring up t 84 mg/kg arsenic and 21 mg/kg selenium.
- Solid materials with absorbed acetone, methanol or methylene chloride are anticipated to be F002 and F003 hazardous waste.

Revision 1:

Revisions are included throughout the body of the document.

Original:

The Biomass Feedstock National User Facility (BFNUF) offers technology and expertise to help the U.S. bioenergy industry overcome challenges during design, scale up and integration of feedstock preprocessing facilities. Research and Development (R&D) at the BFNUF primarily supports the mission of the Department of Energy's (DOE's) Bioenergy Technologies Offices (BETO) to develop and transform renewable biomass resources into commercially viable, high-performance biofuels, bio-products, and bio-power through targeted research, development, demonstration, and deployment (RDD&D) supported through public and private partnerships. BFNUF also is intended to support the mission objectives of other DOE offices, such as the Advanced Manufacturing Office and the Vehicles Technology Office, other government agencies such as Department of Defense programs for upgrading and utilizing waste materials, and industrial entities. Thus, the operations and activities described in this section are used as required based on customer needs.

This ECP does not include activities at locations other than INL, activities that impact historically significant properties (e.g. EBR-I), diesel generator systems, health and safety equipment, or safety and environmental improvements. Activities not meeting the scope of this ECP require separate, project-specific ECPs. This ECP does not cover replacing and upgrading facility systems (e.g. roof replacement, modifying drinking water systems, replacing or upgrading alarm and surveillance systems, etc.) or modifications to laboratories necessary to accommodate research activities that require project-specific ECPs. Project personnel must contact the program environmental lead (PEL) to verify that various projects are within the scope of this ECP.

The goal of the BFNUF is to study and perform the transformation of raw materials into value-added feedstocks for conversion processes that manufacture biofuels and products. Raw materials are defined as those suitable for upgrading and include (with scale of use):

- Both woody forest products such as clean and whole-tree chips from both soft and hard woods, and herbaceous agricultural products, such as corn stover, wheat straw, switchgrass, and sorghum.
- Waste materials such as construction and demolition waste (construction lumber, paneling, drywall, concrete and masonry, etc.).
- Plastics, which can be grouped into the seven commonly used general categories:
    - #1 Polyethylene terephthalate (PET)
    - #2 High Density Polyethylene (HDPE)
    - #3 Poly(vinylchloride) (PVC)
    - #4 Low Density Polyethylene (LDPE)
    - #5 Polypropylene (PP)

  - #6 Polystyrene (PS)
  - #7 Others that may include polycarbonate, acrylates, nylon, bioplastics, composites, etc.

- Sources of plastics include recycled or collected materials, Municipal Solid Waste (MSW), e.g., plastics such as PS and PE, and engineered materials such as composite resins, epoxies, and polyesters.
- MSW, which is a mixture of woody biomass, food and other organic residues, metals, and plastics.
- Composite plastics may also be processed in the BFNUF. Composites are mixtures of materials where the polymer can act as a structural member or a binder. Carbon fiber is an example of a composite that may be processed. Carbon fiber composites consist of carbon fiber mats bound by a plastic resin. Multilayered materials like candy wrappers (multi-layered packaging), printed circuit boards, and other mixed plastic/metal materials are also considered composites.
- Coal (neat, in mixtures with biomass, or as a source of rare earth elements and other valuable materials). Coal is generally not used at the BFNUF at INL, but products from R&D are often used to reduce the amount of coal used at power or heat generation facilities. Torrefied material (i.e. biomass treated at temperatures around 200-300 °C in an inert atmosphere) behave similar to coal and are a material that can be processed in the BFNUF.
- Farm manures (class B biosolids).
- Cost-advantaged algae.

All these feedstock precursors will be handled at multiple scales ranging from lab-scale (grams to kilograms) to processes capable of handling 1-5 tons per hour, depending on project scope and scale of the equipment. The goal is to reduce the amount of material handled to the lowest needed to obtain the desired result.

Most of the work associated with the BFNUF at INL takes place at the Energy Systems Laboratory (ESL) (IF-685), with some biomass characterization occurring at the Energy Innovation Laboratory (EIL), building IF-688, and at the INL Research Center (IRC). All facilities are located at INL's Research and Education Campus (REC) in Idaho Falls.

The BFNUF includes the Process Demonstration Unit (PDU), the Bioenergy Feedstock Library (BFL) and the Bioenergy Feedstock Characterization Laboratory:

Process Demonstration Unit (PDU)

The PDU is a modular feedstock pre-processing system. It is constructed from Original Equipment Manufacturer (OEM) and specially designed equipment to process materials. The PDU equipment offers different processes to breakdown structure, stabilize biological processes, and increase the energy density of these materials. Major capabilities include:

- Size reduction – from gram scale cryogenic attrition mills up to ton scale hammer mills size reduction capabilities span a range of both wet and dry materials.
- Conveyance and separation systems – including pneumatic cyclones and baghouses for dust collection, air classification columns for material separations, as well as oscillating, disc, and ballistic screens for removing dirt and separating 2D from 3D streams in MSW. Additionally, the BFNUF has many drag chain and screw conveyor systems to move materials from one process step to the next.
- Thermal and moisture conditioning systems – these systems range from ton scale rotary drum drying, torrefaction, steam and chemical treatment, and rotating autoclaves to kg scale torrefaction ovens and 3L environmental chambers where the moisture content of a samples can be controlled in detail for month long experiments the BFNUF has many tools to manipulate MSW such that their deconstruction and conversion properties are improved.
- Characterization tools – as part of the characterization laboratory capabilities the BFNUF has many gas and liquid chromatographs, solvent extractors, a pyrolysis unit, particle size analyzers, and spectroscopic characterization equipment like Near IR, Attenuated Total Reflectance, Time Domaine NMR, mechanical analysis, and other tools. These tools help determine what properties of a MSW are being altered by the preprocessing steps as well as what properties matter most to downstream conversion processes.

Equipment operation activities include bulk materials handling using loading equipment, manually feeding materials, manually removing samples, removing processed materials from the equipment, and equipment operation.

Reconfiguration activities include moving the PDU equipment and may also include fabrication of transition pieces and modification to existing equipment. Re-assembling and installing components may require using sealants, glue, epoxies, and mechanical greases.

INL configures and operates equipment in accordance with the recommendations identified in TEV-1712 "Hazards Analysis of the Process Demonstration Unit Operation in Energy Systems Laboratory (IF-685)" and in accordance with the City of Idaho Falls operating permit as approved by the Authority Having Jurisdiction.

Biomass Feedstock Library (BFL)

The BFL is a physical sample repository and database for physical, chemical and conversion performance characteristics of biomass feedstock. The library provides tools to store, record, track, retrieve, and analyze data to help researchers and industry overcome challenges posed by biomass variability. Sample collection is an ongoing effort with public and private collaborators.

Activities associated with the BFL:

- Sample handling and preparation: Handling, preparing, and characterizing field-collected samples and archiving them in the BFL.
- BFL sample and data management: Populating the BFL when samples and data are sent to INL.

Bioenergy Feedstock Characterization Laboratory (BFCL)

BFCL allows researchers to pinpoint important variables such as chemical composition and flowability to align feedstock characteristics with conversion technologies and end products. Capabilities also include automated dilute acid pretreatment with enzymatic hydrolysis.

Many of the methods used in biomass feedstock analysis involve general laboratory techniques and instruments to determine dry matter loss, moisture content, organic extractables, non-structural carbohydrates, and lipids. The methods use common chemical laboratory techniques such as weighing, measuring and dispensing chemicals, acids and reagents; compressed gases; vacuum filtration; pressure and vacuum equipment; measuring pH, redox potential, heat (drying heat, boiling & heating); cryogenic cooling (dry ice and ethanol, ice baths, chilled glycol solutions); salt solutions; extracting or crystallizing chemicals or metabolic products from aqueous or organic phases; using ground joint glassware; freezing and freeze-drying materials; and using a broad range of analytical instruments and equipment.

Activities at the BFCL include:

1. Chemical Compositional Analysis — Analytical procedures offer methods to determine the composition of biomass feedstock materials by fractionating samples to characterize constituents (e.g., ash, individual chemical constituents, carbohydrates, and lignin). The solid sample deconstruction and sampling systems includes hammer mills, cutting mills, centrifugal mills, and automated sample dividers for the analytical preparation of biomass samples. Ovens are typically used to dry and prepare biomass materials for analysis, other preparations, and preservation.

Activities also include measuring the following groups of chemical and physical properties of biomass:

- Elemental C, O, H, N, and S content (ultimate analysis)
- Moisture, volatile matter, ash and fixed carbon contents (proximate analysis)
- Calorific analysis (calorimetry)
- Volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs)
- Variability of inorganic species (i.e., Ca, K, Na, Mg, Si, Al, S, Fe and P)

2. Thermochemical Feedstock Properties — Proximate and ultimate analysis techniques evaluate the thermal efficiency and energy content of a given feedstock. Thermogravimetric analyzer/differential scanning calorimetry and gas chromatography (GC) determine the caloric effects to understand material properties. INL analyzes biomass to determine elements present in ash samples from varying cultivars and locations. The program uses multivariate chemometrics to build predictive models between the spectral measurements and the primary analytical techniques (Inductively coupled plasma mass spectrometry [ICPOES/ MS]) measured on a subset of calibration samples.

3. Rapid-Screening Techniques — Rapid-screening techniques (predictive near-infrared spectroscopy and laser-induced breakdown spectroscopy [LIBS]) determine proximate and ultimate analysis and elemental ash values. The laser is a Class 4 pulsed laser equipped with a control box. A second class 2 laser (less than 1 mW continuous power at 670 nm) is employed to assist in focusing and aligning the primary Class 4 laser. A laser enclosure contains the laser beam and light. A sealed sample chamber within the laser enclosure contains the sample and may be purged with inert argon or nitrogen gas to enhance the LIBS signal and prevent contamination by atmospheric gases.

4. Microscopy and Imaging — Digital, confocal laser, scanning electron and Fourier-Transform infrared microscopy help researchers develop mechanical and chemical preprocessing and densification options that impact the chemical and physical attributes of the feedstocks. Microscopic Observation and Photography of Microorganisms involves researchers attaching microorganisms to solid surfaces such as slides, membranes, or minerals by natural adherence, filtration, heat, or chemical treatment. Cells are prepared using various fixatives, stains, and reagents, including nucleic acid probes and antibodies, with and without fluorescent tags. INL also characterizes the microstructure and binding behavior of biomass pellets using CT scan, SEM, laser microscopy, solid-state NMR, Fourier Transform Infrared Spectroscopy (FTIR), focused ion beam (FIB) tomography, TEM, and XRD techniques.

INL evaluates tissue level changes in biomass anatomical fractions for changing moisture contents using advanced imaging and analysis methods such as scanning electron microscopy and energy dispersive x-ray spectroscopy (SEM-EDS), Transmission Electron Microscopy (TEM), and time domain nuclear magnetic resonance (TD-NMR). TD-NMR characterized free versus bound water in a material, which can impact the energy needed in drying.

5. Particle-Size Distribution and Morphology — Various methods and instruments are used to determine particle size, size distribution, shape and density. Methods include a Sympatec QICPIC system that can determine geometric mean diameter length and width, sphericity, and aspect ratio for materials ranging from microns to 10’s of mm in both dry and wet formats.

6. Particle Characteristics — Pycnometry determines the true density. Gas sorption analysis determines surface area, pore volume, average pore size, and pore size distribution of microporous and mesoporous solids using classical Brunauer-Emmett- Teller (BET) helium void volume. Mercury porosimetry is also available.

7. Rheology — Rheology capabilities include a rheometer, 2- and 3-D image analysis of size and shape distribution of bulk solids, an automated Schulze ring shear tester, uniaxial compressibility and springback analysis, air permeability analysis, auger feeding tests and hopper flow tests. An Anton Parr rheometer and custom capillary rheometer are also available to measure viscosity of biomass slurries as needed.

8. Lignin Chemistry — Lignin chemistry is analyzed using nuclear magnetic resonance spectroscopy.

9. Biomass Storage Simulation — Storage simulation reactors help researchers monitor feedstocks in a variety of storage conditions to understand biomass losses from microbial degradation. These highly instrumented and automated storage reactors determine microbial action by monitoring the evolution of CO2 over time.

INL performs experiments to investigate ensiling and model storage conditions at various temperatures, packing densities, oxygen availabilities, and atmosphere drying. Reactors may be operated to maintain aerobic or anaerobic storage environments. Volatiles emanating from the biomass may be analyzed directly by GC or GC coupled with infrared spectroscopy (GC/IR) or mass spectrometry (GC/MS). Individual experimental systems may be 50 ml to 5 gallons and stored in glass vials, buckets or picnic coolers. Larger systems are used when needed to better achieve model storage and practical experimental conditions and may include the use of 55 gal drums or 100-liter temperature-controlled storage reactors. At the completion of the storage studies, the storage simulators are emptied and the contents sampled for subsequent analyses.

Gas tracer tests measure gas diffusion in feedstocks. This activity uses sulfur hexafluoride (SF6), inserted into a bale or bulk sample then measures the tracer gas in the surrounding air over time, either by photoacoustic detection or GC. For stacks of bales and for bulk storage piles, an estimated volume of SF6 (10 to 100 L) may be used. Storage experiments are also performed with algal biomass alone or blended with lignocellulosic biomass. Algae may be sourced from photobioreactors, open pond raceways, or algal turf scrubbers and obtained through BFNUF collaborators.

Storage experiments may range from 5 ml to 5 gallons. Sulfuric, lactic, and acetic acids may be added to algae to simulate ensiled conditions and will be within the range of pH 2-5 or 0.5-6% acid. Bases may also be added to stabilize biomass and may range from pH 9-11. Mixing algae with lignocellulosic biomass and acid is performed in a chemical fume hood. Nitrogen and argon purging in sealed glass vials or through fermentation airlocks is also performed. All materials contacting algae is decontaminated after use.

Sources for reference materials include the BFL and materials used in research at the PDU. INL uses complete proximate or ultimate and elemental analyses of whole samples and fractions and performs spectroscopy on the samples using the Malvern/Panalytical LabSpec. Researchers combine a secondary method—such as LIBS or energy dispersive x-ray fluorescence spectroscopy (ED-XRF)—with near-infrared spectroscopy (NIRS) to predict elemental ash content.

Microbial inoculants may be added to biomass to promote stabilization. Amendments such as silage inoculum and preservatives may be added to biomass prior to storage. Silage inoculum (e.g., Lactobacillus sp.) is commercially available for use and purchased in a ready-to-use form. Alternatively, organisms may be grown in-house and added to biomass prior to storage. Microbial cultivations use Risk Group-1 (RG-1) whole organisms (e.g., bacteria, yeast and other fungi, viruses, algae). This EC only covers using a C6 fermenting organism, Saccharomyces cerevisiae D5A. Risk Group 1 materials are unlikely to cause disease in healthy adult humans and pose minimal potential hazards to laboratory personnel and the environment. Work with these organisms is done using the Center for Disease Control's (CDC's) Biosafety Level 1 (BSL-1) controls and practices. BSL-1 work is generally conducted on open bench tops using standard microbiological practices.

Cultivation of microbes occurs in a variety of vessels such as flasks, bottles, chemostats, Petri dishes, and culture tubes under aerobic or anaerobic conditions. Cells are collected from the growth media by centrifugation or filtration and washed and stored in physiological saline, nutrient salts solutions, or various buffers pending further use. Cultures are preserved for long term storage by freeze-drying or cold storage in buffer solutions containing glycerol or dimethyl sulfoxide (DMSO). Cryogenic materials, including dry ice and liquid nitrogen, may also be used. INL completes microbial community analysis in collaboration with Idaho State University (ISU). INL will develop metagenomic libraries of bacterial and fungal communities, based on DNA sequences from illumina sequencing, to understand the impact of storage treatments on microbial communities associated with preservation.

10. Lipid analysis of whole biomass—Determination of total lipids is carried out by direct transesterification of whole biomass. To perform the analysis, a small portion (5-50 mg) is contacted with a 2:1 chloroform: methanol solvent (~200 µL) and HCl: methanol (0.6 M) solution (~300 µL) in a 1.5 mL GC vial. The process is performed in a fume hood. Research uses sonication to extract lipid products from inside the cell. The sonicator is in a sound inhibiting booth. When sonication steps are using algae and solvents, the sonicator booth is moved inside the chemical fume hood.

Waste Type	Amount
Non-hazardous, non-sewage regulated, nonrecycled, i.e., unused and quenched biomass feedstock	20-50 L/Yr
Basic or acidic solutions, filtrates, and extracts that are non-hazardous and non- sewer regulated	< 1500 Gal/Yr
Basic or acidic treated biomass	200 kg/Yr
Biomass Pressate (water, dilute-acid, or dilute-alkali)	Estimated to be much less than 10 L/run.
Biomass samples containing arsenic and selenium	2-10 L/Yr
Ethanol or isopropanol wipes (dried)	2-10L/Yr
Feed materials	Minimal; excess around inlet will be collected.
Recyclable waste	< 20 Pounds/Yr
Scrubber condensate	Estimated < 50 gallons per year. This will be measured to better approximate the volume.

Sewer regulated waste	2-10 L/Yr
Sharps such as needles and razors	<5 L/Yr
Solid materials containing any amount of the following absorbed chemicals - acetone, methanol, or methylene chloride	<2 L/Yr each
Spent microbial cultures	20-50 L/Yr
Unused and excess feedstocks (biomass, MSW, plastics, etc.)	1-2 m3/Yr
Unused and excess solid biomass, including dust (samples)	
Used Gear Oil	Multiple gallons from changing the oil in gearboxes.
Water and steam for the steam generator	Minimal; steam will be consumed in pellet making.

Environmental Aspects or Potential Sources of Impact:

Air Emissions

Air emissions from portable generators, stationary units such as the PDU, thermochemical treatment of biomass, the CPS, fugitive dust from grinding activities, discharges from laboratory hoods, and fugitive releases of SF6 as part of biomass bale permeability studies are anticipated. Emissions from portable generators are exempt since the generators are used only a few days per year. If the generators remain in the same location an Air Permitting Applicability Determination (APAD) is required.

Fine dust created in some processes may be combustible. Dusts can be a product of the processing of multiple feedstocks including biomass, plastics, MSW, and coal. The grinding systems are operated under negative pressure and designed to collect any dust. Explosion detection and suppression systems, and an ember detection system with a water deluge are in the facility. Water hoses and hand sprayers are available to cool hot spots on equipment to avoid potential fires. Dust control and mitigation includes adding or modifying ducting, ducting connectors, fabric sleeves, other fixtures and ducted fans, water sprays, other dust control methods, or enhanced cleaning procedures. Controlling fugitive dust under certain conditions is also required under state air regulations.

The Project may involve the discharge of hazardous air pollutants regulated by the state or EPA.

The Pneumatic Transfer System includes a blower to create the required air flow, a cyclone and airlock to remove the material from the airstream at the end of the conveyance, and a baghouse to remove the fine dust that makes it through the cyclones.

The CPS has an off-gas scrubber drum. The vent scrubber system includes the Scrubber Drum (D-260), the Scrubber Drum Pump (P-261), the Scrubber Cooler (E-262), and the Scrubber Blower (B-263). All fugitive emissions are routed to the scrubber system. The exhaust from the scrubber is connected to the facility exhaust system.

Fugitive emissions from chemical use are exhausted through the facility mechanical ventilation or local exhaust systems.

Pyrolyzed or torrified feedstocks can have gaseous emissions. Feedstocks that contain mainly cellulosic materials can generate oxides of carbon and water. Most plastics and MSW also give off similar gases. Materials of note include aromatic and halogenated plastics that can give off toxic or corrosive fumes upon high temperature heating. PVC is an example that has the potential to generate corrosive hydrochloric acid.

During the thermochemical pretreatment process, volatiles and the water contained in the biomass are driven off the material, and the biopolymers (cellulose, hemicellulose and lignin) partly decompose and give off various types of volatile and semi-volatile organic compounds (SVOCs). Thermal treatment includes cooling the exhaust gases to separate and collect condensable liquids and analyzing the condensable and non-condensable gases, including fixed gases, volatile organic compounds (VOCs) and SVOCs. A gas analysis system supports thermochemical pretreatments. A coalescing gas filter may also be used to trap entrained VOC and SVOCs.

Emissions from BFNUF activities are covered in APADs INL-10-005 and INL-14-005 R2.

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

Guide (GDE)-674 gives shipping guidance for receiving and shipping of biomass materials. Appendices include Idaho National Laboratory (INL) Bioenergy Program described materials. All biomass materials will be reviewed against the list of noxious weeds identified in IDAPA 02.06.22. If a biomass material is identified in IDAPA 02.06.22 as a noxious weed, approval from the Idaho Department of Agriculture will be obtained before it is imported.

CULTURAL RESOURCES: Pursuant to the 2023 Programmatic Agreement as amended in 2025, and with respect to INL only, the proposed action does not meet the threshold of a federal undertaking with the potential to affect historic properties and will have no effect to historic properties. See Hold Points for further information.

Generating and Managing Waste

When wastes are generated, how they are disposed can adversely affect the environment. Managing wastes appropriately and responsibly and implementing recycling or reuse practices, where feasible, during project activities can reduce the potential impact on the environment.

Releasing Contaminants

Sewer Releases: Small amounts of chemicals may be discharged to the Idaho Falls sewer system in accordance with sewer regulations.

Microbiological Releases: Good microbiological practices will be followed, and surfaces contacting microbial inoculants will be wiped down with ethanol wipes at the end of the work shift, at a minimum. Contaminated materials will be autoclaved prior to reuse or disposal to prevent release of biologicals.

Solid waste disposal: MSW is a feedstock that is a part of this research. MSW will be received at IRC 603 laboratory A9. The maximum amount that will be sourced at any given time will be 1 m3 boxes. Materials to be sourced include mixed and low grade paper, aseptic and polycoats (layered packaging with plastic and metal layers), food contaminated paper and cardboard, shredded paper, and plastics. These materials will be sourced from recycling facilities that separate single and dual stream collected recyclables. These materials go through two levels of presort prior to receipt at INL. First, these materials are placed in recycling bins by the residential customer. For single stream, the bins receive paper, plastic, metals and sometimes glass. For dual stream, one bin receives paper and cardboard, and the other receives plastic, metals and sometime glass. At the recycling facility, the materials undergo a more rigorous sort process where materials are passed over screens and air columns to separate 2D materials such as paper and cardboard from 3D materials such as bottles and containers as well as remove heavy, wet materials such as food particles and fine materials such as broken glass. Additionally, both ferrous and non-ferrous metals are removed. Unused or unneeded MSW will be dispose of through normal INL waste disposal practices, as informed by Waste Generator Services. INL receives the non-recyclable portion of these streams (see material list above). Because of the multiple sorting steps, receipt of problematic materials such as batteries and medical waste is not anticipated. Materials will be hand-sorted at INL upon receipt as these streams typically have 10-15% non-desirable components (e.g. plastics streams will contain paper and paper streams will contain plastics). Additionally, although the sourced MSW is pre-sorted, small amounts of contaminated materials may make it through the sorting process (e.g., contaminated recyclables that might be encountered include paper towels with blood on them, pizza boxes with food contamination, moldy items, small pieces of metal, larger pieces of glass and other debris). INL's sorting process removes these items. Handful amounts of MSW is removed from the receiving boxes and spread out on a benchtop for further sorting. MSW with visible contamination from fecal material, blood, mold/fungi, and bacteria is segregated and then decontaminated by autoclaving and discarded. Sharps (metal scraps, broken glass, etc.) are placed in hard sided containers, autoclaved and disposed of in general trash. During the visual inspection and hand sorting, work surfaces are decontaminated with 70-85% ethanol or 10% bleach at least once daily throughout the sorting process. The seven types of plastic can be grouped into three general categories: 1) aliphatic polymers such as polyethylene (PE, LDPE, HDPE) and polypropylene (PP); 2) aromatic containing polymers such as polyethylene terephthalate (PET) and polystyrene (PS); and 3) halogenated polymers, such as polyvinylchloride (PVC). Sources of plastics will include MSW (plastics such as PS and PE), and resins such as epoxies and polyesters. Composite plastics will also be processed in the PDU. Composites are mixtures of materials where the polymer can act as a structural member or a binder.

Carbon fiber is an example of a composite that will be processed in the PDU. Carbon fiber composites consist of carbon fiber mats bound by a plastic resin. Plastics preprocessing in the PDU will consist of unbaling, sorting, and size reduction. Size reduction can involve various methods of grinding and shearing plus screening to remove finer particles. The potential for cross-contamination of equipment handling plastics will be addressed by physical cleaning methods, such as manual dusting, sweeping, or scraping. Another possible method is using biomass and its inherent abrasive nature to scour surfaces of equipment prior to running clean batches. Solvents or water are not expected to be needed for cleaning this equipment.

Using, Reusing, and Conserving Natural Resources

The primary purpose of this work is to investigate methods by which energy may be recovered from biomass, replacing other sources of energy. Furthermore, this work will focus on the development of processes and chemistries for conversion of other waste materials, such as MSW and plastics, into feedstocks for energy production. Finally, the work will include engineering to develop feedstocks that can be fed efficiently into conversion systems.

Determination:

References: B3.6 "Small-scale research and development, laboratory operations, and pilot projects"

B3.6 Small-scale research and development, laboratory operations, and pilot projects. Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); and small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment.

Justification: The proposal fits within the classes of actions listed in Appendix B to 10 CFR Part 1021 or Appendix B and C of DOE's NEPA Implementing Procedures and satisfies the conditions that are integral elements of the classes of actions therein. The proposal does not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, or similar requirements of DOE or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities (including incinerators), but the proposal may include categorically excluded waste storage, disposal, recovery, or treatment actions or facilities; (3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources, including, but not limited to, those listed in paragraph B(4) of 10 CFR Part 1021, Appendix B; (5) involve genetically engineered organisms, synthetic biology, governmentally designated noxious weeds, or invasive species, unless the proposed activity would be contained or confined in a manner designed and operated to prevent unauthorized release into the environment and conducted in accordance with applicable requirements, such as those listed in paragraph B(5) of 10 CFR Part 1021, Appendix B.

There is no extraordinary circumstance related to the proposal that is likely to cause a reasonably foreseeable significant adverse effect or for which DOE does not know the environmental effect. Extraordinary circumstances are unique situations presented by specific proposals, including, but not limited to, scientific controversy about the environmental effects of the proposal; uncertain effects or effects involving unique or unknown risks; and unresolved conflicts concerning alternative uses of available resources.

The proposal has not been segmented to meet the definition of a categorical exclusion. Segmentation can occur when a proposal is broken down into small parts in order to avoid the appearance of significance of the total action. However, segmentation does not include proposals that are developed and potentially implemented over multiple phases where each phase results in a decision whether to proceed to the subsequent phase.

Based on my review of the proposed action, I have determined that the proposed action fits within the specified class(es) of action, the other regulatory requirements set forth above are met, and the proposed action is hereby categorically excluded from further NEPA review.

Approved by Robert Douglas Herzog, DOE-ID NEPA Compliance Officer on: 5/11/2026