DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-20-051

SECTION A. Project Title: Application of advanced preprocessing technologies for biopower and biobased products

SECTION B. Project Description and Purpose:

In the proposed project, Idaho National Laboratory (INL) and Lignetics will work collaboratively to assess the feasibility of integrating INL's Advanced Preprocessing technologies (fractional milling, high moisture pelleting (HMP) and low temperature drying) in Lignetics's production facilities. The successful completion of the project relies on the integration of fractional milling and HMP process and low temperature drying in order to improve the economics of woody biomass pellet production for use in biofuel and bioproduct applications. In HMP process the biomass loses some moisture during compression and extrusion through the pellet die due frictional heat developed. Also, as pellets have a definite size and shape, they can be further dried in low-temperature grain or belt dryers. Belt dryers are better suited to take advantage of low-grade and waste heat because they operate at lower temperatures than rotary dryers (Tumuluru, 2014). Rotary dryers, for example, typically require inlet temperatures of 260°C, but more optimally operate around 400°C. In contrast, the inlet temperature of a belt dryer, such as a commercially available vacuum dryer, can be as low as 10°C above the ambient temperature, although more typically they operate at higher temperatures, between 90°C and 200°C. Because of their lower temperature operation, fire hazards and emissions to the air are lower for belt dryers. In addition to reducing drying and overall pelleting costs, the INL technology also has potential to reduce emissions at the Lignetics pellet production facilities, which can have a positive impact on the pellet production process.

The purpose of this project is to understand the woody biomass physical properties (moisture content, bulk density, geometric mean particle length, particle size and size distribution, and particle density) and design a pelleting process that will produce a consistent pellet with desired physical properties at reduced energy consumption. Specifically, the technical goals of the project are to consistently produce a woody biomass pellet product with a moisture content below 5 % (w.b.), a bulk density in the range of 35-45 lb/ft3, and a durability of >97.5%, at a 30% reduced pelleting cost (compared to conventional method followed by the industry) for fuel and byproducts application. INL will develop a material engineering solution, translatable to the Lignetics Inc., which integrates Advanced Preprocessing techniques including fractional milling, HMP, and low temperature drying to produce pellets meeting the required moisture, bulk density and durability specifications. If successful, INL's solution will be tested at-scale at a select Lignetics production facility.
The overall objectives of the project are:

- Develop mathematical models to describe fractional milling, the HMP process, and low temperature drying of representative woody biomass processed by the Lignetics
- Define process conditions and commercial-scale costs (capital and operating) for reducing woody biomass moisture content to below 5% (wet basis [w.b.]) with a >30% reduction of baseline preprocessing cost, optimized to achieve a bulk density of 35-45 lb/ft^3 and durability of >95% and >97.5% for fuel and animal bedding pellets.
- Integrated demonstration of fractional milling, and HMP using INL's Biomass Process Development Unit (PDU) to meet the required density and durability and moisture content for Lignetics applications.
- Demonstrate the process developed at the Lignetics processing facility.

Research plan
The research plan is comprised of the tasks identified in the table below. The target commercial outcome of the project is to integrate the INL fractional milling, HMP, and low-temperature drying technology with the existing the Lignetics pellet production facility to achieve the desired feedstock quality (bulk density, durability, and moisture content) and cost targets (a 30% reduction compared to current baseline cost).

Task 1: Baseline cost estimation of wood pellet production
Description: This task will focus on establishing the baseline cost to produce wood pellets. The data in terms of energy consumption and throughputs of the unit operations collected by INL and Lignetics will be used to establish the baseline preprocessing cost. The techno-economic analysis will be conducted to understand the costs associated with labor, fuel, repairs and maintenance, insurance, housing, and taxes, interest, and depreciation for the conventional pellet production method.

Task 2: Supply of woody biomass feedstocks for high moisture pelleting tests
Description: Lignetics will provide a woody biomass feedstocks (approx. 10 tons) to the INL for doing the high moisture pelleting tests and high moisture pellet drying tests.

Task 3: High moisture pelleting tests on woody biomass
Description: The woody biomass supplied by Lignetics Inc. will be used for testing the high moisture pelleting (HMP) process. HMP process tests on ground woody biomass will be conducted using a one ton per hour pilot-scale pellet mill at the INL PDU. The process variables to be tested include the compression ratio of the pellet die (length to diameter ratio) of the pellet die, the moisture content of the woody biomass, and the screen size used in the hammer mill. The L/D ratio will be varied from five to eleven; the moisture content will be tested between 20–30% (w.b.) (the expected moisture content after stage-2 grinding). A natural and chemical binder, specified by Lignetics, will also be tested to see the impact on the throughput of the pellet mill and the quality of the pellets that are produced. A design of experiments will be used to develop the experimental plan for the process variables to be tested. The data on pellet properties (e.g., moisture content, bulk density, and green and cured durability), pelleting energy and the throughput of the pellet mill will be collected. The experimental data will be used to develop a model for the HMP process. The model developed for the pilot-scale pellet mill will be optimized to identify process conditions which can result in woody biomass pellets below 5% (w.b.) moisture content and bulk density of 35-45 lb/ft^3. The model identified process conditions would be further tested in a commercial scale pellet mill to validate the energy consumption, throughput of the process, and quality of the pellets produced using a pilot-scale pellet mill.

Task 4: Low-temperature drying tests on high moisture wood pellets

Description: Drying tests on high moisture wood pellets produced will be conducted using a laboratory-scale grain dryer available at INL. In case of grain, the moisture is in germ, endosperm, and pericarp, where most of the moisture is concentrated in germ and pericarp which is outer layer acts as a barrier for moisture movement (Ghosh et al., 2007). We hypothesize that high moisture pellets can be easy to dry as they do not have pericarp and moisture is more evenly distributed in the pellets. Care should be taken to see that moisture moves more evenly and steadily in the pellets which otherwise can result in case hardening. The temperatures that will be tested will be in the range of 60-100°C. Drying tests will be conducted to achieve the final moisture content of the pellets to be below 5% (w.b.). The drying studies are planned to understand the impact of drying process variables (drying temperature, residence time, and airflow rates) on drying kinetics which can help to understand constant rate period and falling rate period for high moisture wood pellet drying, pellet properties and energy consumption of the process. A wood pellet drying model will be developed based on the experimental data.

In this task other novel mechanical dewatering technology which can help to manage the moisture in woody biomass will also be tested. The focus of this work will be to reduce the wood chips moisture content from 30-20% (w.b.). The dewatered wood chips will be further used for densification studies especially for high moisture pelleting studies. Data in terms of energy consumption and capital costs will collected in this task to understand the impact of dewatering technology on the cost of pellet production.

Task 5: Supply of woody biomass feedstocks for fractional milling tests
Description: Lignetics will provide a woody biomass feedstocks to the INL for doing the fractional milling tests on commercial scale grinders available at Biomass Fuel National User Facility, at Idaho National Laboratory.

Task 6: Fractional milling tests on woody biomass
Description: The objective of this task is to measure the moisture loss, separation efficiency, and grinding energy of woody biomass provided by Lignetics as a function of in-feed properties and grinder parameters. Fractional milling tests will be conducted on woody biomass using hammer mills associated with INL's PDU. The process variables to be tested include the screen size of the stage-1 grinder, separator, and stage-2 grinder. The stage-1 grinder screen size will be varied between 2-4 inches, while the separator and stage-2 grinder screen size will be varied between 1/4–7/16-inch. The wood processed by chipper will be used in stage-1 grinder. The material that is processed in stage-1 will then be tested further in a separator to understand the impact of initial particle size on the separation efficiency utilizing various screen sizes.

INL studies on the comminution of various biomasses in stage-2 grinding have indicated that for high moisture biomass, rotary shear grinders are more efficient compared to conventional hammer mills. Two types of stage-2 grinders that will be used in the present study are hammer mill and a rotary shear mill. The stage-2 grinder screen size will be varied between 1/4 and 7/16-inch in order to understand the impact of the screen size on the grinding performance of woody biomass. The physical properties such as geometric mean particle length, particle size distribution, bulk density and particle density after stage-1, separator, and stage-2 grinding will be measured. This data will be further used to generate an integrated fractional milling model. The model will be optimized to identify the ideal particle size in terms of physical properties and energy consumption for high moisture pelleting application.

Task 7: Supply of woody biomass feedstocks for integrated fractional milling, high moisture pelleting and low temperature drying tests
Description: Lignetics will provide a woody biomass feedstocks (approximately 10 tons) to the INL for conducting integrated demonstration of fractional milling, high moisture pelleting an low temperature technologies using the commercial scale grinders and pelletizer available at Biomass Fuel National User Facility available at Idaho National Laboratory.

Task 8: Full-Scale Demonstration of fractional milling, high moisture pelleting and low temperature drying
Description: In this task, INL will test the integrated process which includes fractional milling, high moisture pelleting and low- temperature drying using the process demonstration unit at Biomass National User Facility at INL. The objective of these experiments is to (1) test whether high moisture pelleting and fractional milling in combination at PDU-scale yield better results than individually and (2) identify the optimum combination of process conditions in an integrated system to achieve the desired bulk density (35-45 lb/ft^3), durability >95% and moisture content (<5%, w.b.). The process conditions for doing the integrated demonstration will be identified based on the optimized process conditions identified for achieving the desired pellet product properties based on studies conducted in high moisture pelleting, fractional milling and low temperature drying tasks. If the integrated demonstration is successful, INL will design a system and Lignetics will test the process at their facility using the TCF-allocated cost-share funds for a full-scale demonstration at Lignetics Facility. This test will confirm whether the mathematical models developed by INL for the three-unit operations, (fractional milling, high moisture pelleting, and low-temperature drying) will translate to full commercial-scale testing.

Task 9: Data analysis and techno-economic analysis of full-scale demonstration tests

Description: The models from high moisture pelleting, low-temperature and fractional milling tasks will be integrated and used to evaluate optimal process conditions for the entire integrated preprocessing system. This data will be used to perform a TEA to establish the cost of integrating the tested techniques into a commercial-scale processing system and assess whether such a system will produce wood pellets and animal bedding pellets with the desired moisture content and bulk density considering throughput, capital, and product quality.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Potential for fugitive (nuisance) dusts from biomass comminution and handling. The operation of the diesel-powered grinder results in air emissions.

Lab operations will generate small quantities of quantities of chemical emissions via lab hood, secondary ventilation, and exhaust arms. All emissions are expected to be far below limits established in APAD-12-010.

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

N/A

Generating and Managing Waste

Industrial, hazardous, and municipal waste have the potential to be generated. Municipal waste includes common lab waste, PPE, wipes, extracted feedstock materials, and neutralized samples. Waste discharged to the sewer system would include common washwater and waste subjected to elementary neutralization. All solid waste will be managed by WGS. Waste water discharged to the sewer system would meet standards established in the city sewer regulations.

Non-hazardous waste includes milled biomass for disposal in municipal waste disposal facility ("Hatch Pit"). Biomass will be densified by INL PDU staff and disposed of offsite by contract carrier. Samples will be maintained for the useful life of the biomass material and will be disposed of as non-hazardous waste thereafter.

Releasing Contaminants

Although not anticipated, there is a potential for spills when using chemicals. In the event of a spill, notify facility Environmental Staff. If the facility Environmental Staff cannot be contacted, report the release to the Spill Notification Team (208-241-6400). Clean up the spill and turn over spill cleanup materials to WGS.

Using, Reusing, and Conserving Natural Resources

Biomass includes top pine (no concern) and switchgrass (invasive species). Baled switchgrass will be wrapped and covered while in storage at INL. Waste biomass will be disposed of as ground, densified briquettes and is therefore assumed non-viable/non-cultivable and will be taken to the "Hatch Pit" for disposal.

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification: Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not “connected” to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References: 10 CFR 1021, Appendix B to subpart D, items B3.6, "Small-scale research and development, laboratory operations, and pilot projects", and B3.9, "Projects to reduce emissions and waste generation".

Justification: Project activities are consistent with 10 CFR 1021 Appendix B to Subpart D, Categorical Exclusion B3.6, "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." and

CX B3.9, "Projects to reduce emissions and waste generation at existing fossil or alternative fuel combustion or utilization facilities, provided that these projects would not have the potential to cause a significant increase in the quantity or rate of air emissions. For this category of actions, “fuel” includes, but is not limited to, coal, oil, natural gas, hydrogen, syngas, and biomass; but “fuel” does not include nuclear fuel. Covered actions include, but are not limited to:Test treatment of the throughput product (solid, liquid, or gas) generated at an existing and fully operational fuel combustion or utilization facility;Addition or replacement of equipment for reduction or control of sulfur dioxide, oxides of nitrogen, or other regulated substances that requires only minor modification to the existing structures at an existing fuel combustion or utilization facility, for which the existing use remains essentially unchanged;Addition or replacement of equipment for reduction or control of sulfur dioxide, oxides of nitrogen, or other regulated substances that involves no permanent change in the quantity or quality of fuel burned or used and involves no permanent change in the capacity factor of the fuel combustion or utilization facility; andAddition or modification of equipment for capture and control of carbon dioxide or other regulated substances, provided that adequate infrastructure is in place to manage such substances."

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason Sturm, DOE-ID NEPA Compliance Officer on: 7/8/2020