DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-20-040 R2

SECTION A. Project Title: Development of A Deployable Plastic Sorting and Decontamination System

SECTION B. Project Description and Purpose:

Revision 2:

This revision provides insight into the Phase 2 of the project given that Phase 1 of the project was successful. Phase 2 represents a slight scale-up in quantities of muncipal solid waste (MSW) processed.

INL will design and fabricate one customized system for each of the DARPA supported teams. The work will be done in collaboration with the teams to ensure the feedstocks produced are useful in their upcycling systems. The custom systems designed will be shipped to the DARPA supported teams facility for installation and testing for their upcycling process systems. The near infrared (NIR) spectroscope and probe will be used to further develop the system model to include the highly variable plastic #7. In addition, a Raman spectroscope and probe will be added to the sensing capabilities to enhance detection capabilities.

During Phase 2, more MSW will be processed, including MSW collected from the Idaho National Guard training facility near Boise, ID which will be transported by the INL's motor pool vehicles. This is considered "warfighter waste" as it should closely resemble waste produced by soliders in the field. Standard MSW for the project will be obtained from Resource Recycling. The estimated amount of MSW is estimated to be less than 150 kg and less than 100 lbs will be hand sorted, or sorted using the AMP Robotics Cortex automated sorting system. AMP Robotics Cortex is a company based out of Colorado that will be coordinating work for the project. INL will purchase and install a 1 mm shredder head for MSW size reduction. Forest Concepts has designed this shredder and will fabricate it when needed.

A portable model of solvent based cleaning and decontamination system will be designed, fabricated, and tested along with an agitation/recirculating system to improve the material cleaning capabilities. Multiple components will be purchased for the system such as the shredders, NIR spectrometers, Raman spectrometers, and portable solvent cleaning systems. It is anticipated that there will be some testing for the project within the Energy Systems Laboratory (ESL) along with the facilities Energy Innovation Laboratory (EIL) and the INL Research Center (IRC).

Revision 1:

This revision provides 1) a clear statement of INL’s scope, and 2) locations for the different activities and because of the property transfer component of the activity is being revised to a 1st Tier EC.

The location of the work described in Task 3 in this section needs to be changed. All development work conducted on the pretreatment and decontamination system that involves the use of solvents or water will be completed at the Energy Innovation Laboratory (EIL) or at the INL Research Center (IRC). There will be no work with solvents or water at the Energy Systems Laboratory PDU Bay.

INL’s role in this scope is to develop methods and hardware for sorting, cleaning, and size reducing selected wastes in collaboration with partners who will use the materials as feedstocks for conversion into useful materials, such as oils, lubricants, foodstuffs, etc. After receiving feedstock specifications from partners developing the conversion technologies, INL will develop sorting, cleaning, and decontamination methodologies to provide on-spec feedstocks to these partners.

1. Sensor development: Sensor development will occur primarily at Energy Storage Laboratory in the Process Demonstration Unit (PDU) highbay or in the analysis lab. This will involve non-destructive testing of a variety of plastic and paper waste to identify sensors that can rapidly and accurately identify the type or chemical characteristics of the waste.

2. Sorting system development: The sorting system will be primarily assembled in the INL Research Center (IRC). Subcontractors may assemble some of the components, then deliver them to the IRC for integration into the sorting system. Initial evaluation of size reduction methods will occur at ESL in the PDU highbay.

3. Pretreatment and decontamination system development: This work will occur at the Energy Innovation Laboratory (EIL). The components of the system will be manufactured by a subcontractor then delivered to EIL for assembly and process development.

4. System integration: The integration of the sorting and pretreatment/decontamination systems will be performed at IRC. This will be the location of the final build and system testing and demonstration.

The final sentence of this section that reads “Any work beyond Phase 1 of this project will require further NEPA review” should be deleted.

Phases 2 and 3 of this project (if funded) will be completed at IRC. The primary difference between Phases 1, 2, and 3 is the scale of the system being designed and built. The work performed in Phase 2 will involve the scaling up of the sorting and decontamination system developed in Phase 1. The work performed in Phase 3 will involve the scaling up of the sorting and decontamination systems developed in Phase 2. In Phase 1, a single sorting and decontamination system will be designed and constructed to demonstrate the capability. In Phases 2 and 3, scaled up systems will be customized to produce on-spec material that will feed directly into conversion systems being developed by other DARPA-selected teams.

Anticipated maximum quantities of wastes generated in Phases 1, 2, and 3 are shown in Table 1 below. Solids will be discarded in the trash bin. Waste solvents will be placed in the SAA in the lab in which they are generated. Wastewater will be disposed to the Idaho Falls sewer system.

	Solids (non-RCRA)	Liquids
Phase 1	5 kg per week	100 L water per week, 2 L solvent per week
Phase 2	50 kg per week	100 L water per week, 5 L solvent per week
Phase 3	500 kg per week	500 L water per week, 50 L solvent per week

Original EC:

The Defense Advanced Research Projects Agency (DARPA) ReSource program, which has a goal to provide the military with an integrated system to convert plastics, and other energy dense waste, into food and strategic chemicals, selected performers with targeted feedstock, processing, and product plans. Sponsor hopes to develop technologies that should function in austere environments to extend long-term missions by engaging single-use wastes and scavenged material as feedstock, consequently decreasing the logistic burdens and risks associated with delivery of supplies.

Idaho National Laboratory (INL) was selected because it is a leading Research and Development (R&D) center that operates the Biomass Feedstock National User Facility Process Development Unit (PDU). Currently, INL is midway through a ~$10 M upgrade to the PDU. This upgraded PDU will be able to handle a wide range of feedstock materials including plastics, biomass residues, wood residues, MSW, and sludge. INL can treat feedstocks with mechanical, thermal, chemical, and biochemical pre-processing technologies. The PDU can scale technologies from grams through tons per hour. INL also has extensive experience working with both public and private entities and regularly works side-by-side with partners to ensure technology transfer. In addition, INL maintains a library of samples with detailed historical and treatment information.

The first phase of this project will identify gaps DARPA faces and the INL will address. INL will use a modular approach to facilitate rapid design, development, and integration with the other selected performers.

The overall goal of this project is three-fold:

1. Devise a process that will accommodate the breadth of waste stream heterogeneity yet enable the maximized decomposition of military waste stream components into high-purity decomposition byproducts and promote the upconversion of homogeneous materials to high-quality end products such as lubricants, fuels, and nutrients.

2. Devise a process that accomplishes the material throughput capacity identified for each phase of the program, with the added ability of being able to easily scale the process through modular addition of units.

3. Devise processes to meet project goals in a manner that uses simplified, ruggedized equipment that is self-sufficient, set-it-and-forget-it, easy to operate and service, and easy to transport.

The key technical challenge for Phase 1 will be effective integration of the Material sorting and Pretreatment and Decontamination systems with the needs of performers developing the downstream conversion systems. Different conversion systems will require different starting products, thus active communication with the teams working on downstream processes will be essential. For Phase 1, it is envisioned that a single sorting and decontamination system will be developed to demonstrate that all modules of this system are functional and work properly when integrated. In Phases 2 and 3, and after extensive conversations with performers developing the downstream conversion processes, new systems will be designed and customized in function and scale to meet the specific needs of individual downstream performers. These customizations will include sizing of equipment, polymer sorting methods, and decontamination chemistries.

In Phase 1 (15 months), the Sorting System will be constructed, consisting of the system inlet, integrated material characterization sensors, shredder with electrical and hand crank control, a rotating turret of bins with electrical and hand crank controls, and an offloading interface to deliver the contents of the bins to the pretreatment and decontamination system. The physical and mechanical functions of all system components will be tested for function using simulated military feed streams. Waste stream interrogation/identification equipment will be tested to determine best sensor types and best physical arrangement of sensors for the targeted feed streams.

During Phase 1, the Pretreatment/Control will demonstrate >85% success rate for identification and sorting of at least three different plastic types and the successful rejection of all others. Throughput for the Phase 1 Pretreatment and Control step will be targeted to 100-500g incoming waste material per 24-hour period.

It will also be important to develop protocols for removal of incompatible materials prior to further processing. The manual removal of incompatible materials represents the first course decontamination process. Prior to additional decontamination, materials will be shredded to reduce the particle size and ensure that all contaminated surfaces of the waste material are exposed. Combinations of mechanical methods and aqueous/non-aqueous methods will be considered and tested for decontamination procedures, depending upon the contamination type. Cleaning solutions will be recyclable and reusable, and any valuable or useful contaminants will be recovered. Water recycling will be accomplished using commercial reverse osmosis filters, which operate effectively in the lower total dissolved solid (TDS) concentrations anticipated in this work. High performing and most efficient decontamination protocols identified will be automated in Phase 1. Decontamination protocols will be developed for 2 common waste/contaminant types.

1.1 Tasks

Task 1: Sensor Identification and Development

Sensor testing and selection: Based on available spectral information, one or more sensors/filters (UV, IR, XRF, etc.) will be selected that will enable the immediate and accurate identification of plastics 1-7 and paper products. Preference will be given to sensors that are not affected by variables such as temperature, humidity, or moisture content. A variety of household and industrial waste materials and simulated military field waste will be tested using the selected sensors to ensure technology accuracy. The waste materials will be small quantities of plastic containers and packaging. In later stages of the project, larger quantities of material may be sourced from Resource Recycling Systems.

Task 2: Sorting System Development

System design (months 1-3): Design requirements will be determined and a conceptual design will be relayed to a mechanical and electrical engineer. After month 2, sensor dimensions and interfaces will be integrated into the design. Mechanical systems will be equipped with hand-crank back up capabilities. Engineering drawings will be completed that will detail design dimensions, power requirements, computer control system, system components, and construction material requirements. This will be an iterative process between the mechanical and electrical engineer, principal investigator, and research team members.

Development and assembly of the sorting system will occur at the INL Research Center (IRC). No building modifications will be necessary to install or operate the equipment.

Task 3: Pretreatment and Decontamination System Development

Solvent identification and process optimization (benchtop, Months 1-4): Laboratory research will be conducted to identify a suitable solvent or aqueous based treatment for the pretreatment and decontamination system. The preferred solvent will be non-explosive, highly recoverable and reusable, and readily available. Candidate solvents may include dimethylether, siloxanes, hydrochlorofluorocarbons, bromocarbons, carbon dioxide, and glycols. Processes will be developed to treat the plastic material, remove organic components, petroleum, oil, lubricants (POLs), processed plastic polymers, and recover the solvent.

Relative evaluation of Solvent and Aqueous Decontamination (benchtop, Months 3-6): There are tradeoffs between aqueous and solvent based material treatment. The recycling and regeneration process can be radically different between two systems. “Initial” process designs will be developed to compare the potential of each pathway. Metric to consider will be extraction/decontamination efficacy, overall regeneration costs, cost of consumables (detergents and membranes), practical material/solvent losses, energy used (spraying solvents, distilling solvents, filtering solvents) and others.

Experimental Bench-Scale System Scale-Up (months 5-10) The solvent and aqueous processing system will be scaled to 40-200 L for the wash chamber using a 2-10 liters of solvent or water per cycle.

Decontamination System Design and Automation (Months 3-12) One of the systems (Aqueous or solvent) will be selected for further improvement. This will include initial efforts to identify design needs and design system automation and ruggedization. The system will be improved for integration with the sorting system (or a dedicated system will be built).

This work will be conducted in a laboratory at the Energy Storage Laboratory (ESL). The decontamination system will be purchased. No building modifications are necessary for installation or operation of the system.

Task 4: Sorting and Pretreatment Systems Integration and Testing

Mechanically integrate the sorting and pretreatment systems. The sorting system and the pretreatment and decontamination system were designed to function as one, however they will be developed separately. The two systems will need to be assembled into a single system and tested for continuous function. A variety of materials will be tested to ensure correct functions of all systems.

The paper fraction of the waste will be evaluated for carbohydrate content, ash content, higher heating value and lower heating value. Plastics will be evaluated using the primary methods associated with the Thermal Suite Thermogravimetric Analyzer (TGA), Differential Scanning Calorimeter (DSC), Dilatometer (DIL), Thermomechanical Analyzer (TMA). A gas chromatograph and liquid chromatograph, as well as, the mass spectrometer may be used. Other instrumentation may include the time domain Nuclear Mass Resonance (NMR) and the regular NMR. This instrumentation is located in the Energy Innovation Laboratory (EIL) and ESL.

Any work beyond Phase 1 of this project will require further NEPA review.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Possible air emissions from DME (dimethyl ether) are to be expected; however, the system is set up to recycle all DME. An emission would only happen if there was a failure in a seal or pressure relief valve.

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

N/A

Generating and Managing Waste

Generation of waste will include municipal solid waste (garbage) processed and will be less than 100 pounds. Some of the waste generated will end up back in the trash can. Other generation of waste will be PPE (nitrile gloves) that will be disposed of in the trash can.

Releasing Contaminants

Generation of 100 L of wastewater will be generated per week during Phase 2 of the project.

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.

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 B1.24 “Property Transfers.”

Justification: The proposed R&D activities are consistent with CX 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); 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 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."

B1.24 "Transfer, lease, disposition, or acquisition of interests in personal property (including, but not limited to, equipment and materials) or real property (including, but not limited to, permanent structures and land), provided that under reasonably foreseeable uses (1) there would be no potential for release of substances at a level, or in a form, that could pose a threat to public health or the environment and (2) the covered actions would not have the potential to cause a significant change in impacts from before the transfer, lease, disposition, or acquisition of interests."

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

Approved by Jason L. Anderson, DOE-ID NEPA Compliance Officer on: 11/15/2021