Project Overview

- **Decentralization** is key for mitigating disasters and military operations when energy generation can be compromised.
- **Waste management** is critical for public health especially when disasters generate massive quantities of solid and liquid waste.
- Argonne has extensive experience in the development, testing, scale-up, design and field validation of waste separation/recovery/utilization and fit for purpose treatment water technologies.
- Apply our existing expertise for production of high value products from low or negative value waste streams.
- Development of modular technologies for different application scale.

Teaming Overview and Objectives

*Argonne Team:*

- Over twenty years of expertise in developing and scaling up processes in waste and water treatment field.
- Efficient testing capability at multiple scales, of emerging new concepts or technologies, as shown by patented technologies. of Argonne’s Capabilities.
- Bench- and pilot-scale technology demonstration in fully equipped labs.
- Over 40 patents and patent pending applications in Waste and Water Treatment, and Utilization.

**Objectives:**

a) **Products, Fuels and Power from Waste Streams**
   - Integrated Waste to Energy and Nutrient Production System
   - Organic Waste Based Bioplastics Production: 3D Printing Technology
   - Plastics Separation from MSW
b) **“Fit-for-Purpose” Water Treatment**
   - Design and synthesize switchable membrane modules for specific functions to conduct independent treatment operations
   - Electrochemical separations for cost effective desalination

**Impact**

- Development of a flexible feedstock-blending plan for waste streams produced by the military operations.
- Concepts, technologies and tools to transform low value or negative value high-strength waste streams into high value platform chemicals (methane, organic acids, plastics).
- Techno-economic analysis (TEA) and life cycle analysis (LCA by Argonne’s GREET model) for the newly developed technologies to assess economic and environmental viability and further facilitate its implementation at the full-scale to meet military needs.

- New Modular Processes for waste management and water treatment with:
  a) reduced the size and complexity
  b) high process intensity and efficiency modules with 10x reduction in capital cost
  c) high energy efficiency (> 20%)
  d) low production cost (> 20%)
  e) low capital cost (reduce deployment cost by 50%),
  f) low waste and emissions (>20%)

**Contact Information**

Dr. Meltem Urgun-Demirtas, [demirtasmu@anl.gov](mailto:demirtasmu@anl.gov), 630-252-6038
Project Overview

- An electromagnetic reactor with the capability to:
  - Evenly apply an electric and/or magnetic field to each particle within a bulk volume of particles so all particles receive near-equal exposure of radiation;
  - Precisely administer frequency, power, and duration of radiation to each particle in a bulk volume to manage optimum energy transfer for controlled heating of targeted matter particles or bulk volume for gasification, pyrolysis, torrification, carbonization;
  - Maintain all particles receiving radiation in a state of homogeneity along with precise control of reactor environment (pressure, vacuum, temperature, ph);
  - Add additional solids, liquids, or gases and bring to a state of homogeneity to produce new materials; and
  - Contain all radiation to comply with FCC regulations and employee safety.

Teaming Overview and Objectives

- Primary Investigator: Dr. Thomas Baldwin, EE, Idaho State University
- PI Collaborators: Dr. Lyle Castle, Chemist, Vice-Provost, Idaho State University
  Dwight Kinzer, Inventor of EM Reactor

- Dr. Baldwin has the unique expertise with EM radiation that is required for the electrical engineering of the EM Reactor
- The Idaho Falls campus with Idaho National Laboratory, Idaho State University, and University of Idaho has all requisite unique expertise on an “as-needed” basis that will be required of the EM Reactor program. The INL site is ideal for a pilot plant to experimentally process DOD waste.

Impact

- Achieve the DARPA objective of a continuous EM Reactor that can process military waste into a usable material.

Schedule

- Phase 1: Design and build an experiment for proof of concept – dielectric characterization
- Phase 2: Run 10s to 100s of experiments with DOD waste materials to develop data cubes of dielectric characterizations (E & M permeability & spectral absorption at wide range of temps)
- Phase 3: Design and build a lab scale EM Reactor using dielectric characterization data cubes
- Phase 4: Run tens to hundreds of experiments with lab scale EM Reactor
- Phase 5: Design and build a pilot size EM Reactor
- Phase 6: Operate pilot EM Reactor by running 100s of experimental test runs on various types of military waste materials to optimize final design of EM Reactor

Contact Information

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Dwight Kinzer @ dwight.kinzer@gmail.com (701) 388-3645
Project Overview – We propose the integration of several leading-edge technologies for biological and chemical processes for converting wastes to electricity, lubricants, potable water, and food products into a single scalable and deployable system. Our team has developed significant expertise in multiple up-conversion technologies from biomass, as well as dry mixed waste streams. Separately, these projects have demonstrated high-yield potential for the production of critical high-value products in theater. The principal challenges to such integration are resilient control of each component of the system to respond to changes in waste streams, and miniaturization of the infrastructure in a logistically advantageous footprint.

Teaming Overview and Objectives – The Illinois Sustainable Technology Center has managed numerous teams of public and private partners in technology advancement spanning TRL 2-8. In recent years, our research partners in areas relevant to this proposal have included BASF, Linde Americas, Mainstream Engineering, Inc., Trimeric Corporation, Helios-NRG, Metropolitan Water Reclamation District (MWRD) of Greater Chicago, Argonne National Laboratory, USDA National Center for Agricultural Utilization Research, and the U.S. Army Corp of Engineers (USACE). ISTC has also been funded by a variety of federal agencies (DOE, USDA, DoD) to address waste reduction and waste utilization (valorization). This teaming structure enables rapid transition from laboratory testing to field trials and adaptation of technologies that have already been developed for other applications and for other agencies.

PI – Dr. Kevin OBrien has extensive experience with project management for multi-million dollar projects (including DOE) for scaling-up and implementation of new process technologies including engineering design, procurement management, and construction management.

Co-PI – Dr. Brajendra K. Sharma has developed pioneering work in thermochemical conversion of biomass, plastic and oil feedstock to biofuels and bioasphalts; solvent dissolution method for separating plastic of high-value from mixed plastic.

Co-PI – Dr. Lance Schideman focuses on innovation in water and wastewater treatment processes including bio-energy recovery, new materials for water purification, nutraceutical production, integrated water reuse systems, and intelligent infrastructure for self-optimizing water systems.

Nicholas Schwartz, P.E., is chemical engineering manager for Mainstream Engineering Corp. Mainstream designing a modular gasifier-power generation system that can be readily transported in standard shipping containers and operated in a variety of environments.

Stephen D Cosper, an environmental engineer with USACE-CERL, has extensive experience evaluating technologies for the valorization of a variety of waste streams and has conducted demonstrations at U.S. military installations.

We seek collaborators who have expertise in (1) direct processing of plant and animal species into high-quality protein (i.e., Hermetia illucens), and (2) automated process control systems.

Impact – Successful integration of existing technologies into a turn-key system at appropriate scales would satisfy most of the objectives of the ReSource Program. Replacing the burden of military waste with mission-ready supplies would be applicable for combat, peacekeeping, disaster relief, or humanitarian operations.

We have already achieved energy recovery efficiency of 70-80% in chemical conversion methods and above 50% in biological-based systems. We would expect to improve upon those metrics during the proposed project.

Contact Information: Dr. Brajendra K. Sharma, Senior Research Engineer, Illinois Sustainable Technology Center, University of Illinois. 217-265-6810; bksharma@illinois.edu
Project Overview

• Mixed organic waste (e.g. food waste, human waste) can be easily converted into biogas (a mixture of methane and carbon dioxide) using anaerobic digestion.

• Industrial Microbes is a startup company focused on conversion of methane (e.g. from biogas) into useful products, such as industrial chemicals. Our team is focused on building a platform technology that can be installed into the robust microorganism host strains that have been used in industrial biotechnology.

• Our core technology could be applied to Stabilization scenarios, but for certain products, it’s conceivable that it could be useful for Special Operations scenarios as well.

Teaming Overview and Objectives

• Company founders Derek Greenfield, Elizabeth Clarke, and Noah Helman all have science backgrounds in biophysics and synthetic biology. Each has spent more than 10 years in the industrial biotechnology field.

• Between the founding team, we have dozens of patents and pending patent applications in the fields of methane bioconversion, synthetic biology, metabolic engineering, and directed enzyme evolution.

• Our company is based in the San Francisco Bay Area in a lab with access to all the basic tools of our trade: from molecular biology, automated strain engineering, and lab-scale fermentation facilities.

• We are seeking collaborations to construct a properly sized pilot unit for (1) anaerobic digestion of the waste and then (2) an aerobic bioconversion of the methane into the desired product, followed by (3) separations and purification of the product.

Impact

• The main anticipated impact of the team’s success is going to be the ability to do chemistry on methane, which is a famously difficult to convert to anything other than heat/power, at small scale. The end product of the process can be a wide range of useful materials.

• Industrial Microbes platform technology is centered on the ability of standard microorganisms to consume methane – many different useful products have been demonstrated in these hosts, so the flexibility to produce different products is a key advantage.

• The key metrics will be conversion of methane into a product with particular relevance to the target application at a reasonable yield to derisk further development.

Contact Information

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Project Overview

• Innovative technologies to enable an integrated processing system for re-use and upcycling of a range of military waste materials
• LANL can contribute unique R&D products, experimental and computational approaches, to generate transformational waste solutions

Teaming Overview and Objectives

• A multidisciplinary team with broad expertise in biosynthesis, biochemical, chemical and polymer synthesis, computational and data sciences, physics and engineering
• Broad R&D portfolio funded by DOE (Sc, BER; and EERE BETO); NASA, and LDRD
• Experimental and computation facilities, including high performance computing
• Seeking ReSource partners with expertise in conversion technologies and experience in military waste characteristics

Impact

• Completely circularize at least 1 waste stream of interest (e.g. plastic packaging) in a cost and energy efficient manner
• Water treatment, food waste, bio-waste treatment, plastics re-use; applied to onsite, on-demand clean water production, 3-D printing, supply production, nutrient, and fertilizer production, and more
• Final process configuration will be an automated system
• Technical transition will be expedited by early partnerships with military/special operations to build a set of requirements

Highlighted LANL Capabilities

• “We can measure anything, anywhere” (e.g., Mars Rover ChemCam, portable NMR)
• Biopolymer/bioplastic design, development, and degradation
  • Plastic “upcycling” consortium, funded by DOE-EERE-BETO (new in FY20)
  • Tailored biopolymers made from sugar building blocks that degrade to original monomers, funded by BETO
  • Design of biopolymers with target properties (durability of purpose; faster, greener degradation in the environment), funded by LDRD
  • Machine learning and AI-assisted polymer and material design, predictive models for a range of polymer properties inc. structural, energetic, elastic, dielectric, and electronic properties, funded by LDRD
  • High-throughput enzyme/biocatalyst evolution (for biodegradation), funded by NIH, DTRA, BETO, LDRD
• Water treatment using supercritical methods, with concurrent recovery of valuable metals and destruction of organic constituents in the source water, funded by LDRD
• 3-D printing formulations, e.g. from processed waste
• Separations, extraction processes
• Remotely controlled, automated systems, computation/modeling to optimize energy and nutrient recovery from food waste (e.g., anaerobic digester systems), funded by BETO
  • Microbial consortia design and evaluation, funded by BETO and DOE-BER
  • Cellular nanoreactors for segregation of metabolites, or enzyme scaffolding
• Techno-economic analysis, supply-chain risk analysis, funded by BETO

Contact Information

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Project Overview

What the team is trying to achieve: Recognizing DARPA’s objective to revolutionize how critical military supplies are procured, NREL and its partners will develop self-contained, integrated ReSource systems to convert military waste into strategic materials on demand. NREL will assemble a team that has the capabilities required to achieve this objective and will apply the team’s expertise to the investigation of biological and catalytic deconstruction and upgrading of polymer-rich mixed wastes, as well as purification of the target compounds to usable products.

Area and challenges: We will pursue development of a hybrid thermo-mechanical/biological system to rapidly breakdown polymer waste, including common plastics (PE, PP, PET) and food waste. A thermo-mechanical system will convert solids into intermediates that exhibit high surface area necessary for efficient biological deconstruction of polymers. We will employ designer enzyme cocktails in concert with a robust, engineered microbe to convert the heterogeneous mixture of intermediates into lubricants, macronutrients, or material precursors for 3-D printing. Key challenges include 1) design of a thermo-mechanical system that is sufficiently robust to produce intermediates that will be readily biologically transformable, 2) development of enzyme cocktails for a broad substrate panel, and 3) engineering of a robust microbe to rapidly and comprehensively convert all intermediates into target products.

Teaming Overview and Objectives

Existing team members and experience: The team is led by Dr. Gregg Beckham; he heads a 40-person group at NREL developing hybrid biological, catalytic, and thermo-mechanical systems for the breakdown and conversion of natural and synthetic waste polymers. His group has deep expertise in interfacial biocatalysis, enzyme discovery, and cocktail design for the breakdown of polysaccharides, proteins, and plastics1, in the use of synthetic biology to rapidly engineer highly robust microbes to convert atypical, toxic, and highly heterogeneous substrates into single target products using the innovative concept of “biological funneling”2, and holistic capabilities in multiscale process synthesis, integration, and analysis.3

Institutional assets: NREL is DOE’s preeminent national laboratory dedicated to R&D to produce chemicals and materials from renewable resources and waste plastics. NREL’s world-class facilities enable scaling of processes from micro-reactors to fully integrated operations. NREL has broad expertise in design of thermo-mechanical systems to process polymers, novel enzyme cocktails to convert polymers into small molecules for upgrading, and rapid synthetic biology design capabilities to produce valuable products.

Collaborators are sought in areas related to waste sorting, mechanical solids handling including feeding systems, in the design of self-contained robotics systems, 3-D printing, and in novel enzyme discovery.

Impact

The outcomes of the project include a ReSource system capable of: 1) breaking down mixed waste – including recalcitrant, carbon-rich polymers in plastics; 2) converting upgradeable organic molecules into strategic materials and chemicals; and 3) recovering purified, usable products. Potential applications that will be enabled by this technology include on-site production of strategic components (e.g. 3-D printing from waste-derived materials), macronutrients ready for consumption, or lubricants for broad use.

Key milestones are 1) integrated development of a robust thermo-mechanical system to increase the surface area of common plastics for enzymatic conversion, 2) development of a robust and efficient enzyme cocktail to ensure rapid conversion, and 3) engineering of a microbe to funnel a heterogeneous mixture of intermediates efficiently towards the single target product, all in a self-contained system.

Contact Information: Dr. Gregg Beckham: gregg.beckham@nrel.gov; 303-384-7806

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Project Overview

- Our team will work to build a library of organisms capable of building a variety of products to sustain military operations as well as humanitarian relief efforts. These organisms will be engineered to catabolize a variety of waste products (e.g., wood, paper, plastic, organics) and build mission-appropriate products from central metabolic intermediates. We will use microbial strains that sporulate or can be lyophilized in order to provide a final product that is robust and cold chain independent.

- The Keasling lab has engineered a variety of microorganisms to produce small molecules that include: fuels, polymer precursors, commodity chemicals, pharmaceuticals, nutritional supplements, flavors, and fragrances.

- We use a combination of computational design tools and a high throughput strain construction and analysis pipeline to generate our proposed library of organisms.

- Our sweet spot is engineering microorganisms. For example, have demonstrated the production of biodiesel from lignocellulose in a single organism.

Teaming Overview and Objectives

- The Keasling lab is currently composed of the PI, 15 Graduate students, 10 postdocs, and 8 professional career scientists and visiting scholars.

- We also have a strong local network of collaborators to draw upon for additional expertise in catabolism and protein design.

- Technology developed in the Keasling lab has been used to launch 8 companies.

- Institutional assets include world class microbial strain construction and analysis facilities.

- We are seeking collaborators that can build the hardware and chemical processes needed to convert starting materials into microbial feed (TA1) and release and recover products of the process (TA3A&B).

Impact

- The long term impact of this program will be a fundamental change in municipal waste handling and overall reduction in landfill usage.

- Potential applications include: on demand medicine and nutrition, on site production of feedstocks for 3D printing, reduction of burden on the warfighter and sustained operational capabilities.

- Initial milestones will include the conversion of a waste stream feedstock into desired product. Ultimately, success will be beating the incumbent cost of delivering supplies.

- The Keasling lab has a strong track record in commercializing technologies. As many of these strains will have consumer applications, we are confident that one or more startups will be generated to transition this project.

Contact Information

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Project Overview: Re-sourcing wastes to create valuable products will significantly enhance performance of both mobile and fixed military facilities. A significant barrier to value creation is preparing wastes to be up-converted to new materials and products. This challenge arises from the heterogeneity, variability, and diversity of waste materials. Materials can range from organic to inorganic with water content ranging from dry to near 100%, with a range of reactivity, and structural variations across size and morphologies. Some wastes are highly toxic and present risk to people and the environment. Collection, sorting, pretreatment and processing of variable wastes is essential to develop for a viable military re-sourcing program. Appropriate upstream processing will enable reuse of waste plastic, food, sewage, MSW, and other military and local waste streams. Materials recovery, reuse, remanufacturing, and recycling also facilitates water recovery/recycling for reuse in agriculture, industry, cooling, and potentially potable water.

INL is a national leader in recovery, sorting, and other upstream processing methodologies across a range of waste materials. This capability is essential for a range of up-conversion approaches including radiation, microbial, chemical, electrochemical, and pyrolysis. INL will address the upstream processing requirements to enable preparation of mixed wastes for these conversion approaches. INL has strong capabilities from laboratory through pilot scale (tons) and is expanding its fundamental characterization capabilities. INL is prepared to direct these capabilities to help DARPA address it’s Re-source requirements.

Teaming Overview and Objectives: INL is a national leader in recovery, reuse, remanufacturing, recycling and upstream processing of waste materials. INL is home to the Biomass Feedstock National User Facility (BFNUF). BFNUF develops novel processing formats for a wide range of agriculture feedstocks including corn stover waste, woody waste, and grasses, and complex municipal solid waste (MSW). With continued investment from DOE’s Office of Energy Efficiency and Renewable Energy, INL is upgrading BFNUF to process complex polymer and plastic waste. In addition, INL is expanding the facility’s research capabilities in fundamental understanding of the physiochemical and morphological properties of complex wastes.

INL has created a library of feedstock processing technologies and materials. INL has the capability to provide research-size samples along with full documentation of the sample management and characterization. This work has helped standardize research in biomass feedstock and waste utilization. INL has an interdisciplinary team of 25-30 people directly working on this program. The team includes rotating student interns, 3-4 postdoctoral fellows, technicians to maintain and operate equipment, and PhD chemists, chemical engineers, and mechanical engineers. The program leaders have each ~25 years of relevant experience.

Using these capabilities, INL has prepared design and state-of-technology reports for DOE’s Office of Energy and Renewable Energy. These reports document the current advancement of the technology, the technoeconomic costs, and sustainability performance of waste processing systems. In addition, INL has published hundreds of peer-reviewed papers on these subjects. Beyond BFNUF, INL is co-leading DOE Innovation Hubs and Manufacturing Institutes related to re-sourcing wastes, including: Critical Materials Institute, focused on access to materials crucial to advancement of the US economy; REMADE, focused on recovery, reuse, remanufacturing, and recycling of materials in manufacturing processes and at end-of-life; and RAPID, focused on accelerating research in chemical processing. In addition, INL is co-leading DRINC innovation hub (under final DOE review), focused on expanding water supply by reuse/recycling and new process technologies. INL will leverage expertise in these Innovation Hubs and Institutes to meet DARPA’s mission.

Impact: The impact of this work is to develop a coordinated suite of technologies to sort and prepare military wastes for up-conversion. There are several potential conversion technologies that may be of interest to this program. INL will design a sorting and processing system based on the heterogenous waste input and the targeted product output. Critical factors will include techno-economics, capital costs, ease of system installation, complexity of operation, flexibility to variable feedstocks, and energy and resource efficiency. INL has evaluated a range of processing technologies based on physical sorting and fractionation, chemical and enzymatic degradation, followed by molecular-to-atomic separations approaches. The core to the approach is to understand the materials physical properties from the very gross bottle or can level to the molecular and nanoscale morphology and physiochemical properties. This detailed multi-length scale understanding will allow design of a system that is efficient and optimized for the DARPA mission. When evaluating potential process systems INL will consider the input materials, the temporal variability, and the output requirements.

For each major programmatic effort such as this one, INL starts out by conducting a detailed roadmapping process. The roadmap helps to define end state goals, mid-project milestones, and define go/no go decision points. The roadmapping process will help define metrics for success. Ultimate success will be to re-source wastes at a lower cost than the combined cost of purchasing and transporting new materials and the cost for waste disposal. If we achieve these goals, the military will see a cost savings, decreased risk to staff during transport, and improved environmental performance.

INL is committed to enabling technology transitions. INL works closely with the DOE Office of Technology Transitions (OTT) to ensure that viable technologies have a path to market. INL is an active participant in OTT’s commercialization programs include the Technology Commercialization Fund and Energy I-Corps. INL listens to industrial partners from the project concept phase to ensure alignment with industrial performance targets. If a project cannot meet industrial targets, INL re-roadmaps the process to redirect, halt, or replace the project.

CONTACT: Seth W. Snyder, seth.snyder@inl.gov, 312-307-4350
Project Overview

- We envision a transformational **Carbon Redirection (CRED)** process where microorganisms efficiently consume organic waste to produce clean water, fungible energy and useful bioproducts. The platform is inexpensive, portable, flexible, and easily operated.

- We will reinvent the wastewater treatment processes to be portable, low cost, low maintenance, and yield fungible energy and/or value added bioproducts. Our technology disrupts the current paradigm by shuttling what others see as disposable waste to our vision of resource reallocation, capturing unexploited energy and carbon to produce valuable materials.

- Technical challenges include removal of inorganic compounds, and microbial transformation of methane to useful products at relevant titer, rate, and yield. Our solutions will be derived through first in class transformation of metabolic capabilities of microorganisms to create products of value from waste.

Teaming Overview and Objectives

- The team: Diverse group of scientists and engineers including CSM faculty Drs. Junko Munakata Marr, Linda Figueroa, Gary Vanzin, Civil and Environmental Engineering; Lt. Col. Andrew Pfluger, Ph. D., Academy Professor, U.S. Military Academy; Dr. Michael Guarnieri, National Renewable Energy Laboratory.

- Team has authored 10 publications (2015-2019) related to the proposed technology.

- CSM houses a pilot-scale system treating 720 L d$^{-1}$ raw wastewater. A low cost mobile pilot is being installed at a wastewater treatment plant.

- Collaborator needs include fluid dynamics modeling, bioproduct selection and purification, and diversified waste sources (such as food and municipal solid wastes)

Impact

- The technology eliminates the need to deal with waste disposal, and instead catalyzes the discussion of what important products can be generated from waste.

- Potential applications include water purification, fungible energy production, and bio-based product creation (biodegradable plastics, ballistic armor materials, petroleum feedstock replacements.) The process is tunable/flexible/scalable for product creation based on needs.

- Milestones/metrics include an optimized system for diverse feed waste, appropriate bioproduct selection and formulation, and a deployable, modular and portable reactor system.

- Transition to deployable status requires target bioproduct selection and optimization under real world scenarios.

Contact Information

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Project Overview

• Our team intends to partner with other teams possessing expertise in TA1 and TA3 to generate engineered non-model bacteria and yeast capable of making DoD relevant products, inspired by natural consortia and combining into synthetic consortia. We plan to achieve highly productive strains to make products from simple organic substrates derived from deconstructed waste, with a strong preference for C2 and larger substrates.

• We are positioned to pursue TA2: “Buildup”. Our team has capabilities to develop individual rugged microbes and consortia that can produce a variety of products needed in either HADR or expeditionary scenarios. Product preference is geared towards oil/lubricant applications and fatty acid/amino acid/vitamins for food.

• Phase 1: Install product pathways using anticipated intermediates from Breakdown TA1; Creating more rugged strains for anticipated inhibitory compounds. Phase 2: Integration with TA1 and TA3; preparation for confounding factors; size reduction through engineering high titer pathways. Phase 3: System optimization for various exacerbating factors.

Teaming Overview and Objectives

• Dr. Mark Blenner, Associate Professor of Chemical & Biomolecular Engineering, Dr. David Karig, Associate Professor of Bioengineering.

• Blenner has several funded projects using waste substrates (agro-industrial wastes from the rendering industry, and human wastes) as feedstocks for microbial production of biochemicals. NASA-funded project focuses on the use of astronaut wastes and bioprocessing wastes as a feedstock microbial production of mission critical products. Blenner is an expert in Metabolic Engineering and Synthetic Biology of non-model yeast/fungal systems (rugged enough for ReSource applications). Karig is an expert in microbial communities, synthetic biology, and cell-free systems.

• Blenner is the head of the Protein, Metabolic and Cellular Engineering lab; is currently a visiting scientist at NASA, winner of PECASE award for utilizing astronaut wastes for biomanufacturing. Karig is the head of the Synthetic Biology lab and PI of a skin microbiome DoD MURI

• Seeking collaborators for TA1 and TA3.

Impact

• Use of waste-derived intermediates to make valuable products in the field.

Contact Information

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Phone number 864-656-0290
Project Overview

- We plan to create a new platform for food waste utilization, by converting unused/non-usuable parts of plant waste into novel foodstuff.
- We intend to develop a flexible system for hydrolyzing and processing different plant material. We will develop novel fermentation methods to create several foodstuff (e.g. protein, milk, etc.) using both conventional and GMO microorganisms.
- This project is expected to start in Jan. 2020.

Teaming Overview and Objectives

- This project will be led by Prof. Dr. Morten Sommer (PI), and executed by postdocs Leonie Jahn and Felipe Lino. Besides, the group also has experts in synthetic biology, microbiology and bioinformatics. See more at http://www.savingtheworldwithscience.com/
- The group has vast expertise in metabolic engineering, fermentation, synthetic biology, microbiome studies and understanding mechanisms behind the occurrence of antimicrobial resistance. Find a complete list of publications at: http://www.savingtheworldwithscience.com/
- The Novo Nordisk Foundation Center for Biosustainability (DTU Biosustain) has research groups focusing on developing synbio tools for bacteria, yeast and CHO cells, with a focus on big data analytics. Besides, the center has top-level facilities of: biomass pretreatment, analytical chemistry, Adaptive Laboratory Evolution, Next Generation Sequencing, metabolic modelling tools development and integrated bioprocess upscaling. See more at https://www.biosustain.dtu.dk/
- We expect to collaborate with DARPA on the ReSource project, by providing new insights on how to develop novel food sources from wasted or non-edible plant material.

Impact

- We expect to develop a new technology for food production from waste streams, reducing the demand of fertile soil and the environmental impact of the food production industry.
- This technology could enable the increase in food production, even in areas with little agricultural capacity. Also, this technology will enable the production of novel foodstuff, like low-allergy milk and single cell protein products.
- We expect to achieve milestones in biomass processing, fermentation technologies and synthetic biology. Ultimately, we expect to develop a novel food source that could be produced anywhere, and could replace animal based products.
- We intend to protect the invention via patenting, and find interested companies for marketing this solution.

Contact Information

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Project Overview

Mantel desires to be a subcontractor on the DARPA ReSource effort. Mantel’s PI, Mike Cushman, has prior experience in forward military waste stream conversion (TA1), having led several US Army (ARO, ECBC, NSRDEC, TARDEC) and OSD (SERDP, ESTCP) efforts in the areas of pre-processing and conversion of mixed military waste streams into gaseous and liquid products. Further, Mike has experience in resource recovery from waste streams (TA3B), having previously developed reactive extraction processes for both recovery and reuse of critical materials from materials otherwise destined for OB/OD management.

Teaming Overview and Objectives

Mantel’s effort will be led by Mike Cushman (MS Chemical Engineering). Relevant experience includes:

- Served as PI, technical lead, and/or PM on four SBIR/STTR programs that transitioned from Phase I to Phase II, one SERDP program on novel reactor design for waste conversion, one ESTCP program on demonstration/validation of containerized processing system at fixed DOD installation, and one NSRDEC/PM FSS program focused on equipment footprint/weight optimization and demonstration at a fixed DOD installation.
- Preprocessing of mixed military waste streams into useful intermediates for controlled conversion into high quality products
- Design and demonstration of containerized, mobile processing systems for forward conversion of military waste streams
- Development of an R3 process for treatment and recovery of key constituents of triple base gun propellant

Impact

Mantel will bring military waste stream composition knowledge and handling expertise to the team. Additionally, we will bring demonstrated experience in scale-up and at-scale prototyping of containerized and deployed processing systems suitable for field use.

Contact Information

Michael Cushman
President & CEO
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Project Overview

- **Feedstock flexibility:**
  - Demonstrated operation across range of gas compositions
  - Continuous operation on unsorted MSW syngas (including plastics)
- **Product flexibility:**
  - Demonstrated direct production of >50 products
  - Biomass is rich in protein and can be tailored for other nutrients
- **Technical Challenges to be addressed:**
  - Process automation, process intensification/modularization, energy/water utilization optimization, rapid product switching

Teaming Overview and Objectives

- **LanzaTech:**
  - Established multidisciplinary team: Dr. Sean Simpson (PI; Co-Founder & CSO), Dr. Michael Köpke (Director, Synthetic Biology), Dr. Chris Mihalcea (Director, New Applications), Dr. Robert Conrado (VP, Engineering, Design & Development)
  - Leading in feedstock & product flexibility: Global leader in Gas Fermentation; Diverse gas compositions; Waste/plastic conversion; Gas treatment/ handling; Scale Up/Down; Modular units; Synthetic Biology Platform; Microbe manufacturing
  - Global Operations: HQ and State-of-the-art R&D facility in Skokie, IL; US site for large-scale field demonstrations; In field commercial deployment globally; Technical freedom to operate
- **Seeking collaborators in areas of:**
  - Gasification
  - Nutrition/Material sciences

Impact

- Readily deployable process for conversion of plastic and/or mixed waste inputs to food, tactical materials and water
- Modular, integrated, automated unit
- Integrated operation with real waste in field demonstrated
- **End of Project Goal:**
  - Technology ready for final engineering, manufacturing and deployment

Contact Information

Dr. Michael Köpke – michael.Koepke@lanzatech.com – 847 324 2498
Project Overview

We are proposing to create synthetic microbial communities with engineered enzymes to build metabolic pathways for the breakdown of polymer and cellulosic waste and its conversion to POLs (Focus Area 2). We are leveraging our technology in model-based characterization and engineering to enable precise design and control of engineered circuits. We will utilize novel single-cell metabolomics and multi-omics platforms to perform multi-omic reconstruction, build context-specific metabolic models, and perform computationally-guided metabolic engineering.

Teaming Overview and Objectives

BBN Technologies is one of the country’s premier R&D organizations with a long history of successfully priming large efforts. BBN has multi-disciplinary engineering expertise and proven project leadership performance in multiple areas of interest for the ReSource program, including synthetic biology, machine learning, artificial intelligence, sensor technologies and system integration. BBN is experienced applying ML approaches to multi-modal sensing data and ‘omics measurements for characterization of complex systems, in particular through the use of single cell metabolomics. In addition, our expertise includes constraint-based modeling of metabolism and computationally-guided metabolic engineering. Additionally, we developed quantifiable genetic circuits to precisely control cellular behavior, as demonstrated in the DARPA ELM program, where we developed cellular based living materials.

BBN has a proven track-record of integrating software and hardware systems into transitional and commercializable systems. Our transition partners at Raytheon Integrated Defense Systems have expertise in manufacturing and materials qualification and verification for DoD deployment. Additional partners often include academic labs, other technology companies, and other R&D organizations. We have led and contributed to large team efforts for ongoing and past research contracts with DARPA, IARPA, and the service research labs.

We are seeking collaborators with expertise in ‘omics measurements and strain engineering.

Impact

Our success will significantly advance the field of microbial metabolic engineering by developing new methods for enzyme design and microbial metabolic modeling. In addition, the applications of our technology will enable bioremediation of the huge amount of plastic waste, including microplastic pollution. We aim to create a method for the directed design of microbial metabolic pathways to breakdown substrates of interest and to create a desired product. We will leverage the experience of our partners at Raytheon IDS to create deployable systems based on our technology.

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