STUDENT SUSTAINABILITY COMMITTEE

Funding Application – Step II

General & Contact Information

Project Name: Pilot-Scale Implementation of Environment-Enhancing Energy (E2E) Paradigm for Food Waste to Biofuel and Biomaterial
Total Amount Requested from SSC: $150,000

Project Topic Areas: ☐ Land & Water ☐ Education ☒ Energy ☐ Transportation ☒ Food & Waste

Applicant Name: Yuanhui Zhang (PI), Michael Stablein, Aersi Aierzhati
Campus Affiliation (Unit/Department or RSO/Organization): Department of Agricultural and Biological Engineering
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Check one:
☐ This project is solely my own ***OR***
☒ This project is proposed on behalf of (name of student org., campus dept., etc.):

Project Team Members

Name	Department	Email
Yuanhui Zhang (PI, Faculty Lead)	Agricultural and Biological Engineering	Yzhang1@illinois.edu
Michael Stablein (PhD student, team lead)	Agricultural and Biological Engineering	Stablei1@illinois.edu
Aersi Aierzhati (PhD Student, team lead)	Agricultural and Biological Engineering	Aierzha2@illinois.edu
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Claire Hanrahan, Undergraduate	Agricultural and Biological Engineering	Jhanraha@illinois.edu

Student-Led Projects (Mandatory):

Name of Faculty or Staff Project Advisor: Yuanhui Zhang (PI)
Advisor's Email Address: yzhang1@illinois.edu

Financial Contact *(Must be a full-time University of Illinois staff member)*

Contact Name: Ronda Sullivan
Unit/Department: Department of Agricultural and Biological Engineering
Email Address: rsully@illinois.edu

Project Description

Background, goals, and desired outcomes:

Our research team proposes to augment management of food waste produced through the dining halls on UIUC campus, via hydrothermal liquefaction (HTL) for biofuel production. This is an expansion of our Environment-Enhancing Energy (E2E) research program focusing on Waste-to Energy. More than 34 million tons of food waste were generated in the US in 2010 (EPA, 2010). According to Kelly Boeger, the Menu Management Dietician at the University of Illinois, 344,559 pounds (dry mass) per year of food goes unused by the cafeterias on campus, which was worth $425,735 or 2.46 % of the overall budget as of 2015 (Hettinger, 2015). Furthermore, this unnecessary spoilage costs at least the same amount for waste disposal and treatment, in addition to environmental burdens. On the other hand, this spoilage presents an opportunity for UIUC to implement new resource recovery technologies to alleviate waste and increase student activities directly related to sustainability. Hydrothermal liquefaction (HTL) is a technology that utilizes elevated temperatures and pressure to convert wet biomass to oil that can be used in motors or asphalts. This process potentiates greater sustainability by simultaneously remediating the food waste and producing renewable energy.

During the preliminary study funded by SSC in Fall of 2017, we collected food waste from Ikenberry Dining Hall with the help of the university dining hall service. We separated the feedstock into several groups based on biochemical composition of the food waste types. Based on the preliminary results, we have proven that the food waste, both as a mix and in individual components, can be efficiently converted into biocrude oil with different oil yields under different operating conditions (Figure 1). The potential of HTL has been successfully proven in lab scale operations.

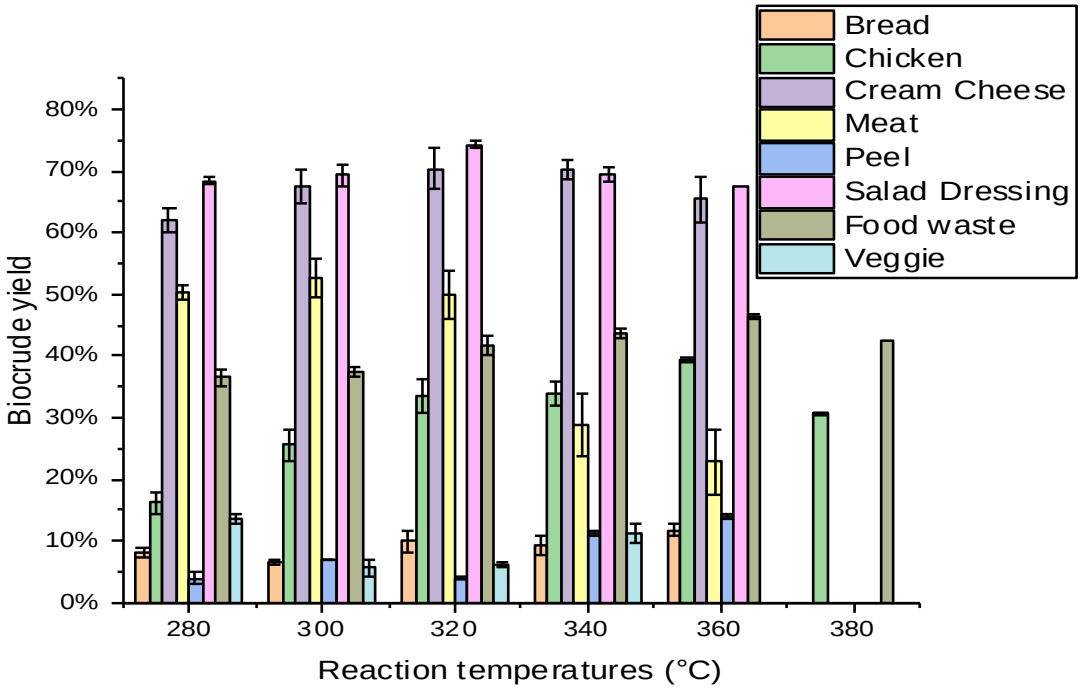

Figure1. Biocrude yield of different food waste components under HTL at different temperatures

We are confident that these preliminary results can be used in a pilot scale HTL process for this proposed Phase-II project. Recent upgrading research in our group has proven the food waste HTL oil can be effectively upgraded into a biodiesel blend used in engines that meet the energy output and air emission standards. Scaling the biocrude refinement process is an integral objective in our Phase-II work as we can complement the existing pilot scale HTL system. We will utilize the previously determined highest yielding feedstocks to derive the best quality biocrude products and generate products on site for direct use on campus. As a result, the scaled operation can determine the full impact of HTL conversion of food waste for biocrude applications on campus.

Where will the project be located? Are special permissions required for this project site?

The Pilot-Scale HTL reactor will be located at the Urbana & Champaign Sanitary District (UCSD) (1100 E University Ave, Urbana, IL) in order to integrate its function into more regular operations of the university and surrounding community. The reactor is scheduled to be setup at this site to simultaneously process the food waste and the resultant Post-Hydrothermal Wastewater (PHW). This collaboration has been long standing with the management from the wastewater treatment plant who have expressed a strong interest in expanding some of these original research goals to scalable applications and operations. Attached is a support letter from the UCSD Director of Operations, Jackie Christensen. Our team has already met with UCSD and a specific reactor site is selected. There is no other permission needed for this project.

Other than the project team, who will have a stake in the project? Please list other individuals, groups, or departments affiliated directly or indirectly by the project. This includes any entity providing funding (immediate, future, ongoing, matching, in-kind, etc.) and any entities that benefit from this project.

Other than the project team, the Department of Agricultural and Biological Engineering (ABE) along with the University of Illinois Dining Halls are primary stakeholders. The ABE Department will provide the lab space needed to continue lab-scale HTL experiments for operational condition optimization, as well as coproduct refinement. Our industry partner, SnapShot Energy, will provide the prototype of the HTL pilot reactor for the demonstration at the UCSD site. Also, the UIUC Dining Halls are stakeholders in this project because we are reducing the amount of waste that they produce and, thus, reducing the operational cost for waste disposal and treatment. Through our project, we will be able to minimize the dining halls' waste products, cost of waste disposal, and improve campus sustainability. Our team will work through the UIUC Dining Hall Management to collect food waste for the HTL process and information for dining hall food waste analyses. Attached is the support letter from the University of Illinois Dining Halls Assistant director, Thurman Etchison.

How will this project involve and/or benefit students?

Currently, our team is comprised of two PhD students and two undergraduate students who will continue on with Stage-II under the supervision of Professor Yuanhui Zhang, a leading expert in the area of HTL of wet biowaste. Several undergraduate students that worked on Stage-I have graduated, and we will recruit more if this proposal is approved. The graduate students will lead the efforts during the project, while educating and instructing undergraduate students who will be involved in the various research and community outreach aspects of the ongoing work. Specifically, this project involves some chemical laboratory tests organized by two graduate students, which will be a good opportunity for undergraduate student to learn and improve their experimental and analysis skills. Undergraduate students will involve in different tasks such as food waste collection, conversion to biocrude oil, product upgrading, campus presentations, and other key responsibilities. These opportunities and presentations can include conferences, events such as Engineering Open House (EOH), and visitor tours. Overall, students will gain valuable practical experience on the sustainability of the campus and beyond.

How will you bring awareness and publicize the project on campus? In addition to SSC, where will information about this project be reported?

Once our phase 2 of the project is initialized, we will organize tours for students, collaborators, staff, and community members who are interested in sustainability initiatives and scaled application of innovative technologies. When our mobile reactor is fully assembled and operational, which is expected three months after the project initiation, the unit will perform demonstrations at UCSD locations. Via this mobile demonstration, people can learn how to convert food waste into renewable products for oil and how it is incorporated into an existing wastewater treatment facility. We can exhibit our project in the Engineering Open House (EOH) for broader groups, especially K-12 students who are interested in STEM programs. This model reactor system and the sustainability concept will be shared with the general public through our website and appointments (for tours). At key milestones and after the project, an innovative food waste disposal approach will be reported and published, via peer-reviewed articles and our own website. We will also publish our results on campus media so that the other students can learn about the sustainability technology.

Financial Information

In addition to the below questions, please submit the supplemental budget spreadsheet available on the Student Sustainability Committee website. Submission of both documents by the submission deadline is required for consideration of your project.

Have you applied for funding from SSC before? If so, for what project?

Yes. We applied for a small project under $10,000 named E2E Paradigm for Food Waste to Biofuel Conversion in the Fall 2017. The Phase-I project will be completed in December 2018.

If this project is implemented, will you require any ongoing funding required? What is the strategy for supporting the project in order to cover replacement, operation, or renewal costs?

After the project is implemented and the HTL reactor is running successfully, it is expected that the revenue of biocrude oil will cover the operating cost (~$10,000 per year). In addition, the pilot reactor will be set on a mobile trailer which can easily be transported from location to location. There are several collaborators that have already expressed interest in using this mobile reactor for different feedstocks, including food-processing waste from Kraft-Heinz, algal bloom from Tainter-Menomin Lake Association, and swine manure from a large pork producer. This mobile HTL reactor could be a great outreach tool for our campus.

At this pilot demonstration stage, the Urbana-Champaign Sanitary District (UCSD) has committed to provide the site, utilities, and post-HTL wastewater treatment for the HTL reactor. The HTL process will recover carbon from the incoming wet biowaste in the form of biofuel and, thus, reduce the food waste COD load and the cost of waste treatment for UCSD.

Please include any other obtained sources of funding. Have you applied for funding elsewhere?

The PI has been awarded two related projects by National Science Foundation: 1) a Conference grant (Zhang, $50,000, 2017-2018) to hold an INFEWS Workshop; and 2) NSF US-China INFEWS: An Integrated Technology-Environment-Economic Modeling Platform for FEW Systems in Arid Regions (PI: Cai, Co-PIs: Zhang and Davidson. $500,000, 2018-2022). PI Zhang submitted a proposal (total $2.5 million, pending) to NSF INFEWS Program Track #2 on Sept 26, 2018. If this project is funded, there will be an operating budget for the HTL pilot reactor to process alternative feedstocks including swine manure and algal bloom. Moreover, our team continuously looks for funding from industry and government agencies, such as DOE and USDA.

Environmental, Economic, and Awareness Impacts

How will the project improve environmental sustainability at the Urbana-Champaign campus? If applicable, how does this project fit within any of the Illinois Climate Action Plan (iCAP) goals?

Two main goals of the Illinois Climate Action Plan are to switch to 100% clean campus energy and achieve zero-waste generation on campus. Our project is aimed at achieving these two goals by 1) producing biocrude oil from a waste stream. The biocrude can then be upgraded into transportation fuels, which are carbon neutral; and 2) turning a negative-value food waste into value-added products, while also reusing carbon and nutrients in the waste stream to achieve zero-waste disposal.

In a broader point of view, the U.S. produces an estimated 79 million dry tons of sustainably collectable livestock manure and food processing waste annually. We will demonstrate that this biowaste stream has the potential to be amplified via multi-cycle nutrient and wastewater reuse to generate 240-800 million tons of mixed algal-bacteria feedstocks that can be converted into 120-400 million tons of biocrude oil (equivalent to 12-40% of the total petroleum consumed annually in the U.S.) via HTL. This can be achieved while also cleaning an estimated 7.9 billion tons of wastewater. Additionally, food is produced using recovered fertilizer in biowaste.

How will you monitor and evaluate the project's progress and environmental outcomes? What short-term and long-term environmental impacts do you expect?

Currently, aerobic digesters and landfill disposal have both economic and environmental costs for the campus disposal of dining hall food waste, in addition to other material management. We propose measuring the impact of HTL technology on minimizing these food waste disposal costs and emphasizing the value of renewable products like biocrude and asphalt binder generated from the process, both for the short and long term of campus sustainability. Scientifically, we can evaluate and compare these systems on different scales through a Techno-Economic Assessment (TEA) and Life Cycle Analysis (LCA). This second stage funding will specifically allow us to scale up, which can offset a significant portion of the food waste produced in the dining halls. If this technology and approach is successful, combined also with the local wastewater treatment facility, our campus will move toward sustainability in terms of zeroenergy and zero-waste.

What are your specific outreach goals? How will this project inspire change at UIUC?

To successfully reach out and impact these communities, we will coordinate and actively participate in numerous professional and educational forums. Some examples of events that will be attended and organized by our team are listed below:

- Reach out to K-12 students, two schools per year
- Co-host events with student organizations on campus
- Hold one workshop and two tours per year
- Present at one scientific conference per year
- Monitor the number of website visits

Among these, we will host presentations for students on campus and in the local community so they can learn about our campus food waste project. K-12 students in the community can learn about engineering projects and campus sustainability by visiting schools and after school programs to conduct workshops. On campus, these similar activities will help to engage new student team members and student organizations for further collaboration. In addition, we will present our approach and results at scientific conferences and publish in peer reviewed journals. Lastly, our site visits and generated discussion can be monitored by the team webmaster.

If applicable, how does this project impact environmental injustice or social injustice?

Our project answers the call to improve environmental sustainability of campus by addressing the current food waste situation of dining halls through a new innovative technology, HTL. This is evaluated by determining feedstock quality, optimizing process conditions, and completing an overall techno-economic analysis as described previously.