STUDENT SUSTAINABILITY COMMITTEE

# Funding Application – Step 2

## General Information

**Project Name:** Pilot-Scale Implementation of Environment-Enhancing Energy (E2E) Paradigm for Food Waste to Biofuel and Biomaterial

**Total Amount Requested from SSC:** $200,000

**Project Topic Area(s):** ✔Energy ☐Education ✔Food & Waste ☐Land ☐Water ☐Transportation

## Contact Information

### Project Lead

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### Financial Contact *(Must be Full-time University of Illinois Staff Member)*

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### Facilities Management Contact *(If Applicable)*

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**Primary Project Team**

| Name | Department | Email |
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# Project Description

**Please provide a brief background of the project, the goals, and the desired outcomes:**

Our research team proposes to expand the Environment-Enhancing Energy (E2E) research program for campus application and to augment management of wet biowaste, such as food waste produced through the dining halls. More than 34 million tons of food waste was 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). Moreover, this unnecessary spoilage creates additional costs and environmental burdens. On the other hand, this biomass 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 biomasses to oil that can be used in motors or asphalts. This process potentiates greater sustainability by simultaneously remediating the food waste going to landfills and producing renewable energy.

**How will the project improve the sustainability of the Illinois campus and how will the project go above and beyond campus standards?**

Our interdisciplinary team is composed of four undergraduate students involved in this project under the supervision of our graduate project leaders and PI. We also expect to have more students participating in the actual daily tasks like food waste collection, conversion to biocrude, upgrading the biocrude, and campus presentations as the project develops. Once our phase 2 portion 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. In addition, people can learn how to convert food waste into renewable products for oil. Moreover, we can exhibit our project in the Engineering Open House (EOH) for broader groups from our community and extended networks. Ultimately, this value recovery model and sustainability concept can be shared through various means to increase awareness of these systems in similar and/or other contexts.

**Where will the project be located? Will special permissions be required to enact the project on this site? If so, please explain and submit any relevant letters of support with the application.**

The Pilot-Scale HTL reactor will be located at the Urbana & Champaign Sanitary District (UCSD). The equipment is scheduled to be setup at this site to simultaneously process the food waste and the resultant Post-Hydrothermal Wastewater (PHW), in order to integrate its

function into more regular operations of the university and surrounding community. 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.

**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 will be benefiting from this project. Please attach letters of commitment or support at the end of the application.**

Other than the project team, the Department of Agricultural and Biological Engineering along with the University of Illinois Dining Halls are primary stakeholders. The Department of Agricultural and Biological Engineering will provide the lab space that we need to successfully conduct our preliminary HTL experiments for operational condition optimization. Our industry partner, SnapShot Energy, will provide the prototype of the HTL pilot reactor for the demonstration at the UCSD site. Also, the University of Illinois Dining Halls are stakeholders in this project because we are ultimately helping them reduce the amount of waste that they produce by alternative economic and environmental means. Through our project, we will be able to minimize the dining halls' waste products, cost of waste removal, and help improve campus sustainability. Our team will work through the UIUC Dining Hall Management to collect both materials for the HTL process and information for dining hall food waste analyses. Attached is a support letter from the University of Illinois Dining Halls Assistant director, Thurman Etchison.

**How this project will involve or impact students? What role will students play in the project?**

Currently, our team is comprised of two PhD students and four undergraduate students under the supervision of Professor Yuanhui Zhang, a leading expert in the area of HTL of wet biowaste. 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. At key milestones and after the project, an innovative food waste disposal approach will be reported and published for industry acknowledgement and scientific peer review, based on the information collected. We will also publish our results on campus media so that the other students can learn about the sustainability technology. Aside from the four undergraduate students listed, we expect that several more students will join the team along the way for 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 like Engineering Open House (EOH), and visitor tours, among others. Overall, students will gain valuable practical experience on the sustainability of the campus and beyond.

# Financial Information

**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.

**If this project is implemented, will there be 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 (~$20,000 per year). The pilot reactor will be set on a mobile trailer which is easy to be moved. Since this is a pilot reactor, it can be used for other feedstocks at other sites, such as the waste treatment site at the Kraft (now Heinz) plant in Champaign.

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 treatment for UCSD.

**Other sources of funding that have been obtained or applied for. Please attach any relevant letters of support as needed in a separate document.**

The PI has obtained a Conference grant from the NSF INFEWS program ($50,000) to hold a Workshop June 13-15, 2018. The PI Zhang is in the process of preparing a proposal (total $2.5 million) for the INFEWS Program Track #2. If this project is funded, there will be an operating budget for the HTL pilot reactor to process alternative feedstocks including swine manure and food processing waste. Moreover, our team continuously looks for funding from industry and government agencies, such as DOE and USDA.

# Environmental, Economic, and Awareness Impacts

**Which aspects of sustainability does your project address, and how? Does the project fit within any of the iCAP goals? If so, how does the project go beyond the university status quo standards and policies.**

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 the carbon and nutrients in the waste stream to achieve zero-waste disposal.

In a broader point of view, the U.S. produces an estimated 7*9 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 the environmental impacts of your project be measured in the near and long term? What specific monitoring and evaluation processes will you be using to track outcomes and progress?**

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. Considering the costs recorded and analyzed by the dining hall managers and through their continual efforts to improve this scenario, 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 the operation, 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 could take a major step in moving toward sustainability in terms of zero-energy and zero-waste.

**What is the plan for publicizing the project on campus? In addition to SSC, where will information about this project be reported?**

We plan to publicize the project on campus through media outlets like the Illini Daily and possibly some local news media. In addition, Engineering Open House would also be another platform where we could educate students about the HTL technology and

sustainability strategy that we are analyzing. This annual event, featuring two days of exhibits led by students, showcases innovative research for families, students, and community members to come and see what various engineering departments are working on. In this sense, we would be able to show the University of Illinois community what our project is about and hopefully spark greater interest in the project.

More importantly, we will establish a website to publicize the project that can be actively managed by one of our team members. This digital network will help to provide updates and connect our food waste management project to larger campus forums, as well as other works in the HTL and sustainability area. Integrating the above publicizing strategies will ensure sharing the success of our campus initiative and inspiring others to undergo endeavors related to social behavior, technologies, and sustainability.

**What are your specific, measurable outreach goals? How will these be measured?**

To successfully reach out to 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 workshops per year, 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.

**Do you have any additional comments or relevant information to aid in evaluation of this application?**

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 two groups based on the particle size. The small particle group has a higher water and lipid content than large particle group because they were collected from the bottom of the food waste bin (Figure 1). The feedstock was homogenized (Figure 2) before being measured for moisture content (Figure 3) and put into the reactors. Based on the preliminary results, we have proven that the food waste can be converted into biocrude oil sufficiently (Figure 4). The oil yield is higher for the small particle group. The energy recovery and carbon recovery are estimated (Table 1). The potential of HTL has been proven in lab scale operations. We are confident that these preliminary results can be improved substantially by optimizing the HTL process in this proposed project.

**Table 1.** Preliminary experimental results of HTL of dining hall food waste

| Sample | Temperature | Time | Total solid | Oil yield | Energy recovery* | Carbon recovery* |
|---|---|---|---|---|---|---|
| **Small particles** | **300°C** | **40 min** | **28.7%** | **32.8%** | **61.8%** | **49.5%** |
| **Large particles** | **300°C** | **40 min** | **34.9%** | **24.9%** | **47.3%** | **37.9%** |

*some properties are estimated based on literature value

1]Wan-Ting Chen, et al. Hydrothermal liquefaction of mixed-culture algal biomass from wastewater treatment system into bio-crude oil. Bioresource Technology 152 (2014) 130–139.

2]Brenna Ellison, et al. Every Plate Counts: Evaluation of a Food Waste Reduction Campaign in a University Dining Hall.

Fig.1 Dining Hall food waste sample

Fig.2 Homogenization using blender

Fig.3 Homogenized samples for analysis

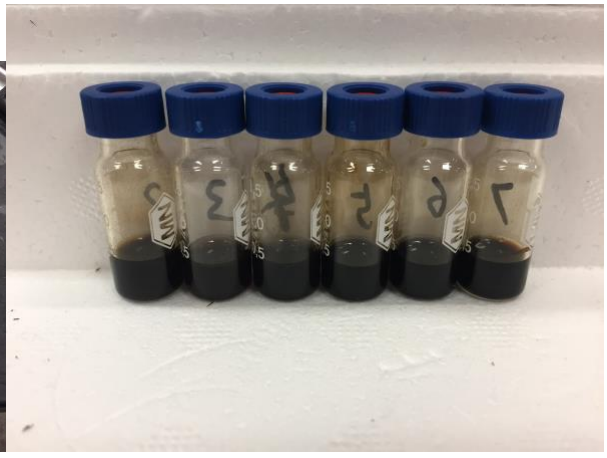

Fig.4 Food waste oil products post HTL