

## **2017 Sustainability Challenge Grant Final Project Report**

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**Project Title: Enhancing Student Development through Experiential Research**

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**Reporting Period: January 1 – December 31<sup>st</sup> 2017**

### **Summary of the project**

This goal of this project was to design and implement a program for undergraduate students that presented unique opportunities for hands on experience, as well as educational and professional development. Pre and post assessments surveys of the students were used to track the efficacy of this type of program in order to inform the development of a more formal Research Experience for Undergraduate program, which could attract further funding opportunities.

By bringing together a multidisciplinary group of students, the University of Kentucky Center for Applied Energy Research (CAER) opened itself up to the unique perspectives of a broad range of fields such as engineering, chemistry, sustainability, and design. Students worked together alongside CAER researchers, as well as conducting individual student projects, that helped improve the existing processes at CAER. Scientific seminars were held weekly to introduce the students to different areas of research at CAER in addition to energy issues facing the Commonwealth. After each seminar, lab tours and Q&A sessions and were held. Speakers provided valuable feedback and resources to students who showed interest in the field. Over the 12 week period, marked interest in continuing education in research was observed in the students.

This project not only provided CAER with meaningful tools to further develop student programs, but also provided the students with a lasting insight into the importance of research, sustainability, and working as part of a multi-disciplinary team.

### **Objectives – What you initially planned to accomplish and objectives achieved**

During the program, a total of seven undergraduate students were exposed to the day to day realities of hands on applied research. Five students from the University of Kentucky were supported directly from the Sustainability Challenge Grant, while two more from Kentucky State University were also involved in the program supported by NSF EPSCoR funding related to developing a bio-economy in Kentucky. All of the students were exposed to cutting edge workplace and laboratory safety culture, and trained to be productive members of a multidisciplinary research group. Two students expressed interest in learning how to use analytical equipment, ion chromatography, to support research activities. The goal of the project was to expose all of the students to this type of training, but not enough interest was shown to warrant this effort.

All of the students put together posters that summarized their contribution to the team, as well as highlight the results of their individual projects. It was the intention to have the students present these posters at the sustainability forum, but the timing of the event conflicted with academic requirements. One student went on to present his work at a national sustainability conference in San Antonio.

One objective that was not met was the exposure of the student team to design thinking and evaluating problems from that perspective. Tragically a co-investigator of this project, Sarah West from the Department of Interior Design, fell gravely ill in March and passed away in July. This limited her contribution to the project and added a certain element of uncertainty to the project program, but also had an important impact on the team. It is a significant loss and was keenly felt by the project team and by the broader UK community.

Pre and post program surveys were brought to bear in an attempt to understand the effectiveness of the program. While the results of these assessments were somewhat inconclusive, they did provide insight into various improvements that could be made going forward. For example, a twelve week program may not be long enough for significant improvement to occur in the metrics which were measured, and the metrics themselves could be adjusted to provide a more detailed picture of overall student engagement.

Overall, the project was a success, with a multidisciplinary research team learning to work together and contribute to hands on, applied energy research.

## **Methods**

During the 1<sup>st</sup> quarter of 2017, the team met with CAER support staff to create a developmental seminar program; a concept that would leveraged formats from successful Research Experiences for Undergraduate (REU) programs and provide opportunities for summer students and researchers to gain a broader perspective on ongoing energy research at the University of Kentucky, and energy challenges facing the Commonwealth. Thus, the “Summer Student Seminar Series” was established; a weekly ‘brown bag’ lunch seminar every Thursday at noon in which senior researchers informally presented their research, led lab tours, and provided networking opportunities. The response from the CAER research community was impressive with the Director of CAER, Dr. Rodney Andrews, kicking off the series.

Student recruitment efforts were also conducted during this time, with a flier (attached) and job posting been made available. <http://ukjobs.uky.edu/postings/142465>

Researchers from the UK CAER worked with staff members with educational background and training to develop assessments to evaluate the potential impact of the program, as well provide background data to pursue further funding opportunities

Five undergraduate students were successfully recruited from the UK community, oriented, and safety trained to perform research this summer related to algae based CO<sub>2</sub> utilization at the

CAER. Additionally, two students joined the team from Kentucky State University funded through the Kentucky EPSCoR program. The team was interdisciplinary, with students from 6 different majors.

In addition to helping out with day to day research, the students spent 30-50% of their time on individual research projects. The students worked with up to 6 full time research staff on their various projects to receive guidance and mentoring.

## **Outcomes**

### **Student/Community Engagement:**

- Seven undergraduate students were directly involved in the day to day execution of this project. Additionally, another 8 students from the CAER participated in the weekly seminar series.
- Food Chain, a local nonprofit, was a great community partner, providing tours to both the research staff to develop collaborative opportunities as well as an educational experience for the cohort of students. This strengthened a relationship with Food Chain, and provided a conduit for further collaboration.
- 8 Senior Staff at UK CAER were impacted, providing an opportunity to informally interact with undergraduate research assistants as well as share their research and experiences.
- The students worked with the Lexington Re-Store to upcycle used and ancillary plumbing parts, directly benefiting Habitat for Humanity, while also cleaning out work and storage areas. The team was able to fill an entire box truck with parts that will be re-used in the broader Lexington community.

### **Campus as a living laboratory**

- This project focused on using an offsite University of Kentucky research campus (CAER) to conduct the majority of this project. The students were hosted using CAER facilities and their work focused on supporting federally funded research focused on algae based carbon dioxide utilization.
- The primary focus of this project was to engage students from the University of Kentucky. The response to the job application for this program was extraordinary and served to highlight the breadth and depth of the talent pool at UK. We easily identified 2-3 times more candidates than we could afford to support.
- The various research interests ongoing at the UK CAER were used as topics for discussion for a weekly seminar series.
- Students and research staff shared their experience with the broader campus community by participating in a radio show on WRFL and presenting a poster at the Tracy Farmer Sustainability Forum.
- This project enabled a broad student base to be exposed to the UK CAER. Because of the sheer numbers of students, an orientation process was formalized to recruit, hire, safety train, and introduce the participants at the lab. This will be valuable moving forward as opportunities for undergraduate experiential education continue.

**Direct contribution to research:**

The cohort of students worked collectively and individually on projects that advanced the ongoing research conducted the UK CAER algae program, part of the Biofuels and Environmental Catalysis research group. The meaningful contribution included:

- The development of a new control system for operating photobioreactors. Madan Archarya (KSU / UK Electrical Engineering) used (mostly) spare parts he found in the greenhouse, designed and prototyped hardware to interface with an existing bioreactor design, and learned a new programming language to implement the process. His efforts enable another photobioreactor (PBR) to be brought online while realizing a cost savings of over 90% compared to existing infrastructure.
- Ashely Cutshaw (UK Biosystems and Agricultural Engineering) conducted experiments investigating the production of high value chemicals from a unique strain of microalgae. During this time she was able to develop a new analytical technique to determine the concentration of 'redness' within the algae culture as well as determine methods to trigger the production of these potentially high value products through stressing the cultures.
- William Azzinaro (UK Mechanical Engineering) developed a new standard operating procedure (SOP) for operating the large scale bioreactors at the UK CAER. Additionally, he provided invaluable assistance performing maintenance on existing infrastructure while also contributing to the design and prototyping of new equipment
- Ryan Lark (Sustainability Studies/Biology) conducted a sustainability assessment of the PBR operation at the UK CAER which highlighted strengths and areas of improvement for the process. He also made invaluable day to day contributions to the day to day operations of the PBR system, and showed incredible maturity and willingness to learn.
- Laura Gruenberg (UK Chemical Engineering / Math) developed analytical tools to analyze process data from the PBR process to better understand and maximize system performance.

**New collaborations:**

Relationships were strengthened with Food chain, with many avenues for synergistic collaborative research discovered and discussed.

Megan Combs from the UK Environmental Research Training Laboratories (ERTL) also emerged as a potential partner moving forward. Her participation would improve access to state of the art analytical techniques, equipment, and training opportunities.

The prospect of applying for the UK CAER to become a Research Experience for Undergraduates (REU) site funded by the National Science Foundation (NSF) was investigated. We learned that the application for such a program would need to be much broader, and be more of a campus wide initiative, with faculty leading the effort. Other funding programs are being investigated, including the development of a proposal to NSF regarding experiential education. Some of the results and program of this project were used as an input into this ongoing development effort.

The research program was highlighted in an article in UKNOW in April 2017 (<https://uknow.uky.edu/research/sustaining-next-generation-energy-innovators>).

Poster Presentations:

R. Lark, “Cradle to Gate Life Cycle Energy Analysis”, Association for the Advancement of Sustainability in Higher Education, San Antonio, TX, October 15-18, 2017.

S. Kesner, “Enhancing Student Development through Interdisciplinary Research & Sustainable Process Development”, Tracy Farmer Sustainability Forum, December, 6, 2017

**Reflection –**

Most of the students were already fairly well-versed in their field and didn’t need much guidance in starting their individual projects, although, as their projects progressed and became more technical, some needed further guidance from the researchers that wasn’t always available. This oversight in time management proved valuable in that it highlights the need to properly budget not only for the cost of students, but to also budget for a certain amount of time to set aside for each of them.

Another unexpected aspect was the high level of skills some of the students already possessed. A few of the students that were proficient with computer coding and data manipulation worked so quickly that at times it became difficult to keep up with them. They were so eager to do more, but the program was not designed rigidly enough to respond to their needs. This issue made it clear that students can work at drastically different paces, so a program must also be flexible to that. While keeping the program flexible regarding focus helped attract broad student interest, a more structured program could have been beneficial.

Overall, this program was an immense success. Initially getting students from different disciplines all working together on the same wavelength was slow going at first, but once commonality was found, the ideas and progress they made together was unique to this particular group. They seemed to learn a lot from each other as well as the program itself.

Budget transfers were not delivered on time and, in some cases, complicated project execution.

The loss of Sarah West was of significant impact to the project and its execution of its goals to introduce design based thinking into the program. In addition to the loss to her family and the broader UK community, further opportunities to work together and develop a cross disciplinary partnership were lost.

**Budget Analysis:**

Table 1 shows the budgeted and actual expenses over the course of the project. An unexpected development occurred in the project whereby CAER covered the cost of the full time research staff. This made more funds available to support student salaries, expanded supply resources, and supported a portion of Ryan Larks trip to Houston.

	Actual	Budgeted
Senior Personnel	\$0	\$12,122
Supplies	\$15,596	\$4,500
Student Salary	\$22,575	\$21,874
Food Chain	\$450	\$500
Travel	\$375	\$0
Total	\$38,996	\$38,996

**Table 1: Actual vs planned program budget**

While this cost sharing was welcome, it was unexpected and should not be counted on in further projects. Another valuable insight was that, in the future, more monies should be dedicated to support supplies as this had a significant impact in the development of the various research projects. Additionally, students aren't interested in working 4 days a week. The properly motivated student wants to work, and be compensated for, a full work week.

Figure 1 shows the team of students and staff researchers in the CAER greenhouse.



*Figure 1: Sustainability Challenge Grant Students and Algae team. Left to right, Ryan Lark, William Azzinaro, Michael Wilson, Daniel Mohler, Steven Hall, Ashley Cutshaw, Laura Grueneberg, and Stephanie Kesner*



*Figure 2: The SCG team visits Food Chain as part of their Summer Seminar Series*

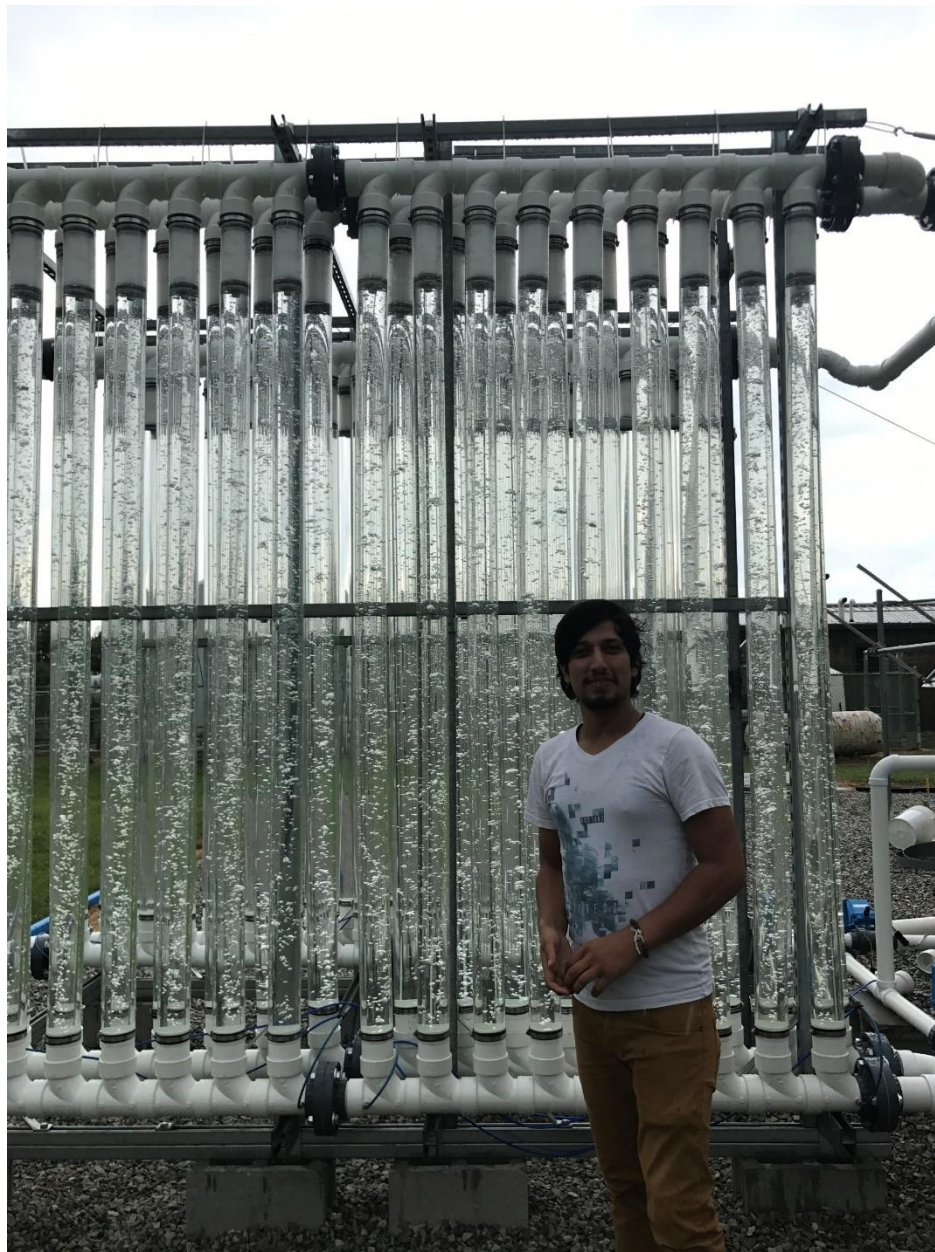


Figure 3: Madan Archaya, a Nepalese Electrical Engineering student from UK /KSU in front of the reactor operated using the control system he developed

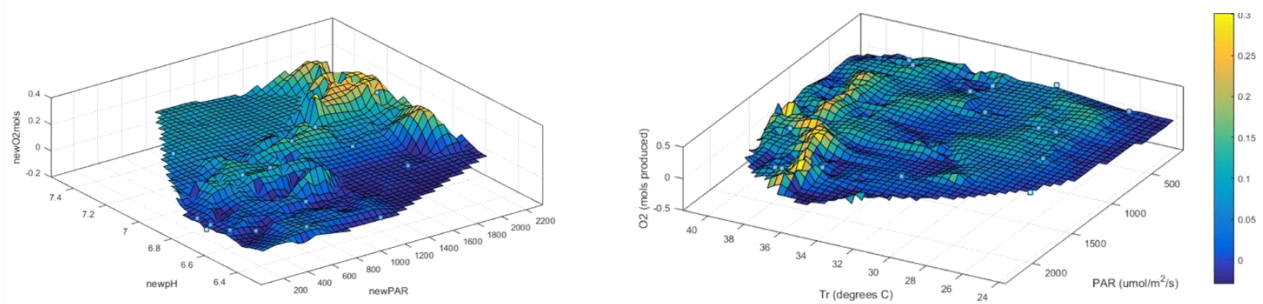


Figure 4: 3D plots of PBR process data produced by Laura Gruenberg





*Figure 5: Expanded facilities at CAER Algae Greenhouse, Fall 2017*



## Research Experience for Undergraduates Opportunity



The Center for Applied Energy Research at the University of Kentucky has been engaging undergraduate students in day to day research since it opened in 1977, focusing on energy and environmental issues relevant to Kentucky. This summer, these activities will be expanded beyond summer employment and experiential learning opportunities, to include weekly seminars, lab tours, and professional development opportunities thanks to funding from the University of Kentucky Sustainability Challenge Grant Program

### Requirements

- Completed sophomore or junior level classes (>3.0 GPA)
- Seeking **engineering, science, design** and **sustainability** majors
- Good written and verbal communication skills
- Ability to work outside
- Willingness to learn and grow!

### Job Description

- Interdisciplinary research team investigating algae based carbon utilization & bioproduct production
- Algae cultivation, reactor design & operation, analytical instrument training, laboratory methods, etc.
- Design thinking and professional development opportunities



***Interested candidates should email a resume and cover letter to [Michael.Wilson@uky.edu](mailto:Michael.Wilson@uky.edu)***

*Figure 6: A copy of the flier to recruit students for the program*