Idaho Incubation Fund Program

Progress Report Form

Proposal No.	**IF17-001**
Name:	**Kevin Feris**
Name of Institution:	**Boise State University**
Project Title:	**Pilot Scale Algae Resource Recovery Unit**
Reporting Period:	**July 1, 2016 to December 31, 2016**

Information to be reported in your progress report is as follows (attach additional information as needed):

1. Summary of project accomplishments for the period just completed and plans for the coming reporting period:
   Project accomplishments for the reporting period 7-1-16 to 12-31-16:

   ARRU system design, cultivation of algal cultivars for inoculation of ARRU, identification of a field site for ARRU system deployment, and personnel changes:

   System design: We have designed the major components and scale of the ARRU. We are currently making modifications to the design based on modeled rates of CO_2 delivery, nutrient availability in the wastewater stream, estimated productivity rates for the system, and site specific criteria to match the power, plumbing, and space availability at the UI diary location. The ARRU will consist of 2 to 3 replicate raceways with an areal surface area of approximately 15-30 m^2. Based on our prior work and our literature survey an areal footprint of this size will be sufficient to sequester the majority of nitrogen and phosphorus released in the effluent from Dr. Coats' PHA reactor on a daily basis. Current design work is targeted towards minimizing pump size and energy requirements for system operation without limiting the algal cultivation potential of the design.

   Cultivation of algae for inoculation of the ARRU: Dr. Feris and the BSU undergraduate research assistant (Gary Dunn) have selected and initiated cultivation and out-growth of a suite of 12 algal cultivars that our prior work established as good candidates for field deployment in the ARRU. This suite of organisms includes a variety of green algae and cyanobacteria that have relatively high growth rates in PHA effluent and are able to be cultivated in untreated dairy wastewater under laboratory and greenhouse conditions. We are initiating greenhouse outgrowth/expansion of these populations in the presence of the colonization substrates we will deploy in the ARRU at the UI dairy. The purpose of these efforts is to generate "pre-colonized" growth substrates that will be deployed in the ARRU to act as source populations and communities of algae that will be able to expand and completely colonize the cultivation surfaces in the ARRU. This work is on-going in the BSU greenhouse. We expect to have up to 15m^2 of pre-colonized growth substrates by the time the ARRU is fully constructed. These pre-colonized substrates will then be transported to the UI dairy and deployed in the ARRU to initiate our pilot-scale experiments.

Siting the ARRU: During the first couple of months of the project Dr. Feris contacted a number of local dairies to pursue potential locations for siting the ARRU. Dairy operators were interested in the project outcomes but were not ready to commit space at their operations for construction and testing of the ARRU for the duration of the project period. Based on this outcome and the fact that it occurred as the growing season in our region was drawing to a close (i.e. mid to late September) we made the decision to pursue a collaboration with Dr. Erik Coats at the University of Idaho and siting of the ARRU at the UI dairy.

Building upon a collaboration with Dr. Erik Coats at the University of Idaho: We recently requested and received approval to create a sub-contract from BSU to UI to facilitate timely and successful completion of this project. One of the sites we initially pursued for deployment our algal resource recovery unit (ARRU) is at the University of Idaho Dairy. All of the necessary site attributes are available at the UI Dairy (i.e. a readily available waste stream, power, water, a relatively secured site on which to perform our study, etc.). By deploying our algal system at this site we will be able to leverage this SBOE funding to co-deploy our ARRU alongside Dr. Coats' bioplastics process. We noted this possibility in our original proposal as something we'd like to pursue as both systems are driven by nutrients and energy in dairy waste streams. Dr. Coats and I have collaborated for a number of years on related projects and he is excited about this opportunity. Such a collaboration between Boise State and the University of Idaho would allow us to simultaneously demonstrate the proposed value of the ARRU and Dr. Coat's bioplastics process at commercially relevant scales, as an integrated suite of technologies, and as separate systems. In addition, co-deployment at UI would allow us to leverage some of the highly trained staff in Dr. Coat's research group, in partnership with our own, to further increase the likelihood of success for our project.

Effect of our collaboration with Dr. Coats on project objectives: The sub-contract will allow us to complete the project as originally proposed while simultaneously building collaboration between Boise State University and the University of Idaho. It will also allow us to generate data comparing ARRU yields when coupled to a dairy manure driven bio-plastics process vs. deriving nutrients for algal cultivation directly from a holding pond. Additionally, Dr. Coats is well connected with the Idaho Dairy Industry and has presented on and discussed the potential of his bio-plastics process with this group for a number of years. We are hopeful that that pairing of the ARRU with Dr. Coats' process will only enhance the likelihood of both technologies being adopted for resource recovery by dairies in Idaho as well as by similar industries in other states. Therefore, expanding our project to incorporate a collaboration with Dr. Coats at the University of Idaho provides the opportunity to demonstrate the value of co-deployment of multiple integrated and optimized resource recovery systems in the dairy industry.

Personnel changes: At the start of the project we had a significant change in personnel. Maxine Passero left the university for a position in private industry. After Mrs. Passero's departure we spent approximately 6 weeks looking for a replacement scientist to continue the project. Based on our search for replacement personnel and the ultimate siting location for

the ARRU we decided the most efficient use of project resources would be to support a PhD student at the University of Idaho, undergraduate research assistants at Boise State University and UI, and research time for PI Feris and our new co-PI Dr. Erik Coats.

Project plans for reporting period 1-1-17 to 6-30-17: During the final six months of this project we will construct replicate ARRU's (minimum of 2 replicates) at the UI Dairy to be fed with nutrient/resource inputs from either Dr. Coat's bioplastics process or diluted wastewater from the manure holding pond at the UI dairy. Both ARRU's will be inoculated with pre-colonized algal support matrices (colonized with algal communities cultivated at BSU), operated under identical conditions or as closely as possibly on a per-nutrient load basis, and the resultant algal productivity and associated resource recovery characterized for each system. It is our intent to operate the systems as continuously as possible given weather and logistical constraints through the end of the project period. If possible we will leverage non-SBOE resources to continue operation beyond the project period in an attempt to acquire data from as long of a cultivation/operational period as is feasible. This additional operational data should prove useful in determining the utility of the ARRU system for as close to a full growing season as possible.

2. Summary of budget expenditures for the period just completed (include project burn rate):

   As of December 31st, 2016 project expenditures are equal to $0. However, as described in #1 above we have been able to leverage other student and faculty support resources for finalizing the ARRU system design, determining a siting location, identifying and recruiting personnel for system construction and operation, and growing up and colonizing the colonization matrix for the ARRU by select cultivars. This leveraging strategy will allow us to focus our expenditures during the latter 6 months of the project for system construction, operation, testing and optimization. In addition, we have developed a strong collaborative relationship with Dr. Erik Coat's lab at the University of Idaho to co-deploy our ARRU along-side his bioplastics process such that we will be able to compare ARRU performance with inputs from both direct from manure holding ponds and with inputs from Dr. Coats' bio-plastics process. This comparison will allow us to quantify both algal biomass yield as well as net resource recovery differences by the ARRU depending on the pre-treatment of the nutrient streams employed. We believe this data will be key in allowing us to demonstrate the utility of both stand-alone algal ARRU systems and that of coupled bio-plastics/ARRU systems.

3. Numbers of faculty and student participation resulting from the funding, including internships:

   As of December 31, 2016 participation is as follows:

   - 2 Faculty members: Kevin Feris, Boise State University and Erik Coats, University of Idaho
   - 1 undergraduate student: Gary Dunn (Boise State University, Biological Sciences Major)

   Participation beginning 1-9-17:

   - 2 Faculty member: Kevin Feris, Boise State University and Erik Coats, University of Idaho

- 1 PhD Student: Nick Guho, University of Idaho
- 3 undergraduate students: 1 at Boise State University and 2 at the University of Idaho
- 1 Research scientist: Cindy Brinkman, University of Idaho

4. List patents, copyrights, plant variety protection certificates received or pending:

None pending.

5. List technology licenses signed and start-up businesses created:

N/A

6. Status of private/industry partnerships (include enough information to judge level of engagement):

7. Any other pertinent information that will indicate to the council that the project is meeting satisfactory progress.

History of successful collaboration between Drs. Feris and Coats: Dr. Feris and Dr. Coats have been collaborating for approximately 10 years on wastewater to biopower-bioplastics-algae systems. We have received funding through the US Department of Agriculture (USDA), Idaho National Laboratory (INL) and the Center for Advanced Energy Studies (CAES), and the Environmental Protection Agency (EPA) in support of this work. Moreover, Dr. Coats bioplastic pilot-scale system with which we will co-locate was previously funded by a HERC grant. Collectively, this research has yielded multiple externally funded projects, graduate students, publications, and a pending patent. We have published a diverse array of scholarly publications from this work and we are positioned to be successful with this project as well.