Section 1: Summary Information

Project Title: Reducing USF CO_2 Emissions With Algae
Duration (months): 6 months
Total Budget ($): $5,000
Requested SGEF Funds ($): $5,000
Matching Funds ($): n/a
Proposed Starting Date: May 2016
PI Graduation Date (if applicable): Summer 2018

Section 2: Application Information

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Section 3: Project Description

Project background and purpose (reasons motivating request) (Max 500 words):

The intention for this feasibility study is to explore the reduction of CO_2 emissions from the USF boilers utilizing microalgae. The hypothesis is that microalgae will consume CO_2 available in a mix of flue gases released by the boiler. Carbon dioxide will serve as a carbon source (nutrient) leading to photosynthetic reproduction of the cells. As a result of CO_2 consumption by algae, USF could realize a way to further reduce its carbon footprint, this time from its actual air emissions.

As algae utilize CO_2 to grow in numbers, the algae cell mass that is generated can be used as natural fertilizer and/or animal feed or can be refined for biofuel production (biodiesel and jet fuel). For the application on the USF campus, which is of relatively small size, we recommend the use of cell mass as fertilizer on the USF grounds.

Microalgae are a promising source of biofuels and bioproducts as they consume CO_2 to grow and multiply quickly (Dogaris, I. et al. 2015). Since algae need nutrients to grow, particularly carbon dioxide, it is of great interest to study whether algae can serve as an effective means of capturing and diverting greenhouse gases, such as CO_2. Diverting greenhouse gases will contribute to USF's goal of eventually becoming carbon neutral. The boilers on campus receive their power from natural gas and the exhaust, flue gas, has a carbon dioxide composition that may be a viable nutrient source for growing the microalgae.

As studying the potential of microalgae is a unique and fairly new research that is increasing all over the world, this is a great opportunity for USF and student researchers to become ambassadors of this sustainability technology. Students will be able to publish their findings in this project, as well as create posters to present at conferences nationally and internationally.

References:

Dogaris, I. et al. (2015). A Novel Horizontal Photobioreactor for High-Density Cultivation of Microalgae. *Bioresource Technology.*

Project activities (Max 250 words)

From our preliminary discussions with USF facilities, although the exact composition of the flue gas is not known, the use of 50% excess air in the boilers will allow us to search the literature and identify an approximate flue gas composition as part of this feasibility study. Using a custom made compressed gas mix of the same composition (to be ordered from Airgas), the student team will conduct small scale lab experiments to test the hypothesis by growing algae in a bioreactor in the Biofuels and Bioproducts Lab of the Patel College of Global Sustainability. The results will help us quantify CO_2 removal from the simulated flue gas of the boilers and enable us to project the extent of carbon emissions reduction that could be eventually achieved on campus. The cell mass resulting from the test will be tested as fertilizer on campus.

Project results (Max 500 words)

This feasibility study will serve as a means to decide on the potential of using algae to reduce CO_2 emissions from boilers. For the production of one kilogram (kg) or 2.2 pounds of algae, it is reported that approximately 2 kg of CO_2 are consumed, but other factors, such as nutrients and growing conditions, play an important role as well. Using a small vertical reactor made of acrylic material, the students will perform experiments in the lab to document and quantify CO_2 consumption and cell mass production using a custom-made gas mix that resembles the composition of the USF boiler flue gas.

To keep costs low, instead of attempting to collect actual flue gas from the boiler exhaust, we will use literature data to identify the composition of flue gas typically generated during the combustion of natural gas using 50% excess air, as is the current practice at USF based on information we have already collected from Mr. Nainan Desai. We will then procure a compressed gas mix from a local vendor and use it as the source of CO_2 for the algae cultivation tests.

Once the reactor is operational, we will be collecting daily samples to measure cell growth and productivity. The findings will be extrapolated to project how much CO_2 could be removed from the flue gas with the use of an appropriate size reactor (pond) on campus. For these calculations, data will also be collected from USF facilities regarding the annual consumption of natural gas by the boilers.

Outcomes of the project (Max 250 words):

In order to understand whether microalgae can serve as a means of reducing CO_2 emissions, we are proposing a feasibility study to first confirm that the composition of the flue gas

is effective in providing enough nutrients for the algae to grow. If the feasibility study is successful, our next step will be to collect actual flue gas from the boilers and pass it through an algae pond allowing the cell to remove some of the CO_2.

Annual Energy Savings in kwH: n/a
Annual Cost Savings: n/a
Return of Investment in %: n/a
Annual GreenHouse Gas Reduction: For 20g of algae to grow, it takes 40g of CO2. The annual number can be calculated once we know how well the estimated flue gas composition works.

Project Sustainability (How is this project sustainable?) (Max 200 words):

According to the benchmarks laid out by the University of South Florida's (USF) Climate Action Plan (CAP), USF is striving to reduce their GHG consumption by 10%. In an attempt to achieve this benchmark, a study is being proposed that will look to assess the feasibility of utilizing CO_2 from flue gas to cultivate microalgae. If initial lab studies produce positive results, then a larger outdoor system (pond) could be developed to remove CO_2 from the actual flue gas of the USF boilers. Ultimately, the proposed technology will allow USF to take one step closer to both its CAP goals and closing the energy consumption loop within the university system. Most importantly this study will serve as a pivotal educational tool to help facilitate sustainability awareness on campus.

Section 4 Workplan and Budget Details

Detailed work plan/schedule of activities (Max 250 words):

1 - 2 Months to build and prepare the system. The students will also learn the techniques for growing the algae and using the system.
1 Month to hook the system up and prepare the water.
3 Months to run tests to collect and analyze data.

Budget Breakdown

Personnel (include all involved vendors):
Equipment: Small Reactor $750
Supplies/Materials: $4,250
Contractual: n/a
Construction: n/a
Other (specify in budget justification):

Budget justification (Max 250 words):
- A vertical reactor will be manufactured from acrylic and used for algae cultivation in BSF 242/244
- Probes will be used to monitor crucial algae growth parameters, such as pH, temperature, and dissolved oxygen (vendor: Cole-Parmer)
- A gas mix with a composition that resembles that of a natural gas-powered boiler (such as those used by USF) will be determined and ordered (vendor: Airgas)
- Chemical nutrients are needed for algae cultivation (vendor: Fisher)
- Pipettes, filters, and other consumables are needed for inoculation and sampling (vendor: Fisher)