Needs Assessment and Project Scope

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Needs Assessment

Global energy production must rise to meet growing demand; along with this comes increased production of greenhouse gases like carbon dioxide, which can lead to undesirable climate change. On top of that, we are facing ever-shrinking supplies of natural resources. As we move toward the future it becomes more necessary maximize the use of produced energy, cultivate renewable forms of energy, re-use waste heat, and reduce carbon dioxide emissions. This project focuses on coupling a trigeneration system with a photobioreactor to increase the yield of algae grown in the bioreactor and clean exhaust gases by sequestering carbon dioxide. This coupling device will link the two existing systems so that a portion of what was originally waste carbon dioxide will be sequestered by virtue of photosynthesis in the algae. The algae can then be used to produce biodiesel and biomass to help meet future energy demand and reduce our dependence on fossil fuels. A modular design for this gas coupler is desired.

Project Scope

Problem Statement

The emphasis of this project is to create a coupling system that will bring the exhaust stream to the photobioreactor without compromising the efficiency of the trigenerator or the algae itself. The main focus will be on the gas coupler itself and algae growth will be a secondary concern.

Objective

This project has four main objectives:

1. Use waste CO_2 to drive photosynthesis in a photobioreactor
2. Mitigate CO_2 emission by sequestering it from the exhaust stream
3. Couple trigenerator exhaust with photobioreactor, preferably in a modular package
4. Integrate photobioreactor life cycle analysis research into final product evaluation

Justification and Background

The system will be built with existing trigeneration unit and photobioreactor, both of which are in need of repair. The trigenerator contains a gasoline fed internal combustion engine, an electrical generator, an absorption refrigerator, a helical heat exchanger and various related subsystems. The photobioreactor consists of three translucent reactor tubes with aquarium monitoring equipment, pumps to circulate water, a diffuser for the introduction of gas, thermometers and pH sensors. Coupling these will lead to more efficient use of energy, less greenhouse gas emissions, and increase algae yield.

Methodology

Before the gas coupler is built, the existing systems it is built around must be returned to working condition. Some missing parts of the trigenerator must be replaced or repaired and all the subsystems should be operational. Some data must be obtained through previous studies or our own experiments. Knowing optimal algae growth conditions is required so that our gas coupler can be designed to not disrupt them. It is also necessary to know whether the presence of gases other than CO_2 in the exhaust stream could harm the growth of algae. Early research indicates that filtration or catalytic conversion is not necessary, but this hypothesis needs to be confirmed by a credible source. Dumping too much carbon dioxide or heat into the bioreactor will decrease algae yield, so a subsystem or capture method must be designed to avoid this. The cost effectiveness of making the system modular needs to be reviewed.

Constraints

- $2500 Budget
- Algae is sensitive to changes in temperature and acidity
- The exhaust system will be prone to corrosion
- Fuel choice will affect the composition of exhaust gases
- At least one additional photobioreactor chamber is needed

Expected Results

- A gas coupling system that can provide the right amount of CO_2 for the bioreactor at the right temperature
- A subsystem or method of capture that will not adversely affect temperature and pH levels in the bioreactor
- Application of life cycle analysis research to evaluate the potential environmental effects of the final product