Iowa Power Fund Board Project Report Update

Project: Green Plains Renewable Energy Inc., IPF 08-02-1043

Power Fund Award: $2,085,000

Payments Issued to Date: $267,848.24 (1 payment issued)

Company Investment to Date: $763,283

Project Award Date: February 19, 2009

Project Description:

The technology used in this proposal is BioProcess Algae's Vertical Mounted Photobioreactor. Inputs to this system are CO2 from a rich source, here an ethanol plant, nutrients, wastewater from the ethanol plant, sunlight and waste heat if available. The outputs from this system are algae oil, which is similar to other vegetable oils, delipidated algae meal, and dry whole algae. Application use of the oil will be biodiesel feedstock, an alternative feedstock for ethanol or as a feedstock for other energy production processes. Application use of algae meal and dry whole algae are animal feed products. The overview of the farm process in converting the inputs to outputs consists of four major processes:

•Gas handling – which consists of taking enriched CO2 gas from a source under site conditions and deliver it to the algae farm at the requisite temperature, pressure and composition;

•Algae farming and cultivation – this is the algae farm itself, where we expect to grow ~200 tons of algae per acre of surface area in the photo bioreactor.

•Dewatering – increasing the algae contraction from 1-2% solids concentration to a 11-15% solids concentration

•Drying and extraction – extracting algae oil from all or a portion of the algae; drying the whole dry algae or delipidated algae to a level of <10% solids and other methods of extracting energy from the algae.

Update:

The Shenandoah, IA pilot plant design has been completed, all equipment items purchased and construction of the skid unit is currently in progress at the company's plant in Portsmouth, RI with an ETA at the Shenandoah ethanol plant of September 15, 2009. The design is based on the BioProcess Algae LLC vertical photobioreactor (PBR) phase 1 with a diameter of 1.5 ft and a height of 10 ft.

The PBR is fitted with proprietary, custom designed media inserts that will serve as a substrate for growing the algae. The substrate insert is gently rotated by a motor installed on top of the reactor and harvesting is provided by a more energetic rotation in a spin with a "wash machine" effect. Due to the large algae agglomerates typical for the BPA PBR settling occurs rapidly so that the amount of water required for harvest is minimized which in turn minimizes water usage and the costs associated with it.

Since the reactors are installed inside, lighting is provided by a Parans natural light concentration unit and supplemented during dark periods by a set of LEDs during in the 400 nm and 700 nm wavelength which is the ideal PAR (photo active irradiation) light.

Water feed to the reactor is provided by the Shenandoah plant RO unit and utilities such as instrument air, electricity, cooling tower water, and NaOH solution provided by the plant as well. In addition, the reactors will be supplied with customized nutrients to ensure optimal growth. For a similar reason, the reactors will be maintained at a temperature of 80 deg F and pH will be controlled in the optimal range.

CO2 gas from the plant scrubber will be compressed to 30 psig into a day storage tank after which it will be mixed with air in the desired ratio controlled by Aalborg mass flow meters. Nutrients are dosed into 50 gal tanks and the resulting solution will be dosed intermittently to the reactors by metering pumps.

The reactors are temperature controlled by Tranter plate and frame heat exchangers with cooling tower water from the plant as the heating/cooling medium. In addition, pH is controlled via a NaOH solution from a 350 gal tote tank provided by the plant also.

A clean-in-place (CIP) system using NaOH solution is also provided to clean fouling of the heat exchangers and reactors if necessary. We expect this to be a very seldom used activity; however, it provides necessary insurance in case fouling does occur.

Once the growth cycle is complete, harvesting occurs whereby the concentrate algae solution at the bottom of the PBR is transported to decanting tanks where solids are settled and the remaining liquid called supernate is separated, filtered, and returned to the reactor. We anticipate this will be a volume between 5 – 10% of the PBR reactor volume so that water transport and associated costs are minimized.

Offgas from the system consisted of degassed unreacted CO2 and oxygen, which is a product of the photosynthesis reaction, will be sent back to the plant scrubber and released to the atmosphere through an existing Iowa DNR permitted emission point.

The Iowa DNR permit affords us a six month operating window after which a phase 2, larger reactor pilot will be installed in the 1st Qtr 2010. These reactors will be larger, 3 ft x 15 ft vessels which represent a 6 x volumetric scale-up factor and a step closer to a commercial unit size.

Data from the pilot plants operation will used to confirm operating capacities and yields, generate better capex and opex numbers, and scale-up data to be used for an engineering design for an algae PBR plant sized to absorb all the CO2 offgas output from the Shenandoah plant (approx. 150,000 tons CO2 per year.)

Dewatering and oil extraction activities are currently being undertaken and various technologies are being investigated for testing as an add-in for the pilot units.

Pic #1 Algae agglomerate growth for better settling and lab analysis

KAS Analysis of BPA Samples July 20, 2009

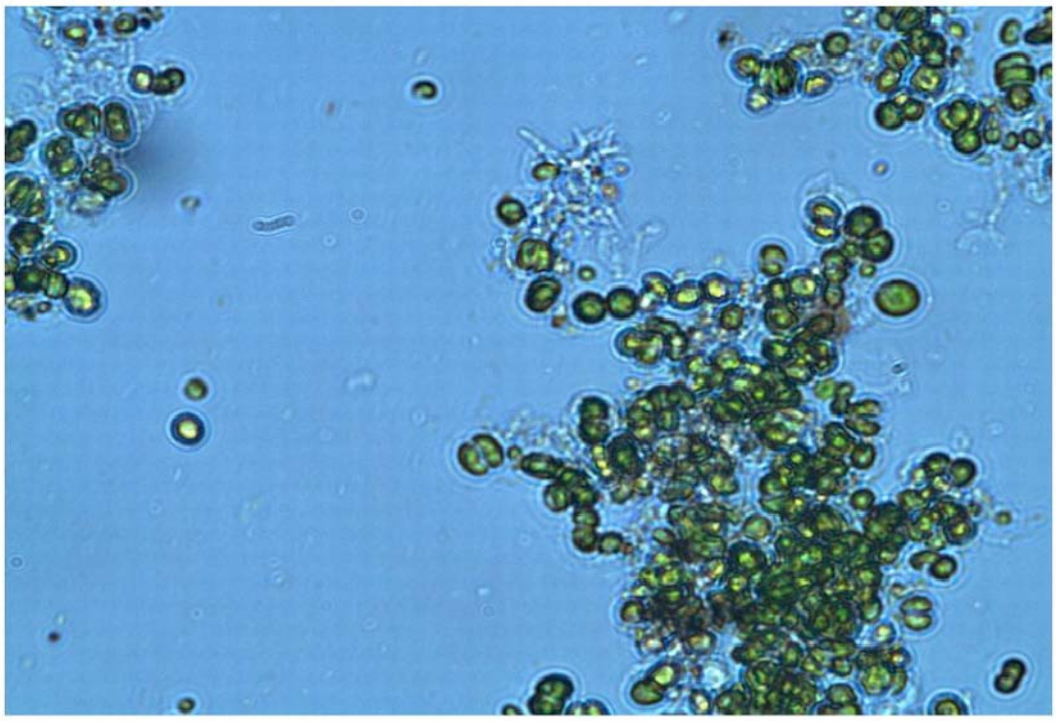
Sample Code	Algae Strain	DW (gl)	AFDW (g/l)	Mean Chl a (ug/ml)	Mean Chl b (ug/mL)	Mean Total Chl (ug/ml)
#12	Chlorella Kessleri	31	18.77	38.66	33.57	52.56

DW- Dry weight; AFDW- Ash-Free Dry Weight

Chl a- chlorophyll a; Chl b- chlorophyll b; Total Chl – Total chlorophyll

* cell count was not possible due to aggregation of cells

PBR #12 Chlorella (UTEX#398 C. kessleri) from 100 ml harvest sample taken from bottom of reactor.



Pic #2 Laboratory R&D Units

Pic # 3 Shenandoah pilot skid unit (front view)

Pic # 3 Shenandoah pilot skid unit (back view)

Pic # 4 Photobioreactor (PBR) with LED lighting