Hybrid Algae Production System (HAPS) to Advance Timetable for Commercial Production

Applicant: Idaho Sustainable Energy, LLC. (ISE)
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The Hybrid Algae Production System (HAPS), built by an ISE consortium of companies, is an engineered closed pond system for production of microalgae biomass combining the commercially scalable advantages of pond systems with the added benefits of closed photo bioreactor systems without the high cost.

There has been a general controversy for years: open ponds or closed photo bioreactors? Both these systems have huge problems to solve. Neither has emerged as the winner. The US Department of Energy (DOE) Aquatic Species Program (ASP), which covered a period of almost 20 years, clearly identified the required physical aspects of systems to increase algal biomass production and lower costs.

In 2007, after many years of research, the team members of this proposal constructed a 100,000 liter HAPS (Hybrid Algae Production System) demonstration facility in Montana, one of the largest algae growth projects ever built in the United States. The purpose of this facility was to address and solve all of the mechanical and environmental problems clearly outlined in the ASP.

The 100,000 liter demonstration facility, which operated for nine months in Montana, clearly addressed the following issues:

1) HAPS covered ponds were manually constructed several times to determine the labor requirements of such systems, demonstrate inexpensive construction methods and prove these significant reductions in construction costs.

2) The coverings were investigated and finally built with no internal structural support. This is clearly an advantage not only in construction cost but in avoiding damaging results from high wind conditions. HAPS covered ponds in Montana successfully survived high winds during the demonstration period of up to 60 mph with no damaging effects.

3) Inexpensive and durable materials for construction of pond liners and coverings were extensively investigated and identified with a 20 year guarantee from the manufacturer at low cost.

HAPS has also addressed many problems which have plagued the algae industry as follows:

1) Temperature control for summer and winter. Summer ambient temperatures of up to 105° F (40° C) were encountered. The HAPS covered ponds maintained temperatures usually associated with successful algae production. Temperature charts were kept during winter conditions where average daytime temperature was 43° F (6° C) (and below freezing at night) and inside pond temperatures were maintained even on cloudy days at 68° F (20° C), which was an efficient temperature range for algae growth. The critical control of daily temperature swings (daily maximum and minimum temperatures) was also successful. Usually average daily temperature swings for much of the United States vary between 30° F (17° C) and as much as 40° F (22° C). These daily swings in temperature shock the algae and significantly reduce algae biomass production. HAPS reduces the daily temperature swing shock from 32° F down to 10° F (18° C down to 5° C). Therefore, significantly increasing production of biomass.

2) Control of evaporation, pH, salinity and light. These factors were also addressed successfully and HAPS exhibited significant control of these parameters due to the unique enclosure.

3) HAPS requires brackish water, saltwater or fresh water, as well as sunlight, carbon dioxide (CO_2) and certain proprietary nutrients. Growth is directly linked to the amount of CO_2 available in the water from, for instance, power plant stack emissions or other industrial sources. The capacity of water to hold CO_2 for maximum algae uptake is optimized by other proprietary processes in HAPS covered ponds.

4) During high algae growth periods, at high sunlight conditions, algae photosynthesis can produce enormous quantities of oxygen. These high levels of oxygen can severely inhibit algae growth. HAPS successfully demonstrates an efficient low cost method for the removal of oxygen.

5) The unique design of HAPS and its associated pond flow dynamics have successfully addressed multiple other problems associated with algae production, including prevention of algae self-shading, nutrient distribution, efficient gas exchange, such as CO_2 intake and oxygen removal, and hydrodynamic parameters to maintain a uniform flow gradient for adequate algae suspension.

The success of the Montana demonstration facility justifies a full scale production system to prove that we can significantly advance the timetable for commercial algae production. The proposal has been previously submitted to the US DOE. It was advanced to the oral presentation stage and the following quotes from the DOE letter to Idaho Sustainable Energy listed the merits of the proposal:

- "The company appears to have a well-qualified and experienced leadership team."
- "The engineer in charge is experienced in design, development, and construction process."
- "The Project Management Plan is fully integrated with financial and business systems."
- "The company has existing operations at the biodiesel facility that substantiate its abilities and experience."
- "The team demonstrates that it has strong commercialization experience and engineering leaders."
- "The applicant has demonstrated an ability to build and operate pilot and commercial scale facilities."
- "The proposal possesses a stage gate method that adequately described and is coordinated with a resource loaded schedule."
- "The project is innovative and ambitious."

The target level of performance of the proposed technology is well establish as it is identified in the ASP that 50 grams per square meter per day of algae growth would be necessary for a successful commercial production. The ASP also proved that on days where the above parameters were met, this target could clearly be reached. Therefore, we believe that by controlling these parameters, HAPS can reach this production target averaged over at least ten months of the year. The ASP in New Mexico was crippled and plagued because of daily shock temperatures, inefficient temperature control during the seasons, invasion of other species in the open pond system, and massive evaporation levels in hot weather. All these problems are prevented by HAPS due to its enclosed environment.

The current Algae Industry has not provided cost effective algae farm commercialization because of high costs of currently proposed setups and the fact that they do not produce enough algae biomass to be commercially successful. HAPS clearly brings the time line closer to large scale commercialization of algae.

The HAPS demonstration facility sufficiently shows the economic viability of this system in a commercial setting. It has overcome all the shortcomings described in the Aquatic Species Program. It is inexpensive to build, controls essential parameters to maximize growth, produces adequate quantities of biomass for commercial success and can easily be implemented for large scale production.

The key technical risk of this project is to prove that we can lower the production cost in a commercial size facility and duplicate the success of the 100,000 liter HAPS demonstration facility in Montana. This first commercial project can justify the investment in larger HAPS algae farms to further reduce the cost of

production by taking advantage of economies of scale.

Other proprietary technology which will greatly benefit this project is the development of nutrient growth boosters by ISE for the commercial scale production of algae to increase growth of algal biomass in shorter time intervals.

Testing of this micronutrient formula by qualified outside research laboratories clearly indicates an increase in algal biomass of up to 200%. The formula was tested on several types of algae including freshwater and saltwater algae and so far we have found all of them to be responsive. The growth seems to be quite unusual in the fact that it increases the number of algae cells and, at the same time, it also increases cellular size of algae. This has been effectively proven by our laboratory photographic evidence. There are no other research data currently available about technologies demonstrating increased number of cells simultaneously with increased cell size. Increasing biomass growth is the key to commercial production and further research is required to identify all the commercial benefits derived from this unique approach to algal nutrition.

Also beneficial to this project is the recent work done by the team which has cultivated and developed two special strains of algae which exhibit high growth rates, high oil content and resistance to environmental changes. In addition, the team has established laboratory facilities including bioreactors for algae incubating and field laboratory facilities. We also have access, through collaboration with universities, to sophisticated high tech lab facilities.

The Principal Investigator (PI) and Project Team have the skill and expertise needed to successfully execute the project plan. The team is highly qualified with more than 50 years of combined experience. It is comprised of professional engineers, PhDs, research and business personnel. All team members have been involved in the algae industry and associated alternative energy fields. The team members have collectively authored or co-authored over 50 technical publications, and have many patents, patents pending and trade secrets to their credit.

The entire team has prior experience which demonstrates an ability to perform R&D tasks of similar risk and complexity. Team members were responsible for building one of the largest algae demonstration projects in 2007. Idaho Sustainable Energy (ISE) also has the availability of entire fabrication facilities and experienced sub-contract personnel who have not only built entire biodiesel facilities but also constructed the demonstration facility in Montana. In addition, we have land, know-how, field construction experience, equipment, and the technical expertise to complete this project.

The Montana demonstration was financed privately. Team members currently maintain R&D facilities, continue relationships with staff at several reputable universities and research institutions and have worked together on prior projects including a large Idaho Sustainable Energy proposal to DOE.

Participating Entities:

Idaho Sustainable Energy, LLC
Biotech Research, Inc. (Bio-Clean Fuels)
Green Star Products, Inc.
BKS Energy, Inc.
Joseph LaStella P.E. Ret.
State of Missouri
Plus four other PhD’s