Green Star Products Complete Algae Demonstration Report

A detailed report on Phase I, II and III of 40,000-liter demonstration algae facility located in Montana.

Green Star Report on Algae Demonstration Facility Phase I

GSPI demonstration facility is located in Montana and is one of the largest demonstration facilities in the world at 40,0000-liters.

Phase I objective in this project is to determine the ability of the GSPI Algae Process System to solve the daunting operational problems for microalgae production, which have plagued the algae production industry for years.

Phase I now is complete and has been successful in controlling the most important variables in algae production, i.e. temperature of water in large systems, salinity (salt content), evaporation, pH (acidity-alkalinity) and most all initial costs of construction.

Experts agree that the major hurdles in production of algae are associated with the control of the mechanical and physical parameters of the growth environment for the algae and the high capital costs of construction of that environment."

Many suitable high-lipid (oil) algae species have been cultivated and already exit to produce the First Generation of sustainable energy farms. Present available algae species can produce 4,000 gallons of oil per acre each year, which is 50 times greater than the oil yield from oilseed crops such as soybean or canola crops.

The DOE analyses indicate, “that significant potential land, water and CO2 resources exist to support this technology. Algae Biodiesel could easily supply several 'quads' of biodiesel - substantially more than existing oilseed crops could provide. Quad is short for 'quadrillion BTUs', which is a unit of energy representing 10 to the 15th level (1,000,000,000,000,000) BTUs of energy, which is also equivalent to approximately one billion gallons of fuel. This perspective led DOE to focus on the concept of immense algae farms.”

Microalgae systems use far less water than traditional oilseed crops. Land is hardly a limitation. Two hundred thousand hectares (less than 0.1% of climatically suitable land areas in the U.S.) could produce one quad of fuel. Thus, though the technology faces many R&D hurdles before it can be practicable, it is clear that resource limitations are not an argument against the technology.

The industry hurdles are mainly associated with costs of construction of algae farms and process systems that can economically control the growth environment of the algae. This is exactly the purpose of GSPI's Phase I demonstration algae facility.

There are only two main types of algae production systems in use as follows:

A) Closed Photobioreactors

All attempts to use closed bioreactors for algae fuel crops have failed. The failure of the closed bioreactors includes the $250 million dollar R&D program spent by Japan. Closed bioreactors are too costly, although they do have a place as a breeder facility (hatchery) for larger systems.

B) Open Pond Systems

The alternative systems, which are open ponds, have had marginal success and are prone to multiple failures from many uncontrolled environmental conditions ranked in order: 1) Temperature and light variances – day and night, summer versus winter, etc.; 2) Infiltration from local algae into open ponds contaminating the cultured algae causing pond crashes; 3) Evaporation, wind blowing dust particles into ponds and rain causing changes in salinity and pH, which affect growth of algae.

The GSPI (licensed) algae system is a Hybrid Algae Production System (HAPS) that incorporates the controlled environment of the closed photobioreactors coupled with inexpensive construction technology to reduce the cost to a level very close to the open pond systems.

In summary, GSPI has developed the field expertise to build and operate the patent pending, proprietary Hybrid Algae Production System (HAPS), a cross between an open and closed pond system. The demonstration, prototype facility is located in Montana with an individual pond capacity of 40,000 liters, which can easily be scaled up to larger systems and acreage.

The GSPI enclosed HAPS have been designed to be constructed utilizing relatively inexpensive local materials anywhere in the world.

Three different pond construction methods (with the same overall design) were used to develop cost factors for time and capital expenditures to determine construction cost data.

The 40,000-liter pond with a four-man crew was assembled in less than 12 hours after the necessary construction materials were onsite. After the water flow commenced, tests for flow rates, mixing rates and pond day and night temperatures changes were charted.

During the test period, varied weather conditions occurred in Montana with temperatures varying from 34°F to 82°F, winds up to 30 mph, heavy rains, some snow, cloudy and sunny periods – all occurred during this time.

The HAPS also offer additional inexpensive external temperature controls, if necessary, to cool ponds in the hot summer and heat ponds in winter conditions, during extended sunless days, to maintain maximum growth conditions.

Also, algae cannot tolerate direct sunlight and they tend to grow best receiving 25% to 50% of direct sunlight. GSPI's HAPS enclosed ponds have a partial light barrier with the enclosed material to promote optimum light conditions for algae photosynthesis.

Temperature and light control are the two most important parameters identified by industry reports and must be accomplished at an effective low cost. The next important parameter to be controlled is salinity. Open ponds continually evaporate large quantities of water and leave salt behind. Each time this cycle is completed additional salt water is added. Salt content continually increases and adversely affects the growth of the algae and must eventually be disposed of and exchanged with new water and algae. GSPI's HAPS ponds do not evaporate the water and can maintain optimum salinity levels for long periods of time.

In summary, GSPI has already addressed the main causes of failures of other systems.

Green Star Report on Algae Demonstration Facility Phase II

Green Star Algae Phase I Demo Facility, explained in detail the five most important operating parameters that need to be controlled. However, management of these parameters has so far eluded the commercial microalgae industry.

These parameters include daily and seasonal pond temperatures, pH, evaporation, salinity and invasion by outside organisms.

The GSPI demonstration facility which is a full-size module of our planned production facility furnished GSPI with a wealth of field information and patentable low-cost construction techniques.

Phase II testing included pushing the survival environmental envelope of the developed algae strain ZX-13 utilized by GSPI.

The ZX-13 algae strain survived at elevated temperatures, much higher than any tested in most of the available literature over the last 50 years. Temperature testing by Universities usually cuts off at 90 Degrees Fahrenheit, this zx-13 strain successfully endured peak temperatures of 115 Degrees Fahrenheit for several hours on successive days.

Also tested were salinity levels outside the normal operating range for saltwater algae and the ZX-13 strain exhibited strong survivability. The zx-13 strain also exhibited acceptable 21% oil content. The balance of the biomass is being tested for high-grade protein content to be used as animal feed and organic fertilizer.

The only item that caught GSPI personnel unprepared was the exponential growth of the algae.

Growth rates of algae are phenomenal, just consider that many algae, including the ZX-13 strain, are capable of reproducing themselves from 1.5 to 4 times per day depending on environmental conditions. This means that, even at nominal growth rates, one cell will grow to one million microalgae cells in 15 days that continue to grow to one trillion cells in the next 15 days if conditions and space for growth are available.

Algae harvesting occurred sooner than expected and GSPI had not yet received all harvesting equipment.

GSPI harvesting techniques allow only the algae cells larger than 2 microns to be captured and the smaller size algae returned to the pond to reproduce.

In an effort to harvest as soon as possible a 1,750 rpm vane pump was used instead of a slurry pump and resulted in shearing and damaging the smaller algae cells returning to the pond, which caused a temporary pond shutdown. This is not an operational problem, it's only part of the learning curve.

The success of the Montana demonstration facility has paved the way for the next stage, which is a 100-acre production facility. At the present time GSPI is in negotiations in three states for this 100-acre facility, i.e. California, Missouri and Utah.

One of the major considerations for our next site is the ability to expand to a much larger facility of 500 to 1,000 acres.

Green Star Report on Algae Demonstration Facility Phase III

Green Star Products has successfully completed Phase III for winter environmental testing of its hybrid algae production facility in Montana.

The GSPI hybrid algae production system is designed to provide a controlled algae growing environment at an affordable capital and maintenance cost, which has eluded engineers for more than three decades.

The GSPI system endured severe Montana winter conditions, which included many nighttime temperatures below -18º Celsius (0º Fahrenheit) and snowfalls of up to 355 mm (14 inches).

The 40,000 liter demonstration facility is located outdoors and had successfully completed Phase I and II of the project in Mid-2007.

The algae demonstration project was not initially scheduled to continue into the winter months; however, the success of the first two phases of the project provided an opportunity to subject the algae hybrid system to severe Montana winter conditions to gather data never before attempted by any other research organization.

The successful testing and results of the cold weather program provided invaluable data that has increased the efficiency of the environmental control system. For example, as winter approached, a small generator (under 1 kW demand) was added to the system to provide electric power for the water pumping system. The exhaust from the generator (CO2) was fed to the algae (algae eats CO2) and the heat from the exhaust was passed into the algae water, which provides some warmth for the algae.

The production of algae was lower during this test period due to reduced daylight hours and cooler water temperatures. However, the algae not only survived, it still managed to grow. The controlled environment of the Montana hybrid system has now given GSPI the pathway to significantly improved cold weather production engineering in the next generation system scheduled to start production in the spring of 2008.

It has required a lot of high-tech ingenuity to create a low-tech, inexpensive algae production system.

Important Information Concerning Algae

Algae are one of the oldest forms of life on Earth.

Algae-to-biofuels is quickly becoming a hot item. Unfortunately, like many new technology trends nonsense prevails and uninformed investors follow the yellow brick road. However, there is reality emerging.

The truth is, that without algae, life on Earth as we know it would not exist. Almost three billion years ago our planet was a hostile place with excess N2, CO2 and toxic gases in the atmosphere until algae in the oceans began to transform CO2 through photosynthesis into oxygen (O2) making the air breathable. Then sunlight split some of the oxygen molecules to recombine into ozone (O3) and created the Ozone Layer, which protected the Earth's surface from the devastating UV rays from the sun. Therefore, without algae we would not be here today.

Today we are calling on algae again to save our planet. It is worth repeating the five major factors that favor algae. These are as follows:

1. Algae produce 100 times more oil per acre than traditional food oilseed crops (i.e. corn, soy, etc.).

2. Algae eat CO2, the major Global Warming Gas, and produce oxygen.

3. Algae require only sunshine and non-drinkable (salt or brackish) water.

4. Algae do not compete with food crops for either agricultural land or fresh water.

5. Algae can reproduce themselves and their oil every 6 hours, while it takes Mother Nature millions of years to produce crude oil in the ground.

Our civilization must learn quickly to wean itself off crude oil or it will not survive.

If you think this statement is not true then let's talk about engineering and scientific facts and not about political rhetoric. You should consider the following facts:

1. The three existing mega oil fields of the world (one in Mexico and two in Arab countries) are all exhibiting steep declines in production.

2. The oil industry finds only one new barrel of oil for every six barrels we burn.

3. The U.S. consumes 25% of all the oil produced in the world each day.

4. The United States has drilled more oil wells than the rest of the World combined yet only possesses 2% of the known oil reserves.

5. The U.N Secretary General Kofi Annan recently stated at the 2006 U.N. Climate Change Conference “Climate change is not just an environmental issue, as too many people still believe. It is an all-encompassing threat.” .

   Mr. Annan went on to say “This is not science fiction. These are plausible scenarios, based on clear and rigorous scientific modeling. A few diehard skeptics continue to deny global warming is taking place and try to sow doubt. They should be seen for what they are: out of step, out of arguments and out of time.”

The above factors present an energy picture that is not sustainable even in the short-term, and it’s getting worst each day.

Algae-to-biodiesel can really make a substantial contribution to energy independence and can provide the U.S. with more fuel than soy oil, canola oil or corn oil combined. Algae oil can provide fuel without increasing food prices and algae meal could reduce animal feed prices or possibly even general food prices.

In New Mexico alone, the U.S. Department of Energy (US DOE) estimates that there are 5 billion acre-feet of salt water under the uninhabitable desert sands, which are good for little except growing algae.

Green Star Products, along with its Consortium partners, believes it has a decisive lead in the algae-to-biofuels race because it already possesses industrial biodiesel technology and has a technology lead in the production of algae.

GSPI Signs Contract to Build Algae-to-Biodiesel Facility

Green Star has signed a contract to build a 100-acre Commercial Algae Facility.

Biotech Research, Inc. (BTR), who is a Consortium partner with GSPI, has signed the contract with GSPI to start initial preparation and material acquisition for field construction to begin in early 2008.

The 100-acre Algae Facility will be constructed adjacent to a biodiesel plant and will use the CO2 emitted from the biodiesel plant's boilers to feed a portion of the algae facility needs (CO2 mitigation), which will reduce Global Warming emissions.

The algae oil produced from the facility will be turned into biodiesel through the biodiesel plant facilities.

After an 18-year study on algae (1978 to 1995), the U.S. Department of Energy (US DOE NREL) arrived at the following conclusions:

"High oil-producing algae can be used to produce biodiesel, a chemically modified natural oil that is emerging as an exciting new option for diesel engines. At the same time, algae technology provides a means for recycling waste carbon from fossil fuel combustion. Algal biodiesel is one of the only avenues available for high-volume re-use of CO2 generated in power plants. It is a technology that marries the potential need for carbon disposal in the electric utility industry with the need for clean-burning alternatives to petroleum in the transportation sector." (Source NREL)

It further stated, "Put quite simply, microalgae are remarkable and efficient biological factories capable of taking a waste (zero-energy) form of carbon (CO2) and converting it into a high-density liquid form of energy (natural oil). This ability has been the foundation of the research program funded by the Office Fuels Development." (Source NREL)

It further stated, "In a world of ever more limited natural resources, algae technology offers the opportunity to utilize land and water resources that are, today, unsuited for any other use. Land use needs for microalgae complement, rather than compete, with other biomass-based fuel technologies." (Source NREL)

In 2006, the energy sector was not aware of the potential of algae.

Now, even the oil companies and Congress are accepting the overwhelming evidence of its potential.

GSPI and its Consortium partners have been researching algae for many years and believe they have a lead in this race as documented in the past press announcements and on our website - GreenStarUSA.com.

In conclusion, the biodiesel production and algae production business activities are very competitive. We believe that GSPI is the only company that has demonstrated a sustainable and efficient commercial-size proprietary process technology in both these arenas. In the past, other companies, many of them start-ups, have carefully reviewed any GSPI information that may be helpful to their own success. This includes project location, business contacts, profit margins, project costs, technical and process information, etc. For this reason, GSPI has limited its intellectual property and business strategy information on its public releases.

U.S. Industry Gets Serious About Cutting CO2 Emissions

Green Star Products, Inc., Algae-to-Biodiesel program has attracted companies that need less expensive CO2 sequestration. Algae growth needs only sunlight, non-potable water (salt, briny or wastewater) and CO2, which is the major global warming gas.

One tank full of gasoline in your car emits over 200 pounds of CO2 to the atmosphere.

Algae eat CO2; convert it to oil, proteins, carbohydrates and other useful products; and, emit only oxygen to our atmosphere.

Several major companies have contacted GSPI in hope of converting their stack emissions into usable products.

The present industry plan (theoretically) is to install miles of large pipes to deliver the stack emissions to a place where it will be pumped under high pressure into the earth. This plan needs a suitable deposition cavity in the earth to properly confine the CO2 in its liquid form. Either deep oil wells or other deep saline water deposits will suffice. Billions of dollars will be spent building pipelines for stack emissions transportation and compression stations to compress the gas to liquid form and pump it deep into the earth. All of this takes a lot of energy to operate and also contributes to global warming in the process.

This is like pouring money down an endless hole.

Industry is beginning to wake up to the fact that there may be another solution that can actually turn a profit from this CO2 ‘waste product’: Algae-to-biodiesel.

Algae farms are glutton eaters of CO2 gas and produce 100 times more oil per acre than traditional oil crops (such as soy oil), which can be converted to biodiesel. Algae can also produce high-grade animal feed (35-40% protein).

A 18-year algae study (1978-1995) was funded by the U.S. Department of Energy (US DOE) and administered by the National Renewable Energy Laboratory (NREL) to investigate algae as a source of fuel and its ability to consume CO2. Twelve universities participated in the research program, which studied 3,000 strains of algae. Green Star’s executives have studied this program since 1995 and has taken the time to accumulate the many conclusions distributed throughout the voluminous report. These conclusions, when read together, will impress the most negative skeptics.

The program's conclusions are as follow:

1. Consumption of coal, an abundant domestic fuel source for electricity generation, will continue to grow over the coming decades both in the U.S. and abroad.

2. Algae technology can extend the useful energy we get from coal combustion and reduce carbon emissions by recycling waste CO2 from power plants into clean-burning biodiesel. .

   When compared to the extreme measures proposed for disposing of power plant carbon emissions, algal recycling of carbon simply makes sense. .

   In a world of ever more limited natural resources, algae technology offers the opportunity to utilize land and water resources that are today unsuited for any other use. Land use needs for microalgae complement, rather than compete, with other biomass-based fuel technologies.

3. Human beings are carrying out a large-scale geophysical experiment of a kind that could not have happened in the past nor be produced in the future. Within a few centuries, we are returning to the atmosphere and the oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years.

4. The burning of fossil fuels is the major source of the current build up of atmospheric CO2. Thus, identifying alternatives to fossil fuels must be a key strategy in reducing greenhouse gas emissions. While no one single fuel can substitute for fossil fuels in all of the energy sectors, we believe that biodiesel made from algal oils is a fuel which can make a major contribution to the reduction of CO2 generated by power plants and commercial diesel engines.

5. High oil-producing algae can be used to produce biodiesel, a chemically modified natural oil that is emerging as an exciting new option for diesel engines. At the same time, algae technology provides a means for recycling waste carbon from fossil fuel combustion. Algal biodiesel is one of the only avenues available for high-volume re-use of CO2 generated in power plants. It is a technology that marries the potential need for carbon disposal in the electric utility industry with the need for clean-burning alternatives to petroleum in the transportation sector.

6. The program envisioned vast arrays of algae ponds covering acres of land analogous to traditional farming. Such large farms would be located adjacent to power plants. The bubbling of flue gas from a power plant into these ponds provides a system for recycling of waste CO2 from the burning of fossil fuels.

7. Put quite simply, microalgae are remarkable and efficient biological factories capable of taking a waste (zero-energy) form of carbon (CO2) and converting it into a high-density liquid form of energy (natural oil). This ability has been the foundation of the research program funded by the Office of Fuels Development.

8. Land, water and CO2 resources can support substantial biodiesel production and CO2 savings.

9. It is possible to sequester as much as 1,000,000,000 (one billion) tons of CO2 per year from algae farms in lands not useful for any other purpose in the Southwestern portion of the U.S. alone.

In summary, does anyone believe that the country that conquered the moon cannot raise algae?

The power and cement industries along with the Governors of several States were the first to address CO2 reductions and sequestration. They should be congratulated.

More recently two major milestones have been reached: The U.S. Congress has passed a huge energy bill and President Bush signed it into law on December 19th, 2007. This is a real Christmas present to our Country.

The bill essentially will increase the efficiency of many items, better mileage cars, efficient light bulbs and billions of dollars to produce ethanol from non-food sources (cellulose ethanol).

Secondly, at the international Kyoto Treaty (or Global Warming) summit held in Bali, Indonesia. Mrs. Paula Dobriansky, under secretary of state for democracy and global affairs leading the U.S. delegation, was under great pressure from Kyoto members to commit the U.S. to support future reductions in global warming gases. Mrs. Dobriansky said, "We will go forward and join consensus," in relation to a deal to launch two years of talks on a new global treaty to succeed the Kyoto Protocol. Kyoto delegates hailed the U.S. reversal.

Mrs. Dobriansky should be congratulated because she had the fortitude to make this decision on her own judgment.

Mr. Joseph LaStella, President of Green Star Products, has long written editorials supporting cellulosic ethanol and algae biodiesel as the only long-term answer to the U.S. fuel problems and global warming issues (see press release dated Nov. 9, 2007 titled "GSPI States: Some Biofuels Add Significant Food to Your Table" and also see press releases dated May 15 and June 28, 2006).

Mr. LaStella believes that GSPI is on the cutting edge of both these technologies through its R&D programs over the past 10 years and has waited a long time for these events to happen.

GSPI Has Acquired A License For Next Generation Algae To Biofuels Process

Green Star Products has acquired a license to utilize a breakthrough processing technology to convert algae biomass to feedstock oil and cellulose sugars for the production of biodiesel and cellulosic ethanol respectively. Efficient production of both biodiesel and ethanol can now be achieved through algae technology.

The new process uses an efficient low-cost method to extract the oil and cellulose sugars from oil-bearing microalgae that eliminates the need to mechanically dry and press-extract the algae oil using traditional methods. The sugars from carbohydrate-rich cellulose and hemicellulose can be used to make a variety of products including ethanol and other high demand chemical products. The oil can be made into biodiesel and other products.

The removal of oil from the microscopic algae has been a stumbling block for the commercial production of fuel from algae for many years.

GSPI has secured the technology license from Biotech Research, Inc. (BTR), one of GSPI's consortium partners. The process continuously strips the oil from the algae and also reduces its biomass into different carbon chain carbohydrates, proteins and other constituents. BTR's intellectual property is protected by patent pending status.

GSPI along with a handful of other high tech companies are leading the industry in algae commercialization; however, there are two major hurdles to overcome: First, an efficient, affordable construction and processing method to control the environment to promote optimum algae growth; Second, efficient harvesting and extraction of oil from the microscopic algae biomass.

The Montana facility has clearly demonstrated a solution to the first problem, i.e. an affordable method to grow algae, and now GSPI has potentially solved the second hurdle – the low-cost extraction and conversion of microalgae biomass to oil and other useful products.

Biotech Research, Inc. (BTR) operates a high tech research facility at the University of Baja California in Ensenada, Mexico (see four-minute video at GreenStarUSA.com), where a team of scientists and engineers are studying short, medium and long-term technologies for the advancement of algae production.

To limit algae research to the production of fuels is a grossly short-sighted view point. Algae have the answer to many of the global problems facing us today. Our old microalgae friends have been around for three billion years and were responsible for creating the oxygen atmosphere we now breathe. Algae

grow as much as 100 times faster than agricultural crops, so algae could potentially solve all of our food and environmental problems.

Algae can reverse our Global Warming problems; provide unlimited biodiesel and cellulosic ethanol; provide high protein food for the World's increasing population; be used as feedstock for an unlimited number of industry products and chemicals; and, the list goes on.

Biotech Research, Inc. is researching a host of algae uses. Some of these 'uses' can be a bit surprising. For instance, Solazyme, Inc., recently announced an algae joint venture with Chevron (NYSE: CVX) and a breakthrough using an algae strain that can reproduce itself without sunlight.

Biotech Research is also involved in "algae that grows in the dark"; however, it is not BTR's top priority research project for the following reasons:

1. Algae that grow without sunlight do not use the photosynthesis process; therefore, dark-growing algae need expensive food sources like sugars, vitamins, etc. to survive and reproduce. This means that it is not obtaining energy from sunlight and it is actually not consuming CO2 but producing CO2 like any other animal or burning process. CO2 mitigation is not possible with these algae strains. The need to increase photosynthetic processes for CO2 sequestration is a major reason why there is interest in algae farm development (see press release titled "Green Star States: U.S. Industry Gets Serious About Cutting CO2 Emissions" from December 20, 2007).

2. Since "grow in the dark" algae do not use the (free) energy from the sun they must get their energy from something else, mainly sugars that are poured directly into the growing algae medium. Where is all this sugar going to come from? Back to agricultural crops?

Biotech Research has the real answer: Making oil and sugars from photosynthesis grown microalgae biomass and non-food biomass that can be derived from a variety of agricultural and municipal waste streams (wood chips, corn cobs, switch-grass, etc.).

It should be understood that the success of this new process is not required for the first generation of algae production. First generation algae production can produce 4,000 gallons of oil per acre per year (versus 50 to 100 gallons for other oil crops) and later generations will produce 10,000 gallons or more per acre.

Green Star Products and Biotech Research are also researching independently, and in coordination with other technology companies, additional high tech processing systems to convert biomass algae into usable fuels and products. These products and systems include:

1. Direct pyrolysis
2. Advanced mechanical extraction
3. Separation of sugar from biomass carbohydrate chains
4. Hybrid fuels
5. Low temperature fuels
6. Enzyme extraction
7. Algae strain development
8. High efficient LED artificial light production
9. Natural algae growing enhancers

… And many other proprietary technologies.

Today, algae and non-food biomass technologies are the most likely tools to change our world on a grand scale.