GREENFUEL
TECHNOLOGIES CORPORATION

Pollute Not...Profit More

Technology

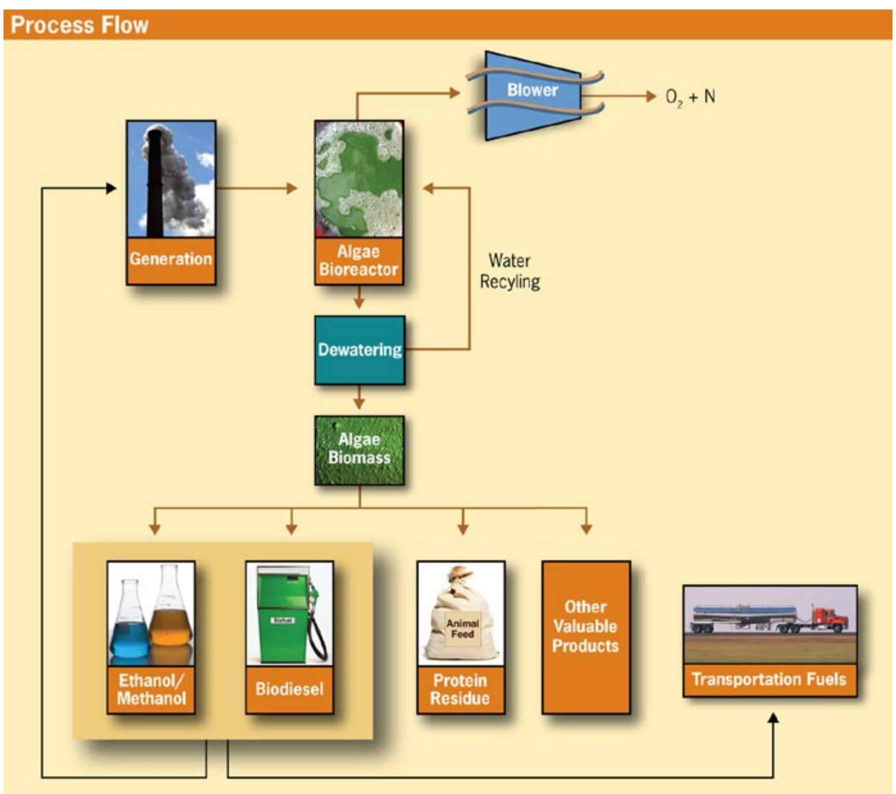
GreenFuel's patented Emissions-to-Biofuels™ (E2B™) process harnesses photosynthesis to grow algae, capture CO_2 and produce high-energy biomass. The process serves as a flexible platform for retrofitting fossil-fired power plants and other anthropogenic sources of carbon dioxide. Using commercially available technology, the algae can be economically converted to solid fuel, methane, or liquid transportation fuels such as biodiesel and ethanol.

Building On a Proven Science

Building on many years of work sponsored by the DOE and international agencies, GFT installed its first field unit on a 20 MW cogeneration facility at the Massachusetts Institute of Technology in 2004. Its second, larger unit was commissioned at a 1,060 MW combined cycle facility in 2005 in the southwest United States. The bioreactor productivities suggest annual yields of 5,000-10,000 gallons of biodiesel and a comparable amount of bioethanol per acre.

How It Works

The Emissions to Biofuels™ process is a flexible platform for converting CO_2 emissions into a range of renewable fuels. The process is designed to be retrofitted to flue stacks with minimal impact to ongoing operations. The process schematic diagram is shown in the following figure:



Flue gas or other CO_2-rich gas streams are introduced to the bioreactor, in which algae are suspended in a media with nutrients added to optimize the growth rate. A portion of the media is withdrawn continuously from the bioreactor and sent to dewatering to harvest the algae. The dewatering operation uses two stages of conventional processing. Primary dewatering increases the algae concentration by a factor of 10-30. Secondary dewatering further increases the algal solids concentration to yield a cake suitable for downstream processing. Water removed from the dewatering steps is returned to the bioreactor, with a small purge stream to prevent precipitation of salts. Make-up water is added to maintain the media volume. A blower pulls the flue gas through the bioreactor. Using an induced draft fan provides several operating advantages, including ensuring minimal disruption to power plant operations, simplifying retrofits to existing facilities.

The process steps from the flue gas inlet through end of dewatering comprise the "front end" of the GFT process. The unit operations for algal oil extraction and conversion of the dewatered algae into final fuel products is the "downstream processing" portion of the flow sheet. In contrast to the front-end unit operations, the downstream processes are conventional technologies currently practiced on a large scale, e.g. biodiesel is currently produced from vegetable oils via transesterification (several algae species have lipids, starch, and protein compositions similar to soy and canola beans). Consequently the same facilities can be adapted to produce biodiesel from algae and conventional agricultural feeds. Some downstream processing options are listed in the following table:

Downstream Processing Options

Processing Step	Final Product
Extraction and transesterification	Biodiesel
Fermentation	Ethanol
Anaerobic digestion	Methane
Gasification	Hydrogen, synthesis gas
Drying	Solid biomass

Uniqueness/Innovation

GreenFuel is unique in its ability to mitigate CO_2 emissions profitably through producing renewable energy in the form of biofuels. Concomitantly, the GreenFuel process is able to produce algae growth rates consistently higher than those ever achieved before. This is achieved with low construction, parasitic and operational costs. In addition, GreenFuel's system does not impact the operations of the power plant.

Comparison With Alternatives

Currently there are few economically attractive options for reducing GHG emissions. While fuel switching, advanced power generation systems and conservation are important, many utilities are investigating CO_2 capture and sequestration. This option has the benefit of producing high-purity CO_2, which can be used for enhanced oil recovery in some markets. However, the process has a high cost and significantly derates as a result of the high parasitic power and extraction steam requirements. Further, the market for CO_2 for EOR is geographically limited. Non-EOR sequestration raises serious technical and legal issues, as well as requiring significant investment in pipelines, compressors, injection wells, and monitoring equipment.

In contrast, the GreenFuel process has a low parasitic power requirement, and does not require extraction steam, although it can beneficially use waste heat from the power plant. The proposed GreenFuel system harnesses solar energy through photosynthesis to generate bioenergy from CO_2. The result is a net gain in value added products from the site in the form of clean products such as biodiesel and ethanol. Because these products have a high market value, their revenues allow the system to operate profitably on a stand-alone basis. Unlike CO_2 for EOR or sequestration, there are no limitations on the markets for biofuels, and no additional infrastructure requirements to integrate them into the existing transportation markets.

The electricity derived from using the fuels generated by GreenFuel systems can be applied towards meeting a utility's renewable energy portfolio requirements. And unlike other solar energy sources the energy generated by GreenFuel system fuels can be dispatched when it has the most value to a utility.