Renewable Biofuels from Microalgae

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Introduction

From 1978 to 1996, the U.S. Department of Energy's Office of Fuels Development funded a program to develop renewable transportation fuels from algae. The main focus of the program, known as the Aquatic Species Program (or ASP)[2] was the production of biodiesel from high lipid-content algae grown in ponds, utilizing waste CO2 from coal fired power plants. Over the almost two decades of this program, tremendous advances were made in the science of manipulating the metabolism of algae and the engineering of microalgae algae production systems.

Algae Research & Development at *SECURA*

Using the information derived from the years of research under the ASP and through the cooperation of equipment manufacturers through SECURA's network of Biotechnology Systems suppliers , a facility to undertake the productivity of local microalgae strains was established in the existing R&D facility of Secura International Corp. in Bgy. Tagpako, Gingoog City, Misamis Oriental. The main objective is to determine the productivity rate of local microalgae strains. Initial results from the pilot plant size of 4 cubic meters photobioreactors showed very encouraging data.

The process and engineering design for a small scale commercial production , 32 ponds of 16 cubic meters each are now in operation at Bgy. Tagpako , Gingoog City, Misamis Oriental.

Biofixation of CO2 by Microalgae

The Philippines lead the world in Marine Biodiversity placing in our hands the vast resources ready to be tapped for our own use. Microalgae are single cell plants, they needed sunlight and CO2 for photosynthesis, just like a tree does. In this process they produce carbohydrate, proteins and lipids (oil).The oil makes their bodies

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[1] Member, Board of Directors, Biotech Coalition of the Philippines, BCP (www.bcp.org.ph)
[2] NREL/TP-580-24190;"A look Back at US Department of Energy's Aquatic Species Program-Biodiesel from Algae" July 1998,J.Sheehan,T.Dunahay,J.Benemann,P.Roessler, National Renewable Energy Laboratory,1617 Cole Blvd., Golden,Colorado 80401-3393

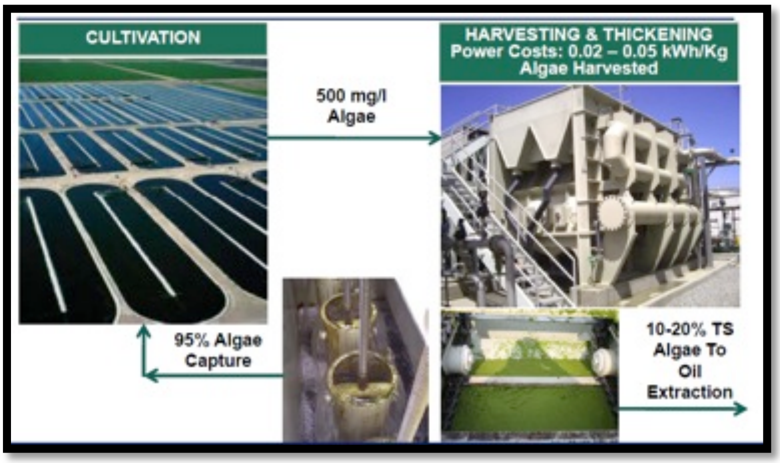
float in the water in order to get maximum sunlight. Providing these single cell plants an environment where they get abundant nutrients, they will proliferate massively and will continuously provides us all the biomass we need to generate power. By selecting the microalgae strain that produces more oil per biomass weight, then we have a rich renewable source of biofuel feedstock. Such microalgae strain are growing even in our own backyard , and with nutrients coming from a run-off irrigation , sunlight and CO2 in the air they can colonize any body of water including lakes and dams.

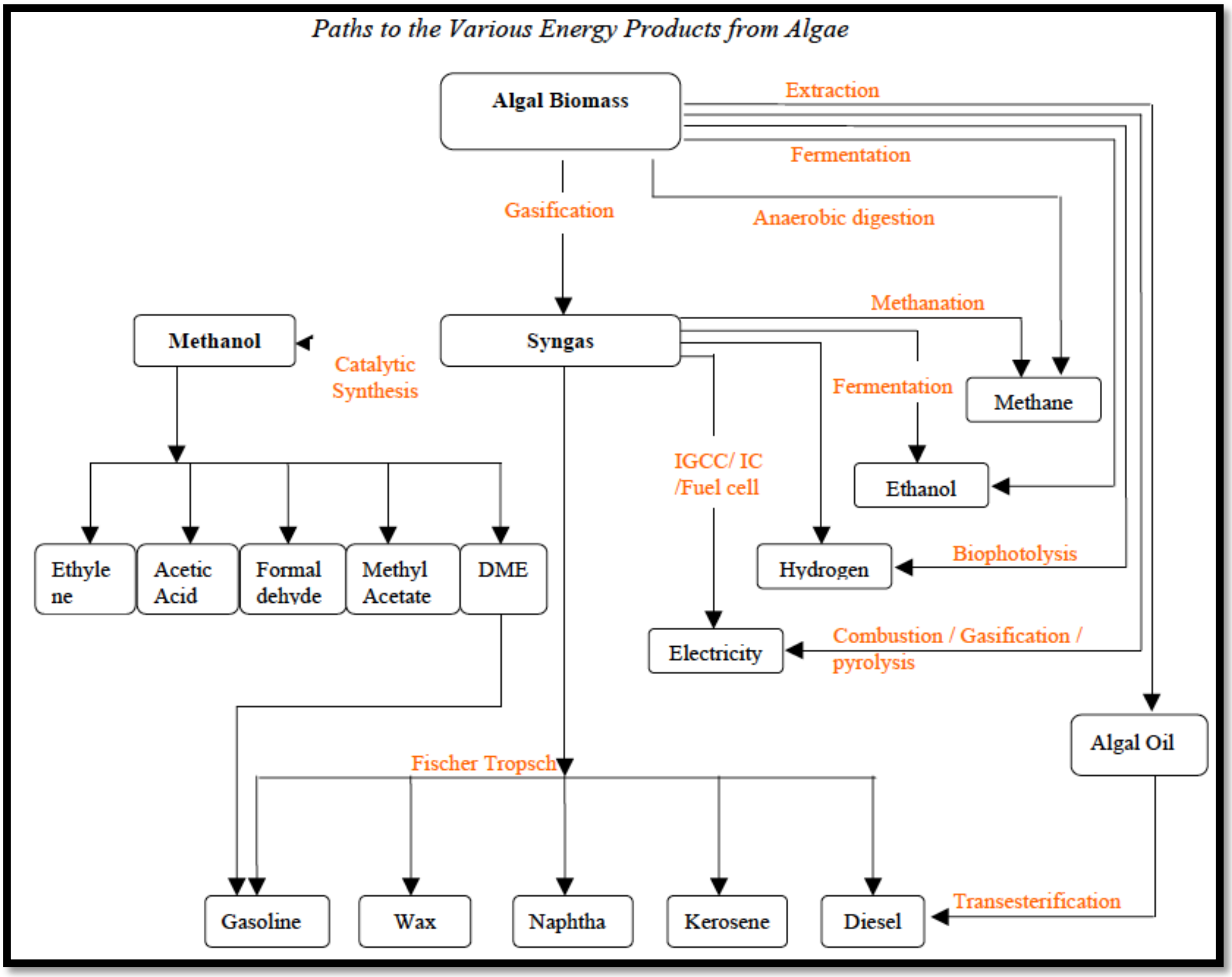
UN-IPCC recommends a formula to estimate the CO2 production of clinker production as, 0.507 tons CO2 per ton clinker. The estimated heating value of this Algae biomass is 49 MJ/kg as compared to Bunker C (Fuel Oil#6) heating value is 40.573MJ/kg,the following table shows estimated yield assuming 100% utilization of emitted CO2 from clinker production.

CO2 sources	gram-CO2
Coal Power Plant	915 gm-CO2/KWHr
Cement Mfg. Plant	507 gm-CO2/kg-clinker
Bunker C Power Plant	760 gm-CO2/KWHr
Natural Gas Power Plant	315 gm-CO2/KWHr
Geothermal Power Plant	55 gm-CO2/KWHr
Bioethanol Mfg. Plant	760 gm-CO2/liter ethanol

Algae Biomass Production and Harvesting Methods

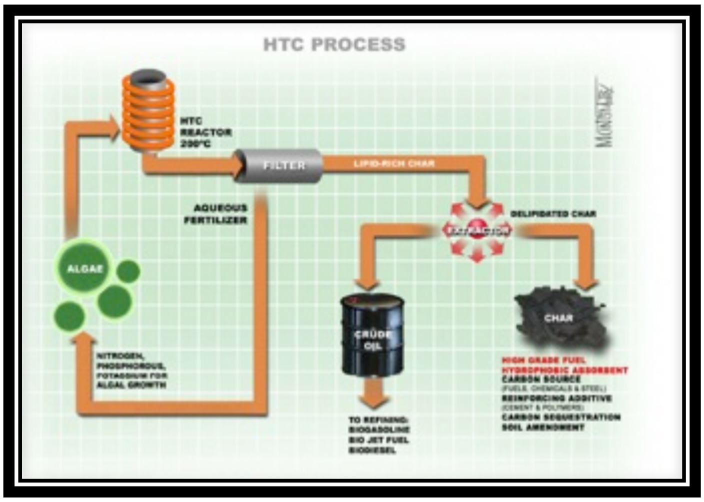
Our Algae strain improvement laboratory allows us to tailor-fit every application. The algae biomass yield is boosted by dissolving CO2 in the algae pond and optimizing the maximum vertical circulation rate of each microalgae cell capturing photons from the sunlight maximizing its growth. A ton of algae biomass sequesters 1.8 metric tons of CO2 dissolved in water. A hectare of algae pond lined with white HDPE liners with a water depth of one (1) meter will produce from 511 metric tons biocoal and 475,000 liters of synthetic diesel up to 1,533 metric tons of biocoal and 1,426,000 liters of synthetic diesel per year when artificial lights from light emitting diodes will be used. Harvesting will be done by an advance Dissolved Air Flotation(DAF) system and a microfiltration based concentration step using vibratory shear enhanced processing (VSEP®) patented technology.





Conversion of Algae Biomass to Biocoal by Hydrothermal Carbonization(HTC)

The carbonization of biomass residuals to char has strong potential to become an environmentally sound conversion process for the production of a wide variety of products. In addition to its traditional use for the production of charcoal and other energy vectors, pyrolysis can produce products for environmental, catalytic, electronic and agricultural applications. As an alternative to dry pyrolysis, the wet pyrolysis process, also known as hydrothermal carbonization, opens up the field of potential feedstocks for char production to a range of nontraditional renewable and plentiful wet agricultural residues and municipal wastes. Its chemistry offers huge potential to influence product characteristics on demand, and produce designer carbon materials. Future uses of these hydrochars (biocoal) may range from innovative materials to soil amelioration, nutrient conservation via intelligent waste stream management and the increase of carbon stock in degraded soils. In Algae biomass conversion to biocoal, the by-products are algae oil , filtrate and CO2 gas. The



algae biocoal has a heating value of more than 13,577 Btu/lb, similar to anthracite coal heating value.

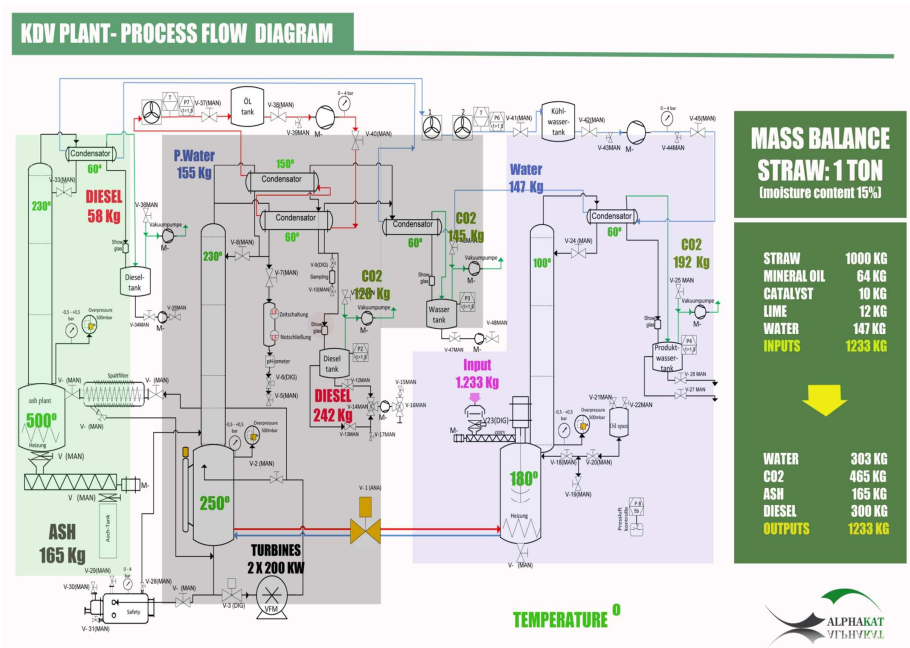
Conversion of Algae Oil or Algae Biomass to Synthetic Diesel by Catalytic Depolymerization[3]

The origin of our technology, 'Catalytic P D (Katalytische Drucklose Veroelung in German or, "KDV"), traces back hundreds of millions of years. KDV technology mimics nature's own method of converting organic matter into crude oil.

It took the earth's oceans billion years with low temperatures of about 20°C and very low concentrations of aluminium-based catalysts convert dead biomass into crude oil. On the other hand, the KDV with, its average 280°C process temperature, a 20% concentration of a highly active, fully crystallized aluminium silicate-based catalyst and increased motion generated by the facilities' turbines, achieves the same result in just 3 minutes.

The most attractive feature of the KDV process is the fact that it does not require vegetable oil or other feedstocks, which could otherwise be consumed as food, but instead utilizes waste materials or biomass, like the husks or straw of wheat, barley and rice plants, press cake from vegetable oil production, wood chips, saw dust, sugarcane bagasse, Napier grass, water lilies, coconut husks, EFB, Jatropha, Coconut Husks or coconut fronds, algae biomass , waste water treatment sludge and other otherwise unusable plant matter.

This versatility, which no other technology can offer, means that it is a simple matter to secure stable high-volume feedstock supply in almost any given region, and in close proximity to the plants—and this allows for an ideal balancing of machine capacity and the seasonal fluctuation of particular feedstocks.



While the KDV process can convert virtually any kind of biomass or fossil hydrocarbons, it is often necessary to adjust the procedure and the feedstock mix to achieve the optimal output of ultra-low sulphur diesel ULSD.

[3] www.alphakat.de

The core process of the KDVsystem, generating energy by the action of a turbine and the process of pressure-less depolymerization is, patented and proprietary to this technology.

The patented KDV turbine, on the other hand, generates energy by thermodynamic means inside the fluid medium by virtue of minuscule temperature differences. No carbon build-up occurs. The process is extremely energy efficient, and generates no toxic substances such as dioxin and furans.

One of the strongest advantages of the KDV technology is its extremely low impact on the environment.

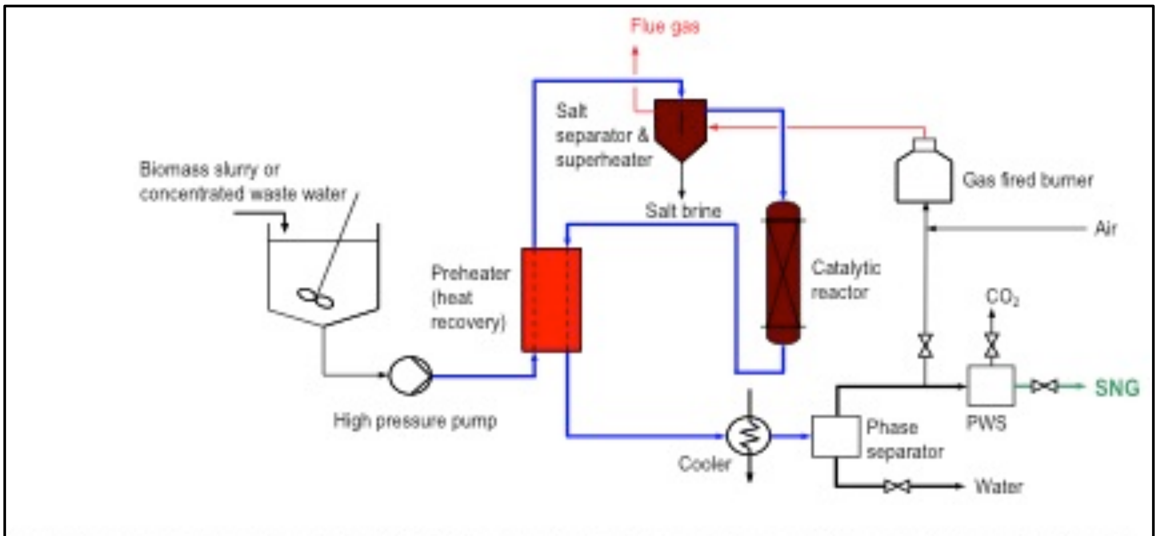
Depolymerization occurs in a closed loop at the molecular level and at low temperatures (270 – 300°C, 520 – 600°F) and is virtually pressure-free (the plant even works with a slight 0.1 bar negative pressure).

- It generates no toxic emissions—notably, no dioxins and no furans.
- It has an efficiency of over 80%.
- Besides diesel fuel, distilled water and a small quantity of ashes (salts) is the only solid and fluid refuse generated.
- Other by-products are suitable for use by chemical manufacturers as raw material and so are an additional potential source of income.
- The residue volume is negligible, and its disposal does not pose an environmental problem.
- The facility is a self-sustaining energy production platform, independent of the public grid. Only about 10% of the clean diesel the KDV generates is required to run the unit via co-generation. Of course, energy input from outside or from the public grid is also viable if preferred.

Conversion of Algae Biomass to Synthetic Natural Gas (RNG) by Catalytic High Pressure Gasification.

Technology

- Catalytic high pressure gasification and methanation in an aqueous (hydrothermal) phase at approx. 300 bar and 400°C.
- On-line separation of nutrient salts by a proprietary process design.
- High thermal process efficiency (biomass to methane) of 60-70%.
- Methane can be obtained directly at a high pressure (up to ca. 280 bar).
- Prerequisites: the feed must be pumpable and it must contain a minimum of 10 wt% of organics.

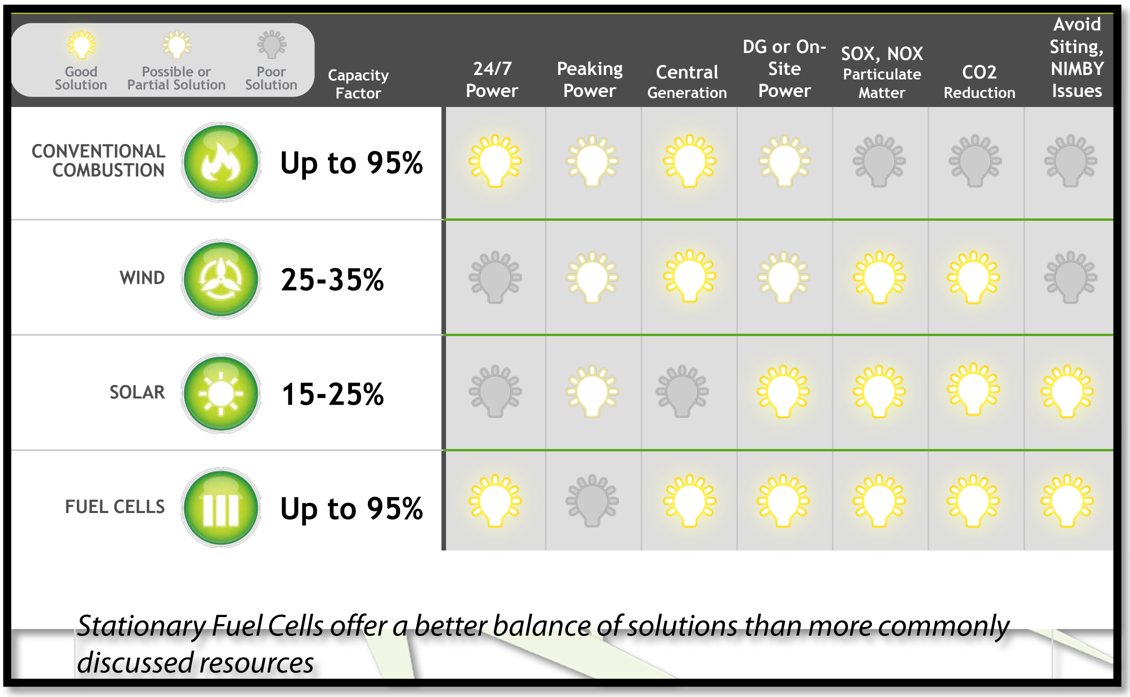


Simplified process schematic (PWS: pressurized water scrubbing, SNG: synthetic natural gas)

Power Generation

The products coming out from the Algae Biomass plants are biocoal (anthracite coal quality),synthetic natural gas and synthetic diesel can be used as a renewable biofuel feedstock for Power Generation. The fuel demand of a combine biocoal fueled power plant and diesel fired "peaking" power plant can be supplied by the Algae biomass.The CO2 gas present in the Power Plant Exhaust after will be collected via a flue gas purification system will enable the CO2 gas to be used in the algae ponds.

The SNG can be used to provide renewable biofuel for Gas fired Power plants or to a base-load Fuel Cell Power Plant.



Clean Development Mechanism (CDM)

Microalgae sequestration of CO2 from exhaust gas of Power plants is qualified as a CDM project. The use of biocoal and synthetic diesel by the Power plant will also qualify as a CDM project.

The **Clean Development Mechanism** (CDM) is one of the "flexibility" mechanisms defined in the Kyoto Protocol (IPCC, 2007).[4]It is defined in Article 12 of the Protocol, and is intended to meet two objectives: (1) to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), which is to prevent dangerous climate change; and (2) to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments (greenhouse gas (GHG) emission caps). "Annex I" parties are those countries that are listed in Annex I of the treaty, and are the industrialized countries. Non-Annex I parties are developing countries. Objective (2) is achieved by allowing the Annex I countries to meet part of their caps using "Certified Emission Reductions" from CDM emission reduction projects in developing countries (Carbon Trust, 2009, p. 14).[5] This is subject to oversight to ensure that these emission reductions are real and "additional." The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC).

The CDM allows industrialized countries to invest in emission reductions wherever it is cheapest globally (Grubb, 2003, p. 159).[6] Between 2001, which was the first year CDM projects could be registered and by 2012, the end of the Kyoto commitment period, the CDM is expected to produce some 1.5 billion tons of carbon dioxide equivalent (CO_2e) in emission reductions.[7] Most of these reductions are through renewable energy, energy efficiency, and fuel switching (World Bank, 2010, p. 262). However, a number of weaknesses of the CDM have been identified (World Bank, 2010, p. 265-267). Several of these issues are addressed by a new modality, the Program of Activities (PoA) that moves away from accrediting single projects but bundles all projects of one type of activity and accredits them together.

OFFTAKERS

[4] IPCC (2007)"Glossary J-P. In (book section);Annex 1 In: Climate Change 2007;Mreport if the governmental Panel on Climate Change (B.Metz et al.) Cambridge University Press, Cambridge,U.K. and New York,N.Y. USA.
[5] Carbon Trust (March 2009) "Global Carbon Mechanisms:Emerging Lessons and implications (CTC748).Carbon Trust website.
[6] Grubb,M. (July-September 2003) "The Economics of the Kyoto Protocol" World Economics 4 (3): 143-189
[7] World Bank (2010) "World Development Report 2010:Development and Climate Change" The International Bank of Reconstruction and Development/The World Bank,1818 H Street NW,Washington DC 20433.

We have identified funders for these projects and we are looking for serious Offtakers that will purchase the products we will produce from your CO2 gas wastes.

For more details please contact the undersigned.

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