



Strategies for Utilizing Whole Algae Biomass



Fourth Algae World Asia
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A BREAKTHROUGH TECHNOLOGY TO EXTRACT OIL FROM ALGAE

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Algae – Its Strategic Use

- q Ancient History
 - q Algae compressed & fossilized into petroleum.
 - q Nature processed the whole biomass – did not separate the oils.
- q Today's Strategy
 - q Lipids and biomass are being separated.
 - q But are they utilized most efficiently?
 - q Algae success is dependent on that efficiency.
 - q What is the most efficient modality?
- q Tomorrow's Strategy
 - q Use whole biomass to create most cost-effective products.
 - q Use extracted oil for high-value products.
 - q Strategy must encompass the full spectrum of Biofuels — Biochemicals — Bionutrients — Food.

Algae – The New Trend

- q Algae Production for End Products Really Divides Into:
 - q Energy products and biochemicals.
 - q Bionutrients and food grade feedstocks.
- q Energy Products and Biochemicals
 - q Require the whole biomass production to be most efficient.
 - q Oil and biomass do not need to be separated.
 - q Multiple downstream processes can handle the whole biomass.
- q Bionutrients and Food Grade Feedstocks
 - q Require that lipids are separated from the biomass and free of chemicals.
 - q The lipids can then be processed into valuable fractions.

**End Uses Determine Feedstock
Requirements**

Dark-Cycle Production for Food-Grade Algae



q Benefits

- q Well proven technology by companies like: Martek & Solazyme.
- q Perfect for nutritional uses:
 - § Nutraceuticals — Pharmaceuticals — Animal Feed — Food — Fertilizer
- q High purity of dark-cycle algae – can even be organic!
- q Solazyme is shooting for \$60-80 production cost Barrel Oil Equivalent (BOE).

q Limitations

- q Sustainability issues:
 - § Land & fresh water use to grow sugar or starches.
 - § Reprocess sugar for algae – duplicate processing.
 - § Then use algae to produce fuel (using a fuel to make a fuel!)
- q None of the CO2 or waste abatement benefits.

**Promising for Food Grade Products
but not Fuel and Chemicals.**

Photosynthetic Algae for Fuel & Chemicals



q Benefits

- q High growth source of biomass for fuel.
- q Higher energy content than other biofuels (up to 100 times greater than corn).
- q Does not compete for farm land for food production.
- q Can use waste water, salt water, brackish water or fresh water.
- q Captures CO₂ and recycles carbon for fuels and co-products.
- q Contaminant removal from waste water streams.
- q Extraction of lipids not required.

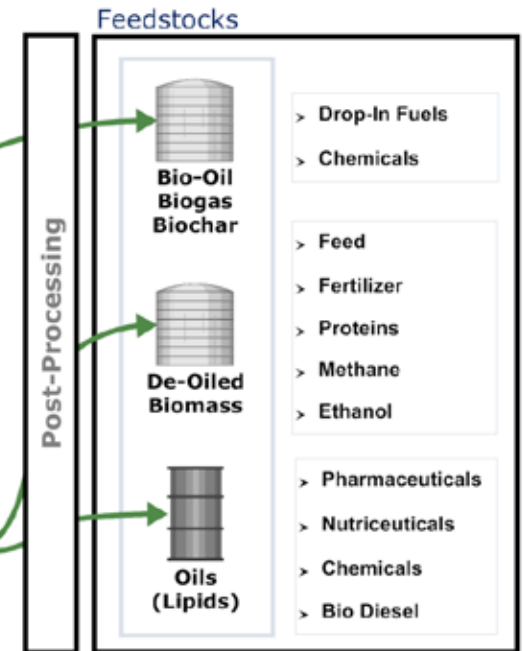
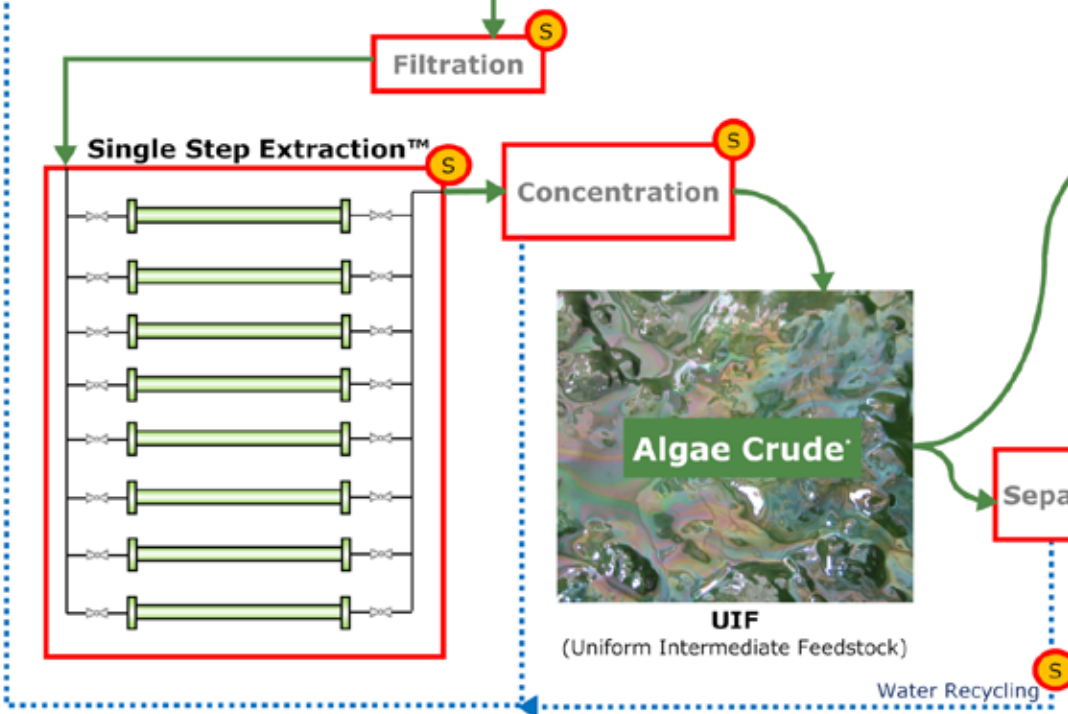
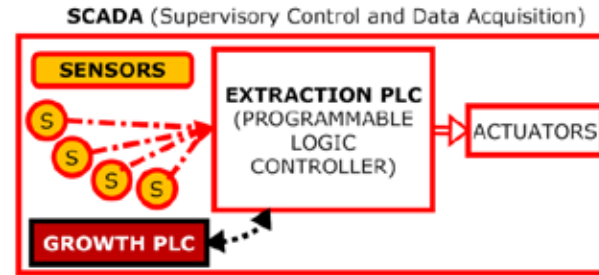
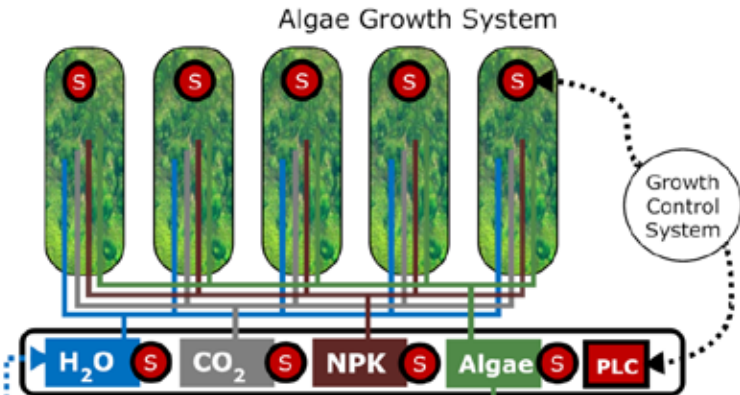
q Limitations

- q Not a good source of nutritional feedstocks.
- q Using capturing waste products = no food use.

q Can photosynthetic algae produce food grade products?

Yes, but strict growth controls required, and no waste inputs possible.

OriginOil Supervised System: _____



Photosynthetic Algae for Fuel

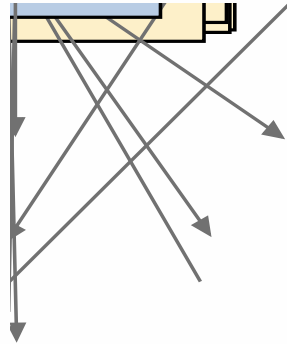
- q Lipid Extraction For Fuel (biodiesel)? Likely not economical.
 - q Cost of separation is very high.
 - q Algae lipids are high in polyunsaturated fats
 - q Must be made into esters adding to the cost
 - q Then still must be blended.
 - q Other uses for lipids are more valuable (Omega3s, etc.).
 - q Biodiesel is not a drop-in fuel.
- q Most efficient fuel output? Whole biomass.
 - q Algae separation not required.
 - q All of the BTU value of algae is preserved.
 - q Standard refining processes supported.

**Whole Biomass Processing Compares
Closely to Petroleum Processing.**

Photosynthetic Algae for Fuel

- q The Strategic Goal is Drop-In Fuels
 - q Utilizes the existing fuel and chemical infrastructure.
 - q Requires a petroleum-equivalent BIOCRUDE.
- q BioCrude - The Best and Most Efficient Route
 - q Flocculate the biomass – “cracking” the cells improves processing.
 - q Dewater to a pumpable slurry – 10% solids.
 - q Delivers a Uniform Intermediate Feedstock – a precursor to Bio-oil.
 - q Pyrolize/Hydrotreat for Bio-oil.
 - q De-oxygenate for refinable BioCrude feedstock.
 - q Normal petroleum refinery processes.
 - q Create the “Products of Petroleum”
 - ...Including many high value products such as bioplastics.
- q Uniform Intermediate Feedstock > Bio-Oil > BioCrude

Products of Petroleum



A BREAKTHROUGH TECHNOLOGY TO EXTRACT OIL FROM ALGAE

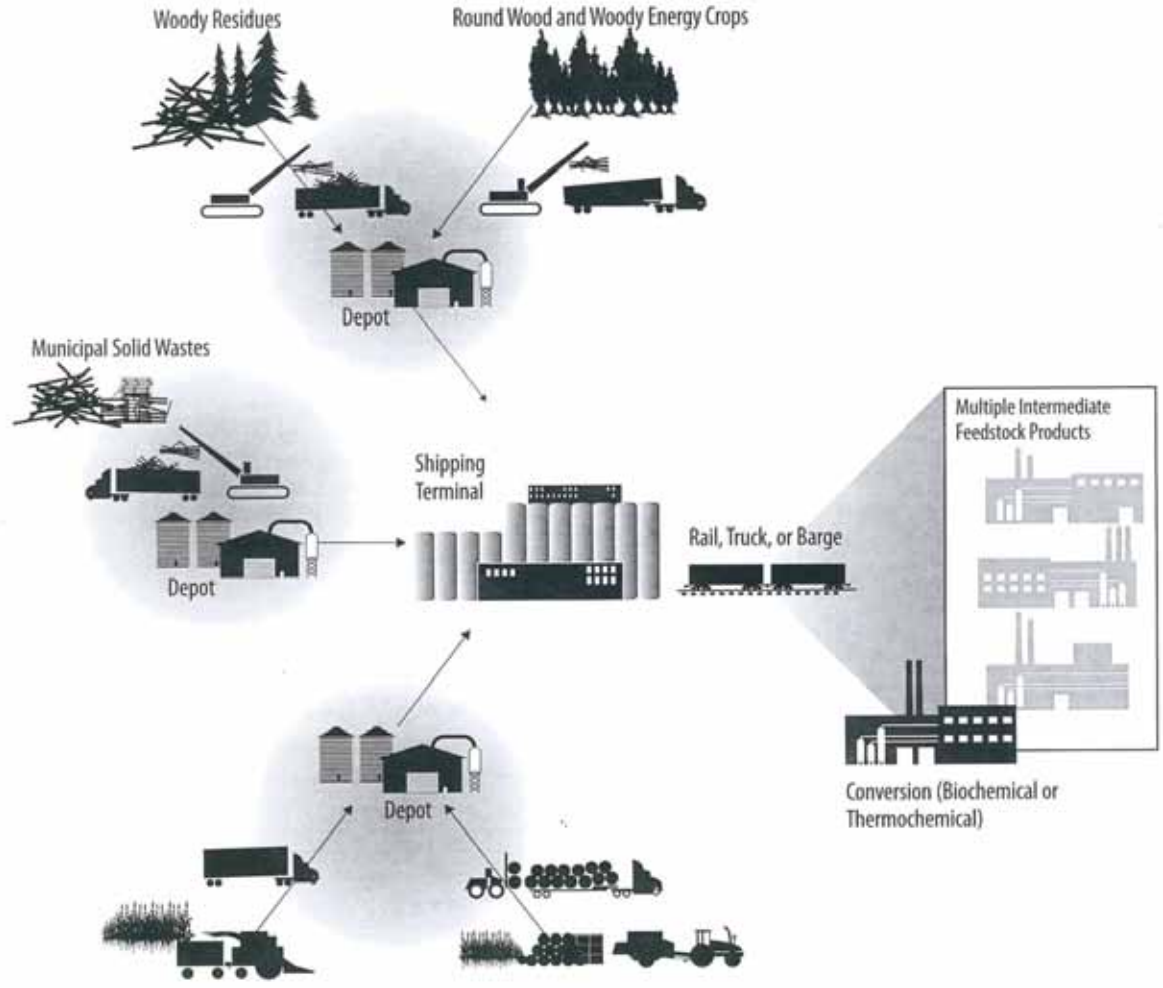
Uniform-Format Feedstock System

Part of DOE's Biomass Program



- q Specifications are necessary for biomass – just as for petroleum products.
- q High DOE priority on developing standard specifications.
- q Uniform Intermediate Feedstock (UIF) is integrated into DOE's Uniform-Format Solid Feedstock Supply System which blends all types of biomass.
- q Algae UIF, with highest BTU value, is “glue” for other Uniform-Format Feedstock.
- q UIF standard enables upstream producers & downstream processors the ability to standardize.
 - q Results in efficiencies in the supply chain.
 - q More secure investment environment for project development.
 - q Faster industry growth.

DOE's Uniform-Format Feedstock



A BREAKTHROUGH TECHNOLOGY TO EXTRACT OIL FROM ALGAE

The Most Effective Way To Create Bio-Oil?



- q Use Single Step Extraction System™, with integrated Concentration
- q Benefits:
 - q No initial dewatering required.
 - q Extremely low energy usage.
 - q No chemicals.
 - q Tunable to a wide range of feedstock.
 - q Small footprint.
 - q Easy installation.
 - q Applicable to all growth platforms.
 - q Fast throughput – highly scalable.
 - q Greatly-reduced Capital Expenditure.
- q Concentration options: Dissolved Air Flotation (DAF), Centrifugation, etc.
- q Product: Uniform Intermediate Feedstock (UIF).

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Algae Appliance™ – A Need Fulfilled



- q OriginOil now building systems to serve one full hectare of production.
This scale is still extremely rare in the algae industry!
- q Next step: create an entry-level system for the algae industry.
- q Announcing the new Algae Appliance, available soon for field testing by select reference accounts.
 - q Standardized starter system so producers, researchers and equipment suppliers can start working with next-generation harvesting technology.
 - q This standardized system is based on the successful research scale system in operation since 2010 at MBD Energy's James Cook University research site.
- q Field test partners benefit from a substantial discount, asked to help OriginOil refine the Appliance.

Algae Appliance Features

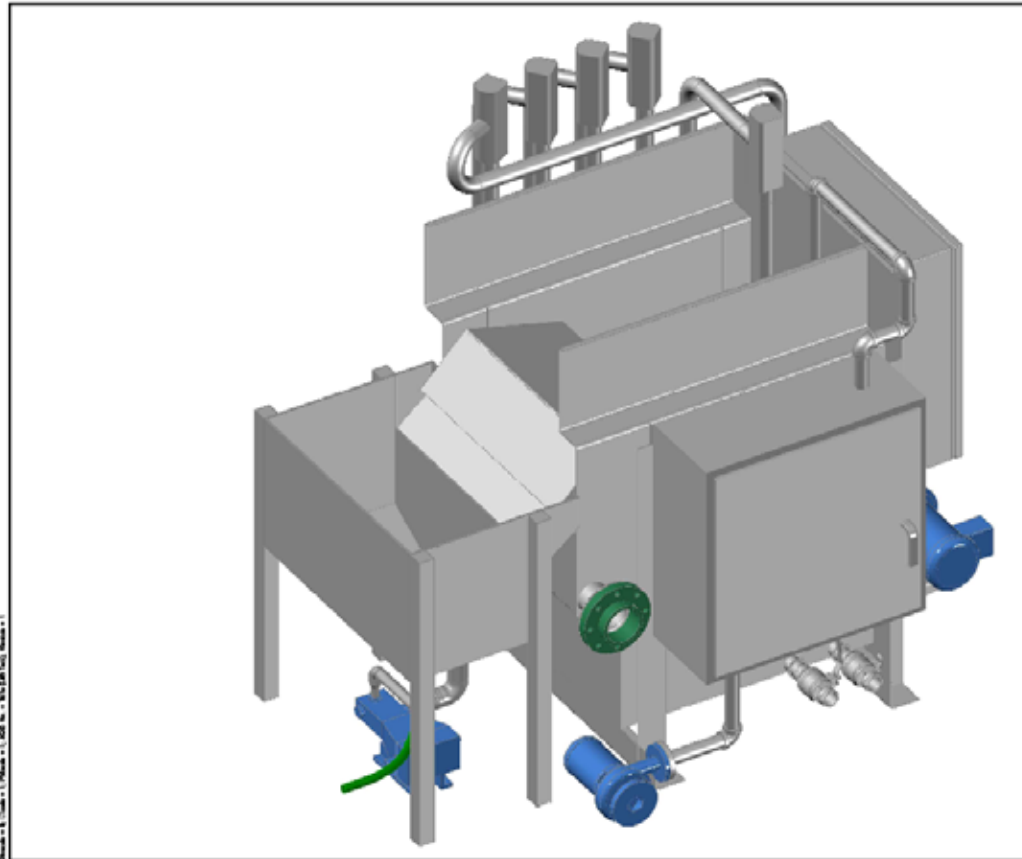


- q Flexible Flow Rates:
 - q Minimum: 2 LPM (0.5 GPM) – processing 3000 liters per day in continuous harvest.
 - q Maximum: 20 LPM (5 GPM) – processing 30000 liters per day in continuous harvest.
- q Wide flexibility of microalgae concentration
 - q From 125mg to 1g/liter dry weight – and beyond.
- q Three-phase Operation:
 - q First phase: low-energy, chemical-free flocculation.
 - q Second phase: concentration to remove up to 90 of the water*, which is recycled.
 - q Third phase: cell wall compromise (“cracking”) for downstream availability.
 - q Optional devices available for greater concentration.
- q Sensor telemetry with touch screen software for real-time control.
- q Remote support by OriginOil technicians (requires support contract).

* Concentration is done using a built-in Dissolved Air Flotation (DAF) unit.

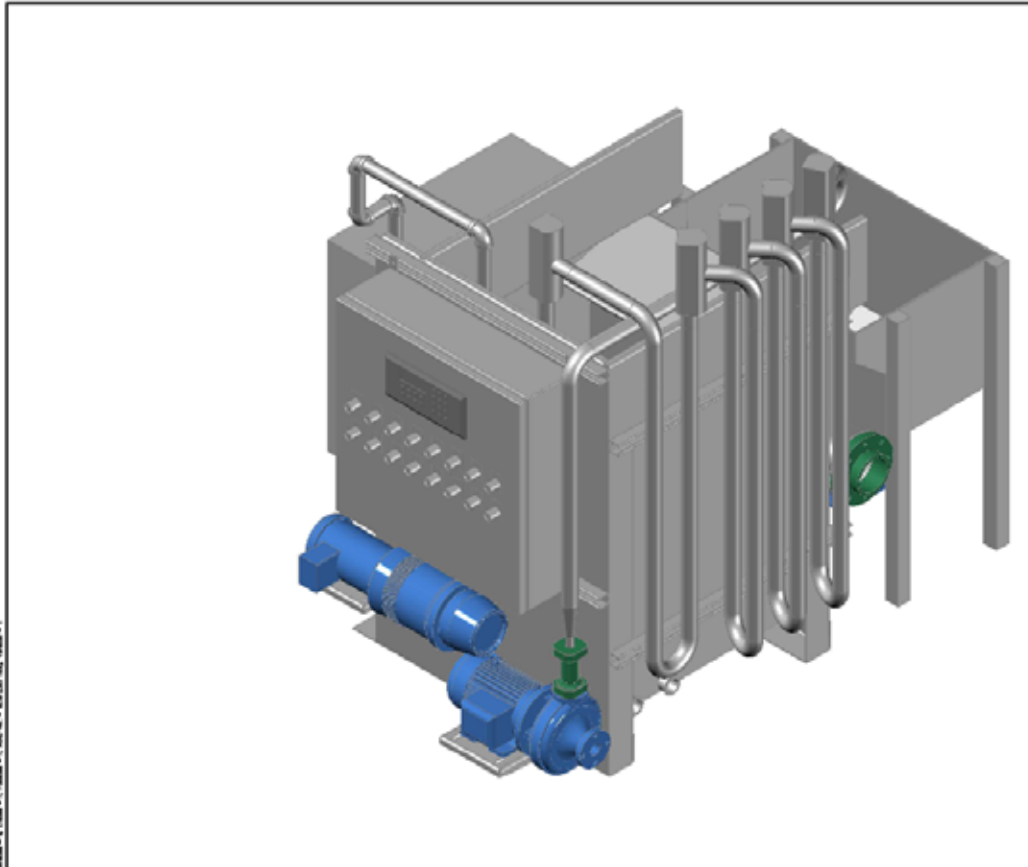
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Algae Appliance Front View



A BREAKTHROUGH TECHNOLOGY TO EXTRACT OIL FROM ALGAE

Algae Appliance Rear View



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Algae Appliance Summary



- q What does the Algae Appliance Accomplish?
 - q Entry-level harvester for early process development efforts.
 - q Dewateres 2 to 20 liters/minute of algae slurry.
 - q Concentrates biomass by removing 90 to 95% of the water.
 - q Very low energy footprint – 0.002 kwh at 10 LPM (estimated).
 - q Uses no toxic chemicals.
 - q Compatible with OriginOil's pre-harvest growth treatments.
 - q Achieves a UIF (Uniform Intermediate Feedstock) – a precursor to Bio-oil.
- q Proven Technology
 - q Research system operating successfully up to 60 liters/minute at MBD Energy's JCU site.
 - q OriginOil has shipped its first commercial 40 liters/minute mobile system to MBD.
 - q OriginOil is building a 1200 liter/minute system for MBD.

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Typical 4-Stage Process to Scale



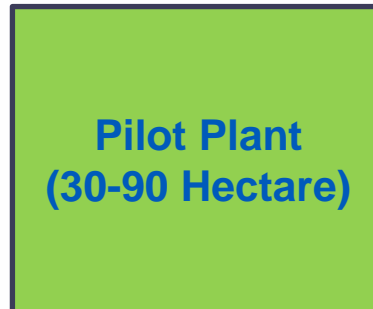
**JCU Research Facility
(5,000 m²)**



**Tarong Energy Display Plant
(1-Hectare)**



**Pilot Plant
(30-90 Hectare)**



**Demonstration Plant
(500-Hectare +)**



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Summary



- q End use of the algae biomass determines feedstock configuration.
- q Use extracted oil for high-value products – Dark cycle most promising.
- q Use whole biomass for fuel and biochemicals – full Separation not required.
- q Single Step Extraction System achieves UIF, a precursor to Bio-oil.
- q Whole Biomass Post-Processing Compares Closely to Petroleum Processing.
- q DOE's Uniform Format blends multiple feedstocks – algae can be energy booster.
- q The Algae Appliance is an entry-level harvester for early process development efforts.
- q Limited field testing partners invited now.

**Visit www.algaeappliance.com to
Request your Algae Appliance!**



Bill Charneski
Senior Director of Product Engineering

Thank you for your interest.
Do you have any questions?

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