



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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A BREAKTHROUGH TECHNOLOGY TO EXTRACT OIL FROM ALGAE

Algae – Its Strategic Use

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

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Algae – The New Trend

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

**End Uses Determine Feedstock
Requirements**

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Dark-Cycle Production for Food-Grade Algae



❑ Benefits

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

❑ Limitations

- ❑ 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!)
- ❑ None of the CO2 or waste abatement benefits.

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

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Photosynthetic Algae for Fuel & Chemicals



☐ Benefits

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

☐ Limitations

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

☐ Can photosynthetic algae produce food grade products?

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

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Photosynthetic Algae for Fuel

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

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

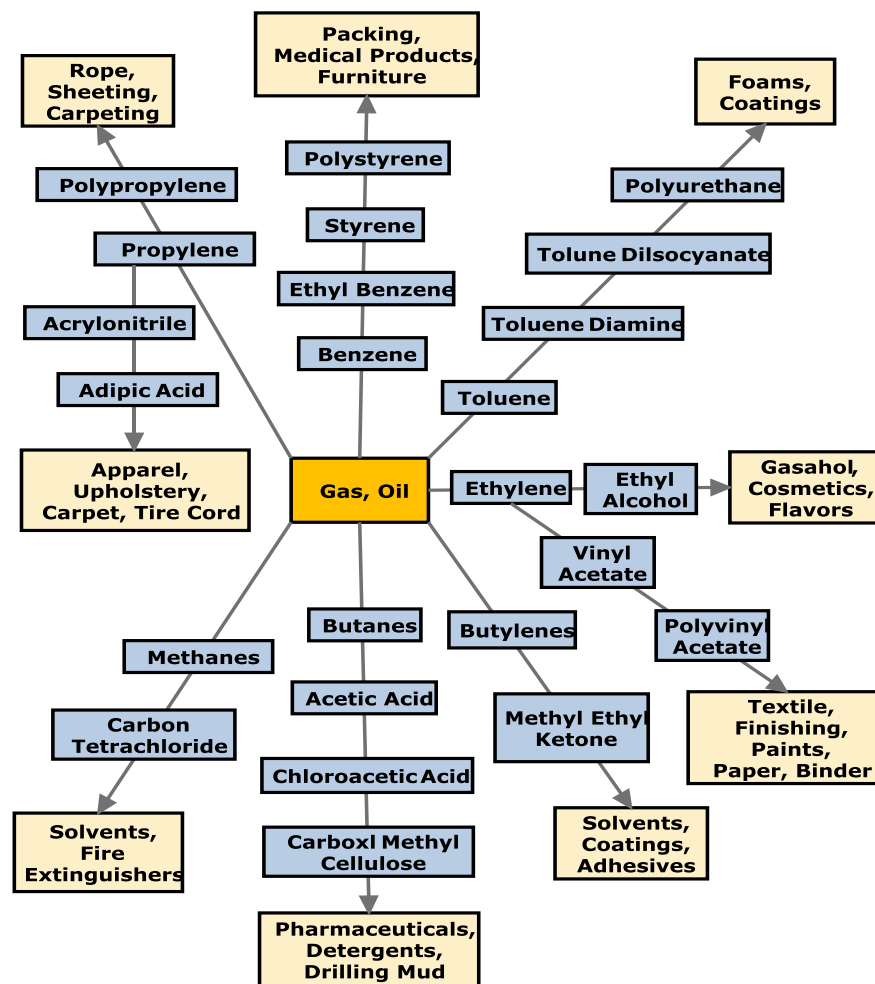
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Photosynthetic Algae for Fuel

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

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Products of Petroleum



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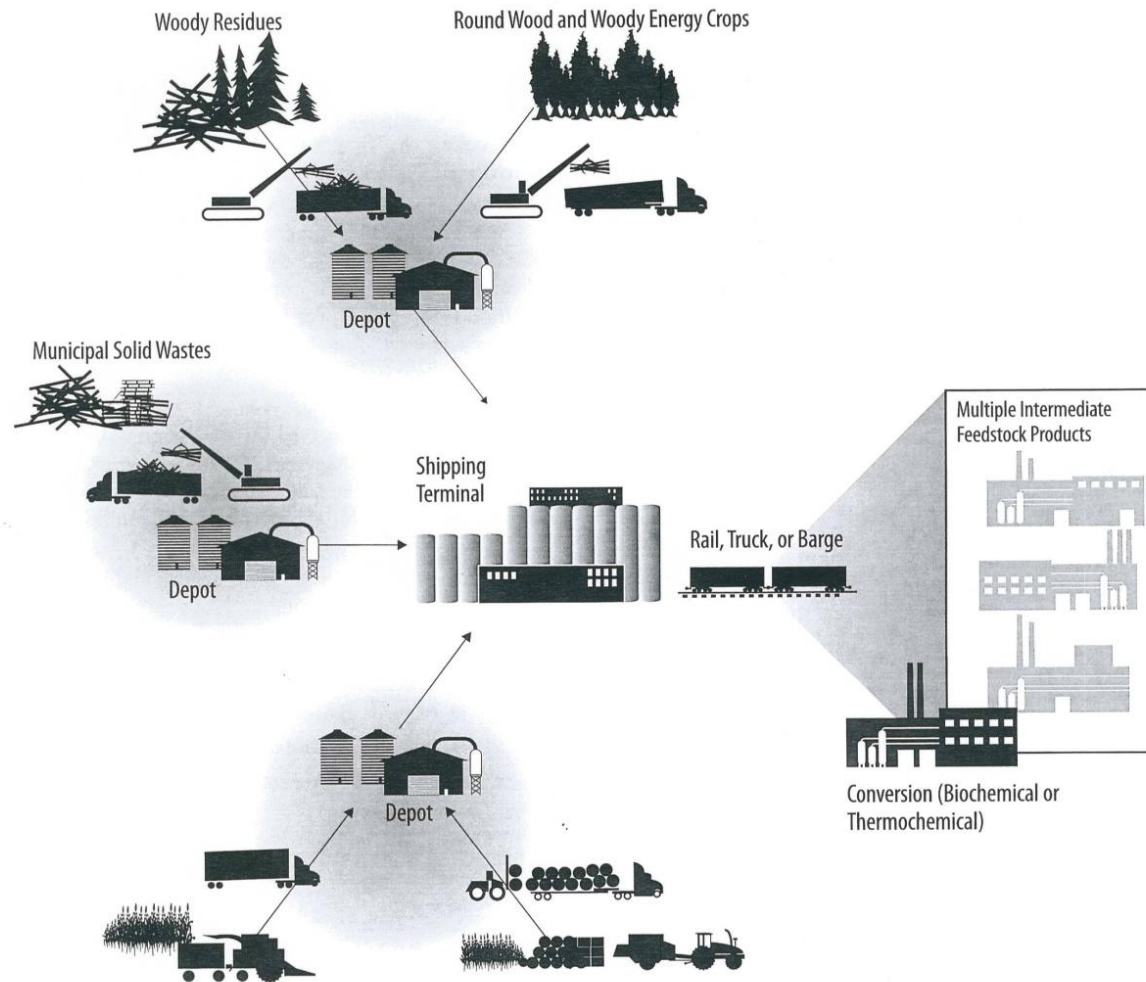
Uniform-Format Feedstock System Part of DOE's Biomass Program



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

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DOE's Uniform-Format Feedstock



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The Most Effective Way To Create Bio-Oil?



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

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Algae Appliance™ – A Need Fulfilled



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

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Algae Appliance Features

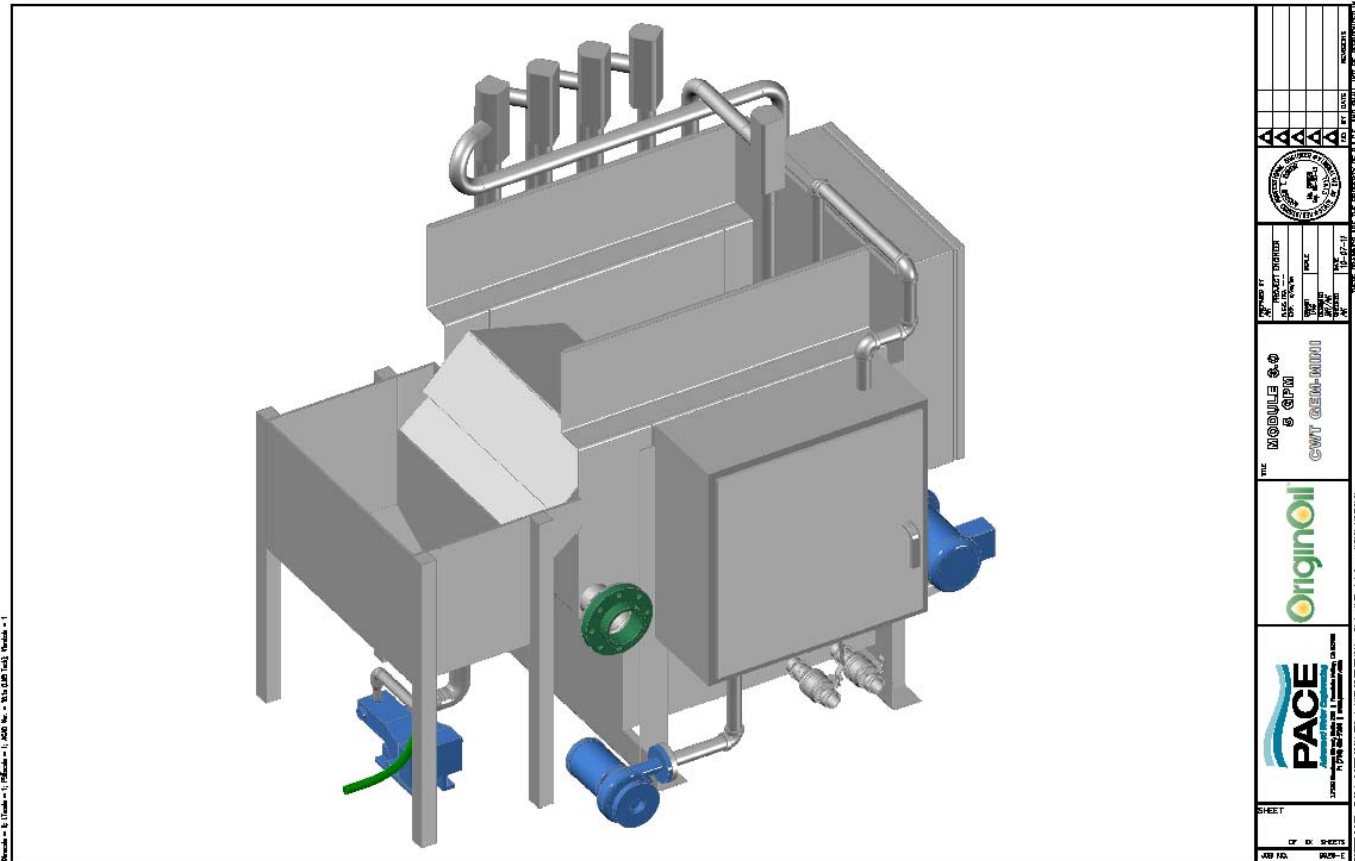


- ❑ Flexible Flow Rates:
 - ❑ Minimum: 2 LPM (0.5 GPM) – processing 3000 liters per day in continuous harvest.
 - ❑ Maximum: 20 LPM (5 GPM) – processing 30000 liters per day in continuous harvest.
- ❑ Wide flexibility of microalgae concentration
 - ❑ From 125mg to 1g/liter dry weight – and beyond.
-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

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

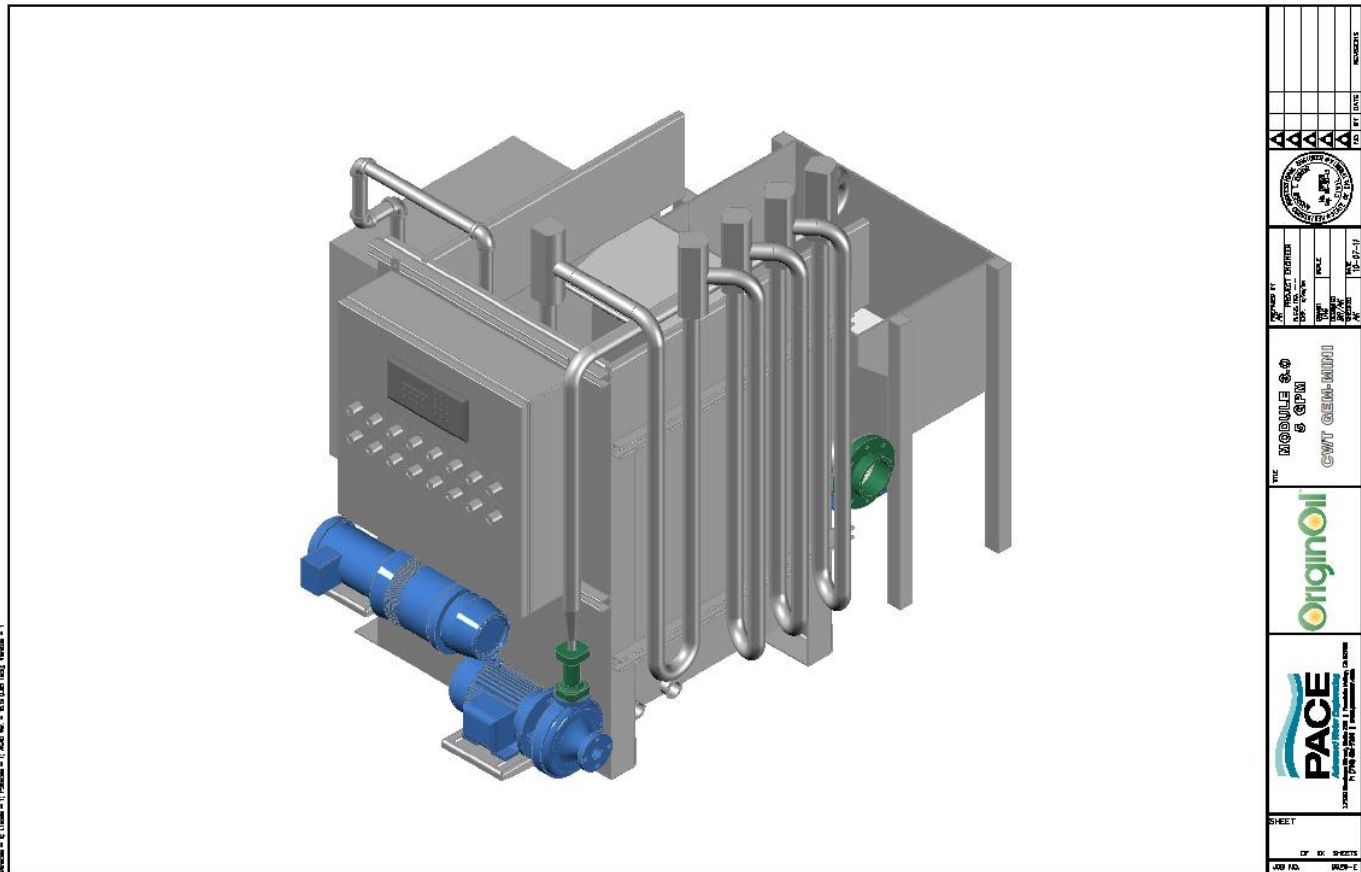
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Algae Appliance Front View



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Algae Appliance Rear View



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Algae Appliance Summary



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

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Typical 4-Stage Process to Scale



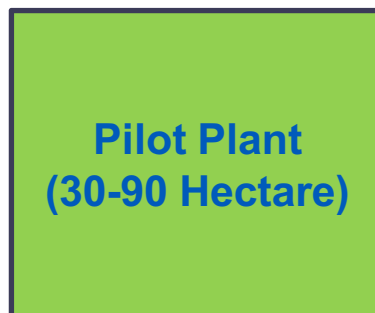
**JCU Research
Facility
(5,000 m2)**



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



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



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



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Summary



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

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

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Bill Charneski
VP Product Engineering

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

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