OriginOil®

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

- 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.

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

Dark-Cycle Production for Food-Grade Algae

- Benefits
  - Well proven technology by companies like: Martek & Solazyme.
  - Perfect for nutritional uses:
    - Nutriceuticals — 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.

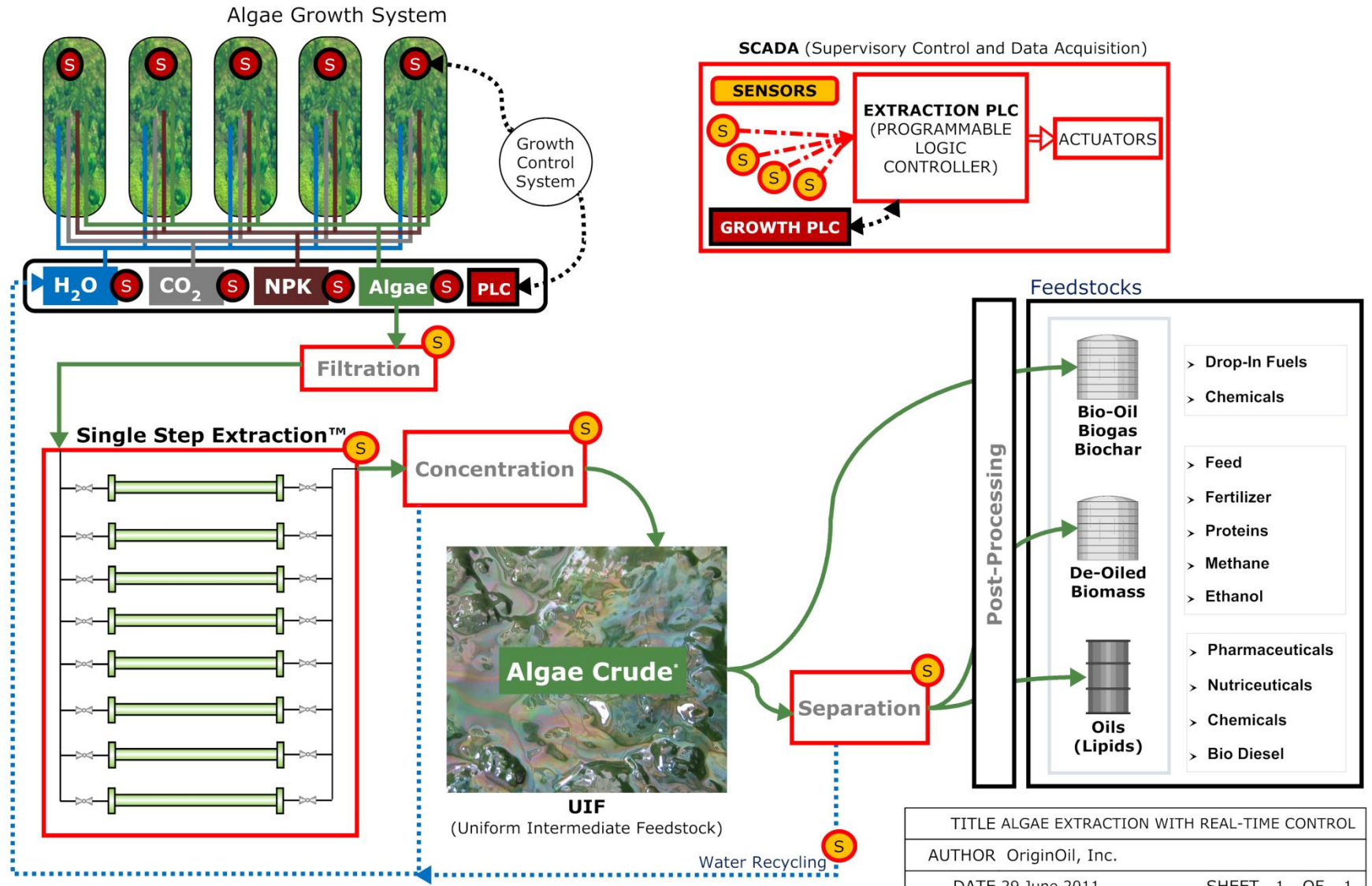
Photosynthetic Algae for Fuel & Chemicals

- 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.

ALGAE EXTRACTION WITH REAL-TIME CONTROL

OriginOil Supervised System: ——



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* sample produced by Evodos™ centrifugation after OriginOil® Single Step Extraction™

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.

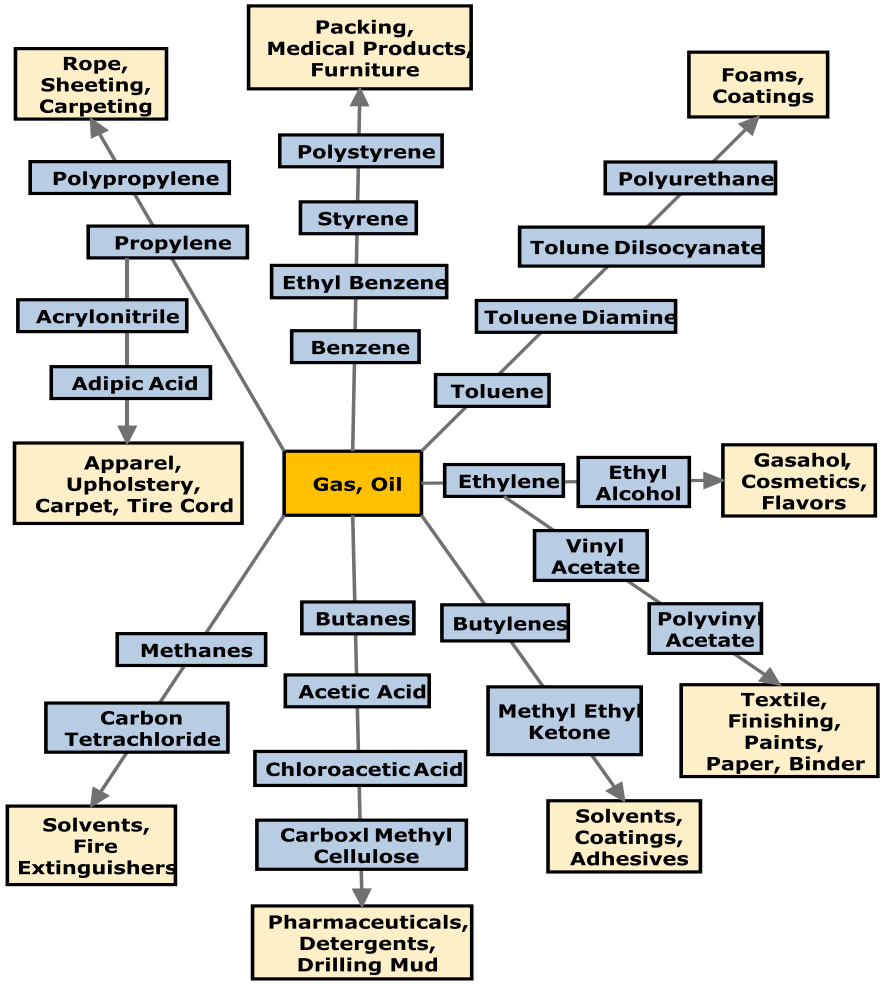
Whole Biomass Processing Compares Closely to Petroleum Processing.

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

Products of Petroleum

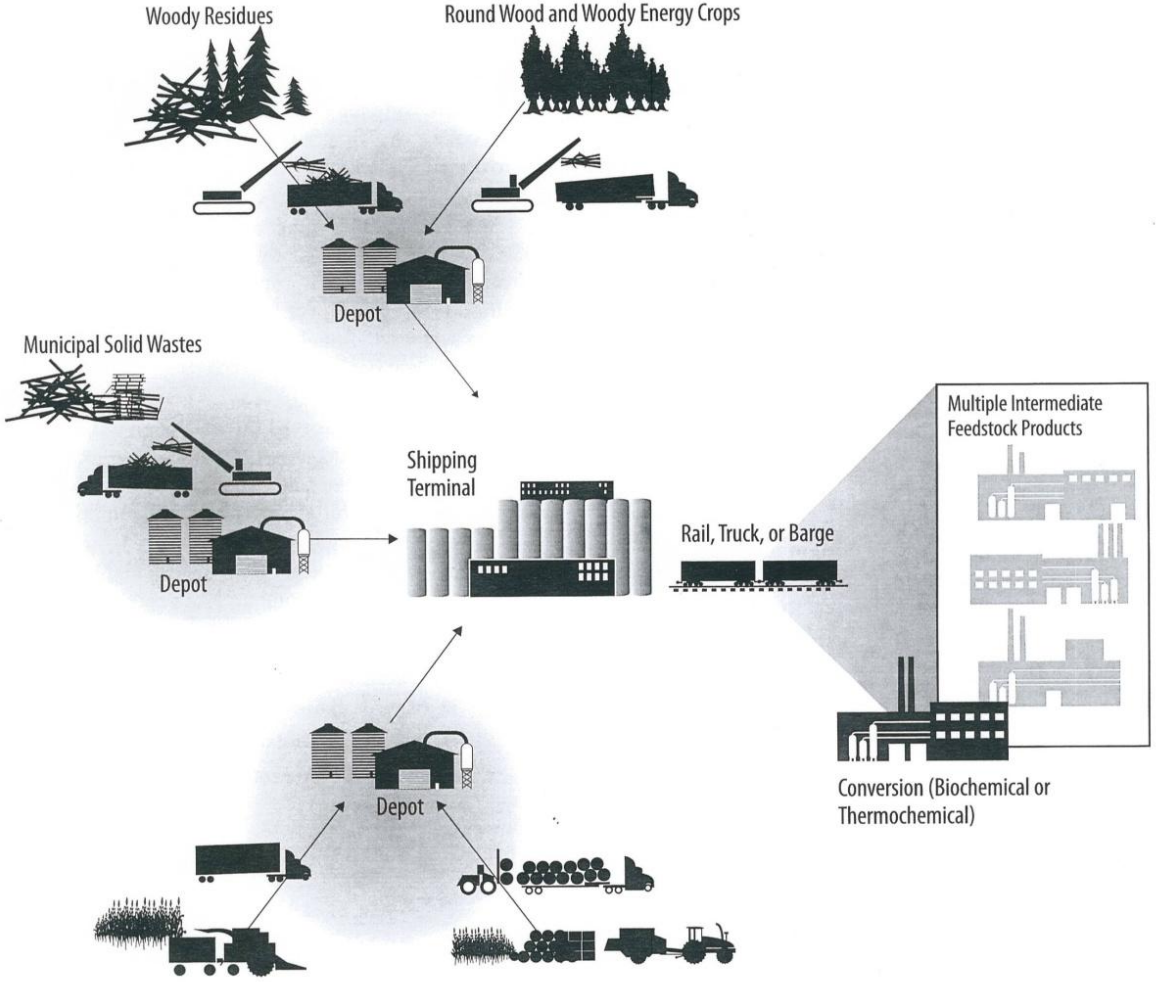


A BREAKTHROUGH TECHNOLOGY TO EXTRACT OIL FROM ALGAE

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.

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).

Algae Appliance™ – A Need Fulfilled

- OriginOil now building systems to serve one full hectare of production.

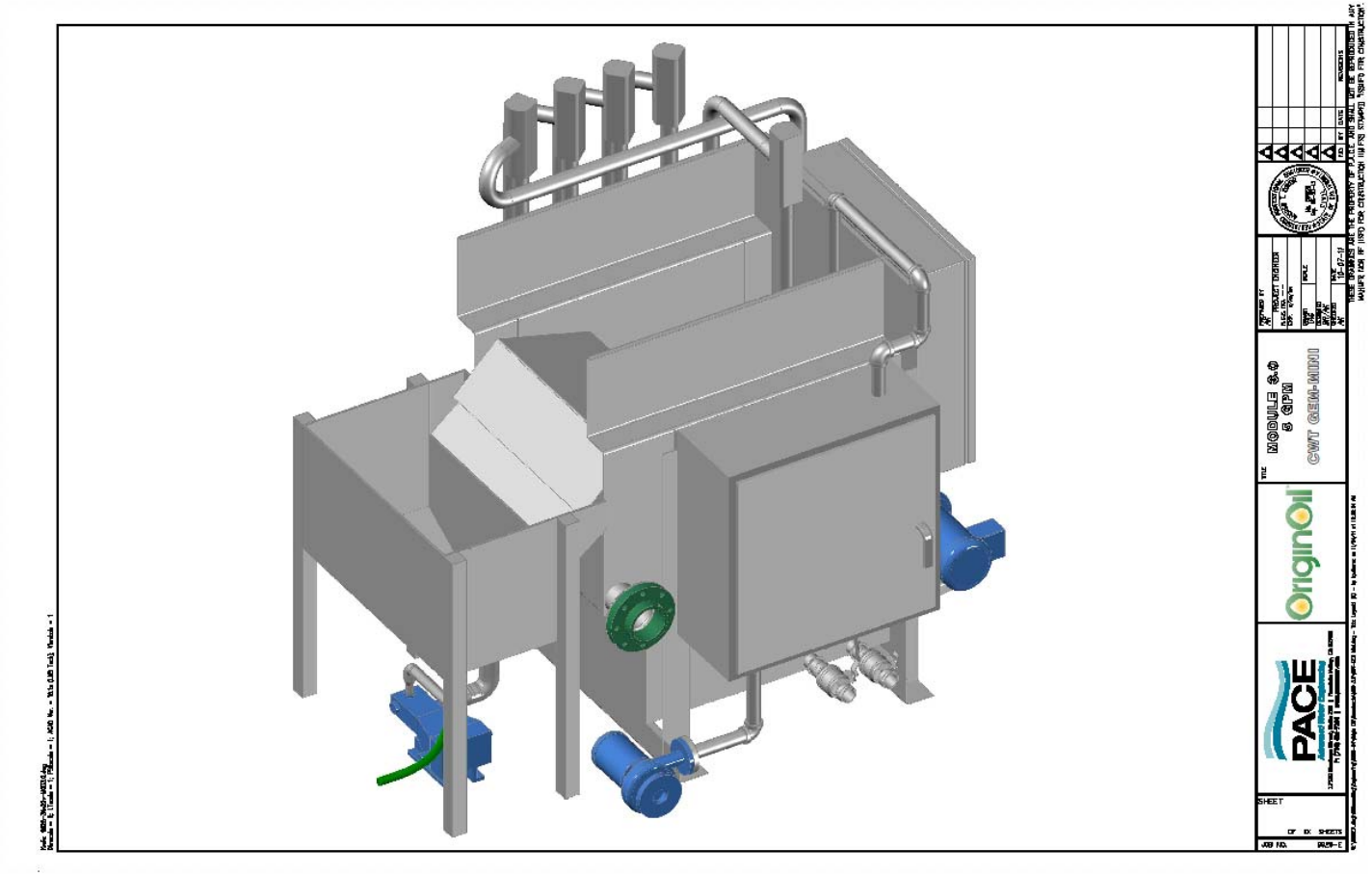
  This scale is still extremely rare in the algae industry!
- Next step: create an entry-level system for the algae industry.
- Announcing the new Algae Appliance, available soon for field testing by select reference accounts.
  - Standardized starter system so producers, researchers and equipment suppliers 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.

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.

Algae Appliance Front View



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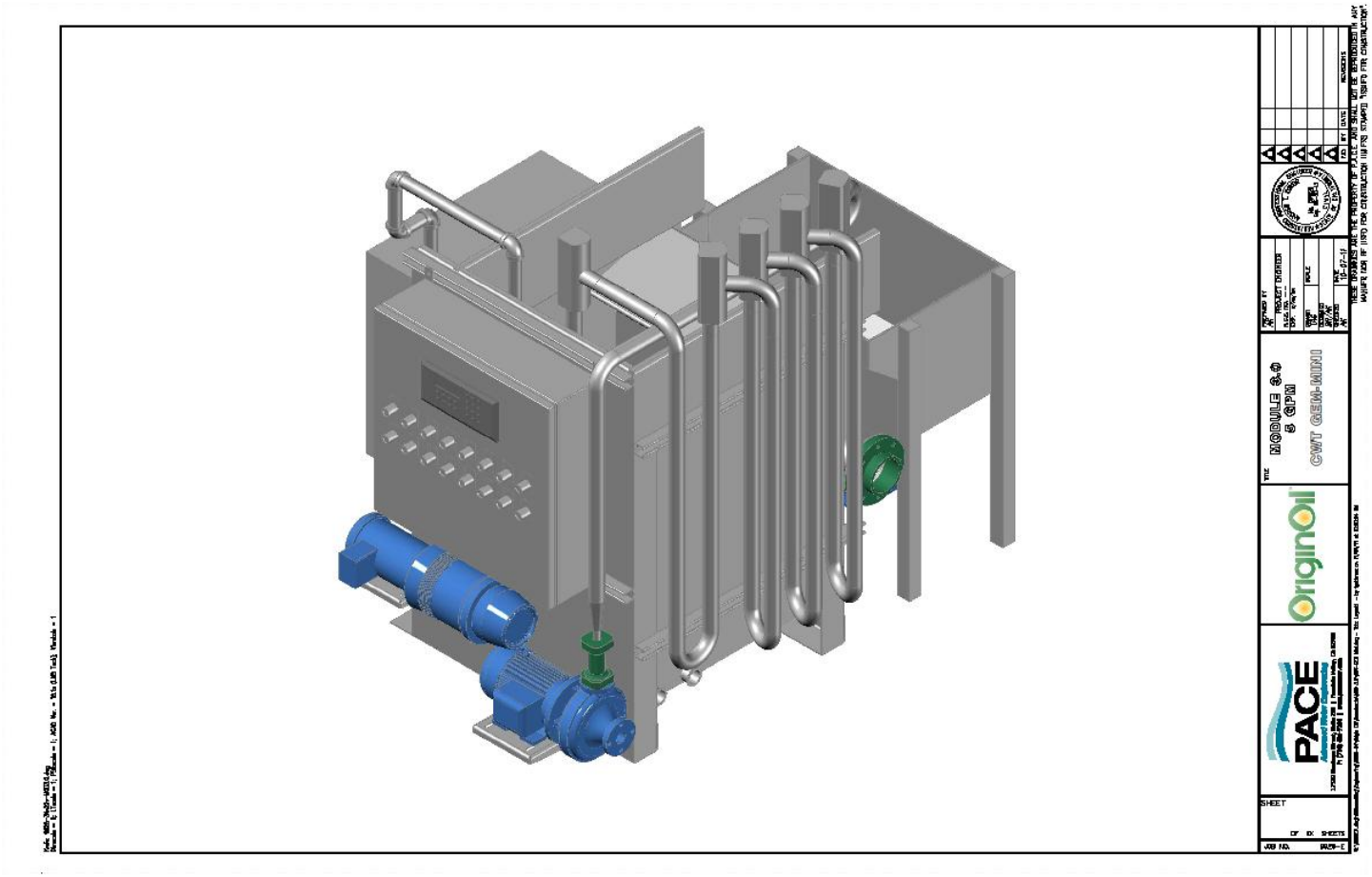
Algae Appliance Rear View



Algae Appliance Summary

- What does the Algae Appliance Accomplish?
  - Entry-level harvester for early process development efforts.
  - Dewaters 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.

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

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