OriginOil®

Developments in Algae Harvesting and Processing

3rd Algae World Summit

San Diego, California

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

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CASE STUDY

ALGAE FOR CARBON CAPTURE

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

The Vision

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

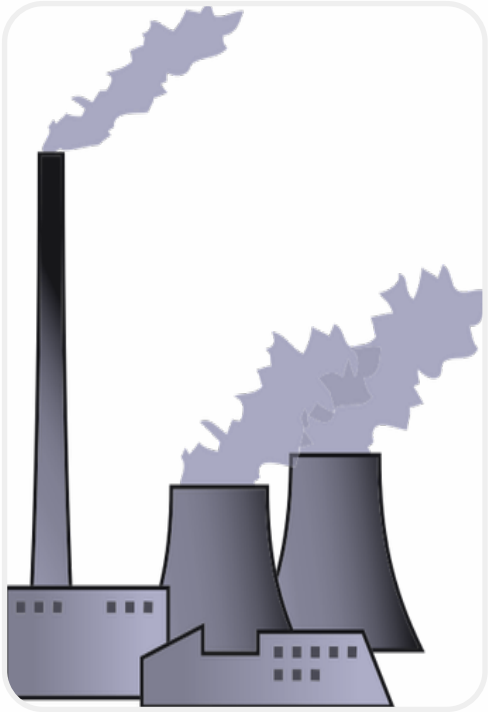
MBD Energy Ltd. – Australia

- *Established in 2006, MBD is Australia's leader in large scale algae based oil and CO2 bio-sequestration.*
- *Cornerstone investor: global mining company Anglo-American Mining.*
- Modular, scalable, fully integrated and automated low cost algae based "CO2 to energy" system
- Signed Formal Agreements with 3 major Australian CO2 emitters
  - First Binding Contract with Tarong Energy
- Staged Deployment of 1 Hectare (ha) "proof-of-concept" Display Plant currently underway at Tarong Power Station over 12 months to Q4 2011
- 3 Stage Commercialization Plan:
  1. Display, 2011;
  2. Commercial, 2013;
  3. Large Scale Expansion, 2015

How is OriginOil Helping?

- Technology To Date:
  1. Quantum Fracturing™ (QF) technology to inject CO2 into algae culture.
  2. Single Step Extraction™ (SSE) for continuous, highly-scalable, chemical-free dewatering and cell lysing.
- Timeline:
  - June 2010: MBD orders research-scale QF & SSE systems. Strategic agreement.
  - August 2010: Research systems ready at OriginOil.
  - December 2010: Research systems operating successfully at James Cook Univ.
  - January 2011: MBD orders construction-phase SSE for Tarong Power Station.
  - April-May 2011: Scale and integration trials at MBD.
  - May 2011: MBD orders full-size SSE for Tarong Power Station 1Ha Display Plant.
  - Looking Ahead: "…a growing pipeline of large-scale CO_2 to Energy Algal Synthesizer installation projects at power stations and other emitters in Australia and around the world." Andrew Lawson, Managing Director, MBD Energy, 23 May 2011.

CO_2 for Value Added Products



Effluent Water
+
Carbon Dioxide
+
Sunlight

Algae

Oxygen
+
Treated Effluent

Water Recycling

Discharge

Algal Biofuels

Algal oils / Plastics

Animal Feed /
Aquaculture

CCS Biochar

Fertilizer

Human Nutrition

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4-Stage Process to Scale

JCU Research Facility (5,000 m2) ü

Display Plant (1-Hectare)

Pilot Plant (30-90 Hectare)

Demonstration Plant (500-Hectare +)

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

The Extraction Landscape: Options available

- Chemical/Enzymatic
  - Protease, surfactants, acids, salts, osmotic, etc.
- Physical
  - Freeze/thaw
  - Heat
  - Electromagnetic
  - Pressurization/expansion
  - Supercritical Gas Extraction
- Mechanical
  - Ultrasound - Sonication
  - Impeller - rotating paddles or surfaces
  - Pressurized Liquid Flow
  - Bead Mills
  - Droplets - atomization

Source: Glen Mills presentation at NAA 28 March 2011
www.glenmills.com

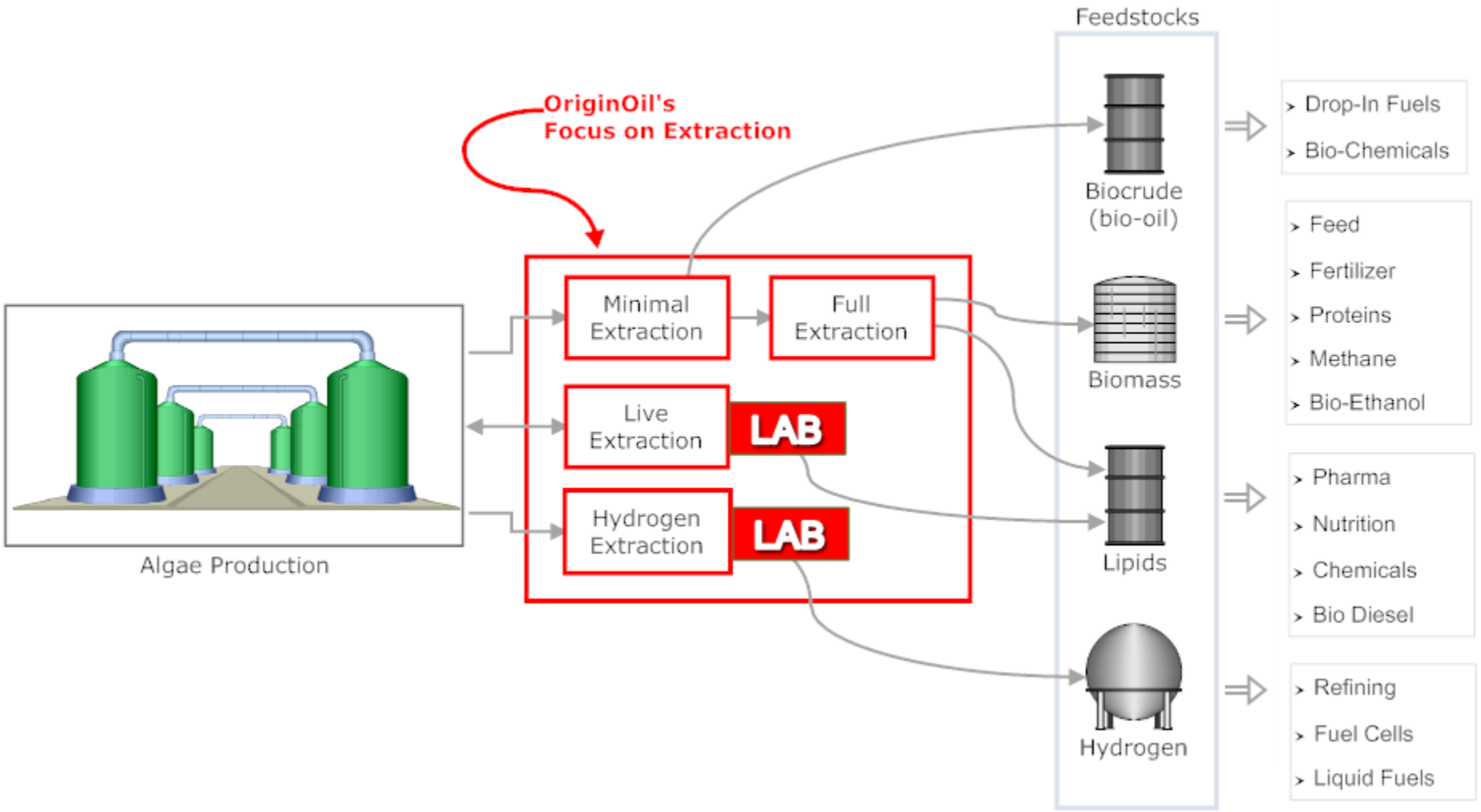
OriginOil's Integrated Harvesting Process

- Single Step Extraction
  - Specifically tuned EMP changes polarity of target organisms
  - Flocculation similar to Polymer/Catalyst without the chemical inputs
  - Lysing of algae cell walls
  - Evolved hardware design, tunable based on species and water makeup
  - Additional process elements may include pH management, Quantum Fracturing, Heat.
- Integrated External Processes:
  - Dissolved Air Flotation (DAF) for Concentration - World Water Works
  - Mechanical 3-Phase Separation post Extraction

Current Scale:
20 GPM Continuous

Single Step Extraction Harvest Benefits

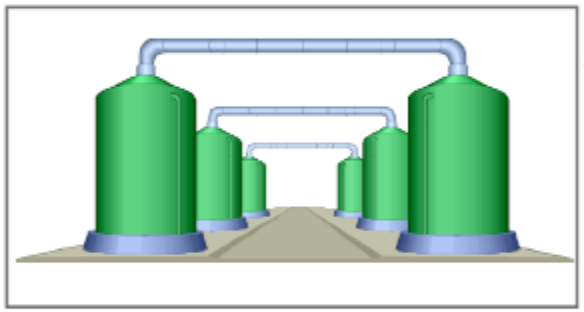
- No chemical treatment, or culture adjustments required
- Significant energy savings compared to existing systems
- Tunable to a wide range of feedstock
- Small footprint, portable configurations
- Easy installation and integration into grower's existing harvest processes
- Straightforward process design
- Applicable to all growth platforms
- CONTINOUS Fast throughput – highly scalable



A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Minimal or full extraction?

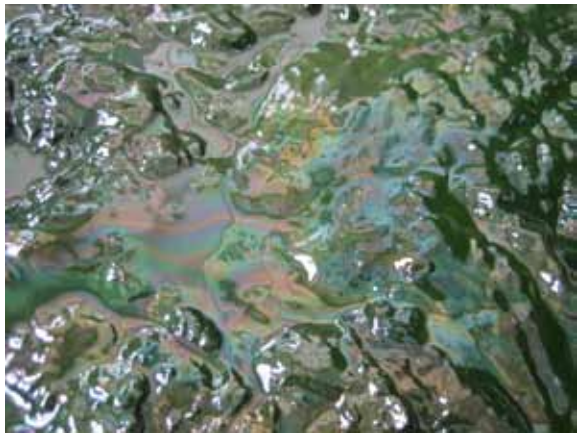
<u>OriginOil's process serves both</u>.



Algae Production

Minimal Extraction

Full Extraction



Feedstocks

Biocrude (bio-oil)

- Drop-In Fuels
- Bio-Chemicals

Biomass

- Feed
- Fertilizer
- Proteins
- Methane
- Bio-Ethanol

Lipids

- Pharma
- Nutrition
- Chemicals
- Bio Diesel

Hydrogen

- Refining
- Fuel Cells
- Liquid Fuels

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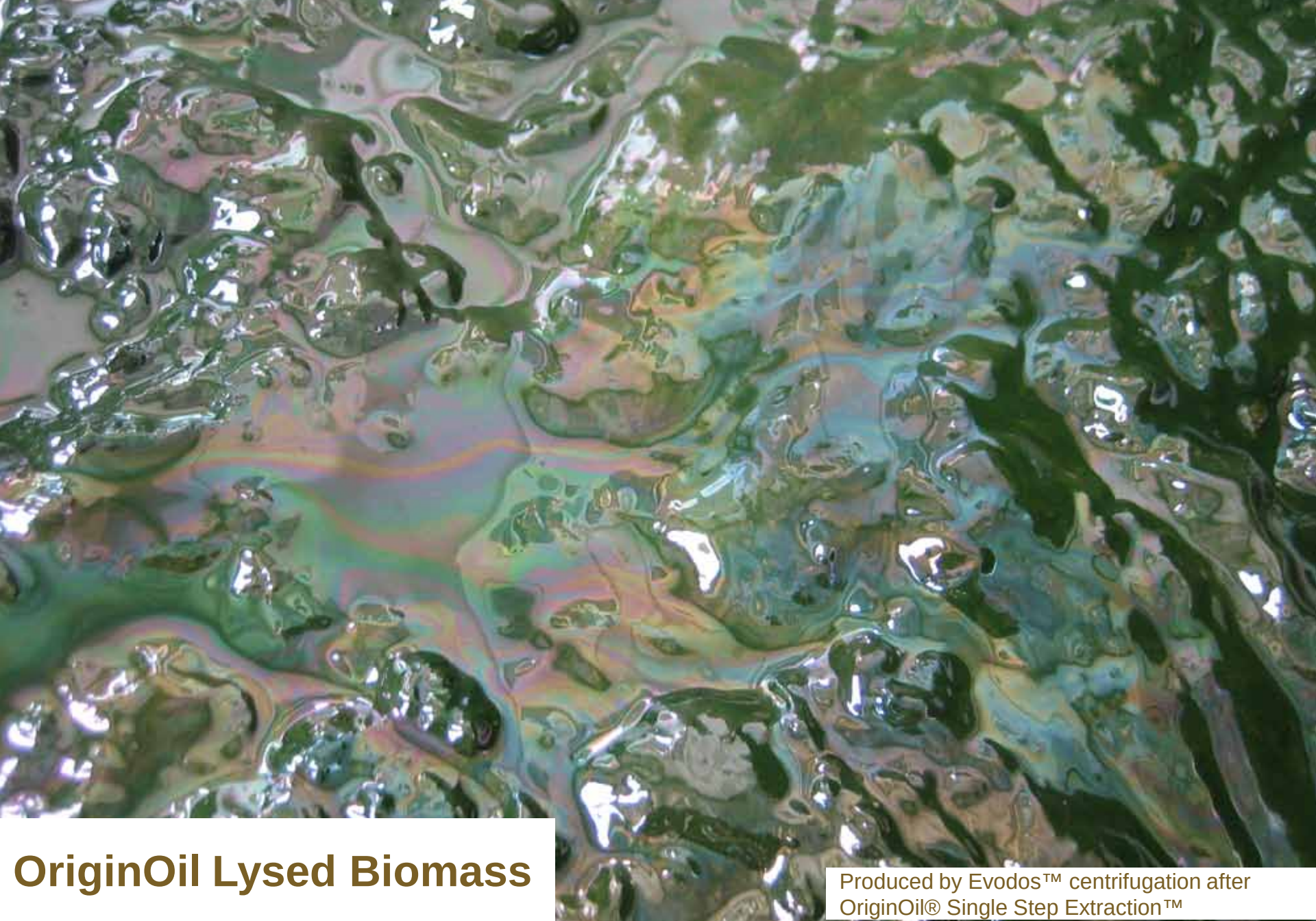


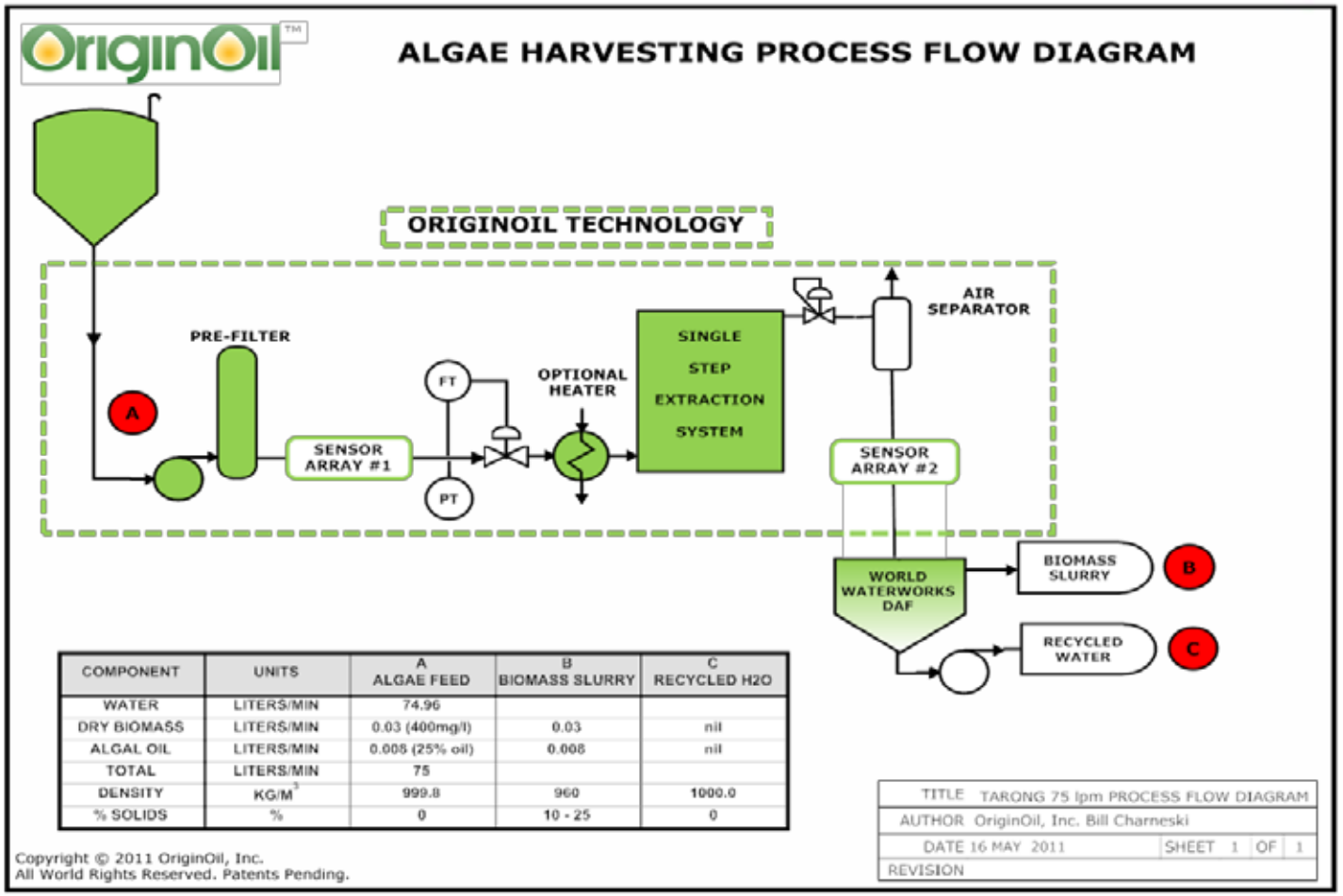
OriginOil Lysed Biomass

Produced by Evodos™ centrifugation after OriginOil® Single Step Extraction™

OriginOil Field Implementation

1. Dewatering
   - Reduce water by about one order (from 1000:1 to ~100:1)
   - Biomass integrity must be preserved
   - A chemical-free solution is preferred
2. Extraction
   - Compromise cell walls
   - Release lipids
   - Release cell components (specialized applications)
3. Concentration
   - Targeting 10-20% solids
4. Separation
   - Fully release all lipid from biomass.
   - Mechanical Three-phase separation: liquid/liquid/solid (oil/water/biomass)

Portable Pilot Plant: 20 GPM



COMPONENT	UNITS	A ALGAE FEED	B BIOMASS SLURRY	C RECYCLED H2O
WATER	LITERS/MIN	74.96		
DRY BIOMASS	LITERS/MIN	0.03 (400mg/l)	0.03	nil
ALGAL OIL	LITERS/MIN	0.008 (25% oil)	0.008	nil
TOTAL	LITERS/MIN	75		
DENSITY	KG/M^3	999.8	960	1000.0
% SOLIDS	%	0	10 - 25	0

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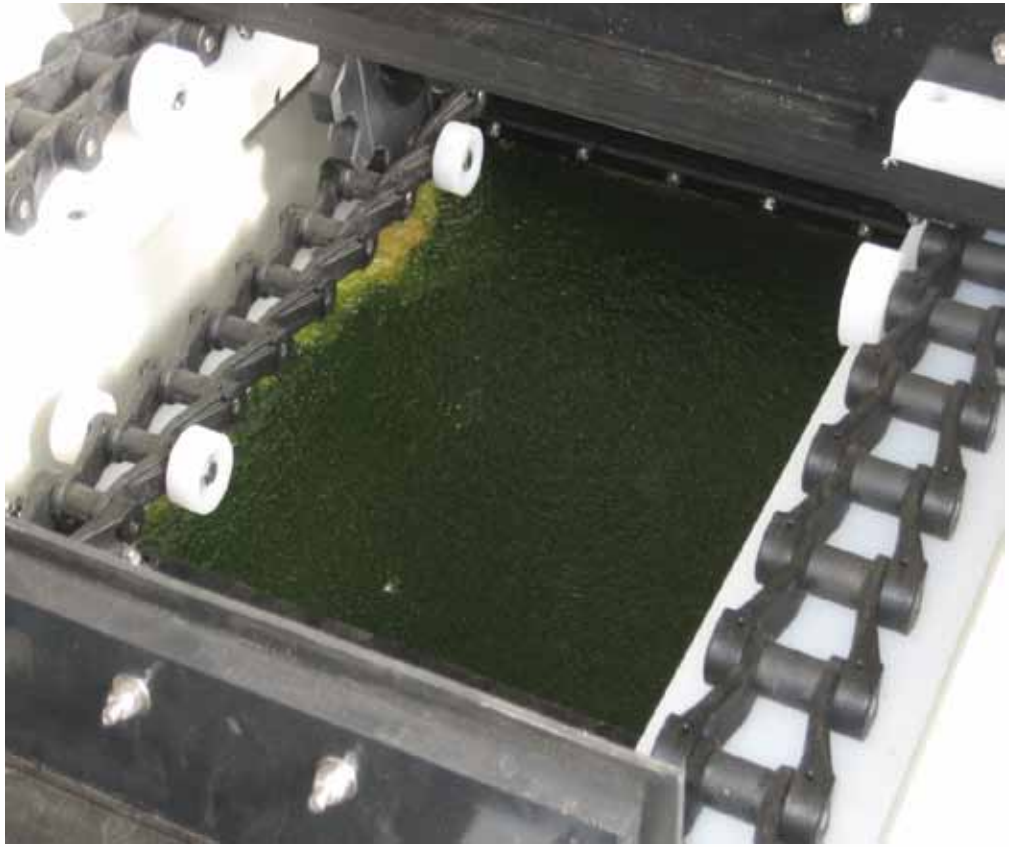
MBD Installation

MBD Installation

Process Images



DAF: oily algae mat with chain drive

Flocculation Sample

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Lysed Biomass as a Standardized Product

- With OriginOil's single step process, growers can deliver lysed biomass ("oily paste") to processors for any application.
- Growers can focus on growing and leave the processing to processors.

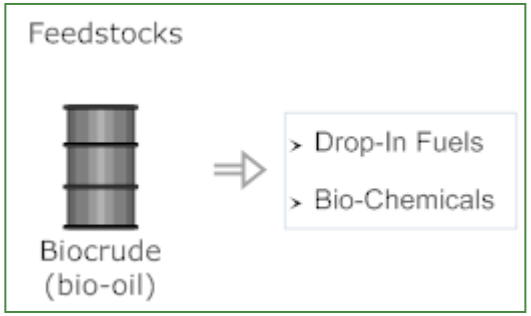
Key decision point: certifying product for food-grade applications.

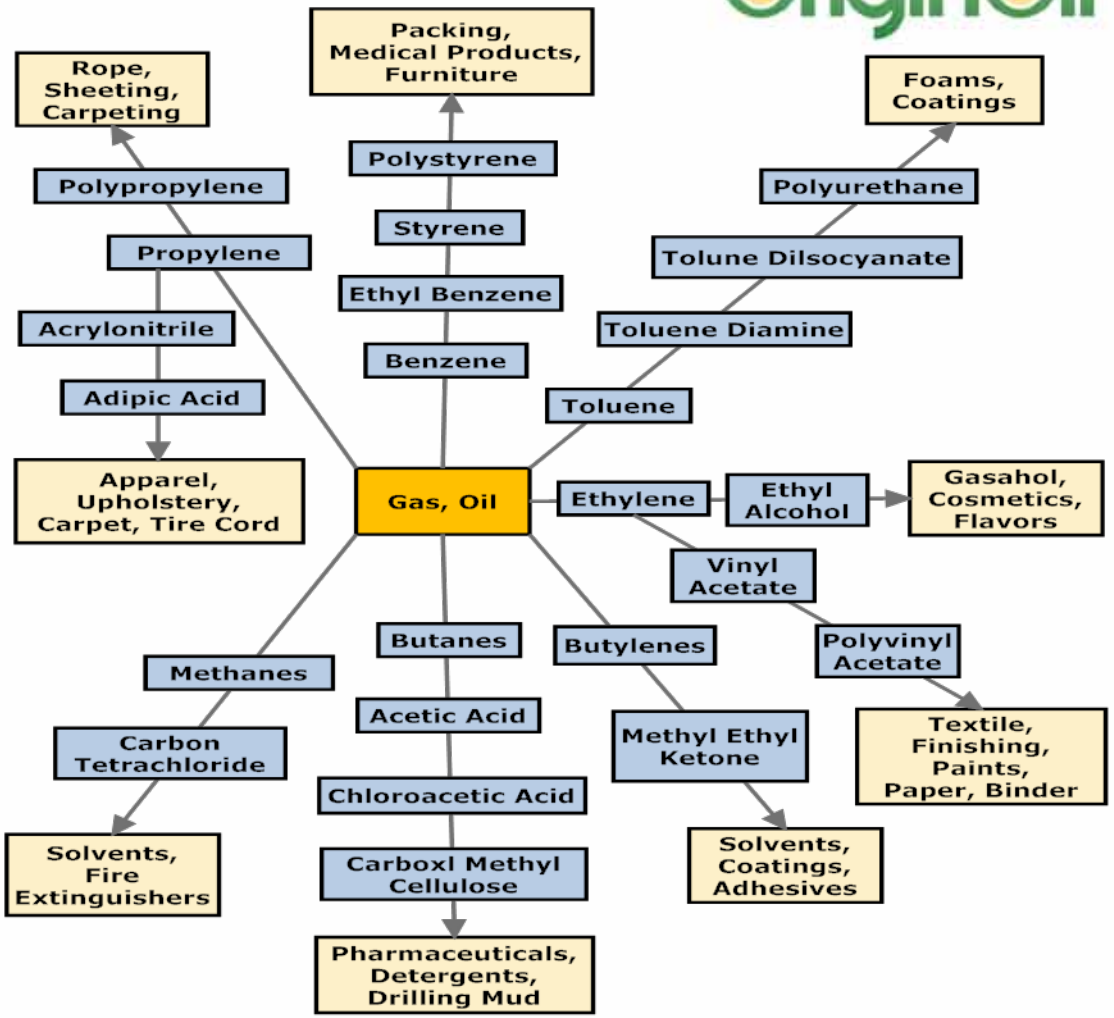
Considerations for Food Grade Applications

- Photosynthetic (autotrophic) growth systems are inherently sustainable:
  - "Free" sunlight for large-scale applications
  - World-class CO2 adsorption
  - Arable land is not required for any phase of operation.
- Key benefits are at odds with food-grade applications:
  - Using waste water for uptake of nitrates
  - Using brackish or salt water
  - Using industrial CO2
  - Using cheap open ponds
- Inputs can be controlled – at a cost – to achieve food-grade purity.
- Planners must consider the costs of food-grade applications in solar growth systems.
- For food grade apps: consider dark cycle growth (heterotrophic).

Fuels and Chemicals

- Biocrude from algae biomass is the most direct route to drop-in fuels and bio-chemicals.
- Every fraction of petroleum is achievable through this route.





Chemicals: price/volume sweet spot

- 90% of crude oil goes into fuel, but 40% of the profits come from petrochemicals.
- The chemicals market can deliver both large volumes and better pricing than fuel.
- Some data points:
  - Renewable chemicals market: US$56.9 billion in sales by 2015.
  - Elevance (Cargill spinoff in biochemicals) grossing $10MM today, forecasts $1 billion in 2016.
  - Elevance raised $100MM in 2010. Looking to transition to algae.
  - Fast-growing renewable chemicals company Cereplast (NASDAQ: CERP) has announced an intention to move from corn feedstocks to algae.

The CO2 Factor

- CO2 is driving major algae rollouts where governments are serious about carbon reduction.
  - Example: MBD Energy (largest stockholder Anglo-American Mining) now rolling out massive algae tracts to absorb CO2 from brown coal power plants.
  - Australia has spent AU$2B to date* on geo-sequestration, now committed to algae as far cheaper, quicker and more sustainable.
  - Algae-based CO2 abatement is an export technology for Australia.
- The CO2 benefit alone justifies algae for major emitters – especially in countries that plan to penalize emissions heavily.
  - 40 euros/ton on the way for CO2 emitters in Europe?

* Source: Austrade briefing at Advanced Biofuels Leadership Conference, Washington DC, 20 April 2011

Summary

- MBD Energy is aggressively scaling up algae production for carbon capture.
- OriginOil's continuous harvest process is essential to achieving scale.
- OriginOil is integrating other vendors into the harvest process for an end-to-end solution for vendors.
- MBD and OriginOil are continuing to expand their strategic partnership.
- A standard for lysed biomass ("oily paste") will allow growers to focus on the growing, processors on the processing.
- Solar-algae growers must carefully consider the cost of certified food-grade operation vs. the benefits.
- Biocrude is the simplest path to fuel and chemicals.
- Chemicals are the sweet spot for non-food grade algae processing.
- CO2 regulation will continue to drive the development of large-scale solar algae systems.

THANK YOU!

Paul Reep

Senior VP Engineering

QUESTIONS?

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