Use of Algae Appliance for Harvesting and Microbiological Control of Algal Biomass

By Jose Sanchez Piña, General Manager Algae Division, OriginOil Inc

OriginOil: In a few words...

- OriginOil develops & licenses **breakthrough technologies** that solve ruinous problems in expanding **multi-billion-dollar energy industries**
- Proprietary technologies boost yields, slash cost, and return profits in:
  - Algae harvesting and shelf life
  - 98% decontamination of oil & gas frack water
- Independent tests and trials in US government and commercial labs, Pacific Rim and European partner sites verify breakthrough results
- Technology protected by 29 patents pending; Australia grants the first
- Income streams from scale-up and deployment partners
- Creating and receiving **enthusiastic media coverage**
- Loyal following of large and small **stockholders**
- **Proven management team** with bull's-eye industry experience
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Further information on our risk factors is contained in our quarterly and annual reports as filed with the Securities and Exchange Commission. As a result there can be no assurance that the forward-looking statements included in this presentation will prove to be accurate or correct. In light of these risks, uncertainties and assumptions, the future performance or events described in the forward-looking statements in this presentation might not occur. Accordingly, you should not rely upon forward-looking statements as a prediction of actual results and we do not assume any responsibility for the accuracy or completeness of any of these forward-looking statements. We undertake no obligation to revise or update publicly any forward-looking statements for any reason.
From R&D to Commercialization

THE ALGAE MARKET TAKES OFF
Algal Biofuels: An Engine of Growth

- World biofuels market is expected to grow at a CAGR of 12%+ through 2017
- $105.4 billion annual revenue forecast for 2018

Sources: Algae 2020, Emerging Markets Online Consulting Services, Biofuel Digest
ALGAE

Large Markets
q In 2010, algae biofuels markets were $217 million
q By 2015, they are forecast to reach $1.6 billion
q One-third of this market will be advanced technologies—such as ours

What Is Our Industry's Greatest Challenge? (Other Algae Companies)
q Extracting algae from the water it grows in
q At harvest, algae is highly dilute—up to 1000:1 water to algae!
q Other harvesting solutions are slow, costly, energy-intensive, and toxic

Algae as a Commodity
q 2013: Algae fuel producers receive $1.01/gallon tax credit on output
q Emerging markets for green commodities: fuels, chemicals, feed, fertilizer
q Mounting global pressure for renewables (France’s Green Buildings law)
q China and India pushing for clean energy technology
q Opportunities for green chemicals and other high-value end products

Source: Algae Biofuels Production Technologies Worldwide Market Research Report
The OriginOil Algae Harvesting Solution

- OriginOil’s breakthrough algae harvesting system:
  - Lower capital and operating costs than any other de-watering process
  - High speed
  - Energy efficient
  - Chemical free
  - Completely scalable
  - Integrates upstream and down
  - Now a standardized, selling product line: The Algae Appliance™
The Algae Appliance, Model 4 (AA4)

- Fully integrated algae harvester
  - Dewaters more thoroughly
  - Decontaminates to extend shelf life
- Model 4 delivers up to 4 LPM
  - In commercial production and sales
  - Entry-level, low-cost
  - Testing, R&D, process improvement
  - Will process 20% of daily harvest at 30,000-liter/day facility
  - Options: Decontamination, pre-harvest stimulation, capacity upgrade
  - Operator training, literature and support included
- 200 LPM (50 GPM) model available
Versatile, Adaptable, Rugged

- Operates with all algae types and conditions: Any strain, salinity, degree of contamination, temperature, grown in light or dark

Harvesting algae grown in light

Harvesting algae grown in dark
Savings Over Other Methods

Capital Cost of Harvesting in USD per Kilogram of dry Algae at different culture densities in USA

Algae Culture Density in g/L

Capital Cost Dollars/Kg Dry Algae

OriginOil 757
Centriguge 40K LPH
Filtration 0.3MGD
Savings Over Other Methods

Operational Cost of Harvesting in USD per Kilogram of dry Algae at different culture densities in USA

Operational Cost Dollars/Kg Dry Algae

Algae Culture Density in g/L

- **OriginOil 757**
- **Centrifuge 40K LPH**
- **Filtration 0.3MGD**

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Savings Over Other Methods

Total Cost of Harvesting in USD per Kilogram of dry Algae at varying culture densities in the USA (Including Labor and Consumables)

![Graph showing total cost per kg of dry algae at varying culture densities. The graph compares OriginOil 757, Centrifuge 40K LPH, and Filtration 0.3MGD methods.](image-url)
Two-Stage Harvesting System

1. **Single-Step Extraction™** neutralizes algae cells’ electrical charge so algae clump together (flocculate)
   - Optionally, cells can be ruptured for non-fuel uses

2. **Hydrogen Flotation™** creates a vapor cloud of micro-bubbles pushing algae solids upwards for surface collection

(Video of Appliance Model 4)
Stage One: Efficient Dewatering

- OriginOil’s first stage dewaterers algae more efficiently than any other solution.
- Single Step Extraction eliminates fatal flaws of current dewatering methods:

### Algae Dewatering Process

<table>
<thead>
<tr>
<th></th>
<th>Membrane</th>
<th>Centrifuge</th>
<th>Chemical</th>
<th>Mechanical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical-Free</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Low Energy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Continuous Process</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Low Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbiological Control</td>
<td></td>
<td></td>
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</tbody>
</table>
Stage Two: Integrated Concentration

- Hydrogen Flotation integrates closely with the extraction stage to concentrate the algae into a high-density slurry.

- No further equipment is required to achieve 5 to 10% concentration of solids.

- Surface concentrate and clear effluent are fully ready for next steps.

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Additional Advantages

q Clean Growth:
  q OriginOil’s Algae Screen™ works on living algae to eliminate most bacteria, rotifers, ciliates and adverse algae
  q Decontaminated algae grows better, demonstrating improved yield at harvest*
  q Degree of improvement exceeds 50%, with potentials exceeding 80%

q Extended Shelf Life:
  q Normally, algae begins to rot after harvesting; short shelf-life complicates yield/ROI
  q Algae Appliance decontamination delivers shelf-life up to one month**

* Source: OriginOil Announces Breakthrough Innovation to Increase Algae Yield
** Source: OriginOil Internal Estimate (3rd party study in progress)
What can OriginOil do for Algaepreneurs?

The Usual Suspects that Crash Algae in Ponds and Reactors...

- Parasitic Diatom
- Bacteria
- Fungus
- Rotifer
- Ciliate
- Adverse Algae

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What can OriginOil do for Algaepreneurs?

The Drama of Contamination (Conventional Paradigms)

- "It's contaminated, it needs to be discarded"
- Use of Antibiotics
- Use of Chemicals such as Sodium Hypochlorite or Hydrogen Peroxide
- Changes in Salinity, pH or nutrients
- Several days to recover production levels due to Algae Stress/damage
What can OriginOil do for Algaepreneurs?

When Contaminated… Harvest the problems away

- 10,000 Liters of Contaminated Algae Culture at 300 mg/L
- 50 Liters of Clean Algae Paste at 57000 mg/L
- 9950 Liters of Clean Water at 15 mg/L
- 90 to 99% Less Bacteria

Harvest with Appliance
What can OriginOil do for Algaepreneurs?

When Contaminated … Harvest the problems away

Water Sterilized with OOIL SSE, Chlorination, UV, Hydrogen Peroxide, etc

Algae Paste (The cells are totally alive)

Back to Production in a few Hour$!!!
Algaepreneur Basic Need for Microbiological Control

From a few cells to Inoculation Carboys in the Culture Room

Need Clean Inoculum?

Inoculation of algal culture and nutrients in the production bags

DO YOU REALLY THINK WE NEED CLEAN INOCULUM??

Production bags or ponds

Need Clean Inoculum?

Culture intermediate scale up to 300 gallons in small photobioreactors

Need Clean Inoculum?

Culture production in large photobioreactors up to 15,000 gallon levels

Harvest Biomass without Bacteria

Increased Shelf Life/Quality
What can OriginOil do for Algaepreneurs?

Clean Intake Water and Inoculum Supply

Bleach? 1 ml/L and Survives

UV Lamps? 70% survival

OriginOil
Titanium SSE
“El Matador”
What can OriginOil do for Algaepreneurs?

Increase in Production through Heterotrophic Jump

Industrial, Agricultural or Municipal Sewage

OriginOil SSE tubes sterilize and reform sewage yielding a “broth” rich in Organic Carbon and Fertilizers

“Broth”

Alive algae green cells (Harvested with OOIL Appliance)

Autotrophic Systems

Heterotrophic Systems

A BREAKTHROUGH ENERGY PRODUCTION PROCESS FOR THE OIL & GAS AND ALGAE INDUSTRIES
What can OriginOil do for Algaepreneurs?

Increase in Production through Heterotrophic Jump

The algae cells produced in autotrophic mode are placed in fermenters that will raise the amount and fat content of algae cells several times. The trick to reduce prices is to assure heterotrophic growth while avoiding contamination without the use of costly beer-industry grade fomenters. This can be achieved by the previous treatment to neutralize micro-organisms of autotrophic algal cells and water by using OriginOil systems.

Conventional Autotrophic Algae Systems

Dark (no light) Heterotrophic Algae Systems
The heterotrophic systems increase the production of lipids by increasing its cell density a dozen times while increasing its fat content from 15 to 55 % by weight. The heterotrophic mode is activated when the algae culture is placed in a fermenter without light, in the presence of Oxygen and a Carbon source. **This can increase the fat content per liter up to 35 times in six days.**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Lipid (%)</th>
<th>Cell density</th>
<th>Cell growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP</td>
<td>10-20</td>
<td>&lt; 5 g l(^{-1})</td>
<td>&lt; 1 g l(^{-1}) d(^{-1})</td>
</tr>
<tr>
<td>HF</td>
<td>50-60</td>
<td>&gt; 100 g l(^{-1})</td>
<td>&gt; 10 g l(^{-1}) d(^{-1})</td>
</tr>
</tbody>
</table>

**AP** Autotrophic photosynthesis  
**HF** Heterotrophic fermentation
A Plan Specifically Tailored for Northern Latitudes

Separate Places and Times for algal growth to optimize production and make it “All-year around”

Autotrophic production carried on sunny-warm climate Mediterranean and Heterotrophic production everywhere with an organic Carbon source (sewage, dairy farms, paper mills, etc).

* Seasonal Autotrophic Production will be carried on in outdoors from April to October
The Heterotrophic biomass is harvested when it is at least 3 grams/Liter with 60% fat content. The Appliance Harvester flocculates, concentrates, lyses and hydrogenate the cells, converting them into the best feedstock for a Hydropyrolysis Refinery.
The Hydropyrolysis Refinery is a cost effective thermochemical platform to convert biomass directly into cellulosic hydrocarbons for use as fuels/blend stocks or sources of renewable hydrocarbons for petrochemical use (IH2 model displayed here).

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1. Feedstock could be a mixture of chips (hardwood & softwood), mill sludge, bark, and or sawdust. Average moisture content of the feedstock is anticipated to be in the range of 5% - 20%, but could be higher. Lower input moisture content results in higher export steam. Particle size is expected to be 2 to 4 mm.
2. Feedstock composition influences resulting product. See IH2 Product Example slide for further information.
3. It is anticipated that the char would be sent to the hog fuel boiler for combustion and production of additional export steam at traditional hog fuel boiler steam pressures.
4. Ammonia in export water is stripped in process. Stripped water is then returned to the Steam Methane Reformer for hydrogen production. Overall export water varies with moisture content of feedstock.
5. Natural gas used only at startup.

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2,000 tpd feedstock @ 5% moisture

Utilities:
Electric: 256 kw
Natural Gas: 7MMSCFD
The Hydropyrolisis Refinery can use almost any kind of Carbon-based feedstock (tires, agricultural waste, sawdust, municipal waste, and algae). If the refinery uses conventional autotrophic algae, it can get yields of 23% gasoline and 22% diesel by weight from the initial feedstock. **If the refinery uses hydrogenated heterotrophic algae, these yields double**

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Wood</th>
<th>Algae</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_4$ + Liquid yields (MAF) wt%</td>
<td>28</td>
<td>46</td>
</tr>
<tr>
<td>Wt% Oxygen in liquid</td>
<td>bd l</td>
<td>bd l</td>
</tr>
<tr>
<td>Wt% Gasoline liquid product</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Wt% Diesel liquid product</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td>Wt% Char (MAF) wt%</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Wt% COX (MAF) wt%</td>
<td>16.4</td>
<td>9</td>
</tr>
<tr>
<td>Wt% C$_1$-C$_3$ (MAF) wt%</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Wt% Water (MAF) wt%</td>
<td>36</td>
<td>26</td>
</tr>
<tr>
<td>Wt% $H_2$ uptake (MAF) wt%</td>
<td>4.6</td>
<td>4.4</td>
</tr>
<tr>
<td>External $H_2$ required for integrated system</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ammonia wt%</td>
<td>0.18</td>
<td>2.4</td>
</tr>
</tbody>
</table>

The cost of production for bio-crude made with this heterotrophic-hydropyrolisis system would be around $66 dollars per barrel, produced in Germany, France, Netherlands or Sweden.
What can OriginOil do for Algaepreneurs?

The need to dispose of your Strain Properly

There might be unforeseen events in which it would be necessary to discard the algae in an economic way:

- Mutation of your strain
- Hurricanes that break your system
- Disgruntled Employees
- Decommissioning
There’s going to be people that will attack GMOs in Algae regardless of how much substantial scientific evidence proves that the benefits outweigh the possible risks. An accidental spill not managed properly could kill any GMO commercial production endeavors. GMO producers must have something to kill 100% of a spill without a doubt.
Thanks!!

Jose L Sanchez Piña
General Manager Algae Division
OriginOil Inc.