ALGAE TO BIOFUEL

OPPORTUNITIES AND CHALLENGES

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Discussion Points

- Why pursue algae?
- Algae process challenges
- Potential solutions
- Concluding remarks

Why Pursue Algae?

- Fastest growing biomass
- No adverse impact on environment, food supplies
- Can grow using…
  - Waste gas (CO_2)
  - Wastewater
  - Waste land
  - Waste energy

Potential of Algae to Replace Petroleum and other Biofuels

- Petroleum came from algae
- Highly efficient organism
- Can contain up to 60% lipids
- Biomass can be digested for methane
- Carbon-neutral energy source

Algae Can Be 1000X More Productive than Corn

Gallons of Oil /Acre/ Year

Corn 15
Soybeans . . . 48
Safflower 83
Sunflower . . . 102
Rapeseed . . . 127
Oil Palm 635
Micro Algae . .1850 (actual)
Micro Algae . . 5000-15000 (potential)

Source: Cultivating Algae for Liquid Fuel Production Thomas F. Riesing, Ph.D.

Process Challenges

- Must bring together
  - Light
  - CO_2
  - Nutrients
  - Water
- Should have the least possible footprint
- Low-Cost Oil Extraction
- Energy-Efficient Continuous Production

= Renewable Oil Anywhere, Any time

Process Challenges

- How much land?
- How much water?

- Let’s do the calculations

Assumptions

- Algae biomass concentration = 0.25 kg/m^3 (g/L)
- Lipid content = 30%
- Lipid density = 920 kg/m^3
- Depth of pond = 0.5 m
- Harvesting rate = 25%

Calculations for 10,000 L/d of algae oil

10,000 L/d = 10 m^3/d = 2,642 gal/d = 63 barrels/d

Therefore, algae biomass required =

10 m^3/d x 920 kg/m^3 x (100 g biomass / 30 g lipid)

= 30,667 kg/d = 30.7 T/d

Calculations for 10,000 L/d of algae oil

To harvest 25% biomass every day
we must maintain 30.7 T/d / 0.25 = 123 T of
biomass in the system

Calculations for 10,000 L/d of algae oil

How much water?

(123 T x 1000 kg/T) / (0.25 kg/m^3)

= 490,000 m^3 of water = 490 ML = 129 MG

Calculations for 10,000 L/d of algae oil

How large a footprint?

490,000 m^3 of water / 0.5 m depth

= 980,000 m^2

= 98 ha

= 244 ac

Biomass productivity = (30,667 kg/d) / (980,000 m^2)

= 0.031 $kg/m^2/d$ = 31 $kg/m^2/d$

Source: http://www.tomorrowisgreener.com/images/biofuelfarms.jpg

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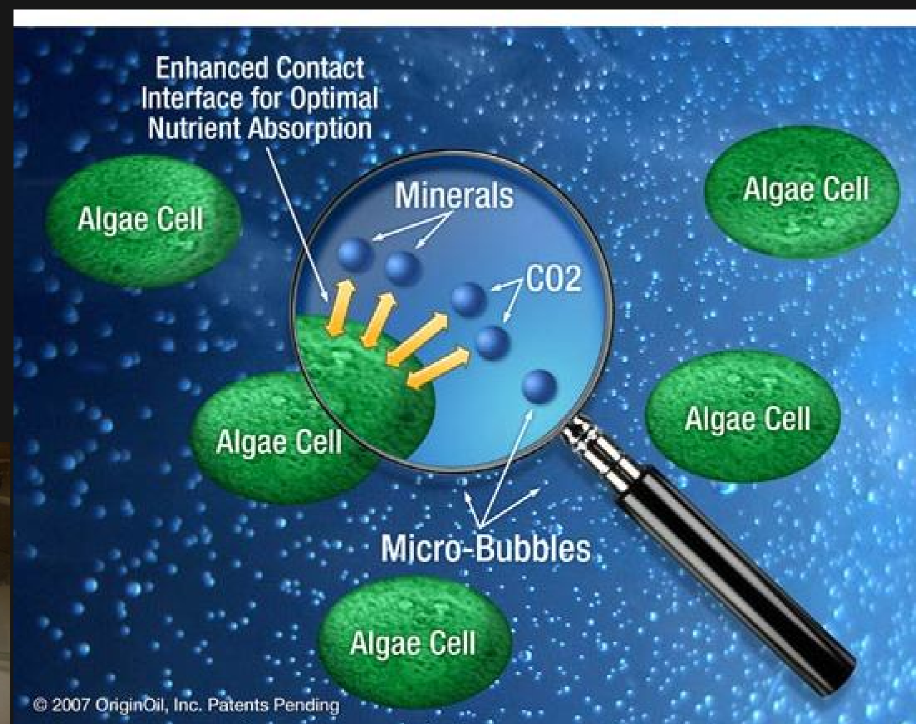
OriginOil's PhotoBioReactor (PBR)

- Optimized Light Delivery
  - Multiple growth layers
    - Small footprint
  - Low energy
    - Energy-efficient lights
  - Frequency-tuned lights
    - Optimum light absorption for efficient photosynthesis
  - Optimum flashing intervals

Courtesy OriginOil Inc

Quantum Fracturing™

- OriginOil's method for efficient and rapid delivery of CO_2 and nutrients



Courtesy OriginOil Inc

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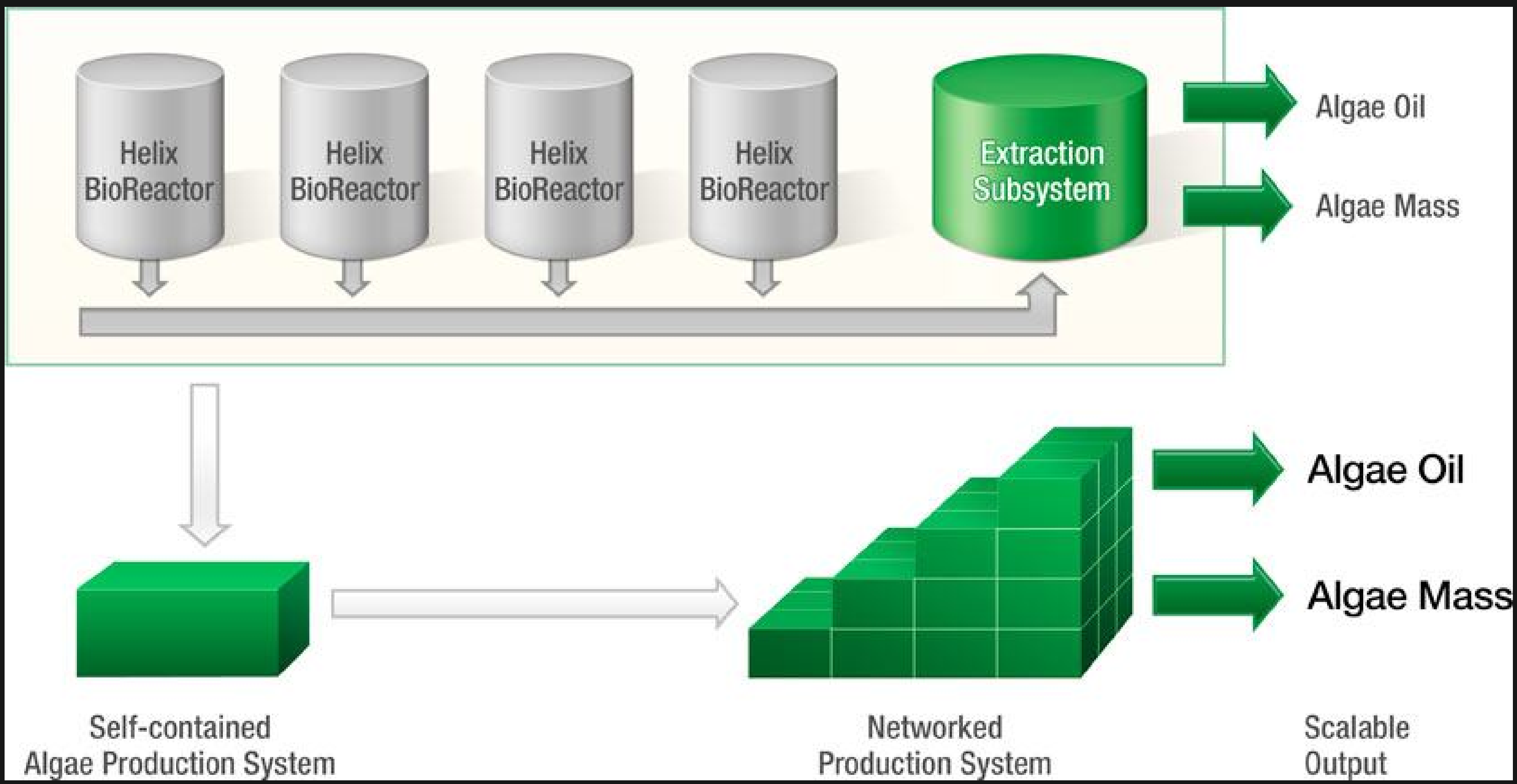
Modular/Scalable Growth System



Courtesy OriginOil Inc

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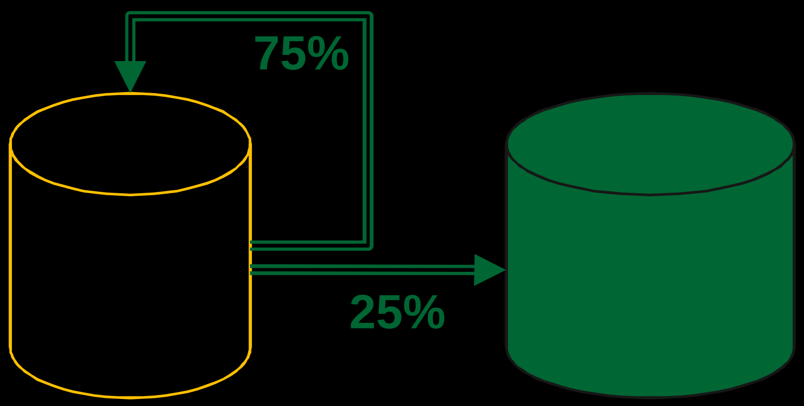
Cascading Production

- Continuous production - harvest part of new growth - use remaining as seed for new batch
- No lengthy incubation period for every new batch
- Periodic harvest of algae oil and mass

Cascading Production Example



Courtesy OriginOil Inc

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The Extraction Challenge

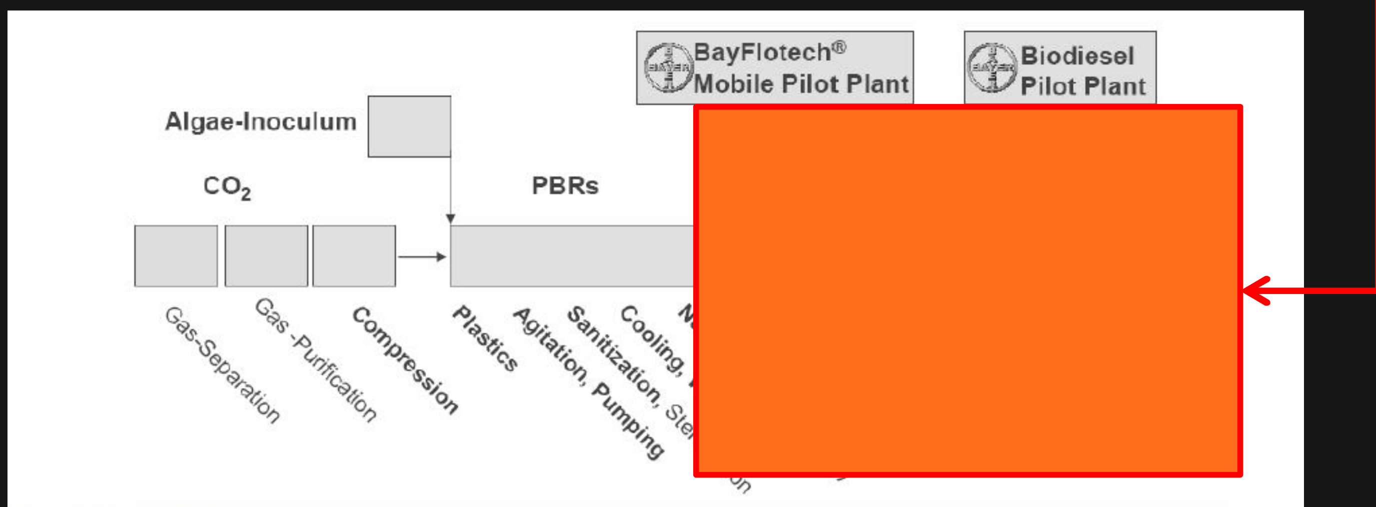
- Algae grow suspended in large volumes of water
- Need cost-effective and energy-efficient dewatering
- Must separate lipid from biomass efficiently
- Need to recycle nutrients and water – conserve resources

Current Technology

- Dewatering (<10% moisture)
  - Filtration
  - Centrifugation
  - Spray Drying
- Lipid Extraction
  - Mechanical (pressing/extrusion)
  - Chemical (solvent extraction)

The Extraction Challenge

- Conventional processing needs dewatering (<10% moisture) before lipid extraction
- High energy cost for dewatering!



Source: Bayer Technology Services.

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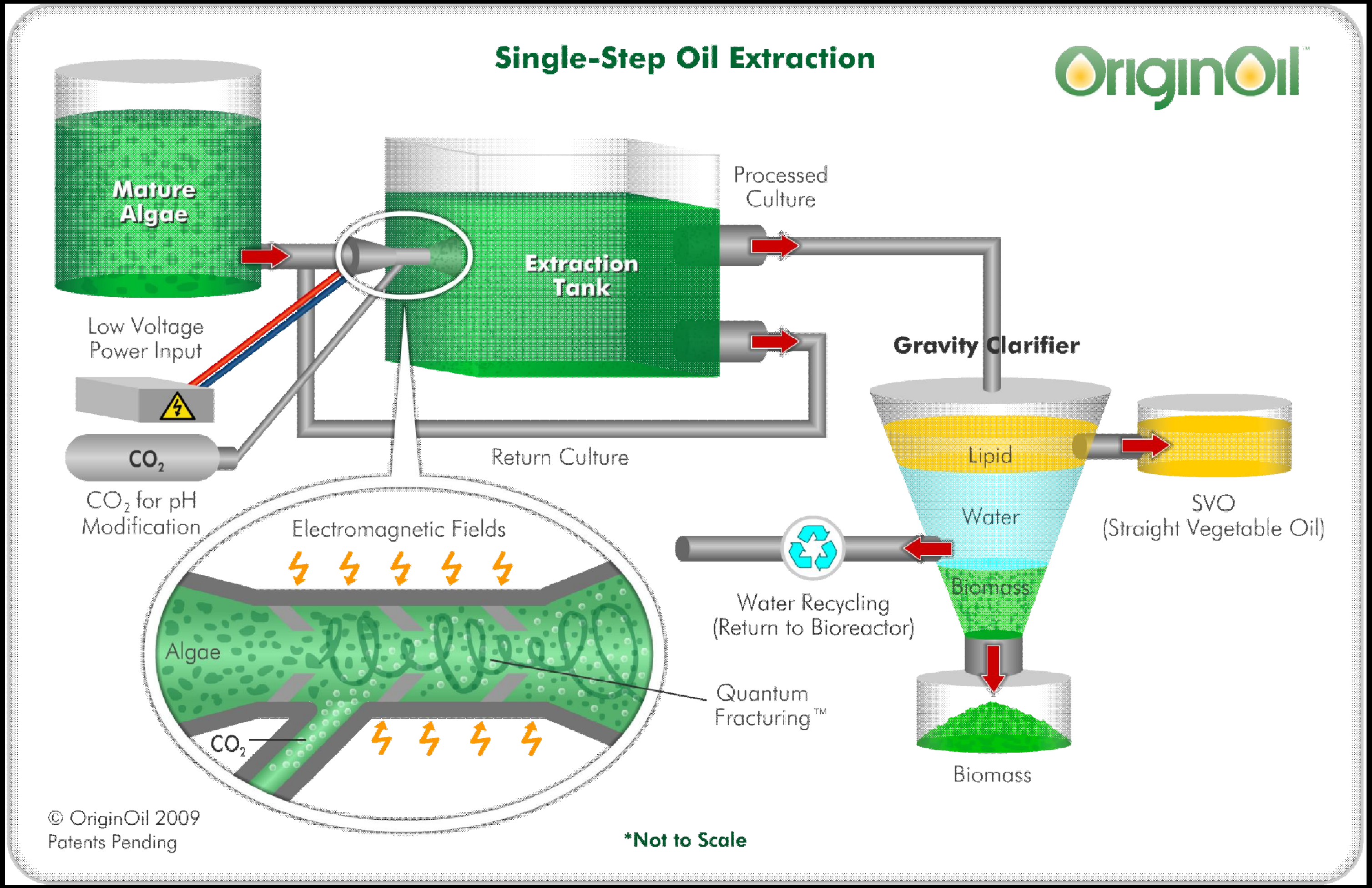
Low-Cost Oil Extraction



Courtesy OriginOil Inc

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OriginOil Extraction Process

- Obviates need for dewatering before lipid extraction
- Approximately 10 times less energy-intensive than conventional process
- Enables recycle nutrients and water – resources conserved!

Potential Solutions to Challenges

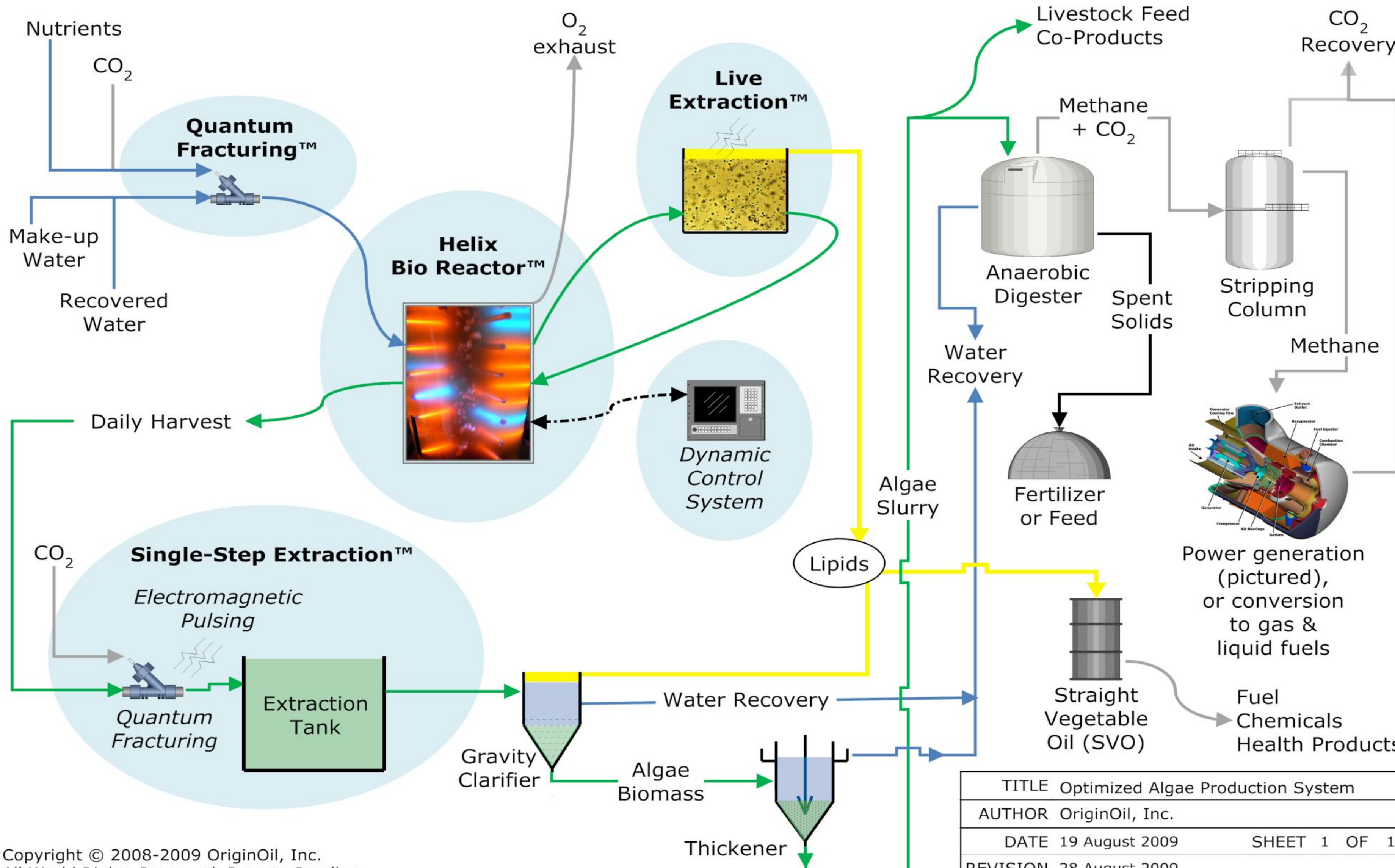
- Optimized Light Delivery
  - **Helix Bioreactor**
- Optimized CO_2 and Nutrient Delivery
  - **Quantum Fracturing**
- Minimal Installation Footprint
  - **Helix Bioreactor**

Potential Solutions to Challenges

- Low-Cost Oil Extraction
  - **Process Innovation**
- Energy-Efficient Continuous Production
  - **Process Innovation**

= Renewable Oil Anywhere, Any time

OPTIMIZED ALGAE PRODUCTION SYSTEM



TITLE	Optimized Algae Production System
AUTHOR	OriginOil, Inc.
DATE	19 August 2009 SHEET 1 OF 1
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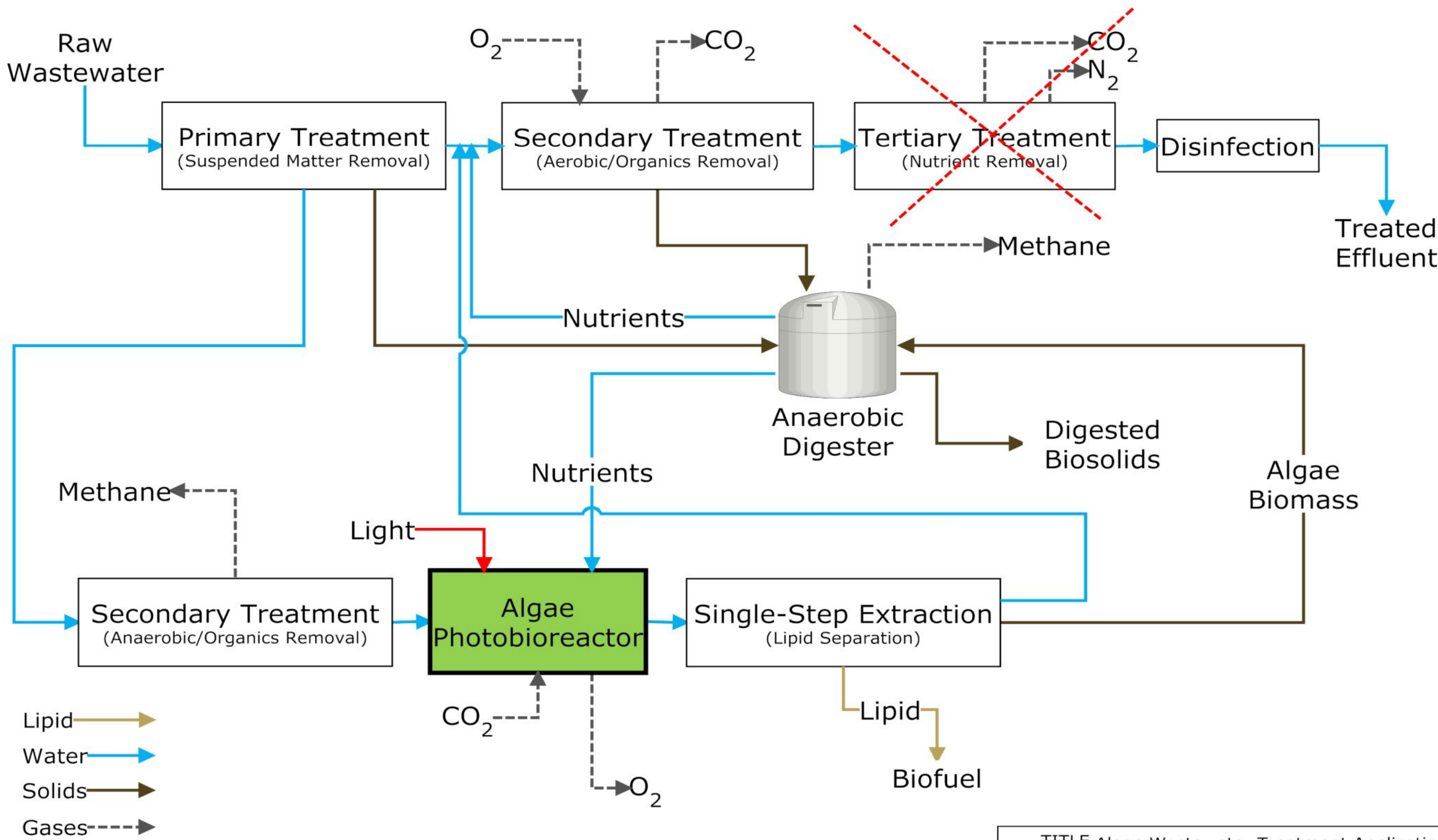
WASTEWATER TREATMENT APPLICATION



TITLE	Algae Wastewater Treatment Application
AUTHOR	Vikram M Pattarkine, PhD
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Concluding Remarks

- Worldwide market demand for biofuels projected to grow to $81 billion by 2017 *(Clean Energy Trends 2008)*
- Algae has the greatest potential
  - High oil content
  - Rapid growth rate
  - Can be converted into liquid fuel and other value added products
- Breakthrough technology being developed to grow algae efficiently and cost-effectively and convert it into renewable biofuel
- On the ground floor of a world-changing energy market

Concluding Remarks

- Economics of algae are complex and challenging
- Current profitability requires:
  - Pursuit of high value co-products
  - Co-location with beneficial site hosts
  - Combine for greatest gain?
- Pursuit of fuel will require:
  - Continued process optimization at all stages
  - Very strong preferences
  - Petroleum price increases
- *With careful planning, algae biofuel can be viable*

THANK YOU!

QUESTIONS?

COMMENTS?

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