ALGAE TO BIOFUEL

2010 SUSTAINABLE ENERGY & INFRASTRUCTURE FORUM

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OriginOil

RESNICKINSTITUTE
science + energy = sustainability

PARSONS

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CALIFORNIA INSTITUTE OF TECHNOLOGY

PRESENTATION OUTLINE

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- Demonstrated Invention – Algae to Biofuel
- Recognized Need
  - Why Algae?
  - Algae Process Challenges
- Process Description – Potential Solutions
- Benefit Compared to Existing Capabilities
- Proposed Path Forward

DEMONSTRATED INVENTION
ALGAE TO BIOFUEL

RECOGNIZED NEED

Why Algae?

- Fastest growing biomass
- No adverse impact on
  - Environment
  - Food supplies
- Can grow using
  - Waste gas (CO_2)
  - Wastewater
  - Waste land
  - Waste energy

Why Algae?

- Highly efficient organism
- Can contain up to 60% lipids
- **Oil Yield (gal/ac)**
- Corn 18
- Cotton 35
- Soybean 48
- Jatropha 202
- Palm 635
- Algae (10 g/m^2/d - 15% TAG) 1,200
- Algae (50 g/m^2/d - 50% TAG) 10,000
- Source: NREL - http://www.nrel.gov/docs/fy08osti/42414.pdf

Why Algae?

- Biomass can be digested for methane
- Carbon-neutral energy source

Process Challenges

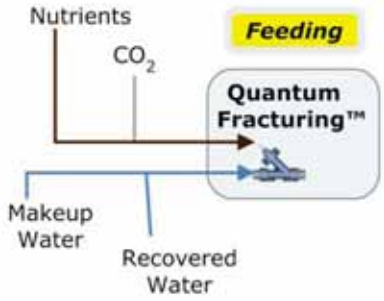
- Algae Growth
  - Must bring together
    - Light
    - CO_2
    - Nutrients
    - Water
  - Should have least footprint
- Oil extraction
  - Must be energy efficient
  - Should ideally use no chemicals

PROCESS DESCRIPTION

ALGAE PRODUCTION SYSTEM

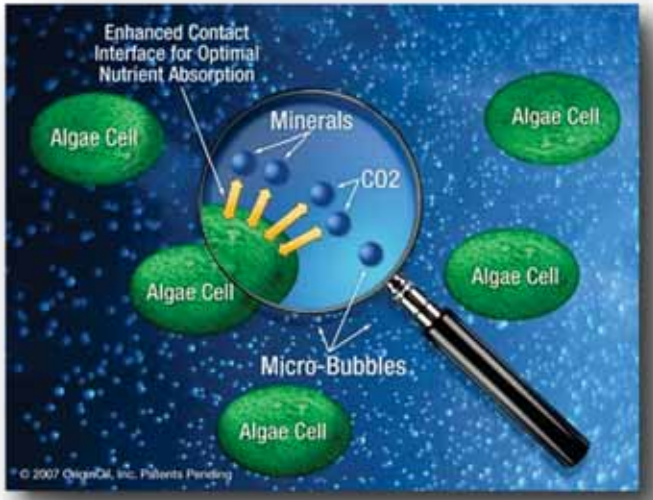
OriginOil™

OPTIMIZED ALGAE PRODUCTION SYSTEM



Quantum Fracturing
An ultra-efficient microbubble device to optimize distribution of CO2 and nutrients throughout the algae culture.

Dynamic Control System
Biofeedback system that allows the algae to dictate the timing and volume of nutrients and other factors to optimize growth.



TITLE	Optimized Algae Production System
AUTHOR	OriginOil, Inc.
DATE	19 August 2009 SHEET 1 OF 1
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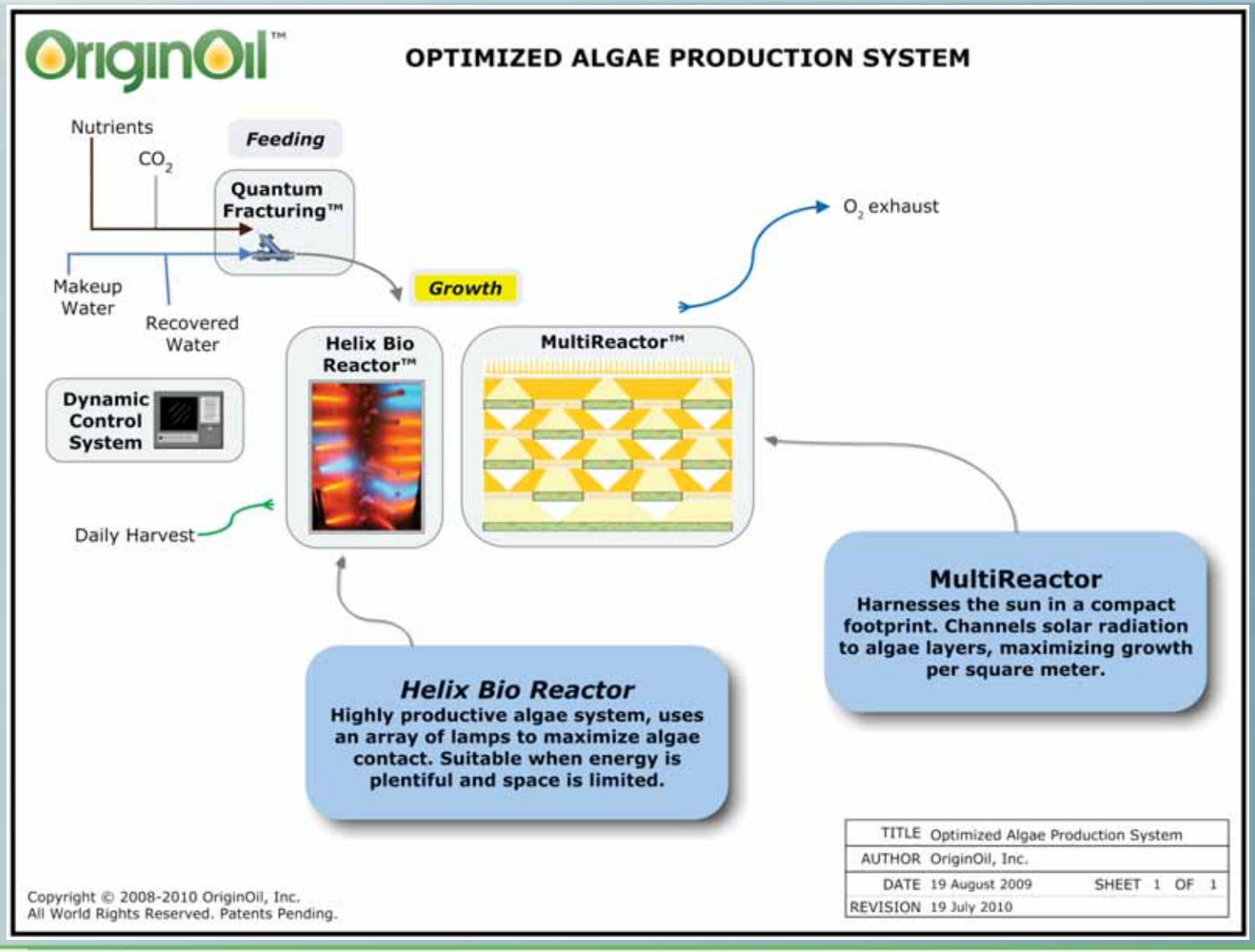
ALGAE PRODUCTION SYSTEM



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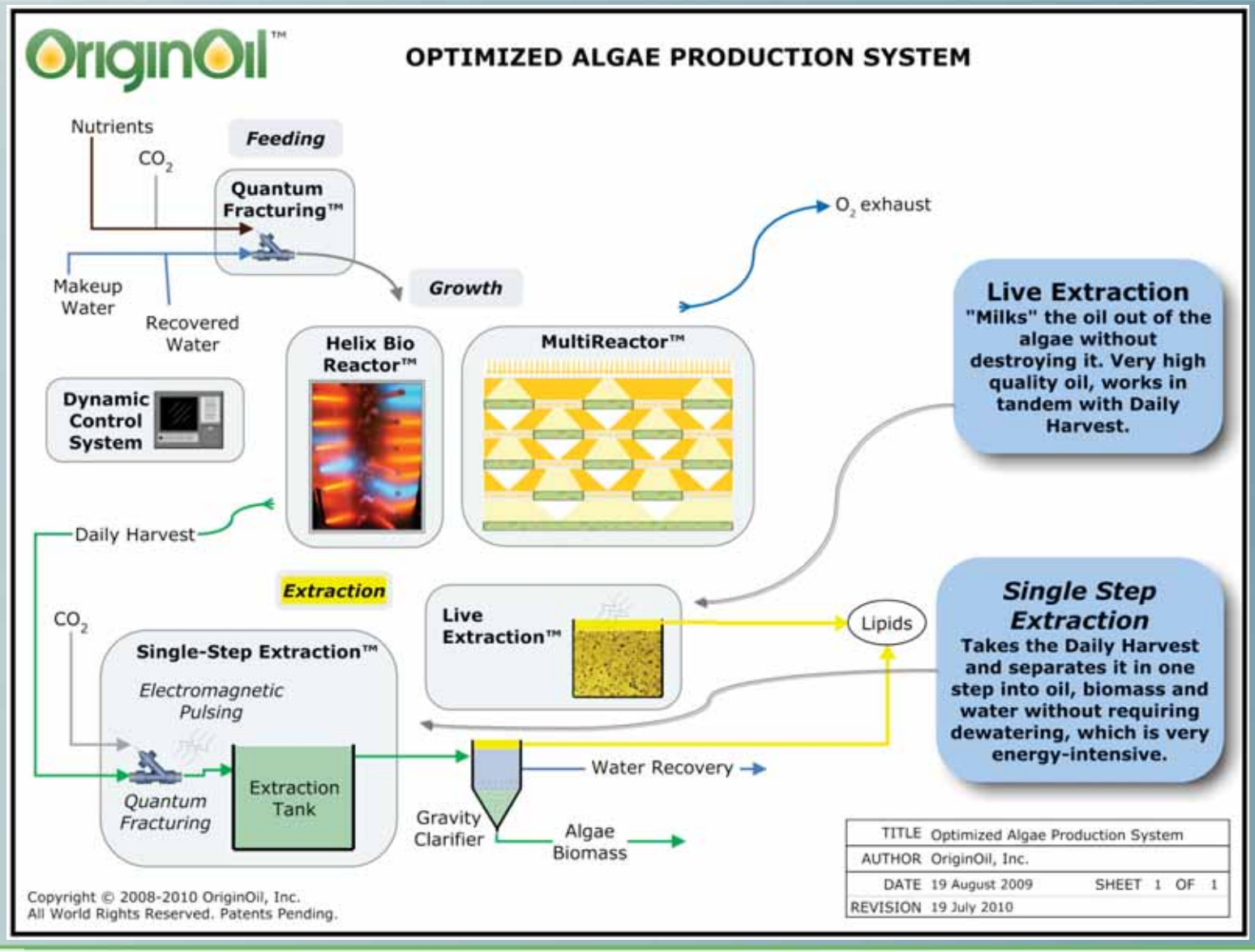

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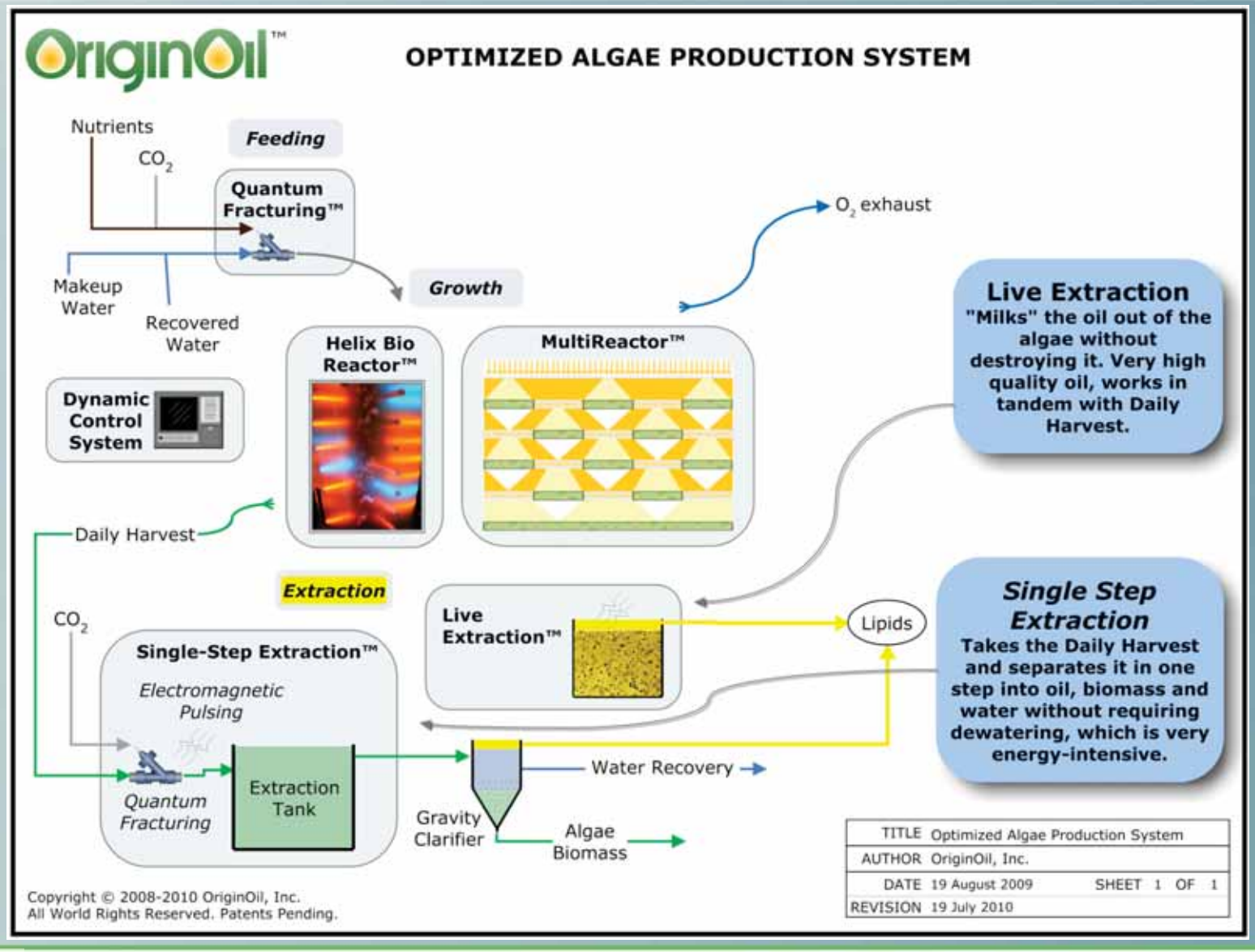

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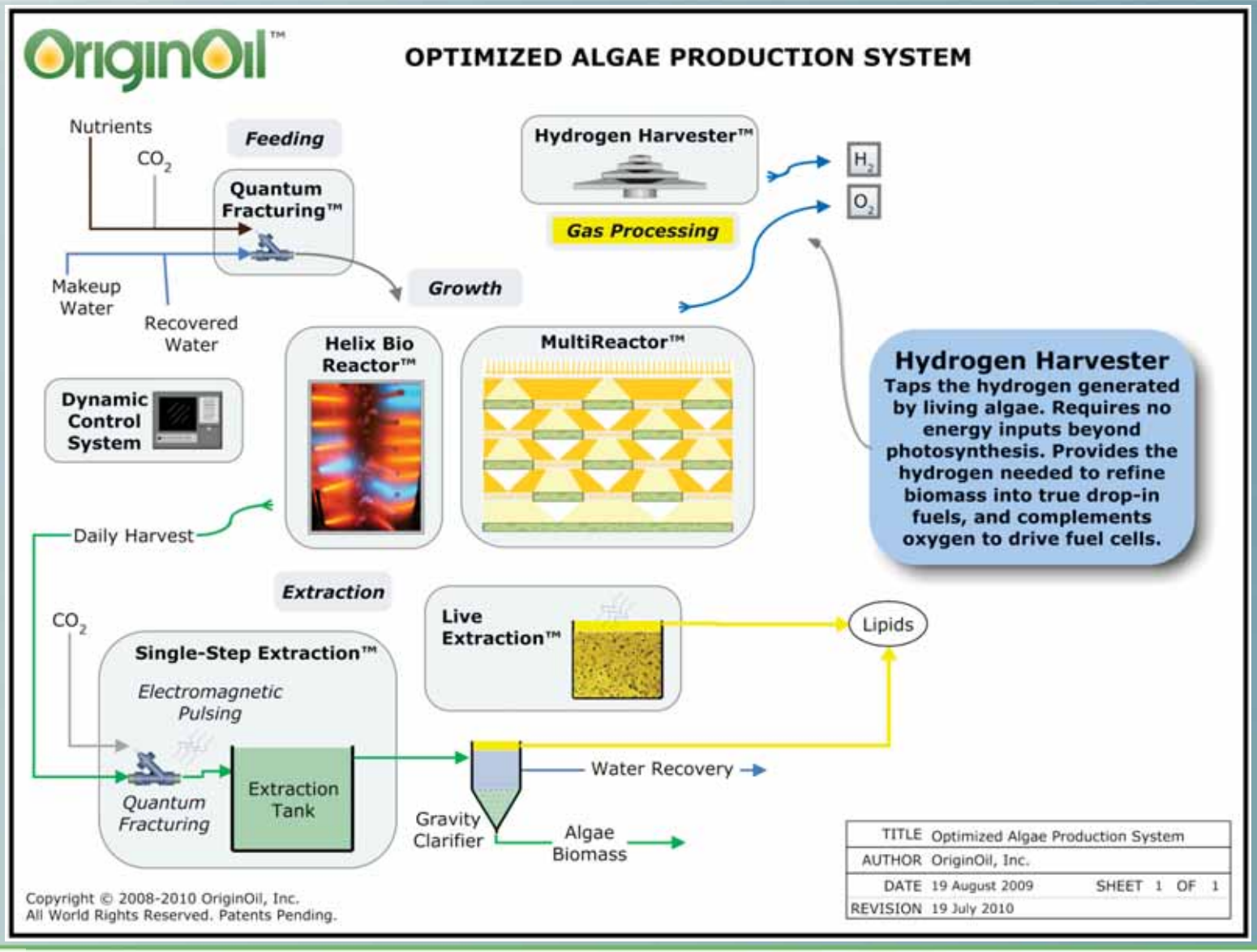

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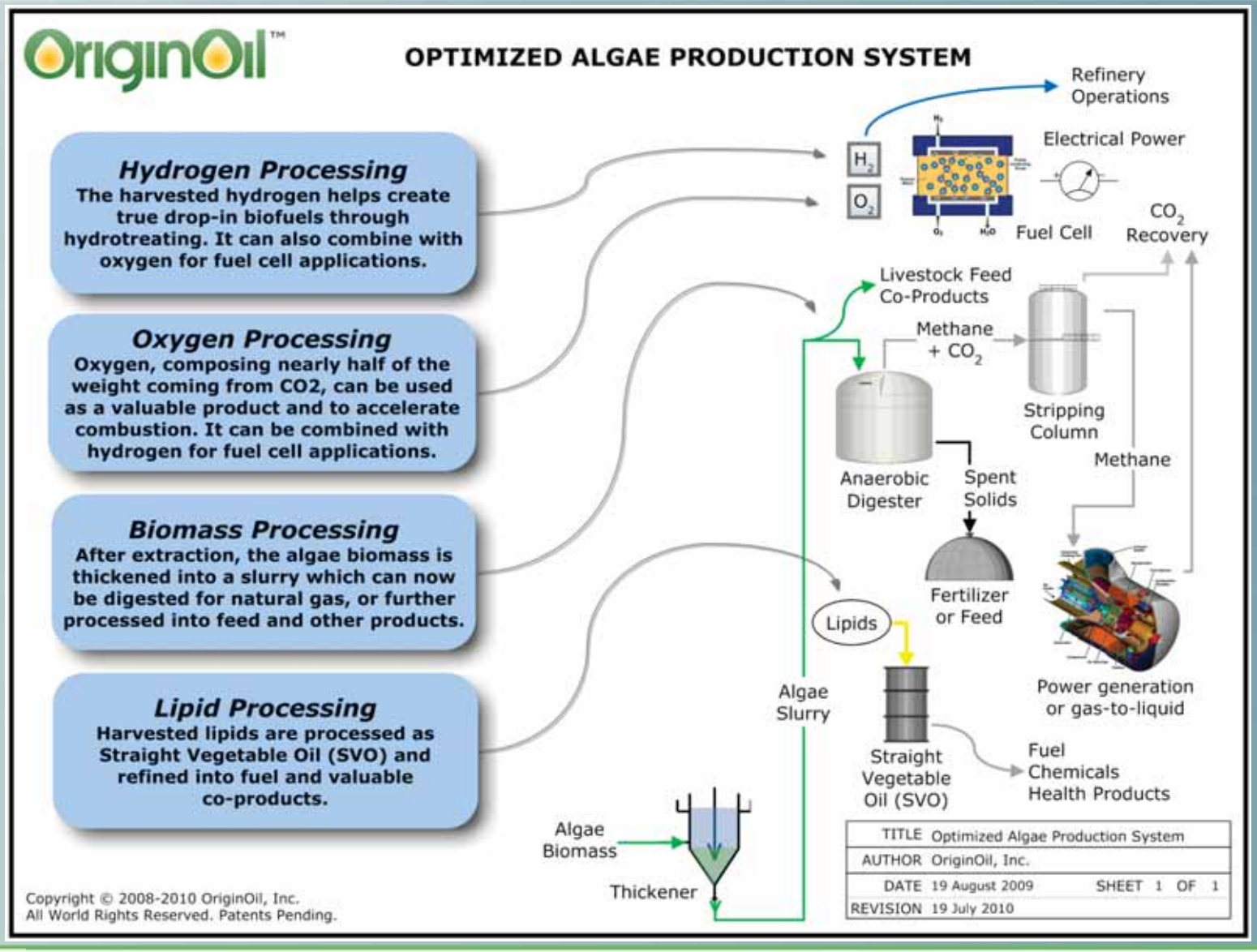

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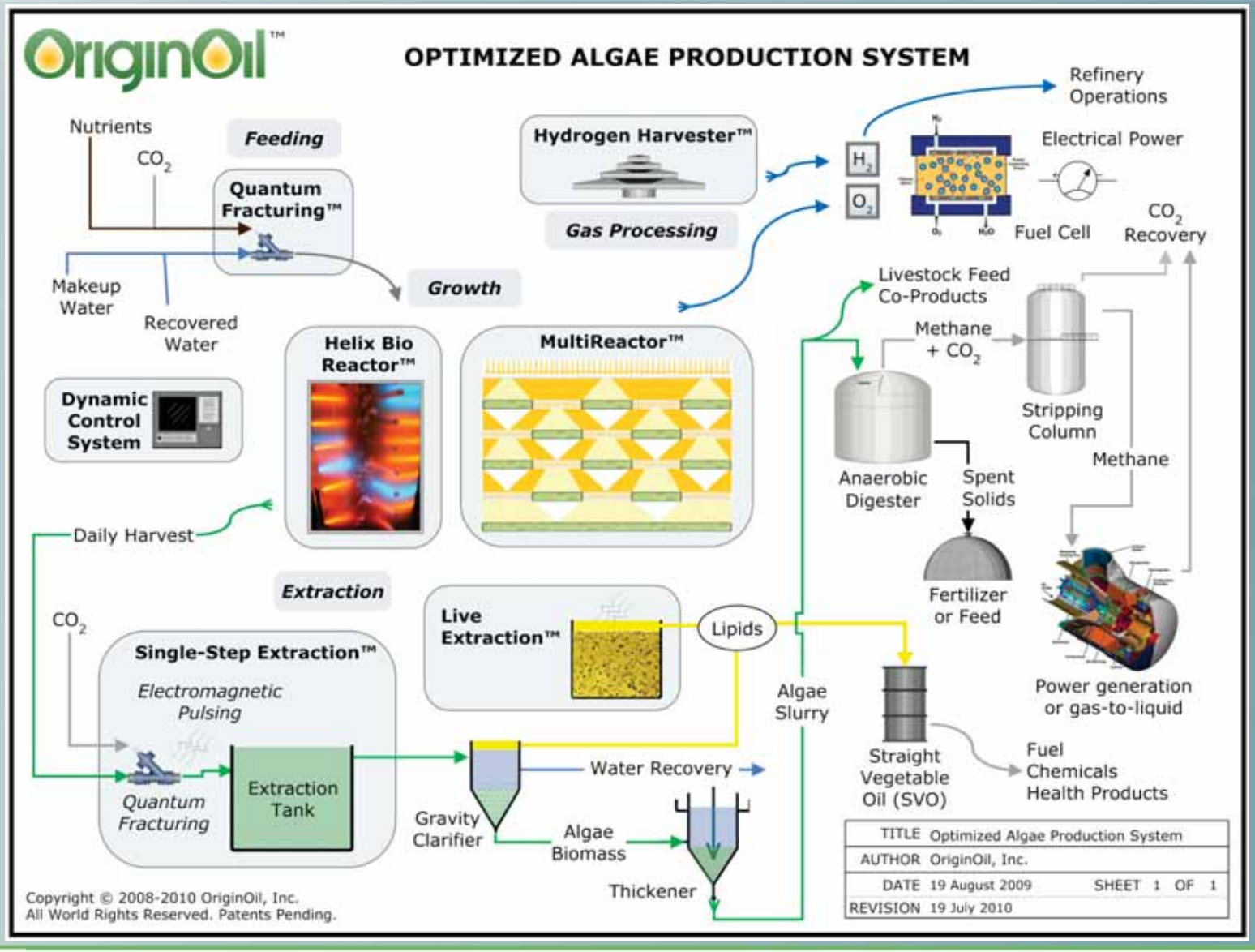


BENEFIT COMPARED TO EXISTING CAPABILITIES

KEY TECHNOLOGY INNOVATIONS

- Quantum Fracturing
  - Optimized nutrient delivery
  - Minimal disruption to culture

KEY TECHNOLOGY INNOVATIONS

- 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

KEY TECHNOLOGY INNOVATIONS

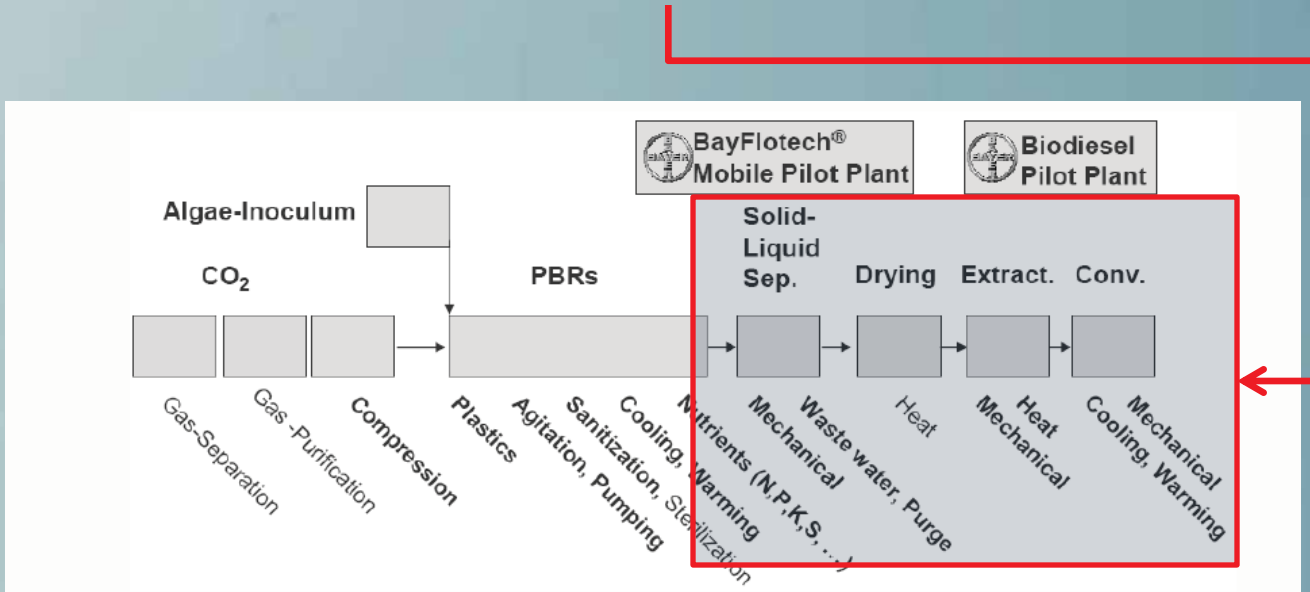
- Lipid Extraction Challenge
  - Algae grow suspended in large volumes of water
  - Need cost-effective and energy-efficient dewatering
  - Must separate lipid from biomass efficiently
  - Need to recycle nutrients and water – conserve resources

KEY TECHNOLOGY INNOVATIONS

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

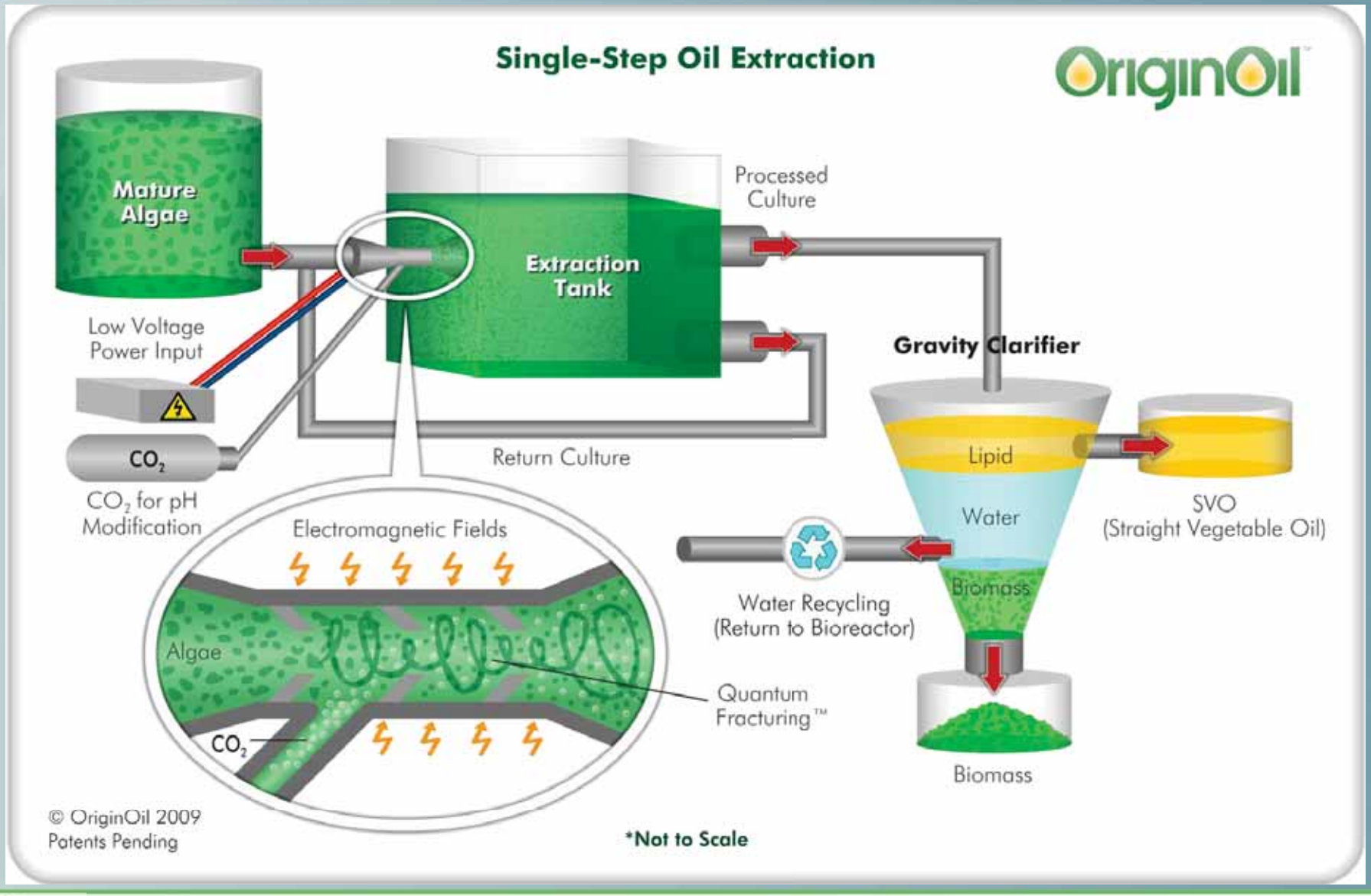
KEY TECHNOLOGY INNOVATIONS

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



Source: Bayer Technology Services.

KEY TECHNOLOGY INNOVATIONS



KEY TECHNOLOGY INNOVATIONS

- SSE Process Advantages
  - Obviates need for dewatering before lipid extraction
  - Requires approximately 10 times less energy than conventional process
  - Enables recycle of nutrients and water – resources conserved!

PROPOSED PATH FORWARD

Similar to intel rather than Exxon

- Like the giants of crude oil, the first-wave of algae oil companies have invested hundreds of millions of dollars in infrastructural build-out, vertical production, and head-to-head competition.

- OriginOil, on the other hand, is a pure *technology* company – competing with few while looking to partner with many.

Similar to intel rather than Exxon

- OriginOil's mission is to design and continually adapt the world's dominant technological platform for algae oil production.

- The Company will commercialize its technology through an integrated system of global partners, including:
  - Original Equipment Manufacturers (OEMs)
  - Country and Regional Partners
  - Device and Component Manufacturers
  - Service and Maintenance Providers
  - Customized Application Developers

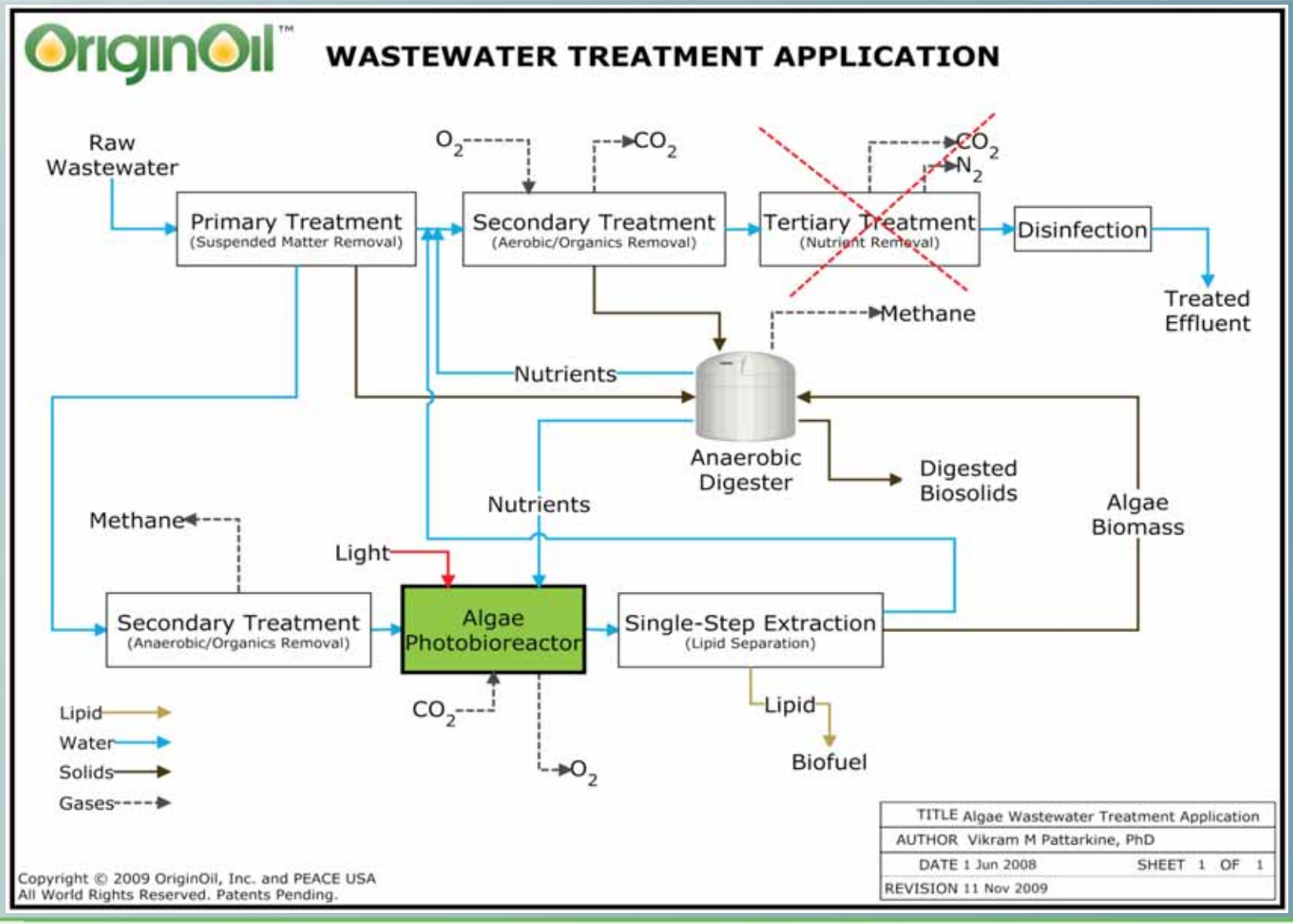
Similar to intel rather than Exxon

OriginOil's distributed partnership model offers a host of potential advantages, including:

- Limited Capital Requirements
- Clean balance sheet and minimal leverage requirements
- Streamlined operational focus on R&D, marketing, and "first mover" product line evolution
- Scalable model for regional and global markets
- Diversified revenue streams

Similar to intel rather than Exxon

Wastewater Treatment Application



APPENDIX: PROCESS CALCULATIONS

Process Calculations

- How much land?
- How much water?
- Let's do the calculations…

How much land and water?

- 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%

How much land and water?

- Calculations for 10000 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

How much land and water?

- To harvest 25% biomass every day…
- Must maintain 30.7 T/d / 0.25 = 123 T of biomass in the system

How much land and water?

- How much water?

- (123 T x 1000 kg/T) / (0.25 kg/m^3)
- = 490,000 m^3 of water = 490 ML = 129 MG

How much land and water?

- 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 g/m^2/d

How much land and water?