ALGAE PRODUCTIVITY MODEL

ALPHA RELEASE

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A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

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Our Mission

- **TO HELP OTHERS MAKE ALGAE**
- Key to success: a global network of…
  - R&D Partners
  - OEMs
  - Application & Service Providers
  - Regional Distributors
- OriginOil supports its network with:
  - Proprietary devices, technology, processes, best practices
  - Certification, financing, carbon credits
  - Access to application and service providers
- *Commitment to broad–based knowledge sharing*

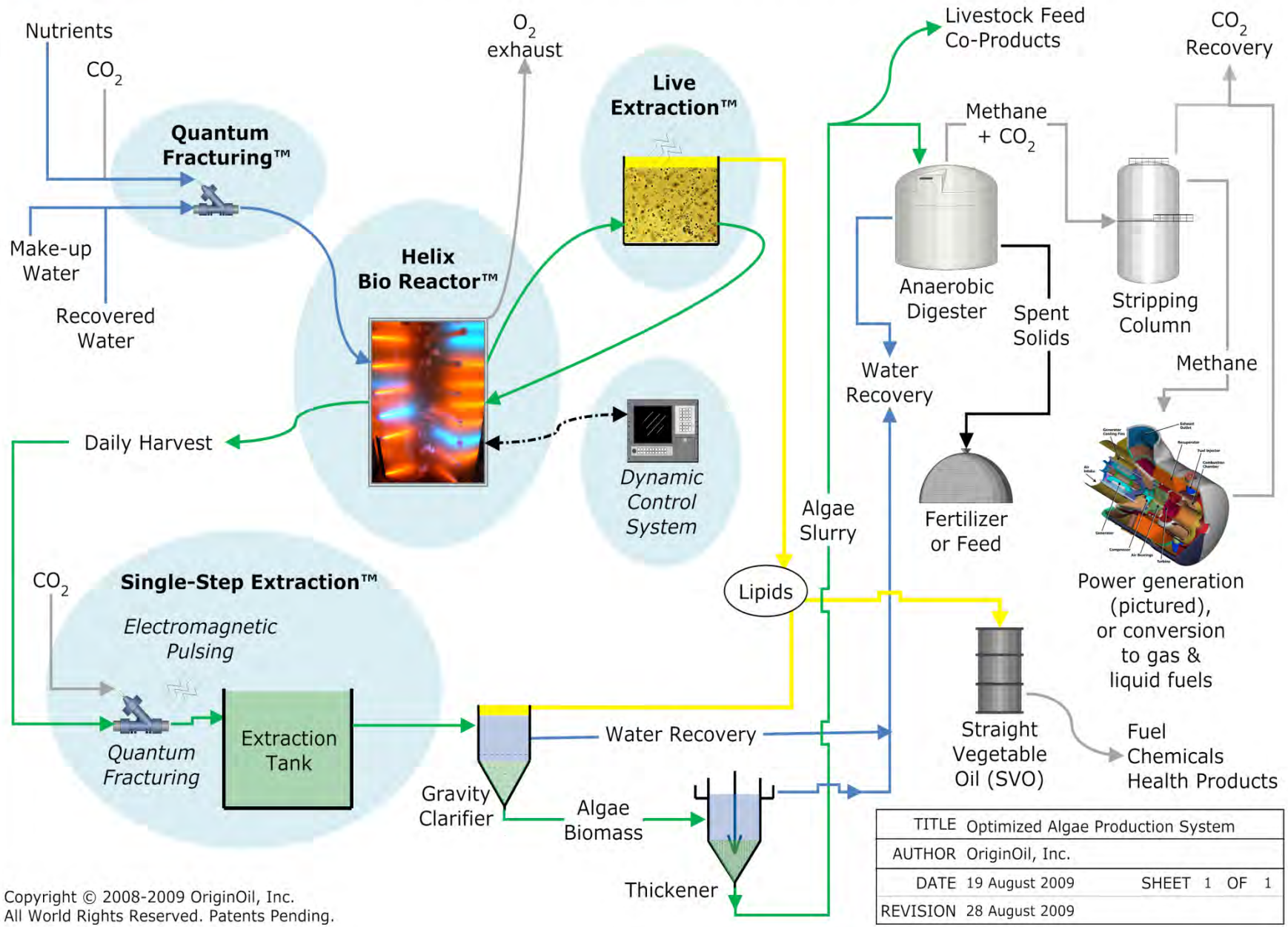
Algae Promises

- Fastest growing biomass
- Can grow on
  - Waste nutrients
  - Waste water
  - Waste land
- No adverse impact on environment, food supplies

Technology Challenges

- CO2 and Nutrient Delivery
- Light Delivery
- Land Use
- Extraction Efficiency
- Harvesting Rates

OPTIMIZED ALGAE PRODUCTION SYSTEM



TITLE	Optimized Algae Production System
AUTHOR	OriginOil, Inc.
DATE	19 August 2009 SHEET 1 OF 1
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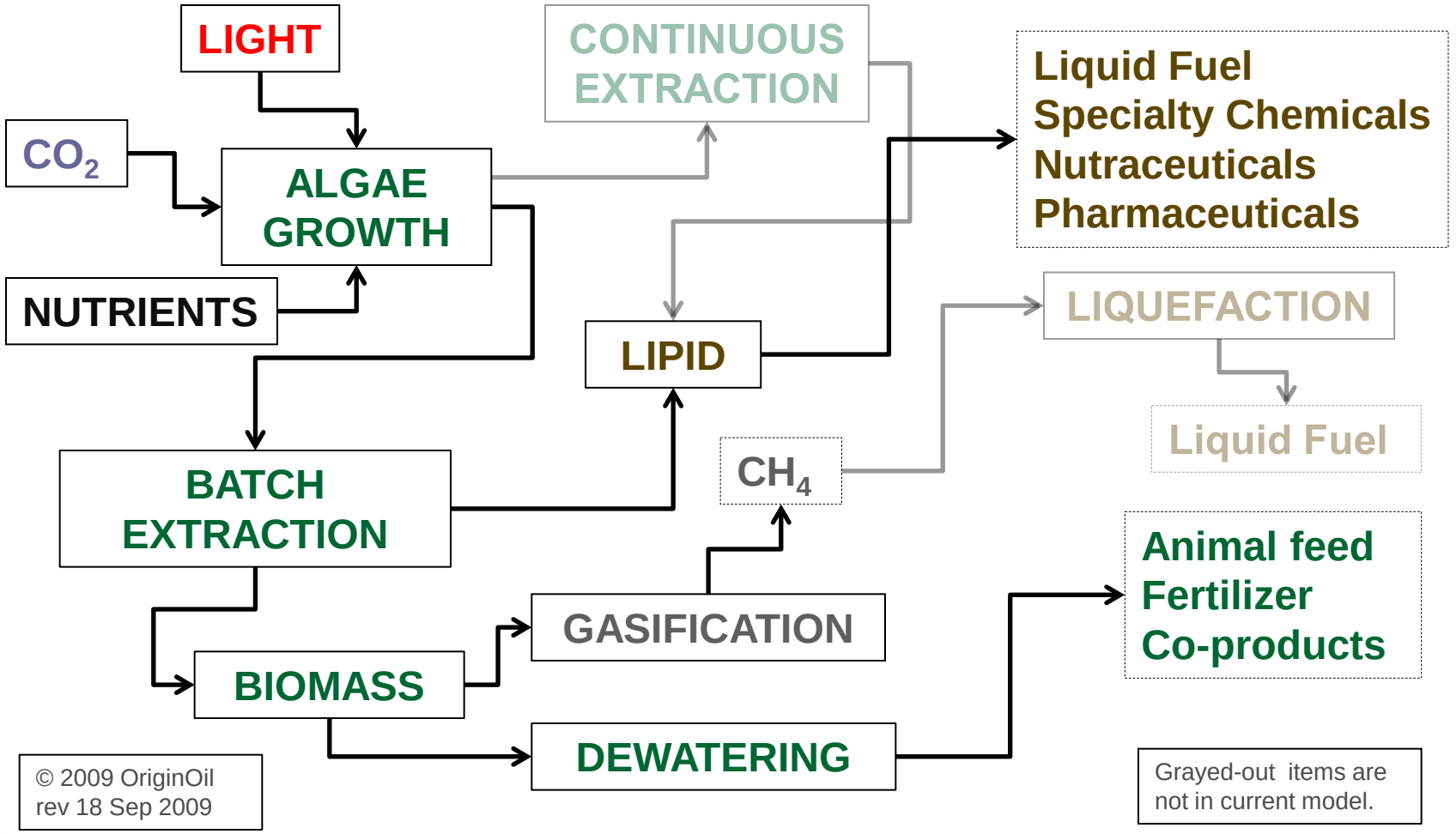
Challenges Addressed!

- CO_2 and Nutrient Delivery: **Quantum Fracturing™**
- Light Delivery: **Helix Bioreactor™**
- Land Use: **Modular Design**
- Extraction Efficiency:
  - **Single Step Extraction™**
  - **Live Extraction™**
- Harvesting Rates: **Cascading Production™**

= Renewable Oil Anywhere, Anytime

Algae Productivity Model



A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Algae Productivity

- Key Variables
  - Algae concentration at harvest
  - Total volume available for algae growth
  - Energy source (waste or ‘free’ energy)
  - Energy inputs
  - Lipid content
  - Lipid extraction efficiency

Algae Productivity

- Algae concentration at harvest
  - 1 g/L considered for productivity model
  - At higher concentration:
    - harvested volume ↓ ∴ processing costs ↓
    - lighting intensity ↑ ∴ energy requirement ↑

1 g/L may be optimum combination of higher harvest volume with lower energy requirement

Algae Productivity

- Total volume available for algae growth
  - Industrial footprint minimizes acreage, enables co-location with sites for CO_2 etc.
  - Agricultural (open pond) footprint less efficient for acreage but other costs far lower.

Current model considers only an industrial footprint. Other footprints are planned.

Algae Productivity

- Energy source (waste energy)
  - Need “free” energy for algae growth
  - Process waste heat is one source

Algae Productivity

- Energy inputs
  - Algae growth
  - Temperature management
  - Lipid extraction
  - Water handling

Algae Productivity

- Lipid content
  - Depends upon algae species grown
  - 30% considered for model

Algae Productivity

- Lipid extraction efficiency
  - 85-90% in bench-scale testing
  - Low energy requirement
  - Biomass flocculation and separation by gravity without chemical addition

Model Inputs

FACILITY			
Real Estate			
Available Land	1.00	ha	1 - 200 ha
Cost of Land	50,000	$/ha	$10,000 - $100,000
Property Tax	5.00%	%	0 - 10%
Plant			
Surface Area for Growth Tanks	60%	%	40 - 80%
Percentage of Artifical Light Concentration	75%	%	10 - 100%
Finance			
Available Capital (Liquid)	17,339,297	$	
Nominal APR	5.00%	%	1 - 7.5%
Lending Term	20	year(s)	10 - 30 years
RAW MATERIALS			
Amount of "Free" or "Waste" Energy Available Daily	25%		
Cost of Energy	0.08	$/kWh	$0.05 - $0.50/kWh
Cost of Water	2.00	$/kL	$0 - $10.00/kL
Cost of Carbon Dioxide (Purchasing or Treating)	5.00	$/MT	$0 - $10/MT
Cost of Nitrogen	2.50	$/kg	$0 - $5.00/kg
Cost of Phosphorus	1.00	$/kg	$0 - $5.00/kg
PROCESS			
Biomass Concentration at Time of Harvest	1.00	g DWT /L	0.5 - 5.0 g DWT/L
Lipid Percentage	30%	%	10 - 60%
Extraction Efficiency	90%	%	80 - 95%

Typical Revenue by Product

ESTIMATED REVENUE FROM DOWNSTREAM PRODUCTS			
Lipids (SVO)			**Suggested Ranges**
Fuel	$0.80	$/L	$ 0.70 - 0.80/L
Specialty Chemicals	$2.00	$/L	$ 1.50 - 2.00/L
Nutraceuticals	$2.00	$/L	$ 1.50 - 2.00/L
Pharmaceuticals	$2.00	$/L	$ 1.50 - 2.00/L
Biomass			
Methane	$10.00	$/28 cu m	$5.00 - $10.00/28 cu m
Livestock Feed	$1.00	$/kg	$0.35 - $1.00/kg
Fertilizer	$0.20	$/kg	$0.10 - $0.20/kg
Specialty Materials	$0.50	$/kg	$0.25 - $0.50/kg
Food Products	$3.00	$/kg	$2.00 - $3.00/kg
ESTIMATED REVENUE FROM ANCILLARY SOURCES			
Carbon Credits			
Value of Carbon Credits	$25.00	$/MT	$5.00 - $30.00/MT
Wastewater Treatment			
Value of Wastewater Treatment Credits	$0.00010	$/L	Placeholder Value

Baseline Scenario

- Self-financed capital structure
- Energy partly from waste/free sources (25%)
- Blend of products heavily weighted toward specialty chemicals, assisted by profitable pharmaceuticals, nutriceuticals, food products.

Result: slightly profitable (4% Net)

Product Allocation, Baseline Scenario

ALLOCATION OF UNREFINED FEEDSTOCK		
Lipids (SVO)		
Fuel	20%	%
Specialty Chemicals	50%	%
Nutraceuticals	20%	%
Pharmaceuticals	10%	%
Biomass		
Methane	35%	%
Livestock Feed	45%	%
Fertilizer	0%	%
Specialty Materials	0%	%
Food Products	20%	%

Baseline Results per Hectare

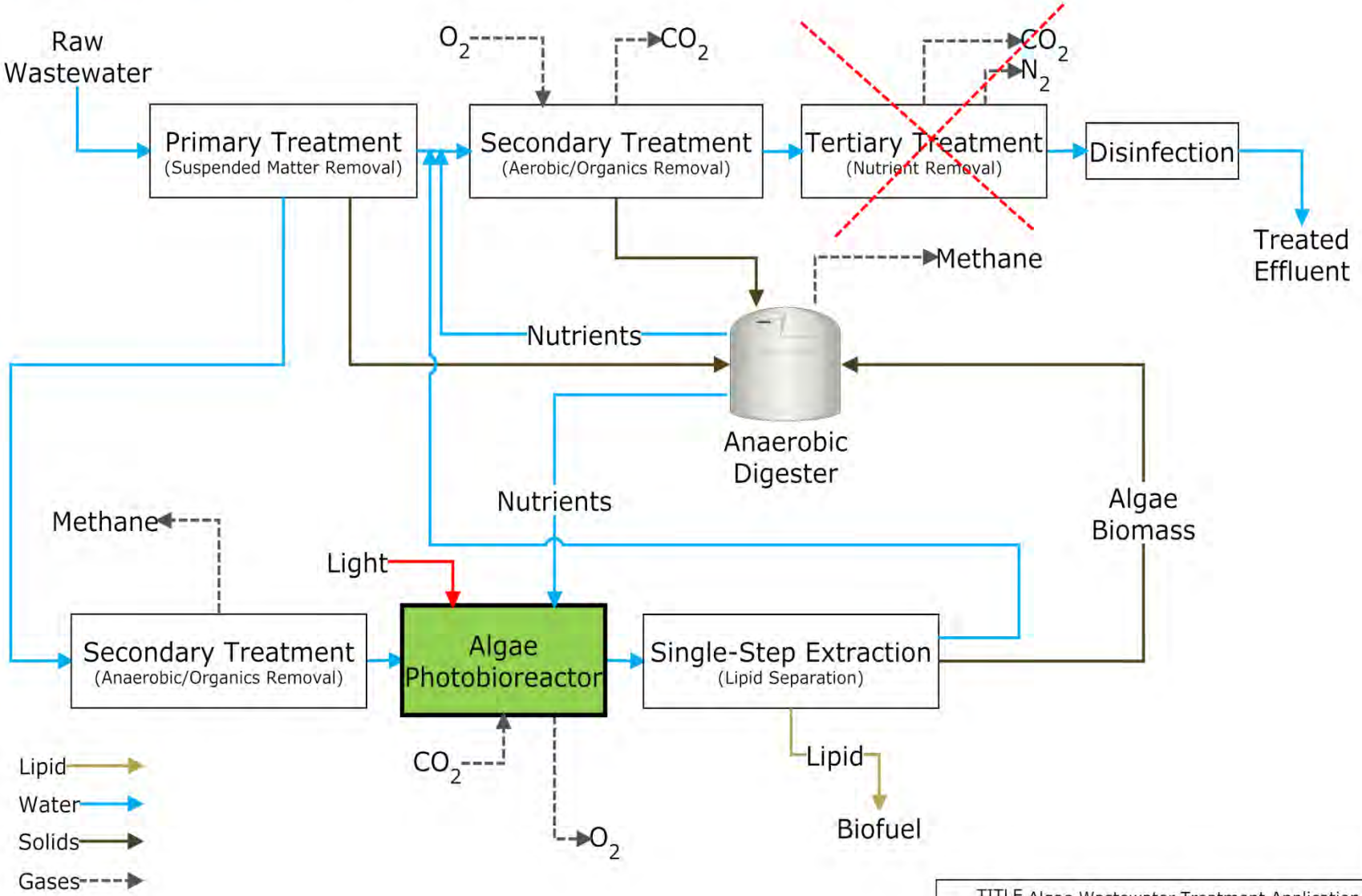
PRODUCT YIELDS			
Daily Lipid Harvest	2,478	L	
Daily Biomass Harvest (after oil extraction)	6,982	kg	
PRODUCTION COSTS			
Cost of Producing Lipid ($/L)	1.45	$/L	
Cost of Producing Biomass ($/kg)	1.20	$/kg	
REVENUE			
Ancillary Sources			
Daily Revenue from Carbon Credits	456	$	
Daily Revenue from Wastewater Treatment	0	$	
Lipids (SVO)			
Daily Revenues from Fuel	396	$	
Daily Revenues from Specialty Chemicals	2,478	$	
Daily Revenues from Nutraceuticals	991	$	
Daily Revenues from Pharmaceuticals	496	$	
Biomass			
Daily Revenues from Methane	292	$	
Daily Revenues from Livestock Feed	3,142	$	
Daily Revenues from Fertilizer	0	$	
Daily Reveunes from Specialty Materials	0	$	
Daily Revenue from Food Products	4189.068166	$	
Annual Revenue	**4,353,800**	**$**	
Annual Costs (Debt Service + Operating Costs)	**4,179,452**	**$**	
Annual Profit/Loss	**174,347**	**$**	4.00%

Wastewater Treatment

- Co-location with wastewater treatment creates synergies:
  - For the wastewater plant:
    - De-nitrification stage eliminated
    - Algae filtering role
  - For algae:
    - Plentiful nutrients, energy
    - Reduced water handling costs

Result: Solidly Profitable (20% Net) – even though food-grade products not feasible.

WASTEWATER TREATMENT APPLICATION



TITLE	Algae Wastewater Treatment Application
AUTHOR	Vikram M Pattarkine, PhD
DATE	1 Jun 2008 SHEET 1 OF 1
REVISION	17 Sep 2009

Product Allocation, Waste Water Treatment

ALLOCATION OF UNREFINED FEEDSTOCK		
Lipids (SVO)		
Fuel	10%	%
Specialty Chemicals	90%	%
Nutraceuticals	0%	%
Pharmaceuticals	0%	%
Biomass		
Methane	10%	%
Livestock Feed	90%	%
Fertilizer	0%	%
Specialty Materials	0%	%
Food Products	0%	%

Wastewater Results per Hectare

PRODUCT YIELDS			
Daily Lipid Harvest	2,478	L	
Daily Biomass Harvest (after oil extraction)	6,982	kg	
PRODUCTION COSTS			
Cost of Producing Lipid ($/L)	1.21	$/L	
Cost of Producing Biomass ($/kg)	1.00	$/kg	
REVENUE			
Ancillary Sources			
Daily Revenue from Carbon Credits	456	$	
Daily Revenue from Wastewater Treatment	997	$	
Lipids (SVO)			
Daily Revenues from Fuel	198	$	
Daily Revenues from Specialty Chemicals	4,460	$	
Daily Revenues from Nutraceuticals	0	$	
Daily Revenues from Pharmaceuticals	0	$	
Biomass			
Daily Revenues from Methane	83	$	
Daily Revenues from Livestock Feed	6,284	$	
Daily Revenues from Fertilizer	0	$	
Daily Reveunes from Specialty Materials	0	$	
Daily Revenue from Food Products	0	$	
Annual Revenue	**4,367,455**	**$**	
Annual Costs (Debt Service + Operating Costs)	**3,492,627**	**$**	
Annual Profit/Loss	**874,828**	**$**	20.03%

Conclusions

- Economics of algae are complex and challenging
- Current profitability requires:
  - Focus on 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
    - grants, subsidies, tax & carbon policy, etc.
  - Petroleum price increases desirable but not essential.
- *With careful planning, algae can prosper today.*

Where Do We Go From Here?

- Alpha release:
  - Immediate improvements – collaborators wanted!
  - Please email: wiki@originoil.com
- Beta releases:
  - Scenario calculators on website
  - Full model available to partners
- General release:
  - Wiki process enabled for long-term development
  - Industry group hosting (e.g. NAA) for objectivity
- *A valid dynamic model is critical to our industry's growth!*

Key Acknowledgments

- Tom Ulrich and Team – Idaho National Lab, Department of Energy:
  - Development of base energy and mass balance (under collaborative research agreement with OriginOil)
- Tim Kemper, CEO of Desmet Ballestra North America:
  - Assistance in modeling capital costs and materials pricing
- Philippe Willems, Partner, Orineo:
  - Guidance on pricing and value-add product strategy

THANK YOU!

QUESTIONS?

COMMENTS?

partners@originoil.com

(SEE FOLLOWING SLIDES FOR PRODUCT PRICING GUIDANCE)

Pricing Guidance (Oil)

- Oil for fuel: equivalent to soy, palm, canola/rapeseed, $0.65-0.80/l long term.
- Markets for unique composition of algae oil: nutriceuticals, pharma, chemical. Benchmark: fish oil sells at $1.5 – 2.0/kg in those markets.
- Highly processed algae feedstock: e.g. oil for Omega-3 to sell at $150/kg. Oil for specific applications such as alkyd resins, paint & varnishes $3-5/kg.

Source: www.orineo.com 2009

Pricing Guidance (biomass)

- Biomass for feed: 1kg pure protein with balanced amino acid profile = $1/kg.
- Algae biomass as fertilizer $0.20/kg, tonnages 100,000,000 T worldwide.
- **Selling algae biomass to third parties for gasification is like wasting gold:** you never get any value for it as such plants can run on mixed agro waste. Invest in gasification and you get the energy value + related subsidies.

Source: www.orineo.com 2009

Pricing Guidance: (specialty)

- Specialty materials: algae fractions for bioplastics at $2/kg; functional proteins $5/kg (vs. best feed value at $1/kg); specialty extract products e.g. $200/kg for synthetic astaxanthin; natural alternatives much more expensive.
- *Rough* example of multiple algae valorization: an algae with 50% proteins, 10% fats (of which 3% omega-3), 30% carbohydrates, 5% colorants, anti- oxidants... could be valued at >$30/kg. However, tonnages are limited and quality requirements high.

Source: www.orineo.com 2009