Phytonix
The Future of Fuel®

Biosafety-guarded Production of Solar Chemicals and Fuels

Sustainable Chemistry Powered by the Sun™

The National Academies of Sciences - Engineering - Medicine
San Francisco,June 27th, 2016

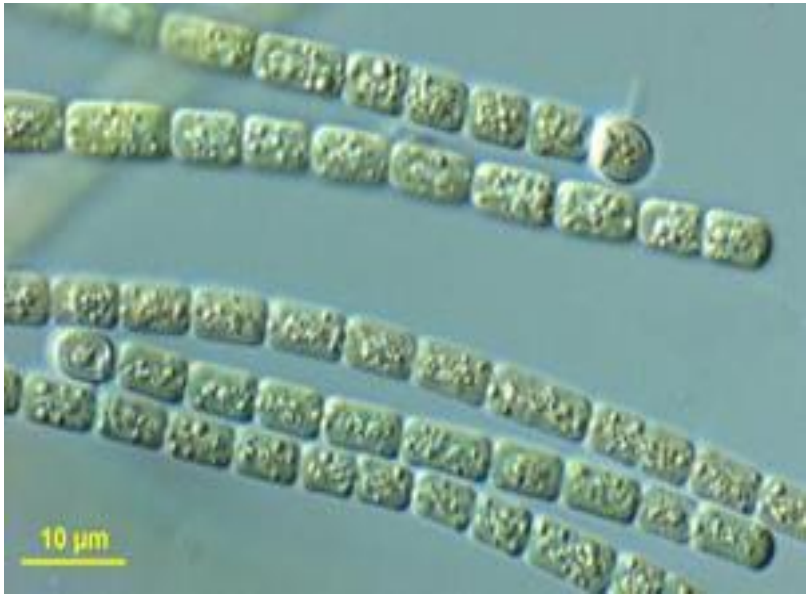
Bruce Dannenberg,
Founder & CEO
bruce@phytonix.com
+1 (828) 230-5892

Gordon Skene,
Executive Vice President & Director
gordon@phytonix.com
+1 (604) 790-8989

www.Phytonix.com

Phytonix uses cyanobacteria as microbial butanol factories

Cyanobacteria are tiny photosynthetic microorganisms abundant in all climates



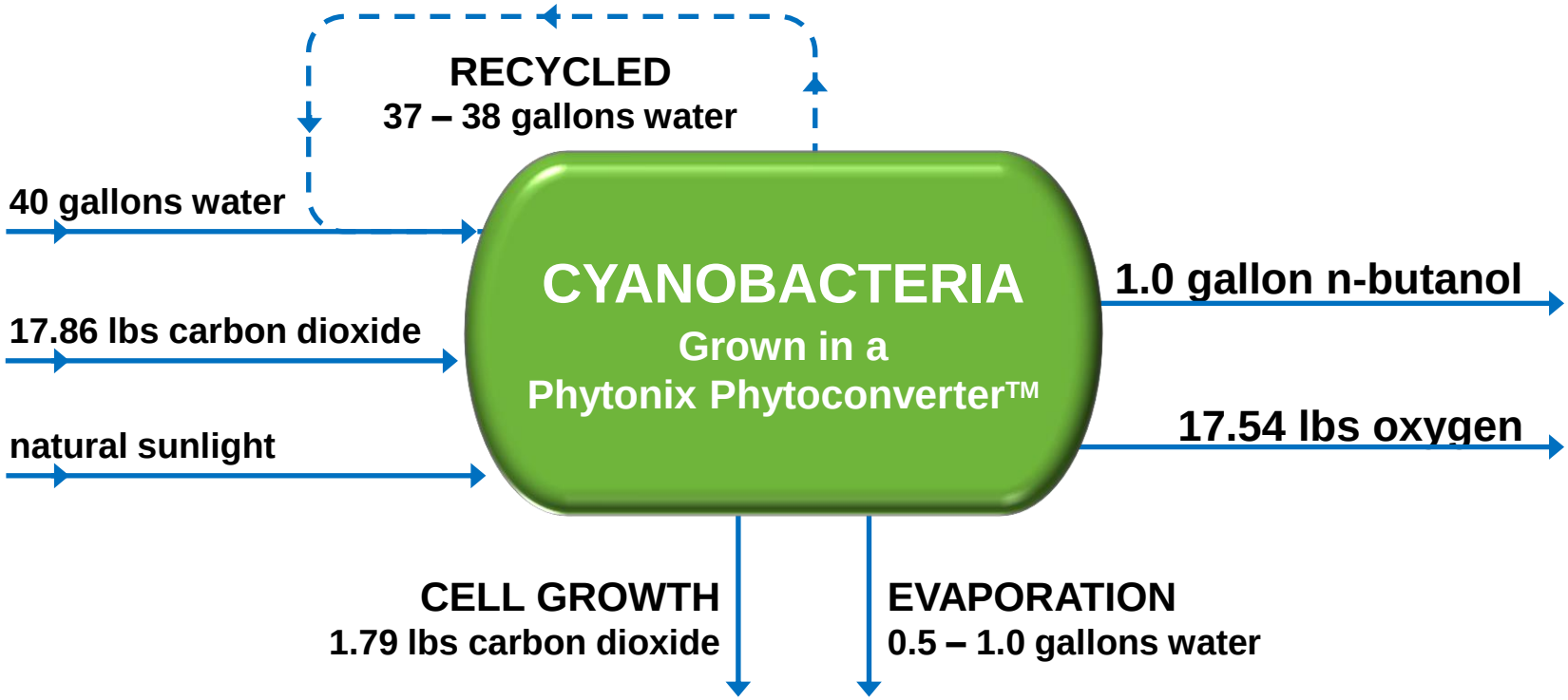
Blue-green aquatic phytoplankton are a type of cyanobacteria

Phytonix has developed genetically engineered cyanobacteria **that directly secrete 100% n-butanol from CO_2 emissions**

Phytonix
The Future of Fuel®

Microbial Chemical Factories

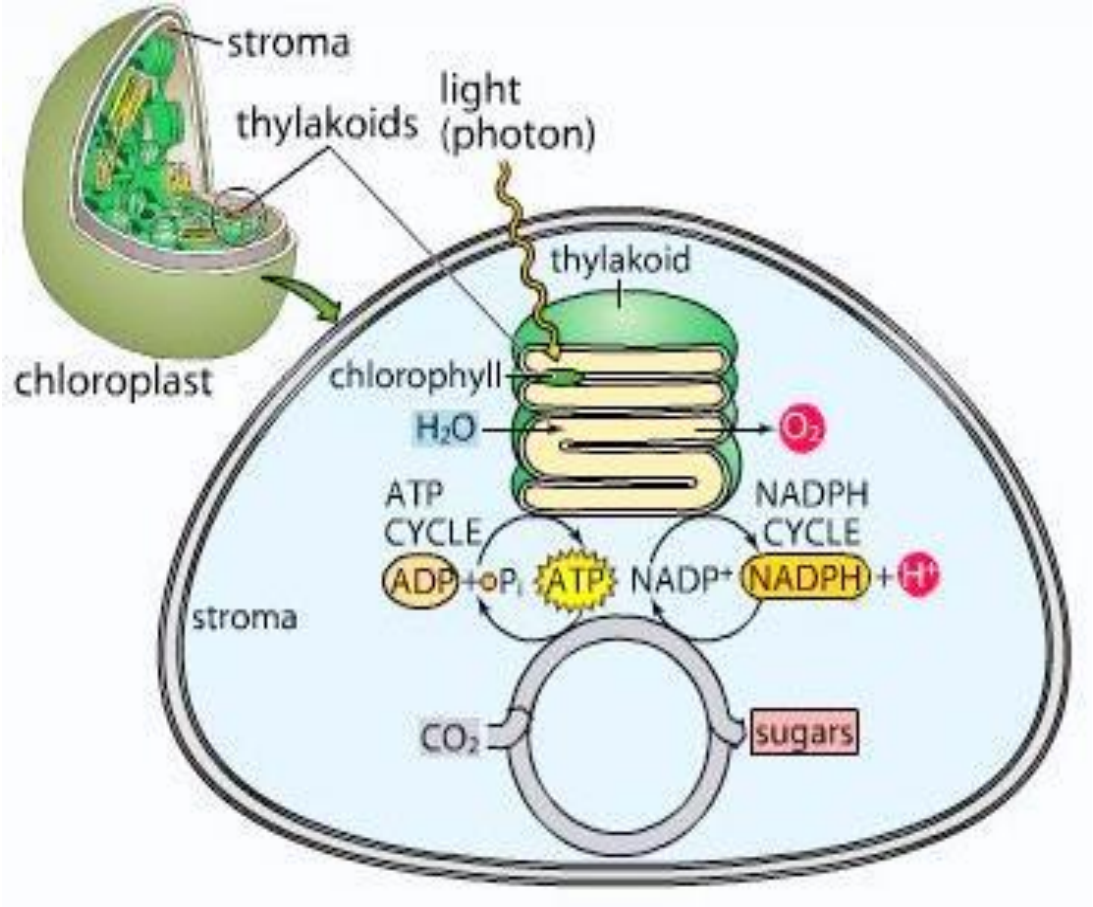
For every gallon of n-butanol produced
16.3 pounds (net) of carbon dioxide is consumed



Production generates 1.3 – 1.5 lbs carbon dioxide

Phytonix
The Future of Fuel®

Photosynthesis and the Calvin Cycle



Photosynthesis in plants, such as algae and cyanobacteria, typically produces sugars from CO_2 using energy from the sun.

Phytonix has globally patented technology for engineering cyanobacteria to **directly produce n-butanol and other chemicals instead of sugars from CO_2**, with oxygen as the co-product.

Phytonix
The Future of Fuel®

Photobioreactors to Grow Cyanobacteria

Phytonix "Basic" photobioreactors (PBRs) will produce 83,000 gallons of butanol / acre / year.

Phytonix
The Future of Fuel®

Solar Chemicals and Fuels: 2030

- Driven by ongoing advances in synthetic biology, metabolic engineering, proteomics and bioinformatics

- Elimination of industrial CO_2 emissions thru widespread adoption of photobiological solar chemical production

- Elimination of petroleum-based feedstocks in industrial chemical and fuel production

- Sustainable, bio-based production of carbon negative industrial chemicals (butanol, hexanol, octonol, etc.) and completely carbon-neutral fuels such as butanol, pentanol, and the direct intracellular production of fuel grade biodiesel

Biosafety: Benefits of Self-regulation Compared to External Regulation

- Internally (company) mandated biosafety strategies and technologies (i.e. “self-regulation”) should reduce the need for and cost of externally mandated regulatory oversight.

- Promotion of biosafety regulation from within will lead to more rapid market adoption and consumer acceptance, shortened time-to-market, and reduced commercialization cost.

- There will be leaders, early adopters, and followers (who “get on-board” once the benefits become clear to them)

Phytonix
The Future of Fuel®

Phytonix: Passive & Active Biosafety Guards and Technology

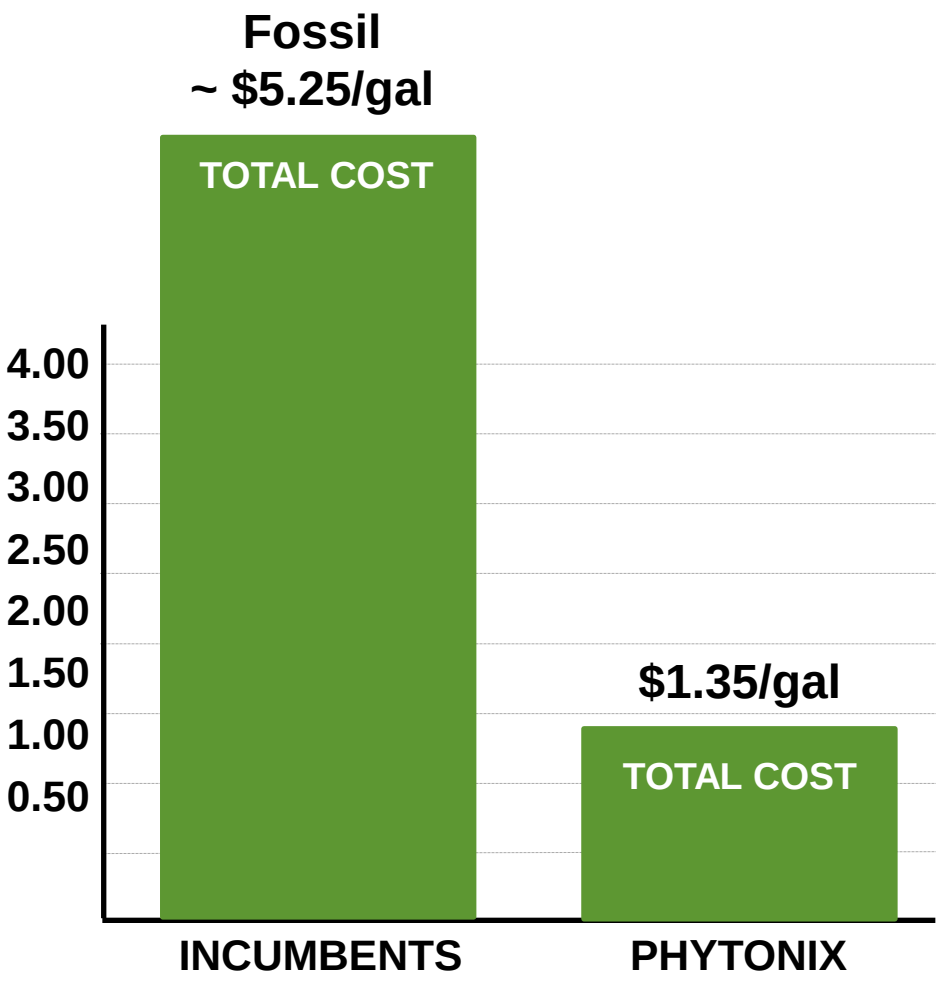
- Organisms are not inherently dangerous: they are at a competitive disadvantage as they make a target chemical rather than food for themselves.

- Passive biosafety-guard: utilizing a highly thermophilic host organism that if released from enclosed PBR would not be viable in any typical water body such as streams, lakes or oceans.

- Active biosafety-guarded technologies: a) bioengineered technologies to: a) stop cell division/replication; b) create a low CO_2 intolerant organism; c) create a nitrogen intolerant organism, etc.

Phytonix
The Future of Fuel®

Phytonix: Low-Cost Butanol Producer



Propylene (fossil) feedstock cost = $3.00/gallon of butanol

Phytonix CO_2 feedstock cost = $0.35/gallon of butanol

(assumes cost of CO_2 = $40/ton)

Fossil variable cost = $3.66/gal

Phytonix variable cost = $0.85/gal

Competitors using propylene (BASF, DOW, OXEA, etc.) have high energy costs + a large carbon footprint.

Phytonix
The Future of Fuel®

Technology Partners Contracted by Phytonix

Angstrom Laboratory, Sweden (Uppsala University):
Engineered the Phytonix cyanobacteria prototype which utilizes carbon dioxide feedstock to produce 100% n-butanol.
(Dr. Peter Lindblad)

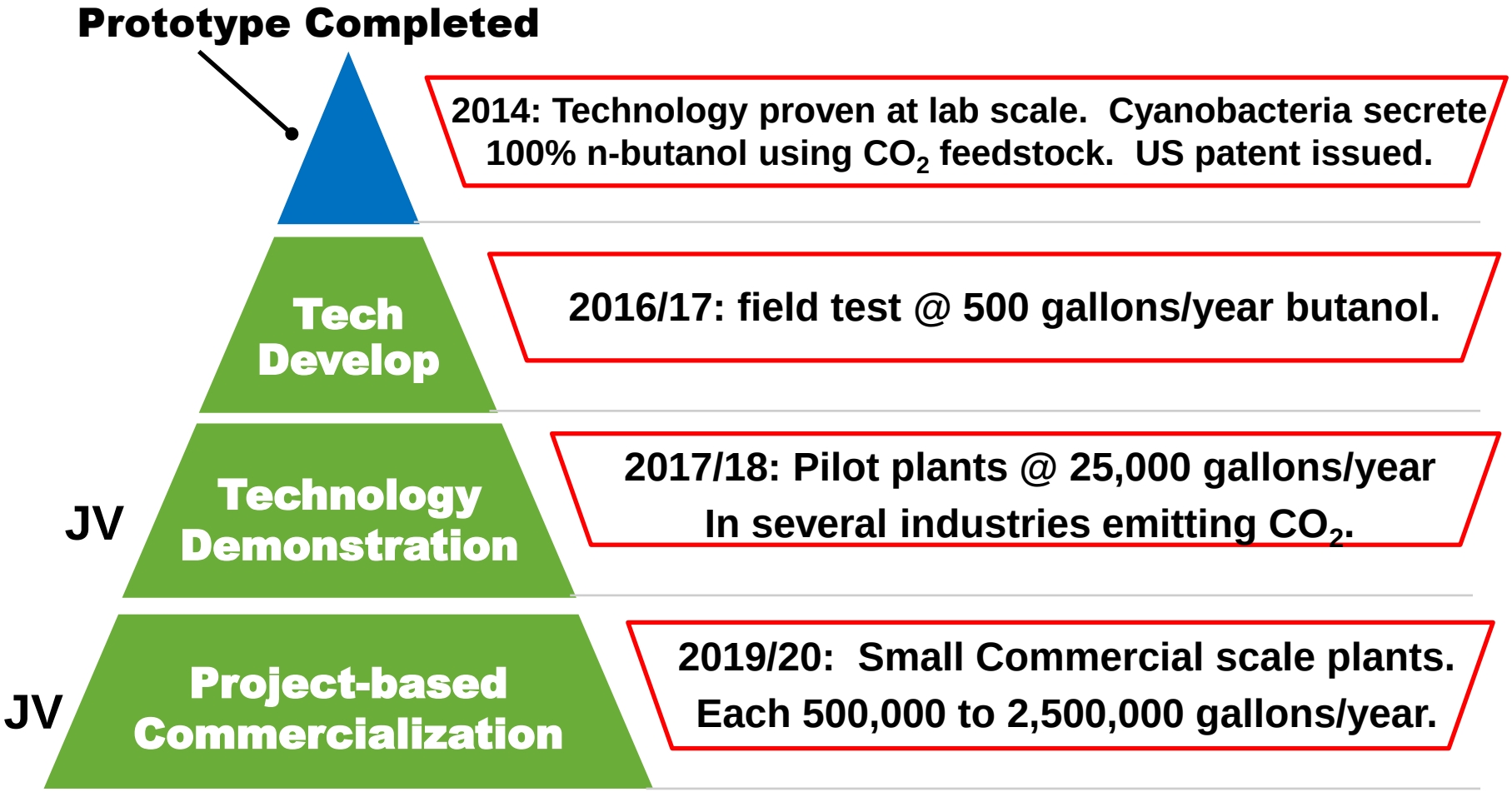
Lee Laboratory, Virginia (Old Dominion University):
Phytonix acquired the exclusive global license for the core patent filed by Dr. Lee. Developing follow-on IP.
(Dr. James Lee)

Anderson Laboratory, South Dakota (SDSU):
Design and bench scale testing of Phytonix photobioreactor with butanol separation system.
(Dr. Gary Anderson)

"Capital-light" innovation by contracting leading international laboratories.
Phytonix investment to date = $2.5M. Value > $25M.

Phytonix
The Future of Fuel®

Development Plan



Phytonix
The Future of Fuel®

Comparative Energy Yield

Process - product	Energy/Acre (per year)	Phytonix Advantage
Phytonix Process - bio-butanol	2.55 GWh	NA
Best Solar Cell Farm - electricity	0.45 GWh	5.7 X
Ethanol from Corn - ethanol	0.021 GWh	121 X

Phytonix PBRs can be located on non-arable land and use about 1.25% of the water required for corn ethanol. Phytonix can use fresh, salt or brackish water.

Phytonix
The Future of Fuel®

Phytonix Summary

- **Patented process, proven at lab scale.**
  - **100% butanol from industrial CO_2 emissions**
- **Scalable, low-cost process. Low CAPEX.**
- **Industrial emitters of CO_2 fund commercialization process.**
- **Carbon-negative process. Huge GHG reduction.**
  - **Can monetize in some jurisdictions.**

For Further Information, please call:

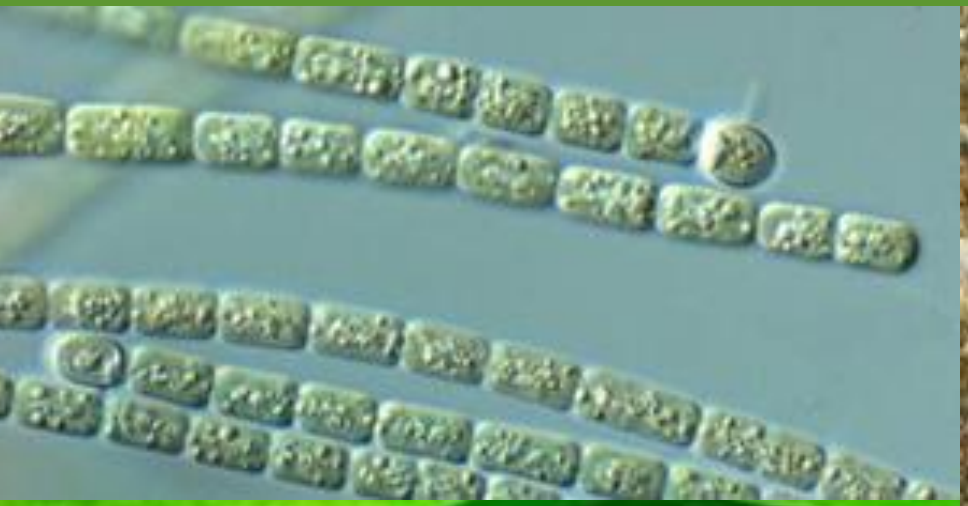
Bruce Dannenberg
Founder & CEO
bruce@phytonix.com
+1 (828) 230-5892

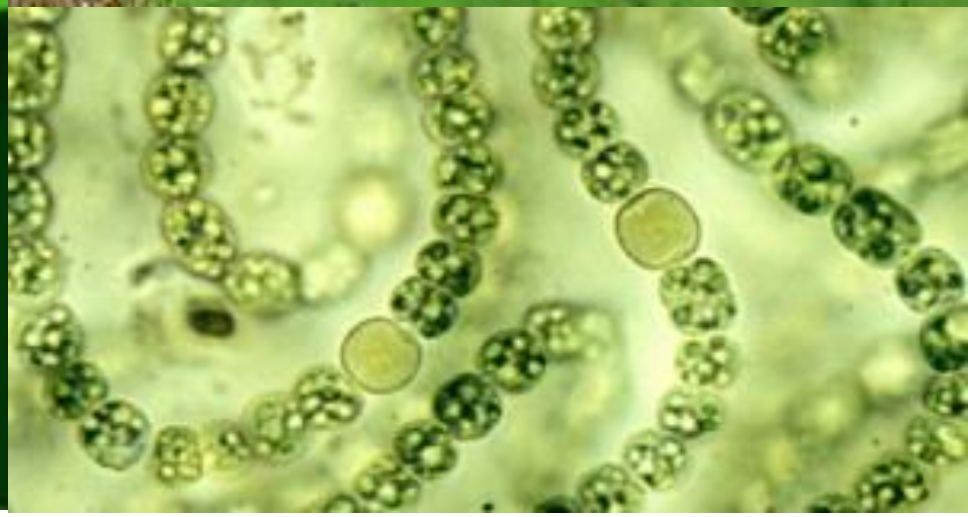
Gordon Skene
Executive Vice President & Director
gordon@phytonix.com
+1 (604) 790-8989

Phytonix
The Future of Fuel®

www.phytonix.com

Backup Slides





Phytonix
The Future of Fuel®

May 2016

Land and Water Requirements

- **20,000 sq. miles of fertile land in the USA is used to grow corn to produce 13 billion gallons/year of ethanol.**
- **245 sq. miles of <u>non-arable land</u> would be required by Phytonix to produce 13 billion gallons/year of butanol** (a far superior biofuel).

Water

- **Cyanobacteria thrive in salt, brackish, or fresh water**
- **H_2O used/gallon of biofuel:**
  - **Phytonix butanol = 2.5 gallons**
  - **Corn ethanol = 200 gallons**

Land

- **Non-arable land. (Saves arable land for food production)**
- **Phytonix butanol yield / acre:**
  - **= 75X yield of corn ethanol**
  - **= 5.7X energy yield of solar**

Phytonix
The Future of Fuel®

Cyanobacterial Chemical Production Platform

Besides butanol, the Phytonix technology platform enables it to genetically engineer patentable species of cyanobacteria that can each directly secrete valuable biochemicals and biofuels such as:

- Pentanol
- Hexanol
- Octanol
- Direct intracellular fuel grade biodiesel
- Medium & long chain fatty acids

Phytonix
The Future of Fuel®

Butanol Competition

- **Incumbent fossil-based producers**: BASF, DOW, Eastman, OXEA, etc.
  - Expensive, carbon intensive and energy intensive.

- **Fermentation/bio-based producers**: Gevo, Butamax (BP/DuPont JV), Cobalt Technologies, Green Biologics
  - Biomass feedstock = expensive, generates CO_2 as a waste product.

- **Phytonix solar-based production:**
  - CO_2 feedstock = very low-cost process, with low energy cost.
  - Highly carbon-negative process.

Phytonix
The Future of Fuel®

Phytonix Energy & Value from PBRs vs Solar Cells on One Acre (per year)

	Solar Cells	Phytonix PBRs	Ratio
Energy created (GWh/year)	≈ 0.45	≈ 2.55	5.7X
Liquid Fuel / Storable Energy (gallons/year)	N/A	83,000	
Amount of Electricity (MWh/year) *(note 1)*	450	N/A	
Value of Electricity @ $60.00/MWh	$27,000	N/A	
Value of Electricity vs. Butanol Biofuel @ $2.00/gal.	$27,000	$166,000	6X
Value of Electricity vs. Butanol Chem. @ $6.25/gal.	$27,000	$519,000	19X

Note 1: ***Bio-butanol could be used in Co-Gen engines to produce 1,147 MWh/year of electricity (45% efficiency). Value = $69,000/year at $60/MWh. ($CO_2$ from Co-Gen used to make more butanol.)***

Phytonix
The Future of Fuel®

Butanol vs. Ethanol as a Biofuel

- **HIGH ENERGY DENSITY:** ≈ 50% higher than ethanol.
- **SAFER:** 7x less evaporative than ethanol.
- **GASOLINE ENGINES CAN RUN ON 100% BUTANOL** (with a minor fuel-air injection ratio adjustment): Not possible with ethanol.
- **ETHANOL IS HIGHLY CORROSIVE**: Except in low concentrations, ethanol cannot be used in existing tanks, pipelines & fuelling stations.
- **BUTANOL HAS MANY INDUSTRIAL USES:** Ethanol does not. (Solvents, plastics, paints, adhesives, cleaning products, etc.).
- **LOW EMISSIONS (both butanol & ethanol):** No sulfur dioxides, carbon monoxide or particulates.

Phytonix
The Future of Fuel®

Potential Industrial Partners Emitting CO_2 as feedstock for Phytonix Biobutanol

Industry	CO_2 Produced (tons/year)	Production of Butanol from CO_2 (gallons/year)	Plant Revenue $6.25/gal Butanol ($/year)
Large fuel ethanol facility	200,000	25,000,000	$156 million
Large natural gas wells	2,000,000	250,000,000	$1.56 billion
Large steel mill	4,000,000	500,000,000	$3.12 billion
Oil Sands	Very high	Very high	Very high

Phytonix plants are scalable and cost-effective:

500,000 gal/year plant. CAPEX ≈ $4M. Sales ≈ $3M/year

500,000,000 gal/year plant. CAPEX ≈ $1.3B. Sales ≈ $3.1B/year.

Broad market opportunity.

Phytonix
The Future of Fuel®

Management Team

SENIOR MANAGEMENT + BOARD OF DIRECTORS	**Mr. Bruce Dannenberg: Founder, President & CEO. Director.** Expertise in innovation and commercialization, genetics, microbiology, financial management and industrial management. Degrees in Zoology, industrial management (M.S.) & M.B.A. **Mr. Gordon Skene: Executive Vice President & Director.** Former CEO of several technology companies and of a VC technology fund. BSc. (Physics & Economics). MSc. Business Administration (Finance). Former Director of Finance for an industrial corporation with sales of $3 billion, listed NYSE. **Mr. Michael Weedon: Independent Director.** Executive Director of the British Columbia Bioenergy Network with 25 years of experience in finance, clean technology and senior management, including a large chemical company.
TECHNOLOGY TEAM	**Dr. Peter Lindblad: Phytonix Technology Director, Organism Development.** Director of the Angstrom Laboratory and Professor of Microbial Chemistry and Molecular Biology at Uppsala University in Sweden. **Dr. Gary Anderson: Phytonix Technology Director, Photobioreactor Development**. Professor of Agricultural & Biosystems Engineering at South Dakota State University. **Dr. James Lee: Phytonix Inventor & Scientist:** Expertise and degrees in photosynthesis, plant physiology, biochemistry, and synthetic biology (Cornell).15 years at Oak Ridge National Lab.

Board of Advisors

Mr. Scott Hickman: 30 years of management experience ranging from startups to Fortune 500 firms; 13 years with Sun Microsystems. MBA (Harvard). BS Industrial Engineering (Stanford).

Mr. William Tate: Senior executive with companies ranging in size from $20M to over $2B. Former CEO of a Fortune 500 company. Expertise in strategy and performance improvement.

Dr. Robert Stewart: Former Biotechnology Manager at Lanxess, Iogen Biofuels and InBev and an expert on renewable routes for biobstanol production.

Mr. Michael Macdonald: Former Senior Vice President, Global Operations, Methanex Corporation, responsible for all manufacturing activities including eight methanol plants.

Mr. Peter Hoyle: Product Manager of Quadra Chemicals, a leading North American distributor of industrial chemicals including butanol. Consultant on renewable resources in industrial applications as replacements to hydrocarbon-based materials.

Mr. John Robertshaw: Industrialist and commercial real estate developer with a substantial real estate and private equity portfolio. An active investor in emerging technology companies.

Dr. Victor Der: Executive Adviser, Global Carbon Capture and Storage Institute. Former Assistant Secretary, US Department of Energy, leading initiatives in clean coal, carbon capture, and oil & gas R&D. Former Chair of the Carbon Sequestration Leadership Forum Policy Group.

Phytonix Summary

- Phytonix process reduces GHG emissions
  - 1 ton CO_2 per 125 gallons of bio-butanol
- Low-cost producer of butanol at $1.35/gallon
- Large industrial chemical market
- Huge gasoline additive/replacement markets
- Patented and patent-pending technology
- Scalable, high-margin process
  - Fast payback for small and large plants

For Further Information, please call:

Bruce Dannenberg
Founder & CEO
bruce@phytonix.com
+1 (828) 230-5892

Gordon Skene
Executive Vice President & Director
gordon@phytonix.com
+1 (604) 790-8989

Phytonix
The Future of Fuel®

www.phytonix.com