Harnessing Photosynthesis through Synthetic Biology to Address Global Challenges: Climate Change and the Transition from a Fossil-based Economy to a CO₂-based Economy

*Sustainable Chemistry Powered by the Sun™*

2017 BIO World Congress on Industrial Biotechnology

Montreal, Canada    July 24th, 2017

Bruce Dannenberg
Founder, President & CEO
Focus: Industrial Butanol Market

$9 Billion/year

Plastics

Paints

Household Cleaners

Solvents

Perfume

Adhesives

\[ N\text{-Butanol} = \text{Normal Butanol} = \text{Butanol} = C_4H_9OH \]
Phytonix uses cyanobacteria to produce butanol from CO₂

Cyanobacteria are tiny photosynthetic plants found in:
- Fresh water
- Salt water

Phytonix genetically engineered cyanobacteria consume CO₂ emissions to secrete 100% butanol
CO₂ Emissions

Phytonix CO₂ to Butanol Conversion System

Production cost
≈ $1.95/gallon

Wholesale Price
≈ $5.00/gallon (Q2, 2017)

Butanol

High-Value, High-Margin Product
Microbial Chemical Factories

For every 125 gallons of butanol produced by Phytonix
1 ton of carbon dioxide is consumed

**Water** (fresh or salt)
2.5 gallons

**Carbon Dioxide**
16.3 lbs (net)

**Sunlight**

**N-Butanol**
1.0 gallon

**Oxygen**
17.5 lbs

**CYANOBACTERIA**
Grown in a Phytonix Phytoconverter™

Greenhouse Gas Reduction
No other economically viable process reduces GHGs as effectively!
Photosynthesis in plants, such as algae and cyanobacteria, typically produces sugars from CO$_2$ using energy from the sun.

Phytonix is the only company in the world with patented technology for engineering cyanobacteria to directly produce n-butanol instead of sugars from CO$_2$, and with oxygen as a by-product.
Phytonix’s Proprietary N-Butanol Synthesis Pathways

FIG. 1
# International Patent Portfolio

| UNITED STATES PATENT | Patent No. US 8,735,651 issued in 2014  
“Designer Organisms for Photobiological Butanol Production from Carbon Dioxide and Water” |
|----------------------|----------------------------------------------------------------------------------|
| OTHER MAJOR MARKETS  | EU, Eurasia, Australia and South African patents issued.  
Patents expected in other major markets in 2017 |
| PATENT COST          | Over $850,000 invested to secure Phytonix patents. |
Proviron PBRs to Grow Cyanobacteria

Proven Design to Cultivate Microalgae. May Offer Low Capex, Low Opex, and High Ground Coverage
Phytonix: Dual Market Strategy - Target Market: Industrial Chemicals not Biofuels

• Fuels are a low-price, low-margin market

• Wholesale price of gasoline & ethanol $\approx$ $1.50$/gallon
• Butanol price - industrial chemical mkt. $\approx$ $5.00$/gallon

• Potential future Phytonix biofuel market for butanol:
  – Approved for a 16% blend with gasoline. $\sim$ $140$ billion/year.
  – Gasoline engines can run on 100% butanol. $\sim$ $900$ billion/year.

Phytonix will initially pursue high-margin, industrial markets for butanol and other solar chemicals.
Management Team

MANAGEMENT + BOARD OF DIRECTORS

- Bruce Dannenberg: Founder & CEO
- Gordon Skene: Chairman & EVP
- Michael Weedon: Independent Director
- Rick Hopp: Independent Director
- Bill Cory: Independent Director

TECHNOLOGY & ENGINEERING TEAM

- Dr. Peter Lindblad: CSO and Organism Development
- Patrick Neill: Director of Engineering
- Dr. Gary Anderson: Director, PBR Development
- Dr. James Lee: Phytonix Inventor & Scientist

BOARD OF ADVISORS

- Advisors with expertise in:
  - Chemicals Market, Gov’t Climate Change Policy,
  - Business, Finance, Synthetic Biology, Clean Technology.
Technology Partners
Contracted by Phytonix

Angstrom Laboratory, Sweden (Uppsala University):
Dr. Peter Lindblad - organism development

Lee Laboratory, Virginia (Old Dominion University):
Dr. James Lee - inventor

Anderson Laboratory, South Dakota (SDSU):
Dr. Gary Anderson – photobioreactor design

“Capital-light” innovation by contracting leading international university laboratories.
Phytonix investment to date = $3.5M. Value > $25M.
Phytonix’s Key Scientists at Angstrom Laboratory, Uppsala Sweden

Dr. Peter Lindblad

Dr. Pia Lindberg

World leaders in synthetic biology, photosynthesis, and solar chemical production utilizing cyanobacteria

All IP developed by Angstrom under contract is owned 100% by Phytonix.
Phytonix: Low-Cost Butanol Producer

Propylene feedstock cost (Q1/17) = $2.25/gallon of butanol

Phytonix CO₂ feedstock cost = $0.35/gallon of butanol
(assumes cost of CO₂ = $40/ton)

Competitors using propylene (BASF, DOW, OXEA, etc.) have high energy costs + a HUGE carbon footprint.
US Wholesale Price Butanol & Crude Oil

10 year History (2007 – 2016)

Butanol Prices closely correlated with Crude Oil Prices


Crude Oil Price Jan 2017 ~ $53/bbl.
Plant Profit vs. Butanol Price
(5.0M gal/year Plant. High-end Cost Estimate = $1.95/gallon)

Pre-tax Profit & % Profit Margin

Butanol Wholesale Price per gallon

- $4.00: 51%, $10,250,000
- $5.00: 61%, $15,250,000
- $6.00: 68%, $20,250,000
- $7.00: 72%, $25,250,000

Plant Revenue
Strategic Industrial Partners

Industrial partners emitting CO$_2$ host and fund pilot plants.

• U.S. industrial manufacturing company (CO$_2$ from natural gas power plant)
  - $5 million, 3 stage Phytonix pilot plant project. 2017/18.
  - Commercial plant to follow 2019/20

• Large electric power producer. Coal & natural gas.
  - Estimated start date for Stage 1: Q4, 2017

• Praxair Inc.
Other Phytonix Industrial Chemicals

Market > $30 Billion per year

Phytonix can genetically engineer cyanobacteria to produce other valuable industrial chemicals from CO₂

- Iso-butanol
- Pentanol and Iso-pentanol
- Hexanol, Heptanol & Octanol
- Direct intracellular production of fuel grade biodiesel
- Other chemicals

Multiple chemicals = multiple liquidity events
Butanol Competition

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

- **Fermentation/bio-based producers**: Gevo, Butamax, 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 Process Flow Diagram – Modified Photosynthesis To Produce Butanol**

1. **Cell Culture Room**
   - Cells are dividing and producing/storing glycogen.
   - No butanol production at this stage.

2. **Cell Culture Tank**
   - Cells are dividing and producing/storing glycogen.
   - New strains of CB in H₂O for inoculation.

3. **Series of Photobioreactors (PBR’s)**
   - (Phytonix “Basic” PBRs are culture bags + Arrays)
   - “Butanol Syntheses Mode”
     - Cell division halted.
     - Glycogen production stopped.
   - Cells are secreting n-butanol into PBR culture media.

4. **Pervaporation System**
   - N-butanol is separated from culture media.
   - CB and culture piped to additional PBRs to produce more n-butanol.

5. **Butanol Storage Tanks**
   - 100% n-butanol stored for delivery.

6. **Settling Tank/Separation System**
   - Remove dead CB solids.
   - Used for biodiesel feedstock, etc.

7. **Water Source Storage**
   - Recycled Water

8. **Energy Source**
   - Sun (+/or LED)

9. **CO₂ Storage & Flue Gas Cooling System**
   - CO₂ fed to PBRs

10. **Flue Gas Emissions**
    - From industrial sources

11. **Water & Cyanobacteria**
    - Sun (+/or LED)

12. **CB = Cyanobacteria**
    - New strains of CB in H₂O for inoculation

13. **Nutrients & Minerals**
    - Cell Culture Room

14. **Cell Culture Tank**
    - Cells are dividing and producing/storing glycogen.
    - No butanol production at this stage.

15. **Water Recycling**
    - Used for biodiesel feedstock, etc.
Anthropogenic Climate Change – 2030 not 2100?

By 2100:

- Highest temps in 30 million years.
- Sea-level rise of 3-6 feet.
- Drought over 40% of inhabited land.
- Hundreds of millions of refugees.
- Half of all known species extinct.
- Prof. Kevin Anderson: “a 4°C future is incompatible with an organized global community.”
Theoretical Maximum Phytonix Potential for Reducing Annual Global Carbon Dioxide Emissions

- 11.6 gigatons carbon dioxide per year reduction if all annual global gasoline, diesel fuel, and the industrial butanol and pentanol chemical markets were to be replaced with Phytonix photosynthetic fuels and industrial chemicals.

- Represents ~ 29% of total annual global carbon dioxide emissions of 40 gigatons.
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 (> $30 billion)

- Patented and patent-pending technology

- Scalable, high-margin process
  - Fast payback for small and large plants
Information

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For Further Information, please call:

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Cell: +1 (604) 790-8989

www.phytonix.com
# Management Team

## Senior Management + Board of Directors

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Experience / Degrees</th>
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<tbody>
<tr>
<td>Mr. Bruce Dannenberg</td>
<td>Founder, President &amp; CEO. Director.</td>
<td>Expertise in commercialization, genetics, and microbiology. Degrees in Zoology, industrial management (M.S.) &amp; M.B.A.</td>
</tr>
<tr>
<td>Mr. Gordon Skene</td>
<td>Chairman &amp; Executive Vice President.</td>
<td>Former CEO of several technology companies and of a VC technology fund. BSc. (Physics &amp; Economics). MSc. Business Administration (Finance). Former Director of Finance for an industrial corporation with sales of $3 billion, listed NYSE.</td>
</tr>
<tr>
<td>Mr. Michael Weedon</td>
<td>Independent Director.</td>
<td>Former COO of a large chemical company with 25 years of experience in finance, clean technology and senior management. MBA, Western Ontario.</td>
</tr>
<tr>
<td>Mr. Richard Hopp</td>
<td>Independent Director.</td>
<td>Over 30 years experience in conventional, and renewable energy, biomass and in advancing companies from concepts to commercial realities. MA in Admin.</td>
</tr>
<tr>
<td>Mr. Bill Cory</td>
<td>Independent Director.</td>
<td>Process engineer with 30 years experience in operations mgmt., strategic planning and finance. Former executive with Sun Microsystems and Atari. MBA Stanford.</td>
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## Technology & Engineering Team

<table>
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<tr>
<td>Dr. Peter Lindblad</td>
<td>Phytonix Technology Director, Organism Development.</td>
<td>Director of the Angstrom Laboratory and Professor of Microbial Chemistry &amp; Molecular Biology at Uppsala University.</td>
</tr>
<tr>
<td>Patrick Neill P. Eng.</td>
<td>Phytonix Director of Engineering</td>
<td>Experienced engineering manager in the water/wastewater industry, including commercializing new technologies. Formerly with Honeywell.</td>
</tr>
<tr>
<td>Dr. Gary Anderson</td>
<td>Phytonix Technology Director, Photobioreactor Development.</td>
<td>Professor of Agricultural &amp; Biosystems Engineering at South Dakota State University.</td>
</tr>
<tr>
<td>Dr. James Lee</td>
<td>Phytonix Inventor &amp; Scientist.</td>
<td>Expertise and degrees in photosynthesis, plant physiology, biochemistry, and synthetic biology (Cornell). 15 years at Oak Ridge National Lab.</td>
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Board of Advisors

**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.

**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. 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).

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

**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.
### 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.
- 1,000 sq. miles of non-arable land would be required by Phytonix to produce 13 billion gallons/year of butanol (a far superior biofuel).

<table>
<thead>
<tr>
<th>Water</th>
<th>Land</th>
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<tr>
<td>Cyanobacteria thrive in salt, brackish, or fresh water</td>
<td>Non-arable land. (Saves arable land for food production)</td>
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<tr>
<td>H₂O used/gallon of biofuel:</td>
<td></td>
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<tr>
<td>- Phytonix butanol = 2.5 gallons</td>
<td></td>
</tr>
<tr>
<td>- Corn ethanol = 200 gallons</td>
<td>Phytonix butanol yield / acre:</td>
</tr>
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<td>= 20X yield of corn ethanol</td>
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### Phytonix Plant Economics @ $4.50/gallon
Cost Estimate = $1.95/gallon

<table>
<thead>
<tr>
<th>Butanol Production</th>
<th>Small Size Phytonix Plant</th>
<th>Medium Size Phytonix Plant</th>
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<tr>
<td>2.5 million gal/yr.</td>
<td>25 million gal/yr.</td>
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<tr>
<td>20,000 tons/yr.</td>
<td>200,000 tons/yr.</td>
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<tr>
<td>Revenue: Butanol @ $4.50/gallon</td>
<td>$11.2 million/year</td>
<td>$112 million/year</td>
</tr>
<tr>
<td>EBITDA</td>
<td>$8.5 million/year</td>
<td>$89 million/year</td>
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Phytonix plants are **scalable & profitable**

- Small Plant: 500,000 gallons/year of butanol
- Huge plant: 500,000,000 gallons/year of butanol