

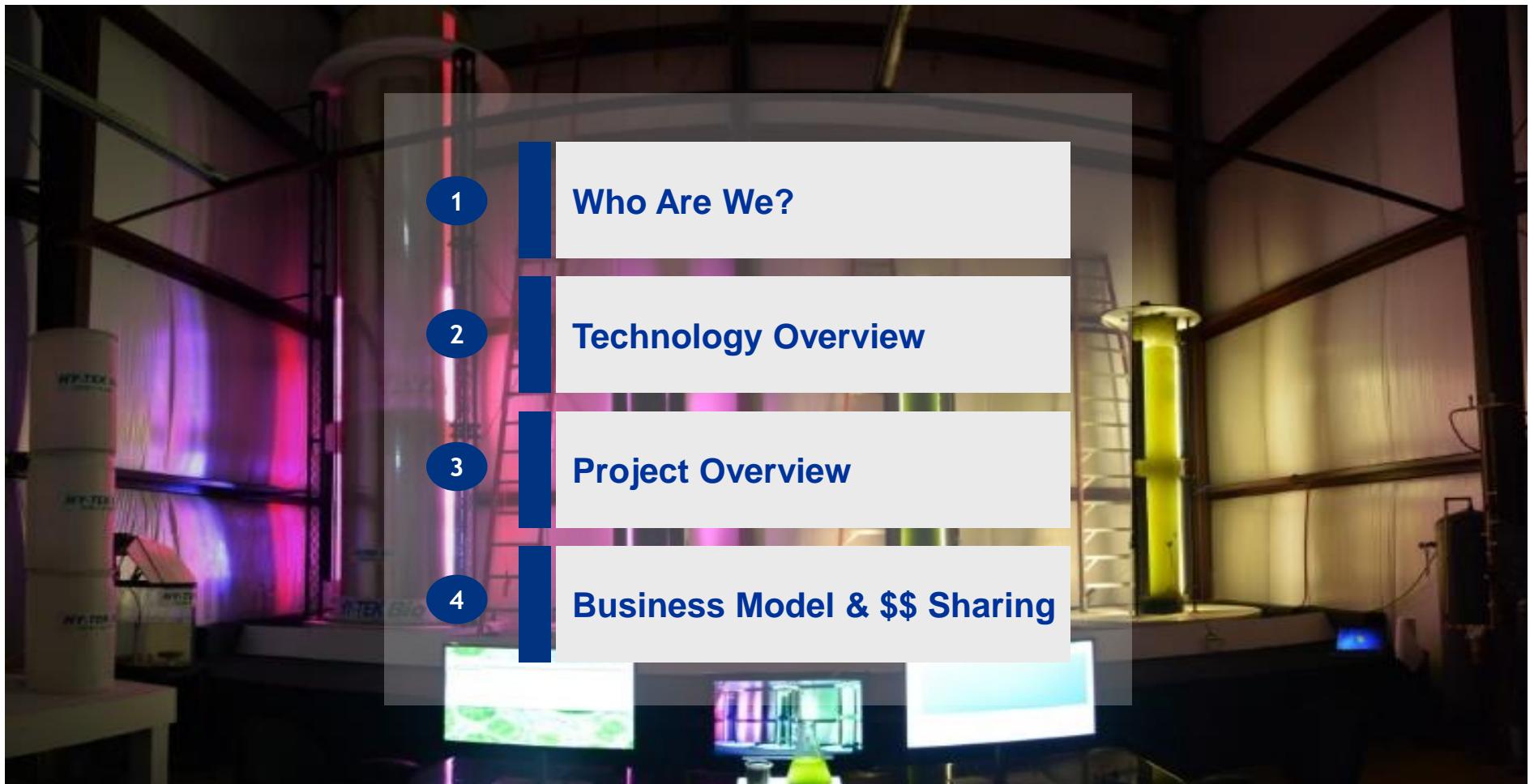
Clean Energy Solutions for Biogas Utilization

Ed Weinberg, PE, ESSRE Consulting
Robert Mroz, HY-TEK Bio



This presentation contains confidential information regarding HY-TEK Bio LLC's proprietary technologies. By accepting this presentation the recipient agrees that it will cause its directors, officers, employees and representatives to use the presentation and such information only to evaluate a specific transaction with Landfill Owner Operator and HY-TEK Bio LLC, and for no other purpose. HY-TEK Bio © 2009 - 2018

ESSRE Presentation Outline



This presentation contains confidential information regarding HY-TEK Bio LLC's proprietary technologies. By accepting this presentation the recipient agrees that it will cause its directors, officers, employees and representatives to use the presentation and such information only to evaluate a specific transaction with Landfill Owner Operator and HY-TEK Bio LLC, and for no other purpose, HY-TEK Bio © 2009 - 2018

Outline

1

Who Are We?



HY-TEK Bio, LLC.

Role: Technology provider; engineering, procurement and construction support.

- **Privately held – Headquartered in Dayton, Maryland between Baltimore and Washington, DC; Technology Center located at Baltimore's Back River Waste Water Treatment Plant**
- **Original Equipment Manufacturer (OEM) of patent-pending Algae-based GHG Mitigation & related systems/processes**
- **Currently mitigating up to 5% of a 3 MW Digester Gas Plant since July 2012**
- **CO₂ and NO_x mitigation rates of 85% and 100% respectively, via one-fifth sized pilot scale bioreactors; fully scaled system will provide 100% mitigation capability**



HY-TEK Bio

The Team



President & CEO, Robert M. Mroz, is co-author of the technology, B.S.E.E. and Computer Science, University of Maryland College Park, 30 years with the Federal Communications Commission as District Director and Director of FCC Advanced Technologies Group and 36 years experience running his own technology company producing World Class Sports Software, Professional Weapons Management software and various leading edge technology products.

Board of Advisors consisting of business owners and operators with advanced technology backgrounds, automation control design and implementation, extensive fabrication experience with multiple materials, marketing, business development, legal and financial management expertise.



Outline

2

Technology Overview



HY-TEK Bio Technology – Algae-based CO₂ GHG/NOx Mitigation

- A breakthrough technology that can profitably mitigate 100% of CO₂, NOx and provide Carbon Capture & Utilization (CCU).
- A CCU solution for any source of CO₂ (landfill, WWTP, power plant or other carbon emitter).
- “Natural” NOx mitigation without the use of chemicals or catalysts
- An innovative LED Grow Light System which increases algal growth, reduces heat and power consumption and increases mitigation/volume of algae.
- Modular/scalable design speeds implementation and works with any generating capacity - from small landfills to large power plants.
- Over 12,000 hours of operating experience backed by credible third party validation.
- CCU: Produces algae and oxygen as marketable, high-value products, which generate significant revenue sharing opportunities.



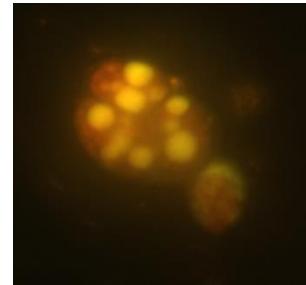
Greenhouse Gas Emission Mitigation Rates	
Emission	Rate
CO ₂ , NO _x , SO _x , VOCs	85-99% *

* Note: Obtained from Algae Demonstration Center.

A Break-through, Patent-Pending, Natural, Clean Energy Solution

FIVE KEY COMPONENTS TO GHG MITIGATION

- 1. ALGAE** – A unique strain of algae indigenous to the Chesapeake Bay that rapidly consumes NOx, CO2 GHGs and other emissions; *thrives at up to 100% CO2 levels*; and, is high in lipid oil and other marketable products
- 2. CONTAINMENT** – Employs a patent-pending tank construction using a laminated Mylar/Kevlar bond that reduces the cost of closed bioreactors by 90%
- 3. LIGHTING** – Employs a patent-pending high intensity LED Grow Light System that uses only photosynthesis light combined with a “flash effect” that enhances algal growth to produce more mitigation per volume of algae
- 4. GAS INJECTION** – A patent-pending gas injection system that insures rapid transfer of gas chemistry to the algal culture for enhanced algal growth
- 5. NUTRIENT** – Uses a patent-pending process that converts poultry litter or wastewaters into a concentrated N-P-K nutrient solution for cost-effective maximum growth and density of the algal strain.



Initial Algae Pilot GHG Mitigation

■ **CO₂ Results**

- 85% Removal Efficiency (RE) in just 9 feet
- 11.8 % vol CO₂ IN; 1.8% vol CO₂ OUT

■ **NO_x Results**

- ~100% Reduction
- 208 ppmv IN – Non-Detect (ND) OUT

■ **Data Derived from 1/15th Scale Bioreactor**

- Approx. 5 cfm, 1.5 ft. diam., 9 ft. algae culture

■ **Early Version Reactor Design -**

- All of the Key Technology Components were not used

Commercial Demonstration Project: Why Algae?

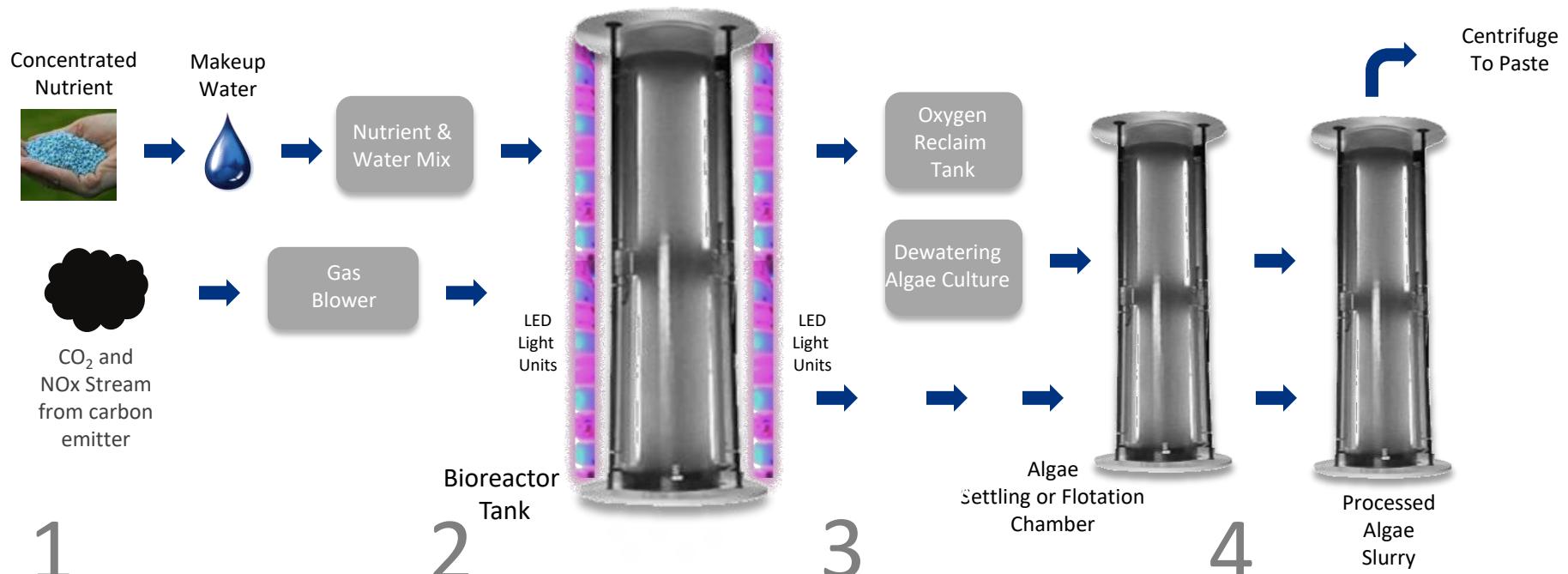
- Algae and algae oil is used in the following products (partial list)



- ✓ Eye surgery and eye cleansing solutions
- ✓ Skin conditioners
- ✓ Omega-3 Fatty Acid, Nutraceutical products
- ✓ Cosmetic and paint thickeners
- ✓ Bioplastics A recycling symbol with the word "PLASTIC" inside.
- ✓ Animal and human food supplements
- ✓ Biofuels
- ✓ The HY-TEK Bio algae *s.HTB-1* can bring as much as \$40/lb from an algae brokerage house
- ✓ 90-95% Oxygen from photosynthesis is a marketable commodity
- ✓ Direct replacement for Palm Oil A small icon of a palm tree.



HY-TEK Bio Technology – Algae Production from CO₂



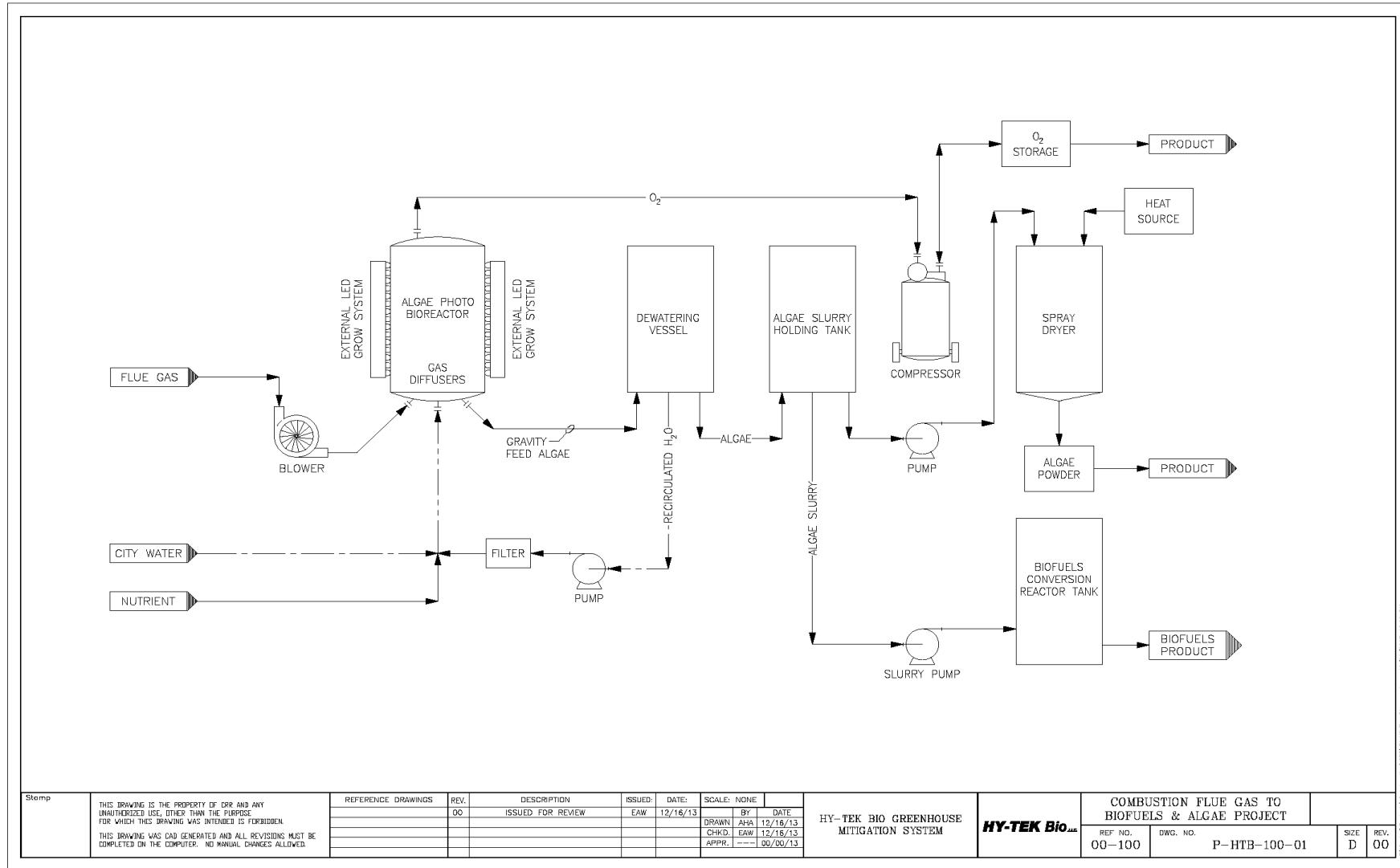
Given light, CO₂, water, and nutrient including NOx, the algal culture will grow by consuming flue gas until it reaches an optical density (OD) set point where the light can no longer penetrate the core of the Bioreactor. Hence, air emissions are used as a raw material to produce a new, 21st century cash crop: microalgae

At the OD set point, the Bioreactor drain valve automatically opens and 10% of the tank flows by gravity into a Settling Tank. Coagulant / flocculant agents are used to dewater the culture in the Settling Tank and the decant water is drained off, filtered and recycled to the Bioreactor.

Sustainable nutrients and makeup water are added. The algal slurry in the Dewatering Chamber is pumped through a spray dryer, converted to powder, vacuum packed and stored for shipping.

This operation cycles every 90 minutes, mitigates the Greenhouse Gas emissions 24/7 and produces 40-75 lbs of algae and 12,000 cubic feet of oxygen per day for sale from one Bioreactor. This operation mitigates NOx and CO₂ emissions from flue gas exhaust.

HY-TEK BIO Technology: CO₂ to Algae Process Schematic



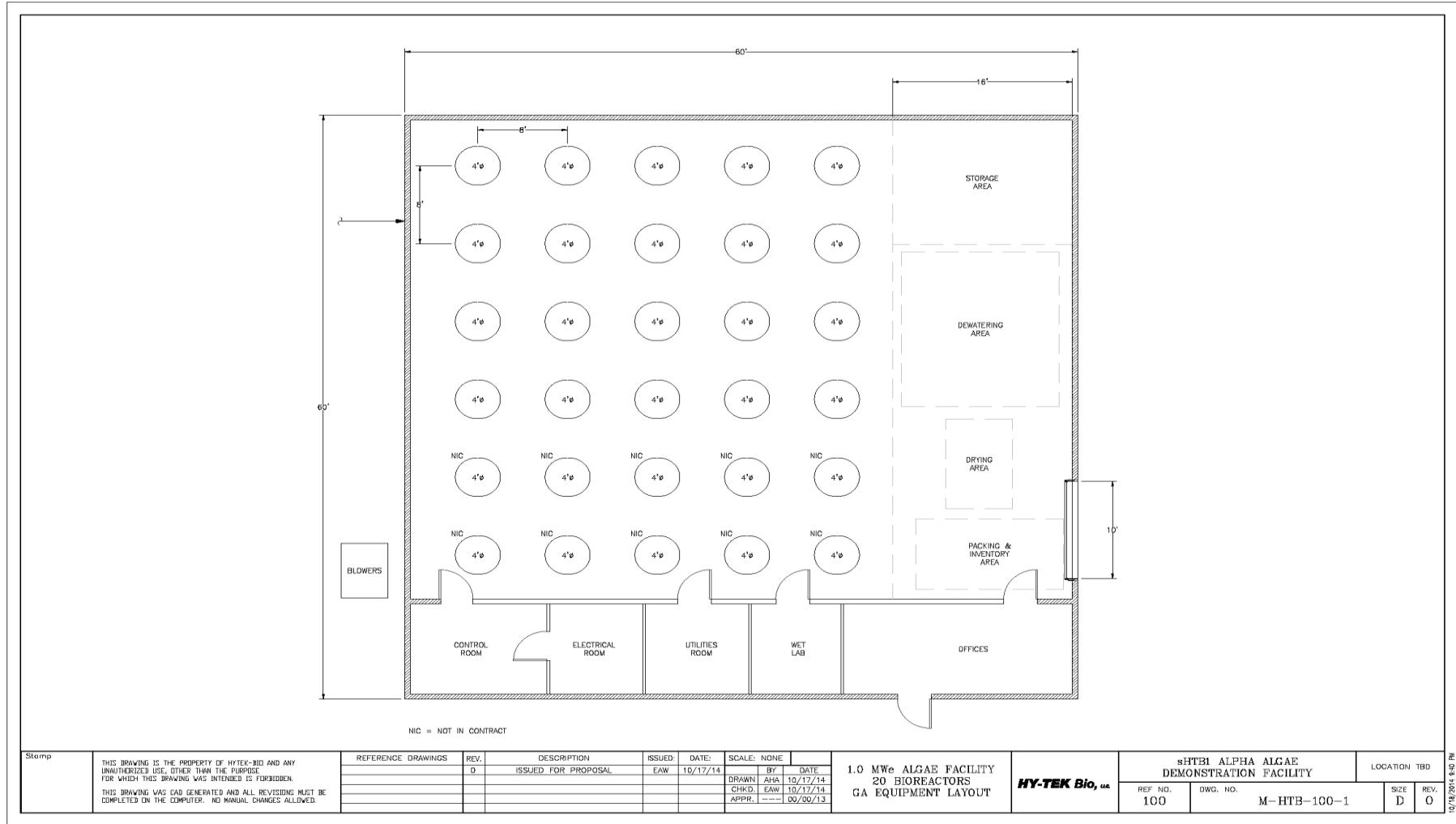
Flue Gas Cooling and Waste Heat Recovery



Flue Gas Cooling and Waste Heat Recovery



HY-TEK BIO Technology: Algae Facility GA Equipment Layout



Commercial Project Overview: XYZ Landfill, Inc.

- Located in Somewhere, US
- Active or Closed
- XXX scfm LFG combusted for sufficient C
- 1 MW Engine for LFG Combustion - Methane Destruction
- Electric Utility Tie-Ins

- Greening the LF: upgrade generating equipment, lower NOx emissions, reduce carbon footprint
- Interest in greening projects that generate revenue
- LFG Utilization Managed by Owner or Energy Group or Other



Outline

3

Project Overview



Algae Pilot Performance Metrics

■ Growth & Harvesting – *s.HTB1*

- Specific Growth = <1 day
- Culture Density = 5 g/L
- 75lbs/day/bioreactor
- Oil Lipid Content = 48%
- Aerial Utilization = 1.6 kg/m²/day (30 bioreactors)

Microalgae Benefits

■ Air Quality Improvement

- Priority air pollutant, NO_x, to Non-Detect
- S in the flue gas is reduced by consumption as a secondary macronutrient
- Lab evidence of VOCs mitigation (as an additional carbon source)
- Landfill NMOCs capture to be evaluated in the future

■ Industrial Grade O₂ Production for Reuse

■ GHG CO₂ Mitigation: 1 Ton Algae “fixes” 1.83 Tons of CO₂

■ Algae Facility Installation and Operations Are Paid for by Algae Revenue

■ Air Permit as a Separate Entity

■ Excess maintenance (and costs) for engines to comply with NO_x emissions eliminated

■ CCU & GHG Mitigation via Microalgae is Independent of Wastewater Treatment Operations

■ Nutrient Recovery

- No P in flue gas – requires approx. 50 lb./day P from treated wastewater, landfill leachate, or poultry litter
- 100% NO_x may not be sufficient – N recovery from wastewater

Nutrient Requirements for Mass Algae Cultivation



- Algae critical N:P ratio, approximately 16:1
- Most of N requirement for *s.HTB1* comes from the flue gas NO_x
- 20 Bioreactors will require approx. 50 lbs. per day P
- How to supply that P sustainably?
 - Extracted from wastewater
 - Extracted from digestate
 - Extracted from landfill leachate
 - Extracted from animal waste, e.g. Poultry Litter (PL)
 - Extracted from PL or Sewage Sludge Ash
- In essence, Pollutant Nutrient Redistribution

Outline

4

Business Model and \$ Sharing



Revenue Sharing: Direct Algae Revenue Components to O/O

- ✓ **Land (Space) Annual Rental Fee**

- At or Above Fair Market Rates Based on Revenue from Algae

- ✓ **Algae Facility Electric Bill**

- Parasitic load at premium above established PPA rate

- ✓ **Project Credits, O & M Credits, Profit Sharing**

- If O/O takes on Investment, becomes the creator of new jobs, and avoids cost of 3rd party O&M profit margins

NJ Specific Project Credits

- **New Jersey Clean Energy Program** www.njcleanenergy.com
- **Biopower Solicitations (FY 2018)**
- **Clean Power Choice Program**
- **Renewable Energy Incentive Program**
- **EDA Programs**
- **Carbon Credits**
- **Emission Reduction Credits**

PROJECT FINANCING (20 Bioreactor Basis)

- **800 lb. Algae per day (approx. half the pilot rate)**
- **Daily Algae Revenue = $800 * \$10/\text{lb} = \$8,000$**
- **Annual Revenue = \$2.6MM**
- **Initial Capital Investment = approx. \$4MM**
- **Simple Payback Period = < 2 years and Annual ROI = 45%;**
- **IRR = >20% (derated); > 45% at pilot production metrics**

Algae Revenue Drives the Profit Engine for Owner/Operators & Technology Providers

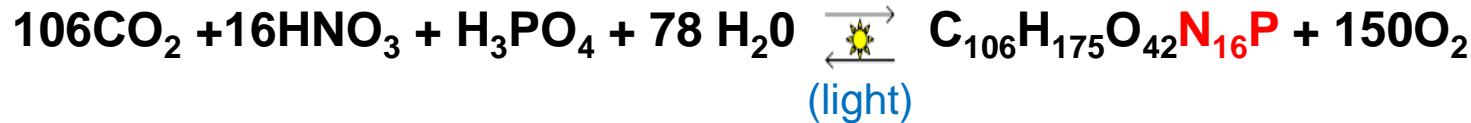
Multitude of Product Markets – Highest Valued is Lutein/Zeaxanthin at \$18,000/kg

“Natural” NOx Emissions Reduction and CO2 Utilization for Profit

“Green” Nutrient P from Waste

- Proprietary conversion process for producing a customized N-P-K liquid nutrient solution from Poultry Litter to sustain mass algae growth
- Novel nanomaterials are used - HIX-Nano and “6R’s”
- 6R’s Pollutant P Stewardship for *sHTB-1* specific N-P-K formulation from Animal Manures:
Remove/Recover/Reconcentrate/Reuse/Recycle/Redistribution
- Chemical Fertilizer Avoidance adds additional CO₂eq emissions reductions

GHG Calculator



- Almost half of the algae by weight is C, hence,
- 1 Ton of Algae “FIXES” 1.83 Tons of CO₂
- 20 Algae Facilities will mitigate 4,325 Metric Tons of CO₂ annually
- The CO₂ emissions reduction from 10 Algae Facilities is equivalent to:
 - 15 acres of trees planted
 - 520 cars removed from the road
 - *1390 tons of synthetic N fertilizer (as A-NH3)**
 - *12,015 tons of synthetic P fertilizer (as TSP)**

* Blonk Consultants Report, GHG Emissions of N, P and K Fertilizer Production A. Kool, M. Marinussen, and H. Blonk , November, 2012

GHG N₂O Fertilizer Calculator

- The CO₂ emissions reduction from 20 Algae Facilities is equivalent to:
 - 1390 tons of synthetic N fertilizer (as A-NH3)*
 - 12,015 tons of synthetic P fertilizer (as TSP)*
- Direct N₂O air emissions reductions from N Fertilizer land application:

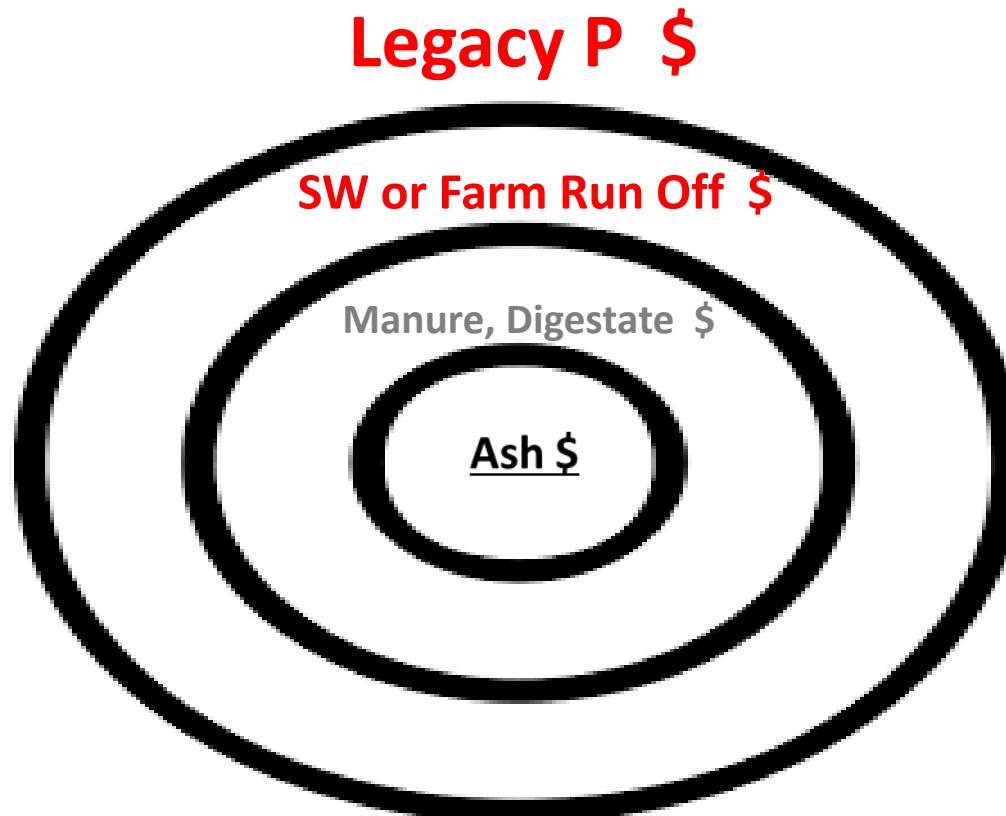
$$N_2O \text{ Emissions} = (FC * EC * 44/28)^a$$

- *Using the 1390 Tons of N Fertilizer above:*
$$1390 * 0.017 * 44/28 = 37.13 \text{ Tons N}_2O \text{ per year}$$
- *Assuming the CO₂ equivalent for N₂O = 320*

11,880 Tons of CO₂ eq

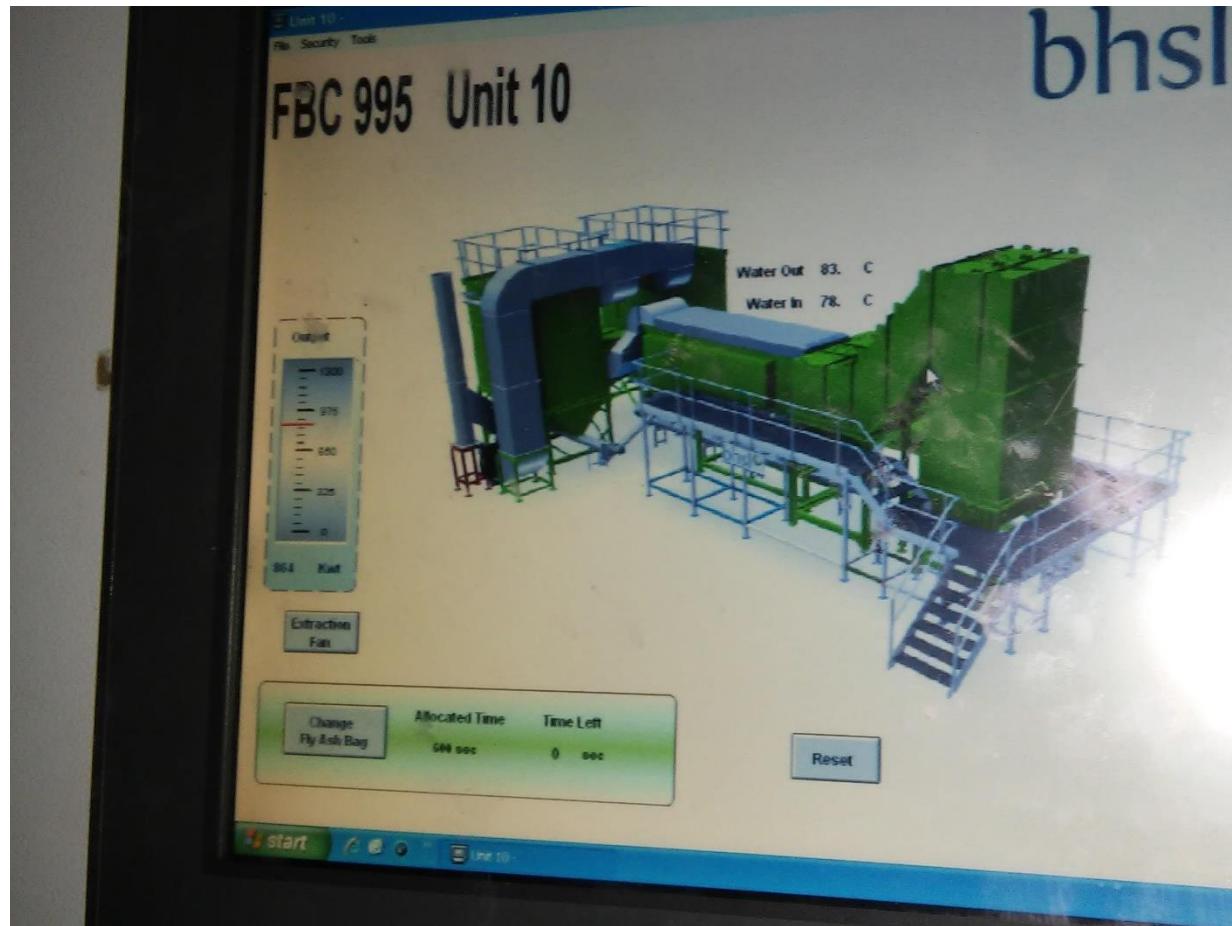
(a) USEPA AP-42, CH 14.1: Emissions From Soils - Greenhouse Gases

P-Recovery Targets: Ash is the Bullseye



Combustion of Biomass Further Reduces GHG Emissions

Sustainable Carbon-Negative Poultry Production



Poultry Litter Combustion with CHP, Algae CCU at the Stack, and P-Recovery from the Ash

Outline

SUMMARY



This presentation contains confidential information regarding HY-TEK Bio LLC's proprietary technologies. By accepting this presentation the recipient agrees that it will cause its directors, officers, employees and representatives to use the presentation and such information only to evaluate a specific transaction with Landfill Owner Operator and HY-TEK Bio LLC, and for no other purpose, HY-TEK Bio © 2009 - 2018

Conclusions and Highlights

- ✓ HY-TEK Bio's clean energy solution is break-through technology, which eliminates NOx emissions and has the potential to eliminate 100% of the CO2 (GHG) emissions from the flue gas it processes while generating high market value algae end products.
- ✓ The technology mitigates NOx more "naturally" than SCR/NSCR with additional project benefits and uses CO2 emissions as a raw material for PROFIT.
- ✓ Allows flexibility - use with any size capacity and any fuel source while being able to handle either a portion or all of the O/O's flue gas emissions.
- ✓ The end result is Carbon Capture and Utilization (CCU)
- ✓ Provides designs that are modular and scalable, which speeds implementation.
- ✓ Requires a low CapEx compared to other NOx & GHG mitigation technologies.
- ✓ Provides opportunities to O/O for new revenue streams.
- ✓ Seeking a Gamma Commercial Demonstration Site (preferably fossil fuel plant, approx. 1 MWe and 10,000 ft2 required).

NJWEA 103rd Annual Conference & Expo Air Pollution – Greenhouse Gases

Ed Weinberg, PE
President
ESSRE Consulting, Inc.
edweinberg_essre@Verizon.net
(215) 630-0546

?? QUESTIONS ??

Atlantic City, NJ
May 7, 2018

Robert Mroz
President & CEO
HY-TEK Bio LLC
Bob@HY-TEKbio.com
(410) 262-5113

