

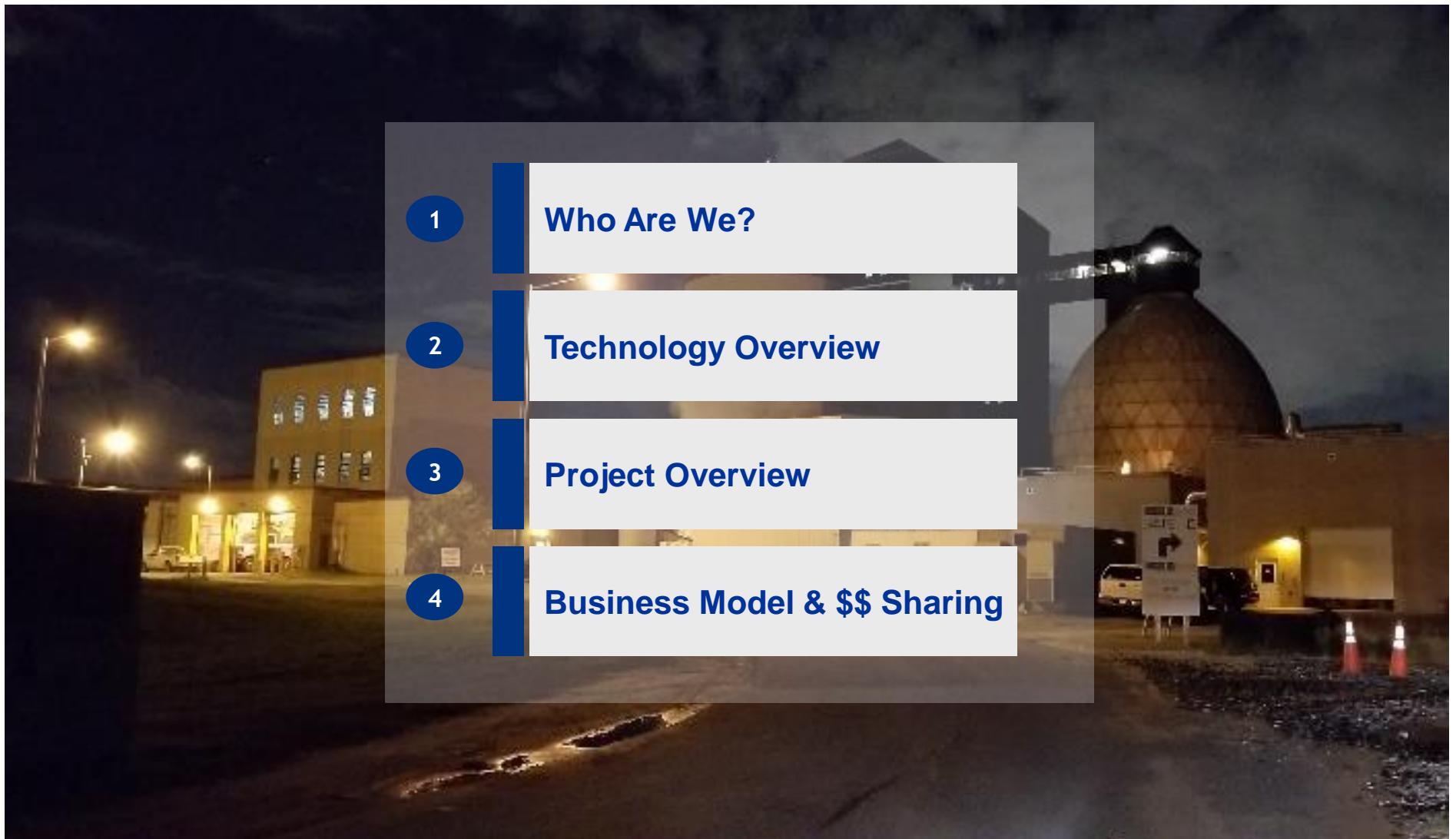
Clean Energy Solutions for Biogas Utilization

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 Owner Operator and HY-TEK Bio LLC, and for no other purpose, HY-TEK Bio © Copyright 2009 - 2019

ESSRE Presentation Outline



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**
- **100% mitigation of both CO₂ and NO_x using one-fifth sized pilot scale bioreactors; fully scaled system will provide 100% mitigation capability at varying volumetric flow rates**



HY-TEK Bio Team

Founder & CEO



Robert M. Mroz, is 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 the FCC's Advanced Technologies Group plus 40 years experience running his own technology companies producing World Class Sports Software, Professional Law Enforcement Weapons Management software, numerous technical consulting projects as well as the production, marketing and sales of various leading edge hardware & software technology products.

HY-TEK Bio's Board of Advisors consists of business owners and operators with extensive experience in business development and operations, financial, marketing and legal backgrounds and experience, including advanced technology backgrounds, automation control design and implementation, and extensive fabrication experience with multiple materials.



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.

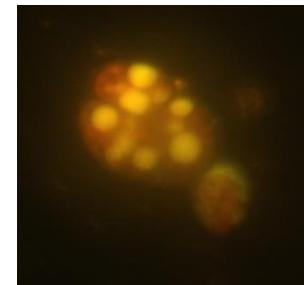


HY-TEK Bio, LLC.

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 and other locations around the world that rapidly consumes **NOx**, CO2 GHGs and other emissions; *thrives at up to 85% 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. GROW LIGHTING** – Employs a patent-pending high intensity internal 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 organic waste 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. 7.5 cfm, 1.5 ft. diam., 9 ft. algae culture

■ **Early Version Reactor Design -**

- Key Technology Components are constantly being implemented to further optimize for scaled up operation

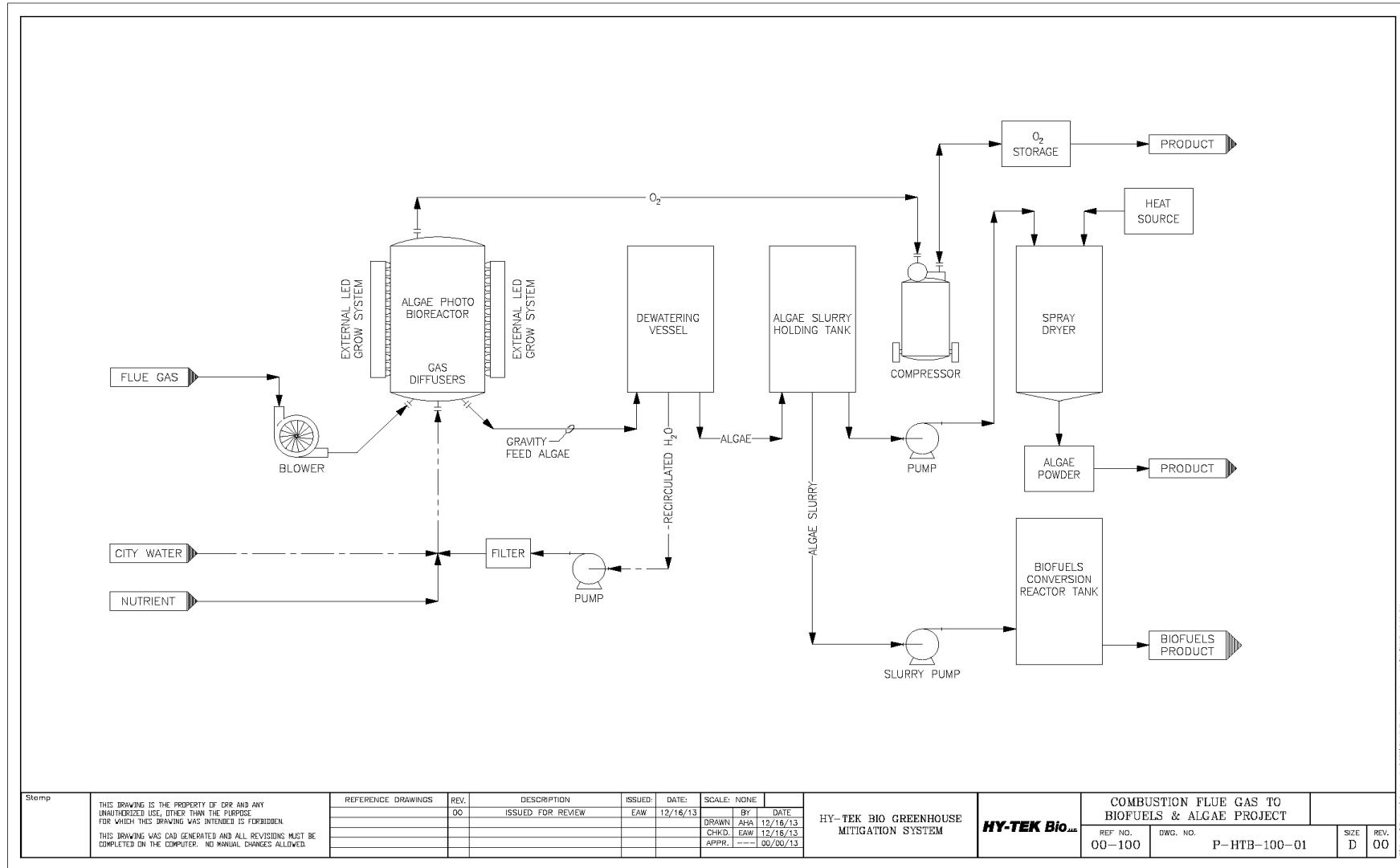
Commercial Demonstration Project: Why Algae?

➤ 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 
- ✓ 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



HY-TEK BIO Technology: CO₂ to Algae Process Schematic



Demo Facility Flue Gas Cooling and Waste Heat Recovery

Challenge - 1100F Engine Exhaust to 80F Input to Bioreactor



Waste Heat Recovery and Flue Gas Cooling



Turboden ORC

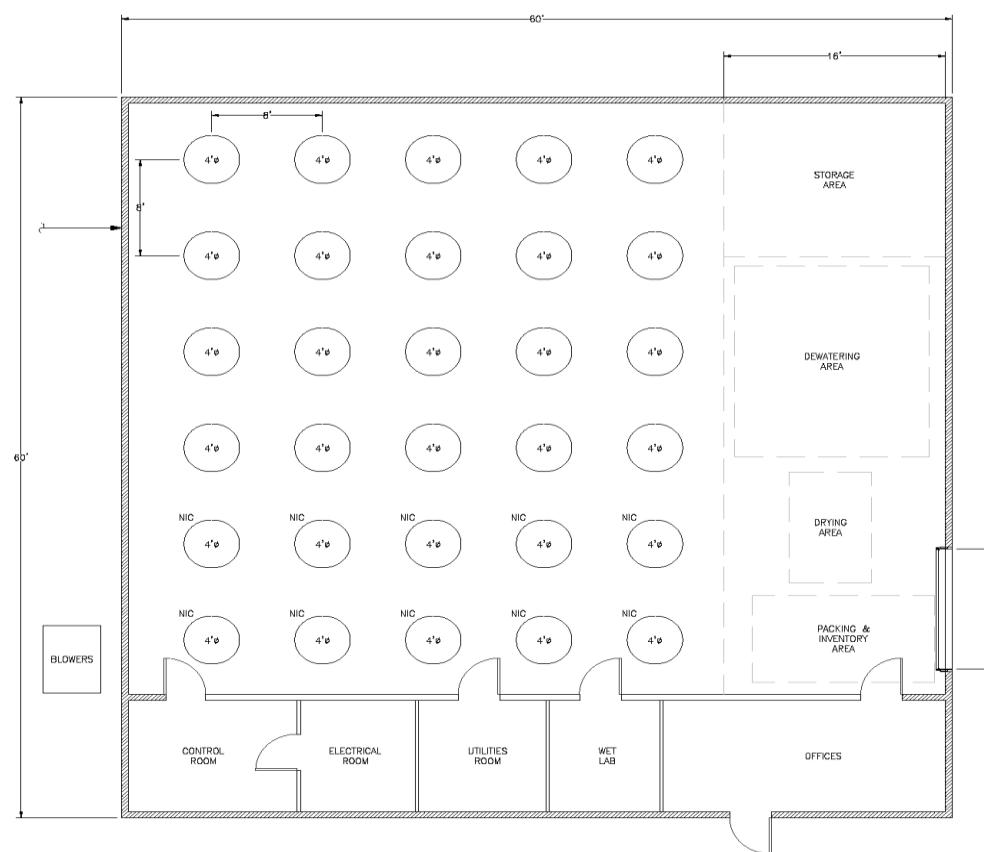


MultiGen Waste Heat Chiller



Sidell Flue Gas Economizer

HY-TEK BIO Technology: Algae Facility GA Equipment Layout



NIC = NOT IN CONTRACT

Stamp	THIS DRAWING IS THE PROPERTY OF HYTEK-BID AND ANY UNAUTHORIZED USE, OTHER THAN THE PURPOSE FOR WHICH THIS DRAWING WAS INTENDED IS FORBIDDEN. THIS DRAWING WAS CAD GENERATED AND ALL REVISIONS MUST BE COMPLETED ON THE COMPUTER. NO MANUAL CHANGES ALLOWED.	REFERENCE DRAWINGS	REV.	DESCRIPTION	ISSUED:	DATE:	SCALE:	NONE		1.0 MWe ALGAE FACILITY 20 BIOREACTORS GA EQUIPMENT LAYOUT	HY-TEK Bio, Inc.	sHTB1 ALPHA ALGAE DEMONSTRATION FACILITY			LOCATION TBD
		D		ISSUED FOR PROPOSAL	EAW	10/17/14	BY	DATE				REF. NO.	100	DWG. NO.	M-HTB-100-1

Commercial Project Overview:

XYZ Landfill ABC Food Processor

- Located in Anywhere, US
- Active or Closed (LF)
- 1 MWe Engine
- scfm exhaust gas for sufficient CO2 loading
- Electric Utility Tie-Ins

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



Outline

3

Project Overview



This presentation contains confidential information regarding HY-TEK Bio, LLC's proprietary technologies. By accepting this presentation the recipient agrees that

Algae Pilot Performance Metrics

■ Growth & Harvesting – *s.HTB1*

- Specific Growth (Doubling) = <1 day
- Culture Density = 5 g/L
- 75lbs/day/bioreactor
- Oil Lipid Content = 33%
- Aerial Utilization = 1.6 kg/m²/day (30 bioreactors)
- Up to 4% Lutein-Zeaxanthin Combined Content

Microalgae Benefits

■ Air Quality Improvement

- Priority air pollutant, mitigates NO_x, to Non-Detect
- SO_x in the flue gas is reduced by consumption as a secondary macronutrient (S)
- 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

■ Eliminates excess maintenance/costs for engines to comply with NO_x limits

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

■ Nutrient Recovery

- No P in flue gas – requires approx. 50 lb./day P from treated wastewater, landfill leachate, biosolids or other organic waste
- 100% NO_x from flue gas is not be sufficient – needs N recovery from wastewater

Nutrient Requirements for Mass Algae Cultivation



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

Outline

4

Business Model and Revenue Sharing



Revenue Sharing: Direct Algae Revenue Components to O/O in Public Sector

- ✓ **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
- **Customer Tailored Energy Efficiency Pilot Program (CTEEP)**
- [Edison Innovation Green Growth Fund](#)
- **Biopower Solicitations (FY 2019)**
- **Clean Power Choice Program**
- **Renewable Energy Incentive Program**
- **EDA Programs**
- **Carbon Credits**
- **Emission Reduction Credits**
- **Business Energy Investment Tax Credit (ITC)**

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 = \$2.6M
- Initial Capital Investment = approx. \$5M
- Simple Payback Period = < 3 years and Annual ROI = 45%;
- IRR = >20% (derated); > 45% at pilot production metrics

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

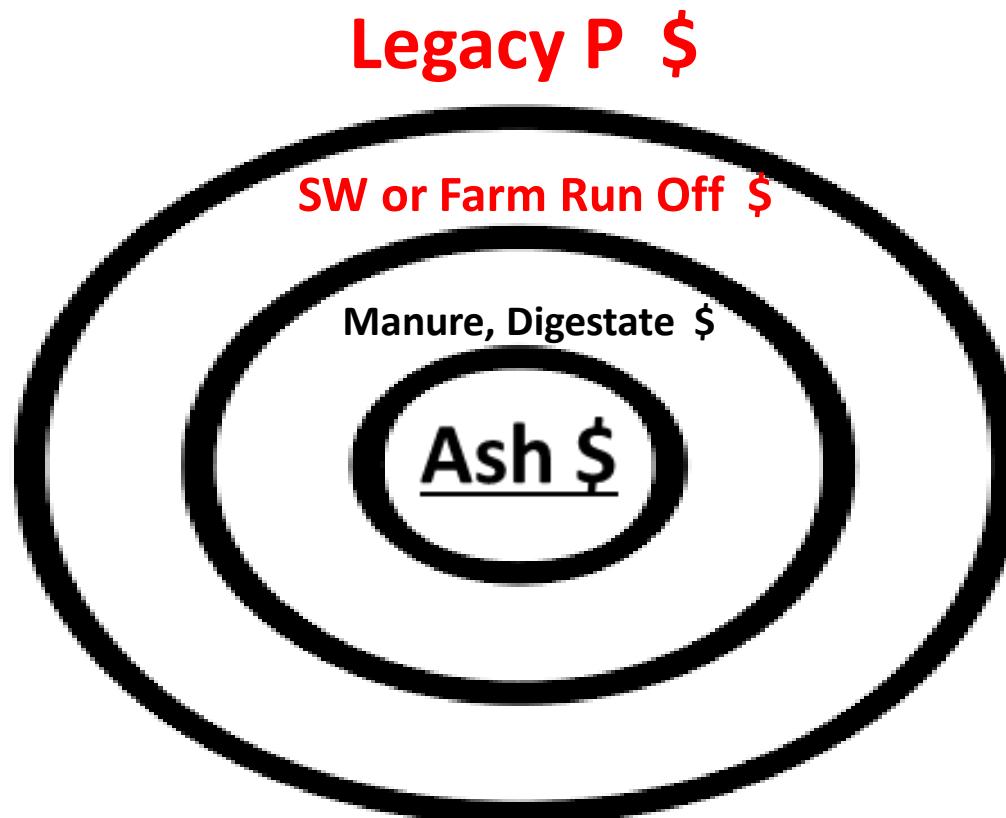
Multitude of Product Markets – Highest Valued is Lutein/Zeaxanthin at \$18,000/kg

“Natural” NOx Emissions Reduction and CO2 Utilization for Profit

“Green” Nutrient P from Waste

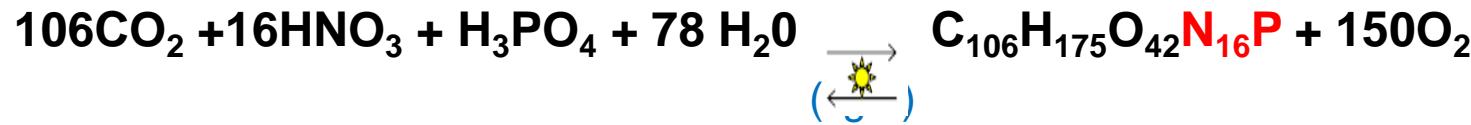
- Proprietary conversion process for producing a customized N-P-K liquid plant food from wastewater or organic matter to sustain mass algae growth
- Commercially available nano-enhanced adsorptive media used for “6R’s” of Soluble Reactive Phosphorus:
- 6R’s Pollutant P Stewardship for sHTB-1 specific N-P-K formulation from concentrated P sources:
Remove/Recover/Reconcentrate/Reuse/Recycle/Redistribution

P-Recovery Targets: Ash is the Bullseye



Combustion of Biomass Further Reduces GHG Emissions

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
- Chemical Fertilizer Avoidance adds additional CO₂ eq. emissions reductions
 - *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

Outline

NEW PROSPECTS & 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 - 2019

Sustainable Carbon-Negative Biosolids Management



Biosolids Bubbling Bed Combustion with CHP, Algae CCU at the Stack, and P-Recovery from the Ash

Second WRRF CCU Target: ATAD Biosolids



Auto Thermal Aerobic Digestion: Self-heating exothermic biological reaction. No external heat added – even during startup – operates at 130 – 150 F

2 MGD WWTP at 600 mg/L BOD influent produces **7.33 TPD CO₂** available for CCU

100% CO₂ Mitigation Requires ~ 4 TPD *sHTB1* Algae

2400 Metric Tons of CO₂ and 20 Tons P Recoverable per Annum

Port Authorities Join Forces in Climate Action Program via CCU



- The ports of Hamburg, Barcelona, Antwerp, Los Angeles, Long Beach, Vancouver and Rotterdam are joining forces to fight global warming
- Twenty per cent of Netherlands GHG emissions originate from the port of Rotterdam
- A Pilot-Scale demonstration of HY-TEK Bio Algae technology will be field demonstrated for zero GHG emissions from ship generators berthed at Port of Los Angeles

Conclusions and Highlights

- ✓ HY-TEK Bio's clean energy solution is a 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. Provides designs that are modular and scalable, which speeds implementation.
- ✓ The end result is Carbon Capture and Utilization (CCU).
- ✓ Requires a low CapEx compared to other NOx & GHG mitigation technologies.
- ✓ Provides opportunities to O/O for new revenue streams.
- ✓ Currently fabricating a portable DEMO unit to be tested at shipping port for CCU.
- ✓ Seeking a Gamma Commercial Demonstration Site (preferably biomass fuel plant, approx. 1 Mwe, 10,000 ft2 required).

NJWEA 104th 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, 2019

Robert Mroz

Founder/CEO

HY-TEK Bio LLC

bob@hytekbio.com

(410) 262-5113

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 - 2019

<https://www.youtube.com/watch?v=hbQbEgK6u-M>