## Presentation to:

## Energy from Biomass and Waste Expo

# "Organic Recycling for Distributed Generation"

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# Outline

- Introduction to BBI International
- Review of Biomass Utilization for Distributed Generation
- Focus on "Organic Recycling with Anaerobic Digestion"
- Case Study of Organic Recycling in a Corporate Setting

# BBI International

BBI founded in 1995 by Mike and Kathy Bryan

- 120 full-time employees
- Integrated RE Services Firm with 3 divisions:
  - Engineering & Consulting
  - International Conferences and Workshops
  - Publications: Biomass, Biodiesel, EPM
- Offices in Colorado, North Dakota, Canada, Australia
- Dedicated to ***Biomass Utilization for RE***

# Biomass

**"All plant and animal matter on the Earth's surface; all Biomass is ultimately derived from the Sun."**

- Agricultural Products
- Ag-residues
- Manure and Biosolids
- Wood
- MSW (60-70%)
- Construction & Demolition Debris (C&D)
- Forest Products Residues
- Forest Thinnings & Green Waste
- Industrial & Municipal Sludges
- ***Commercial & Residential Food Residuals***

# General Categories of Biomass Utilization

- Bioproducts
- Biofuels
- *Bioenergy*

# Biomass Energy Technology Applications

- Biomass Combustion…...Heat. Steam, Electricity
- Biomass Gasification…...Syngas, Chemicals, Electricity
- Biomass Pyrolysis……..“Bio-oil”
- Biofuels Production…….Ethanol, Biodiesel, Renewable Diesel
- Thermal Depolymerization…….“Bio-oil”
- ***Anaerobic Digestion……Methane***

# What is "Organic Recycling"?

- Organic Recycling is recycling organic materials, not just bottles, cans, metals and plastic
- Organic Recycling seeks to reuse and add value to waste biomass
- Organic Recycling recycles the nutrients & energy in biomass

# Why Practice Organic Recycling

- Current waste management practices have negative social and environmental impacts
- Municipal and corporate waste generators face rising energy and disposal costs
- Economic and legislative drivers are forcing waste generators to see waste as a valuable resource
- Organic recycling contributes to distributed generation

# Examples of Organic Recycling Applications

- Pellet Boilers: Austria, Scandinavia
- Aerobic Composting: throughout USA
- Biofuels production: biodiesel, syngas, mixed alcohols
- Bioproduct Manufacturing: Particleboard from cellulosic waste
- Anaerobic digestion of animal manure and food residuals
- Not all  organic recycling methods generate energy

# The Emerging Organic Recycling Opportunity: U.S. Solid Waste Market

- 6.75 billion tons of domestic solid waste
- 250+ million tons of MSW per year
- 5+ tons animal waste per person per year
- Growing at 3-5% per year
- GHG Reduction/Revenue from Carbon Offsets/RECs

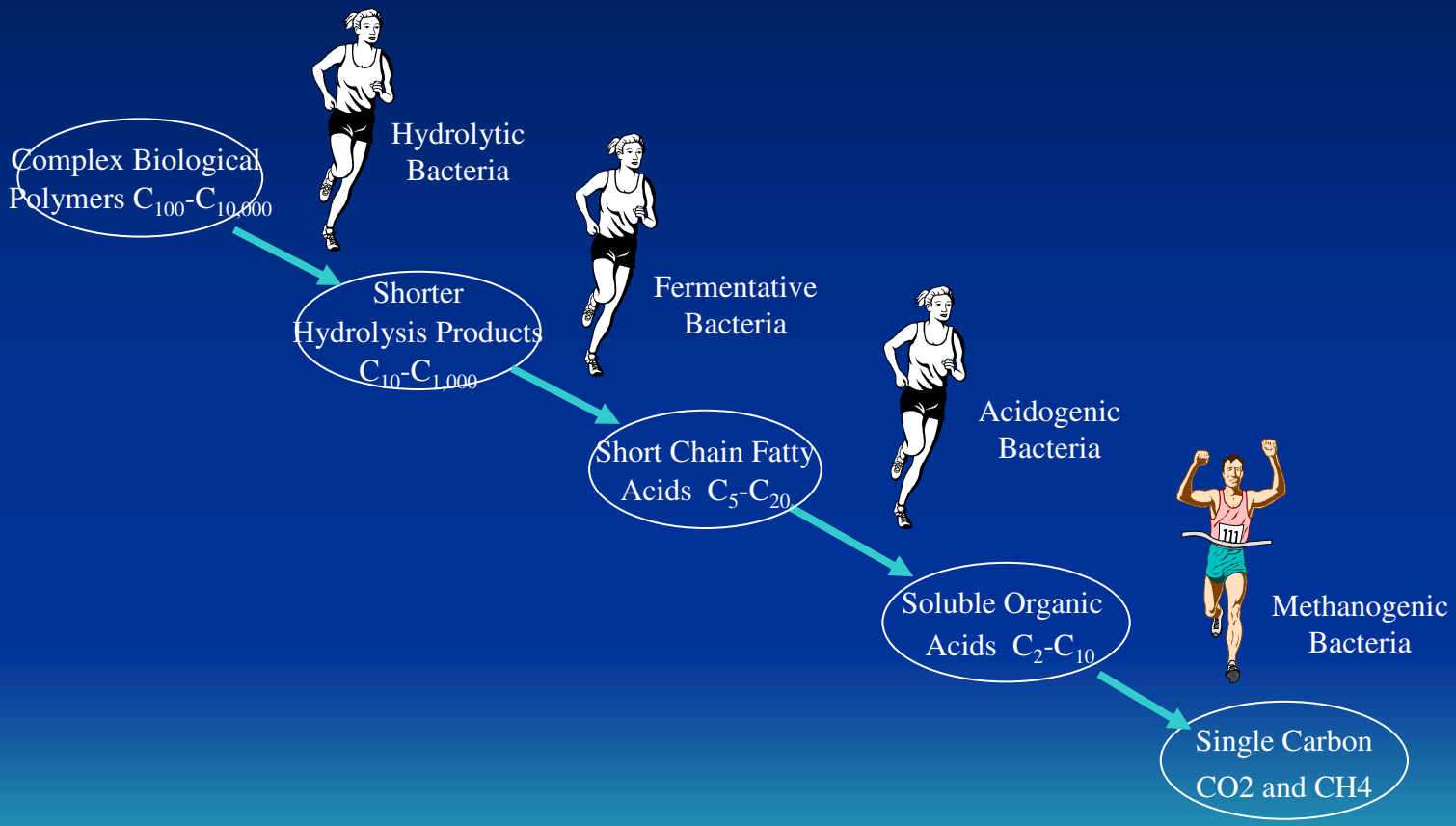
# Brief History of Anaerobic Digestion

- Anecdotal references as far back as 900 AD
- First municipal use in 1859 at leper colony in India
- Used to power streetlights in Britain in 1895
- First used for MSW in US in 1939
- China: >6,000,000 backyard digesters
- AD is the state of the art for municipal WWTPs worldwide

# The Basics of Anaerobic Digestion

- AD is a microbial bioconversion process
- Occurs in absence of air
- Occurs naturally in lakes, bogs, wetlands, landfills
- Occurs over wide range of temperature (5-100°C)
- Generates biogas and recycles valuable nutrients

# "The Anaerobic Digestion Relay Race: Passing the Carbon Baton"



# Potential Feedstocks for Anaerobic Digestion

- Wastewater, Sewage
- Spent Beverages
- Food Processing Wastes
- Food Residuals
- Organics in MSW
- Industrial Sludges
- Biosolids
- Slaughterhouse Waste
- Animal Mortalities
- Animal Manure

# Feedstock Base Drives Reactor Design

- Low Solids Feedstocks
  - <3% total solids by weight
  - little or no suspended solids
  - single phase liquid system, readily mixed
- Medium Solids Feedstocks
  - 3% to 12% total solids by weight
  - contains suspended solids
  - slurry system, can still be mixed
- High Solids Feedstocks
  - 15% to 30% total solids by weight
  - "solids-processing" system
  - requires non-traditional mixing

# Low Solids Anaerobic Digestion: Covered Lagoon


Photo Courtesy P. Harris

# Medium Solids Anaerobic Digestion: Complete Mix Slurry Digesters

(Photo Courtesy of the Danish Biogas Program)

# High Solids Anaerobic Digestion: Plug Flow Digester

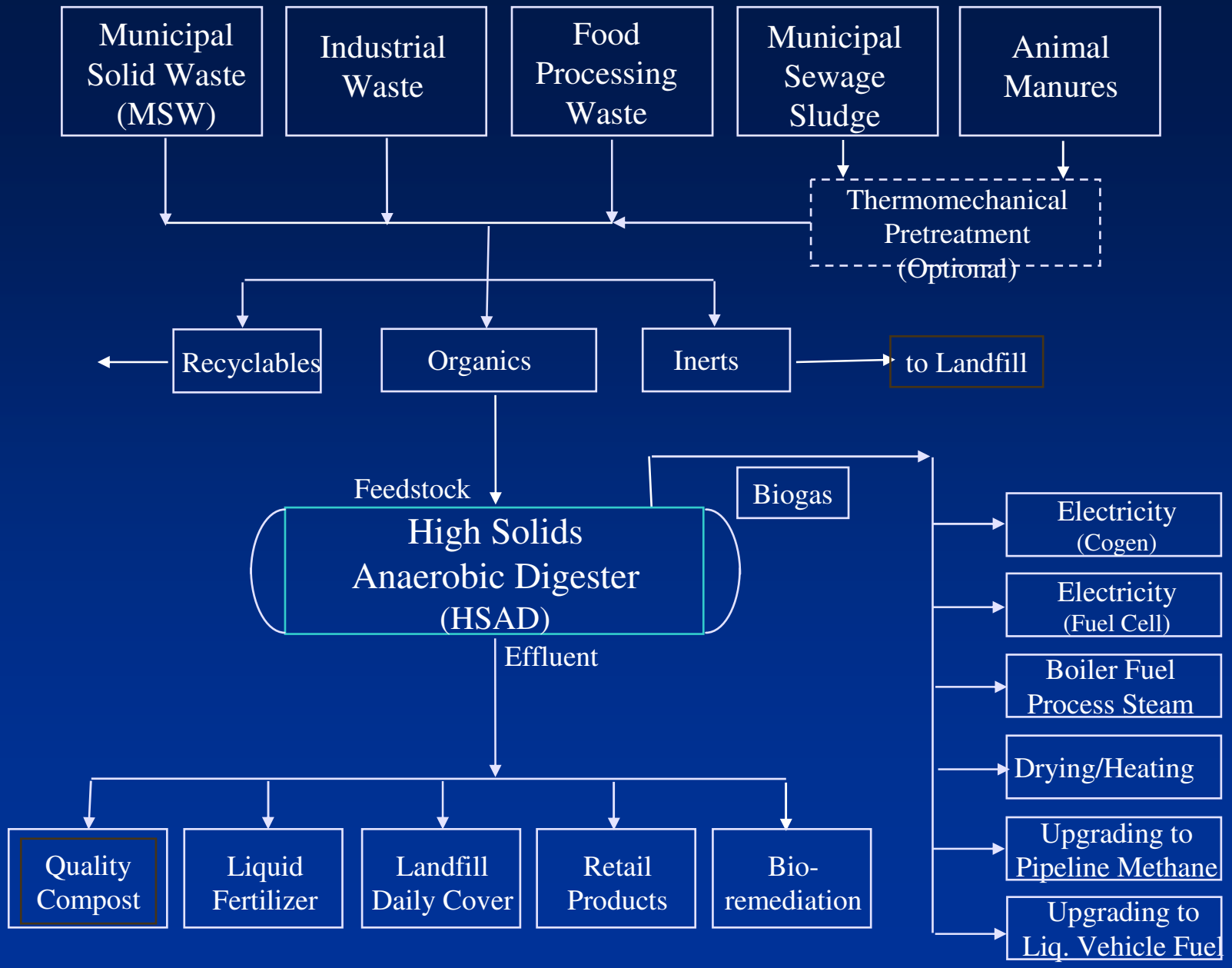

(Photo Courtesy of www.kompogas.ch)

# High Solids Anaerobic Digestion: Plug Flow Digester

# Organic Recycling for Distributed Generation: High Solids Anaerobic Digestion (HSAD)

- HSAD is an extension of established low-solids AD technology
- 2nd Generation Technology: solids handling approach
- Based on special bioreactor design and control system
- High Solids: 15 - 30% TS

# HSAD Block Flow Diagram



# Key Attributes of HSAD:

- **Order of Magnitude Increase in Volumetric Productivity**:
  - High-solids means more gas per cubic foot of reactor
  - OOM Increase in Organic Loading
  - Corresponding reduction in reactor size and capital cost
- **Thermophilic Regime (55-65°C):**
  - Faster kinetics
  - Reduced residence time

# The Benefits of HSAD: Energy

- Net Energy-Producing Process
- Decentralized, Distributed Power System
- Increases Self-Reliance of Industrial Operations
- Products include Electricity, Heat, and Transportation Fuel

# The Benefits of HSAD: Environmental

- No emissions or leachates
- Kills human pathogens and weed seeds
- Generates Sanitized, Class A Compost Product
- Diverts organic wastes from landfills
- Reduces greenhouse gas emissions by capturing methane and converting it to CO2

# The Benefits of HSAD: Economic

- Lower capital costs & higher productivity
- Avoided disposal costs
- Reduced energy expenditures
- Qualifies for GHG, enterprise zone, recycling, and RE credits

# Organic Recycling with HSAD: A Corporate Case Study

- Fortune 500 fish packer and pet food manufacturer
- Disposing of 20+ tpd of DAF Sludge at $50/ton
- Looking for alternative to current disposal option: land application 150+ miles away
- Steam at $7.00 MMBTU; electricity at $0.075/kwh
- Interested in distributed power generation & self-sufficiency
- Progressive management open to new ideas

# A Corporate Organic Recycling Case Study: Feedstock

- First step was a "Waste and Energy Audit" for process design
- 20 tpd of TS DAF Sludge at $50/ton
- 40 tpd of organics: screenings, out-of-spec product, paper, packaging, and office waste; $35/ton
- Daily organic waste totaled 60 tpd (~$2400/day in fees)

# A Corporate Organic Recycling Case Study: Drivers

- Client concerned about energy brownouts and price swings
- Client primarily interested in heat, avoided disposal costs
- Client wanted "Over-the-Fence" relationship
- Client required payback term of 2 to 4 years

# A Corporate Organic Recycling Case Study:

## Process Design Basis

| Process Inputs | Value | Units |
|---|---|---|
| Incoming Feedstock processed | 60 | tons/day |
| Incoming Feedstock average solids content | 45.8 | % |
| Total adjusted feedstock volume including recycle | 110 | tons/day |
| Blended feedstock solids content | 25 | % |
| Volatile solids conversion rate | 75 | % |
| Organic loading rate (grams of volatile solids per liter-day) | 12.2 | gVS/l-d |
| Process Outputs | | |
| Volatile solids converted to biogas | 17.1 | tons/day |
| Biogas production | 319,669 | ft3/day |
| Fuel gas energy produced | 192 | MMBTU/day |
| Methane production | 4.27 | tons/day |
| Electricity production with 35% co-generation efficiency | 19,663 | kWh/day |
| Electrical generating capacity | 0.82 | MW |
| Process heat available for recovery at 40% efficiency | 77 | MMBTU/day |
| Compost production | 20 | tons/day |
| Liquid Fertilizer production | 11,500 | gallons/day |

# A Corporate Organic Recycling Case Study:

## Summary of Feasibility Modeling Inputs

| | *Scenario* | |
|---|---|---|
| **Feedstock & Product Prices** | ***Low Income*** | ***High Income*** |
| Feedstock #1 Tipping Fee ($/ton) | 50 | 50 |
| Feedstock #2 Tipping Fee ($/ton) | 35 | 35 |
| Feedstock #3 Tipping Fee ($/ton) | 35 | 35 |
| Fuel Gas Value ($/MMBtu) | | |
| Electricity Value (cents/kwh) | 5 | 10 |
| Process Heat ($/MMBtu) | 2 | 6 |
| Compost ($/ton) | 5 | 20 |
| Liquid Fertilizer (cents/gallon) | -0.1 | 2 |
| Conc Liquid Fertilizer (cents/gallon) | 0 | 0 |
| Value of CO2 GHG Credit ($/ton) | 0 | 3 |
| | | |
| **Financial Input Parameters** | | |
| System Service Life (years) | 20 | 20 |
| System Financing Term (years) | 4 | 4 |
| Interest Rate (%) | 10 | 10 |
| System Total Installed Costs ($/sys.ton) | $20,000 | $20,000 |
| O&M (Estimate as % of TIC) | 25.00% | 25.00% |

# A Corporate Organic Recycling Case Study:

## Summary of Modeling Results

| | | |
|---|---|---|
| **Installed Capital Costs** | | |
| Total Capital Costs ($) | $2,200,000 | $2,200,000 |
| Principal | $2,200,000 | $2,200,000 |
| Total Payback Amount | $2,640,000 | $2,640,000 |
| Debt Service Costs/Yr | $627,000 | $627,000 |
| Debt Service Costs/Mo | $52,250 | $52,250 |
| | | |
| **Annual Revenues** | ***Low Income*** | ***High Income*** |
| Avoided Tipping Fees | $864,000 | $864,000 |
| Medium Btu Gas Sales | $0 | $0 |
| Electricity Value | $353,939 | $707,879 |
| Process Heat | $55,239 | $165,716 |
| Compost | $35,929 | $143,718 |
| Liquid Fertilizer | -$4,138 | $82,766 |
| Conc Liquid Fertilizer | $0 | $0 |
| GHG Reduction Credit | $0 | $101,553 |
| **Total Revenues** | **$1,304,969** | **$2,065,633** |

# A Corporate Organic Recycling Case Study:

## Summary of Modeling Results

| | | |
|---|---|---|
| **Annual Operating Costs** | | |
| Projected O&M Cost | $550,000 | $550,000 |
| Projected Debt Service Costs | $660,000 | $660,000 |
| Total Expenses | $1,210,000 | $1,210,000 |
| **Annual Pre-tax Income during Payback:** | $94,969 | $855,633 |
| **Total Pre-tax Income Over Payback Term:** | $379,877 | $3,422,530 |
| **Annual Pre-tax Income over Balance of Service Life:** | $754,969 | $1,515,633 |
| **Total Pre-tax Income Over Service Life:** | $12,459,387 | $27,672,651 |
| **IRR on Pre-tax Basis:** | 9% | 37% |
| **11-Year Average Annual ROI Based on 100% Equity** | 11% | 43% |

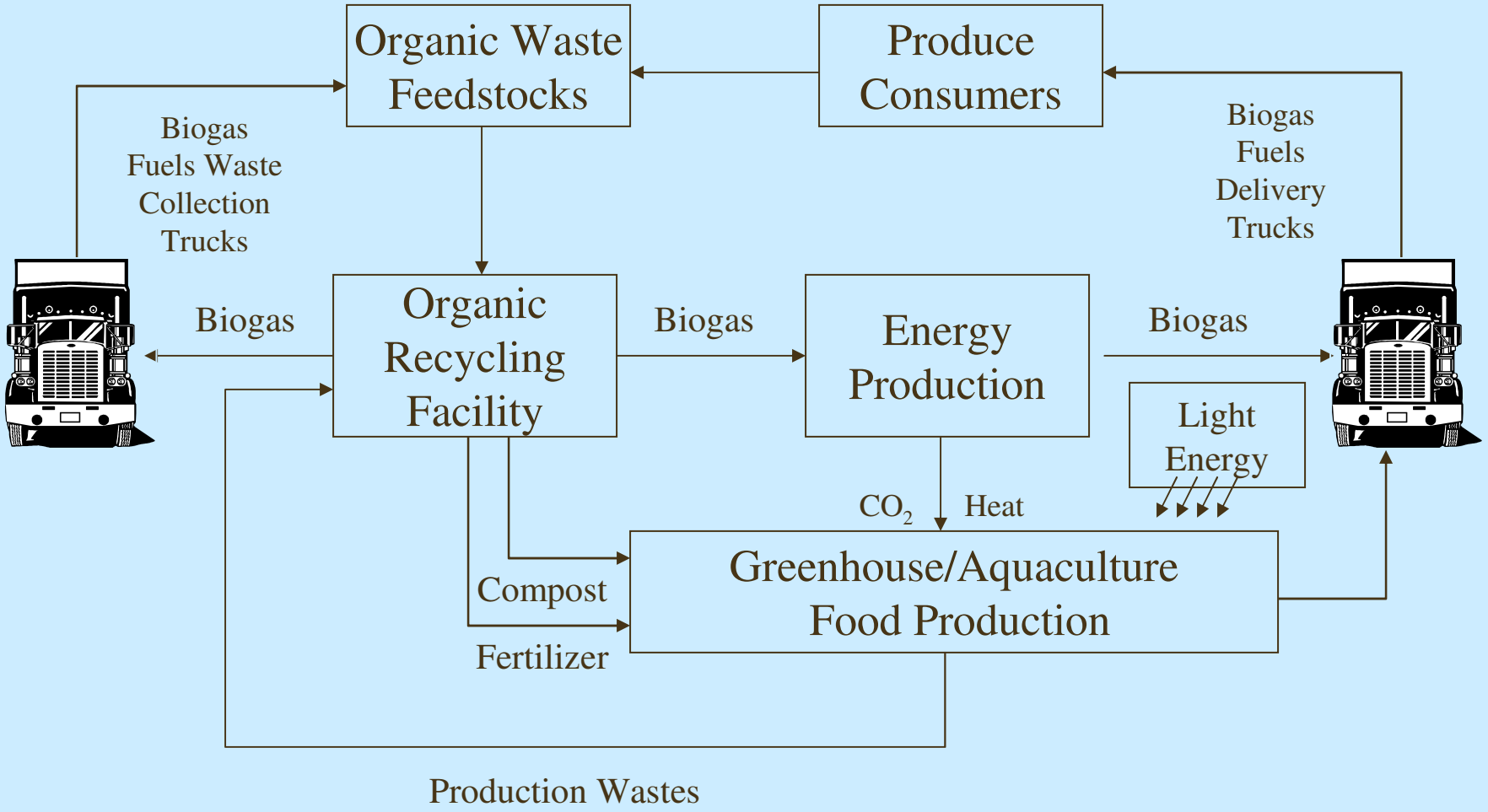
# Corporate Organic Recycling Case Study: Conclusions

- TIC of 110 tpd HSAD system: $2.6MM
- $864,000/year in avoided disposal costs
- Energy savings of $409,000 to $873,500/year
- System rated for 0.82 MW
- $12.4MM to $27.6MM in additional revenues over service life
- Converts 1,500 tons of methane/year into CO2 with additional revenue potential of $100,000 (with CO2 equivalent @ $3/ton)

# Organic Recycling for Distributed Generation: Summary

- Interest in Organic Recycling is growing globally
- Disposal costs, climate and energy security are drivers
- Organic Recycling with AD is an integrated solid waste & energy management strategy
- Organic Recycling with AD has substantial economic and environmental benefits
- Certain site-specific applications of AD for renewable energy generation are cost-effective now, without subsidies

# Organic Recycling with HSAD "Closes the Loop"!



# *Thank You!*

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# *Any Questions?*