Organic Recycling: Coming to a State Near You

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Amy McCrae Kessler, Esq.
Turning Earth, LLC
Founder, EVP, Head of Environmental & Regulatory Affairs
American Biogas Council
Vice Chair, Board of Directors, Co-Chair Federal Legislative & Regulatory Affairs Committee, Co-Chair AD Co-Products Working Group
We recycle organic waste into a number of valuable resources generating significant benefits for our host community.

Organic “waste” in... food and compost out... and renewable energy in between!

1. **Renewable Energy**
   Using a biological process called anaerobic digestion, we produce biogas which can be converted into many energy end products, including electricity, vehicular fuels and pipeline quality natural gas.

2. **Compost**
   Following the biogas extraction process, the material is converted into compost and further refined into a variety of engineered soil products with a myriad of industrial, residential and agricultural uses and environmental benefits.

3. **Food**
   Utilizing heat produced from our biogas conversion activities, we create ideal conditions for the production of sustainably and locally grown foods.

**Organic Waste**
Food waste, yard waste, industrial organic waste streams and agricultural waste are diverted from landfills and incinerators and brought to our facilities.

Mismanaged organics contribute to climate change.
Recycling organics benefits the environment and enhances our quality of life.

Recycling organics benefits the environment and enhances our quality of life.
### Significant Volumes of Organic Waste

- Approximately one third of the entire MSW stream is up for grabs as organic waste is diverted away from landfills and incinerators.

- 62% of municipal solid waste ("MSW") is organic material that can be recycled for beneficial reuse.

- Food waste and yard trimmings alone represents over 27% of MSW with less than 3% of food waste currently being recovered.

<table>
<thead>
<tr>
<th>Tons Generated</th>
<th>Tons Recovered</th>
<th>% MSW</th>
<th>% Recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Waste</td>
<td>36</td>
<td>2</td>
<td>14.5%</td>
</tr>
<tr>
<td>Yard Trimmings</td>
<td>34</td>
<td>20</td>
<td>13.5%</td>
</tr>
<tr>
<td>Paper</td>
<td>69</td>
<td>44</td>
<td>27.4%</td>
</tr>
<tr>
<td>Wood</td>
<td>16</td>
<td>2</td>
<td>6.3%</td>
</tr>
<tr>
<td>Total Organic Fraction</td>
<td>155</td>
<td>68</td>
<td>61.7%</td>
</tr>
</tbody>
</table>

Note: (1) In millions of tons per year.

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6/28/2015
Compost – Nature’s Multi-Tasking Master

- Roadside and construction
- Food production – outdoor and indoor farming
- Golf course applications
  - Rooftop gardens
- Athletic fields and parks
  - Commercial and residential landscaping
- Erosion control and remediation projects

Aikan®
## Common Digester Types

<table>
<thead>
<tr>
<th>Solids Content in Digester</th>
<th>Horizontal Mixed Plug Flow</th>
<th>Vertical Pumped Plug Flow</th>
<th>Dry Fermentation</th>
<th>Completely Stirred Tank Reactor</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 45% Solids (pumpable and stackable)</td>
<td>&lt;45% Solids (pumpable and stackable)</td>
<td>25-70% Solids (stackable)</td>
<td>&lt;25% Solids (pumpable)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Digestion Process</th>
<th>Continuous</th>
<th>Continuous</th>
<th>Batch</th>
<th>Continuous</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Digester Loading and Unloading</th>
<th>Automated</th>
<th>Automated</th>
<th>Manual (Front End Loader)</th>
<th>Automated</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Digester Mixing</th>
<th>Entire Vessel</th>
<th>Partial Pump Circulation</th>
<th>Static – no Mixing</th>
<th>Localized Mixers to Stir Vessel</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Foot Print / Height</th>
<th>Smaller / Medium</th>
<th>Smaller / Larger</th>
<th>Larger / Medium</th>
<th>Larger / Vessel Dependant</th>
</tr>
</thead>
</table>

Credit: Eisenmann
American Biogas Council: The Voice of the US Biogas Industry

- The only U.S. organization representing the biogas and anaerobic digestion industry
- Over 220 Organizations from the U.S., Germany, Italy, Canada, Sweden, Belgium and the UK
- All Industry Sectors Represented:
  - project developers/owners
  - anaerobic digestion designers
  - equipment dealers
  - waste managers
  - waste water companies
  - farms
  - utilities
  - consultants and EPCs
  - financiers, accountants, lawyers and engineers
  - Non-profits, universities and government agencies
- Join Us!
  - www.AmericanBiogasCouncil.org OR info@americanbiogascouncil.org OR 202.640.6595
Some of our members

American Biogas Council
Biogas Systems
The Basics

1. Organic material
   - Animal waste
   - Food waste
   - Agricultural waste

2. Digestion tank

3a. Biogas
   - Electricity
   - Heating
   - Vehicle fuel

3b. Digestate
   - Dry: livestock bedding, compost
   - Wet: fertilizer
Organic material is delivered to the digester system

This may include animal manure, food scraps, agricultural residues, or wastewater solids.

Digested material may be returned for livestock, agricultural and gardening uses.

Organic material is broken down in a digester

The digester uses a natural biological process under controlled conditions to break down organic material into products for beneficial use or disposal.

Raw biogas is processed

Typically, water, carbon dioxide and other trace compounds are removed, depending on the end use, leaving mostly methane.

Processed biogas is distributed and used

The gas may be used to produce heat, electricity, vehicle fuel or injected into natural gas pipelines.

Digested material is processed and distributed

Solids and liquids from the digester may be used to produce marketable products, like fertilizer, compost, soil amendments or animal bedding.

Biogas Processing

http://americanbiogascouncil.org/biogas_processing.asp
Increasing Education

Biogas Systems
The Basics

1. organic material (e.g., animal waste, food waste, agricultural waste, wastewater sludge)

2. digestion tank

3a. biogas (e.g., electricity, heating, vehicles, biodiesel)

3b. co-products (e.g., biogas to produce compost, fertilizer, nutrients)

Biogas Systems
Wet Systems

Biogas Systems
Dry System

American Biogas Council
What goes INTO a biogas system?
(organic materials)
Food Waste
Food Waste
Green Waste
Wastewater Solids
Manure
What wastes are BEST for making biogas?

35x manure
25x manure
10x manure
What comes OUT of a biogas system?
(gas, solid and liquid products)
Electricity
Heat
Fuels
Products for sale made from digested materials


http://www.magic-dirt.com/
Other Products

• Products that use methane as a feedstock
  – e.g., diesel replacements, hydrogen, chemicals, biopreferred products

• Nutrients
  – e.g., phosphorus, nitrogen, potassium, struvite pellets

• CO2
  – e.g., greenhouses, carbonation
Phosphorus Treatment

Primary and Secondary Screening
- Various screens used for separation of solids
- 15-30% recovery of P and N

Solids/Polymer Coagulation
- 80-90% recovery of P
- 35-55% recovery of N

Struvite Crystallization
- 75% recovery of P
- 30% recovery of N

Biogas Project Profiles
www.americanbiogascouncil.org/projects
Working Groups

- **AD Co-Products**: To address barriers to and open new market opportunities for the use of digested residuals.
  - **Digestate Standard Task Force**
- **Finance**: To enhance ability of biogas projects to get funded
- **Operators**: A private forum for digester operators to share and work through issues that will improve digester performance
- **RNG**: Develop a set of presentations which describe how biogas upgrading technologies work and some project applications
- **Research and Development Advisory**: Encourage 1) the development of US based biogas research; 2) equal support of biogas research compared with other advanced biofuels and 3) a research agenda with funding within USDA, DOE, EPA and NSF

Committees

- **Legislative and Regulatory Affairs**
  - Federal Co-chairs: Amy Kessler, Turning Earth; Norma McDonald, Organic Waste Systems
  - State Co-chairs: Wayne Davis, Harvest Power, Tony Callendrello, NEO Energy LLC
- **Marketing and Education**
  - Co-chairs: Nora Goldstein, BioCycle, Lisa McFadden, Water Environment Federation, Kendall Christiansen, Gaia Strategies
- **Membership and Fund-raising**
  - Paul Greene, Natural Systems Utilities, LLC, Ron Skinner, E&R Agri-Sales, LLC
Legislative and Regulatory Opportunities

**Federal (Agencies)**
- Biogas Opportunities
- Roadmap: USDA, EPA, DOE

**Federal (Congress)**
- Tax Reform (elec.)
- Renewable Fuel Standard (gas)

**State Activities**
- Top 11 States for putting Organics Recycling Laws in place: CA, WA, OR, WI, MN, NY, MA, PA, NJ, MD, NC
Federal Agencies

- Agriculture (USDA) — Rural Development, Conservation
- Environmental Protection EPA:
  - AgStar
  - Landfill Methane Outreach Program
- Energy (DOE)
- Federal Energy Regulatory Commission (DOE) — interstate pipelines
- Defense (DOD) — shore power, base energy needs
**Vehicles: Recent EPA changes to Renewable Fuels Standard (RFS2)**

**Before:**
- Feedstocks: Biogas from manure, wastewater and landfills
- Uses: CNG vehicles
- RIN credit: D5 “advanced biofuel”

**After:**
- Feedstocks: Biogas from virtually ALL feedstocks (all the ones before + non-manure agricultural waste, food waste, yard waste, MSW, energy crops, crop residues)
- Uses: CNG vehicles + LNG, electric vehicles (battery and fuel cell), DME (renewable diesel)
- RIN credit: mostly D3 “advanced cellulosic biofuel” (**more valuable**) and some D5, depending on project.
Hierarchy Confusion

EPA’s Food Recovery Hierarchy
http://epa.gov/foodrecovery/

EPA’s Solid Waste Hierarchy
http://www.epa.gov/waste/nonhaz/municipal/hierarchy.htm

Digestion
Composting
Incineration

GOOD for Biogas

Composting
Digestion and Incineration

BAD for Biogas
A Wave of New Food Waste Recycling Policies

Municipalities: San Francisco, Seattle, Austin, Vancouver, New York City, most starting in 2009-10

2011: CT, Public Act 11-217 (updated in 2013)


2013
- CT: Public Act 13-285 (update to 2011)—Commercial organics, effective 1/1/14
- NYC: Local Law 146-2013—Commercial organics, effective 7/1/2015

2014
- MA: 310 CMR 19.000 regulations—Commercial organics, effective 10/1/14
- CA AB 1826: Mandatory Commercial Food Waste Recycling, effective 1/1/2016

2015: MD, NJ, NY?
Connecticut
- June 20, 2013: Governor Malloy signs SB 1081 into law
- Commercial operations generating more than 104 tons per year of source separated organic material must separate and divert to a permitted facility
- Effective January 1, 2014

Massachusetts
- November 20, 2012: MassDEP streamlines permitting for organics recycling
- Organics landfill ban slated for 2014
- Progressive goals and action to build AD capacity:
  - 2012: AD given incentive parity with wind and solar power
  - 2014: 3 operating AD / CHP projects
  - 2020: Divert 350k tons per year of organic waste / 50 MW AD energy production

New York City
- February 17, 2013, Bloomberg proposes ambitious food waste initiative.
- Launches curbside residential organic waste pilot program in Staten Island
- City-wide roll-out now planned following strong participation levels
- Mandatory residential organics recycling expected by 2016
- Commercial organics ban pending and expected by 2016

"Converting organic waste to energy through anaerobic digestion is not just a win-win; it is a quadruple win."
MassDEP Commissioner Ken Kimmel (Boston Globe, 5/3/12)

“We’ll also tackle New York City’s final recycling frontier: food waste.”
New York City Mayor Michael Bloomberg (New York City Mayor’s Office, 2/17/13)
New York Biogas Study Group (NYBSG.)

NYBSG strategy is simple: unite with stakeholders who share our interest in reducing GHG emissions and making New York a renewable energy leader.

We will represent all biogas industry sectors and pursue two policy priorities in 2015:

To intervene in the ongoing Public Services Commission (PSC) proceedings to reform NY’s utility regulations and tariff structure. The PSC intends to accelerate distributed energy production, increase renewable energy and grid resilience. The proceedings will transform the electricity market in the state. The solar and wind industries have already fully engaged the process. Now, the biogas industry will take its place at the table;

We will also work with state and municipal policy makers to help develop biogas solutions to the problem of diverting food waste from landfill.

Join with us to help the industry grow and prosper in New York.  http://nybsg.org/
Best of Class Integrated Organics Recycling Technology
Simple, proven and best-of-class technology

Turning Earth holds the exclusive license to the Aikan Technology in North America

Two U.S. patents in place protecting the Aikan IP

Unique 3-step integrated high-solid anaerobic digestion and in-vessel composting process

Organic waste is introduced into the process modules

Both processes take place in the same module providing significant odor and environmental control
The facility will be capable of recycling a broad range of organic waste streams.

<table>
<thead>
<tr>
<th>Targeted Organic Waste Streams</th>
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</thead>
<tbody>
<tr>
<td><strong>Food Waste</strong></td>
</tr>
<tr>
<td>• Commercial, municipal and residential</td>
</tr>
<tr>
<td><strong>Yard Trimmings</strong></td>
</tr>
<tr>
<td>• Alternative solution to municipality operated facilities</td>
</tr>
<tr>
<td><strong>Soiled or Unrecyclable Paper</strong></td>
</tr>
<tr>
<td>• Commercial, municipal and residential</td>
</tr>
<tr>
<td><strong>Industrial Organic Waste Streams</strong></td>
</tr>
<tr>
<td>• Food related (e.g., potato sludge or brewery waste)</td>
</tr>
<tr>
<td>• Non-food related (e.g., paper mill sludge)</td>
</tr>
<tr>
<td><strong>Manures</strong></td>
</tr>
<tr>
<td>• Fully capable of managing</td>
</tr>
</tbody>
</table>
The Aikan Technology provides a number of very important competitive advantages.

These competitive advantages are significant drivers of value and are sustainable – they are the result of over 9 years of optimizing the technology and process.

Even with a similar technological approach, these advantages are not easily replicable – they are the result of a deep pool of know-how accumulated over many years.

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable Baseload Energy</td>
<td>24/7/365</td>
</tr>
<tr>
<td>Proven</td>
<td>10+ years in commercial operation</td>
</tr>
<tr>
<td>Unique Design</td>
<td>Proprietary 3-step integrated HSAD and in-vessel compost technology</td>
</tr>
<tr>
<td>Robust</td>
<td>Designed to manage wide range of organic waste streams and contamination levels</td>
</tr>
<tr>
<td>Scalable</td>
<td>Modular design – efficient future expansion</td>
</tr>
<tr>
<td>Flexible</td>
<td>Can be modified to maximize financial performance based on local conditions</td>
</tr>
<tr>
<td>Methane Rich, Clean Biogas</td>
<td>70% methane; no need to clean or condition</td>
</tr>
<tr>
<td>Efficient Footprint</td>
<td>Significant processing capacity on 6 acres</td>
</tr>
<tr>
<td>Odor Control</td>
<td>Nearly a decade of proven odor control</td>
</tr>
<tr>
<td>Zero Waste Process</td>
<td>Recycling of inorganic contamination Fully closed loop system – no waste water</td>
</tr>
</tbody>
</table>
Aikan – Process Overview

Organic waste is loaded into sealed process modules.

Liquid percolate is continuously recirculated through the organic waste and into the percolate tank for biogas generation.

After the conclusion of the methane production process, the organic waste is composted within the same module.

Organic waste is never exposed to the environment.

1. Organic waste received
2. Emptied in receiving building
3. Sorting and screening
4. Mixing
5. Loading process modules
6. Biogas production optimized in percolate tank
7. Material is further converted into a rich compost
8. Sorting and screening final product
9. Sale of engineered soils

ORGANICS RECYCLING & RESOURCE RECOVERY
### Turning Earth Facility: Just The Specs, Ma’am

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Volume (Annual)</td>
<td>50,000 long tons of organic waste</td>
</tr>
<tr>
<td></td>
<td>25,000 long tons of structure</td>
</tr>
<tr>
<td>Biogas</td>
<td>141.3 MM cft (3.6 MM m³) of biogas</td>
</tr>
<tr>
<td></td>
<td>88.9 MM cft of methane</td>
</tr>
<tr>
<td>Electricity</td>
<td>10,882 MWh (1.4 MW inst. cap.)</td>
</tr>
<tr>
<td>Heat</td>
<td>38,120 MMBtu</td>
</tr>
<tr>
<td>Co₂ Reduction</td>
<td>50,000 tons per year</td>
</tr>
<tr>
<td>Compost</td>
<td>40,000 cubic yards of compost</td>
</tr>
<tr>
<td>Footprint</td>
<td>6 acres</td>
</tr>
</tbody>
</table>
Turn Organic Waste Into Biogas & Compost: Aikan

Aikan: An Elegant Organics Recycling Solution
Turning Earth Central Connecticut – Facility Overview
Turning Earth Central Connecticut – Facility Overview
Turning Earth Central Connecticut
Turning Earth Central Connecticut

ORGANICS RECYCLING & RESOURCE RECOVERY
Turning Earth Central Connecticut
Significant Community Benefits

We look forward to being a productive, valued and long term member of the Central Connecticut community

- High quality permanent jobs at the facility and supporting businesses
- 100+ direct construction jobs plus significant secondary jobs
- New sources of tax revenue
- Good corporate citizen – assist state and towns meet sustainability objectives
- Renewable energy to power 1,000 homes
- CO$_2$ reduction equivalent of taking 9,800 cars off the road
- Compost to replenish soil nutrients, control erosion and run-off, sequester carbon, conserve water
- 1.5 million heads of lettuce annually from a single acre of greenhouse
Meeting State & Local Policy Goals

Higher recycling rates as set forth in Connecticut’s Solid Waste Management Plan

Mitigating green house gas emissions and climate change

Increasing local renewable energy capacity and energy security

Providing lower-cost, higher-value disposal options to businesses and residents

Growing local economy

By providing a recycling option for organics directed to diversion under Connecticut Public Act No. 11-217, Turning Earth will help get valuable resources out of the waste stream and into local commerce to be made into valuable products like clean energy and compost.
Significant Market & Sustainability Opportunity
$16Bn+ U.S. Market Opportunity

“Biogas can meet demand in power...address a range of environmental issues, and may be deployed on both an integrated and distributed basis.

“Worldwide Power Generation Capacity from Biogas Will Double by 2022.” Pike Research. 5 November 2012

“There’s no question that waste is an opportunity.

Waste has incredible energy potential, and if that potential can be harnessed in a way that doesn’t unleash pollution, it can be transformative on a national scale.”

US EPA administrator Lisa Jackson on anaerobic digestion (Boston Globe, 5/3/12)

“...demand for local foods in [NYC alone] was as much as $860 million annually. This far outpaced supply at that time, which was estimated to be under $200 million.”

“FoodWorks. A Vision to Improve NYC’s Food System” The New York City Council. 22 November 2010

“...this fast-growing market reached $17.3 billion in global revenue in 2011 and will nearly double by 2022, hitting 33.1 billion in that year”

“Global Biogas Market to Nearly Double in Size to $33 Billion by 2022.” Pike Research. 21 June 2012

Key Assumptions

Product volumes based on applying the Aikan mass balance to the aggregate organic fraction of MSW

Product pricing based on averages for various products

Does not capture the large opportunity relating to recycling industrial and agricultural organic waste streams

Biogas $2.8 to 4.2Bn

Tipping Fees $6.2 to 9.3Bn

Engineered Soils $1.8 to 3.0Bn

Sustainable Agriculture $1.5 to 2.0Bn

Carbon Credits $0.1 to 0.7Bn

$16Bn+ U.S. Market Opportunity
U.S. Biogas Market—Current and Potential

2,000+ Operational Biogas Systems Today

11,000+ Potential New Biogas Systems

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Farm (Dairy and Swine)</td>
<td>239</td>
</tr>
<tr>
<td>Wastewater</td>
<td>1,241</td>
</tr>
<tr>
<td>At Landfills</td>
<td>636</td>
</tr>
<tr>
<td>Total</td>
<td>8,000</td>
</tr>
<tr>
<td>Total Biogas</td>
<td>2,440</td>
</tr>
<tr>
<td>Total Landfills</td>
<td>450</td>
</tr>
</tbody>
</table>
U.S. Biogas Market – Potential Impact

13,000+ Biogas Systems

Emission reductions equivalent to removing 1 - 11 million passenger vehicles from the road

Enough energy to power 3.5 million American homes
Thank You!

- Learn More
  - Sign up for the FREE Biogas News
- Become a Member
  - Dues start @ $75-$1,300
  - Application online, or contact us

Patrick Serfass, Executive Director
American Biogas Council
1211 Connecticut Ave NW
Suite 650
Washington, DC 20036
202.640.6595
[info@americanbiogascouncil.org](mailto:info@americanbiogascouncil.org) (yes, it will come to my inbox)