WELCOME TO THE OCTOBER EDITION OF THE 2015 M&R SEMINAR SERIES
BEFORE WE BEGIN

• PLEASE SILENCE CELL PHONES OR SMART PHONES

• QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION

• PLEASE FILL EVALUATION FORM

• SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE

• STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE
  (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)
Thomas E. Kunetz, PE

**Current:** Assistant Director of Engineering, the Metropolitan Water Reclamation District of Greater Chicago
In charge of strategic engineering initiatives for the District

**Experience:** Twenty-nine years of experience in the environmental and civil engineering field

**Education:** Graduate of the Water and Wastewater Leadership Center, Kenan-Flagler Business School, University of North Carolina
M.S., Water Resources Engineering, Villanova University,
B.S., Environmental Engineering, Penn State University

**Profession:** Registered Professional Engineer in Illinois
Board Certified Environmental Engineer (BCEE)
Member of the Steering Committee for the WERF LIFT program
WEF (Water Environment Federation) Board of Trustees
Past Chair of the WEF Municipal Wastewater Treatment Symposium
WEF Fellow

**Award:** 2012 national recipient of the Charles Walter Nichols Award for Environmental Excellence from the American Public Works Association
MWRD Perspectives on Co-Digestion and Biogas Utilization

Thomas E. Kunetz, P.E., BCEE, WEF Fellow
Assistant Director of Engineering

M&R Seminar Series

October 30, 2015

The Metropolitan Water Reclamation District of Greater Chicago

--Recovering Resources, Transforming Water
Energy-Water Nexus

Image: World Bank
On an annual average, to produce as much renewable energy as the energy that is imported
Energy Imported

- Electricity
- Natural Gas
- Diesel
- Gasoline
- Propane
Energy Produced

- Digester Gas
- Hydroelectricity
- Solar Thermal
- Sewer Thermal
- Photovoltaic
- Wind
Energy Neutrality as of 2014

27%
Domestic wastewater contains 5 times the energy needed to treat it.

- 80% Thermal energy
- 20% Chemical energy
- <1% Kinetic (hydraulic)
Anaerobic Digestion

- Biological process in which different groups of bacteria play a role to systematically break down organic matter into simpler compounds in the absence of oxygen ("anaerobic")
- Reduces the volatile organic matter in the wastewater solids.
- Bacteria require heat to grow—"mesophilic"
- Byproduct is digester gas or "Biogas"
Biogas Composition

- 60-64% methane
- 35-39% carbon dioxide
- 5% VOC, sulfur compounds, siloxanes
- Heating value of ~600 BTU/cubic foot
- (Natural gas is ~1,000 BTU/cubic foot)
Biogas Utilization

- Boiler
- Electricity generation
- Pipeline gas
- CNG Fuel
Biogas Utilization—Boilers

- High pressure steam or hot water
- Digester heating
- Building heat
- Stickney, Calumet, Hanover Park, Egan
Biogas Utilization—Electricity Generation

Gas Turbine

Engine Generators
Biogas Utilization—Electricity

- Digester gas cleaning
- Carbon dioxide
- Moisture
- Siloxanes
Combined Heat and Power (CHP)

Natural Gas

Fuel In
Air Intake
Cold Water in from Building

Gas Engine

Water Pipes
Exhaust Gas Heat Recovery Heat Exchanger
Catalytic Converter
Boilers

Hot Water or Steam to Building

Exhaust Gases

Electricity
Biogas Utilization—Pipeline Gas

- High BTU facility
- Cleans biogas using Pressure Swing Absorption (PSA) technology
- Recover 92% of methane from biogas
- Biomethane sold to natural gas pipeline for environmental attributes under Renewable Fuel Standards program
Biogas Utilization—CNG

Janesville, WI WWTP
CNG Vehicles improve air quality through dramatic reductions in emissions:

- Reducing carbon dioxide (CO$_2$) emissions by 20% to 30%
- Reducing carbon monoxide (CO) emissions up to 75%
- Reducing nitrogen oxide (NOx) emissions by approximately 50%
- Reducing up to 95% of particle matter (PM) emissions
- Reducing volatile organic compound (VOCs) emissions by 55%

Energy efficiency of various alternative fuels

Gasoline: about 38% eff.

Source: The Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) Model 1.8b
Water intensity of transportation fuels

Source: NGVC.org: Environmental Benefits of Natural Gas Vehicles.

Gasoline with 10% irrigated ethanol blend: ~ 200 gallons water consumed per 100 miles driven
Renewable Fuel Standards

- **USEPA Renewable Fuel Standards Program (2005)**
- Establishes minimum volumes of renewable fuels that must be used for transportation fuel
- Volumes set by USEPA each year through Renewable Volume Obligations (RVO) for transportation fuel suppliers
- RVO compliance is measured by a unit called a Renewable Identification Number (RIN)
- Transportation fuel suppliers can meet the RVO by purchasing the credits for renewable fuels
- 1 RIN = 11.727 mmBTU
Renewable Fuel Standards

• Four categories of fuel:
  - Conventional Biofuels
  - Cellulosic Biofuels
  - Biomass-based Diesel
  - Advanced Biofuels

• USEPA sets RVO for each category

• RVO for Cellulosic Biofuels and Advanced Biofuels is required to increase each year
Low Carbon Fuel Standards (LCFS)

- Issued by California Air Resources Board
- Issues LCFS credits to reduce emission of carbon dioxide from vehicles through use of clean fuels.
- Measured in metric tonnes of carbon dioxide avoided through the use of clean fuels
- Regulated fuel producers must meet annual carbon intensity targets
- Can purchase LCFS credits to meet targets
Biomethane Economics

Biomethane sale price made up of 3 components:

• Percent of Natural Gas market price (aka “Brown Gas”)
• Percent of RIN market price
• Percent of LCFS market price
Historical D5 RIN & LCFS Pricing

- **LCFS $/MMBtu**
- **OPIS D5 $/MMBtu**
- **RIN**
- **LCFS**

*Note: The graph shows the historical pricing trends of D5 RIN and LCFS from January 2011 to July 2014.*
Co-Digestion

Digester

Biogas

High strength waste

Food Waste

Sewage Solids

Fats, oils, greases
Resource Recovery Legislation

✓ Signed into law in July 2014

✓ Grants the District the authority to capture and sell recovered resources and produce renewable energy resources.

✓ “The District has the opportunity and the ability to change the approach to wastewater treatment from that of a waste material to be disposed of to one of a collection of resources to be recovered, reused, and sold, with the opportunity to provide the District with additional sources of revenue and reduce operating costs.”
Co-Digestion

GOAL:

• *Find a consistent, long term supply of organic waste to provide stability from both a process perspective and a financial perspective*
Feedstock Market--Analysis and Challenges

<table>
<thead>
<tr>
<th>Organic Feedstock</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOG, Yellow Grease</td>
<td>Easily digestible. Competitive uses. Limited quantity.</td>
</tr>
<tr>
<td>High Strength Waste</td>
<td>Available, variable quality, variable availability.</td>
</tr>
<tr>
<td>Good quality industrial food waste</td>
<td>Available, often sold for animal feed.</td>
</tr>
<tr>
<td>Source separated organics (SSO) (pre-consumer food wastes)</td>
<td>Variable availability, variable quality. Potential for increasing availability if disposal options available</td>
</tr>
<tr>
<td>Wet Commercial Waste/Municipal Solid Waste</td>
<td>Available in large quantities, but organic material co-mingled with non-organics.</td>
</tr>
</tbody>
</table>
Liquid Organic Waste

Rock River Water Reclamation District
Fats, Oils and Greases (FOG)

West Lafayette, IN
Source Separated Organics (SSO)

Marin Sanitary Service
Source Separated Organics (SSO)
Source Separated Organics (SSO)
Source Separated Organics (SSO)

Marin Sanitary Service
Source Separated Organics (SSO)

Central Marin Sanitation Agency
Source Separated Organics (SSO)

Central Marin Sanitation Agency
Source Separated Organics (SSO)

Central Marin Sanitation Agency
Wet Commercial Waste

Wet Commercial Waste

Waste pulping/ screening

Digester Feed

Images: GE Monsal
Organics Extrusion Press (Anaergia)

Photos: Anaergia Services

Wet Fraction

Dry Fraction
Calumet WRP
Co-Digestion and Biogas Utilization Plan

13-RFP-06 Biogas Renewable Energy Project at the Calumet Water Reclamation Plant--May 2013
## CWRP Co-Digestion and Biogas Utilization Plan

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Organic Waste (High Strength Waste) and FOG</td>
<td>Liquid Organic Waste Supply Chain Manager—15-RFP-27</td>
</tr>
<tr>
<td></td>
<td>(Dec. 2015)</td>
</tr>
<tr>
<td>Liquid Organics Receiving Station</td>
<td>Engineering Dept. Design</td>
</tr>
<tr>
<td></td>
<td>(Summer 2016 award)</td>
</tr>
<tr>
<td>Digester Gas Cleaning Facility and Biomethane supply pipeline</td>
<td>Ameresco, Inc. Design/Build Contract</td>
</tr>
<tr>
<td></td>
<td>(Nov. 2015 award)</td>
</tr>
<tr>
<td>Biomethane Offtake Agreement</td>
<td>BP</td>
</tr>
<tr>
<td></td>
<td>(Jan. 2016 award)</td>
</tr>
</tbody>
</table>
CWRP Co-Digestion and Biogas Utilization Plan
## Biogas Production--CWRP

<table>
<thead>
<tr>
<th>Factor</th>
<th>Annual Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Digester Gas Production</td>
<td>1,100 Mcf/d</td>
</tr>
<tr>
<td>Liquid Organics Gas Production</td>
<td>857 Mcf/d</td>
</tr>
<tr>
<td>Total Digester Gas Production</td>
<td>1,957 Mcf/d</td>
</tr>
<tr>
<td>Biomethane Production</td>
<td>1,026 mmBTU/d</td>
</tr>
<tr>
<td>Move Towards Energy Neutral</td>
<td>~40%</td>
</tr>
</tbody>
</table>
## CWRP Biomethane Economics

<table>
<thead>
<tr>
<th>Capital Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Organic Waste Receiving Station</td>
<td>$7,400,000</td>
</tr>
<tr>
<td>Gas Cleaning Facility and Biomethane Delivery</td>
<td>$14,300,000</td>
</tr>
<tr>
<td>Pipeline</td>
<td></td>
</tr>
<tr>
<td>Interest on loan</td>
<td>$1,800,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operations Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>$1,680,000/yr</td>
</tr>
<tr>
<td>Electricity</td>
<td>$675,000/yr</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$360,000/yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential Revenue Source</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Organic Waste Tipping Fee</td>
<td>$2,500,000/yr</td>
</tr>
<tr>
<td>Sale of Biomethane</td>
<td>$4,500,000/yr*</td>
</tr>
</tbody>
</table>

* Assumes $12/mmBTU for environmental attributes plus brown gas
Stickney WRP
Co-Digestion and Biogas Utilization Plan
## SWRP Co-Digestion and Biogas Utilization Plan

<table>
<thead>
<tr>
<th>Description</th>
<th>Project Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSO--Food Waste, Collected and Pre-processed offsite</td>
<td>RFP for Supply Contract (2016)</td>
</tr>
</tbody>
</table>
| Organics Waste Receiving Station:  
  - Food Waste Slurry  
  - HSW  
  - FOG | Engineering Dept. Design (2017 award) |
| Digester Gas Cleaning Facility (High BTU Plant) and Biomethane supply pipeline | RFP for Design/Build (2016) |
| Biomethane Offtake Agreement | RFP (2017) |
| Digester Gas Piping? Additional Flares? | Engineering Dept. Reviewing Options |
| Digester Mixers? | Engineering Dept. Reviewing Options |
SWRP Co-Digestion and Biogas Utilization Plan

Dig. Gas Cleaning Facilities
Organics Receiving Station
Biomethane Delivery Pipeline
Digester Capacity Analysis
Assumptions

- Imhoff tanks replaced with West Side Primary Settling Tanks by year 2018
- New Gravity concentration facility and pre-digestion thickening centrifuges on-line: 5% solids to digesters
- Operational procedures to control solids loading to digesters to dampened peak loadings
- Reduce hydraulic retention time in digesters to 15 days from current 20 days (per PFRP)
- Result: Approximately 1,000,000 gal additional capacity available for outside organic wastes
# Biogas Production -- SWRP

<table>
<thead>
<tr>
<th>Condition</th>
<th>Annual Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Digester Gas Production</td>
<td>3,000 Mcf/d</td>
</tr>
<tr>
<td>WS Primary Settling Tanks</td>
<td>3,000 Mcf/d</td>
</tr>
<tr>
<td>1,000,000 gal/d high VS organic waste (eg. food waste)</td>
<td>6,000 – 11,000 Mcf/d</td>
</tr>
<tr>
<td>Total Projected Digester Gas:</td>
<td>12,000 – 17,000 Mcf/d</td>
</tr>
<tr>
<td>Biomethane Production</td>
<td>6,300 – 8,900 mmBTU/d</td>
</tr>
<tr>
<td>Organic Waste Trucks per day</td>
<td>150-200</td>
</tr>
<tr>
<td>Potential Biomethane Revenue</td>
<td>$27 - $39 million*</td>
</tr>
<tr>
<td>Potential GHG Reduction</td>
<td>500,000 MT CO₂e/yr</td>
</tr>
<tr>
<td>Move Towards Energy Neutral</td>
<td>100%</td>
</tr>
</tbody>
</table>

* Assumes $12/mmBTU for environmental attributes plus brown gas
Rome’s sewers weren’t built in a day...
Acknowledgements

- Chris Nam, Engineering Department
- Brian Perkovich, Calumet M&O Department
- Reed Dring, Stickney M&O Department
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- Ellen Avery, Law Department
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