Water and Sewage Treatment Energy Management Joint Conference

Hosted By:
Delaware Valley Regional Planning Commission,
PA DEP southeastern Regional office,
EPA Region III.

Montgomery County Community College
April 25, 2012
Identify ways that energy can be conserved or recovered in Water and Wastewater Treatment.

Typically energy saving opportunities are more prevalent in Wastewater than Water Treatment.
Water Treatment;
Example: Energy Savings Measures

• Energy Recovery by using raw or finished water for heat recovery. To be installed at the Ridley water treatment plant

• Chemical Dose Optimization.

• Pumps and Motors.

• Process Changes.

• Cyclic operation; if possible.
Water Treatment Case Studies; Energy Savings Measures

Bristol Water Treatment Facility Upgrade

Retrofitting two sedimentation basins with plate settlers increased basin settling capacity ten-fold over the typical settling capacity. Operating costs have been reduced by 22 percent.

Upgrade to the Morrison Coulter Water Treatment Facility at Ingrams Mill

Retrofitting sedimentation basins with plate settlers increased basin capacity from 2 mgd to 7 mgd per basin. The upgraded basins provide improved settled water quality, reduced chemical usage, and increased filter run times. Operating costs have been reduced by 25 to 30 percent.
Construction of a baffled blend tank to mix the two water sources achieves hydraulic mixing with no additional energy cost. Four existing settling basins were retrofitted with inclined plate settlers, increasing treatment capacity from 10 MGD to 15 MGD per basin.

55 percent reduction in settled water turbidity. The reduction in settled water turbidity has allowed increase average filter run times from 48 to 72 hours, reducing backwash water consumption by 33 percent.
Wastewater treatment typically consumes about 35% of municipal energy budgets.

Aeration and Solids Handlings are typically the largest energy users.

Solids Handling 20 to 25%
Wastewater Plants Are Being Viewed as Resource Centers

Resource Supply (fuel line)

Solar and Wind

Organic Waste

Fuel

Energy (Heat, Power)

Fertilizer & Nutrients

Reclaimed Water & Hydrothermal

Slide Courtesy WEF, Dave Perry, CDM
Aeration System Blowers

Multi Stage Centrifugal
- Inlet Throttled Efficiency 50 to 70%
- VFD Driven Efficiency 60 to 70%

Single Stage Centrifugal
- Dual Vane Control Efficiency 70 to 85%

Positive Displacement
- VFD Driven Efficiency 45 to 60%

Aeration Tank
Aeration System Instrumentation

Screened, Degrited Wastewater

Blowers

Blower

DO Probe & Transmitter

Ammonia and Nitrite Probe & Transmitter

VFD

Aeration Tank

Clarifier-Settler

Recycle Sludge

Waste Sludge

To Sludge Treatment
Nitrification and Denitrification

*Nitrification removes ammonia by conversion of the ammonia to Nitrate and Nitrite.*

Nitrification:
- Consumes significant electrical power
- Consumes Alkalinity.

*Denitrification removes Nitrate and Nitrite made by Nitrification step to elemental Nitrogen.*

Denitrification:
- Recovers some of the power required by Nitrification (25 to 35%)
- Recovers some Alkalinity (25 to 40%)
Case Study; Abington Township WWTP 3.91 MGD

**NEEDS STATEMENT**

**Ammonia Nitrogen**

<table>
<thead>
<tr>
<th>Month</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
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</thead>
<tbody>
<tr>
<td>2008</td>
<td>3.0</td>
<td>3.1</td>
<td>2.9</td>
<td>2.3</td>
<td>2.5</td>
<td>2.7</td>
<td>2.1</td>
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<tr>
<td>2009</td>
<td>2.8</td>
<td>2.9</td>
<td>2.7</td>
<td>2.2</td>
<td>2.4</td>
<td>2.6</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Winter Permit Limit**
2.16 mg/l

**Summer Permit Limit**
0.72 mg/l
Post Project Configuration
Aeration Energy Control at Abington Township – Nitrification / Denitrification WWTP

BIOS Optimal Control System

Courtesy; Biochem Technologies
Post Project - Effluent Ammonia

Ammonia Nitrogen

Winter Permit Limit
2.16 mg/l

Summer Permit Limit
0.72 mg/l
**Abington WWTP - Added Electrical Load**

- Third Aeration Reactor – About 50 kw  
  \(1,200\ \text{KWH} / \text{day}\)
- Pumping Station – About 30 kw  
  \(720\ \text{KWH} / \text{day}\)
- Filters – About 10 kw  
  \(240\ \text{KWH} / \text{day}\)
- Mixers, Chem. Feed – About 7 kw  
  \(150\ \text{KWH} / \text{day}\)

**TOTAL**  
\(2,310\ \text{KWH} / \text{day}\)

**69,300 KWH / month**

About 20 to 25% increase
Abington Township
Before and After Electrical Energy Demand

Months

2006

2007

2010

2011
• Costs
  – Construction Cost total $11,216,578.
  – $815,387 grant awarded by PA DCED for the project.
  – Interest of $239,990 earned on the bond was made available to supplement project funds.
  – Change orders totaled $138,801, less than 1.25% of construction cost.
Cumberland County Utilities Authority
Monthly Electric Usage Costs - 2001 (Main Plant)

Monthly electric usage costs dropped significantly upon completion of the improvement project in August 2001.
Other Energy Conservation and Recovery opportunities in Wastewater Treatment

- Pumping & Screening
- Power Factor Correction
- Primary Settling (optional)
- Disinfection
- Chemical Addition

Solids Handling Systems
Biosolids – Energy Recovery Pathways

- **Wastewater Biosolids**
  - **Digestion**
    - **Anaerobic Digestion**
      - **Mechanical Dewatering**
      - **Thickening**
    - **Aerobic Digestion**
  - **Mechanical Dewatering**
    - **Thermal**
      - **Direct Combustion**
        - **HEAT**
        - **POWER**
      - **Gasification / Pyrolysis / Others**
        - **HEAT**
        - **POWER**
        - **Biochar, Other Derivatives**

- **POWER** + **HEAT**
- **No Energy to Recover**
Wastewater Treatment
Anaerobic Digestion

WWTP Solids

Volatile & Ash Solids (IN)
(as liquid slurry)
(± 85% VS)

Anaerobic Digester
(95 to 100 deg F)

Biogas (OUT)
about 600 BTU / cu. ft.
14 to 18 ft³ / lb VS destroyed

Solids (OUT)
(40 – 50% less than Solids IN)

Heat (IN)
(from biogas combustion)

Heat (OUT)
from biogas combustion

Natural Gas or Oil

Boiler / Heat Exchanger

Waste Heat
Anaerobic Digestion with Combined Heat and Power (CHP) Cogeneration

### CHP SYSTEM
- **Recovered Power ± 30%**
- **Recovered Heat ± 50%**

### Overall Efficiencies
- up to 85%

### Components
- **Anaerobic Digester**
  - **Solids**
  - **Biogas (OUT)**
  - **Waste Heat Dump**
  - **Emergency Flare**
- **Boiler / Heat Exchanger**
  - **Natural Gas or Oil**
  - **Heat (IN)**

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**Diagram Notes:**
- Arrows indicate the flow of materials and energy:
  - Red arrows: heat flow, including recovered power and heat.
  - Green arrows: biogas flow.
  - Blue arrows: solid material flow.

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**Key Terms:**
- CHP: Combined Heat and Power
- Anaerobic Digestion
- Overall Efficiencies up to 85%
Combined Heat and Power Cogeneration

Prime Mover Options

- Fuel Cell
- Microturbine
- Internal Combustion Engine

Biogas Cleaning

Biogas

Other Uses

Digester

HEAT

and

POWER

HEAT
Biogas Conditioning and Utilization

Flow Schematic

- **Digester**
- **H₂S Removal Device**
- **Meter**
- **Chiller**
- **Siloxane Filter**
- **Gas Compressor (1.5 to 2 psig)**
- **IC Engine**

- **Cost Effective for Mid-Sized WWTP**

- **POWER**
- **HEAT**

- **Condensate**
Landis Sewerage Authority  CHP System

- IC Engine / Induction Motor Generator 185 kw
- Waste Heat Radiators
- Chiller
Co-Generation Power

LSA Power Generated less Parasitic Losses 2008

Graph showing the Kwh generated from January to December 2008.
LSA Power Gless Parasitic Losses 2009

Co-Generation Power

Generator Bearing Failure
CoGen Investment Breakeven Analysis
(36 CFM Gas, 5% Interest, $500K Grant)

Estimated Invested Value
Estimated Value of Net Savings
Case Study
Derry Township Municipal Authority, Hershey, PA

5.0 MGD WWTP Currently operated at 3.8 MGD

Co-digested Grease Waste and pretreated sludge from Hershey Foods

Biogas Conditioning – 300 scfm Engine Biogas Demand – 90 scfm max.

Construction Cost - $2.0 Million Grant Amount - $500,000.
DTMA Biogas Conditioning System

H₂S Filter

Siloxane Filters
DTMA Biogas Conditioning System

Moisture / Siloxane Reduction Heat Exchanger
DTMA 280 kw, 375 HP  Cogen Engine Housing

Engine Housed in Existing Building

Summertime Waste Heat Radiator
DTMA 280 kw, 375 HP Cogen Engine
8 cylinder, Lebeir
DTMA Cogeneration Efficiency Values

- **Overall Efficiency**
- **Thermal Efficiency**
- **Electrical Efficiency**
DTMA Electrical Power Profile and Savings

- **KWH**
- **Months**

2010

2011

- **Savings per Month**
- **Months**

2010

2011
Thermal Bioenergy Potential Of Biosolids

8,000 to 10,000 BTU / lb.

4,000 BTU / lb.
Indirect Dryers

Indirect dryers use hollow metal paddles or trays with hot fluids inside to dry the biosolids.

Hot fluids include:
- Steam
- Thermal fluid (high flash point oil)
Belt Dryers recycle lower temperature hot air.
Solar Sludge Drying
Worlds Largest Solar Dryer

Palma De Mallorca, Spain
## Estimated Energy Comparison

<table>
<thead>
<tr>
<th></th>
<th>Gas Fired Dryer</th>
<th>Solar Dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal energy consumption</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy needed (BTU) per ton of H₂O evaporated</td>
<td>3,100,000</td>
<td>Free</td>
</tr>
<tr>
<td>Price per Million BTU’s (approximate)</td>
<td>$10.00</td>
<td>$10.00</td>
</tr>
<tr>
<td>Cost per ton of water evaporated</td>
<td>$31</td>
<td>Free</td>
</tr>
<tr>
<td><strong>Electricity consumed (equipment)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption per ton of H₂O evaporated [kWh]</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>Cost per kWh</td>
<td>$0.10</td>
<td>$0.10</td>
</tr>
<tr>
<td>Cost per ton of H₂O evaporated</td>
<td>$10.00</td>
<td>$3.00</td>
</tr>
<tr>
<td><strong>Total energy cost per ton of H₂O evaporated (approx. at today’s cost)</strong></td>
<td>$41.00</td>
<td>$3.00</td>
</tr>
</tbody>
</table>
Pyrolysis Typical Heat & Material Balance

Process Flow
Typical Values

Biomass

Dryer

Moisture Removal

Heat

Pyrolysis Reactor

Process Heat

Process Heat or Engine/Generator

15 - 20% Combustible Gas

60% BioOil (Varies with Organics content)

15 - 25% Charcoal

Char Furnace

Ash
The PyroBioMethane Process (patent application filed) converts ligno-cellulosic materials which are recalcitrant to anaerobic digestion into digestible compounds that can then be converted into biogas (~65% CH4; 35% CO2).
The PyroBioMethane process incorporates a slow, low temperature pyrolysis step. This is not to be confused with the numerous flash pyrolysis processes attempting to produce a “bio-oil” from biomass.
Other Case Studies
## Case Studies:

<table>
<thead>
<tr>
<th>Facility</th>
<th>Capital Improvement</th>
<th>Capital Cost ($)</th>
<th>Energy Saved (in KWHs/yr)</th>
<th>Payback (in Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Bay WWTP (8.0 MGD)</td>
<td>6 New Blowers; air bearing turbo type</td>
<td>$850,000 (2004)</td>
<td>2,143,974 (50% reduction)</td>
<td>13</td>
</tr>
<tr>
<td>Cumberland Co. Utilities Auth. NJ, (7.0 MGD)</td>
<td>New VFD driven multi-stage cent. blowers; new diffusers, new DO controls, new RAS system</td>
<td>$1.2 Million Annual Revenue $10,000 to $20,000</td>
<td></td>
<td>Self Amortizing Project</td>
</tr>
<tr>
<td>Hatfield Township Municipal Auth., PA</td>
<td>ReHeat Oxidization new Multiple Hearth Furnace system.</td>
<td>$10 Million 50,000 Million BTU/yr</td>
<td></td>
<td>Paid for in 4 to 5 yrs.</td>
</tr>
<tr>
<td>Burlington, VT</td>
<td>New turo Blowers, DO Controls</td>
<td>$56,000 Rebate, electrical utility $21,000</td>
<td>250,000</td>
<td>1</td>
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</tbody>
</table>
## Case Studies:

<table>
<thead>
<tr>
<th>Facility</th>
<th>Capital Improvement</th>
<th>Capital Cost ($)</th>
<th>Energy Saved (in KWHs/yr)</th>
<th>Payback (in Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELCORA</td>
<td>Change from fuel oil to natural gas for incineration system</td>
<td>$2.3 Million</td>
<td>Parallel Furnace Operation: Oil - $4,000 Gas - $650</td>
<td>5</td>
</tr>
<tr>
<td>Derry Twp. Mun. Auth., PA</td>
<td>280 kw (350 HP) CHP Cogeneration</td>
<td>$2.1 Million</td>
<td>1.5 to 2 Million KWH 17,000 gal. Fuel Oil</td>
<td>9</td>
</tr>
<tr>
<td>Landis Sewerage Auth., NJ</td>
<td>185 kw (240 HP) CHP Cogeneration</td>
<td>$1.4 Million</td>
<td>0.75 to 1.25 Million</td>
<td>6</td>
</tr>
<tr>
<td>East Norriton, Plymouth, Whitpain JSA, PA</td>
<td>ReHeat Oxidization system on Multiple Hearth Furnace</td>
<td>$1.2 Million</td>
<td>25,000 to 45,000 MMBTU/yr</td>
<td>6 to 7</td>
</tr>
</tbody>
</table>
## Example Projects/Measured Benefits

<table>
<thead>
<tr>
<th>Client</th>
<th>Project</th>
<th>Energy Reduction Results</th>
<th>Cost Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landis Sewerage Authority</td>
<td>Biogas Recovery and Cogeneration Facilities</td>
<td>About 1,000 Mw-hrs per year</td>
<td>$155,000 savings in 2008</td>
</tr>
<tr>
<td>New York State Energy Research &amp; Development Authority</td>
<td>Energy Performance Evaluation Through Submetering Municipal Wastewater Treatment Plants</td>
<td>Varies for all of the 11 WWTPs evaluated; the total recommended savings was 7,400 Mw-hrs</td>
<td>Total annual savings was approximately $833,000</td>
</tr>
<tr>
<td>Cumberland County Utilities Authority</td>
<td>Aeration Process Optimization Project</td>
<td>200 HP</td>
<td>$102,000 savings annually</td>
</tr>
</tbody>
</table>
# Cost Savings

<table>
<thead>
<tr>
<th>WWTP Location</th>
<th>Existing Energy Costs</th>
<th>Energy % Savings</th>
<th>Electrical $ Saved</th>
<th>Gas\Oil $ Saved</th>
<th>Operational $ Saved</th>
<th>Total $ Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village of Marcellus (0.4 mgd)</td>
<td>$50,495</td>
<td>28%</td>
<td>$13,715</td>
<td>$315</td>
<td>$5,700</td>
<td>$19,730</td>
</tr>
<tr>
<td>Village of Clayton (0.5 mgd)</td>
<td>41,889</td>
<td>35%</td>
<td>14,800</td>
<td></td>
<td>59,000</td>
<td>73,800</td>
</tr>
<tr>
<td>Village of Heuvelton (0.5 mgd)</td>
<td>105,745</td>
<td>45%</td>
<td>48,000</td>
<td></td>
<td></td>
<td>48,000</td>
</tr>
<tr>
<td>South &amp; Center Sewer (2 mgd)</td>
<td>152,345</td>
<td>14%</td>
<td>21,600</td>
<td></td>
<td></td>
<td>21,600</td>
</tr>
<tr>
<td>Town of Grand Island (2.1 mgd)</td>
<td>195,174</td>
<td>22%</td>
<td>42,000</td>
<td></td>
<td></td>
<td>42,000</td>
</tr>
<tr>
<td>Town of Bethlehem (3.5 mgd)</td>
<td>162,725</td>
<td>21%</td>
<td>34,000</td>
<td></td>
<td></td>
<td>34,000</td>
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<tr>
<td>Erie Co. Big Sister (4.9 mgd)</td>
<td>381,145</td>
<td>21%</td>
<td>77,325</td>
<td>$4,100</td>
<td>151,000</td>
<td>232,425</td>
</tr>
<tr>
<td>Orangetown (7.5 mgd)</td>
<td>150,374</td>
<td>52%</td>
<td>78,000</td>
<td></td>
<td></td>
<td>78,000</td>
</tr>
<tr>
<td>Saratoga Sewer Dist. (21 mgd)</td>
<td>787,563</td>
<td>11%</td>
<td>8,680</td>
<td>$75,365</td>
<td></td>
<td>84,045</td>
</tr>
<tr>
<td>Onondaga County (80 mgd)</td>
<td>1,615,965</td>
<td>12%</td>
<td>200,000</td>
<td></td>
<td></td>
<td>200,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3,643,420</strong></td>
<td><strong>17%</strong></td>
<td><strong>$538,120</strong></td>
<td><strong>$79,780</strong></td>
<td><strong>$215,700</strong></td>
<td><strong>$833,600</strong></td>
</tr>
</tbody>
</table>
QUESTIONS

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