Kenosha Wastewater Treatment Plant - Energy Optimized Resource Recovery Project

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MIWEA
June 21st, 2016
Thanks & Acknowledgement

• The entire Kenosha Water Utility (KWU) Staff, including:
  • Ed St. Peter, Curt Czarnecki, Melissa Arnot, Katie Karow, & Tom Tetzlaff

• J. F. Ahern – General Contractor

• Pieper Power – Electrical Contractor

• CD Smith – Civil Contractor

• Donohue & Associates – Engineer including Dennis Dineen & Allen Williams

• Centrisys Corp. including Geoff Harvey & Christine Smith

• CNP – Gerhard Forstner
Presentation Outline

- Kenosha Water Utility (KWU) and Wastewater Treatment Plant (WWTP) Overview
- Drivers for Energy Optimized Resource Recovery Project
- Technology Overview
- Preliminary Results
- Economics (Added Value)
- Conclusion
**WWTP Service Area Overview**

- **Population:** 110,000
- **Service Area:** 85.7 mi² (222 km²)
- **Collection System**
  - Gravity Sewer System: 332 mi (535 km)
  - Lift Stations: 13
- **Permitted Annual Average Daily Flow:** 28.6 MGD (1.253 m³/s)
- **2015 Annual Average Daily Flow:** 21.9 MGD (0.961 m³/s)
- **Effluent Discharge:** Lake Michigan
**WWTP Loadings**

**Average Day (Current Loadings Based on 2015 Data):**

- **BOD**
  - Influent: 32,910 lbs/day (180 mg/l)
  - Effluent: 2,475 lbs/day (13 mg/l)
  - 92% Removal

- **TSS**
  - Influent: 32,863 lbs/day (180 mg/l)
  - Effluent: 1,415 lbs/day (8 mg/l)
  - 96% Removal

- **Ammonia**
  - Influent: 4,881 lbs/day (27 mg/l)
  - Effluent: 530 lbs/day (3 mg/l)
  - 89% Removal

- **Phosphorus**
  - Influent: 533 lbs/day (3 mg/l)
  - Effluent: 85 lbs/day (0.5 mg/l)
  - 84% Removal
Sludge Characteristics

Primary Sludge:
- Average Flow: 68,620 gal/day (260 m³/day)
- Solids Concentration: 3.3%
- Solids Production: 19,020 lbs/day (8,626 kg/day)
- Volatility: 77%

Waste Activated Sludge (WAS):
- Average Flow: 151,350 gal/day (570 m³/day)
- Solids Concentration: 1.05%
- Solids Production: 13,010 lbs/day (5,900 kg/day)
- Volatility: 72%

Digested Sludge
- Solids Concentration: 2.7%
- Volatile Solids: 54%
- Volatile Solids Reduction: 60%
- Sludge to Landfill (2015): 2,500 dry US tons, 2,270 dry metric tons
Motivation Behind Project

• Aging WWTP infrastructure
• An effort to combat ever rising utility costs:
  – Natural Gas
  – Electricity
• Reduce or eliminate landfill disposal fees
Project Objectives

• Increase biogas production
• Generate electricity from biogas
• Achieve 90% dry and Class A biosolids
• Utilize waste heat as the main thermal energy supply
• Maintain existing effluent quality
• Maintain or decrease noise, odor and particulate levels
Design Approach

- Wisconsin allows for design/build approach on resource recovery projects
- Design/Build was utilized due to the varying technologies and complexity of the project.
- In the RFP the design/builder was tasked with the following:
  - Preparation of the design
  - Assisting KWU in obtaining all necessary permits
  - Procuring, constructing and installing all components
  - Integrating the new system with the existing plant SCADA network
  - Startup and commissioning
  - Preparation of O & M manuals
  - Warrantying the system
## Anaerobic Digestion Modifications

<table>
<thead>
<tr>
<th></th>
<th>Before Project</th>
<th>After Project</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Digesters</strong></td>
<td>4 primary</td>
<td>2 primary</td>
</tr>
<tr>
<td></td>
<td>2 secondary</td>
<td>1 secondary</td>
</tr>
<tr>
<td><strong>Total Capacity</strong></td>
<td>633,550 ft³</td>
<td>319,650 ft³</td>
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<tr>
<td><strong>Mixing Condition</strong></td>
<td>Unmixed</td>
<td>Fully mixed with mechanical hydraulic mixing</td>
</tr>
<tr>
<td><strong>Sludge Feed Operation</strong></td>
<td>Batch feeding operation based on 8-hour shifts</td>
<td>Continuous feed</td>
</tr>
<tr>
<td><strong>Feed</strong></td>
<td>Primary (3.3% TS)</td>
<td>Primary (7% TS)</td>
</tr>
<tr>
<td></td>
<td>WAS (5.0% TS)</td>
<td>WAS (7% TS)</td>
</tr>
<tr>
<td><strong>HRT in digesters</strong></td>
<td>Primary=30 days</td>
<td>Current operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary=17 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ultimate Operation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary=22 days</td>
</tr>
</tbody>
</table>
Mechanical Hydraulic Mixing
Rotamix by Vaughan Company

System consists of:
• Chopper pump
• Internal piping
• Six nozzles (per digester)

Benefits:
• More even heating of contents
• Improved volatile solids reduction
• Increased gas production
Primary Sludge Thickening Centrifuge
THK 200 by Centrisys Corporation

Before Project: Gravity thickened sludge (3.3% TS) pumped directly from the clarifiers into the digesters

Operational Characteristics
• Sludge Feed: 3.1% TS
• Cake Material: 6.1% TS
• Avg. Power Consumption: 5.7 kW
• Capture Rate
  • Without Polymer: 89%
  • With Polymer: 98%*

*Emulsion Cationic Polymer 46% active @ 0.5 gallons/hour
WAS Thickening Centrifuge
THK 200 by Centrisys Corporation

• Prior to our partnership: A DAFT system was utilized to thicken the WAS flow stream from 1% TS to 3.5-4.0% solids before being pumped into the digesters.
• A WAS thickening centrifuge was previously pilot tested and installed in 2011.

– Due to downstream limitations the WAS flow stream was thickened to roughly 5% solids with the thickening centrifuge.
– This project allowed us to further thicken the WAS flow stream to 7% solids.
WAS Thickening Centrifuge Installation

Operational Characteristics

- Sludge Feed: 1.1 - 1.3% TS
- Cake Material: 6.9% TS
- Average Power Consumption: 13.6 kW
- Capture Rate:
  - Without Polymer: 90%
  - With Polymer: 97%*

*Emulsion Cationic Polymer 46% active @ 0.2 gallons/hour
Thermo-Chemical Hydrolysis
PONDUS by CNP-Technology Water and Biosolids Corporation

Components of Hydrolysis Process:

• Thermo: TWAS is heated to 140 - 160°F (60 - 70°C)

• Chemical: 1.5 to 2.0 liters of caustic soda (50% concentration) is injected per 1 m³ of TWAS

• Detention Time: Circulation through the reactor and heat exchanger for 2 to 2.5 hours.
Thermo-Chemical Hydrolysis
Thermo-Chemical Hydrolysis

pH

- Upon addition of caustic soda pH = 11 (+/-)
- Following hydrolysis process pH = 6.8 to 7.0
- Hydrolysis process breaks down the cell walls and releases internal organic acids which brings the pH of the flow stream back to neutral.
- Hydrolysis causes the pH adjustment and therefore no additional chemical addition is necessary prior to anaerobic digestion process.
Thermo-Chemical Hydrolysis

Thermal Efficiency
• The blending of hydrolyzed TWAS and unheated thickened primary sludge results in a final temperature of roughly 40°C (100°F) which is ideal for the mesophilic anaerobic digestion process
• All thermal energy required for the hydrolysis process is transferred into the digesters.

Atmospheric Pressure
• The entire hydrolysis process is completed at atmospheric pressure

Additional Volatile Solids Reduction
• Volatile solids reduction of 60% (before) and 65% (currently)

Increased Dewaterability of Digested Sludge
PONDUS Reactor Installation
PONDUS Heat Exchanger
Reduced Viscosity Provides for:
- Lower mixing energy requirements
- Higher digester loading rates
Biogas Production

Additional Biogas Production

2-Week Average Daily Biogas Production

Increased Biogas Production from 2012 level (Contract Base Year)
Biogas Conditioning
Gas conditioning and siloxane removal by Unison Solutions

• **Before Project:** Raw biogas was utilized by
  – Raw water pump engines
  – Hot water boilers
  – Flared to the atmosphere

• A package system was incorporated to condition and compress the biogas
  – moisture
  – particulates
  – siloxane
Electric & Thermal Energy Generation
Electric & Thermal Energy

Generation CHP Generators by Kraft Power

• Before Project:
  – All electricity was purchased exclusively from the local utility.
  – All heat was provided by our boilers using either natural gas or biogas as their fuel source.

• Two combined heat and power (CHP) generators were installed to utilize the biogas as a fuel source to generate electrical as well as thermal energy.

• The CHP units are each capable of producing:
  – 330 kW of electrical energy
  – 422 kW of thermal energy

• The electricity produced will power the new system as well as supply the excess electricity to the main plant power network for beneficial use elsewhere throughout the plant.

• The thermal energy will be utilized by the PONDUS system, the compact belt dryer and the central WWTP heating loop.
Biosolids Dewatering
CS 21-4HC Centrifuge by Centrisys Corporation

• The centrifuge was installed in 2009 & replaced three plate and frame presses.
• This project met or exceeded all design criteria and provided a payback of one year!
• The dewatering centrifuge has historically been fed digested sludge with a 2.7% TS concentration and consistently achieved 26-29% TS on the cake material.
Centrifuge Room
Drying of Biosolids
Compact belt dryer by Sulzle-Klein

• Previously dewatered biosolids went to local landfill
• Now, biosolids are dried using the recovered heat from the co-generation units as the thermal supply.
• The belt dryer achieves all the requirements of Class-A and KWU is currently in the process of getting our final biosolids product re-classified with the Wisconsin Department of Natural Resources.
• The dried product is discharged into a conveyor system and automatically deposited into the bed of a dump truck.
Drying of Biosolids
Drying of Biosolids

Distributor extrudes the biosolids into noodle-like strands to maximize the surface area for maximum evaporation capacity.
Drying of Biosolids
Odor Control
KWT 1000/1300 by Sulzle-Klein

- Treats the exhaust air from the belt dryer, the buffer & mix tanks, the PONDUS reactor, and the thickening & dewatering centrifuges.
- Water cools the exhaust air and removes particulates.
- Sulfuric acid neutralizes ammonia odors.
- Caustic soda neutralizes sulfur compounds such as mercaptans.
Other Items Incorporated Into Project
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## Estimated Added Value

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<thead>
<tr>
<th>Criteria</th>
<th>Daily</th>
<th>Annual</th>
<th>Unit Cost</th>
<th>Unit</th>
<th>Annual Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Peak Electricity (kWh)</td>
<td>4,752</td>
<td>1,734,480</td>
<td>$0.07660</td>
<td>per kWh</td>
<td>$132,861</td>
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<tr>
<td>Off-Peak Electricity (kWh)</td>
<td>8,448</td>
<td>3,083,520</td>
<td>$0.05238</td>
<td>per kWh</td>
<td>$161,515</td>
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<tr>
<td>Electric Demand (kW)</td>
<td>550</td>
<td>6,600</td>
<td>$12.65</td>
<td>per kW</td>
<td>$83,490</td>
</tr>
</tbody>
</table>

**Electrical Total** $377,866

| Cake Sludge (wet tons)                | 25    | 9,249          | $38.01    | per ton | $351,554       |

**Disposal Total** $351,554

**TOTAL Value** $729,420
Grant from Local Utility

• Due to the nature of the project KWU was awarded over $500,000 in grants for implementing the new biosolids process from Focus on Energy.

• The installation of the thermo-chemical hydrolysis system, co-generation units, and LED lighting all qualified for the largest grant this organization awards to an individual project.
Conclusion

Through innovative thinking KWU was able to:

- Become more energy efficient
- Less reliant on purchased electrical and thermal energy, reducing operating costs
- Produce a higher quality end product (Class A Biosolids)
Questions?

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