Keys to an Effective Wastewater Treatment Plant Energy Audit

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PRESENTATION GOALS

• Relationship between GHG and energy with plant O&M

• Benefits of a coupled energy & mass balance for future:

• Understand the dynamics of baselining a wastewater plant

• Beyond the ECM
Operations, Maintenance & Management

Operations

Effluent Quality

Technologies

Maintenance

CM

PM

Management

Finances

CIP
Operations, Maintenance & Management

- Energy
- Operations
- Management
- Maintenance
  - CM
  - PM
- Effluent Quality
- Technologies
- Finances
- CIP
Example 1: Preventative Maintenance

Building HVAC Filters and Motor Inlets

• Although typically small energy consumers, a clogged filter:
  • Results in lower air movement
  • Higher energy draw
  • Many filters add up!

• Dirty motor cooling fan inlets:
  • Allows dust to enter the motor can damage the motor
  • Can reduce motor efficiency
Example 2: Corrective Maintenance

Pump efficiencies change over time from curve data

- Pump efficiencies can decrease due to use
  - Worn impeller
  - Bearings

<table>
<thead>
<tr>
<th>ACTUAL AVERAGE EFFICIENCIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
</tr>
<tr>
<td>85%</td>
</tr>
<tr>
<td>83%</td>
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</table>

Operating Pump 1 requires 20% more KWH/D compared to Pump 2

Use efficiencies to determine maintenance and guide operations
To clearly show the relationship between Operations and Energy several concepts need to be introduced:

• Coupling of energy and mass balances

• Baselining

• System Analysis
Historically, wastewater treatment plants were analyzed using only a mass balance.
The comprehensive analysis incorporates an energy balance with a mass balance:

- **Primary Treatment**
  - Pumping Energy
  - Solids Capture/Removal

- **Secondary Treatment**
  - Pumping Energy
  - Solids Production
  - Aeration Energy
  - Mixing Energy

- **Solids Treatment**
  - Pumping Energy
  - Solids Thickening
  - Heating
  - Digester Gas Utilization
THE FULL BALANCE - BASELINE
Converting mass into energy (AND ITS NOT $E=mc^2$)

Configuration CEPT Optimized - Plant Energy Balance

Energy Flow Line Thicknesses are Equivalent: 1 kWh/d = 3.6 MJ/d = 142.2 BTU/hr
Three examples follow on how energy, and the energy/mass balance coupling is connected to operations

• Squeeze play - $\alpha$
  
• Digester
  • Prediction
  • Cleaning

• Pumping
With KWH, O₂ Demand, Diffuser Type, OTR – Match Airflow and Energy using Alpha and Blower Efficiency

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actual</th>
<th>Calculated</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airflow (scfm)</td>
<td>150,933</td>
<td>146,526</td>
<td>3%</td>
</tr>
<tr>
<td>Energy (Kwh/yr)</td>
<td>38,140,168</td>
<td>39,254,287</td>
<td>-3%</td>
</tr>
</tbody>
</table>
Grit, hairballs, and inerts accumulate in digesters – particularly for combined sewer systems thus requiring periodic digester cleaning.

**Mass/Energy Balance can help determine when!**

- \( \text{%VS Destroyed} = \frac{(18.9 + \ln(\text{HRT}) \times 13.7)}{100} \) (From M&E 4th Edition)
  
  [Equation is general and due to different sludge types (primary, secondary, BNR, etc.) a plant specific correlation should be developed first]

- **Reduced %VS destruction**
  - Reduces digester gas production
  - Increases sludge for disposal
Pumping systems using VFDs takes advantage of the Affinity Laws

\[
P_1/P_2 = (Q_{13}/Q_{23})
\]

(for friction and flow only)

- Power can be reduced significantly and operating an additional pump can reduce power.

- Real-time power monitoring can help operational energy control.
 OPERATIONS & Energy

Pumping

Pumping Specific Energy in kWh per Mgal
Based on 5 Interval Data for June, 2016 with a 21.9 to 22.1 Wet Well Elevation

1 pump Operation

2 pump Operation

3 pump Operation
Note: Lower scores indicate more potential for energy reductions.

Note: Smaller Energy Benchmarking Scores indicate more room for potential GHG reductions.
Energy End Use Analysis

Hunts Point
- Main Sewage Pumping (11%)
- Primary Treatment (4%)
- Secondary Treatment (42%)
- Disenfection (<1%)
- Thickening (2%)
- Digestion (15%)
- Dewatering (19%)
- Odor Control (5%)
- ADG System (<1%)
- Process Supports (2%)

North River
- Main Sewage Pumping (14%)
- Primary Treatment (2%)
- Secondary Treatment (25%)
- Disenfection (0%)
- Thickening (1%)
- Digestion (2%)
- Dewatering (0%)
- Odor Control (52%)
- ADG System (2%)
- Process Supports (2%)

26th Ward
- Main Sewage Pumping (12%)
- Primary Treatment (5%)
- Secondary Treatment (31%)
- Disenfection (0%)
- Thickening (1%)
- Digestion (28%)
- Dewatering (17%)
- Odor Control (5%)
- ADG System (0%)
- Process Supports (1%)

Newtown Creek
- Main Sewage Pumping (8%)
- Primary Treatment (0%)
- Secondary Treatment (34%)
- Disenfection (0%)
- Thickening (25%)
- Digestion (19%)
- Dewatering (3%)
- Odor Control (7%)
- ADG System (0%)
- Process Supports (4%)
CIP and Energy

Where does Energy Fit Into CIP

• Revamp existing projects
  – Centrifuge with Rotary Drum Thickeners

• Re-evaluate timeline due to energy savings

• Group smaller energy project work with larger projects with in the same process area

• Investigate advanced or emerging technologies
Programmatic and Institutional Controls

**In-Plant Programmatic Controls**
- Reduce recycle flows (washwater, draining tanks, ducking weirs, etc.)
- Automatic lighting controls
- Automatic heating/cooling levels
- Diffuser cleaning schedule
- Fan filter replacement schedule

**Institutional Controls**
- Energy usage/purchase reduction goals
- Identifying and Screening Protocols (FOG/food waste program, etc.)
- Energy policies (e.g. LEED)
- SOPs for design specification
- Energy analysis/consideration during design
SOP and Policy Development

Design

- Create Energy Profile Report part of BODR
- Update EPR as Design is Refined

Construction

- Update EPR with change orders

Operations

- Include in O&M manuals and Training
Design Consideration: Example

- Design: 200 ft pipe run with 15 ft lift at 400 gpm
- Consideration: 3” vs. 4” pipe – same pump

<table>
<thead>
<tr>
<th></th>
<th>3”</th>
<th>4”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Cost</td>
<td>$16,890</td>
<td>$18,540</td>
</tr>
<tr>
<td>Energy Cost ($0.11/kwh)</td>
<td>$2,813/year</td>
<td>$2,200/year</td>
</tr>
</tbody>
</table>

Savings: Over $600/year

Simple Pay Back: Under 4 years
Case Study

- Rehabilitate an old Stormwater Pump Station
- Initial construction in 1950’s – 9.8 MGD
Case Study

Work:

• Replace three axial flow pumps with submersible pumps
• Improve lighting (LED)
• Install electrical room
• Improve pump station access
# Case Study

<table>
<thead>
<tr>
<th>Storm Return Period</th>
<th>Future</th>
<th>Current</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Electric</td>
<td>GHG Emissions</td>
<td>Cost</td>
</tr>
<tr>
<td>Year</td>
<td>kWh/event</td>
<td>lb CO2e</td>
<td>$/event</td>
</tr>
<tr>
<td>1</td>
<td>43</td>
<td>28</td>
<td>$7.78</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>34</td>
<td>$9.34</td>
</tr>
<tr>
<td>10</td>
<td>69</td>
<td>46</td>
<td>$12.45</td>
</tr>
<tr>
<td>25</td>
<td>86</td>
<td>57</td>
<td>$15.57</td>
</tr>
<tr>
<td>50</td>
<td>104</td>
<td>68</td>
<td>$18.68</td>
</tr>
<tr>
<td>100</td>
<td>121</td>
<td>80</td>
<td>$21.80</td>
</tr>
</tbody>
</table>

**Future - Current (+ is increase/- is decrease)**

<table>
<thead>
<tr>
<th>Asset</th>
<th>Future</th>
<th>Current</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power kWh/yr</td>
<td>GHG Emmission tons CO2e/year</td>
<td>Cost $/yr</td>
</tr>
<tr>
<td>Fan</td>
<td>13,065</td>
<td>4</td>
<td>$2,352</td>
</tr>
<tr>
<td>Unit Heaters</td>
<td>86,880</td>
<td>29</td>
<td>$15,638</td>
</tr>
<tr>
<td>Total HVAC System</td>
<td>99,945</td>
<td>33</td>
<td>$17,990</td>
</tr>
</tbody>
</table>

**Future - Current (+ is increase/- is decrease)**
Case Study

The design needs in this case justified an increase in energy costs. Due to the need to improve climate conditions particularly for the electrical components: A less efficient submersible pump as opposed to a centrifugal pump was needed to facilitate footprint.

<table>
<thead>
<tr>
<th>Change from Current Operations to FSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Electrical Consumption</td>
</tr>
<tr>
<td>Estimated Annual GHG Emissions</td>
</tr>
<tr>
<td>Estimated Annual Operating Costs</td>
</tr>
<tr>
<td>Future – Current (+ is increase / - is decrease)</td>
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</tbody>
</table>
QUESTIONS?
THANK YOU

May 11, 2017
CIP and Energy Program Timeline

NEW CONSTRUCTION
- Primary Tanks
- Fermenters
- Thickenning Upgrades
- (Reduced Recycles)

PROGRAM ELEMENTS
- ECM 2 (Lower Blower Pressure)
- ECM 2A (Thickened Solids)

PROGRAM ELEMENTS
- Co-digestion
- Feedstock Receiving Station
- Expand Digester Gas Handling
- PSA Digester Gas Cleaning
- Natural Gas Pipeline Tie-in

Baseline 2014
4,988,251 kBtu/d

2019
5,523,478 kBtu/d

2019+
4,909,706 kBtu/d

2022
4,687,140 kBtu/d

OR

2022 (Co-Dig) + Pipeline Only
4,925,838 kBtu/d

2022 (Co-Dig) + Pipeline + Cogen
5,218,045 kBtu/d