Factoring Energy Savings into a Plant Upgrade
WWOA – 46th Annual Conference
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Presented by:
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Rich Boden, Village of Plover
• Project background
• Identifying energy reduction opportunities
• Energy reduction elements
• Focus on Energy incentive grant
Project Background
Background

- Village of Plover WWTF
  - Serves population of 12,000
  - Current average flow of 1.2 MGD
  - Last major upgrade in 1987
    - Digesters 1999
Background

- **Project drivers**
  - Capacity for industrial growth
  - New ammonia limits

- **Project timeline**
  - Facility planning – January 2009
  - Design – May 2009
  - Bidding – September 2009
  - Construction - January 2010 to July 2011
Background – Main Project Elements

- New Blower Building
- New WAS Tanks
- New Aeration Tanks w/ BPR
- New Influent Pump VFDs and Controls
- New Septage Receiving
- New Aeration Tanks w/ BPR
- New Blower Building
- New WAS Tanks
- New Aeration Tanks w/ BPR
- New Influent Pump VFDs and Controls
- New Septage Receiving
Identifying Energy Reduction Opportunities
Identifying Energy Reduction Opportunities

- Typical energy usage at WWTFs

- Aeration, 54.1%
- Clarifiers, 3.2%
- Belt Press, 3.9%
- Lighting and Buildings, 8.1%
- Aeration, 54.1%
- Wastewater Pumping, 14.3%
- Anaerobic Digestion, 14.2%
- Return Sludge Pumping, 0.5%
- Grit Removal, 1.4%
- Chlorination, 0.3%
- Gravity Thickening, 0.1%
• Creation of the “long list”
  – Energy Best Practice Guidebook from Focus on Energy
  • Technical Best Practices
    – Water and Wastewater
    – General Facility
Identifying Energy Reduction Opportunities

• Identified opportunities
  – Influent pumps (self explanatory upgrades)
    • Adding VFDs
    • Automated level control
  – Activated Sludge
    • Fine pore aeration
    • Turbo compressors
  – Oxidation ditch aerators (self explanatory upgrades)
    • Adding VFDs
  – WAS holding tanks
    • Fine pore aeration
    • Tri-lobe PD blowers with VFDs
    • Automated controls for anoxic cycling
  – Demand-side energy management
  – Digester blower replacement
Energy Reduction Opportunities
Energy Reduction Opportunities

• Activated sludge
  – Fine pore aeration
  – 20 ft side-water depth
  – Anaerobic zones for phosphorus removal
  – Optical dissolved oxygen probes
Energy Reduction Opportunities

• Activated sludge
  – Turbo compressors - 3 APG Neuros Units
  – 150 HP, 2,500 cfm each
  – D.O. setpoint control
Energy Reduction Opportunities

• Activated sludge
  – Efficiency comparison between:
    • Positive displacement
    • Multi-stage centrifugal
    • Single stage turbo
Energy Reduction Opportunities

• Positive displacement
  – Break horsepower doesn’t account for speed reducer and motor efficiencies

1400 cfm

65 HP

15 PSI
Energy Reduction Opportunities

- Multi-stage centrifugal

![Image of a blower](image)

**Blower Performance Curves**

- 1400 cfm
- 76 HP
- 8 PSI

![Graph showing blower performance](graph)
Energy Reduction Opportunities

- Single stage turbo
  - Energy reduction of 25% to 35%
Energy Reduction Opportunities

• WAS holding tanks
  – Part of aerobic digestion upgrades
    • Increase WAS storage volume
    • Increase digestion capacity
    • Increase digested sludge storage volume
Energy Reduction Opportunities

• Aerobic Digestion Process

![Diagram showing original and upgraded operation of aerobic digestion process with labels for Aerobic Digesters, WAS Holding, Digested Sludge Storage, and WAS Holding, Aerobic Digesters, Digested Sludge Storage.](image)
Energy Reduction Opportunities

• WAS holding tanks
  – Fine pore aeration
  – 20 ft side-water depth
  – Tri-lobe positive displacement blowers
Energy Reduction Opportunities

• Tri-lobe positive displacement blower
  – 61 BHP, 66 HP (92% Eff)

Technical data:

Package: EB 420C
Blower: OMEGA 53P
Motor power: 75.0 hp
Operating voltage: 460V/60Hz

Performance data:

- max. load
  - Pressure difference ΔP: 12.6 psig
  - Inlet flow Q1*: 1042 icfm
  - Inlet airflow Q1 (standard): 1059 icfm
  - Discharge temperature*: 288 °F
  - Motor shaft power: 76.8 bhp
  - Blower shaft power*: 60.9 bhp

- design point
  - Blower speed: 3330 rpm
  - Connection ANSI: 6”
  - % of maximum speed: 79
  - Volumetric efficiency: 0.86

1060 cfm @ 10 psi

61 HP
Energy Reduction Opportunities

- Dual-lobe positive displacement blower – 70 BHP, 76 HP (92% Eff)

<table>
<thead>
<tr>
<th>Lobe Type</th>
<th>BHP</th>
<th>Motor Shaft HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual-lobe</td>
<td>70</td>
<td>76</td>
</tr>
<tr>
<td>Tri-lobe</td>
<td>61</td>
<td>66</td>
</tr>
</tbody>
</table>

Tri-lobe provides 15% power reduction
Energy Reduction Opportunities

• WAS holding tanks
  – Process energy reduction
    • Increased alpha in first stage (WAS holding tanks)
    • High rate of digestion at lower energy
    • Secondary benefit of reduced digestion demand in second stage
Energy Reduction Opportunities

Automated controls for anoxic cycling

• **Aeration ON**
  – Oxygen is utilized for electron acceptor
  – Ammonia is nitrified to nitrate
  – Alkalinity is consumed
  – pH decreases

• **Aeration OFF**
  – Nitrate is utilized as electron acceptor
  – Nitrate is denitrified to nitrogen gas
  – Alkalinity is recovered
  – pH increases

• **Significant blower energy savings**
• **50/50 aerobic to anoxic cycles ideal**
• **Typically 3 to 4 hour increments**
Demand-Side Energy Management
Energy Reduction Opportunities

• Demand-side energy management
  – Facility is already highly automated
  – Incorporate power monitoring into SCADA automatic control logic
Energy Reduction Opportunities

• Demand-side energy management
  – Is this worth the effort?
    • Monthly demand cost = $12.08 per kW
    • Demand costs are 33% of monthly bill
    • A 70 kW reduction over 12 months = $10,000 in savings
• Demand-side energy management
  – Establish kW ceiling for high kW alarm
  – Large HP items get maximum speed setpoints during on-peak hours.
    • Aeration blowers, mechanical aerators, digester blowers
  – Non-essential items get shut off if kW ceiling is reached
    • WAS holding blowers
  – On-peak and off-peak D.O. setpoints
Energy Reduction Opportunities

1. Track and Trend Energy Real-time
2. Record 15 minute and daily peak demand
3. Report hourly, daily and monthly usage
Digester Blower Replacement Project
Blowers

- 3 aerobic digesters
- Three 100 hp dual lobe Roots PD blowers
- Installed 1999
- One blower dedicated to each digester
- Each blower operated by VFD
- Max turn down is 58% of full speed
  - Second digester normally has excess O2 levels at min blower speed
Existing Blower
Blower No 3

- Seized up June 12, 2011
- Burning belts caused a small contained fire
- Damage to filter assembly and motor
- Blower badly damaged
Alternatives

• Rebuild bare blower
  – $8,200 estimated
  – No energy saving

• Replace bare blower with new OEM
  – $11,400
  – No energy saving

• Replace unit with tri-lobe blower
  – $22,000 installed
  – Significant energy saving
New Blower Advantages

- Tri-lobe design is more efficient
- Size blower to meet final digester demand
- Meet the aeration requirements with 60 hp blower vs. 100 hp blower.
- Greater turndown to match demand
  - TURN DOWN TO 33% FULL SPEED
Focus on Energy

• Contacted FOE
• Calculated annual savings
  – 777,139 KWH
  – 9.4 KW system demand
  – $5,815
• Grant $4,280
• 4 year payback
New Blower
Additional Savings

- Old blowers peak demand 77 BHP
- Replace 100 hp motors with 75 hp motors
  - Downsize motors to meet blower HP demand
  - Save ~2.5 amps motor magnetizing current
  - Save about $950 per year per motor
Motor Replacement

75 hp motor installed
Focus on Energy Incentive Grant
Focus on Energy Incentive Grant

• Incentive grant program
  – VFD grant $50/HP
    • Equipment must have 2,000 hrs operation
  – Custom project grant
    • $0.06/kWh usage savings
    • $200 per kW demand savings
  – Grant can cover up to 30% of project cost
  – Simple payback must be over 1.5 years and under 10 years
Focus on Energy Incentive Grant

- Applied for VFD incentives and custom incentives – received $136,000

<table>
<thead>
<tr>
<th>Description</th>
<th>Average kW Savings</th>
<th>Peak kW Savings</th>
<th>Estimated Cost of Upgrades</th>
<th>Estimated Energy Savings</th>
<th>Payback Period (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Wastewater Pump VFDs and Automated Controls</td>
<td>10</td>
<td>23</td>
<td>$55,000</td>
<td>$6,300</td>
<td>9</td>
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<tr>
<td>Fine Pore Aeration and Turbo Compressors for Activated Sludge</td>
<td>135</td>
<td>36</td>
<td>$428,000</td>
<td>$80,000</td>
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<tr>
<td>Oxidation Ditch Aerator VFDs</td>
<td>20</td>
<td>16</td>
<td>$58,000</td>
<td>$13,700</td>
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<td>WAS Holding Tank Fine Pore Aeration, Blowers, Automated Controls</td>
<td>29</td>
<td>17</td>
<td>$194,000</td>
<td>$22,900</td>
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<td>Demand-Side Energy Management</td>
<td>0</td>
<td>70</td>
<td>$62,000</td>
<td>$7,200</td>
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<tr>
<td>Aerobic Digester Blower</td>
<td>9</td>
<td>83</td>
<td>$23,000</td>
<td>$5,800</td>
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<td><strong>Totals</strong></td>
<td><strong>203</strong></td>
<td><strong>245</strong></td>
<td><strong>$823,000</strong></td>
<td><strong>$136,000</strong></td>
<td><strong>6</strong></td>
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