Energy Management at Municipal WWTPs

Session 2
April 22, 2021

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Terry Albrecht, PE, CEM
Waste Reduction Partners
Energy Management Target

Reduce Energy use per Million gallons wastewater and potentially provide better treatment

Discover and use lower cost energy options
Purpose – Increase awareness of energy use and potential for reducing plant operating expenses for wastewater operators

Remember our Drivers from Session 1:

- Budget considerations
- Water-Energy Nexus
- Importance of Energy Efficiency
- Continuous Improvement
- Municipal Sustainability Initiatives, ISO 14001
WWTP Energy Management Sequence

1. Organize an Energy Management Program
2. Discover your Plant Baseline Energy Use
3. Plant(s) Evaluation
4. Energy Savings Possibilities
5. Start with No-cost and Low-cost Items
6. Get involved in setting Priorities for Higher Cost Potentials
7. Be aware of Planning for capital improvement
8. Assist in Tracking and Reporting Results
Agenda – Two Sessions
Energy Management Training

**Session 1:** Organize an Energy Management Program
- Energy Vocabulary Literacy
- Utility Billing – Understanding your billing
- Baseline Data & Tracking (at utility billing level)
- Benchmarking
- Plant Survey & Evaluations:

**Session 2:** Common BMPs for Energy Management
- Renewables

OWASA: Energy Management Case Example – Mary Tiger

Resources for Taking the Next Step
Energy Savings Possibilities

• Identifying ways to use less energy or reduce costs using lower cost energy

• Stay informed about energy management by reading, study, participating in continuing education relative to energy
Typical Energy Balance – 1 mgd plant

1 mgd Plant - kWh/day

- Aeration (diffused air)
- Biological nitrification
- Lighting and Buildings
- Wastewater pumping
- Filter feed pumping
- Filtration
- Chemical addition
- Return sludge pumping
- Aerated grit removal
- Belt filter press
- Secondary clarifiers
- Primary clarifiers
- Gravity thickening
- Screens
- Chlorination

Source: WEF MoP 32, 2009
Energy Savings Possibilities

- Capital program or equipment replacement - example replace electric motors with high Eff
- Process change - change regular aeration to sequence batch reactor
- Operational change – Use fewer units if hydraulic conditions allow
- Automation or controls - Rely on ORP instead of DO for oxidation, Add process control
- Maintenance improvements – Consider a rewinding program for motors
- Business measures – train operators, make energy management a priority
Best Management Practices are available for reducing energy use and costs of operation.

Energy Savings Categories:
- Organizational Energy Management
- Treatment Process Energy Management
- Building Systems Energy Management
- Renewable Distributed Generation
Questions?
Comments?
Organizational
Divert Flexible Use to Off-Peak Times

Plant Example: 40% of the electric bill could be monthly peak Demand charge (kW)
60% is for energy consumption in kilowatt hours (kWh) for the month.
The off-peak energy charge ($/kWh) is 20% less during off-peak hours verse on-peak times.
Return clarifier or basin contents to head of plant during off-peak time so that increase pumping is at lower cost:
Saving potential: 20% of the pumping energy charges.
Organizational:
Motor Management & Rewind Standards

- Establish rewind quality standards with vendors
- Vendors should follow ANSI/EASA standard AR100-2015 Recommended Practices
- Strive to have zero to less than 0.5 percent efficiency losses for rewinds of large motor (=>50 HP),
- Vendor certified to Proven Efficiency Verification (PEV) program by Advanced Energy.org (National experts right in Raleigh!).

- Don’t rewind less than ~ 50 HP
- Procure only NEMA Premium Efficiency and
- Consider Super Premium Efficiency (IE4) Induction Motors (1-2 % efficiency gain over Premium Efficiency)
Organizational:
Motor Operating Costs Examples

10 year Life Cycle Cost - 50 HP @ 8000 hrs/yr

- Energy Cost: 98%
- Purchase Cost & Maintenance: 2%

50 HP Motor - Std vs. Premium Efficiency Savings

Year
1  2  3  4  5  6  7  8  9  10
$ 0  1,000  2,000  3,000  4,000  5,000  6,000  7,000  8,000
Organizational:
Energy-Use Monitoring & Control on SCADA

- How are your monitoring current energy use on SCADA?
- Look for opportunities to manage energy use on SCADA monitored and controlled equipment.
- Energy kW Demand Management and kWh monitoring should be goal for SCADA
Treatment Process Energy Management

Evaluate some of the changes suggested in earlier sessions covering nitrification and phosphorus removal
Treatment:
Aeration Upgrade with Duke Rebates

Project: Coarse to Fine Bubble Diffusers on Aeration Basin
Automate DO control with throttle control on primary blower

Project Cost: $1.4 Million
Duke Energy Smart Saver “Custom” Incentive: $340,000

Savings: 4 million kWh and 450 kW
Annual Electric Cost Savings: $280,000
Consider installing or using existing VFD to match process demand
Energy use with decreased speed for centrifugal pumps

Flow is proportional to the pump's speed but energy use is proportional to the cube root of the speed. This results in a reduction of approximately 15% energy use for a 5% reduction in flow.

\[ V_2 = V_1 \times \left( \frac{R_2}{R_1} \right) \]

Volume: gallons or gallons per time

\[ H_2 = H_1 \times \left( \frac{R_2}{R_1} \right)^2 \]

Head: ft of water typical

\[ P_2 = P_1 \times \left( \frac{R_2}{R_1} \right)^3 \]

Power: Horsepower (convert to kW, 1 hp = 0.746 kW)
# Treatment Process Energy Management

## Jackson Crk Effluent Pumps 2 units

<table>
<thead>
<tr>
<th>KW Average</th>
<th>KW Annual</th>
<th>VFD factor</th>
<th>$/hr</th>
<th>Motor HP Load</th>
<th>Motor efficiency</th>
<th>VFD Speed Reduction</th>
<th>Annual costs</th>
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</thead>
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<tr>
<td>425028</td>
<td>73.78</td>
<td>4.50</td>
<td>90</td>
<td>91%</td>
<td>0%</td>
<td>$25,926.71</td>
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<td>396665</td>
<td>65.41</td>
<td>3.99</td>
<td>77.2</td>
<td>88%</td>
<td>5%</td>
<td>$24,196.55</td>
<td></td>
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<tr>
<td>356009</td>
<td>55.62</td>
<td>2.39</td>
<td>65.6</td>
<td>88%</td>
<td>10%</td>
<td>$21,716.57</td>
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<tr>
<td>317552</td>
<td>46.85</td>
<td>2.86</td>
<td>35.3</td>
<td>88%</td>
<td>15%</td>
<td>$19,370.64</td>
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</tbody>
</table>

Note: Actual annual cost for 2019 is in the SRU total billing.

<table>
<thead>
<tr>
<th>Permit -</th>
<th>7.5 MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFD - gpm</td>
<td>6336</td>
</tr>
<tr>
<td>Extra hours/yr</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Energy use with decreased speed for centrifugal pumps.

Motor Load 90%

Motor Efficiency 91%

Motor HP 100

### 40655 KW saved annually for 5% avg speed reduction

Pump affinity laws used for operation with VFD

$\text{Savings per year for average rate} = \frac{\text{40655 KW}}{100\text{ KW}} \times$ $\text{2,479.98}$

At 5% reduction with VFD is a 10% annual savings
Treatment Process Energy Management

Energy use with decreased speed for centrifugal pumps
Treatment Process Energy Management
Hours operation and costs with decreased speed for centrifugal pumps

Cost Drops with VFD Speed Reductions & Increased Run Hours
same gallons pumped/month - 100 HP
Treatment Process
Energy Management

Slow and Steady
wins the race
Questions?
Comments?
Building Systems: LED Lighting Upgrades

75% wattage reduction possible

Lab/Office: 106 Watt 2’x4’ fluorescent troffer to 26 Watt LED retrofit kit
0.08 kW saved x 3000 hours x $0.089 per kWh = $21 savings per fixture per year ($40 Panel Duke rebate)

High Bay Lighting: 440 Watt Metal Halide to a 150 Watt LED
0.2 kW saved x 5000 hours/year x $0.089 per kWh = $89 savings per fixture per year ($150 Duke rebate)

50% wattage reduction typical

Strip Fixtures Work Space: 32 W 4 ft. fluorescent lamp to 15 W LED
0.017 kW saved x 3000 hours x $0.089 per kWh = $5 per lamp per year ($3 Duke rebate)

LED pricing can make simple payback in 2 to 5 years, less with rebates or higher use
Building Systems: Unit Electric Heaters

Commonly 5 KW or even 10 KW
Manual controlled
How many unit heaters do you have?

Cost to run one heater 24 hours:
5 kW x 24 hours x $0.089/kWh = $10.68 ($320/month)
10 kW x 24 hours x $0.089/kWh = $21.36 ($640/month)

• Consider electric radiant (better w/ bay doors and high bay areas)
• Consider natural gas radiant heaters
• Consider the need for use - to avoid freeze impacts
• Consider setting at 50 - 55 degrees
Unit Heater Impacts

Gravity Supplied water plant seasonal energy use

25 unitary electric fan heaters

Mountain Region Water Plant Energy Use vs. Heating Degree Days
Questions?
Comments?
BREAK
Renewable Distributed Generation
Town of Taylorsville: Solar Peak Shaving
Renewables:
Anaerobic Digestion: “Renewable Natural Gas” Opportunities

Anaerobic Digesters

Floating Roof

Heater – Natural gas fired
Microbial Fuel Cell
Questions? Comments?
Energy Management at OWASA

April 22, 2021

Carrboro-Chapel Hill’s not-for-profit public service agency delivering high quality water, reclaimed water, and wastewater services.
WATER SUPPLY

University Lake
Cane Creek
Quarry Reservoir
Jordan Lake
Jones Ferry Road Water Treatment Plant

WASTEWATER MANAGEMENT

Mason Farm Wastewater Treatment Plant
Reclaimed Water
Energy Management Plan Achievements

52% reduction in greenhouse gas emissions*

32% reduction in electricity use*

20% reduction in natural gas use*

Investment in Cost-Effective Energy Projects

Energy-Minded Decision Making

Operations and Maintenance

Capital Projects

Biogas-to-Boiler Restoration

Over $550,000 annual savings purchase of electricity and natural gas purchases*

*Since 2010 Baseline
Mason Farm WWTP

Capacity: 14.5 MGD
Annual Average: 8 MGD
42% reduction in purchased kWh per year
44% reduction in energy use intensity
Energy Efficiency Upgrade: Aeration and Aeration Basin Mixing Process Equipment

Old System

- **Four NSL and Six East Aeration Cells**
  - Jet Mixing / Aeration Pod(s)
  - Up to 1000 scfm / pod
  - 14 HP pump(s) – continuous operation

- **Six West Aeration Cells**
  - Jet Mixing / Aeration Header
  - Up to 3000 scfm / header
  - Two 50 HP pumps – continuous operation

- **Two Aeration Cells – 5A / 5B**
  - Jet Mixing / Aeration Header
  - Up to 1500 scfm / header
  - 50 HP pump – continuous operation

- **Multistage Centrifugal Blowers**
  - Three 3600 scfm – 150 HP blowers
  - Three 5600 scfm – 250 HP blowers
  - Use between 500-650 HP – depending on time of the year
Energy Efficiency Upgrade: Aeration and Aeration Basin Mixing Process Equipment

New System

• Four NSL Cells
  – High Efficiency Mixer - < 5 HP
  – Aluminum Covers and Odor Control

• Twelve Aeration Basin Cells
  – Fine Bubble Diffusers – 2000 or 3000 scfm
  – High Efficiency Mixer - < 5HP (standby)
  – Aluminum Covers and Odor Control (6 cells)

• Two Aeration Cells – 5A / 5B
  – Fine Bubble Diffusers – 1500 scfm
  – Four High Efficiency Mixers - < 3HP (standby)

• High Efficiency Blowers
  – Four 5000 scfm – 250 HP blowers
  – One 5600 scfm – 250 HP Multistage (backup)

• New SS Air Header, 3 Carbon Scrubbers
New Aeration System: Financial Impact

- Capital Costs: $8 million
  - $6.56 million, 20-Year, No-Interest Loan: NC Clean Water State Revolving Fund (Saved an estimated $1.7 million over lifetime of loan)
  - Duke Energy Customer SmartSaver Incentive: $168,000

- Estimated Energy Savings: $220,000/year

- Realized Energy Savings: $275,000/year
Pump Station Evaluations

Recommendations included:

• Speed adjustments
• Operating set points: (E.g. wet well levels)
• Simultaneous operation
• Pump replacement
• System modifications (e.g. hydropneumatic tanks, piping)
Energy-Minded Decision Making

• Extend backwash filter cycles and reduce air scouring frequency
• Optimize odor control system
• Online ORP/nitrate monitoring
• Phased HVAC upgrades
• Reduce I&I
• Pump station monitoring
• WWTP Master Plan
Energy Management Pyramid

- Renewable Energy
- Energy Efficiency
- Energy Conservation/Optimization
Solar Leasing

• Public-private partnership
• 25-year term
• OWASA’s lease payment is less than energy savings
• Down-payment covered by Duke Energy rebate
• System owned and operated with private partner
Progress Towards Goal: Solar Photovoltaics

Solar Lease Clean Energy Generation

- Biosolids (150 kW)
- Operations Center (59 kW)
- Administration Building (99 kW)
- Cane Creek Reservoir (353 kW)
Thank you

Mary Tiger

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OWASA’s Energy Management Program

Systematic identification, evaluation and pursuit of energy management opportunities

- Energy and water conservation & process optimization
- Energy-minded decision making
- Investment in cost-effective energy management projects
Objective 2: Reduce use of purchased natural gas by 5% by the end of CY2020 compared to the CY2010 baseline.

Purchased Natural Gas, by Functional Area (2010 - 2020)

- Water Treatment
- Wastewater Treatment
- Support Facilities
- Goal

28% decrease since 2010
Questions?
Comments?
Resources to take the next step

• Dominion Energy: RNG Projects (Lee McElrath, Dominion Energy NC 828-230-7118)
• Your Local COOP/Municipal Utility Rep
• Your Peer Networks: PWOC-WEF
• Your Consulting Engineer
• State Grant Sources: Green Project Reserve
• Advanced Energy: Kitt Butler, kbutler@advancedenergy.org
• Energy Efficiency Assessment Providers
  • Waste Reduction Partners (serving all of NC)
    • Russ Jordan, Energy Manager, rjordan@wrpnc.org, (828) 251-7477
  • NC Rural Water Association (serving populations <10,000)
    • Natalie Narron, Energy Efficiency Circuit Rider, natalienarron@ncrwa.org, (336) 887-0741
• EPA: Brendan Held & Team
Land of Sky’s WRP program provides no-cost energy efficiency and waste assessments.

Clients: Any water/wastewater plant, business or institution in NC.

The Team: 40 staff and volunteer engineers (statewide)

Past energy work with: Asheville Water Resources Department, Town of Salisbury, Town of Boone, Cape Fear Public Utility Authority, Kerr Lake, and others

Results: past 5 years: 275 clients served, $16.4 million in utility cost savings, 130,000 MWh saved

Initiate a Project: WasteReductionPartners.org or Russ Jordan rjordan@wrpnc.org
Questions?
Comments?
Thanks to following utilities for sharing demonstration information and photos.

Acknowledgements
THANK YOU