Energy Self-Assessment Tools and Energy Audits for Water and Wastewater Utilities

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Eric Byous, US EPA Region 9
Energy Use and Water Utilities

• Water and Wastewater treatment represents about 2% of the nation’s energy consumption
  – About $4.7 billion is spent annually for energy costs to run drinking water and wastewater utilities\(^1\)
  – Equivalent to approximately 69 billion kilowatt hours (kWh)\(^2\)
  – Equates to adding approximately 52 million tons of greenhouse gas to the atmosphere\(^3\)

• Energy represents the largest controllable cost of providing water or wastewater services to the public
  – About 15,000 municipal treatment plants and 51,000 community water systems in the US\(^4\)
  – Energy costs often one of the top 3 O&M costs in this sector

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1 Based on EIA’s average utility electric rate per kWh for industrial customers, 2013 data
2 Electric Power Research Institute, Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, November 2013 (EPRI)
3 Calculated from EPRI figures using EPA GHG emissions calculator: [http://www.epa.gov/cleanenergy/energy-resources/calculator.htm](http://www.epa.gov/cleanenergy/energy-resources/calculator.htm)
4 EPRI
Energy Reduction at Water Utilities

• Water and Energy Efficiency at Utilities =
  – Reduced energy usage
  – Reduced operating costs
  – Reduced climate impacts/carbon footprint
  – Sustainability of water infrastructure
  – Save Water
Why Focus on Management?

• Energy issues are here to stay and will only get more serious—no quick fixes!
• Individual projects and technologies are fine, but something is needed to pull it all together (a system)
• Systematic management will ensure continuing focus on energy efficiency
• The Plan-Do-Check-Act management systems approach has worked in many different sectors
Managing to Maximize Energy Efficiency

Designed to help utilities:

– Systematically assess current energy costs and practices
– Set measurable performance improvement goals
– Monitor and measure progress over time

Uses a management system approach for energy conservation, based on the successful Plan-Do-Check-Act process [based on Environmental Management Systems (EMS)]

http://water.epa.gov/infrastructure/sustain/cut_energy.cfm
The Plan-Do-Check-Act Approach

- **PLAN**
  Establish baselines, identify priorities, set improvement goals and targets

- **DO**
  Implement Action Plans to achieve goals

- **CHECK**
  Monitor, measure, find and fix, document results

- **ACT**
  Evaluate, apply lessons learned, and modify as necessary

- **Continually improve**

- **Allows utilities to systematically assess and manage energy opportunities and take action**
- **NOT a project—a system to manage for the long haul**
Energy Audit Approaches

• Conduct a Self-Assessment of your utility’s energy use
• Conduct a Level II or III energy audit at your facility
• Start an energy management program to implement audit recommendations
Section 1: Self-Assessment Tools

- Free
- Easy to Use for Operators of Any Size Facility
- Available Online
- Do Not Require Outside Assistance
Energy Self-Assessment Tools For Small Utilities

• EPA Office of Groundwater and Drinking Water Energy Use Assessment Tool
• EPA Energy Management Planning Self-Assessment worksheet (aka “radar graph”)
• NYSERDA/CEE Checklists
• Mass Energy Insight (available to local governments in Massachusetts)
EPA’s Energy Use Assessment Tool

• What is the Energy Use Assessment Tool?
  – Free of charge, downloadable tool based in Excel that can be used by small and medium water and wastewater systems
  – Allows a utility to conduct a utility bill analysis to assess baseline energy use and costs
  – Use prior to a full-scale energy audit
  – Drills down to equipment level
  – Printable summary report
    • Presentation of energy consumption & costs (broad to detail)
    • Graphs energy use over time
    • Highlights areas of energy efficiency
How the Energy Use Tool can Help Drinking Water And Wastewater Systems

• The tool:
  – Acts as a repository of up to 5 years of your energy use, cost, equipment and operational data
  – Analyzes your data and displays cost and energy use trends
  – Includes lighting and HVAC
  – Compiles equipment data
EPA’s Energy Use Assessment Tool: Information Needed to Enter in the Tool

- All plant utility data (use and cost information) by month (minimum of 12 months) for up to 5 years of analysis
  - Collect from utility bills such as electric, natural gas, water/sewer, fuel oil, alternative energy, and other utilities

- Non-process information (by building)
  - List of lighting fixtures
  - HVAC equipment

- Drinking water and/or Wastewater treatment plant information
  - Monthly treatment/discharge volumes
  - Pump and motor nameplate data (horsepower, efficiency rating, full load amp rating)
  - Average motor operating amperage
### EPA Energy Use Assessment Tool for Wastewater Systems

#### General Information

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#### 2011

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| Alt. Energy ($/CCF) | |
|---------------------||

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#### 2010

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| Alt. Energy ($/CCF) | |
|---------------------||

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#### Specific Utility Information

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<th>Natural Gas Cost ($)</th>
<th>Consumption (CCF)</th>
<th>No 2 Fuel Oil Cost ($)</th>
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<th>Water &amp; Sewer Cost ($)</th>
<th>Consumption (GAL)</th>
<th>Alternative Energy Cost ($)</th>
<th>Consumption (GAL)</th>
<th>Total Utility Cost ($)</th>
<th>Treatment Volume (MGAL)</th>
<th>Utility Cost/Treatment Volume ($/MGAL)</th>
<th>Electric Utilization (kWh/MGAL)</th>
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#### Additional Information

- Electric Utilization (kWh/MGAL) 2011: 1,753.39
- Electric Utilization (kWh/MGAL) 2010: 1,753.58
- Water/Sewer (GAL) 2011: 1,607.54
- Water/Sewer (GAL) 2010: 1,607.58
Result is a report format for the utility to share with decision makers.
COMING SOON: Online Self-paced training modules

– Introduction to Performing Energy Use Assessments at Water and Wastewater Systems

• The first module focuses on the need to and the benefit of performing energy use assessments at water and wastewater systems.

• The second module focuses on performing energy use assessments at water and wastewater systems using EPA’s Energy Use Assessment Tool.

http://water.epa.gov/infrastructure/sustain/energy_use.cfm
Energy Use Assessment Tool Guidance

Current Guidance Available at:
http://water.epa.gov/infrastructure/sustain/energy_use.cfm

Click on:
“Energy Use Assessment Tool User’s Guide” (full version)
“Energy Use Assessments at Water and Wastewater Utilities” (pocket guide)
EPA Energy Management Planning Self-Assessment Worksheet

• Standalone worksheet included in “Ensuring a Sustainable Future” guidebook.

• 30 questions quickly allow users to evaluate strengths and weaknesses in existing energy management plans across 10 areas

• Intended to be used periodically to check progress on PDCA cycle

• Available on request: turgeon.jason@epa.gov
Before & After Roundtables: Town A

Assessment Plot

- Energy Audit
- Renewable Sources of Energy
- Adoption of Plan-Do-Check-Act, Management Systems
- Measurement
- SOPs/Operational Controls
- Energy Policy
- Energy Goals
- Energy Management Action Plans
- Training & Awareness

Comparison of energy management before and after initiatives.
NYSERDA Water Energy Program

• Water and Wastewater Focus Program:
  – Water and Wastewater Best Practices Handbook
  – 10 Steps to Energy Efficiency for Water and Wastewater Treatment Facilities
  – Payback Analysis Tool
  – Wastewater Check List
  – Wastewater Benchmarking Tool
  – Water Treatment Check List
  – Water Treatment Benchmarking Tool
  – [link]
  – [link]

Courtesy Nabeel Mishalani, Hazen and Sawyer
NYSERDA Self-Audit Checklists

- Designed for small water and wastewater facilities
- Simple Yes/No questions designed to point to opportunities for efficiency in operation and equipment
## SMALL WASTEWATER TREATMENT PLANT CHECKLIST

*(If any are not applicable, do not provide a response for that particular question)*

### 1. INFLUENT/EFFLUENT PUMPING

- **A.** Do you have influent and/or effluent pumps?  
- **B.** If yes, do you have variable speed control on the influent pumps?  
- **C.** If yes, are premium-efficiency motors currently installed on the influent pumps?  
- **D.** If yes, do you have variable speed control on the effluent pumps?  
- **E.** If yes, are premium-efficiency motors currently installed on the effluent pumps?

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<th>YES</th>
<th>NO</th>
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</thead>
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Additional comments and information

Subtotal Grayed

### 2. PRE-AERATION/POST-AERATION

- **A.** Does your plant utilize aeration blowers/compressors for pre-aeration, post-aeration or other aerated channels?  
- **B.** If yes, are there currently means to throttle the amount of air delivered or otherwise adjust output?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
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Subtotal Grayed

### 3. INTERMEDIATE PUMPING

- **A.** Do you have intermediate pumps to convey flow from primary to secondary processes or from secondary to tertiary treatment processes?  
- **B.** If yes, do you have variable speed control on the intermediate pumps?  
- **C.** If yes, are premium-efficiency motors currently installed on the intermediate pumps?

<table>
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<th>YES</th>
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Subtotal Grayed

### 4. BIOLOGICAL PROCESSES - ACTIVATED SLUDGE PROCESSES

- **A.** Does your plant utilize activated sludge processes or part of the
CEE Self-Audit Checklists

- Adapted from NYSERDA Checklists
- Designed for small water and wastewater facilities
- Simple Yes/No questions designed to point to opportunities for efficiency in operation and equipment
- Available from Efficiency Vermont: https://www.efficiencyvermont.com/For-My-Business/Solutions-For/Water-Wastewater-Facilities
Mass Energy Insight

• Available to any Massachusetts government entity including water/wastewater districts
• Data automatically uploaded from electric/gas utilities
• Provides a variety of built-in reports for water/wastewater industries
• Ability to interface automatically with ENERGY STAR Portfolio Manager
• www.massenergyinsight.net/
CASE STUDY 1: Freeport, ME

Freeport Sewerage District Electricity Use (kWh)

- 55% Electric Savings
- Eliminated Fuel Oil Use
- Combined Savings ~$97,000/year
Section 2: Energy Audits

• Conducted by outside experts

• Available in a variety of costs from free to high 5 figures

• Available in a variety of levels from walk-through to “investment-grade”
Energy Audits

• Types of Audits
• Costs & Providers
• Results
• Examples
Energy Audits

- Typically identify capital improvements (motors, blowers, variable frequency drives, etc) and operational improvements

- Operational improvements can result in substantial savings with little to no cost
  - Time of operation, load demand contracts, unnecessary equipment, energy management systems, etc.

- Audits can be conducted on plant designs – very cost effective

- Can identify renewable energy opportunities
Types of Energy Audits
DEMAND vs SUPPLY

• ASHRAE Tiered Energy Audits
  – Level I (Walk-Through Analysis)
  – Level II (Energy Survey & Analysis)
  – Level III (Detailed Analysis of Capital – Intensive Modifications, aka Process Audit)

• Renewable Energy Assessments
  – Simple Discussion of Alternatives
  – Desktop Analysis
  – Feasibility Study
EPA Goals:
Address Both Demand & Supply

• All facilities will benefit from Level II or Level III audit
  – Uncover operational and equipment changes for efficiency
  – These audits are NOT free, but have very fast paybacks

• All facilities should discuss renewable energy options and have a desktop analysis of promising alternatives
  – Feasibility studies performed where potential exists for significant energy production

• All facilities should use BOTH to develop a prioritized action list to guide their next steps!
Other names/types of audits

• Evaluate existing power consumption and metrics
  – Utility bill analysis
  – Benchmarking

• HVAC/Mechanical system audit
  – Evaluate gas requirements (process & heating systems)
  – Evaluate ventilation (efficiency & effectiveness)
  – Controls (programmable thermostats, etc.)

• Electrical system audit
  – Motor efficiency / type
  – Variable frequency drives
  – Lighting (systems, bulb type, controls)

• Process system audit
  – Process improvement
  – Operations optimization
  – Efficiency planning
Important Terms in Utility-Funded Audits

• Utility = Not you! The energy (electric or gas) provider.

• PA = Program Administrator = Utility Energy Efficiency personnel. Your new best friend - can help pay for audits and provide incentives ($$$) for projects!

• Identification of Energy Efficiency Opportunities = ~ Level I audits
Audit Costs and Providers

• PAs can and will fund audits in many service territories across the country
  – Audit costs usually split 50/50
  – You may be able to negotiate with PAs to develop something that works for you
  – PAs will often do a free walk-through with a simple checklist (aka Identification of EE Opportunities)
Audit Costs and Providers (cont’d)

- Find your PA by contacting your utility or visiting www.dsireusa.org and selecting your state.
- Some states have state-run efficiency programs instead of utility contacts (VT, WI, OR, ME, NY, NJ) but your utility can always tell you who to contact.
- Some utilities, especially when owned by a municipality, may not offer assistance.
- US DOE funds a network of Industrial Assessment Centers (IACs). Some IACs will work with water/wastewater clients at no cost.
  www1.eere.energy.gov/industry/bestpractices/about_iac.html
ASHRAE Audit Levels

**Preliminary Energy-Use Analysis**
- Calculate kBtu/sf
- Compare to similar

**Level 1: Walk-through**
- Rough Costs and Savings for EEMs
- Identify Capital Projects

**Level 2: Energy Survey & Analysis**
- End-use Breakdown
- Detailed Analysis
- Cost & Savings for EEMs
- O&M Changes

**Level 3: Detailed Survey & Analysis**
- Refined analysis
- Additional Measurements
- Hourly Simulation
Renewable Energy Assessments

• Start small (discussion) and end large ($100k+ feasibility studies)

• Some energy auditors will do some level of renewable energy assessment, usually discussion and desktop analysis with recommendations for further study

• Renewable energy projects usually only cost-effective AFTER all energy efficiency projects are completed.

• Some states have programs to fund assessments for certain types of projects
## Audit Results: One Size Does Not Fit All

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<tr>
<th>FACILITY NAME</th>
<th>AUDIT TYPE, LENGTH</th>
<th>AUDIT COST (free audits no longer standard)</th>
<th>ANNUAL ENERGY COST</th>
<th>ANNUAL SAVINGS</th>
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<td>Name Withheld (CT Water Facility)</td>
<td>Level III plus Desktop Renewables</td>
<td>~$25,000</td>
<td>$319,000</td>
<td>$55,000 efficiency, additional potential from up to 530 KW renewables</td>
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CASE STUDY 2

• Rural New Hampshire wastewater facility
  – 0.15 MGD average daily flow
  – Designed for 0.29 MGD average flow and 1.1 peak flow
  – Average annual electric use 462,000 kWh at a total cost of $63,000
Energy Balance example

Figure 1.1: 2011 WWTP Energy Use Breakdown

- Aeration: 58%
- Plant Water: 10%
- Misc Process: 4%
- Building Systems: 11%
- Prelim Treatment: 6%
- RAS/Clarifiers: 4%
- Dewatering: 7%
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<td><strong>Total</strong></td>
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<td>$34,685</td>
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Review

- All facilities will benefit from an audit
- Audits vary in size, scope, complexity, and cost
- PAs will help you fund audits and projects
- Renewable energy assessments are important but should come after efficiency projects
- Audits that don’t lead to completed projects don’t save any energy!
Two Tools to Help with Audits

• Maine DEP Sample Audit RFP Language
  – MS Word based to allow for easy cut-and-paste
  – Designed to incorporate most important elements of Level III audits at lowest cost
  – Available at http://www.epa.gov/region1/eco/energy/designing-rfps-contracts.html

• EPRI Energy Audit Manual for Water/WW Facilities
  – Older (1994) but still relevant
Questions
Section 3: Evaluation of Energy Audit Pilot Program Results in AZ, CA, HI, and NV
EPA Region 9’s Auditing Pilot Program

• Water and wastewater utilities that received ARRA funding were eligible to receive Level II/III energy audits...15 were selected

• Results show recommendations with a maximum 7.5 yr payback have potential:
  – $1.4 million/yr cost savings with a 4.5 yr payback (16% ROI)
  – 6,900 megawatt hours/yr reductions
EPA Region 9’s Auditing Pilot Program

• 15 recommendations with <1 yr payback period, with total annual savings of $190K/yr (>100% ROI)

• Non-capital improvements such as rate modifications, time-of-use, depowering equipment, and shutting down unnecessary processes

• These could likely be identified with low cost self-assessments or walk-through audits
EPA Region 9’s Auditing Pilot Program

• Recommendations identified an average:
  17% savings in energy use
  26% savings in energy costs

• Critical to note these audits were not prioritized to “ideal” candidates due to limited duration of funding

• Interestingly, no statistical differences between small and large utility results
Lessons Learned – Audit Process

• Target proper level of audit
• Discuss your payback period thresholds with auditor
• Request an initial simple draft report with brief summary of recommendations
• Discuss draft report with contractor to determine where further detail is required
• Leads to an effective final report...expensive contractor time not wasted on unwanted info
<table>
<thead>
<tr>
<th>Energy Conservation Opportunities (total # identified during Pilot Project)</th>
<th>Payback Period (yrs.)</th>
<th>Costs (Implementation)</th>
<th>Annual Savings ($)</th>
<th>Annual Energy Cost Savings</th>
<th>MWh/Year Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Rate Modifications (2): modifying rate schedules to be most efficient during peak and non-peak hours</td>
<td>avg = 0.12 0.1 to 0.14</td>
<td>$500</td>
<td>$3,600 - $10,000</td>
<td>13 - 48%</td>
<td>N/A</td>
</tr>
<tr>
<td>Electrical Demand Management (5) : monitoring total energy use/demand with installation of electrical metering, maximizing off-peak operations</td>
<td>avg = 0.2 0 to 1</td>
<td>$0 - $75,000</td>
<td>$1,000 - $115,800</td>
<td>0.7 - 7.3%</td>
<td>N/A</td>
</tr>
<tr>
<td>Operational Improvements (11): Noncapital improvements to optimize treatment</td>
<td>avg = 1.7 0.7 to 5</td>
<td>$0 - $220,000</td>
<td>$100 - $35,700</td>
<td>0.1 - 26.5%</td>
<td>1 - 284</td>
</tr>
<tr>
<td>Pump Modification (6): adjusting effluent pumping, inline flow meters in collection/distribution systems, and pump controls</td>
<td>avg = 4.1 0 to 10.7</td>
<td>$0 - $35,600</td>
<td>$250 - $7,000</td>
<td>0.5 - 7.2%</td>
<td>2 - 26</td>
</tr>
<tr>
<td>Motor Efficiency Upgrades (4): replacing inefficient motors with high efficiency motors</td>
<td>avg = 4.9 0.7 to 8.2</td>
<td>$3,100 - $175,000</td>
<td>$2,800 - $44,300</td>
<td>1.3 - 7.6%</td>
<td>9.6 - 136.4</td>
</tr>
<tr>
<td>Component System Upgrades (5): Capital and operational improvements on UV, process water, scrubber, and compressed air systems</td>
<td>avg = 5.1 4 to 6.3</td>
<td>$130,000 - $500,000</td>
<td>$20,500 - $98,000</td>
<td>2.2 - 28.3%</td>
<td>105.7 - 441.5</td>
</tr>
<tr>
<td>Efficient Lighting Fixtures (5): implementation of more efficient lighting; includes reduced use and sensors</td>
<td>avg = 6.6 2.6 to 11.2</td>
<td>$7,000 - $154,000</td>
<td>$2,650 - $24,700</td>
<td>0.5 - 2.9%</td>
<td>9.1 - 122.1</td>
</tr>
<tr>
<td>Variable Frequency Drive Installation (3)</td>
<td>avg = 7.2 2.4 to 12</td>
<td>$15,700 - 126,500</td>
<td>$1,620 - $51,600</td>
<td>0.4 - 4.2%</td>
<td>15.4 - 482</td>
</tr>
<tr>
<td>Aeration Control/Improvements (4): smaller blower installation, operation changes, better control with meter installation</td>
<td>avg = 8.3 4.7 to 13.3</td>
<td>$5,000 - $244,000</td>
<td>$760 - $24,400</td>
<td>1.6 - 26.9%</td>
<td>6 - 200</td>
</tr>
</tbody>
</table>
CASE STUDY 3

• Selma-Kingsburg-Fowler County Sanitation District (Fresno County, CA)
  – Serves a population of 40,000
  – Aeration improvements (blower and fine bubble diffuser replacement)
  – SCADA installation improved controls, including dissolved oxygen in aeration basins
  – Verified savings of $500,000 (6.1 year payback) and 4,544,688 kWh per year
## Renewable Energy Highlight

<table>
<thead>
<tr>
<th>Utility</th>
<th>Treatment Capacity (MGD)</th>
<th>Solar Generating Capacity</th>
<th>Annual Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moorpark WWTP (Moorpark, CA)</td>
<td>3</td>
<td>0.958 MW</td>
<td>$250,000</td>
</tr>
<tr>
<td>Santa Rosa WRF (Murrieta, CA)</td>
<td>5</td>
<td>1.1 MW</td>
<td>$152,000</td>
</tr>
<tr>
<td>Kihei WWTF (Kihei, HI)</td>
<td>7.5</td>
<td>1.9 MW</td>
<td>$500,000</td>
</tr>
</tbody>
</table>
Section 4: Suggested Next Steps

• Conduct a Self-Assessment of your utility’s energy use
  – EPA’s EUAT and self-assessment checklists available at
    http://water.epa.gov/infrastructure/sustain/energy_use.cfm
    http://www.epa.gov/region9/waterinfrastructure/audit.html

• Conduct a Level II or III energy audit at your facility

• Initiate an energy management program to implement audit recommendations
Resources for Funding Audits

- Add energy audit to your next capital improvement project grant/loan/bond (or amend scope of existing project)
- Your utility operations budget
- State Revolving Fund Programs (Clean Water and Drinking Water)
- USDA Rural Development
- US Bureau of Reclamation’s WaterSMART Program
- Your energy provider
- Additional opportunities can be found at -
  [http://www.epa.gov/region9/waterinfrastructure](http://www.epa.gov/region9/waterinfrastructure) (Funding tab)
  [http://water.epa.gov/infrastructure/sustain/energy_use.cfm](http://water.epa.gov/infrastructure/sustain/energy_use.cfm)
Water Efficiency for Energy Savings

• Water Utilities - Keep in mind substantial energy benefits can be realized by reducing the real losses in your water system

• AWWA’s Free Water Audit Software is a widely-used and effective tool to help you identify cost-effective water savings opportunities
Questions
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