Energy Management Systems

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JKMuir.com
What are our Goals? What do we really want to know?

• Cost Savings
• kWh Savings
• Understanding/benchmarking
• Equipment Monitoring
• Reporting
• Demand – Variation mapping [potentially for on-site generation opportunities]
Obstacles

- Cost
- Making the data meaningful
- Requires understanding of billing and costs
- May not get to equipment level – data may not be detailed enough
- Not always directly relatable to kWh or cost savings
How do we make data meaningful?

- Benchmark
- Who is monitoring/watching?
- What are the triggers/set-points?
- Can we equate it to dollars?
- Make the business case
Energy Management Plans Then and Now

• Step 1: Perform energy audit
• Step 2: Develop Low Cost Operational Measures and Energy Conservation Measures
• Step 3: Create an Energy Management Plan to implement energy savings operational measures and energy conservation measures
• Step 4: Develop long term goals & strategies
Energy Conscious Operations

• **Energy Management Program**
  - Goals
  - Account & billing management
  - Demand management

• **Asset Management**
  - Equipment performance monitoring
  - Root failure analysis
  - Prioritization
What is an Energy Audit?

• Understanding billing and rates
  • Supply and Demand
• Evaluate equipment efficiency
• Evaluate process efficiency
• Evaluate building systems
• Energy rebate funding
Energy and Cost Saving Opportunities

- System optimization
- Aeration/process air/blowers
- Pumping
- Solids Handling
- Mixing
- Process optimization
- Chemical addition & disinfection systems
- Demand monitoring & control
- Demand response
Acceptance (Management & Staff)

- Many facilities already use Building Management/Automation Systems (BMS/BAS)
  - BMS/BAS Systems are Energy Management Systems with a focus on HVAC and Lighting
  - Overview of temperature, airflow, and equipment status/setpoints as well as energy usage of building systems and equipment
  - Historic trends stored in system
- Energy Management Systems expand BMS System process wide
  - Customizable sensors and data points on switchgear, MCCs, or equipment level
  - Overview of system sensors and historic trends
How to implement an Energy Management System

- Levels of monitoring
  - Main switchgear or distribution panel
  - MCC level
  - Building level
  - Equipment level

- Types of monitoring systems
  - Hardwired
  - Wireless
  - Integrated with existing network or overlaid
Submetering

- Real time power data
- Break down of plant energy usage
- Pinpoint energy intensive equipment
- Recover stranded data
- Trends that benchmark process performance data against energy usage data
- Analytics to sort through and pull conclusions out of data
## Turning Monitoring into Energy Savings

<table>
<thead>
<tr>
<th>Pump Name</th>
<th>Speed</th>
<th>Leg</th>
<th>EMF (VAC)</th>
<th>Current (Amp)</th>
<th>Power (kW)</th>
<th>Power Factor</th>
<th>Flow (GPM)</th>
<th>Motor Eff. (%)</th>
<th>VFD Eff. (%)</th>
<th>Suction (psi)</th>
<th>Discharge (psi)</th>
<th>TDH (feet)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAS Pump #4</td>
<td>62%</td>
<td>A</td>
<td>279</td>
<td>18</td>
<td>1.8</td>
<td>0.36</td>
<td>2,215</td>
<td>93.0%</td>
<td>97%</td>
<td>6.8</td>
<td>10.0</td>
<td>7.4</td>
<td>61%</td>
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<tr>
<td></td>
<td></td>
<td>B</td>
<td>280</td>
<td>19</td>
<td>1.9</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>280</td>
<td>18</td>
<td>1.9</td>
<td>0.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOT/AVG</td>
<td>483.8</td>
<td>18.4</td>
<td>5.6</td>
<td>0.37</td>
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<td></td>
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<tr>
<td>RAS Pump #4</td>
<td>92%</td>
<td>A</td>
<td>289</td>
<td>25</td>
<td>5.9</td>
<td>0.83</td>
<td>3,738</td>
<td>93.0%</td>
<td>97%</td>
<td>4.5</td>
<td>10.1</td>
<td>12.9</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>280</td>
<td>25</td>
<td>6.0</td>
<td>0.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>279</td>
<td>25</td>
<td>6.1</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TOT/AVG</td>
<td>489.0</td>
<td>25.2</td>
<td>18.0</td>
<td>0.84</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>PWS Pump #3</td>
<td>86%</td>
<td>A</td>
<td>278</td>
<td>11</td>
<td>2.3</td>
<td>0.76</td>
<td>105</td>
<td>92.4%</td>
<td>97%</td>
<td>5.2</td>
<td>81.0</td>
<td>175.1</td>
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<tr>
<td></td>
<td></td>
<td>B</td>
<td>278</td>
<td>10</td>
<td>2.4</td>
<td>0.83</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>279</td>
<td>13</td>
<td>3.3</td>
<td>0.90</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>TOT/AVG</td>
<td>482.0</td>
<td>11.5</td>
<td>8.0</td>
<td>0.83</td>
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<td></td>
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<td></td>
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</tr>
</tbody>
</table>
The graph shows the relationship between average daily flow (MGD) and kWh/MG. The data points suggest a trend where lower average daily flow corresponds to higher kWh/MG values.
Membrane Tanks/Filtration 44%
Headworks and Primary Treatment 13%
Aeration System 18%
Solids Handling 0.2%
Sludge Pumping 2%
Plant Water System 7%
Odor Control System 15%
Building Systems 2%
Understanding Power Bills

- Supplier charges
- Delivery charges
- On-Peak charges
- Off-Peak charges
- kWh charges
- Demand (kW) charges
- Power factor charges
Supply Charges

Supply Services

SUPPLIER: ConEdison Solutions
100 Summit Lake Drive
Valhalla, NY 10595

PHONE: 1-844-245-8350
ACCOUNT NO:

Electricity Supply: 0.0962 x 4320 kWh = 415.58

Total Supply Services: $415.58
## Delivery Charges

### Detail of Current Charges

#### Delivery Services

<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Current Reading</th>
<th>Previous Reading</th>
<th>Difference</th>
<th>Multiplier</th>
<th>Total Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>3157 Actual</td>
<td>3146 Actual</td>
<td>9</td>
<td>460</td>
<td>4320 kWh</td>
</tr>
<tr>
<td>Peak</td>
<td>1168 Actual</td>
<td>1163 Actual</td>
<td>5</td>
<td>480</td>
<td>2400 kWh</td>
</tr>
<tr>
<td>Off Peak</td>
<td>1989 Actual</td>
<td>1885 Actual</td>
<td>4</td>
<td>480</td>
<td>1920 kWh</td>
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</table>

**Total Energy**: 4320 kWh

#### Demand-kW

<table>
<thead>
<tr>
<th>Type</th>
<th>Multiplier</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>480</td>
<td>177.5 kW</td>
</tr>
<tr>
<td>Off Peak</td>
<td>480</td>
<td>177.6 kW</td>
</tr>
</tbody>
</table>

#### Demand-kVA

<table>
<thead>
<tr>
<th>Type</th>
<th>Multiplier</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>480</td>
<td>205.4 kVA</td>
</tr>
<tr>
<td>Off Peak</td>
<td>480</td>
<td>201.6 kVA</td>
</tr>
</tbody>
</table>

**Meter Number**: [Redacted]

**Next Scheduled Read Date On or About**: Aug 22

**Service Period**: Jun 19 - Jul 21

**Number of Days in Period**: 32

**Rate**: Time of Use G-3 Voltage Delivery Level 0 - 2.2 kV

<table>
<thead>
<tr>
<th>Charge Type</th>
<th>Multiplier</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge</td>
<td></td>
<td>223.00</td>
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<tr>
<td>Dist Chg On Peak</td>
<td>0.01617</td>
<td>x 2400 kWh 38.81</td>
</tr>
<tr>
<td>Dist Chg Off Peak</td>
<td>0.00864</td>
<td>x 1920 kWh 16.59</td>
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<tr>
<td>Transition Charge</td>
<td>0.00058</td>
<td>x 4320 kWh 2.51</td>
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<td>Transmission Charge</td>
<td>0.02059</td>
<td>x 4320 kWh 88.95</td>
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<tr>
<td>Distribution Demand Chg</td>
<td>5.76</td>
<td>x 185.8 kW/kVA 1,070.21</td>
</tr>
<tr>
<td>Energy Efficiency Chg</td>
<td>0.00957</td>
<td>x 4320 kWh 41.34</td>
</tr>
<tr>
<td>Renewable Energy Chg</td>
<td>0.0005</td>
<td>x 4320 kWh 2.16</td>
</tr>
</tbody>
</table>

**Total Delivery Services**: $1,463.57
Impacts of Peak Loads

- Peak load require more plants to be on-line:
  - Older
  - More expensive
  - Dirtier
  - Less efficient
  - Pay plants to be “on-call”
  - Construction of peaking plants
Power Factor

- Inductive loads
- When magnetic fields are produced all of the power applied does not accomplish work.
- Power factor is a measure of how well the energy supplied is converted to measurable work (kW).

Power Factor Triangle
Why Power Factor Matters & kVA Billing

- Reactive Power is repeatedly demanded by the load and returned to the source.
- Can require the use of wiring, switches, circuit breakers, transformers, transmission lines with higher current capacities.

### Maximum Demand and Energy Use Information

<table>
<thead>
<tr>
<th></th>
<th>KW Demand</th>
<th>KVA Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand</strong></td>
<td>126.9</td>
<td>130.0</td>
</tr>
<tr>
<td><strong>KVA Multiplier</strong></td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td><strong>Adjusted Demand</strong></td>
<td>126.9</td>
<td>104.0</td>
</tr>
<tr>
<td><strong>Off Peak Multiplier</strong></td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Net Demand</strong></td>
<td>126.9(A)</td>
<td>104.0(C)</td>
</tr>
<tr>
<td><strong>Maximum Demand</strong></td>
<td>127</td>
<td>56.9(D)</td>
</tr>
</tbody>
</table>

**Note:** Maximum Demand for billing purposes is the greatest of (A), (B), (C) or (D) to the nearest whole number of units.
Reducing Your Bill

- Third Party Contracts
- Power Factor Correction
- Demand
  - Peak vs. Off-Peak
  - 30 min, 15 min, single month, 12-month
- Significant load reduction
- Demand response
- Rate schedule analysis
- Justify energy bills through equipment inventory and data collection
“IIoT is real and it is going to be here sooner than later. End users will be inundated with various predictive devices from a variety of manufactures. Keeping up with them will be virtually impossible, so picking a savvy distributor to help sort through the array of new smart products will be critical”

- Randy Breaux Senior Vice President of Marketing, Distribution & Purchasing, Motion Industries Inc.
Internet of Pumps

**Added Value**

- **CONVENTIONAL** (Consultancy)
  - No intelligence or connectivity
  - Connected data loggers
  - Provide external data (paper report)

- **INSTRUMENTED** (On-site audit)
  - Connected data loggers
  - Enhanced data feeds

- **SOFTWARE DEFINED** (BMS/SCADA)
  - Some local intelligence (controller) to tune pump
  - Self optimization
  - Interact with ecosystem
  - Enhanced intelligence

- **SMART** (Connected pump)
  - Active condition monitoring
  - Self optimization
  - Interact with ecosystem
  - Enhanced intelligence

- **AUTONOMOUS**
  - Internet of things by 2020*
  - 26 billion installed units, $263 billion new revenue and $1.9 trillion value-added services
  - Additional sensors
  - Real time diagnostics
  - Embedded execution
  - New business models
  - Performance guarantee
  - Customer loyalty
  - Connect everything

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*Source Gartner, Forecast The Internet of Things worldwide*
Cyber Risks

There are many options available to increase cyber security

- Monitoring network separate from control network
- Separate program that overlays onto SCADA
Cost, Savings & Payback

- Real time data vs Spot Testing
- Wired vs. Wireless
- System expandability
- Data Analytics
- Predictive Maintenance
- Reduced downtime
- Payback Period
Thank You

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Content Hub:
http://empoweringpumps.com/blog/category/company-articles/jkmuir/
# Turning It Into Savings

<table>
<thead>
<tr>
<th>Cost Saving Measures</th>
<th>Annual Energy Savings (kWh)</th>
<th>First Year Annual Dollars ($)</th>
<th>Initial Cost ($)</th>
<th>Simple Payback (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM 1 Aeration Blower Optimization</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>OM 2 Solids Handling and Off-Peak Hours of Operation</td>
<td>$30,852</td>
<td></td>
<td>$30,379</td>
<td>&lt;1.0</td>
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<td>ECM 1 Influent Pump Rebuild</td>
<td>216,994</td>
<td>$30,379</td>
<td>$60,000</td>
<td>2.0</td>
</tr>
<tr>
<td>ECM 2 RAS Pump Rebuild</td>
<td>243,830</td>
<td>$34,136</td>
<td>$34,000</td>
<td>1.0</td>
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<tr>
<td>ECM 3 Aerobic Tank Mixing</td>
<td>78,420</td>
<td>$10,979</td>
<td>$15,000</td>
<td>1.4</td>
</tr>
<tr>
<td>ECM 4 Ammonia Based Process Control</td>
<td>96,360</td>
<td>$13,490</td>
<td>$67,000</td>
<td>5.0</td>
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<tr>
<td>ECM 5 Post-aeration System Optimization</td>
<td>38,933</td>
<td>$5,451</td>
<td>$40,000</td>
<td>7.3</td>
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<tr>
<td>ECM 6 UV System Optimization</td>
<td>164,250</td>
<td>$22,995</td>
<td>$41,000</td>
<td>1.8</td>
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<td>ECM 7 Digester Mixing System</td>
<td>56,984</td>
<td>$7,978</td>
<td>$93,750</td>
<td>11.8</td>
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<tr>
<td>ECM 8 Sludge Recirculation Pump</td>
<td>14,499</td>
<td>$2,030</td>
<td>$15,000</td>
<td>7.4</td>
</tr>
<tr>
<td>ECM 9 Plant Water System Replacement and VFDs</td>
<td>71,179</td>
<td>$9,965</td>
<td>$80,000</td>
<td>8.0</td>
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<tr>
<td><strong>Savings</strong></td>
<td><strong>981,449</strong></td>
<td><strong>$168,254</strong></td>
<td><strong>$445,750</strong></td>
<td><strong>2.6</strong></td>
</tr>
</tbody>
</table>
Pump System Efficiency

Utility feed
Transformer
Breaker/starter
VFD

Motor
Pump
Fluid system

Energy Loss
Existing Systems

Efficiency testing includes:

- **Flow** monitoring
- **Pressure** instrumentation to determine pump head
- **Power (kW)** measurements
- Data loggers to evaluate energy use changes over a period of time

Compare to the original pump performance

Evaluate Efficiency Options
Partnering Opportunities

• Bring water/wastewater facilities into municipal projects
• Mine savings at these facilities for maximum benefit & comprehensive projects
• Develop business case
• Show savings + permit compliance
• Long term customers
• Vital infrastructure
Value Added Services

• In-Plant Training – Pump System Optimization
• Instrumentation & testing equipment
• Integration of pumping & process technology
• Custom measure projects – EE funding programs
• Independent/third party analysis
• Develop business case
How Can Pump Efficiency Be Restored?

- Pump Rebuilds/Replacements
  - Maintain and restore
  - More efficient / new standards
  - Application of Interior Coatings
- VFD Installation
  - Head and Flow reduction
- Change Operating Point
  - BEP
- System Configuration
  - Piping Modifications
  - Setpoint Modifications
What is Pump Efficiency

Pump Efficiency = \( \frac{\text{Flow} \times \text{Head} \times 0.746}{3960 \times \text{kW} \times \text{Motor Eff.} \times \text{Drive Eff.}} \)