Adaptive Energy Management at Wastewater Treatment Facilities

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Texas Association of Clean Water Agencies
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7 billion people projected to call Earth home in 2012

The world’s population will reach 7 billion in 2012, according to a U.S. government projection released Thursday.

The world has 6.7 billion people today. The USA ranks third in population, with 304 million, behind China (1.33 billion) and India (1.15 billion), according to Census Bureau figures. The world’s population surpassed 6 billion in 1999.

There is no consensus on how many people the Earth can sustain, said William Frey, a demographer at the Brookings Institution, a Washington think tank. He said it depends on how well people manage resources.
The Brundtland Commission in 1987 defined Sustainable Development as:

“…development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”
Or in the Words of Countless Kindergarten Teachers

Don’t take more than your fair share!
The “Umbrella” of Sustainability

E=mc²

CO₂

H₂O

Biosolids
For Some Utilities Sustainability Could be Considered As?

- Using less energy, while providing more treatment and optimizing process.
- Integrated water resources management – potable water, reclaimed water, stormwater, etc.
- Reuse of byproducts – biosolids, biogas, effluent, etc.
E = mc^2
National Impacts Associated with Wastewater Utilities

- Over 16,000 facilities treating nearly 28 billion gallons per day
- Most prevalent treatment process is activated sludge

Water and Wastewater utilities represent approximately 3% of the nation’s electric load – about 56 billion KWY
What are the Future Challenges that Utilities Face?

- Doing more with less
  - Budget minded utilities → Budget minded customers
- Regulations and ever decreasing effluent limits
  - Nutrients, microconstituents, etc.
- Best practices for process efficiencies
  - Process models → optimize chemicals, energy, etc.
- Smart management and expansion
Can You Produce 100% of the Energy Needed to Operate?

- Some of the nations best performing facilities can produce most of the energy needed to operate.
- They can do this by:
  - Process control
  - Modifications to operations
  - Implementing resource recovery and reuse options
  - Employing new technologies
More than 500 WWTFs in the US with capacities greater than 5 mgd that incorporate anaerobic digesters to process their biosolids.

If all of these facilities used their biogas for fuel, they could generate:

- An additional 340 MW of clean electric capacity each year. This increase would:
  - Eliminate approximately 2.3 million metric tons of carbon dioxide annually.
  - Which is equivalent to removing the emissions of almost 430,000 cars or planting nearly 640,000 acres of forest.

Source: USEPA
Utilities Use a Diverse Mix of Energy Sources

- Coal (50%)
- Natural Gas (19%)
- Nuclear (19%)
- Hydro (7%)
- Oil (3%)
- Other (2%)
Typical Activated Sludge WWTP Energy Cost Breakdown

- Aeration: 54.12%
- Anaerobic Digestion: 14.24%
- Wastewater Pumping: 14.26%
- Belt Press: 3.91%
- Clarifiers: 3.15%
- Grit Removal: 1.36%
- Lighting and Buildings: 8.14%
- Gravity Thickener: 0.06%
- Chlorination: 0.27%
- Sludge Pumping: 0.46%
- Screening: 0.02%

Actual Aeration % Depends on:
- Overall Treatment Process
- Process Design Parameters
- Operational Strategy

Many Factors Affect Plant Energy Consumption

- Influent characteristics (e.g., organic, solids, flow, etc.)
- Effluent requirements
- Type of facility (activated sludge, fixed film, etc)
- Method of disinfection
- Sludge treatment process
- Weather/Location
- Operational strategy
What can Utilities Do to Manage Their Energy Costs?

- Convert to a more efficient process or method of aeration
- Optimize pumping and blower configurations, operations and controls
- On-line analyzers for liquid and solids processes
- Upgrade to VFDs and premium motors
- Modify operating strategies
Approach to Energy Management

ASSESSMENT

- Analyze current energy portfolio & costs
- Evaluate new energy sources, costs, integratability, & revenue potential
- Assess existing energy demand processes
- Assess existing energy demand components

IMPLEMENTATION

- Develop Comprehensive Energy Roadmap
- Facilitate cost-effective implementation of new technologies
- Facilitate access to capital & revenue streams
Case Studies

- City of Atlanta
- Jacksonville Electric Authority
- City of North Port
City of Atlanta – Overview of Their WRCs

- Four wastewater treatment facilities
  - R.M. Clayton
  - Utoy Creek
  - South River
  - Intrenchment Creek: 2-stage trickling filter
## Findings – Areas With the Greatest Potential Impacts

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<th>R.M Clayton</th>
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## A Unit Energy Cost Variance Template Enables Alternative Operating Strategy Identification

### 2005-2007 Average Real Time Pricing (RTP) Energy Cost (¢/kWh) by Hour

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**Average**:

- 4.29
- 4.00
- 4.27
- 4.61
- 4.71
- 5.61
- 7.92
- 5.00
- 4.64
- 4.47
- 4.71
- 4.90
Caustic Soda Usage Reduction

Current Situation – Wastewater has low alkalinity

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<th>R.M. Clayton WRC</th>
<th>Utoy WRC</th>
<th>South River WRC</th>
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<tr>
<td>Average Alkalinity mg/L</td>
<td>123</td>
<td>88</td>
<td>142</td>
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<tr>
<td>Average gallons of caustic soda per million gallon of water treated</td>
<td>27</td>
<td>17</td>
<td>17 to 27</td>
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<tr>
<td>Annual cost for caustic soda ($1,000s)</td>
<td>$1,325</td>
<td>$334</td>
<td>$401 to $636</td>
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Alternatives
- Hydrated lime in dry or slurry form
- Mixed liquor recycle pumps for denitrification/recover alkalinity
Caustic Soda Reduction Improvements

- R.M. Clayton WRC and Utoy Creek WRC
  - Short Term: Use hydrated lime
  - Long Term: Incorporate mixed liquor recycle pumping
- South River WRC
  - Long Term: Incorporate mixed liquor recycle pumping

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<th>Facility</th>
<th>Construction Cost</th>
<th>Annual Savings</th>
<th>Payback Period</th>
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<td>R. M Clayton WRC</td>
<td>$510,000</td>
<td>$935,000</td>
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<td>Utoy Creek WRC</td>
<td>$273,000</td>
<td>$145,000</td>
<td>22 months</td>
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<td>South River WRC</td>
<td>$510,000</td>
<td>$283,000 - $447,000</td>
<td>14 to 22 months</td>
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Dissolved Oxygen Control System Improvements

- R.M. Clayton WRC
  - Refurbish control panels and upgrade software
  - Upgrade software
  - Replace DO meters

- Utoy Creek WRC and South River WRCs
  - Upgrade software
  - Replace DO meters
Dissolved Oxygen Control System Improvements
RM Clayton WRC

~ $300,000 Annual Saving
## Dissolved Oxygen Control System Improvements

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<td>$130,400</td>
<td>$313,600</td>
<td>5 Months</td>
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<td>Utoy Creek WRC</td>
<td>$93,000</td>
<td>$60,000</td>
<td>1.6 years</td>
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<td>South River WRC</td>
<td>$67,000</td>
<td>$102,800</td>
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Summary - $3M Savings at the City’s Three BNR Facilities ($2M Investment)

- Reduce Ferric Requirements: $423,000
- Modify Effluent Filters Operation: $52,000
- South River Residuals: $600,000
- South River Pump Improvements: $65,000
- Aeration System Controls: $476,000
- Reduce Caustic Feed: $1,445,000
JEA – Wastewater System Overview

- 124 MGD treatment capacity
- 78 MGD average daily flow
- 16 Wastewater treatment facilities
- 1,165 Pump stations
- 3,400 miles of pipe / 44000 manholes
- 64 DTPD Biosolids pelletizing facility
Clean Power Generation

- Digester gas used to fuel the dryer
- Excess gas will be used in a generator to supplement the power grid
- The generator has a heat recovery unit to convert waste heat for use by the digester heaters.
- FOG program to increase gas generation of digesters.
• Aeration system upgrades – Converted from mechanical and coarse bubble aeration to fine bubble aeration
• BioWin process model
• On-line Analyzers
  – Optimize nitrogen removal
  – Reduces energy
Pump Station Optimization

• Using intelligent systems allows for optimal pumping
• Allows system can be recalibrated when head conditions change
• Reduce sanitary sewer overflows
• Estimated to save 20% of energy consumed
• Pumps can achieve 90% efficiency when operating in the optimum range
JEA Sustainable Initiatives
Results to Date

- Annual energy savings: $1.02M (23%)
- Annual chemical savings: $3.5M (55%) – converted from chlorine to UV.
- Reuse of over 9.5 mgd (13%) of effluent produced
- Production of 38 dtd of marketable pellets - GreenEdge™
- Excess biogas used to supplement the power grid.
- Reduced the nitrogen load in their surface water discharges by nearly 70%.
Overview of the City of North Port

- 3 mgd conventional activated sludge facility (currently under construction to expand facility to 7 mgd)
- Serves the City and portions of Sarasota County Counties in southwest Florida
- Public access reclaimed water (golf courses, residential and greenspace irrigation)
City of North Port’s Sustainable Initiatives

- Minimize energy required for treatment and pumping requirements
  - Converted from coarse bubble to fine bubble
  - Installed energy efficient centrifugal blowers
  - Nutrient and DO analyzers for process control
- Maximize capacity - rerating programs
- Implement a city-wide public access reclaimed water system
- $1M added for sustainable initiatives
- Water quality – nitrogen reduction initiative
Current Diurnal DO Trend (09/28/09)
Conversion from coarse to fine bubble and upgraded blowers reduced energy costs by \( \approx 23.2\% \)

System payback period \( \approx 7\text{-years} \)
North Port’s Sustainable Initiatives
Results to Date

- Currently reuses 100% of wastewater treated
- Rerating program resulted in the ability to connect 6,200 ERCs – no capital investment
- Green roofs/cisterns/rain gardens/solar panels
- Reduced Effluent TN – 68%
- Energy costs are projected to be reduced by nearly 31% next year
Successful Energy Management – Takeaways

- Future designs centered around energy management and resource recovery.
- Everything is site specific.
- Changing energy supply and procurement practices can reduce energy costs at a minimal investment.
- Development of consistent and effective energy saving action plans
- Monitor/analyze energy trends relative to costs/reliability will maintain low costs.
- Plan and Take Action.
“The world will not evolve past its current state of crisis by using the same thinking that created the situation”

Albert Einstein

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