Sustainable City Network

“Developing An Energy Master Plan For The Water/Wastewater Industry”

Thursday, November 3rd, 2011
Overview of Presentation

• The New “Energy Reality”
  – Internal drivers
  – External drivers
  – Learning from the past

• The “Integrated Energy Plan™” => a 5-Step Process

• What’s conventional, what’s new?
  – Concepts, technologies, institutional solutions

• Case studies:
  – San Jose/Santa Clara WPCP
  – CCCSD

• Summary
Internal Industry/Agency Drivers for a Renewed Focus on Energy

• Regulations
  – Increased level of treatment => more energy use

• Aging Infrastructure/Repair and Replacement
  – Asset Management and Life-cycle costing

• Expansion to accommodate planned growth
  – More capacity and associated energy requirements

• Management Efficiencies/Optimization
  – Push to “do more with less”
External Drivers for a Renewed Focus on Energy

- Economic
  - Increasingly limited conventional energy resources (i.e., oil, natural gas, etc.)
  - Changes in financing options (e.g., P3 agreements)
- Environmental
  - Climate change concerns/GHGs
- Social
  - To “be green”
Oil Price Trends

Natural Gas Price Trends

Fundamental Short-Comings in our Approaches in the Past...

- **Didn’t Consider “Systems”** We didn’t take into account the *interconnections* in our environment and our bodies
  - E.g., DDT was a great pesticide, but we didn’t understand the consequence of a ‘conservative’ pollutant vs. “the solution to pollution is dilution”

- **Didn’t Consider “Time”** We focused on the short-term, and not the *long-term that is required to fully realize the full consequences* of our actions
  - E.g., climate change due to lack of oceans to fully assimilate CO₂
The 5-Step Process for Developing an “Integrated Energy Plan™”

- Existing Situation
- Future “Vision”
- Gap Analysis
- Alternatives Analysis
- Solution
Step 1: Assess the Existing Situation
Step 1: Assess the Existing Situation (continued)

• Energy audit (i.e. field evaluation and data collection)
  – **Verify data**, i.e. compare actual daily operations/practices with design data and plant capacities
  – Review **energy-intensive processes** (e.g., pump stations, process air blowers, centrifuges, etc.)
  – Identify areas where the **demand** can be controlled and reduced
Typical Relative Energy Demand (WWTP)

- Influent Pumping: 12%
- Headworks: 12%
- Primary Sedimentation: 12%
- Aeration: 39%
- Secondary Sedimentation: 10%
- RAS Pumping: 10%
- UV Disinfection: 10%
- Thickening: 10%
- Anaerobic Digestion: 10%
- Dewatering: 10%
- Lighting: 10%
- HVAC: 10%
- Odor Control: 10%

Step 2: Identify the Future “Vision”
Step 2: Identify the Future “Vision” (continued)

- Set levels of service (LOS):
  - Standards:
    - NPDES permit requirements (EPA/local authority)
    - Public safety (State/Local Departments of Health)
    - Process requirements (e.g., aeration needs)
  - Conditions:
    - Critical/ upset conditions
    - Full plant operation conditions
Step 2: Identify the Future “Vision” (continued)

- “Energy Independence” (how to meet?)
  - Supply side options:
    - Add renewable (“green”) energy to portfolio

- Add “contract purchase”
  - Demand management options

Source: National Renewable Energy Laboratory Energy Analysis Office
Step 3: Perform a “Gap Analysis”
• Defining the gap:
  – Total energy need vs. supply => additional energy?
  – Existing vs. desired reliability => additional reliability?
  – Dependent vs. independent energy user => okay?

• Considerations:
  – Estimate the future plant energy and reliability needs (influent flows and loads, possible future treatment requirements, etc.)
  – Compare with the “current and future power generating portfolio”
    • e.g. San Jose/Santa Clara WPCP
San Jose/Santa Clara WPCP “current power generating portfolio”

- **2040:**
  - Externally-generated Power = 60%
  - Self-generated Power = 40%

- **Power, MW**
  - **Digester Gas**
  - **Landfill Gas**
  - **Purchased Power**
Step 4: Perform an Alternatives Analysis

- Existing Situation
- Future "Vision"
- Gap Analysis
- Alternatives Analysis
Step 4: Perform an Alternatives Analysis (continued)

• Non-process efficiency improvements
  – Fuel cell
  – Mercury turbine
  – Pretreatment (e.g., CAMBI®, OpenCel®)
  – Turbo-type blowers
Step 4: Perform an Alternatives Analysis (continued)

- Process modifications
  - Chemically enhanced primary treatment (CEPT)
  - WASAC®
  - Sidestream treatment (e.g., ANAMMOX®, DEMON®)
New Biological Nitrogen Removal Processes

Conventional Nitrification-Denitrification

- Oxygen (O₂) 75% Ammonium → Nitrite
- Oxygen (O₂) 25% Nitrite → Nitrate
- Electron Donor (Carbon) 40% Nitrate → Nitrite
- Electron Donor (Carbon) 60% Nitrite → Carbon Dioxide (CO₂)
- Alkalinity → Nitrogen Gas

ANAMMOX® Process

- Oxygen (O₂) 40% Ammonium → Nitrite
- Alkalinity 50% Nitrite → Nitrogen Gas
- 55% 45%

anammox reactor, KU Nijmegen
Step 4: Perform an Alternatives Analysis (continued)

- Renewable energy options
  - External feedstocks
  - Solar
  - Wind
Characterization of High Strength Wastes is Critical for the Estimation of Performance

- Grease Traps
- Residual Fats
- Flotated Fats
- Commercial Kitchens
- Restaurant Waste
- Food Discards
- Cafeteria Waste
- Food Waste
- Soup Processing
- Corn Silage
- Grass Silage
- Raw Sludge
- Brewer’s Grain
- Green Waste
- Sugar Beet Silage
- Vinasse
- Beets
- Fooder Beet
- Whey
- Poultry
- Swine Manure
- Cattle Manure

Methane Yield, cf/lbs

Raw WWTP Solids
Step 5: Develop the Solution

- Existing Situation
- Future “Vision”
- Gap Analysis
- Alternatives Analysis
- Solution

Gap Analysis
Step 5: Develop the Solution (continued)

- San Jose/Santa Clara WPCP phased implementation plan:
  - Continue with digestion and purchasing landfill gas
  - Install a 1.4 MW fuel cell
  - Perform digester improvements in two phases
  - Phased transition to higher-efficiency turbines
  - Develop a FOG (and food?) import program
  - Consider 1 to 7 MW solar power facilities
San Jose/Santa Clara WPCP “future power generating portfolio”

2040:
Externally-generated Power = 10%
Self-generated Power = 90%

- Landfill Gas
- Digester Gas
- Purchased Power
- FOG and Food
- Cogen Improv.
- Digester Improvements
- Fuel Cell

Power, MW

2010 2015 2025 2040
Step 5: Develop the Solution (continued)

• CCCSD current energy portfolio:
  – Natural gas turbine
  – Multiple-hearth furnaces using landfill gas as supplemental fuel
  – Purchased electric power (shortfall)

• GHG limitations:
  – Landfill gas no longer available
  – 25,000 MT/year emissions cap

• CCCSD future energy portfolio:
  – Replace gas turbine
  – Two alternatives (replace MHFs with fluidized-bed incinerators, or digestion with thermal pretreatment)
CCCSD Greenhouse Gas (GHG) Analysis
Summary

• There are both internal and external drivers creating the new “energy reality”

• We have presented a 5-step “Integrated Energy Plan™”

• Conventional and new elements of our 5-step plan:
  – Conventional => Energy balance and gap analysis
  – New => Concept of “power generating portfolio”
Questions?

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WASAC® Process Advantages

**Secondary Treatment Quality**
- Same effluent quality as conventional secondary
- Process configurations for nitrification/denitrification

**Reduces Capital Costs**
- Reduces basin volume up to 45%
- Reduces blower needs up to 45%
- Investment Pay-Back in under 20 years

**Reduces O&M costs**
- Reduces aeration electrical use up to 45%
- Reduces maintenance of blowers and aeration system

**Increases Energy Production**
- Doubles the methane production from WAS
- Results in reduction of purchased power up to 90%
- Potential for energy self-sufficient treatment

**Small Carbon Foot Print**
- Less energy required from the ‘grid’
- Less ‘carbon foot-print’ in construction
- Less release of GHG
Conventional Activated Sludge Process
...with Anaerobic Selector for Phosphorus Accumulating Organisms (PAO)
Waste Activated Sludge Anaerobic Contactor (WASAC®) Configuration
WASAC® Configured for Nitrification/Denitrification
Fuel Cells – The Efficient, Sustainable Choice for Digester Gas Utilization

- Highest efficiency available for power generation equipment
  - Electrical efficiency 47%
  - Constant over 40-100% load

- Nearly 2x the reduction in plant carbon footprint over other cogeneration technologies

- Exempt from most, but not all, air permitting requirements. Some agencies have required permits; even though fuel cells easily comply.

- Approximately 1/3 the overall WWTP emissions of criteria pollutants:
  - NOx, CO, VOC, PM
  - Order of magnitude reduction
Technology – Fuel Cell Energy

- **General Features**
  - Uses commonly available materials
  - No noble metal catalyst
  - High temperature byproduct heat

- **Internal Reforming**
  - \( \text{H}_2 \) generated internally
  - High efficiency
  - Simple system
  - Negligible \( \text{NO}_x \) and \( \text{CO} \)

- **Atmospheric Pressure Operation**
  - Allows unattended operation
  - Highly reliable