Municipal Water/Wastewater Breakout Session
1:30 – 3:00 p.m.

Ted Jones
Program Manager, CEE
January 18, 2007

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Today's Session

Opportunities for programs to achieve energy savings in wastewater aeration systems

- Introduction to CEE Water and Wastewater Initiative
- A Look at Aeration Systems as an Energy Savings Opportunity
  - Operations and Management Perspective
  - Equipment Efficiency Perspective
- Discussion of Program Approaches and Experience
- Update on EPA Water and Wastewater Focus

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Session Objectives

- Questions/Comments from yesterday's presentation from SCE/UCLA on the opportunity to capture energy savings in wastewater treatment plants through improved oxygen transfer efficiency in wastewater aeration.
- Identify other opportunities that programs could promote to improve wastewater aeration efficiency.
- Identify the implications to program design when targeting process-related energy savings. How do you do that?
- Identify next steps.

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CEE's Interest in the Municipal Water and Wastewater Sector

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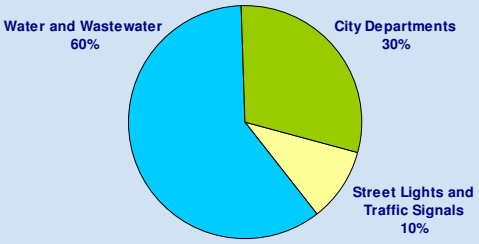
Energy Savings in Water and Wastewater Treatment

National Opportunity

- 60,000 community drinking water systems and 15,000 wastewater systems in U.S.
- Water and wastewater industries account for approximately 3 percent of total U.S. electric load

Municipal Opportunity

- Energy account for about 35% of municipal energy usage, sometimes more.
- Energy use in Austin, TX:



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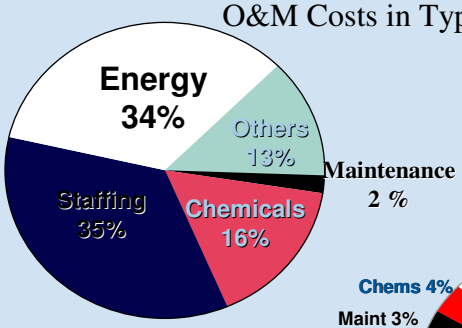
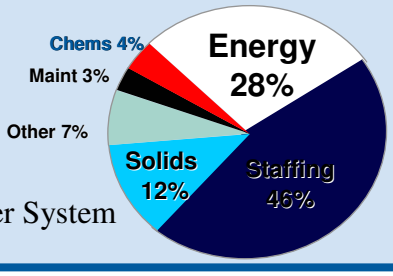
Energy is Significant O&M Cost for Most Water and Wastewater Facilities

O&M Costs in Typical Water System





O&M Costs in Typical Wastewater System

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Challenges

- Understanding the market
  - How energy is used
  - Energy saving opportunities
  - Decision-making process
- Identifying best practices for energy-efficiency
- Promoting awareness in the market
- Gaining support for enhanced energy performance from water/wastewater customers and their suppliers (services and products)

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CEE Municipal Water and Wastewater Facility Initiative - 2005

- **Objective**: increase awareness of and demand for energy efficiency within the municipal water and wastewater sector
- **Strategy**: To build a template of nationally consistent tools and messages for members to incorporate into their programs and to deliver nationally

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Water/Wastewater Facility Initiative – Proposed Direction for 2007

- Continue to support national efforts to educate water and wastewater customers about the benefits of efficiency
  - ENERGY STAR's Water and Wastewater Focus
  - Development of an energy performance benchmark
- Continue to provide a forum for members to exchange innovative program approaches in the sector.
  - Identify best practices for programs serving municipal water and wastewater customers and serve as a clearinghouse.
- Develop program guidance on specific energy-saving opportunities will be through the development of application guidelines for key systems, such as water pumping, variable speed drives and blowers.
- Continue to foster relationships with national water-wastewater industry associations, water-related research associations, as well as product and service providers, including the pump industry.

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Water/Wastewater Facility Initiative – Direction for 2007

- Providing a forum for members to exchange innovative program approaches in the sector.
  - Identify best practices for programs serving municipal water and wastewater customers and serve as a clearinghouse.

- Developing program guidance on specific energy-saving opportunities for key systems/processes through the development of application guidelines and program templates, where appropriate.

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Municipal Wastewater Treatment

- 15,000 plants processing on the order of 28 billion gallons per day (mgd)
- Activated Sludge is the most common treatment type, especially for plants larger than 1 mgd, representing some 90 percent of treatment capacity in the U.S.
- Aeration consumes 40%-70% of the energy used in activated sludge.

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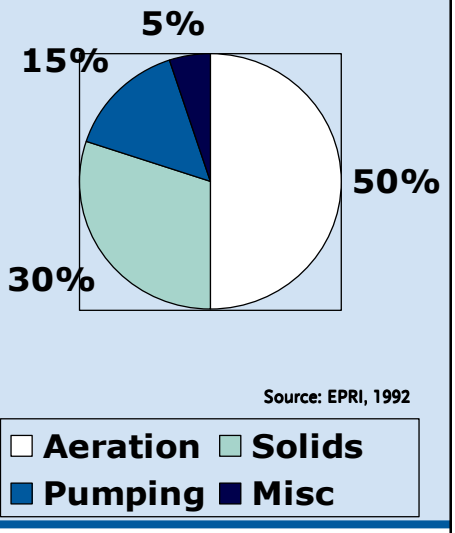
Wastewater Treatment

- Wastewater aeration, pumping and solids processing account for most of the electric energy used in wastewater treatment.
- Most common form of biological treatment used in wastewater treatment is activated sludge
- Activated sludge requires aeration to supply oxygen.



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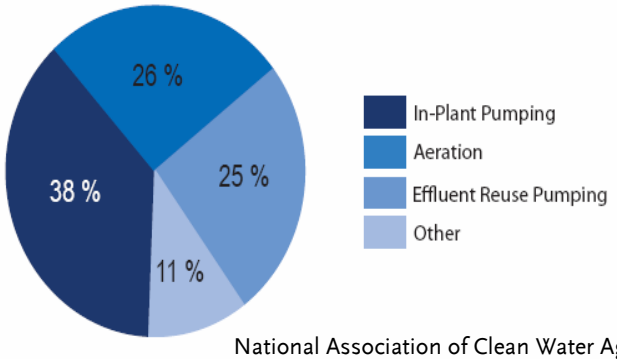
NACWA Survey Highlights
Plant Energy Use in 2004 (Process)

Figure E-3-3 Percent Breakdown of 2.1 billion kWh Plant Energy Use (47 Respondents)



National Association of Clean Water Agencies, 2005

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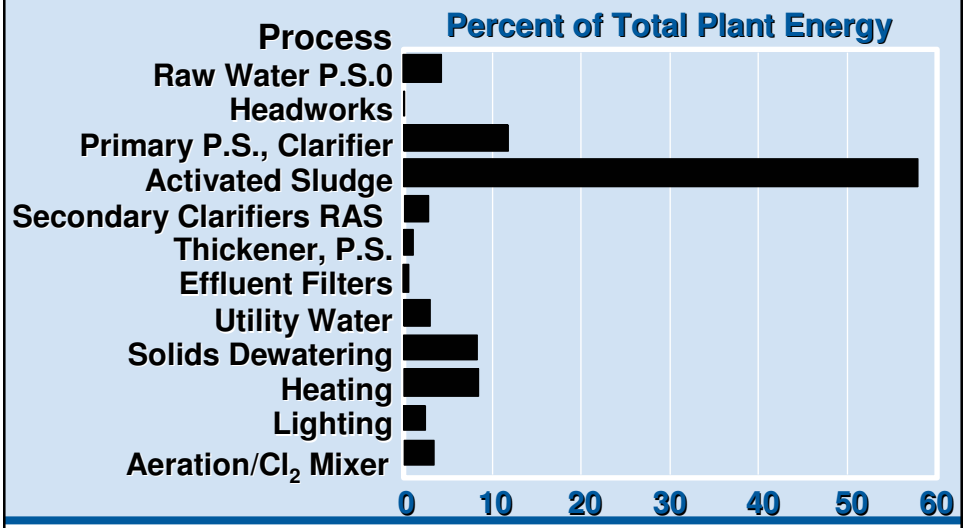
Relative Distribution of Plant Power
7.5 mgd WWTP



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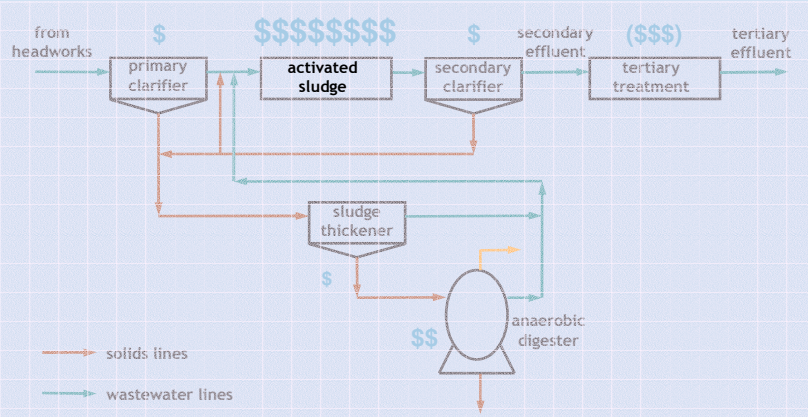
WHERE IS THIS ENERGY SPENT?



Aeration cost = 45 – 75% of plant energy cost

Rosso and Stenstrom (2005) *Wat. Res.* 39: 3773-3780

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What is Aeration??

- *Aeration introduces air into liquid, providing an aerobic environment for microbial degradation of organic matter. The purpose of aeration is two-fold:*
  - *to supply the required oxygen to the metabolizing microorganisms*
  - *provide mixing so that the microorganisms come into contact with the dissolved and suspended organic matter.*
- *Aeration is the process by which the area of contact between water and air is increased, either by natural or mechanical means, resulting in air being suspended in water.*

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Major Types of Aeration

- **Subsurface** – air is introduced by diffusers or other devices submerged in the wastewater (e.g., coarse bubble, fine bubble, others)
- **Mechanical** – system agitates the wastewater by various means to "mix" and to introduce air from the atmosphere (e,g., propellers, blades or brushes)

Potential Energy Savings Wastewater Facilities

- 10-20 % energy savings thru process optimization (e.g. lower D.O.)
- 10-20 % energy savings thru equipment modifications

Estimates based on 200 audits (audit process developed by EPRI and HDR Engineering)

Technologies to Improve Energy Efficiency

Savings over Conventional Technology

Technology	kWh/MG	kWh/ 1,000 m^3
Fine pore diffusers	140	37
Ultra-fine pore diffusers	210	55
DO control systems	50 to 100	13 to 26
Blower control systems	50 to 150	13 to 40
Energy efficient blowers	100 to 150	26 to 40
SCADA Systems	0 to 150	0 to 40
ASD's, efficient pumps/motors	10 to 100	3 to 26

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References

- Burton, Franklin and Electric Power Research Institute. *Water and Wastewater Industries: Characteristics and Energy Management Opportunities.* St Louis, Missouri: EPRI, 1996.
- EPRI. *Quality Energy Efficiency Retrofits for Wastewater Systems.* Palo Alto, California: EPRI, 1998.
- Water Environment Federation. Energy Conservation Task Force. Energy Conservation in Wastewater Treatment Facilities: A Manual of Practice, Chapter 8 WEF, 1997.
- EPA Fact Sheets: http://www.epa.gov/owm/mtb/mtbfact.htm
  - Wastewater Management Fact Sheet
  - Fine Bubble Aeration
- *Surface Aeration Revisited*, Philadelphia Mixing Solutions, www.philamixers.com
- National Association of Clean Water Agencies, 2004 Financial Survey Results. NACWA. 2005.

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Program Implications

- How might programs achieve energy savings by promoting monitoring and managing oxygen transfer efficiency?

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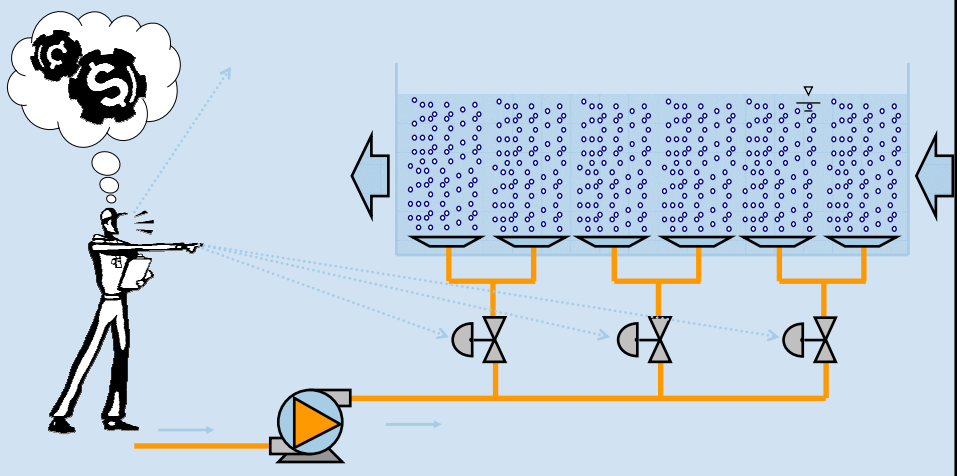
Managing Aeration Energy Consumption



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CONCLUSIONS from SCE Presentation

- **Aeration costs have the highest impact on plant operating economics and energy consumption**
- **Transfer efficiency monitoring is essential for minimizing energy expenditure**
- **Real-time off-gas analyses can obtain time-varying information previously not obtainable**
- **The new instrument will make off-gas testing available as a routine procedure**

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Terminology

OTE: Oxygen Transfer Efficiency (%)

OTR: Oxygen Transfer Rate (mass/unit time)

SOTE: Standardized OTE in clean water

αSOTE: Standardized OTE in process water

MCRT: Mean Cell Retention Time

α = αSOTE/SOTE (water quality estimate)

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Improved Aeration Management Metrics

- **Oxygen Transfer Efficiency (OTE**)- fraction of oxygen in the bubbles supplied that dissolves in the mixed liquor. Depends on:
  - conditions of aeration
  - equipment
- Standard test procedure exist to test and compare efficiencies of various types of aeration equipment using clean deoxygenated water under standard conditions of 20° C and one atmospheric pressure.
  - **Standard OTE** – operating aeration equipment under standard test conditions.
  - **Standard Aeration Efficiency (SAE)** - Standard OTE divided by the energy used per unit of weight of oxygen delivered.
  - **Alpha Factor** - Ratio of normalized field OTE to standard OTE reflecting the effects of contaminants.

Traditional Program Approaches

	Non-Residential Sector		
Custom Projects			
Third-Party			
New Construction			
Retrofit			

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Current Program Trend

	Water & Waste-water	Oil & Gas	Winery	……
Project				
Custom Projects Third-Party New Construction Retrofit : :				

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Program Implications

- How do aeration efficiency measures fit within this model?

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Current Program Approaches to Aeration Efficiency

- Southern California Edison
  - Improved Monitoring Technology (management approach)
- Tennessee Valley Authority
  - Improved Metering Technology (management approach)
- Pacific Gas & Electric
  - Savings by Design - Energy Baseline Study for Municipal Wastewater Treatment Plants
  - Guidance on energy-efficiency measures to look for and evaluate
- NYSERDA
  - R&D, Technical Assistance, Project Assistance

PG&E Program Offerings for Wastewater Treatment Plants

- Integrated Energy Audits
- Non-Residential New Construction Design Assistance
- Non-Residential Retrofits
- Emerging Technologies
- Promotional Materials, Education and Training
- Focusing specific technologies that support common water and wastewater treatment processes.
  - Conducted technology baseline study

PG&E Savings By Design New Construction Program Wastewater Baseline Study Results

	Base Case	Energy Efficiency Measure
Aerators (Blowers)	Course Bubble Diffuser	Fine Pore Diffuser
	Inlet/Discharge Vane or No Control	Variable Frequency Drive (VFD) Control
	Multi-stage centrifugal blowers	Single-stage Centrifugal Blower with VFD Control
	Fan System Assessment Tool (FSAT) Achievable Efficiency or Average Efficiency from Manufacturers' Data	High Efficiency Blower with Efficiency Better than Achievable/Average Efficiency
Aerators (Mech.)	Constant Speed Motor	VFD Control Based on O2 Content
Dissolved Oxygen System	Manual Control	Automatic Control

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Discussion Questions

- What kind of guidance could/should CEE offer to programs in this area?
- What should program designers/administrators know (keep in mind) when it comes to aeration systems efficiency? What should they look for?
- What have programs learned through past experience that could be captured?
- What barriers currently exist that programs could address by working together nationally?
- What aspects of aeration efficiency are universal and which are site-specific?

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