

**POLLUTION PREVENTION THROUGH ENERGY EFFICIENCY  
AT A PUBLIC WASTEWATER/STORMWATER UTILITY**

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**ABSTRACT**

Louisville & Jefferson County (KY) Metropolitan Sewer District (MSD) is a nonprofit wastewater and stormwater management utility. MSD's energy management program realizes the usual benefits of pollution prevention (P2) programs: reduced environmental pollution, lowered operating costs and improved staff comfort/productivity. Energy efficiency (E2) has allowed MSD to treat significantly larger volumes of wastewater, from a growing customer base, to higher standards, yet stabilize energy costs.

Upgrading the lighting at 850,000 ft<sup>2</sup> of facility space earned MSD the 1998 EPA Green Lights Partner of the Year Award for the public sector. MSD's Main Office, renovated in 1994, was one of 24 buildings in the US to be designated by the EPA as an Energy Star Showcase Building; that building now requires about \$1/ft<sup>2</sup>/yr. Other projects addressed fuel conversions (at treatment plants, garages and shop facilities), shifts to time-of-day rates, more efficient electric motor purchases and alternative fuel vehicles.

These efforts have saved a total \$3+ million ratepayer dollars! The rate of savings is currently \$600,000+ annually, and grows each year as new projects are completed. The reduced energy use and fuel switching has reduced atmospheric emissions of CO<sub>2</sub>, SO<sub>x</sub> and NO<sub>x</sub>. Employees regularly volunteer testimonials of improved comfort. Because electricity in Kentucky is inexpensive (MSD generally pays \$0.035-\$0.055 per kWh, including demand charges), project payback periods average just over three years.

Programmatic emphasis has shifted to focus on process energy – motors, blowers, pumps and compressors – and reducing tailpipe emissions through alternative vehicle fuels, an employee commute options (ECO) program and a policy to limit engine idling.

Whether utility managers are concerned about fiscal conservancy, pollution prevention or both, attention to E2 is a win-win opportunity that warrants their attention.

**KEYWORDS:** energy management, pollution prevention, cost control, process energy

## INTRODUCTION

Energy – its costs, its environmental impact and even availability – are again making the headlines in the mainstream media. The rolling blackouts in California threaten the economic highs of the 1990s. The energy industry will probably continue to be deregulated, albeit at a more cautious pace, but deregulation's terms and its impact on the wastewater industry and the environment are uncertain. Perhaps more than ever, wastewater utilities are looking for ways to reduce energy use.

Louisville & Jefferson County (KY) Metropolitan Sewer District (MSD) is a public, non-profit wastewater and stormwater management utility, serving about 700,000 residents.

In 1990, MSD adopted the CERES Principles<sup>1</sup>, a commitment to progressively better environmental stewardship, including improved energy efficiency (E2). This principle was particularly apropos to MSD. Energy costs represent 20-25% of MSD's operating budget, (but can consume 30-40% of small POTW budgets)<sup>2</sup>. The wastewater industry represents about 1% of the nation's electricity consumption<sup>3</sup>. Global climate change causes not just warmer temperatures, but also more severe weather patterns of all types, including more severe storms, thereby posing special concerns to a stormwater utility.

Coincidental to MSD's adoption of the CERES Principles, the USEPA began its voluntary pollution prevention (P2) programs<sup>4</sup>.

Participants in the Green Lights program agree to survey 90% of their floor space and exterior lighting for lighting efficiency opportunities and to actually do 90% of those relamping jobs, within 7 years of enrolling in the program.

Green Lights was so successful that EPA began to view lighting as an appropriate first step in a sequence of E2 improvements that could reduce capital and operating costs, i.e., reduced lighting wattage allows smaller cooling capacities, and incorporated Green Lights into the Energy Star Building program.

Participants in the Energy Star Building program agree to take the following steps:

- Measure, track and benchmark their organization's energy performance
- Develop and implement a sequential plan to improve facility E2 (lighting, window and roof improvements, HVAC tune-ups, HVAC plant and distribution upgrades)
- Educate their staff and the public about Energy Star, and highlight their achievements with the Energy Star label, where available.

The now joint USEPA/DOE Energy Star programs support participants with strategies, products, resources and special tools.

This paper will discuss MSD's efforts to reduce process, non-process and transportation energy use and the related costs savings and pollution-prevention benefits.

## METHODOLOGY

### Getting Started

When the program was initiated in 1992, MSD operated numerous and diverse facilities: 4 large publicly-owned treatment works (POTWs), 60 small “package” wastewater treatment plants, around 200 wastewater and 15 flood pumping stations, offices, workshops, warehouses and garages. Two more POTWs have since been brought on-line, allowing for the elimination of about half of those package plants.

The task demanded a thoughtful strategy. MSD’s Executive Director, Gordon Garner, thought it best to begin with manageable bites that would demonstrate success and develop employee buy-in. EPA’s Green Lights program fit the bill perfectly.

The first step of the Green Lights process is to conduct an energy audit. The Louisville Resource Conservation Council (LRCC), a 501(c)3 group dedicated to assisting local non-profit organizations to reduce energy and water use, was hired to review MSD’s utility bills and to conduct site audits of most MSD facilities. Using that information, LRCC generated a menu of E2 projects – and discovered rate optimization opportunities totaling \$120,000/year! The windfall savings were reinvested into the program. LRCC also discovered a few natural gas leaks along the way!

Decisions on which upgrades to do first were based on where they would expose large numbers of staff to the program or coincide with other planned improvement projects.

### Lighting

Upon meeting our Green Lights commitment in 1997, MSD had upgraded the lighting at 850,000 ft<sup>2</sup> of facility space.

In office areas, relamping projects were designed to reduce energy demand and to address the shift to extensive use of personal computers that came after the buildings were originally built, i.e., to reduce monitor glare. Ambient light at work surfaces was reduced to 30 ft-candles/ft<sup>2</sup>, by reducing the number of fixtures and/or the number of lamps in each fixture. This reduced ambient light is augmented with task lights, which allow users to aim the light onto working materials and away from monitors.

Retained ceiling troughs were fitted with the newer T-8 fluorescent lamps<sup>5</sup> that demand only 60% of the electricity used by the older T-12 lamps, while emitting comparable lumens. T-8 lamps typically use a mixture of phosphors, which provide color rendition much closer to the sun’s spectrum. Fixtures were also retrofitted with electronic ballasts that eliminate the unpleasant flicker and hum often associated with fluorescent lighting.

As MSD removed older fluorescent lamps, the glass, aluminum end-caps and mercury were recycled. From the old ballasts, the potting material was incinerated; the steel and copper were recycled.

Compact fluorescent lamps were retrofitted into recessed lighting fixtures. Exit lights were either retrofitted or replaced with new LED models, that are expected to function a minimum of 35 years without maintenance, while reducing utility bills 24/7.

Well before the Green Lights program commitment was met, MSD began expanding into a wider range of other E2 projects.

## **Buildings**

MSD's 77K- ft<sup>2</sup> Main Office, renovated in 1994, was one of 24 buildings (and the only wastewater industry building) enrolled in the EPA Energy Star Showcase Building program. Participation in that exemplary program requires the building's energy demand to be cut by at least 50%.

MSD invested \$396K into relamping, installing occupancy sensors to control ambient lighting and upgrading the heating, ventilation and air conditioning (HVAC) systems.

Two types of occupancy sensors were used. Wall-mounted passive infrared (PIR) sensors control lights in conference rooms; an override switch allows a conference room to be darkened, e.g., for viewing a training video. Ceiling-mounted sensors combine PIR and ultrasonic technology and "see" around office partitions and toilet stalls; they can be adjusted to control how much movement is required to activate the lights, and how long they stay on after activated.

Computer software was installed to manage the HVAC equipment. Along with variable speed drives (VSDs), MSD saves significant power in the spring and fall.

Replacement toilets and urinals were low-flush designs – even if MSD doesn't pay itself wastewater treatment fees! Electrical-eye-activated faucets were installed in the toilet rooms to reduce disease transmission; in practice, they also reduce water consumption. The building uses one-third less water, despite one-third more employees. Less hot water used means less energy is used.

The cost savings are expected to be about \$42,000 per year, yielding a pay-back period of under 10 years. While such a payback could be a hard sell in the private sector, MSD's standard is whether life-cycle benefits are meaningfully greater than life-cycle costs.

MSD disarmed the lights, including disconnecting the ballasts, in the soft-drink vending machines. These custom T-12 lamps not only demand power, but also place extra load on the refrigeration compressors. This simple act saves \$97/yr/machine!

MSD specifies Energy Star compliant PCs, printers and copiers. These machines can take naps and go to sleep, if so enabled, after predetermined times of inactivity. Most PCs meet the Energy Star specifications nowadays. The issue is that most PCs are shipped with the energy management software turned off. Any utility can save energy by merely rewriting their PC purchasing specifications and activating the software.

To address the Y2K bug, MSD replaced a large mainframe computer with more efficient client/server architecture, and reduced the total building electrical demand by about 20%!

Though it is an all-electric building, it now costs only about \$1/ft<sup>2</sup>/yr, to light, heat, cool, provide hot water, power computers, etc.

### **Garages, Shops and Warehouses**

Besides the above measures, most garage and shop facilities have also been converted from electric-resistance to natural gas Co-Ray-Vac infrared space heating. This heat naturally goes to thermal mass, i.e., concrete floors and people. This use of significantly cleaner and more comfortable natural gas saves MSD about \$20K/building/yr.

### **Treatment Plants**

The addition of bioroughing towers to the largest POTW, Morris Forman Wastewater Treatment Plant, a 105-MGD UNOX facility, allowed for the reduction in energy-intensive O<sub>2</sub> production, while increasing biological treatment capacity.

Two of MSD's POTWs were built when natural gas wasn't available. In the 1990s, however, MSD was able to have the distribution lines extended to serve these facilities. That natural gas, and the new high-efficiency equipment to burn it, replaced older, less efficient and more polluting equipment that operated on electricity or propane. Because they are so much cleaner, natural-gas-fired boilers require much less O&M than propane-fired boilers. (Living next to a POTW does not usually provide many benefits to nearby residents. Because of the volume of gas sales to MSD, however, the local gas utility provided gas service to both facilities' neighbors and waived the extension fees.)

MSD's last two POTWs included tertiary filters. The buildings that house them are heated with Co-Ray-Vac systems, because it is so effective and efficient at preventing freezing of the water and filter media in winter.

The specifications for the influent pumps at the most recently constructed POTW received unprecedented scrutiny to ensure the selection of most efficient combinations of smaller and larger, constant- and variable-speed pumps, to optimize handling initial and eventual, dry- and wet-weather flows.

That plant's administration/classroom building uses geothermal exchange for heating and cooling. Using closed loops of one-inch (high-density polyethylene) plastic pipe, several 300-ft deep wells and a heat exchanger, geothermal exchange provides high-efficiency HVAC, at low operation and maintenance (O&M) costs.

Outdoor lighting has been upgraded from mercury-vapor to more-efficient alternatives, high pressure sodium or metal halide, depending on whether staff will need to read or do detail work under it after dark.

Taking advantage of time-of-day (TOD) rates, weekly biosolids pumping from one POTW to another has been shifted to off-peak hours, saving about \$16K/yr. This effort could theoretically also reduce emissions, because TOD rates reduce demand peaks, which are sometimes met with the oldest and most polluting power plants.

Replacement electric motor purchases are evaluated for E2 ratings, using USDOE's MotorMaster<sup>6</sup> software, though performance and reliability remain the primary selection criteria. New electric motor specifications require "premium efficiency" rating, unless unavailable or documented by the designer as inappropriate in that specific application.

### **Regional Planning**

MSD's long-term program for acquiring and eliminating (often old and limping) package treatment plants and pump stations, typically situated on smaller streams in residential areas, through the extension of comprehensive trunk sewers and the diversion of flow to POTWs, has the following benefits:

- Public health risk reductions by eliminating package plant outfalls – and all the septic systems along the route
- Economy-of-scale reductions in process energy demand
- Less O&M staff travel from small facility to small facility
- Reduced biosolids hauling, from remote plants to the solids processing facility

### **Vehicle Fuel Use**

As MSD cross-trains and reorganizes staff to increase productively, more vehicles are needed. Local air quality may soon reach attainment for ozone, for the first time. When the new Clean Air Act standards for ozone and PM<sub>2.5</sub> come into effect, however, our air will be reclassified as being in nonattainment. Federal sanctions are a realistic threat. Meanwhile, transportation is North America's fastest growing contributor of greenhouse gases. MSD is therefore taking steps to reduce transportation energy use.

Compressed natural gas (CNG) significantly reduces tailpipe emissions, and fleet maintenance costs. MSD installed its own CNG fueling station. MSD's CNG fleet, now 10% of the total, includes passenger cars, 1-T utility trucks, dump trucks and step vans. More CNG vehicles will be added to the fleet as manufacturers make them available.

Employees working at MSD's Main Office, which is well-served by public transportation, must participate in an employee commute options (ECO) program. Free parking was replaced with the following three options:

- Drive in a single-occupied vehicle and pay \$10/month to park
- Carpool with an MSD coworker and use free, designated parking
- Ride public transportation and receive Commuter Checks to cover the full cost

To make the above policy work, bus riders and carpoolers are reimbursed up to \$24/month in garage fees, to allow for medical appointments, parent-teacher meetings, etc. An “emergency ride home” policy ensures that they may use an MSD pool car or hire a taxi at MSD’s expense, should, for example, a sick child need to be unexpectedly picked up and taken home.

Showers and bike lockers were installed to support bicycling employees.

When MSD sought to consolidate its current two maintenance staging facilities, the real estate agents offered only suburban sites. Seeking to help redevelop an older, disinvested urban neighborhood, MSD is instead converting a 220K-ft<sup>2</sup> bowling alley into its Central Maintenance Facility. The 300+ employees to be based there will be served by six bus lines. MSD will offer them free Commuter Checks to encourage them to use transit.

To combat the outmoded habit of running diesel engines all day, MSD instituted a policy of limiting the idling of all engine types. Employees have a simple chart with limits on how many minutes they may warm a cold engine, based on season and fuel type.

All employees are also trained to always turn off warm engines when not needed. This policy saves fuel costs. It also reduces emissions, safety risks (if the vehicle is unattended) and negative, wasteful impressions to ratepayers.

## **RESULTS**

MSD’s energy management program realizes the benefits so frequently associated with pollution prevention (P2) programs:

- lowered operating costs,
- reduced environmental pollution
- improved staff comfort/productivity

MSD is treating significantly increasing volumes of wastewater, from a growing number of customers, and treating it to higher standards, yet stabilizing controllable energy costs.

MSD has reduced electricity consumption by over 1.5 million kWh per year, saving \$3+ million ratepayer dollars! The rate of savings is currently \$600,000+ annually and grows each year as new projects are completed.

Project payback periods are typically just over three years, including the extensive recycling of the various components of the replaced lamps. Electricity in Kentucky is relatively inexpensive. MSD generally pays 3.5-5.5 cents per kWh, including demand charges. Savings and payback elsewhere in the US are usually much more attractive.

Because producing that energy requires burning coal, MSD's energy management efforts are reducing air emissions from power plant at the following rates:

- nitrogen oxides (NO<sub>x</sub>), precursors to ground-level ozone, 6 T/yr
- sulfur oxides (SO<sub>x</sub>), precursors to acid rain, 9.5 T/yr
- carbon dioxide (CO<sub>2</sub>), a greenhouse gas, 1875 T/yr

Employees regularly volunteer testimonials of improved comfort. Employees who voiced doubt about the reduced ambient light prior to its installation, later volunteered that their fears were misplaced and note the reduced eye strain. Mechanics enthusiastically tout Co-Ray-Vac heating. They went from being uncomfortable the rest of a winter workday after opening tall garage doors to move equipment in and out to being completely comfortable within no more than 20-30 minutes.

MSD regretfully failed to realize the value of measuring productivity before and after these E2 projects, but presumes that more comfortable employees make more productive employees.

Managers everywhere tell their employees to work "cleaner, cheaper and smarter." MSD's experience says that employees who see management investing in E2 take that mantra more seriously and respond by increasingly speaking up with their own E2 ideas.

MSD received the 1998 EPA Green Lights Partner of the Year Award for the public sector, an honor that instills pride in employees and precipitates more E2 suggestions.

### **Lessons Learned**

MSD can offer the following experience-based advice to anyone interested in implementing E2 projects:

1. Get upper management support. When the natural human resistance to change rears its ugly head, you'll need the backing of the boss.
2. Take advantage of the free, non-commercial assistance provided by the EPA/DOE voluntary P2 programs, Energy Star and Motor Challenge.
3. Don't overlook the little things, as they, too, add up and pay off indefinitely.
4. Don't let design consultants, contractors or suppliers talk you out of E2. Providing standard designs and products is easier and less risky for them. After they have the job, some will try to revert to what is familiar -- despite their earlier sales promises.
5. Involve all employees, if you hope to hear their creative E2 ideas. Educate them on the program goals and benefits. The CERES Principles require regular auditing and reporting. The work involved in collecting and organizing all that detailed data pays big dividends in improved awareness and support. Continuously analyze your E2 program as a whole, benchmarking against yourself, and share the results widely.

## DISCUSSION

Still, after all of the above efforts, MSD must normalize its energy use to show the downward trend in energy consumed per million gallons pumped and treated, due to the following uncontrollable factors:

- When the elevation of the Ohio River rises to 400 ft, the largest POTW (105 MGD design capacity) must pump its discharge over a floodwall. Every day of “flood pumping” costs 30,000 kWh or \$1650; the average year has 74 such days.
- A significant portion (23% of the sewers, but 60% of the customers) of MSD’s service area is served by combined sewers. Because that portion is also less pervious, heavy rains demand large increases in power to manage the additional wet-weather flow. Even in separate-sewer portions of the service area, the intensity of rain events in context with concurrent soil saturation determines the amount of infiltration that MSD must manage. Very severe storms can cost hundreds of thousands of dollars in energy.

### The Next Frontiers

The wastewater industry is energy intensive, but lights and HVAC aren’t what spin our electric and gas meters so feverishly. It’s process energy – motors, blowers, pumps and compressors – that consumes approximately 20 billion kWh annually at US wastewater facilities. So, MSD has placed top priority on reducing our demand for process energy.

Current construction projects underway at the largest (105 MGD) POTW, will have significant impacts on its energy consumption.

Rehabilitation of the high purity oxygen (HPO) generation system is expected to save about \$90,000/yr, through higher efficiency equipment. Reduced oxygen leakage from the reactors and improved dissolved oxygen (DO) control will further drop energy use for oxygen generation.

The Alternative Solids Project will replace the existing Zimpro system with anaerobic digestion and yield a biosolids product suitable for land application. Biogas produced on-site will offset a significant portion of the energy required to produce a biosolids product dry enough to market.

After those two projects are complete, additional energy savings should be realized by optimizing the biotower recycle strategy to achieve the most cost-effective treatment.

At the next largest (23.5 MGD) POTW, West County Wastewater Treatment Plant, aeration demands the most energy use. Historically, it was run on two large blowers 24/7. After refurbishing a blower, operators now cut back to one blower at night, and yet recover sufficient DO levels by 7AM-8AM with a second blower.

Automatic, DO-based blower controls will be in place there later this year. Next year, it will also be retrofitted with fine-bubble diffusers. Together, those modifications will enable the plant to operate on one blower continuously.

Biosolids from West County are pumped to Morris Forman on a weekly basis. That process currently requires 10-12 hrs of pumping, followed by 10-12 hrs of flushing with raw sewage. A recent analysis showed that flushing for about 5 hrs should suffice.

MSD recognizes that some opportunities for improved energy management will come only with improved people management; the following not always obvious, double-edged sword reality must be addressed:

POTW operators have been acculturated to do whatever it takes to meet discharge permit conditions. That's a good thing, not without value. That compliance priority has, however, made routine operation with wide margins the norm. Excessive and expensive aeration, for example, is one such common practice.

Until operators can see for themselves that they can move out of their comfort zones and meet permit, they will avoid going there. A project now under development will provide MSD's POTW managers – the people closest to the process – with real-time reports on exactly how much electricity, natural gas and water their facilities are using, via process-control computers. They will connect operational decisions to the related energy demand and costs, and make adjustments on the spot.

## **CONCLUSIONS**

The current energy crisis will not go away soon, yet ratepayers will not be hospitable to wastewater utility managers that merely pass-through cost increases to them. There are fiscal and pollution prevention benefits for taking advantage of win-win E2 opportunities. The wastewater industry can – and should – lead the way, serving as community models.

## **ACKNOWLEDGEMENTS**

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## **REFERENCES**

1. The CERES Principles, originally called the Valdez Principles, were developed by the Coalition for Environmentally Responsible Economies, shortly after the 1989 oil spill by the Exxon *Valdez*. The Principles call for voluntary superior environmental performance in the following 10 areas: protection of the biosphere, sustainable use of natural resources, reduction and disposal of wastes, energy conservation, risk

reduction, safe products and services, environmental restoration, informing the public, management commitment and auditing/reporting. See [www.ceres.org](http://www.ceres.org) .

2. Water Environment Federation, Energy Conservation in Wastewater Treatment Facilities, WEF Manual of Practice No. FD-2, Alexandria, VA, 1997.
3. USEPA, Electrical Power Consumption for Municipal Wastewater Treatment, 1973, EPA-R2/73-281, Washington, DC.
4. For more information on the USEPA's Energy Star programs, call 1-888-STAR-YES (1-888-782-7937) or visit [www.energystar.gov](http://www.energystar.gov).
5. T-8 fluorescent lamps look like traditional T-12 lamps, only narrower. T-8 lamps are 8/8<sup>ths</sup>, or one-inch, in diameter; T-12 lamps are 12/8<sup>ths</sup>, or 1.5 inches, in diameter.
6. MotorMaster+ 3.0 software is an energy-efficient motor selection and management tool that includes a catalog of over 20,000 AC motors. Version 3.0 features motor inventory management tools, maintenance log tracking, efficiency analysis, savings evaluation, energy accounting and environmental reporting capabilities.