Benchmarking Wastewater Facility Energy Performance Using ENERGY STAR® Portfolio Manager

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ABSTRACT

The rising cost of energy has led a growing number of wastewater treatment facility managers to consider ways to lower their energy consumption. Assessing progress in reducing energy consumption over time requires understanding current consumption levels and developing a system to measure and manage energy consumption. In October 2007, EPA added municipal wastewater facilities to the ENERGY STAR® program's online energy management tool, *Portfolio Manager*. This paper will describe how the ENERGY STAR performance benchmarking capability for wastewater facilities works, including data inputs, features and outputs. The goal is to highlight the subtleties of using Portfolio Manager and possible implications of the benchmarking results.

KEYWORDS: ENERGY STAR, Portfolio Manager, wastewater, benchmarking, energy, energy-efficiency, Consortium for Energy Efficiency (CEE), EPA Region 1, Massachusetts Department of Environmental Protection (MassDEP).

INTRODUCTION

Energy represents a substantial and rising cost to water and wastewater utilities. On average, wastewater treatment facilities spend seven percent of their operating budgets on energy (AwwaRF, 2003). In some cases, energy costs can be as much as 55% of a facility's operating budget (Dimitriou, 2007). The Electric Power Research Institute (EPRI) estimated total electricity consumption at publicly-owned treatment works (POTWs) in the United States to be approximately 21 billion kilowatt-hours (kWh) in 2000, or about 1,800 kWh per million gallons of water treated (EPRI, 2000). This energy intensity reflects an average across the various treatment types and facility sizes, and does not account for onsite electricity generation from biogas.

Given the substantial energy requirements, a standardized approach to tracking energy use in this sector could have several benefits. These include identifying opportunities for energy savings, providing a baseline for measuring improvement in performance, allowing the trending of energy performance over time, and uncovering best practices for superior energy performance. The ENERGY STAR benchmarking tool for wastewater facilities opens the door to these opportunities as well as leveraging the ENERGY STAR platform to raise awareness of energy management.

Energy Use in Wastewater Treatment
Typically, the majority of energy is consumed in the secondary treatment process. Seventy-five percent of the facilities in the US with flows exceeding 2 million gallons per day (MGD) utilize activated biosolids for secondary treatment (AwwaRF, 2007). Figure 1 below shows the typical distribution of energy consumption at an activated biosolids facility. Regardless of facility size, this distribution tends to remain relatively consistent.

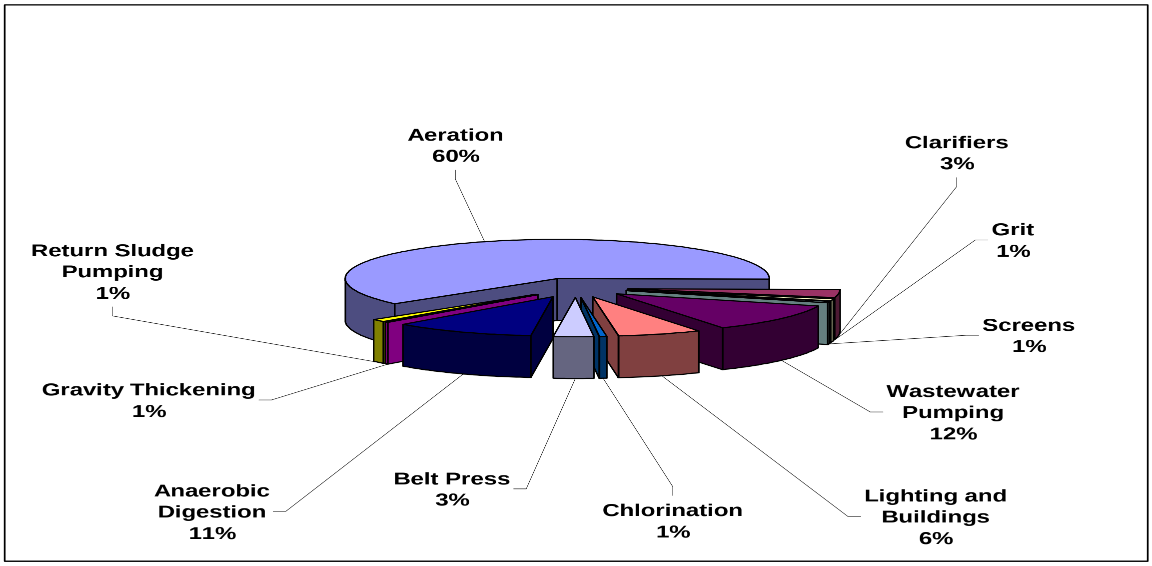

Figure 1: Electricity Requirement for Typical Activated Biosolids Facility (WEF, 1997)

At facilities that include activated biosolids treatment, aeration typically accounts for the largest share of energy consumption with pumping also accounting for a substantial portion (Burton, 1996). The secondary treatment process and pump systems are often the first systems evaluated when trying to identify where system energy efficiency improvements can be made.

Energy issues are only one of the many competing priorities that must be managed by facility operators. Facility operators focus primarily on ensuring that facilities meet effluent quality requirements and keeping operating costs in line with expectations. Capital improvements are typically driven by the need to increase capacity and comply with permit requirements. Energy costs, though, are becoming a top priority. A recent industry survey of utility directors rated energy cost as one of their top five concerns (Dimitriou, 2007).

Rising energy consumption in the water and wastewater sector has caught the attention of federal and state regulatory agencies as well as the electric and gas utilities (and their regulators) that deliver energy to these facilities. This paper will outline results from the efforts of three entities: EPA Region 1, Massachusetts Department of Environmental Protection, and the Consortium for Energy Efficiency. Each of these organizations is testing the ENERGY STAR benchmarking as a tool to assess the opportunity for energy savings in this sector and as an avenue to reach out to facility managers.

EPA Region 1

EPA Region 1 serves Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, and the 10 federally recognized Tribal Nations in New England. EPA Region 1 has dedicated resources to reducing the environmental impacts of energy use. In New England, energy production is the leading source of air pollutants like sulfur dioxide, nitrogen oxide, and carbon dioxide, all of which pose significant hazards to human and environmental health. Wastewater treatment facilities are some of the largest energy consumers in most municipalities, placing a demand both on the environment and local budgets. With energy prices in New England among the highest in the nation, addressing energy use at wastewater treatment plants is an ideal way to help both the environment and local budgets.

The Region has been evaluating and testing the ENERGY STAR benchmarking tool at facilities in New England since before its official release in October, 2007. To date, EPA Region 1 has benchmarked 42 wastewater facilities in New England, and more than 100 wastewater facilities across the nation have been benchmarked using Portfolio Manager. The region organized and supported wastewater benchmarking trainings in Rhode Island, Maine, and New Hampshire which guide local operators through using ENERGY STAR Portfolio Manager, the online system which houses the wastewater benchmarking tool.

Massachusetts Department of Environmental Protection (MassDEP)

The MassDEP enforces water and air regulations and administers the state revolving loan fund (SRF) program in Massachusetts. MassDEP's State Revolving Fund program, which annually provides over $500 million in loans for drinking water and wastewater infrastructure projects, allows communities to integrate renewable energy and energy conservation into new or retrofit construction projects. Statewide, cities and towns spend approximately $150 million per year in electrical costs to treat 662 billion gallons of wastewater and drinking water. In Massachusetts, thirty-five to forty percent of a treatment plant's operating budget involves the purchase of energy to treat drinking water or wastewater (MassDEP, 2007).

Reducing the amount of energy currently consumed by Massachusetts wastewater and drinking water treatment facilities would have significant environmental benefits. To this end, in December of 2007, MassDEP launched the Massachusetts Energy Management Pilot for Water & Wastewater Facilities, a project designed to reduce the amount of energy Massachusetts municipal facilities currently use to treat wastewater and drinking water by 20%. Fourteen facilities throughout Massachusetts are participating in this pilot project (7 wastewater, 7 drinking water) which will guide them from assessment of current energy performance to implementation of energy saving and renewables projects (http://www.mass.gov/dep/public/publications/0108ener.htm). If energy use in municipal water treatment facilities in Massachusetts could be reduced by 20%, emissions attributable to energy production would be reduced by approximately 200,000 tons of carbon dioxide, 760,000 pounds of sulfur dioxide, and 250,000 pounds of nitrous oxides. As a component of this pilot, each of the seven wastewater facilities involved in the project were benchmarked using the ENERGY STAR tool for wastewater in order to obtain a baseline rating of their current performance. This baseline provides a useful starting point to evaluate a facility's progress in the context of this pilot effort.

Consortium for Energy Efficiency (CEE)
Virtually all of the ratepayer-funded efficiency programs in the United States, and many in Canada, are administered by members of CEE, a nonprofit organization based in Boston. Energy efficiency programs exist to help reduce demand for power and the corresponding emissions associated with power production. These programs are generally funded through a mandated charge per kWh or therm on a consumer's utility bill, such as a system benefits or public goods charge. These accumulated funds are collected and distributed to support programs that promote efficiency, renewable energy, and alternative fuels. Generally, budget and administrative oversight is enabled by the state legislature, while state regulators are tasked with approving program designs and determining to what extent the organizations administering programs are reimbursed for their efforts. Efficiency program administration is commonly performed by the utility (investor-owned or municipal), a state energy office, or a regional-or state-level efficiency organization (Jones, 2007).

By working together through CEE, efficiency program administrators are able to achieve greater energy efficiency and make better use of their funding. CEE helps programs achieve mandated energy saving targets by coordinating their programs to address entire markets. In December 2004, CEE's Board of Directors approved a Municipal Water-Wastewater Facility Initiative to help focus efficiency programs on energy savings available in the water and wastewater sector and to raise awareness of the benefits of energy-efficient water facilities among senior-level decision-makers at municipalities. In order to accelerate demand for energy-efficient products and services in the municipal water and wastewater sector, CEE identifies nationally consistent tools and messages for members to incorporate into their programs.

The ENERGY STAR benchmarking tool for wastewater facilities is an example of a nationally consistent tool that the CEE committee has undertaken to evaluate. CEE is currently working with efficiency program administrators across the country to pilot test the ENERGY STAR benchmarking system. The following efficiency program administrators are participating in this pilot: Commonwealth Edison (Illinois), Wisconsin Focus on Energy, and Bonneville Power Administration. The field test was designed to evaluate the benchmarking process and how it might be used to raise the profile of energy management in this sector. In the course of the CEE field test, twelve facilities were benchmarked.

The ENERGY STAR Benchmark for Wastewater Treatment Facilities
The wastewater treatment facility benchmarking functionality was introduced on October 1, 2007 as part of ENERGY STAR Portfolio Manager, available online at www.energystar.gov/benchmark. The benchmark calculation for wastewater treatment facilities is based upon the model developed through the American Water Works Association Research Foundation (AwwaRF) study, Energy Index Development for Benchmarking Water and Wastewater Utilities [Project #3009]. In the course of this

study, AwwaRF collected data on energy use and facility characteristics for 266 wastewater utilities and used regression analysis to determine the parameters most highly correlated with energy use. ENERGY STAR made minor modifications to the AwwaRF benchmarking model for the purpose of consistency with established Portfolio Manager benchmarking methodology (ENERGY STAR, 2007). The most significant adjustment to the calculation involved the inclusion of weather data.

Weather Adjustment

The ENERGY STAR model includes weather data, expressed in Heating Degree Days (HDD) and Cooling Degree Days (CDD). The AwwaRF study revealed weather to be a statistically significant variable yet omitted it from their final model due to their assumption that individual facilities would have difficulty obtaining accurate HDD and CDD data (AwwaRF, 2007). Portfolio Manager accesses weather data from the National Oceanic and Atmospheric Administration's National Climatic Data Center in order to associate the appropriate HDD and CDD information with a facility based on the zip code entered. This removes the burden to obtain HDD and CDD data.

Benchmark Score Calculation

The ENERGY STAR benchmarking system compares the energy intensity of an individual wastewater facility with similar facilities nationwide using the following variables: zip code, average influent flow, average influent biological oxygen demand (BOD_5), average effluent biological oxygen demand (BOD_5), facility design flow rate, presence of fixed film trickle filtration process and presence of nutrient removal process. A performance rating is generated by taking the ratio of a facility's actual source energy intensity to the energy intensity predicted by the ENERGY STAR model (Table 1). That ratio corresponds to a benchmark score on a scale of 1-to-100, where a rating of 75 or higher indicates that a facility is in the top quartile for its peer group.

Table 1: ENERGY STAR Wastewater Benchmarking Model (ENERGY STAR, 2007)

General Characteristics	
Dependent Variable	Source Energy Intensity
Number of Observations in Analysis	257
Model R^2 value*	0.388
Implied R^2 value**	0.81
Model p-value	0.000

Model Parameters and Coefficients

Parameter	*Center Value*	*Coefficient*	*Std Err*	*t-Value*	*p-value*
Intercept	NA	10.127	.310	32.658	.000
C_ln_inf_average	1.86248	-.942	.245	-3.846	.000
C_ln(Inf_BOD)	5.20389	4.875	.776	6.284	.000
C_ln(eff_BOD)	1.65988	-2.082	.419	-4.963	.000
C_ln(inf_lf)	4.17069	-4.668	1.236	-3.778	.000
C_process_tf	0.17899	-2.577	.825	-3.122	.002
C_treat_nr	0.45914	1.235	.663	1.861	.064
C_LN_HDD	8.72357	2.354	1.214	1.939	.054
C_LN_CDD	6.50017	1.243	.743	1.672	.096

Notes:
** The Model R^2 expresses the variability in the dependent variable: Source Energy per gallon per day*
*** The Implied R^2 re-evaluates the R^2 to express the variability in units of Source Energy*
Definitions:
Source Energy Intensity is the source energy (kBtu) divided by the average annual flow (gallons per day)
C_ preceding each variable indicates that it is centered (i.e. the difference between the actual value and the mean. This mean value is presented under the "Center Value" column)
ln(inf_average) – The natural log of the average influent flow (mgd)
ln(inf_BOD) – the natural log of the influent biological oxygen demand (mg/l)
ln(eff_BOD) – the natural log of the effluent biological oxygen demand (mg/l)
ln(inf_lf) – the natural log of the facility load factor (ratio of influent flow to facility influent capacity)
process_tf – binary variable indicating the presence of trickle filtration (0 if no, 1 if yes)
treat_nr – binary variable indicating the presence of nutrient removal (0 if no, 1 if yes)
ln(HDD) – the natural log of the value for heating degree days
ln(CDD) – the natural log of the value for cooling degree days

The R^2 statistic can be interpreted as the proportion of dependent variable variation explained by the regression equation. The model shown above has a low R^2 value of 0.388, indicating that the model explains 38.8% of the variability in source energy per flow for wastewater treatment facilities. Since source energy per flow is the model's dependent variable, the predictive power of flow is not included in this R^2 value. When R^2 is calculated in units of source energy (the Implied R^2 listed in Table 1), the value rises to a more robust 0.81 (ENERGY STAR, 2007). For a more in-depth discussion of the mechanics of the benchmarking calculation, please see "Energy Performance Rating for Wastewater Treatment Plants," a PDF available at www.energystar.gov.

A Note on Source Energy

Portfolio Manager allows for the benchmarking of many different building types. These facilities use a variety of energy sources. In order to compare the performance of facilities that use different types of energy it is necessary to convert each energy source into a common unit. EPA (and ENERGY STAR) expresses that unit in terms of kBtus of source energy, which incorporates energy lost in the production and transmission of energy from power source to power user (ENERGY STAR, 2007).

In order to calculate the source energy, the site, or metered, energy must be first converted to kBtus and then converted to source energy, using ratios calculated by the EPA (Table 2). This calculation is done automatically in Portfolio Manager; the user need only enter their metered energy data in the appropriate units (kWh, therms, etc.). Electricity, the primary energy source for most wastewater treatment processes, has the highest Source-Site ratio.

For example, one kWh is equal to 3.412 kBtus. To calculate the source energy of one kWh, multiply one by 3.412 (to convert to kBtus) then by 3.34 (the source-site ratio). One kWh of metered energy is equal to 11.4 kBtus of source energy.

Table 2: Source-Site Ratios for all Portfolio Manager Fuels

Fuel Type	Source-Site Ratio
Electricity	3.340
Natural Gas	1.047
Fuel Oil (1,2,4,5,6,Diesel, Kerosene)	1.01
Propane & Liquid Propane	1.01
Steam	1.45
Hot Water	1.35
Chilled Water	1.05
Wood	1.0
Coal/Coke	1.0
Other	1.0

Benchmarking Outputs

As described above, the ENERGY STAR tool provides a score of 1 to 100 based on a facility's performance relative to similarly sized facilities as well as a measurement of energy intensity, identified as "Current Source Energy per Flow." This unit of measurement for energy intensity is kBtu per gallon per day (kBtu/gpd). The system also returns a National Average Source Energy Use Intensity (EUI), measured in kBtu/gallons per day.

If the Current Source Energy per Flow of a facility is equal to the National Average Source EUI, the facility will receive a score of 50, indicating it is in the 50th percentile for performance. In the example in Figure 2 below, if the Current Source Energy per Flow was 2.6 and not 1.8072, this facility would have received a score of 50. In this case, though, since the Current Source Energy per Flow is actually 1.8072, the facility is using less energy per unit of flow than a facility in the 50th percentile, thus resulting in a rating above 50 (a 78 to be exact).

Current Rating (1-100)	Average Flow (MGD (million gallons per day))	Current Source Energy per Flow (kBtu/gallons per day)	Influent BOD5 (mg/l (milligrams per liter))	Effluent BOD5 (mg/l (milligrams per liter))	National Average Source EUI (kBtu/gallons per day)
78	0.7	1.8072	107.0000	41.0000	2.6

Figure 2: Screenshot of ENERGY STAR Benchmarking Outputs

Facilities with an average daily flow of below 0.6 million gallons per day will not receive a benchmark score although a Current Source Energy per Flow number is calculated for these facilities. ENERGY STAR has determined that below 0.6 MGD the predictive ability of the benchmarking model breaks down. That said, a facility with an average daily flow below 0.6 MGD can compare its Current Source Energy per Flow to the National Average Source EUI to determine if its performance is above or below average.

METHODOLOGY

The field testing of the ENERGY STAR benchmarking tool involved the collection of the necessary data from the participating facilities. Portfolio Manager offers flexibility in terms of the options available for the entry and sharing of data, but requires that the data be formatted precisely. Below is a description of the processes used by the participants in this field test.

Data Collection & Entry

There are multiple options for entering data into Portfolio Manager:

- The data can be entered directly into an online account
- ENERGY STAR provides a downloadable Excel spreadsheet into which the data can be entered and then emailed to ENERGY STAR for upload into Portfolio Manager
- Third party providers that can automate energy data upload

The inputs required are:

- Facility Zip Code (to normalize for weather)
- 12 months of energy use data for all fuels–monthly (kWh, therms, gallons of oil, etc.)
- Annual Average Daily Influent Flow (MGD)
- Annual Average Influent Biological Oxygen Demand (mg/l)
- Average Effluent BOD - average over 12 months (mg/l)
- Facility Design Capacity - treatment design (MGD)
- Fixed Film Trickle Filtration Process (y/n)
- Nutrient Removal (y/n)

The annual period used for energy data collected should correspond to the annual period used for the other variables. For example, the user must use energy data for 2006 with flow and BOD data from 2006. Please note that energy cost data is not required in order to obtain a benchmark score. When possible, though, energy cost data was collected.

Outreach

EPA Region 1 facilitated the collection of the necessary benchmarking data by contacting regional wastewater facilities. The data collected was input directly into the Portfolio Manager account created by the facility, either by the facility operator or by a representative from Region 1. MassDEP solicited the necessary benchmarking data from the participating facilities as part of the initial data collection phase of the energy management pilot. The data was then entered by EPA Region 1, which is supporting the pilot effort in Massachusetts.

For the purpose of the CEE field test, the data was input into the Excel spreadsheet available on the ENERGY STAR website and emailed to CEE. CEE reviewed the spreadsheets for completeness then forwarded them to ENERGY STAR for upload into Portfolio Manager. Once each spreadsheet was uploaded into Portfolio Manager, the appropriate wastewater facility manager received an email alerting them that a new account had been created for them and that they could view the results.

Data Flow

The Portfolio Manager system is designed to be used at the facility or facility level but there are options for users to track the energy use for facilities owned or managed by several different individuals or organizations. In order to view data from a number of individual accounts, a user needs to register for a Master Account. Portfolio Manager allows individual facilities to share their data with the master account user. This is the structure that has been used by participants in gathering the data for this report.

Data entered into Portfolio Manager is considered confidential information and can only be shared with the permission of the user. The participants in these field tests were assured that their specific results would remain confidential. While this paper does provide benchmarking results, it does not include the names of the benchmarked facilities for the purposes of confidentiality.

Challenges of Data Collection

One of the hurdles encountered during this project was the collection of 12 months of energy usage data. Facility energy use has not, historically, been a priority for facility managers. One survey of wastewater facility operators in Wisconsin showed that only five percent of operators saw their monthly energy bills and only one percent both saw their energy bills and were able to understand them. (Cantwell, 2007) Several of the facilities that participated in this project had difficulty retrieving accurate and complete energy use data. Many use a number of different fuel sources (electricity, natural gas, fuel oil, hydroelectric, etc.) and are not always diligent about recording the bills in an organized and easily accessible manner.

The ENERGY STAR benchmarking tool requires a years worth of continuous energy use data for all fuel sources. The date gap between periods can be no more than one day and a billing period can be at most 65 days. Below are examples of actual data that illustrate two challenges that arose in data collection.

Table 3: Date Gap Error in Data

Fuel Type	Units	Start Date	End Date	Usage
Electricity	kWh	6/26/2006	7/26/2006	72960.00
Electricity	kWh	7/29/2006	8/28/2006	69280.00

In Table 3, there is a gap of 3 days between the end of the previous billing cycle and the start of the new billing cycle. Portfolio Manager returned an error message when this data was entered. The operator who entered this data erred when entering the start date for the second period, but this illustrates the need for precision in data collection and entry.

Table 4: Billing Period exceeds 65 days

Fuel Type	Units	Start Date	End Date	Usage
natural gas	therms	12/20/2004	3/18/2005	866.88

In Table 4, the billing period is 89 days long. Portfolio Manager has a limit of 65 days. To correct this, the usage number was split up over 3 periods, each attributed a third of the energy use of the original period.

The other inputs needed for benchmarking were more readily available from the facility operators. Many of the facilities report these variables as part of their permit requirements. This data is stored in the National Pollutant Discharge Elimination System (NPDES) database though there is currently no link between NPDES and Portfolio Manager.

RESULTS & DISCUSSION

Benchmarking Results

As a result of these combined efforts, 54 wastewater facilities were benchmarked using the ENERGY STAR tool. The scores ranged from 1 through 99, with an average score of 58. Eleven facilities were below the 0.6 MGD threshold and thus did not receive a benchmark score. The Source Energy per Flow ranged from 1.8072 to 38.0188 with an average of 10.8125 kBtu/gpd.

Table 5: Results Summary

Number of Facilities: 54	**Minimum**	**Max**	**Average**
Benchmark Score	1	99	58
Energy Intensity (kBtu/gpd)	1.8072	38.0188	10.8125

Table 6: Complete Results

Score	Average Flow (MGD)	Source Energy per Flow (kBtu/GPD)	Influent BOD5 (mg/l)	Effluent BOD5 (mg/l)	Energy Cost per MG ($/MG)
1	2.4	14.2536	83	12	N/A
1	0.8	16.1574	115	10	N/A
3	4.1	25.1918	240	6	N/A
11	35.8	7.5981	140.4	11.9	$264
12	2.5	2.7642	76.5	5	N/A
15	0.6	19.2133	200	10	$658
17	15.2	14.1673	213	7	N/A
19	14	8.3902	155	27	N/A
22	4.2	6.0112	130.6	8.5	$146
22	0.7	17.5787	141	3	N/A
25	0.7	17.0923	184.66	7.66	$733
28	35	7.774	157	10	$237
29	1.5	13.4442	127	2	N/A
32	56.7	7.3125	156	7	$248
53	51.9	3.2169	136	13	$79
53	0.6	12.461	327.7	20.54	$360
62	1.7	7.5691	275	14	$242
64	3.7	3.8944	221.2	13.72	$89
64	1.6	9.491	245	7.2	N/A
67	17.6	4.2009	149	7	N/A
67	21	7.3099	300	10	N/A
67	2	11.0025	221	6.7	$409
70	0.8	8.6593	154	6	$201
72	6.5	5.8779	225	20	$58
74	2.1	9.9839	174.2	1.8	$315
77	11	7.0726	132	1.4	N/A
78	0.7	1.8072	107	41	N/A
80	10.8	5.5817	106	1.3	$203
83	3.8	4.8567	238	17.5	N/A
83	350	5.485	159.7	5.9	$109
84	5.1	6.271	210	3	$236
85	3	5.8557	160.4	10.2	$152
86	5.2	7.5364	275	5	$167
89	2.6	5.2	117.8	4.09	N/A
89	3.2	7.0592	295	4.68	N/A
90	33	2.825	154	5.8	$113
91	3.4	4.4514	188	7	N/A
91	1.9	7.8693	237	3	$202
96	8.3	3.2994	180	8	$107
98	2.3	3.8788	186	11	$124
98	1.9	4.7437	265	9.1	$131
99	10.1	4.7589	209	3.4	N/A
N/A	6	4.2999	165	9	$141
N/A	0.3	10.0426	71.3	5.1	N/A

N/A	0.2	10.6631	164	21	N/A
N/A	0.3	11.7095	140	9	N/A
N/A	0.1	13.8256	92	11	N/A
N/A	0.4	14.0751	135	16	N/A
N/A	0.2	16.1016	268	4.58	N/A
N/A	0.05	21.5715	128	7.1	N/A
N/A	0.04	28.6369	100	8.8	N/A
N/A	0.1	32.4975	176	19.4	N/A
N/A	0.4	33.2649	200	5	$1,187
N/A	0.5	38.0188	146	2.5	N/A

Implications of Facility Size

The wastewater benchmarking capability is the first Portfolio Manager feature that is not geared toward square footage; it reports energy intensity in terms of kBtu per unit of flow (gallons per day). The tool is not process specific and normalizes the energy use per flow as a means of comparing energy performance across facilities. Figure 3 charts the energy use per flow versus facility size for the 54 facilities in this study. Smaller facilities, in general, tend to be less energy efficient than larger facilities but this is not always the case.

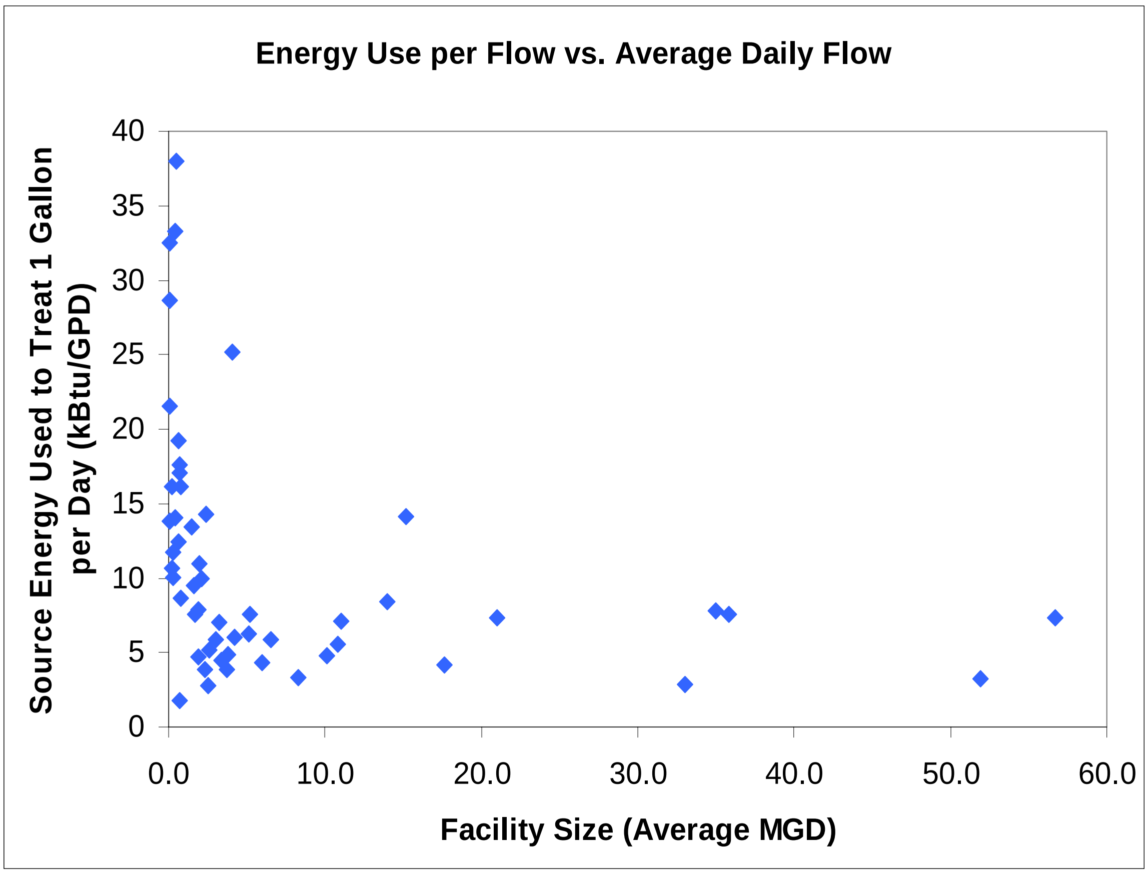

Figure 3: Energy Use per Flow vs. Average Daily Flow

Over 80 percent of wastewater facilities in the United States are defined as small (1.0 mgd or less in capacity) (AwwaRF, 2007). Though smaller facilities (below 1 MGD) tend to be less efficient than larger facilities, within the population of small facilities there is a considerable range of energy performance. Within the population of smaller facilities, average daily flow and energy intensity are not strongly correlated. Figure 4 illustrates the energy intensity ratings of the facilities below 1 MGD included in this report. While the average energy intensity for the small facilities in this sample (17.96535 kBtu/GPD) is considerably higher than the average energy intensity of the sample population as a whole (10.8125 kBtu/GPD), four of the small facilities performed better than that average.

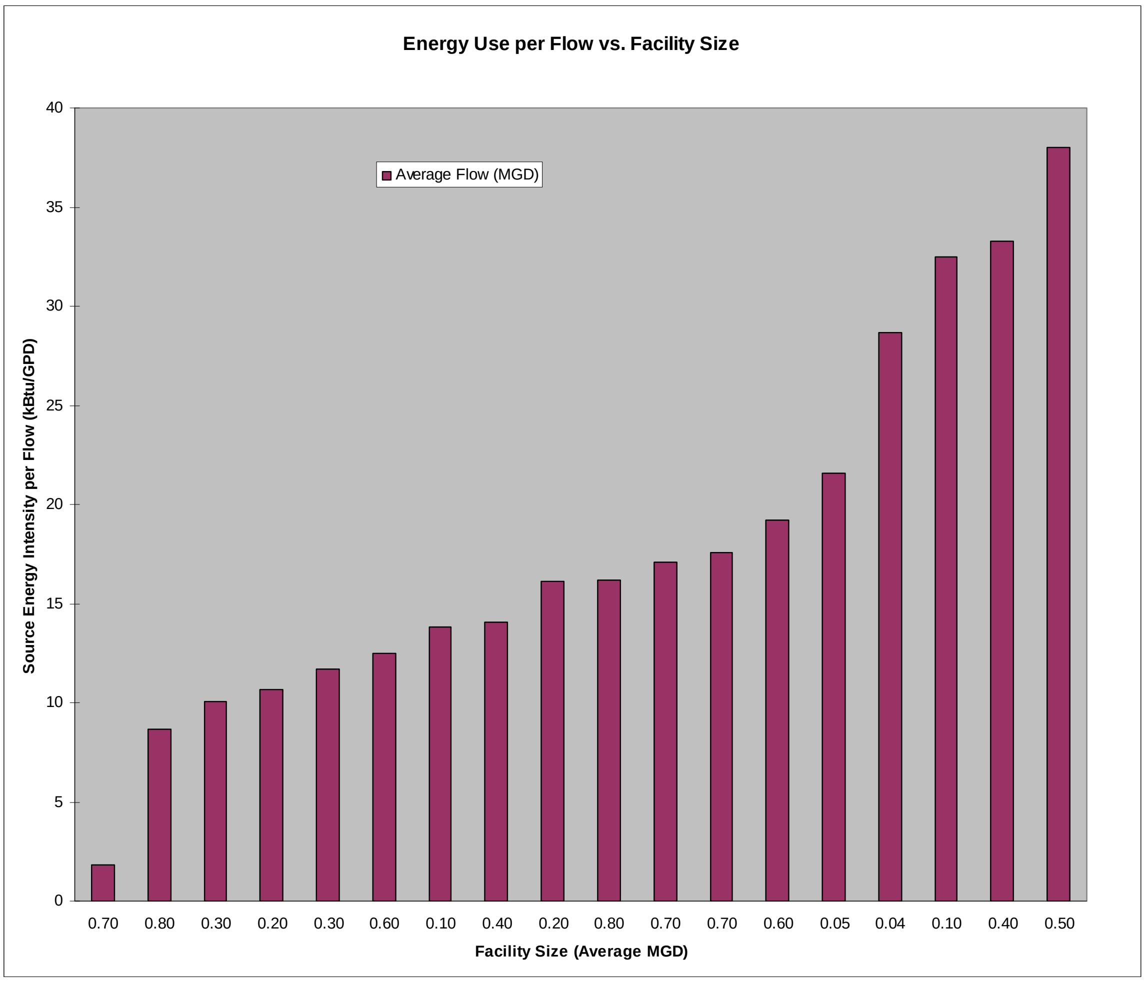

Figure 4: Energy Intensity for Facilities below 1 MGD in Average Daily Flow

The data also indicates that similarly sized facilities can vary widely in terms of energy use. The six similarly sized facilities in Figure 5 demonstrate a wide range in terms of energy use per million gallons treated. The facility on the far right uses almost three times as much energy per million gallons treated as the facility on the far left.

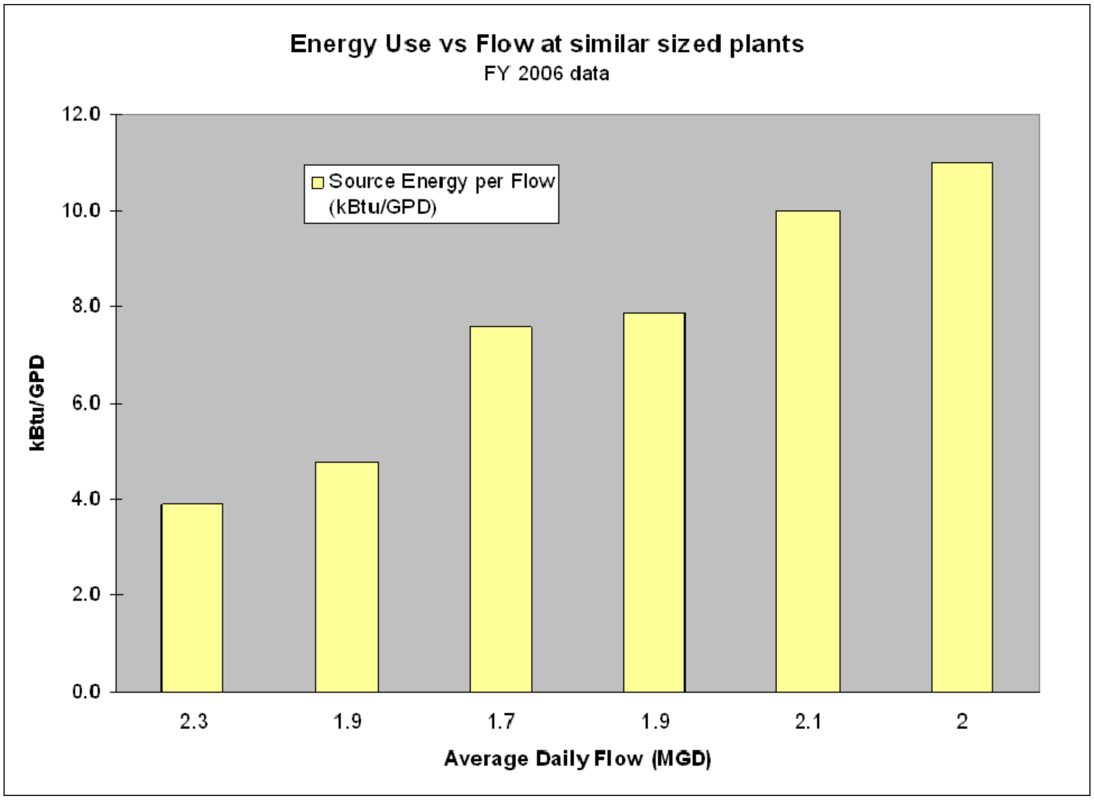

Figure 5: Energy Use v. Flow

As mentioned, smaller facilities do tend to be less efficient than larger facilities. That said, a facility's average daily flow is not a proxy for the energy efficiency, either actual or potential, of that facility. As this data shows, facilities of similar sizes can vary widely in their energy consumption.

Implications of Biosolids Handling

The ENERGY STAR benchmarking tool only normalizes for variables deemed to be beyond the control of the facility operator (weather, BOD levels, facility configuration, and daily flow). Biosolids handling decisions are considered to be within the facility manager's control. As shown in Figure 1 in this paper's introduction, biosolids handling processes typically will not have as large an impact on a facility's energy use profile as pumping and aeration energy but can still consume over 15% of the energy used at a facility.

The implication of biosolids handling decisions is demonstrated by two of the facilities in the field test. One of the facilities received a score of 89 but does not currently engage in biosolids treatment; biosolids are pumped to a retention reservoir and the waste is trucked to a landfill. The facility manager recently decided to upgrade the treatment process to include energy-efficient biosolids dewatering equipment. This will reduce the volume of biosolids that is trucked away but will increase energy consumption at the treatment facility. As a result, the post-upgrade benchmark score will go down.

Another large facility included in this report uses a considerable amount of natural gas to incinerate biosolids from other area facilities. When all the energy used for incineration of biosolids is included in the benchmarking data, the facility receives a low score of 28. When the additional energy used to treat the imported biosolids is excluded from the benchmarking calculation, giving a more accurate assessment of the actual wastewater treatment process at that facility, the score rises to a more respectable 72. (See Table 7 below)

Table 7: Benchmarking Implications of Biosolids Incineration

Facility	Current Rating (1-100)	Average Flow (MGD)	Source Energy per Flow (kBtu/gallons per day)	Energy Cost (US Dollars ($))	Annual Influent BOD5 (mg/l (milligrams per liter))	Effluent BOD5 (mg/l (milligrams per liter))
With Biosolids Incineration	28	35	7.774	$3,028,851	157	10
Without Biosolids Incineration	72	35	4.7255	$1,962,705	157	10

The benchmarking tool was not designed to indicate the efficiency of a specific internal process, but this example demonstrates that there is some flexibility in appraising the facility's performance. If a facility operator can determine the energy used for a specific process, that data can be manipulated within Portfolio Manager to indicate the impact of that process on a facility's overall energy performance.

Before & After

The ability to track performance over time is a significant benefit of any benchmarking approach. The ENERGY STAR tool allows users to establish a baseline for energy use and track their performance over time. For example, one facility in the study provided data from both before and after a series of facility renovations designed to improved energy efficiency. These improvements included the installation of premium efficiency motors, the addition of variable frequency drives to pumps, and an upgrade to the aeration system. As shown in Table 8 below, there was a considerable improvement in rating as well as Source Energy per Flow between 2004 and 2007. This demonstrates the utility of the tool in tracking energy performance.

Table 8: Benchmarking Over Time

12 Months Ending	Current Rating (1-100)	Average Flow (MGD)	Source Energy per Flow (kBtu/gallons per day)	Annual Influent BOD5 (mg/l (milligrams per liter))	Effluent BOD5 (mg/l (milligrams per liter))
December 2004	69	11.2	7.0292	203	14
December 2007	99	10.1	4.7589	209	3.4

On-Site Generation, Renewables, and Carbon Dioxide Emissions

The Portfolio Manager system only formally incorporates purchased energy, not energy that is generated on-site. For example, if a facility uses natural gas to generate electricity, only the purchase of natural gas will be recorded in Portfolio Manager, not the generated electricity. If the gas is created on site, no energy use data need be entered into Portfolio Manager. On-site renewables, such as wind, solar, or hydroelectric, lower the electric demand from the grid, and therefore translate to higher energy performance ratings (ENERGY STAR, 2007).

Though Portfolio Manager does not track energy used from on-site or renewable sources, this energy is in fact being used in the treatment process. This results in lower energy intensity for facilities using these technologies. Two identical facilities that use the same amount of energy could get different scores depending on the ratio of on-site to off-site energy generation. It is possible in Portfolio Manager to enter the energy data for on-site or renewable generation. The data on electric energy generated by solar panels, for example, could be entered as a separate electric meter. This energy, though, would be ascribed a source energy value equivalent to a kWh purchased from the grid. For this reason, on-site and renewable energy was not included in the benchmarking of the facilities in this study.

The ENERGY STAR benchmarking tool provides a carbon dioxide emissions rate. The rate is reported in lbs or CO_2 per MWh and based upon the electric distribution utility and regional power grid that is supplying electricity to the facility. By using the facility zip code, Portfolio Manager locates the facility in a subregion of the U.S. power grid defined by the U.S. EPA's Emissions & Generation Resource Integrated Database (eGRID). The eGRID region has an emissions rate associated with it based upon the fuels used to generate electricity for that region. That rate is ascribed to the facility. For this project the emissions rates were not analyzed, but if reporting of CO_2 is required in the future, facility operators could use this tool to determine their emissions.

Relative Energy Efficiency and Opportunities for Improvement

The ENERGY STAR benchmarking tool was designed to provide a relative assessment of energy performance. The score reveals how a facility is performing relative to other facilities, but it does not provide information on the specific energy efficiency of each process in a facility. A facility could score 100, indicating the top boundary of relative performance, but still have opportunity for energy efficiency improvements. A facility could, in other words, be more efficient than the most efficient facility included in the survey sample upon which the model is based. Many of the operators at the highest scoring facilities recognize this and continue to pursue energy saving measures at their facilities.

The tool provides a relative assessment of performance and EPA is investigating the top scoring facilities to provide insight into the best practices for energy management in wastewater treatment. ENERGY STAR is working to provide information about best practices that will be incorporated into the ENERGY STAR suite of resources for this sector, available at www.energystar.gov/waterwastewater. This information will provide facility operators with insight into ways to improving the energy efficiency of their processes.

CEE, in addition to testing the benchmarking tool, is analyzing energy saving projects in this sector that have been implemented by its member efficiency programs. This project will provide guidance on the range of energy savings and payback periods for a variety of energy conservation measures. To date CEE has identified forty-eight unique measures that have been implemented at facilities across the United States. A facility with a low benchmark score can review these measures and consider which ones might help improve energy efficiency and what kind of improvement they might expect.

There exists a gap between the recognition of opportunities for efficiency improvements and the implementation of those improvements. Benchmarking is a crucial step in assessing these opportunities. There are an increasing number of resources dedicated to capturing these opportunities. These resources, however, are not always organized in a manner accessible to facility operators. Through efforts such as those by the Massachusetts DEP, the necessary framework for coordinating these resources could be established.

CONCLUSION

The ENERGY STAR benchmarking capability for wastewater treatment facilities in US EPA's Portfolio Manager provides a mechanism for a high-level assessment of a facility's relative energy efficiency. The tool requires minimal data inputs, though careful attention must be paid to insure that the data entered is complete. The process of benchmarking compels a facility operator to collect relevant energy use data, a critical first step in any energy management approach. The benchmarking results can highlight the opportunity for improved energy efficiency, though determining the scale of this opportunity would involve a more thorough analysis of a facility's operation.

Each of the organizations involved in field testing the ENERGY STAR benchmarking tool sees value in including it as part of their approach to capturing energy savings in this sector. By encouraging facility operators to track their performance, the ENERGY STAR benchmark increases the awareness of energy management and highlights the potential for cost-effective energy savings. CEE, EPA, and MassDEP continue to pursue mechanisms for realizing those energy savings.

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