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Nebraska Wastewater Treatment Facilities Benchmarking Guide

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Nearly all wastewater treatment plants have opportunities to improve their energy efficiency and reduce their costs. Many operators and municipal managers want to know what opportunities they might find before undergoing an internal or external assessment. Benchmarking allows them to see how their facility compares with other wastewater plants while still taking factors like influent loading and flow rates into account.

Introduction

The Portfolio Manager® benchmarking tool is an ENERGY STAR® tool developed by the U.S. Environmental Protection Agency (EPA). The Portfolio Manager can score wastewater plants with greater than 0.6 MGD (million gallons per day) of wastewater influent, but it is most reliable for facilities with influent flows greater than or equal to 1 MGD.

In 2016, the University of Nebraska–Lincoln (UNL) developed a methodology to benchmark small Nebraska wastewater (SNW) facilities operating at less than 1.5 MGD. More specifically, the methodology is designed to best serve non-lagoon and non-fixed-film plants operating under 0.6 MGD.

Hyperlinks to resources, like portfolio manager, at www.energystar.gov, are located throughout this NebGuide and are also listed at the end with their respective URLs.

ENERGY STAR Portfolio Manager

The Portfolio Manager benchmarking tool can compare the energy efficiency of nearly any building or facility with similar entities nationwide. After creating an account and putting relevant data into the system, the benchmarking tool will give a percentile-based score between 0 and 100, with 0 indicating some of the lowest energy efficiency and 100 indicating the highest energy efficiency nationwide.

Portfolio Manager is designed to be both powerful and user-friendly. Three steps demonstrate how to find and interpret an ENERGY STAR score.

Step 1: Gather Data

The Portfolio Manager benchmarking tool requires the following pieces of information as inputs:

- Facility Name
- Facility Address
- Total Gross Floor Area (indoors)
- Irrigated Area
- Year Built/Planned for Construction Completion (or most recent major upgrade)
- Occupancy (percentage of Total Gross Floor Area)

- Number of Buildings
- At least 12 consecutive months of energy data
- At least 12 consecutive months of flow rate data (preferably influent data)
- Plant Design Flow Rate
- Average Influent Biological Oxygen Demand (BOD_5)
- Average Effluent Biological Oxygen Demand
- Presence/Absence of Fixed-Film Trickle Filtration Process
- Presence/Absence of Nutrient Removal

ENERGY STAR has created a worksheet that simplifies the collection of this information as well as a glossary of terms.

Here are a few tips for gathering data:

- Portfolio Manager requires 12 complete consecutive months of energy and flow rate data. Thus data for parts of two months (e.g., 3/15/2017 to 3/15/2018) would not be sufficient, as there is not data for one or two complete months (of March)–only two separate halves.
- The tool will also require the 12 complete consecutive months be the same for both energy and flow rate data.
- Determining floor areas from plant design plans may be difficult or time consuming. An alternative method of estimating floor areas is to use an internet accessible map tool such as Google Maps' "Measure Distance" tool. Links to such tools can be found at the end of this document. It is important to note that these tools will only calculate footprint, and the area of a building with more than one floor can usually be calculated as follows:

$$Gross\ Floor\ Area = Footprint \times \#\ of\ Floors$$

- Portfolio Manager has spreadsheet templates to aid data entry. For plants with several utility meters, users might find it easier to enter meter data in a spreadsheet and then upload the data to the ENERGY STAR website.

Not including the time needed to gather bills, an individual who is knowledgeable about the plant's operations will be able to fill out the worksheet in an hour or less.

Step 2: Input Data to Portfolio Manager

New users must create an account at www.energystar .gov/portfoliomanager. ENERGY STAR has created the Portfolio Manager Quick Start Guide to help users enter their plant's information into the benchmarking tool once they have created an account and logged in. There is also a training section with how-to guides, videos, and webinars to help operators and managers benchmark their facilities.

Here are some tips for putting data into the system:

- The "Date Meter Became Active" should be the first day of data.
- If meter data is collected in a spreadsheet that is not formatted like the Portfolio Manager template, consider downloading the template and copying and pasting data into it.
- After the data has been uploaded, a score should appear in the upper right-hand corner. If it says, "No score," "N/A," or gives a EUI instead of a score, click directly on this result. This will open the troubleshooter screen to show what might be going wrong.

Users can anticipate that initial data entry will require two to three hours.

Step 3: Interpreting the Score

Once the necessary data has been entered into Portfolio Manager, a percentile-based score between 0 and 100 is calculated. A score of 100 indicates extremely high efficiency, while a score of 0 indicates extremely low efficiency. A wastewater operator or municipal manager can use this score to determine what steps he or she should take regarding energy efficiency.

Scores less than 40: The wastewater plant's energy efficiency is below average. There are probably numerous opportunities for significant energy reductions in the plant, some of which may be simple to implement. The operator or manager should seriously consider requesting resources to perform a detailed internal and/or external assessment.

Scores from 40 to 60: The wastewater plant's energy efficiency is about average. There are likely opportunities to reduce energy usage and demand. The operator or manager should consider requesting an internal and/or external assessment.

Scores above 60: The facility's energy efficiency is above average. There are still likely to be opportunities to improve energy efficiency, but they may be limited in scope or have higher payback periods. Still, some Nebraska wastewater plants with above-average scores have been able to identify and implement significant energy saving improvements.

More information on Portfolio Manager

Facilities can also use Portfolio Manager to track their energy performance over time. If newer data reflect better energy efficiency, operators and managers will be able to see the plant's score increase over time.

ENERGY STAR (www.energystar.gov) has more information on Portfolio Manager and the methods and data they used to create it in their Data Trends, Technical Reference, and Utility Access Fact Sheet documents.

Equations for Small Nebraska Wastewater Treatment Facilities

While the ENERGY STAR Portfolio Manager tool is equipped to benchmark wastewater facilities operating at more than 0.6 MGD, the university has developed equations for Nebraska facilities treating less than 1.5 MGD. These equations are recommended for plants operating under 0.6 MGD, and are not valid for fixed-film or lagoon systems.

The ENERGY STAR and SNW models have some other major differences. First, while Portfolio Manager more strongly resembles a black-box tool, a person using SNW equations will perform the calculations manually. Second, while Portfolio Manager gives a percentile score between 0 and 100 (100 being the most efficient), the SNW score is based on a ratio of the actual energy use of the plant to the energy use that would be expected based on previous benchmarking. The lower the SNW score is, the more efficient the plant is. Additionally, SNW equations featured herein are only valid for plants that primarily use electrical energy. Operators and managers who want to benchmark small wastewater plants that use a significant amount of natural gas or other non-electric energy should request assistance from the Nebraska Industrial Assessment Center (NIAC) or their consulting engineer.

The basis for the SNW model is the energy intensity of a wastewater plant. Energy intensity is the amount of energy needed to treat a certain volume of wastewater. Here, the unit for energy intensity is Megawatt hour per million gallons (MWh/MG). The model was developed after studying the energy intensity of 83 wastewater plants in Nebraska and 71 wastewater plants in Pennsylvania.

Researchers found that they could not base a fair, useful benchmarking process on average energy intensity alone. Factors such as the presence of extended aeration or the influent of Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) will affect the energy intensity of a wastewater plant, regardless of how well the operators maximize their energy efficiency. The SNW equations take these factors into account to give operators and municipal managers a better way to compare the efficiency of their wastewater plants with those in the study.

The following three steps demonstrate how to calculate and interpret the results of the SNW model.

Step 1: Gather Data

The SNW equations require the following information as inputs:

- Presence/absence of the following operations
    - Extended aeration
    - Supplemental energy usage for sludge treatment (e.g., aeration for aerobic digesters or electric or gas heating for anaerobic digesters)
    - Dewatering equipment
- Total climate controlled floor area (ft^2)
- At least 12 consecutive months of energy data, with usage in kWh
- Average flow for the study period (preferably over the same time period as the energy data)
- Plant design flow
- Average influent Carbonaceous Biological Oxygen Demand ($CBOD_5$)

SNW computations will also require the use of the natural logarithm and ex functions. Therefore, a calculator or spreadsheet program capable of performing these functions will be necessary.

Step 2: Calculate the Score

The following equations use some alphabet symbols to represent certain pieces of information. Here is a list of what these symbols represent.

- Y_A = Actual Electric Intensity (MWh/MG)
- Y_P = Predicted Electric Intensity (MWh/MG)
- x_1 = Extended Aeration Plant (Yes = 1, No = 0)
- x_2 = Supplemental Energy Usage for Sludge Treatment (Yes = 1, No = 0)
- x_3 = Dewatering Equipment (Yes = 1, No = 0)
- x_4 = Climate Controlled Floor Area (ft^2)
- x_5 = Average Flow (MGD)

- x_6 = Portion Design Flow (as a decimal)
- x_7 = Average Influent $CBOD_5$ (mg/L)
- x_8 = Design Flow (MGD)
- x_9 = Total Annual Flow (MG)
- x_{10} = Total Annual Electric Usage (kWh)

The first thing to calculate is the portion design flow ratio, which the following equation gives as a decimal.

$$x_6 = \frac{x_5}{x_8}$$

Next, calculate the predicted electric intensity of the plant using a regression equation developed based on data from Nebraska plants.

$$ln(Y_P) = -2.1 + 0.26x_1 + 0.26x_2 + 0.27x_3 + 0.17\, ln(x_4) - 0.32\, ln(x_5) - 0.27\, ln(x_6) + 0.26 ln(x_7)$$

The best way to use this in practice is to compute everything on the right side of the equation first, which will make the equation look similar to this:

$$ln(Y_P) = \#$$

Then, we can take e to the power of each side of the equation, making it look like this:

$$Y_p = e^{\#}$$

In this case, Y_p is the average energy intensity of a plant in Nebraska with similar characteristics. The units of Y_p are MWh (kWh*1000) per million gallons of flow, or MG. After calculating the plant's predicted electric intensity, calculate its actual electric intensity. First, use the electric bills to find the total number of kWh used during the 12 months of data. This will probably look something like this:

$$x_{10} = Jan.usage + Feb.usage + \cdots + Dec.usage;\ with\ units\ in\ kWh$$

Next, find the total annual flow of the plant. Generally, the simplest calculation is

$$x_9 = x_5 \times 365$$

where 365 is the number of days per year. Those who have 12 months of monthly averages can also use this method. Note that the numbers 31 and 28 refer to the number of days in the respective month.

$$x_9 = Jan.flowrate \times 31 + Feb.flowrate \times 28 + \cdots + Dec.flowrate \times 31$$

Once the annual electric usage and total annual flow have been calculated, the actual energy intensity of the plant can be found as shown.

$$Y_A = \frac{x_{10}}{x_9}$$

The final calculation is the percent average Nebraska facility, which is also referred to as the SNW score. It is simply the actual energy intensity of the plant divided by the predicted energy intensity, then multiplied by 100 to convert the number to a percent.

$$SNW\ score = \frac{Y_A}{Y_p} \times 100\%$$

Step 3: Interpret the Score

The percent average Nebraska facility describes how much energy a plant is using compared with what a Nebraska operator would expect to use. A score of 100 percent means that the plant is running exactly as efficiently as the average Nebraska plant. A value over 100 percent means that the plant is less efficient than would be expected, while a score between 0 and 100 percent indicates that the plant is more efficient than average. A negative score indicates a mathematical error or an over-extrapolation of the equation. The following guidelines give managers and operators a better idea of how to interpret and use their SNW score.

Scores greater than 115 percent: The wastewater plant's energy efficiency is below average. There are probably numerous opportunities for significant energy reductions in the plant, some of which may be simple operational changes.

Scores 85 to 115 percent: The wastewater plant's energy efficiency is about average, but there are probably still opportunities to significantly reduce energy usage and demand.

Scores below 85 percent: The facility's energy efficiency is above average. There are still likely to be opportunities to improve energy efficiency, but they may be limited in scope or have high payback periods. Still, some Nebraska wastewater plants with above-average scores have been able to find significant ways to improve.

Facilities can track their scores over time to determine if their energy performance is improving their energy efficiency by seeing if their score is decreasing over time.

Energy Efficiency Suggestions for Small Wastewater Facilities

While every plant has different opportunities for improvement, here are some common suggestions for how small wastewater facilities can improve their energy efficiency:

- Install motion sensor lighting controls or place signs near light switches that instruct operators to turn off lights when they leave the room for an extended period of time.
- Replace incandescent and compact fluorescent lightbulbs with LED bulbs.
- Install timers on aerobic digester blowers to allow for planned on/off cycles.
- Install tarps or covers on aerobic digesters to allow for alternating on/off cycles during the winter.
- Turn off heaters during the summer.
- Fix holes and leaks in windows and doors, and install weather stripping.

Useful Links

Those reading printed versions of this document can type the following addresses into an internet browser to find the hyperlinked items. The external links will contain the most current information, but the authors cannot ensure that they are operational as external parties maintain them. The authors work to keep NIAC links as current and operational as possible, but some information may be outdated.

External ENERGY STAR Links/Addresses

Portfolio Manager	https://www.energystar.gov/portfoliomanager
Portfolio Manager training section	https://www.energystar.gov/buildings/training
ENERGY STAR glossary	https://portfoliomanager.energystar.gov/pm/glossary
Portfolio Manager worksheet	https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet
Portfolio Manager Quick Start Guide	https://www.energystar.gov/buildings/tools-and-resources/portfolio-manager-quick-start-guide
Portfolio Manager Data Trends	https://www.energystar.gov/buildings/tools-and-resources/datatrends_energy_use_wastewater_treatment_plants
Portfolio Manager Technical Reference	https://www.energystar.gov/buildings/tools-and-resources/energy-star-score-wastewater-treatment-plants
Portfolio Manager Utility Access Fact Sheet	https://www.energystar.gov/buildings/tools-and-resources/utilities_increase_access_energy_data_help_commercial_customers _benchmark

Other External Links/Addresses

Free Map Tools area calculator	https://www.freemaptools.com
Google Maps	https://maps.google.com

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