



Energy Efficiency as a Pathway Towards Sustainable Wastewater Infrastructure

Nina Wuerch

U.S. Department of Energy

Naushita Sharma

Oak Ridge National Laboratory

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The Presenters



Nina Wuerch is an ORISE Fellow in DOE's Office of State and Community Energy Programs.

Her cross-cutting work focuses on technical assistance for the public sector. Beyond supporting energy efficiency at wastewater facilities through the SWIFt initiative, Nina also works on technical assistance offerings for states, local governments, and K-12 school districts.

This work involves the Better Buildings Initiative, a resource and funding hub known as the State and Local Solution Center, and two data tools – SLOPE and LEAD.



Naushita Sharma is a Postdoctoral Research Associate at the Oak Ridge National Laboratory.

Her research focuses on *understanding the occurrence and treatment of emerging water contaminants; Water-Energy Nexus; Big Data Modeling and Analysis; Climate Sustainability & Resiliency Planning.*

Her work in the diverse areas has resulted in over 15 peer-reviewed journal articles, with wide interaction with municipal water and wastewater utilities.

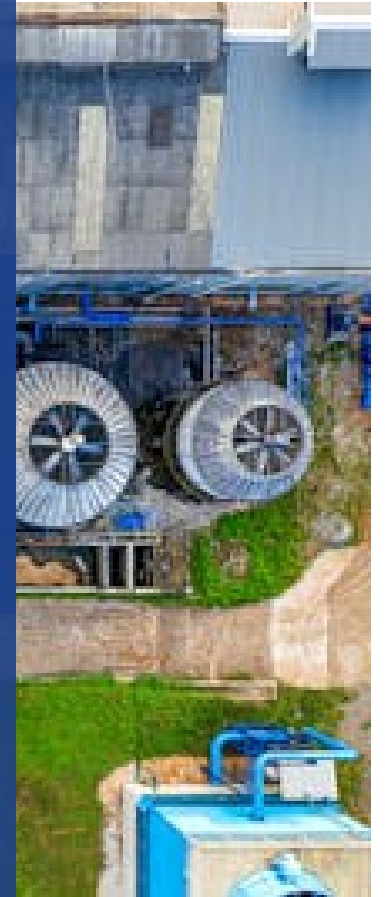
She also engages with mentoring and teaching undergraduate and K-12 students.

AGENDA

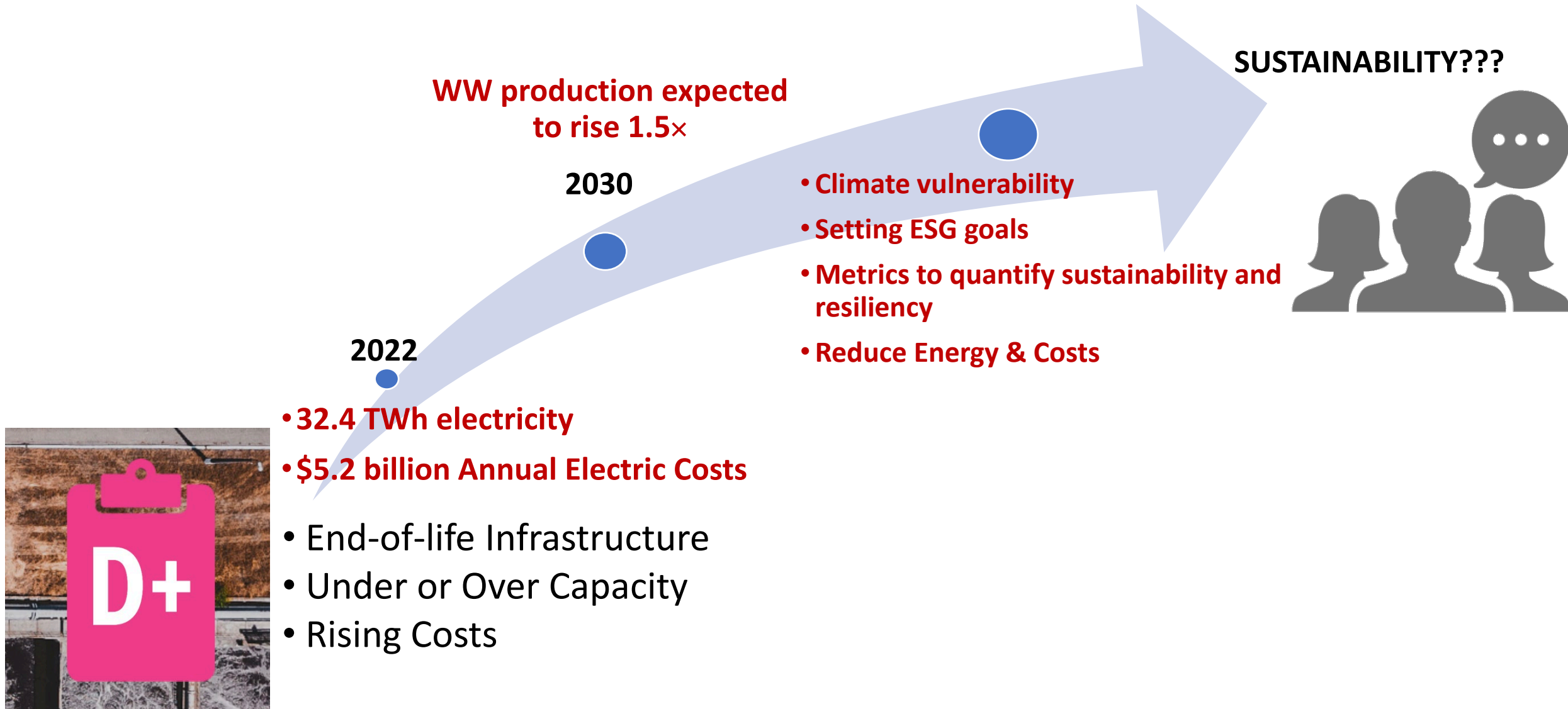
- Energy Efficiency in WWTPs
- SWIFt Initiative
- Energy Management Systems
- Low- to No- cost Energy Efficiency Measures
- Median energy saving opportunities for WRRFs
- Available Tools from DOE
- Resources
- Future Opportunities
- Concluding Remarks
- Questions & Discussion



POTW



“Sustainability” in Wastewater Industry



Why Energy Efficiency?



1% of US Energy Consumption



30-40% of Municipal Energy Consumption



Energy

- Largest Controllable Costs
- Top 3 O&M Costs



Energy Efficiency?



Operating Costs
Energy Costs
Labor Costs



Process Efficiency

Controlled Customer Rates

SWIFt: The Sustainable Wastewater Infrastructure of the Future Initiative

DOE's Sustainable Wastewater Infrastructure of the Future (SWIFt)

SWIFt is engaging with facilities in a voluntarily partnership to achieve 5% short-term and 25% long-term facility-wide energy savings by implementing next-generation technologies across 4 technology pillars



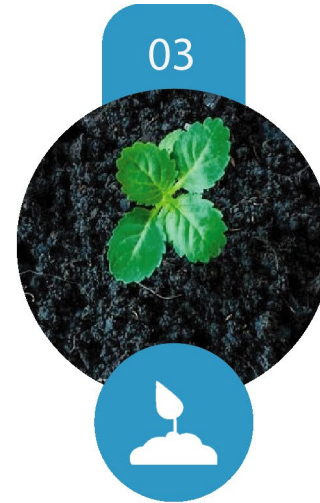
Energy Capture

Resiliency, onsite generation, and renewable energy integration (e.g., combined heat and power, solar photovoltaic, biogas, heat recovery, and energy storage)



Energy Efficiency

Advanced energy efficiency technologies (e.g., ammonia based aeration control, optimized pumping system technologies, and membrane bioreactors)



Resource Recovery

Biosolids recovery for land application as fertilizer and water recovery



Advanced Data Management

Advanced data management, sensing and control for optimized energy performance (e.g., Supervisory Control and Data Acquisition (SCADA) systems and Artificial Intelligence (AI) techniques)

Session Recordings: <https://bptraining.ornl.gov/swift/>

Overview of SWIFT



Training in data management, EE improvements, advanced technology integration, and project financing



Average utility energy savings between 5-25%



154 signatory partners representing over 328 facilities across 43 states

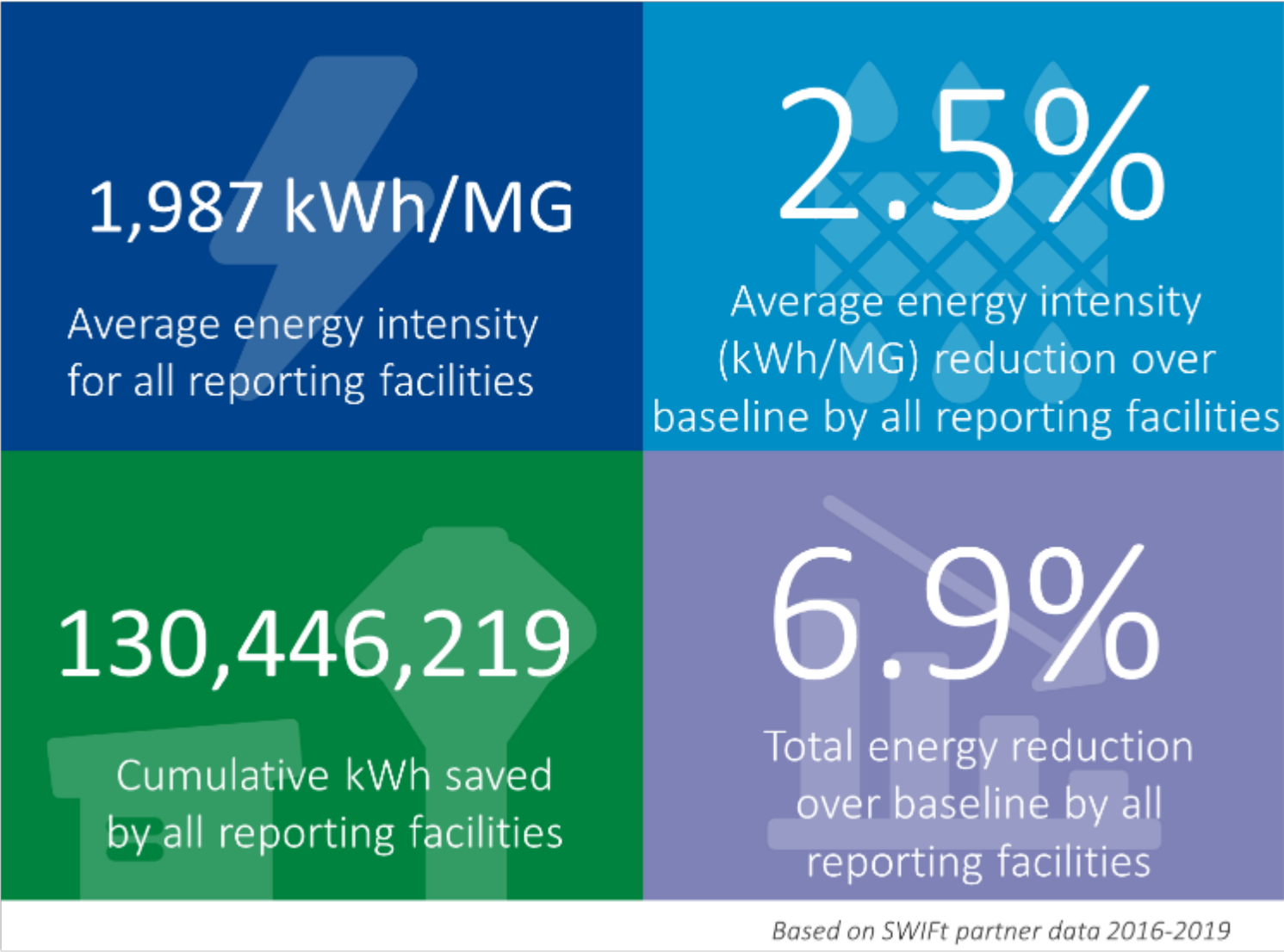


Participating in the virtual training is free and open to all staff at the utilities

Results So Far: Energy Savings

Based on
results from
2016-2019.

Data from
2020-2023
forthcoming.





Summer 2023 Virtual Training Sessions

01

Energy
Management
Tools

02

Process Energy
Conservation
and W3

03

Energy Map,
BOD, and
Pumping

04

Headworks
and Blower
Energy

05

Aeration
Process
Requirements

06

Sludge Quality,
SRT, and Fans

07

Secondary
Clarifier
Optimization

08

Dewatering,
Digestion, &
Decarbonization

09

Renewable
Energy &
Financing

10

Nutrient Recovery
& Emerging
Contaminants

Zoom Poll

Who is in the Room?



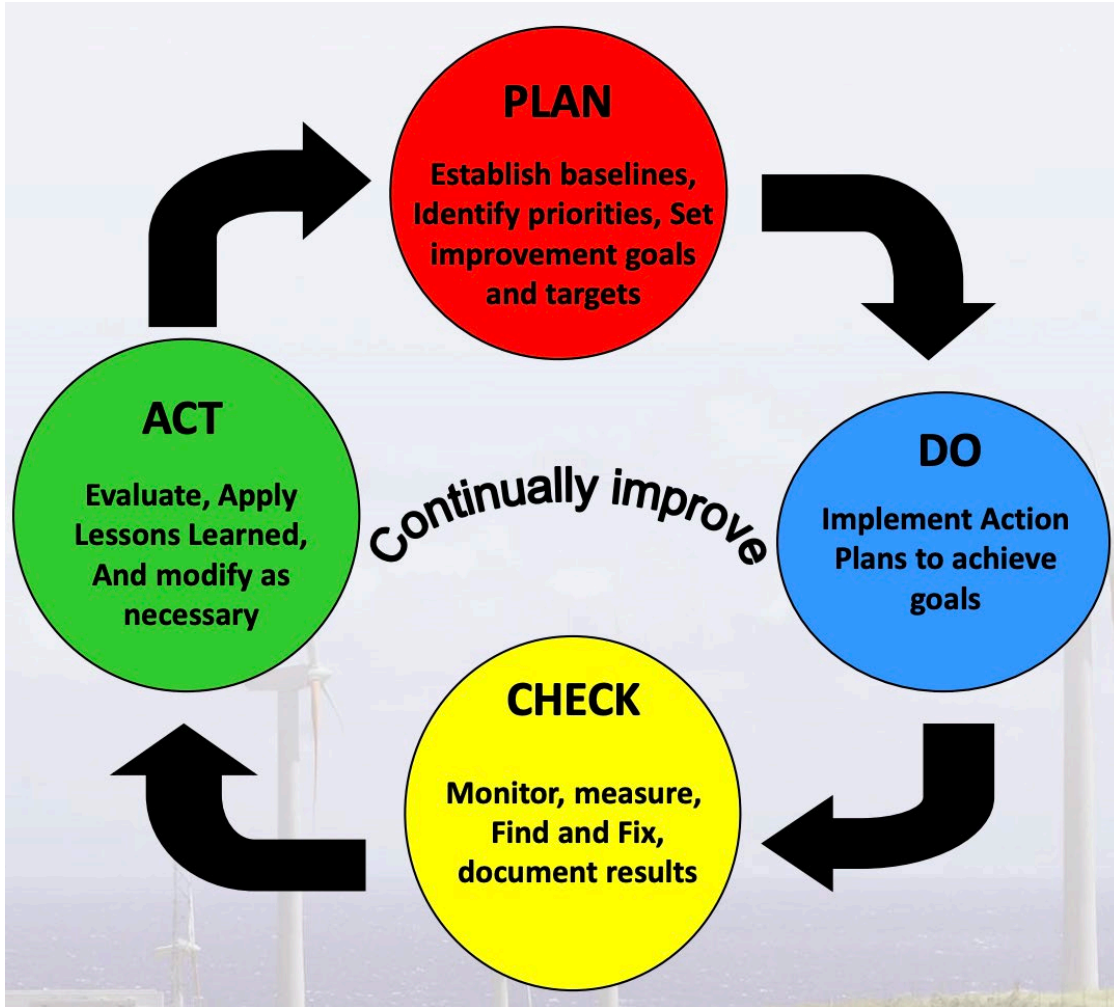
Energy Management Systems

What is an energy management system?

- An energy management system helps organizations better manage their energy use, thus improving productivity.
- It involves developing and implementing an energy policy, setting achievable targets for energy use, and designing action plans to reach them and measure progress.
- This might include implementing new energy-efficient technologies, reducing energy waste or improving current processes to cut energy costs.



Energy Management Systems and Programs



50001 Ready
U.S. DEPARTMENT OF ENERGY



Superior Energy Performance 50001™
U.S. DEPARTMENT OF ENERGY



Industrial Assessment Center
U.S. DEPARTMENT OF ENERGY



Onsite Energy
Technical Assistance Partnerships
U.S. DEPARTMENT OF ENERGY

What is ISO 50001?

Overview

- Develop a *policy* for more efficient use of energy
- Fix *targets and objectives* in line with that policy
- Use *data* to make informed decisions about energy use
- *Measure the results* to identify areas of energy efficiency improvements
- *Review the policy's effectiveness* and results of improvements
- *Continually improve* energy management practices

ISO 50001 provides organizations with an internationally recognized framework for implementing an energy management system (EnMS).



DOE's 50001 Ready program recognizes facilities that attest to the implementation of an ISO 50001-based EnMS.

Benefits

- A Tried and Tested Framework to Manage Energy.
- Greater Visibility of How Energy is Being Used and Where Performance can be Improved.
- Reducing Energy and Costs
- Carbon Reduction
- Organizational Engagement
- Continuous Improvement System
- Staff turnover is eased by having written practice in place

The program is a self-paced, no-cost way for facilities to build a culture of structured energy improvement that leads to deeper and sustained savings.

Voluntary standard for establishing an energy management system

How 50001 Ready Works

1. Implement ISO 50001 principles

Complete 25 Tasks in US DOE's 50001 Ready Navigator free, self-guided online tool

2. Present energy performance

Submit energy performance data. May use 50001 Ready Nav's Consumption Tracker, EPA's Portfolio Manager, DOE's EnPI Lite

3. Self-attest to 50001 Ready

Sign-off by management of 50001 Ready implementation and commitment

energy.gov/50001Ready



**50001 Ready
Site 2021**

U.S. DEPARTMENT OF ENERGY

Company Name

Is recognized as an Energy Management Leader for instituting DOE's 50001 Ready program across its [Facility] in [location]

UNDER THE LEADERSHIP OF

Facility Level Energy Manager Corporate (or Agency) Energy Manager

Recognized [or if re-attested since YYYY of initial recognition]
by the United States Department of Energy
[Date of certificate issuance]

Delivered by **Better Plants**
U.S. DEPARTMENT OF ENERGY


U.S. DEPARTMENT OF
ENERGY

DOE and others recognize
50001 Ready achievement

50001 Ready Navigator - Overview

- Free online 'Turbo Tax-like' tool, with step-by-step approach to ISO 50001 implementation
- Guidance broken into straight forward sections, including:
 - Getting It Done – what specifically needs to be accomplished
 - Task Overview – how does this task connect with ISO50001
 - Full Guidance – comprehensive guidance about the task
 - Transition Tips – from other management systems or ENERGY STAR
- Form teams, assign tasks, setup multiple projects
 - Great project management tool**
- Downloadable guidance
- URL: navigator.lbl.gov

Guidance in Navigator is based on ISO 50001 Principles. There is no fee to use the tool.



Context of the Organization

Task Status (click to jump): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Task: An EnMS and Your Organization

← BACK TO DASHBOARD 1 2 3 NEXT →

Task 1: We determine the strategic issues that affect our ability to improve energy performance and achieve the goals of our 50001 Ready energy management system.

Central Office role for this task: Contributor
Current Task Status: Completed

Not Started ✕ In Progress ⚙ Ready For Review 🔍 Completed ✓ Next Task →

Your roles for this task: Contributor & Approver

Detailed Guidance: An EnMS and Your Organization

Getting It Done Task Overview Full Description Notes 🟡 Playbook 👤 Assignments

Getting It Done

1. Identify the external and internal strategic issues that affect your organization's ability to improve its energy performance and achieve the intended outcomes of the energy management system (EnMS).
2. Record this information.

Detailed Guidance: An EnMS and Your Organization

Getting It Done

Task Overview

Full Description

Notes 0

Playbook

👤 Assignments

50001 Ready Navigator Features – Wastewater Specific

■ Example Playbooks

■ Tool Tips

Detailed Guidance: Scope and Boundaries

Getting It Done Task Overview Full Description Notes 0 **Playbook** Assignments

Name	Type	Description
50001 Ready Playbook Task 03	W	Scope and Boundaries
Wastewater Treatment		
Wastewater Example Playbook Task 03 - Filled Out	W	Playbook Example File

Detailed Guidance: Scope and Boundaries

Getting It Done Task Overview **Full Description** Notes 0 Playbook

Full Description

► **Wastewater Treatment Sector - Additional Guidance**

When establishing the scope and boundaries of an Energy Management System, it is easy to over-simplify this process and simply state that all people and equipment within the facility footprint are what constitute the scope and leave it at that. Thus, it is important to think deeper to ensure nothing is being left out, for example:

- Is approval needed from people outside of the wastewater treatment plant, such as city/county operations?
- Does the municipality have authority over changes in controls, equipment, or other operations?
- Will the Energy Management System apply to pumping stations / control instruments located outside the boundary of the wastewater treatment plant fence line, such as collection and transmission systems?

Help Desk:

Free email and phone support from LBNL's EnMS experts at: 50001Ready@lbl.gov

Reach out to us and we can facilitate communication with staff to provide specific ISO 50001 training

50001 in Action

- **The Noman M. Cole, Jr. Pollution Control Plant (NMPCP) - Fairfax County**
 - 50001 Ready helped NMPCP's Energy Team account for inefficiencies across its wastewater treatment process. For example, the plant had employed a treatment process that remained relatively unchanged for nearly 10 years, only occasionally adjusting the chemicals used in that process. Engaging with 50001 Ready provided the plant's staff with a framework within which they could perform a thorough assessment of their treatment process that enabled the Energy Team to identify savings opportunities in the tank mixing process.
- **The Glenbard Wastewater Authority (GWA) - Illinois**
 - In using DOE's 50001 Ready Navigator tool, GWA staff found the energy mapping exercises to be most beneficial for their needs. Taking stock of the finer details of the facility's operations – such as tracking runtimes and evaluating energy bills – ensured that staff were capturing the system accurately. Having numbers at hand also allowed them to determine the facility's biggest energy users, some of which were impacting energy use in ways that previously had gone unnoticed.



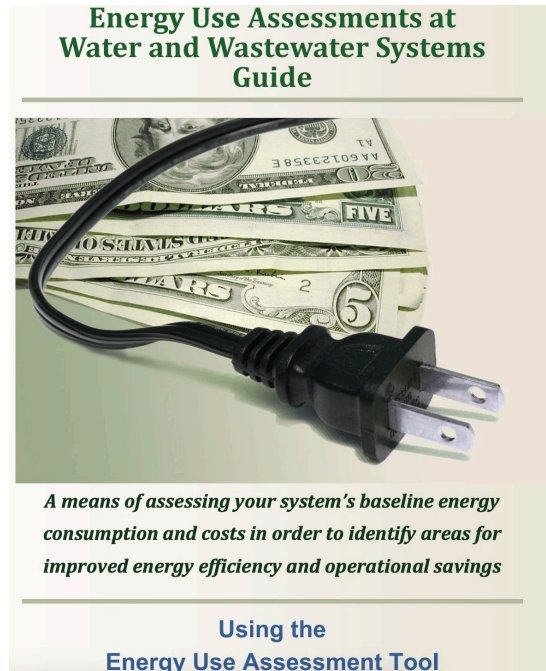
Summary: 50001 Ready...

- ✓ Helps facilities get recognized for best-in-class energy management
 - ✓ Is a tool for onboarding new staff
 - ✓ Institutionalizes energy management that can survive leadership change
 - ✓ Builds off of current energy efforts
 - ✓ Supports your efforts to meet mandates
 - ✓ Is a way to develop and prioritize a list of continuous improvement opportunities
- ✓ Can be delivered by utilities, contractors, ESCOs
 - ✓ Enhances resiliency by surviving staff disruptions
 - ✓ Can break down internal stovepipes by creating collaboration

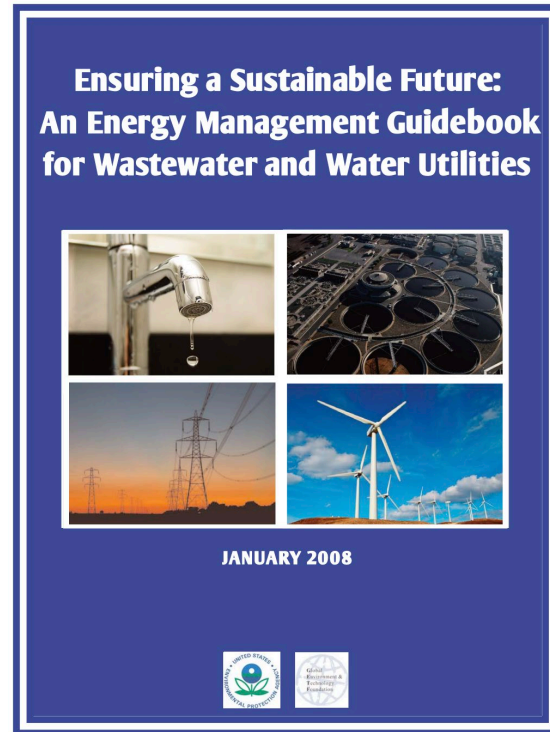


Other Available Resources for EnMS

EPA's Energy Use Assessment Tool



EPA's Guidebook



Energy Data Management Manual



Energy Star Program Partnership Member



Des Moines Water Works General Office Facility has earned the Energy Star. The facility outperforms 82% of similar buildings nationwide and used 32% less energy per square foot than the national median.

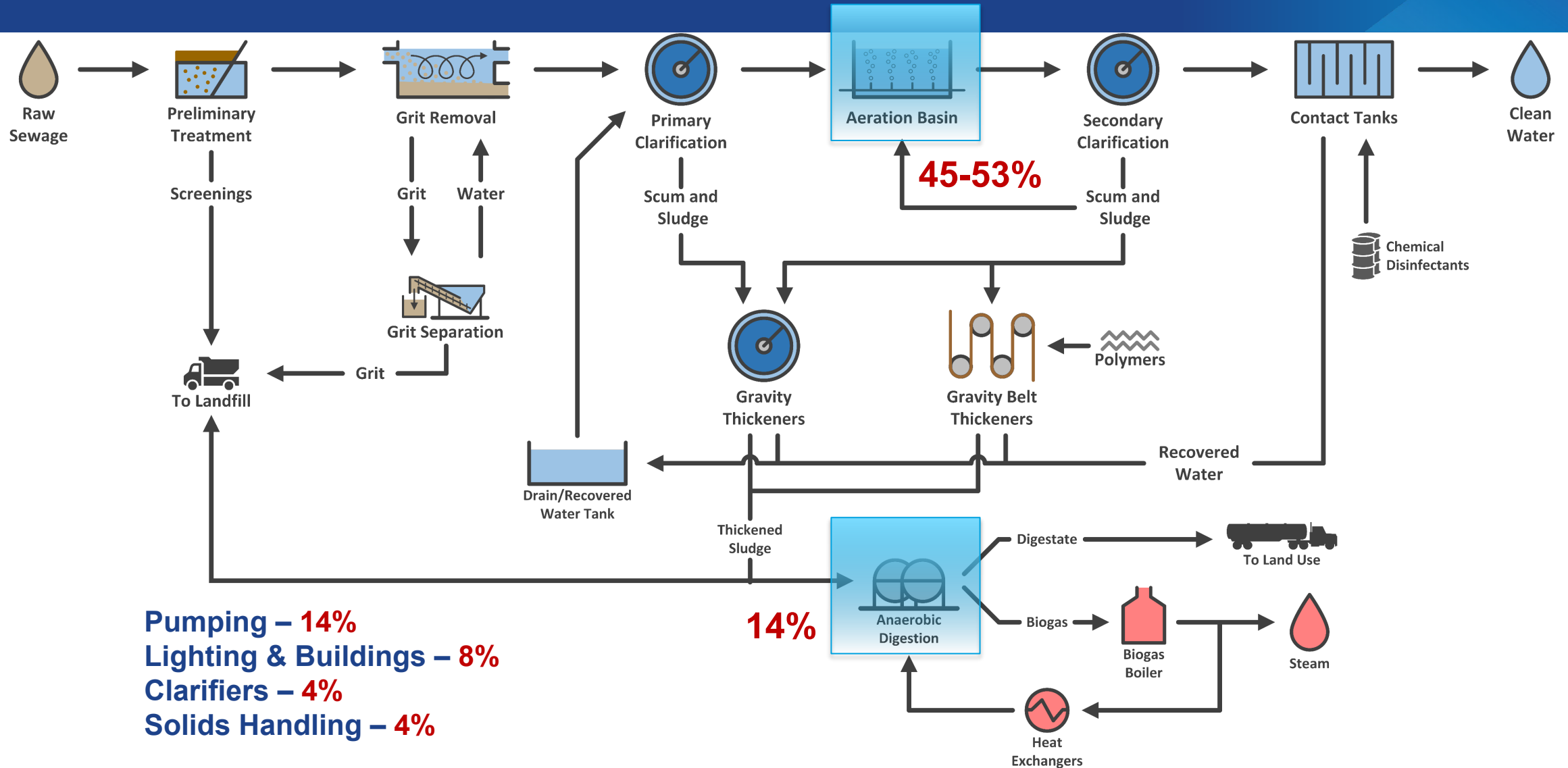


Example Successful Utilities

- City of Santa Cruz, CA
- Des Moines Water Works, IA

Low- to No- cost Energy Efficiency Measures

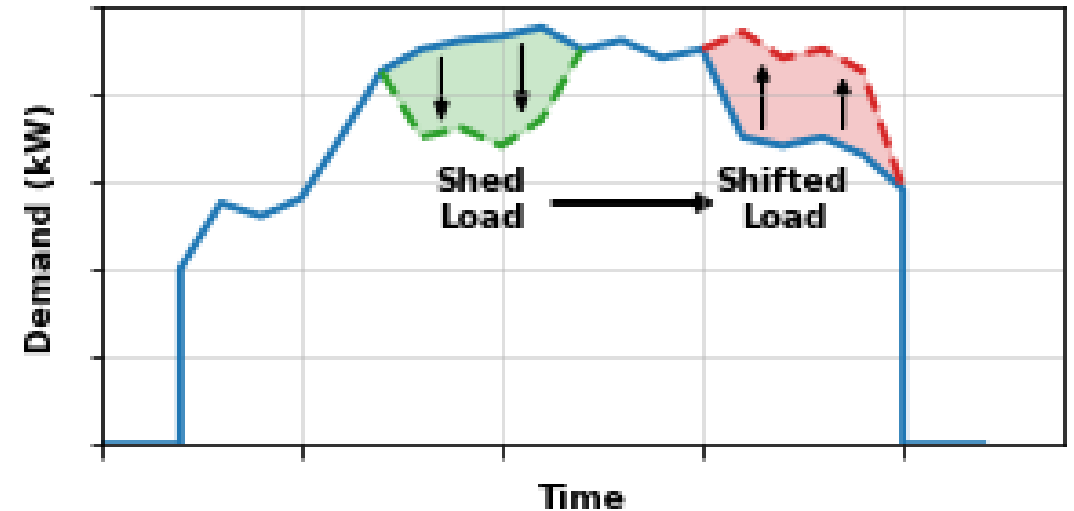
Low- and no-cost energy efficiency practices, and median energy saving opportunities for WRRFs



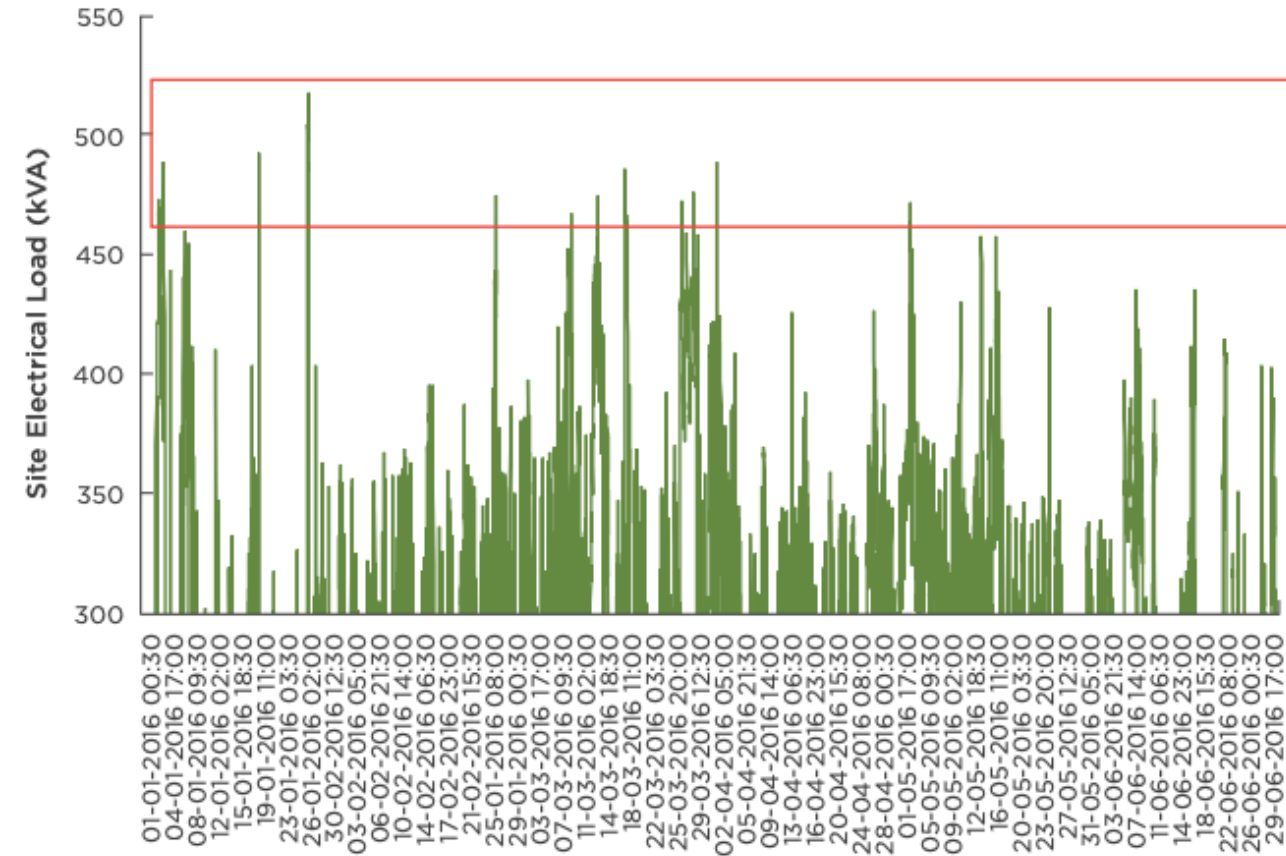
Reference: [Water and Wastewater Treatment Energy Savings Guide](#)

Managing Your Demand

- Lowering your demand costs means managing your facility's load profile
- Two main strategies:
 - 1) **Load Shedding:**
A temporary reduction in demand
 - 2) **Load Shifting:**
A transfer of load to off-peak hours
- Some utilities offer financial **Demand Response** incentives to shed or shift load during times of high grid stress



Electricity & Energy Demand Response



- Shifting demand response for charging energy at different rates
 - Centrifuges & Backwash Pumps
- Identifying Retailer's Peak, Shoulder and off-peak times
- [Use DOE's Energy Performance Indicator \(EnPI\) Tool](#)
 - Establish baseline and variations in energy consumption
- Other Caveats in Energy and electricity bills with the retailers
 - Pay-on-time discounts
 - Metering charge
 - Time-of-use variations

Low- & No-Cost Measures List | ≤ 2-year payback periods

Installation

- ☐ Install timers on light switches and occupancy sensors in little-used areas and adjust for scheduled operations as needed.
- ☐ Install programmable thermostats and use night set-back/setup settings.
- ☐ Turn off unnecessary lighting and install occupancy sensors.
- ☐ Identify and use energy-efficient belts compatible with your facility's equipment.
- ☐ Change aeration blower intake filters regularly to minimize air intake resistance. ¹
- ☐ Use automatic controls when available to optimize equipment, process monitoring, and operations.

Example: Lighting Replacement

A WWTP operates 24 hours a day, 7 days a week.

- The plant has several light fixtures that run continuously, each consuming 100 watts of power.
- The plant management decides to install timers on these light switches so the lights only run 12 hours a day instead of 24 hours.

Given:

1. Power consumption of each light fixture: 100 watts (0.1 kW)
2. Number of light fixtures: 50
3. Current operation time: 24 hours/day
4. New operation time with timers: 12 hours/day
5. Cost of electricity: \$0.12 per kWh

Tasks:

1. Calculate the current daily energy consumption of the light fixtures.
2. Calculate the new daily energy consumption after installing the timers.
3. Determine the daily energy savings.
4. Calculate the daily cost savings.
5. Determine the annual cost savings after installing the timers.

1. Current Daily Energy Consumption:

- Total power consumption per light fixture per day:
 $0.1\text{kW} \times 24\text{hours} = 2.4 \text{ kWh}$
- Total energy consumption for 50 light fixtures:
 $50 \times (0.1 \times 24) \text{ kWh} = 120 \text{ kWh}$

2. New Daily Energy Consumption:

- Total power consumption per light fixture per day with timers:
 $0.1\text{kW} \times 12\text{hours} = 1.2 \text{ kWh}$
- Total energy consumption for 50 light fixtures:
 $50 \times (0.1 \times 12) \text{ kWh} = 60 \text{ kWh}$

3. Daily Energy Savings:

$$120 \text{ kWh} - 60 \text{ kWh} = 60 \text{ kWh}$$

4. Daily Cost Savings:

$$\begin{aligned} &\text{Difference in energy consumption} \times 0.12\text{USD/kWh} \\ &60 \text{ kWh} \times 0.12\text{USD/kWh} = 7.2 \text{ USD} \end{aligned}$$

5. Annual Cost Savings:

$$\begin{aligned} &\text{Daily cost savings} \times 365\text{days} \\ &7.2 \text{ USD} \times 365\text{days} = 2,628 \text{ USD/year} \end{aligned}$$

Low- & No-Cost Measures List | ≤ 2-year payback periods

Assessment

- ☐ Review and assess ventilation requirements to optimize efficiency, reduce space conditioning during non-working hours, and manage space conditioning energy use during non-occupancy times.
- ☐ Assess the potential to remove organics prior to entering the secondary treatment system. Assess the capability for high strength organic dischargers to feed directly to an anaerobic digester.
- ☐ Review operations to identify any pumps or blowers that are being throttled and assess them to determine if they can be adjusted to operate more efficiently.
- ☐ Assess air and water piping systems in need of insulation (exposed piping).
- ☐ Identify equipment speeds and resheave blowers where needed.
- ☐ Consult your energy utility account manager to evaluate rate schedules and determine the most efficient rate for your facility.

Low- & No-Cost Measures List for Operations | \leq 2-year payback periods

- ☐ Test, calibrate, and maintain dissolved oxygen level/sensors in aeration tank(s).²
- ☐ Shift to smaller HP pumps/blowers during nightly low-flow periods or seasonal low-flow periods, if applicable.³
- ☐ Reduce blower pressure to the minimum required through proper maintenance of aeration diffusers and distribution system to minimize head loss. Control the set point in the aeration blower control strategy. Also, identify, assess and repair aeration system air main leaks - (replace gasket, repair corrosion, underground maintenance) and lower aeration tank levels to reduce air header static pressure, if applicable. (May need sensing O₂ level).
- ☐ Turn off equipment when not in use (e.g., turn off aerobic digester blower periodically or operate intermittently).
- ☐ Adjust system operations when there is a change in wastewater load.

Low- & No-Cost Measures List for Operations | \leq 2-year payback periods

- ☐ Raise wet well levels to reduce static head in the pump system. Coordinate all control points (low-level alarm, pump start/stop, high-level alarm) to adjust the wet well level upward. Consider hydraulic profile of the facility when doing so.
- ☐ Eliminate leaks in inert gas and compressed air lines/valves.
- ☐ Operate select aeration tanks as needed while also establishing operating protocols to enable the plant to bring tanks back on line efficiently.
- ☐ Routinely clean UV lamp sleeves to enhance transfer efficiency and decrease the number of UV lamps where/when possible while still meeting disinfection needs.
- ☐ Idle aeration basins/zones, if not needed (periodic maintenance may still be needed).
- ☐ Reschedule plant operations or reduce load to avoid on-peak hours (e.g., operate dewatering equipment during off-peak, load digesters during off-peak, repair equipment, and shift recycling of supernatant to off-peak).

Median energy saving opportunities for WRRFs

Opportunities- Median Energy Savings

Measure	Median Energy Savings (facility-wide/annual, unless otherwise noted)
TECHNOLOGIES	
Dissolved Oxygen (DO) Control	15%
Blower Technologies + Optimization	15%
Emerging Diffuser Technologies	25%
Pumping System Technologies + Optimization	10%
Ultraviolet (UV) Disinfection Systems	13%
Membrane Bioreactors (MBR)	15%
Pure Oxygen (Pure Ox) System	15%
Solar Photovoltaic (PV)	N/A
MANAGEMENT APPROACHES	
Energy Assessments	15%
Real-Time Monitoring & Control	10%
Energy Management Systems	15%
Infiltration/Inflow (I/I) Studies	38% (annual wet weather flow reduction)
Energy Conservation Programs	25%
Rate Structure Management	15%

- Optimum DO Set-point → Reduced Blower Energy
- Optimize mechanical mixing & bubble diffusion
- Upgrade from coarse bubble diffusion to fine bubble diffusion to increase the efficiency and reduce blower load
- Variable Frequency Drives to adjust speeds based on process needs in real time
- Control UV lamps with turbidity sensors
 - Optimizes the number or intensity of operating UV lamps
 - Upgrade to low-pressure high-output UV

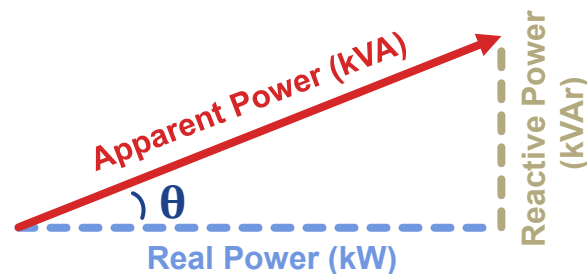
Opportunities- Median Energy Savings

Measure	Median Energy Savings (facility-wide/annual, unless otherwise noted)
PROCESS IMPROVEMENTS	
Ammonia-based Aeration Control (ABAC)	15%
Chemically-enhanced Primary Treatment (CEPT)	10%
Modifying System Operations Seasonally	25%
RESOURCE RECOVERY	
Anaerobic Digestion	25% (equivalent energy generation)
Combined Heat & Power (CHP)	38% (equivalent energy generation)
Heat Recovery	25% (equivalent energy generation)
Biosolids Energy Recovery	\$500,000 (annual cost savings)
Inline Hydropower	25% (equivalent energy generation)
Onsite Water Reuse	30% (annual effluent flow diverted)

- Adjust digester mixing systems to use the minimum number of mixers possible for adequate mixing of influent and a high volume of gas
- Upgrade existing systems such as gas lance or draft tube systems to a linear motion mixing system

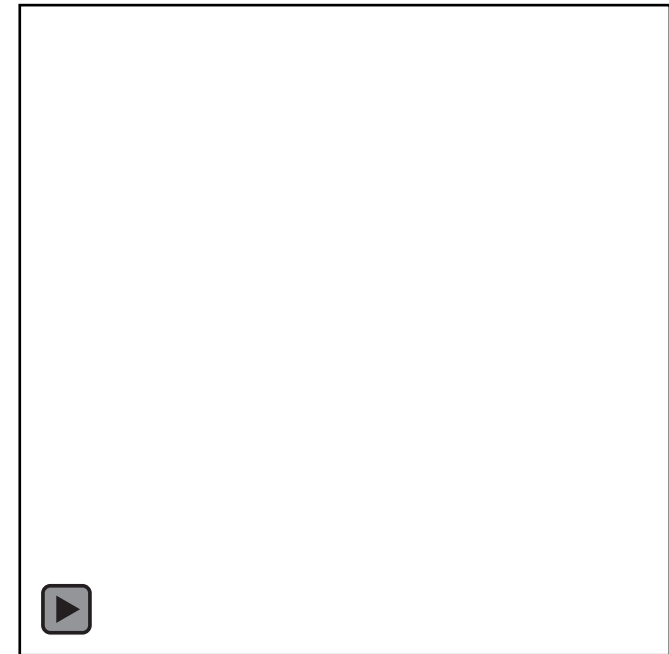
Power Factor Penalties

- **Power Factor (PF)** is inherent to systems supplied with AC power
- **PF** is a number between 0.0 and 1.0
- Instantaneous power has two parts:
 - Real Power (kW) – Does work!
 - Reactive Power (kVAr) – Does no work!
- Utilities penalize facilities with low **PF**
 - Must deliver extra **Apparent Power (S)**



$$S = \sqrt{P_{avg}^2 + Q^2}$$
$$PF = \frac{P_{avg}}{S} = \cos(\theta)$$

Example: 100 kW of Real Power
➤ Watch Apparent Power as PF decreases...

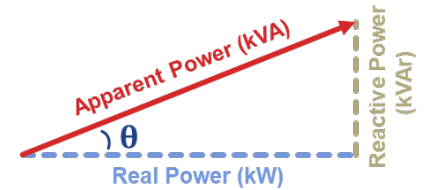


Managing Power Factor

- **Power Factor** is the ratio of real power (kW) to apparent power (kVA)
 - When the power factor is low, the apparent power is higher for the same amount of real power
 - Utilities often charge based on apparent power, so improving the power factor reduces the kVA demand.
- **Power Factor Correction (PFC) System**
 - Minimize costs associated with the switch to demand-based charges
 - Improves power factor and reduce monthly peak kVA demands
 - Reduction in Reactive Power Charges
 - Some utilities charge for reactive power (kVAR) separately or impose penalties for low power factors.
 - Installing a PFC system reduces the reactive power, which can eliminate these penalties or charges.
 - Improved Energy Efficiency
 - Reduces losses in the electrical system by minimizing the current flow.
 - Lower current flow means reduced losses in cables, transformers, and other electrical components, leading to better overall energy efficiency.
 - Increased Capacity
 - Electrical system can deliver more real power without increasing the current.
 - This means that existing infrastructure can handle more load without requiring upgrades, indirectly saving costs
 - Avoidance of Utility Penalties
 - Many utilities impose penalties for maintaining a power factor below a certain threshold (e.g., 0.90)

Power Factor Penalties

- PF is usually listed on your bills
- PF penalties are rarely listed directly on your bills
- Penalties depend on how you are billed for demand:



Billed for Real Power (kW)

$$\text{PF Adjusted Demand (AD)} = RD \times \frac{PF_{req}}{PF}$$

$$\text{PF Penalty} = C_d \times (AD - RD)$$



Penalized only if $PF \leq PF_{req}$

Billed on Apparent Power (kVA)

$$\text{PF Penalty} = C_d \times (BD - RD)$$

$$\text{PF Penalty} = C_d \times BD \times (1 - PF)$$



Penalized for any $PF < 1$

How Much Does Low PF Cost?

- Consider a facility whose average PF is 0.85 ($PF_{avg} = 0.85$)
- Utility requires a minimum PF of 0.95 ($PF_{req} = 0.95$)
- Demand cost is \$8/kW with no ratchet clause ($C_d = \$8/kW$)
- Average billed demand is 2,000 kW ($BD_{avg} = 2,000 \text{ kW}$)

$$\text{Real Demand } (RD_{avg}) = BD_{avg} \times \frac{PF_{avg}}{PF_{req}} = 1,790 \text{ kW}$$

$$\text{PF Penalty} = C_d \times (BD_{avg} - RD_{avg}) \times 12 = \text{\textcolor{red}{\$20,160/yr}}$$

How Do You Fix Low PF?

- Nearly all facilities have low PF because of large motors used in their production process
- Windings act as large inductors causing current lag
- Install capacitor banks to offset inductive loads
- Two types of capacitors:
 - 1) Static (\$)
 - 2) Dynamic (\$\$)
- Fix baseload phase difference with static capacitors
- Fix remaining difference with dynamic capacitors



Wikimedia Commons

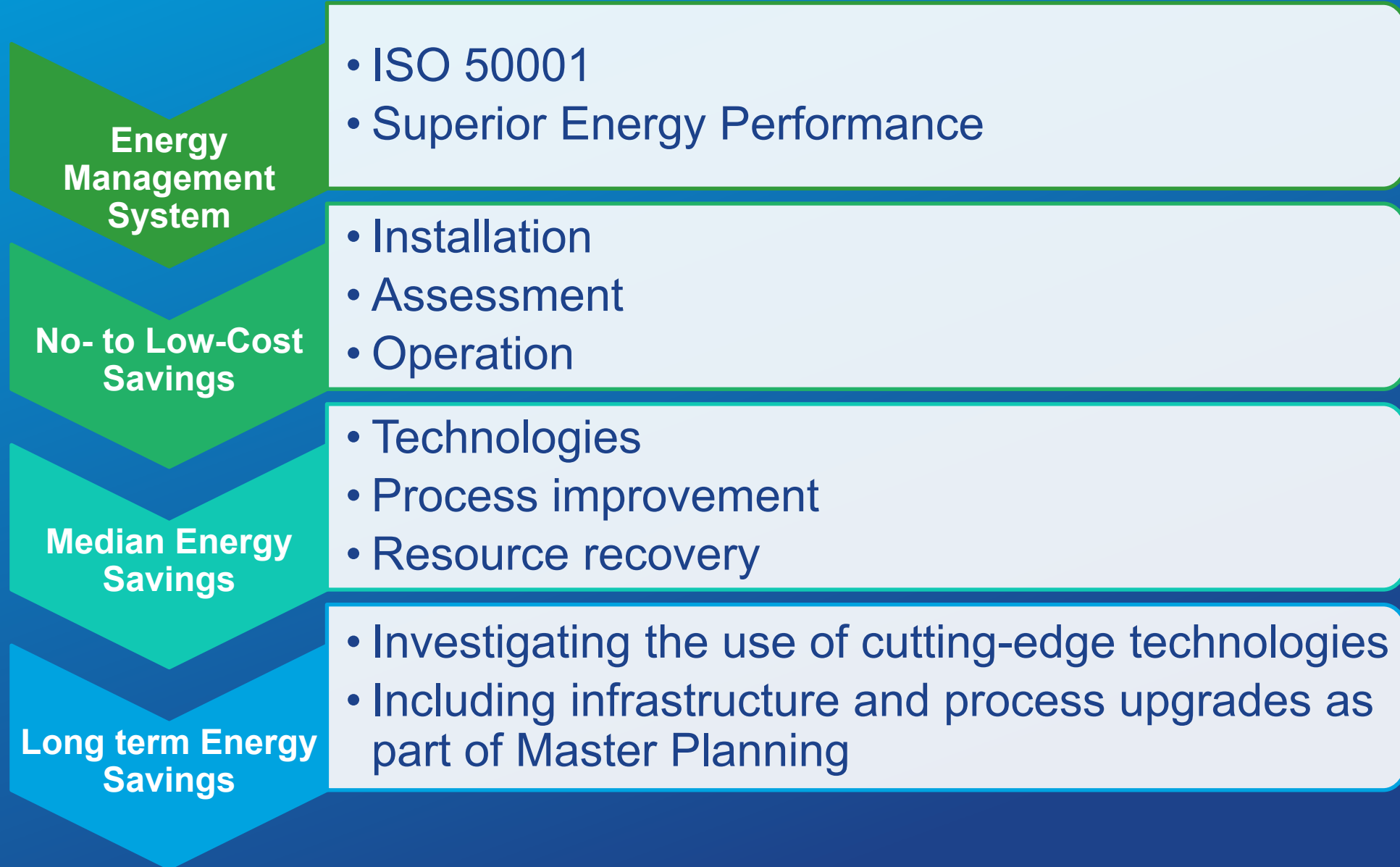
Pumping System Improvements

- Improve controls – to more efficiently deliver the required output
- Modify pumps – to better match the required conditions
- Replace or upgrade equipment – use more efficient technology or more suitable equipment
- Re-design the system – to minimize friction losses, static pressure or required flow rate

Secondary Improvements: Optimize Return Activated Sludge (RAS) Flow Rate

- Purpose of RAS is to re-seed incoming sewage with the activated sludge biomass needed for treatment
- RAS is pumped from the bottom of clarifiers to the bioreactors
 - mixing and aeration of biomass with influent sewage takes place
- Higher RAS rate = higher microbial activity = higher air consumption = higher energy consumption
- To minimize the required RAS pumping rate while ensuring sufficient microbial activity to treatment C and N

Wrapping Up Energy Efficiency



Zoom Poll Technology Queries



Break

Tools to Evaluate Energy and Efficiency Measures

DOE Industrial Software Tools

Help energy and sustainability teams identify opportunities for energy and emission savings in their operations.

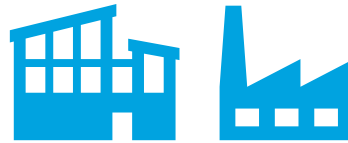
Energy Systems



MEASUR

Electrification for Decarbonization
Compressed Air Scoping Tool

Energy Management



VERIFI

50001 Ready Navigator
Energy Footprint Tool
Plant Energy Profiler
Implementation Guidance Toolkit

Carbon, Water, & Waste



Plant Water Profiler
Plant Carbon Footprint &
Decarbonization Assessment Tool
Carbon Emissions Calculator
Waste Stream Energy Content

MEASUR

Helps identify, assess, and quantify energy savings and decarbonization opportunities in their manufacturing operations and energy support systems.

- Energy savings analysis
 - Open source
 - Cross-platform tool
 - Technology and vendor agnostic
- Key User Features
 - Similar workflow for all assessment modules
 - Graphs & Figures!
 - Easy unit system switching and translation functionality
 - Accessible help text and examples



Find this tool at
<https://measur.ornl.gov>
<https://www.energy.gov/eere/amo/measur>

MEASUR

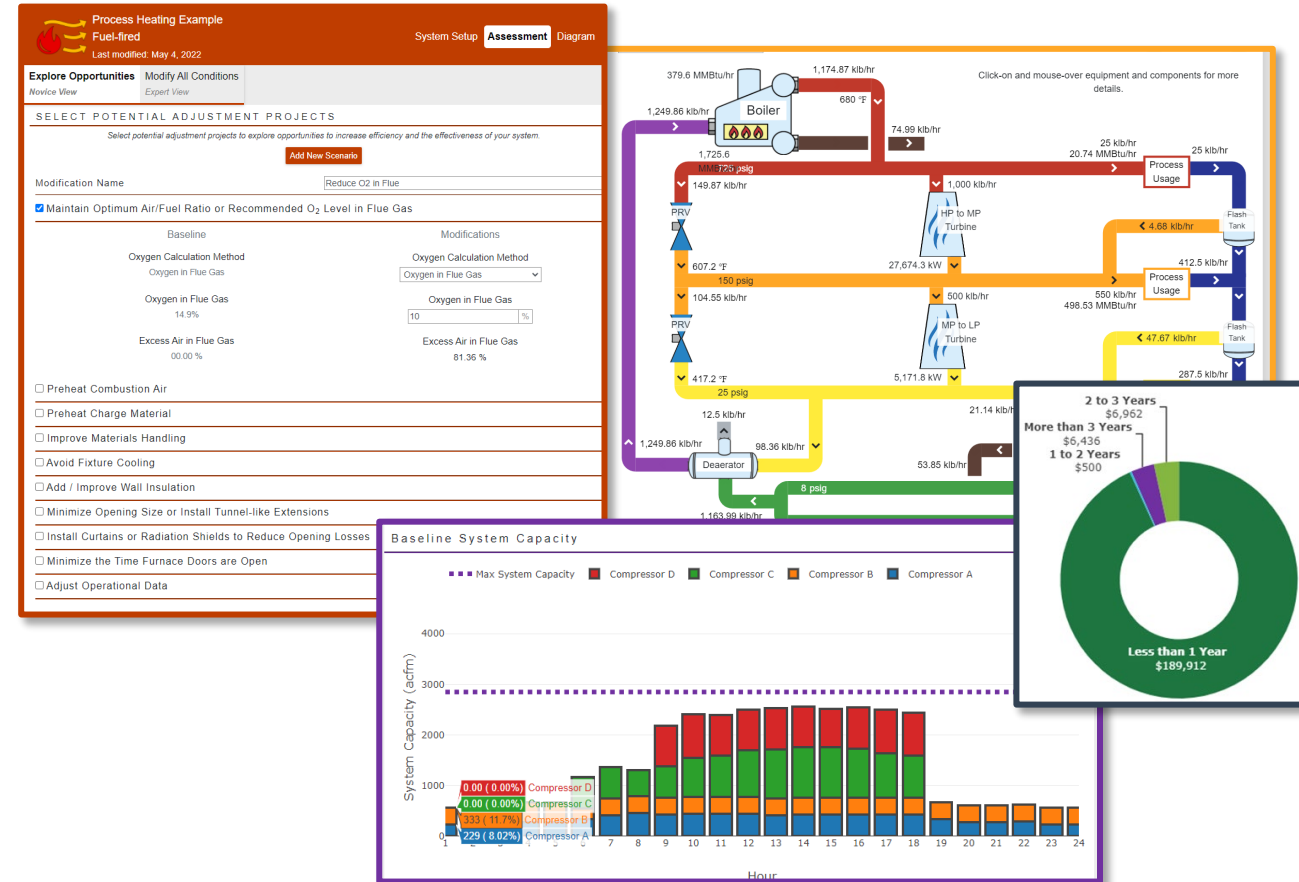
Has 7 industrial system assessment modules, plus equipment inventory and data analysis modules, and over 70 standalone calculators!

Assessment Modules

- Pumps, Fans, Process Heating, **Compressed Air**, Steam, **Wastewater**, and Treasure Hunt
- Baseline and What-if Analyses (Novice & Expert Views)
- Explore energy, cost, and **carbon emissions** impact of projects

Other Modules

- **Motor Inventory** (others coming soon)
- **Data Analysis** (day type & visual analyses)



Find this tool at
<https://measur.ornl.gov>
<https://www.energy.gov/eere/amo/measur>

MEASUR – Getting Started

- ➡ Start an assessment
- ➡ Create an inventory
- ➡ View Assessment Dashboard
- ➡ Use Properties & Equipment Calculators
- ➡ Help and User Experience
 - Change Settings
 - View Tutorials
 - Manage Custom Materials
 - Provide Feedback
 - Translate

The screenshot shows the MEASUR web application interface. On the left is a sidebar with the U.S. Department of Energy logo and a navigation menu. The main content area features a large 'MEASUR' title, a welcome message, and a grid of icons for various assessment and inventory tools. Colored arrows from the text on the left point to specific elements: a blue arrow points to the 'Add New' button; a red arrow points to the 'All Assessments' link; a yellow arrow points to the 'Data Exploration' link; an orange arrow points to the 'Settings' link; a blue arrow points to the 'View Assessments' icon; a yellow arrow points to the 'Equipment Calculators' icon; and a green arrow points to the 'Motor Inventory' icon.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

MEASUR

Welcome to the most efficient way to manage and optimize your facilities' systems and equipment.

Create an assessment to model your system and find opportunities for efficiency or run calculations from one of our many property and equipment calculators. Get started with one of the following options.

If you need help at any point along the way, click on a [User Manual](#) icon.

View Assessments **Equipment Calculators**

Pump Assessment **Compressed Air Assessment** **Process Heating Assessment** **Fan Assessment** **Steam Assessment** **Treasure Hunt** **Wastewater Assessment** **Motor Inventory**

Data Exploration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Clearing your browser cache DELETES online assessments

MEASUR - Assessments

Fan 1
Last modified: Nov 15, 2021

System Setup Assessment Diagram Report Sankey Calculators

1 Assessment Settings 2 Operations 3 Fan and Fluid 4 Motor 5 Field Data

MOTOR

Line Frequency: 60 Hz
Rated Motor Power: 500 hp
Motor RPM: 1785
Efficiency Class: Energy Efficient
Rated Voltage: 480 V
Full Load Amps: 557.95

HELP

Motor Help
Enter measured data to calculate your system's annual savings potential.

Motor RPM
Motor RPM is the nameplate speed of the motor.

This value is used with the line frequency to determine the number of motor poles. This, in turn, is used (along with motor class and size) to estimate motor efficiency and output shaft power for the measured electrical power or current conditions.

Standard and Energy Efficient Motors

Motor Size	Minimum	Maximum
60 Hz	540 rpm	3600 rpm
50 Hz	450 rpm	3000 rpm

Premium Efficient Motors

Motor Size	Minimum	Maximum
60 Hz	1050 rpm	3600 rpm
50 Hz	900 rpm	3000 rpm

Create a baseline
Enter data about current
system setup

1

Create an assessment
Modify key variables to create
What-if scenarios and compare

2

Cooling Pump 2
Last modified: Sep 23, 2020

System Setup Assessment Diagram Report Sankey Calculators

Explore Opportunities Modify All Conditions

SELECT POTENTIAL ADJUSTMENT PROJECTS

Modification Name: Improve Vent, Motor and Pump (E)

1) Install More Efficient Drive

Baseline Motor Drive: V-Fed Drive
Modification Motor Drive: Direct Drive

2) Install More Efficient Pump

Baseline Pump Type: End Suction ANSI/API
Modification Pump Type: End Suction ANSI/API
Pump Efficiency: 88.72 %

3) Reduce System Flow Rate

4) Reduce System Head Requirement

5) Adjust Operational Data

6) Install More Efficient Motor

Baseline Efficiency Class: Standard Efficiency
Modification Efficiency Class: Premium Efficient

RESULTS

Percent Savings (%)

Pump efficiency (%)	63.5
Motor shaft power (hp)	200
Motor shaft power (kW)	142
Pump shaft power (hp)	138.3
Motor efficiency (%)	83.8
Motor power factor (%)	82.9
Percent Loaded (%)	71
Drive efficiency (%)	96
Motor current (amps)	164.1
Motor power (kW)	113
Annual Energy (kWh)	990
Annual Energy Savings (kWh)	—
Annual Cost	\$49,014
Annual Savings	—

Process Heating - Fuel Example
Fuel-fired
Last modified: Sep 23, 2020

System Setup Assessment Diagram Report Sankey Calculators

Explore Opportunities Modify All Conditions

OPERATIONS

BASELINE

Operating Hours: 8912
Fuel Costs: \$5.00/MMBtu
Steam Costs: \$5.00/MMBtu
Electricity Costs: \$0.05 \$/kWh
Implementation Cost: \$

ALL OPPORTUNITIES

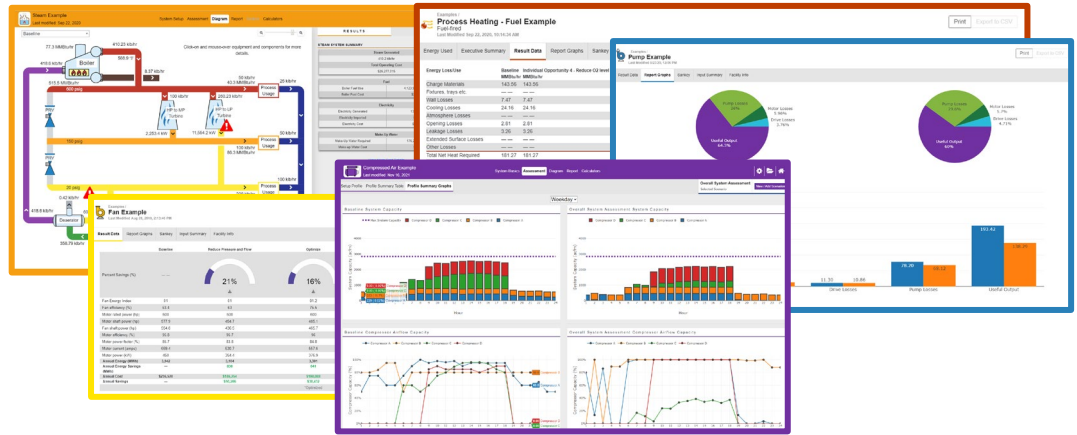
Operating Hours: 8912
Fuel Costs: \$5.00/MMBtu
Steam Costs: \$5.00/MMBtu
Electricity Costs: \$0.05 \$/kWh
Implementation Cost: \$

RESULTS

Energy Loss/Line	Baseline MMBtu/hr	All Opportunities MMBtu/hr
Charge Materials	143.36	128.20
Features, trays, etc.	—	—
Wall Losses	7.47	3.50
Cooling Losses	24.16	24.16
Extended Surface Losses	—	—
Opening Losses	2.81	1.56
Leakage Losses	3.26	1.63
Other Losses	—	—
Total Net Heat Required	151.27	129.06
Available Heat (%)	59.21	64.0%
Fuel Gas Losses	124.42	89.60
Exothermic Heat from Process	—	—
Gross Heat Input	206.09	248.65

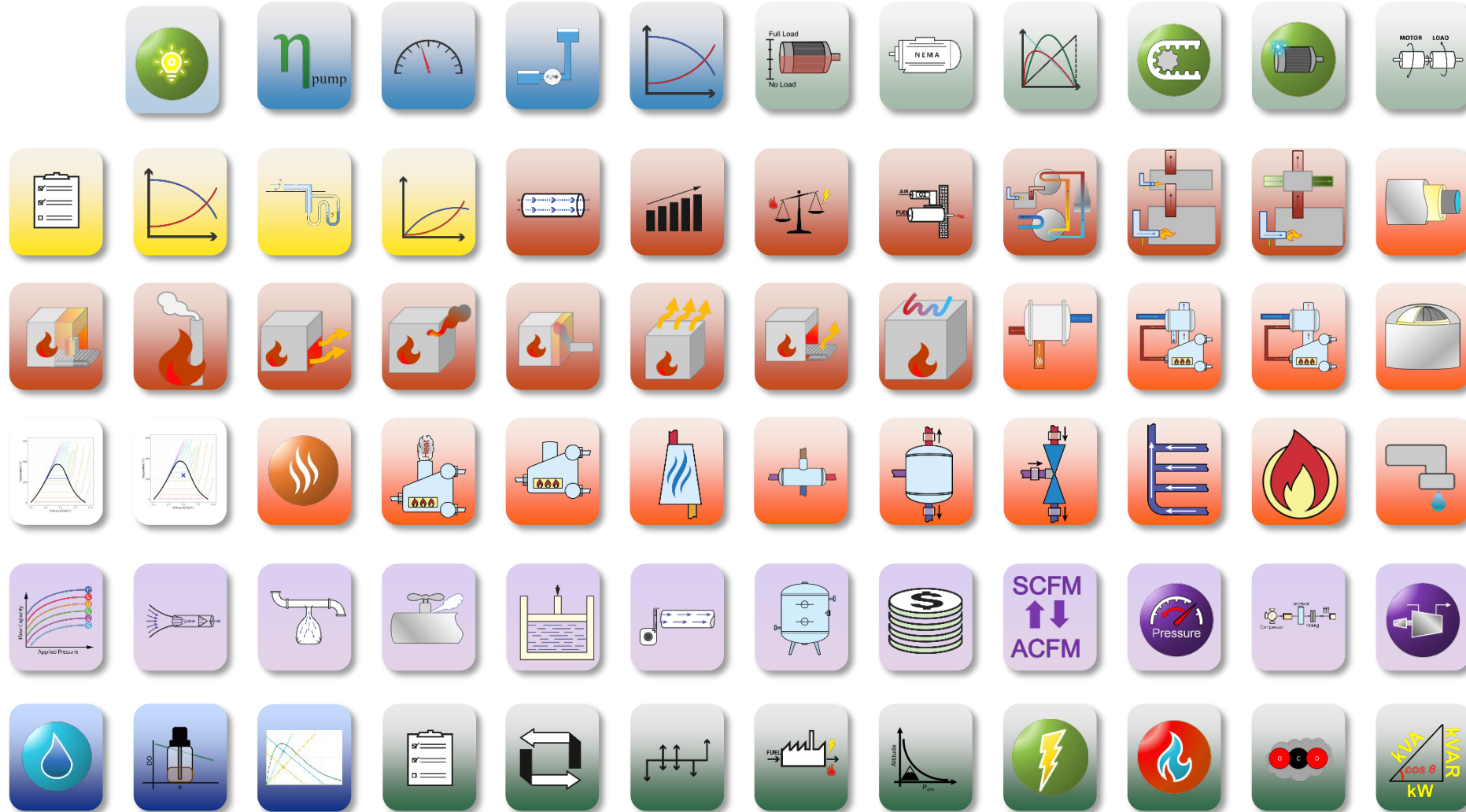
Review Results

3



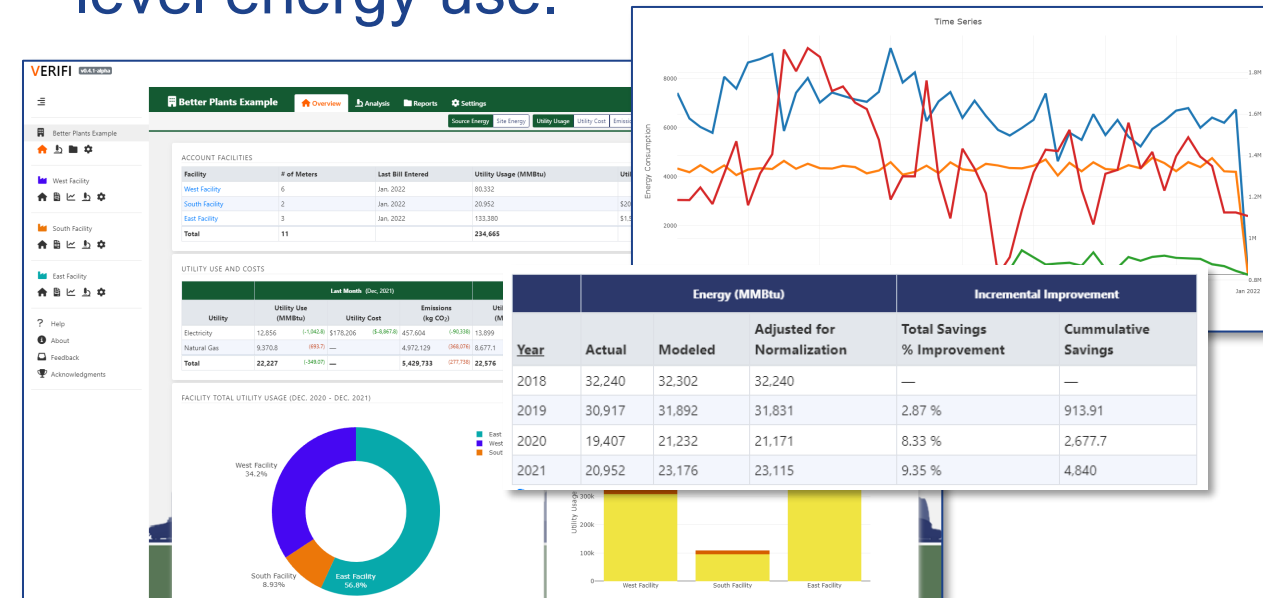
MEASUR - Calculators

- 70+ Stand alone Calculators
 - Motors
 - Pumps
 - Fans
 - Process Heating
 - Process Cooling
 - Steam
 - Compressed Air
 - Lighting
 - General
- Most have graphical results



- Corporate and facility-level views
- Enter utility bills and see total energy use in a new way
 - Calendarization of energy data
 - Annual cost, energy use, and limited carbon emissions overview
- Analyze your data and generate a Better Plants Annual Reporting Form or other custom reports
- Available for “Beta” testing
 - Will replace EnPI tool and other DOE facility-level utility analysis tools
 - Updates currently about every two weeks
 - Updates may impact functioning of existing data

Will help energy management and decarbonization teams track and understand their facility and corporate level energy use.

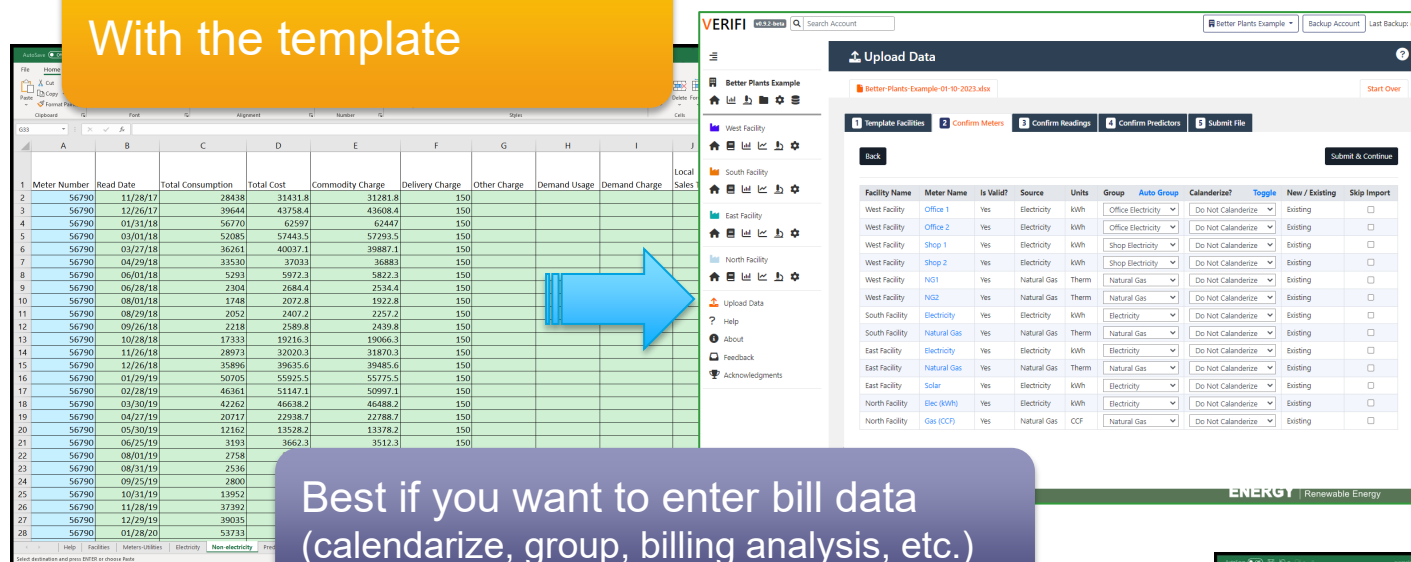


Find this tool at
<https://verifi.ornl.gov/>
<https://github.com/ORNL-AMO/VERIFI/releases>

VERIFI – Entering Data

There are several ways to enter data into VERIFI

With the template

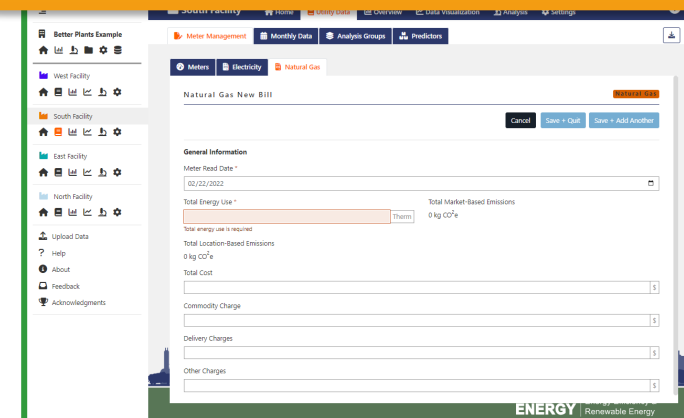


The screenshot shows the 'Upload Data' interface in VERIFI. It features a sidebar with facility selection options (West, South, East, North) and a main table listing facilities and their associated meters. The table columns include Facility Name, Meter Name, Is Valid?, Source, Units, Group, Auto Group, Calendarize?, Toggle, New / Existing, and Skip Import. A blue arrow points from the 'With the template' text to the 'Upload Data' interface.

Facility Name	Meter Name	Is Valid?	Source	Units	Group	Auto Group	Calendarize?	Toggle	New / Existing	Skip Import
West Facility	Office 1	Yes	Electricity	kWh	Office Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
West Facility	Office 2	Yes	Electricity	kWh	Office Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
West Facility	Shop 1	Yes	Electricity	kWh	Shop Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
West Facility	Shop 2	Yes	Electricity	kWh	Shop Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
West Facility	NG1	Yes	Natural Gas	Therm	Natural Gas		Do Not Calendarize		Existing	<input type="checkbox"/>
West Facility	NG2	Yes	Natural Gas	Therm	Natural Gas		Do Not Calendarize		Existing	<input type="checkbox"/>
South Facility	Electricity	Yes	Electricity	kWh	Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
South Facility	Natural Gas	Yes	Natural Gas	Therm	Natural Gas		Do Not Calendarize		Existing	<input type="checkbox"/>
East Facility	Electricity	Yes	Electricity	kWh	Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
East Facility	Natural Gas	Yes	Natural Gas	Therm	Natural Gas		Do Not Calendarize		Existing	<input type="checkbox"/>
East Facility	Solar	Yes	Electricity	kWh	Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
North Facility	Elec (kWh)	Yes	Electricity	kWh	Electricity		Do Not Calendarize		Existing	<input type="checkbox"/>
North Facility	Gas (CCF)	Yes	Natural Gas	CCF	Natural Gas		Do Not Calendarize		Existing	<input type="checkbox"/>

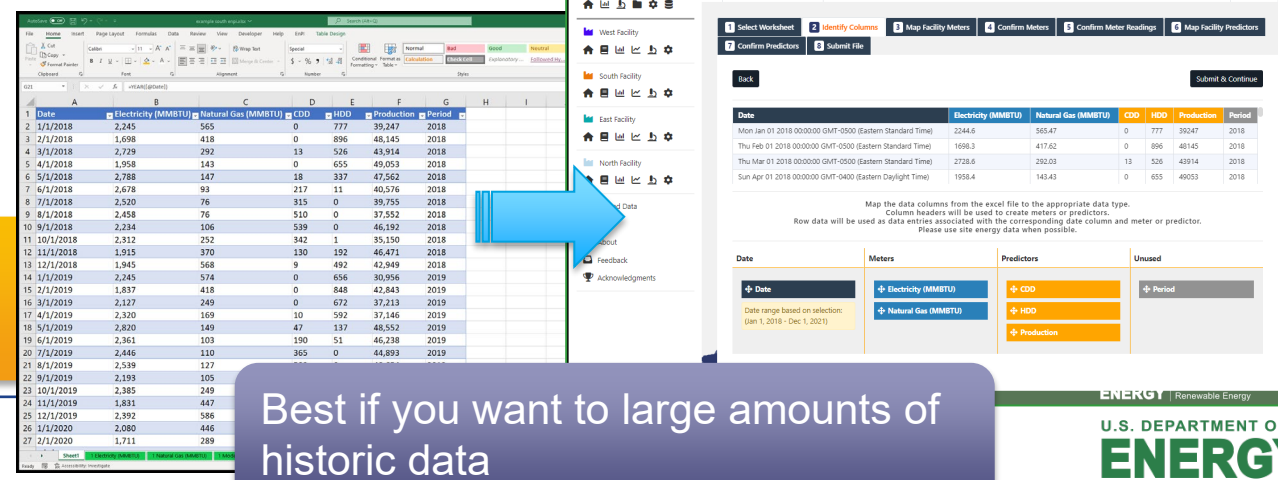
Best if you want to enter bill data (calendarize, group, billing analysis, etc.)

Enter each bill individually (best when maintaining)



The screenshot shows the 'Meter Management' interface in VERIFI, specifically the 'Natural Gas New Bill' form. It includes fields for 'Meter Read Date', 'Total Energy Use', 'Total Market-Based Emissions', 'Total Cost', 'Commodity Charge', 'Delivery Charges', and 'Other Charges'. A blue arrow points from the 'Enter each bill individually' text to the 'Meter Management' interface.

Directly enter old EnPI files



The screenshot shows the 'Upload Data' interface in VERIFI, displaying a large table of historic data. The table columns include Date, Electricity (MMBTU), Natural Gas (MMBTU), CO2, H2O, Production, and Period. A blue arrow points from the 'Directly enter old EnPI files' text to the 'Upload Data' interface.

Date	Electricity (MMBTU)	Natural Gas (MMBTU)	CO2	H2O	Production	Period
1/1/2018	2,245	565	0	777	39,247	2018
2/1/2018	1,698	418	0	896	48,145	2018
3/1/2018	2,729	292	13	526	43,914	2018
4/1/2018	1,958	143	0	655	49,053	2018
5/1/2018	2,788	147	18	337	47,562	2018
6/1/2018	2,678	93	217	11	40,576	2018
7/1/2018	2,520	76	315	0	39,755	2018
8/1/2018	2,458	76	510	0	37,552	2018
9/1/2018	2,234	106	539	0	46,192	2018
10/1/2018	2,312	252	842	1	35,150	2018
11/1/2018	1,915	370	130	192	46,471	2018
12/1/2018	1,945	568	9	492	42,949	2018
1/1/2019	2,245	574	0	656	30,956	2019
2/1/2019	1,837	418	0	848	42,843	2019
3/1/2019	2,127	249	0	672	37,213	2019
4/1/2019	2,320	169	10	592	37,146	2019
5/1/2019	2,820	149	47	137	48,552	2019
6/1/2019	2,361	103	190	51	46,238	2019
7/1/2019	2,446	110	365	0	44,893	2019
8/1/2019	2,539	127				
9/1/2019	2,193	105				
10/1/2019	2,385	249				
11/1/2019	1,831	447				
12/1/2019	2,392	586				
1/1/2020	2,080	446				
2/1/2020	1,711	289				

Best if you want to large amounts of historic data

VERIFI – Savings Analysis

1 Setup basic info

Pick a useful name!!

Analysis Setup

Name: South Analysis Baseline Year: 2018

Energy displayed as site or source? ☒ Source Energy ☐ Site Energy

Reporting Year: ☐ Calendar Year ☐ Fiscal Year

Energy Unit: Million British Thermal Units (MMBTU)

Report Year: 2021

Choose Analysis Type

2

Natural Gas Setup

1. Select Analysis Type

- ☐ Absolute Energy Consumption
- ☐ Energy Intensity
- ☐ Modified Energy Intensity
- ☒ Regression

2. Add Baseline Adjustment

Has Baseline Adjustment ☐

3. Regression Model

Use "Regression Model" tab to setup the regression model for this group.

3

Regression made easy!

Natural Gas Regression Model

Select Modeling Method: Calculate Models [Update Models]

Current Models Generated: 1/10/23, 3:41 PM

Show Invalid Models: ☐

Select Model	Model Year	Variable p-Values	R2	Adjusted R2	Model p-Value	Formula	Model Notes
<input checked="" type="radio"/>	2021	HDD: 0.00	0.582	0.540	0.00	$102 + (0.429 \times \text{HDD})$	No production variable in model
<input type="radio"/>	2021	Production: 0.01	0.553	0.508	0.01	$880 + (-0.0219 \times \text{Production})$	Production coef < 0
<input type="radio"/>	2018	HDD: 0.01 Production: 0.17	0.591	0.500	0.02	$901 + (0.603 \times \text{HDD}) + (-0.0186 \times \text{Production})$	Production coef < 0 Adjusted R2 < .5
<input type="radio"/>	2020	CDD: 0.02 Production: 0.09	0.583	0.490	0.02	$160 + (-0.435 \times \text{CDD}) + (0.00550 \times \text{Production})$	CDD coef < 0 Adjusted R2 < .5

4

View results!



5

Roll up to corporate level!

Better Plants Example

Analysis Setup Select Facility Items Analysis Results Reports Settings Custom Data

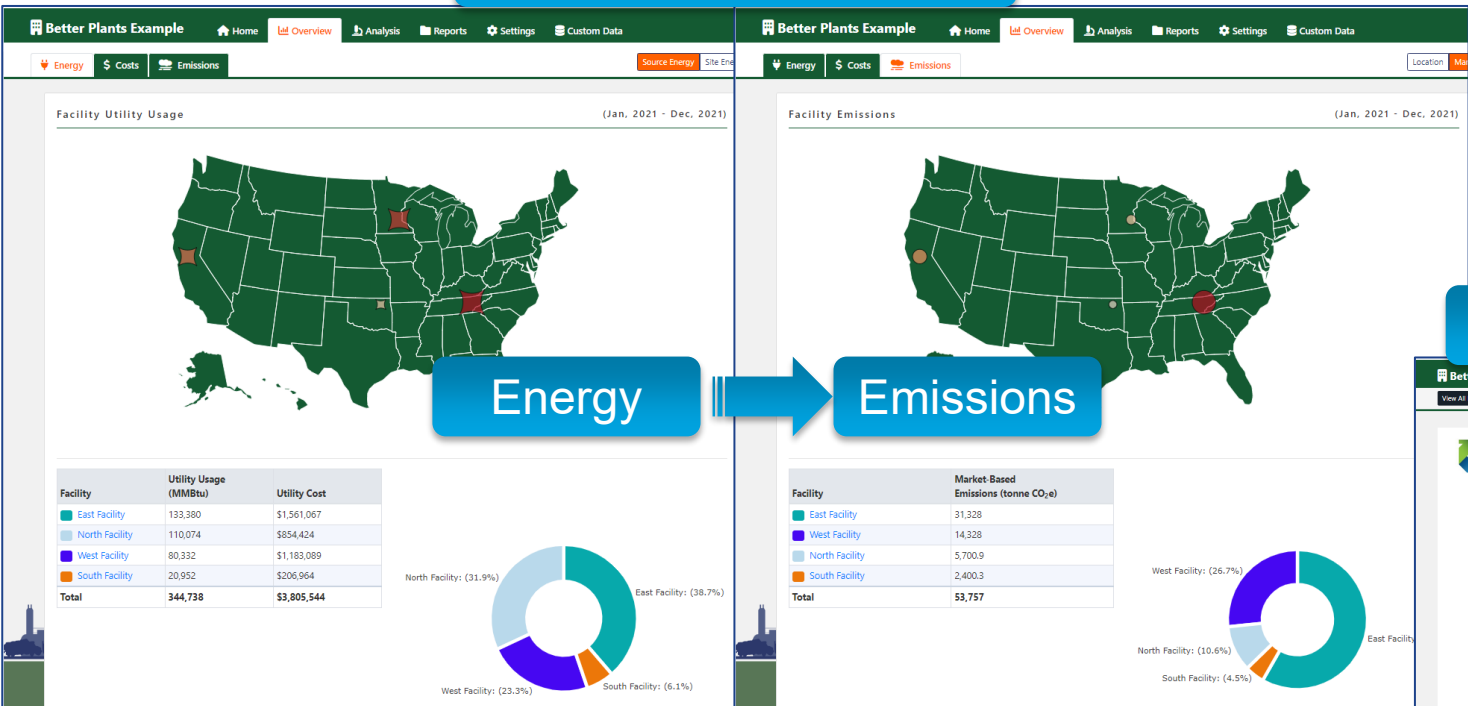
West Facility South Facility East Facility North Facility

South Facility Analysis Items

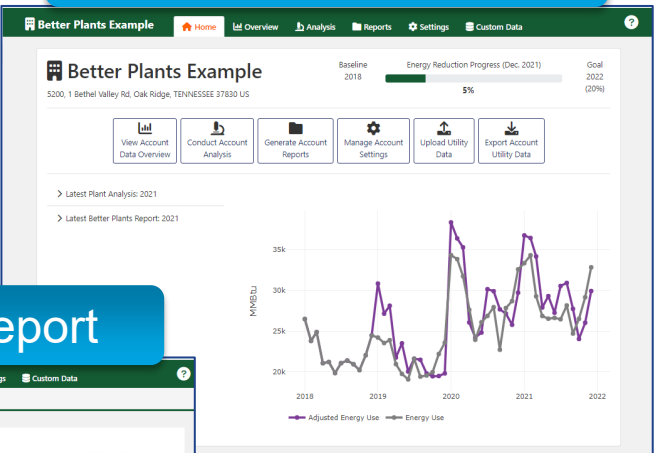
Analysis Item	Group Analysis	Last Modified
<input checked="" type="radio"/> South Analysis	Electricity: Energy Intensity Natural Gas: Regression	1/10/23, 3:41 PM
<input type="radio"/> Skip Facility		

VERIFI – Dashboards & Reports

Overview Dashboard



Home Dashboard



Better Plants Report

The Better Plants Report is an Annual Reporting Form for Better Buildings Better Plants. It includes contact information and a table of energy and emissions data.

Annual Reporting Form
BETTER BUILDINGS BETTER PLANTS

GENERATED BY VERIFI

Better Plants Example
5200, 1 Bethel Valley Rd Oak Ridge, TENNESSEE 37830 US

Contact Information
Name: —
Phone: —
Email: —

	Baseline Year 2018	Report Year 2021
Number of Participating Plants*	3	4
Primary Energy Consumed (MMBtu)		
Electricity	184,028	236,011
Natural Gas	83,254	108,728
Total Primary Energy Consumed (MMBtu)	267,282	344,738
Weather/Production/Other Normalizing related Adjustment for Baseline Primary Energy (+/- MMBtu)	93,708	
Baseline Adjustment Due to Increase/Decrease in the Number of Facilities Reporting Relative to Baseline Year or Other Operational Changes (+/- MMBtu)	0	
Adjusted Baseline of Primary Energy (MMBtu)	360,990	
New Energy Savings for Current Year (MMBtu)		4,936.8
Total Energy Savings since Baseline Year (MMBtu)		16,251
Annual Improvement in Energy Intensity for Current Year (%)**		1.32 %
Total Improvement in Energy Intensity (%)**		4.5 %

*Participating plants should be only include those located in the United States.
**Please refer to the DOE's Energy Baseline Guidance document to determine changes in intensity; improvement in performance should be reported as a positive number.

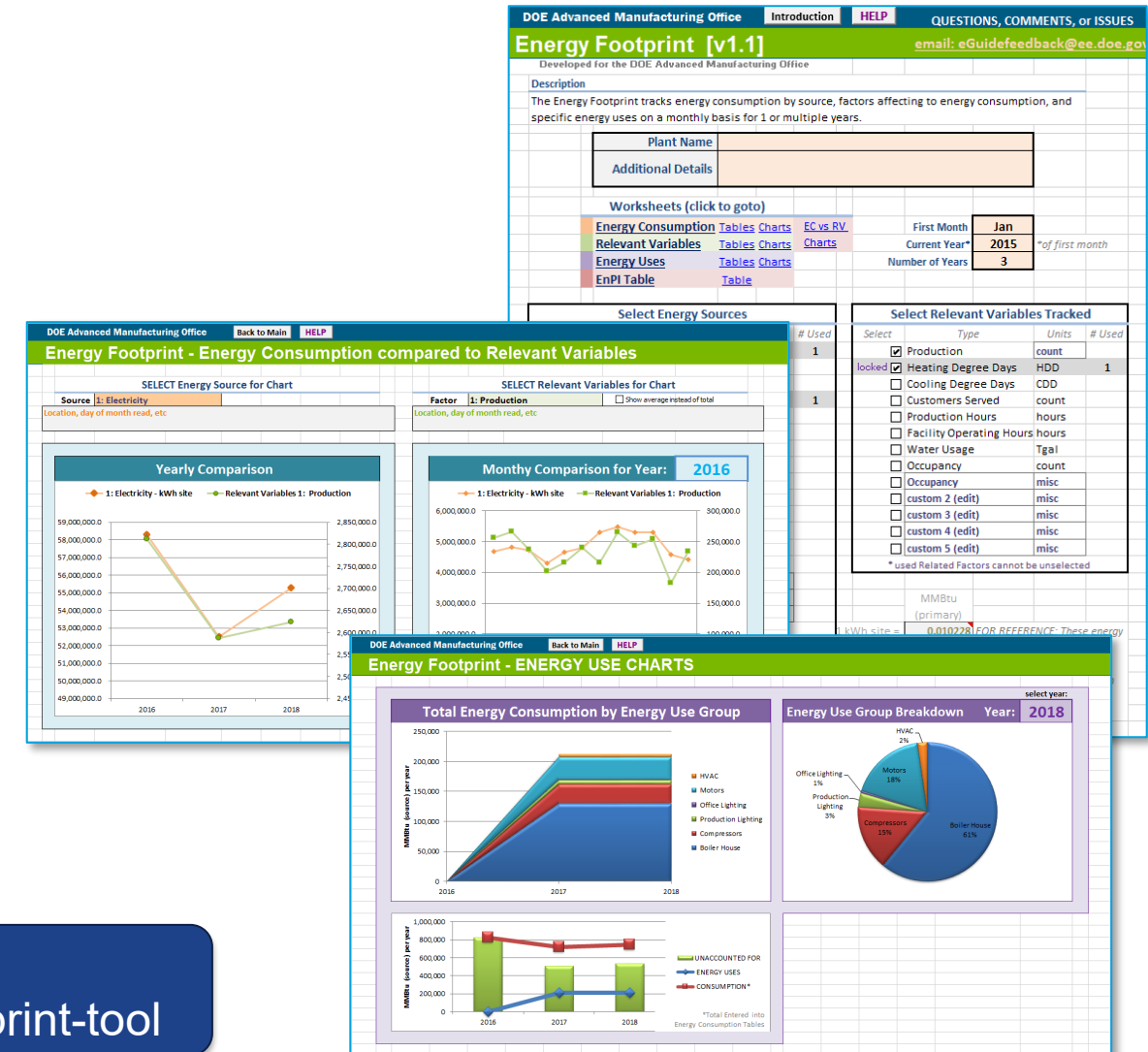
More Features
& Reports to
come!!!

- Several Dashboards & Reports to help keep an eye on energy, costs, and decarbonization efforts

Plant Energy Footprint Tool

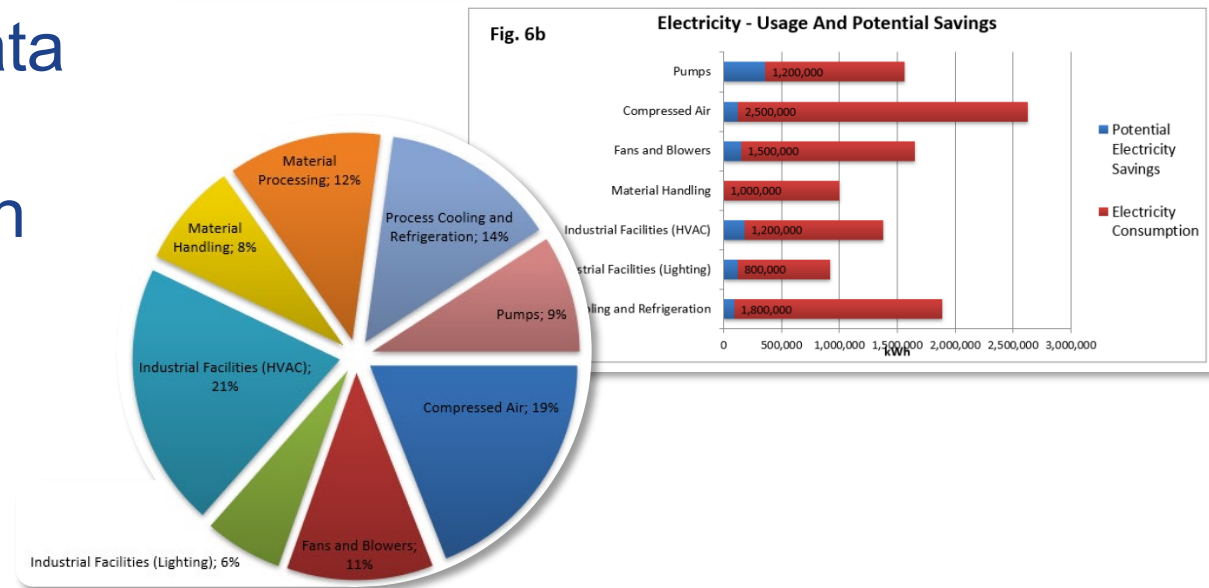
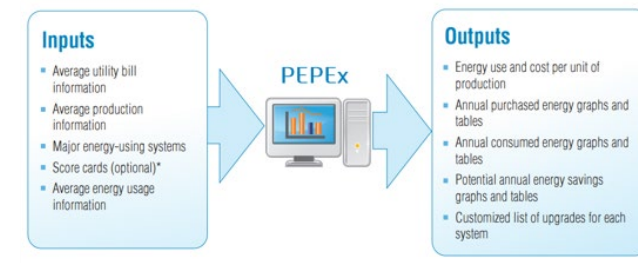
- Helps commercial and industrial facilities understand their energy consumption
 - Track energy consumption
 - Track relevant variables affecting energy consumption
 - Identify significant energy users
 - Discover trends and learn where to focus your efficiency efforts
 - Requires MS Excel and enabling macros

Find this tool at
<https://www.energy.gov/eere/amo/articles/energy-footprint-tool>



Plant Energy Profiler Tool (PEPEX)

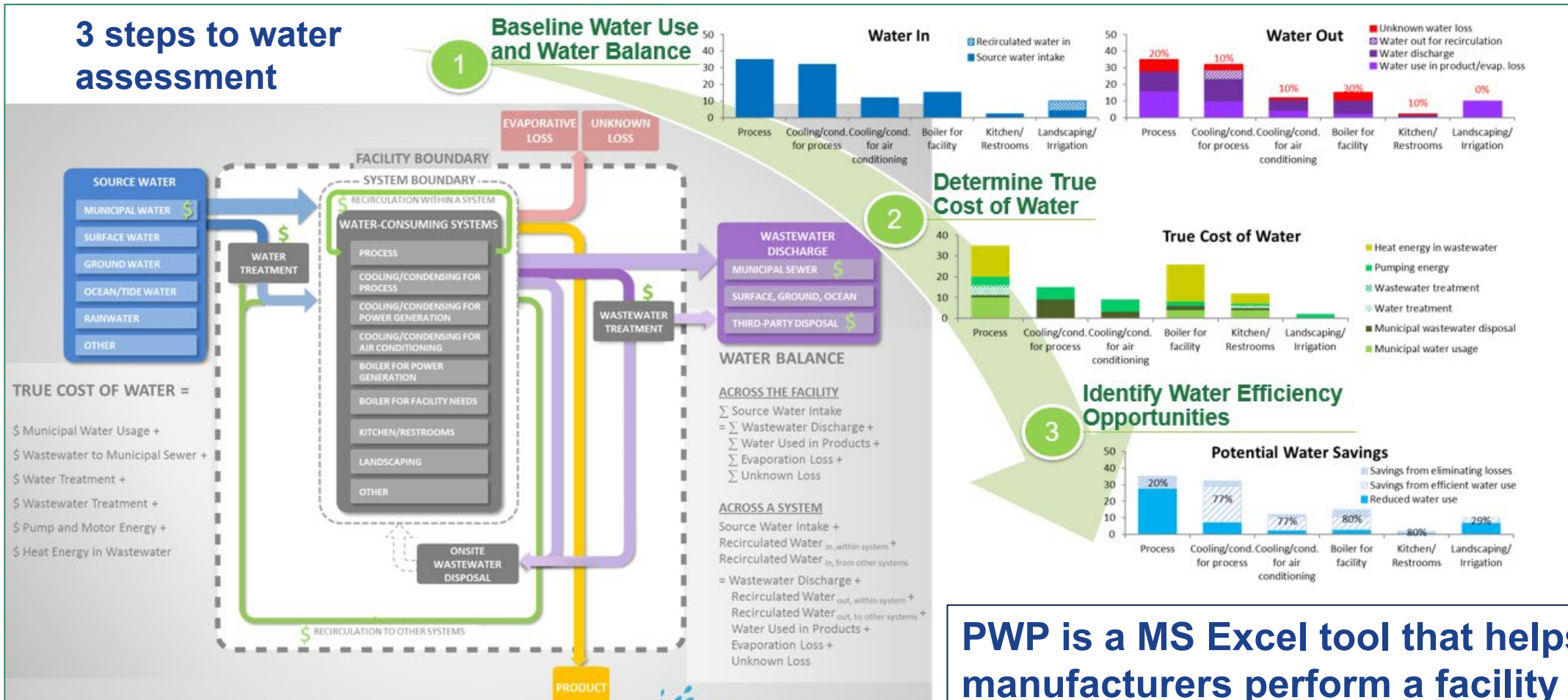
- Identify how much energy is being purchased and consumed and identify and quantify potential energy and cost savings
- Enter basic energy & production data
- System scorecards
- Energy use and costs by production and system
- Energy & cost savings estimates
- List of energy savings measures
- MS Excel-based tool



Find this tool at
<https://www.energy.gov/eere/amo/downloads/plant-energy-profiler-excel>

Plant Water Profiler Tool (PWP)

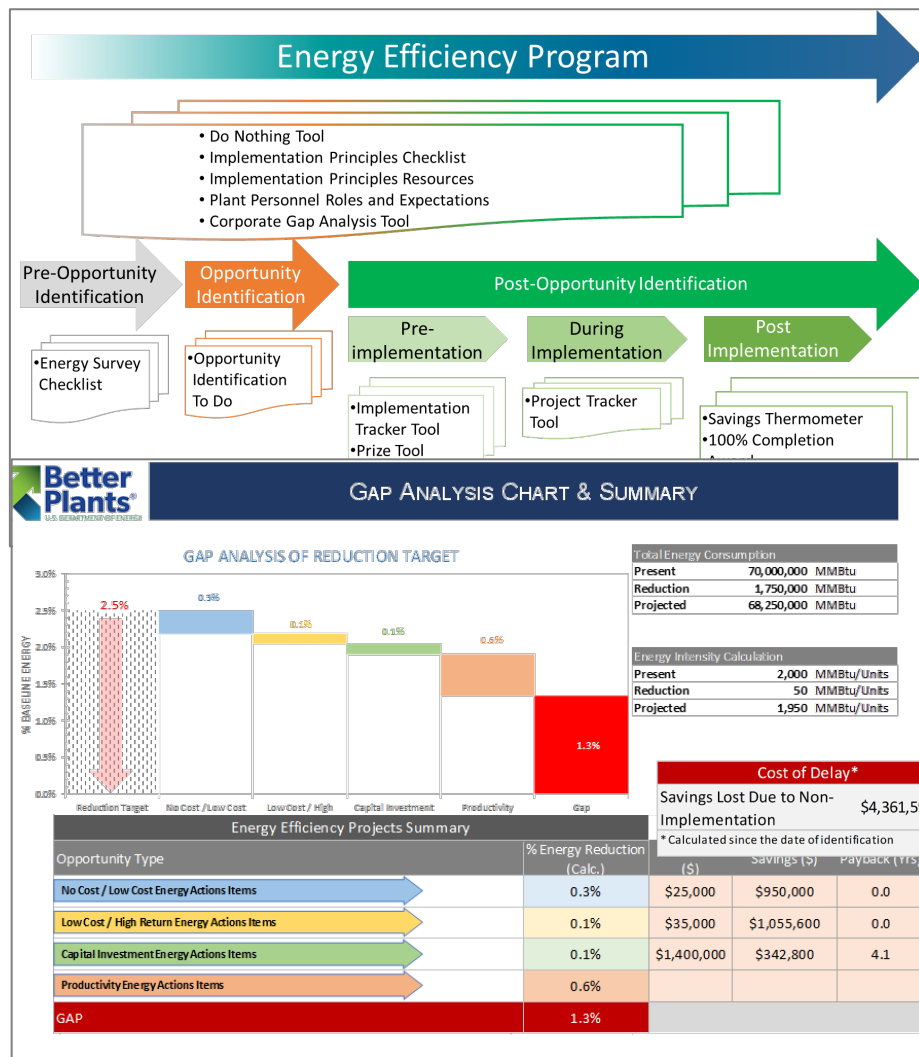
3 steps to water assessment



Find this tool at <https://www.energy.gov/eere/amo/plant-water-profiler-tool-excel-version-10-pwpex-v10>

PWP is a MS Excel tool that helps manufacturers perform a facility level water assessment and understand their true cost of water.

Implementation Guidance Toolkit



Better Plants
U.S. DEPARTMENT OF ENERGY

The "Prize" Tool

To get senior management attention you should identify the "Prize". This will answer the question "Whats in it for me??" (WII-FM: Management's favorite radio station). The following describes a method to identify the "Prize". Use space in the appropriate box to plug-in the values for your company and calculate your "Prize".

LEGEND:
Input
Calculation

Sr.	Task Description	Calculation / Data	Explanation
Calculation of Equivalent Sales			
1.	Determine the plant's annual energy expense (\$)	\$15,000,000	Annual energy expense of the plant is, \$15,000,000
2.	Set annual energy expense reduction goal (%)	3	3% Annual reduction in energy expense means total reduction will be 15% over this goal horizon.
3.	Set the energy expense reduction goal horizon in years (yrs)	5	The horizon for this energy management goal is 5 years.
4.	Multiply the annual expense by the cumulative goal to get the \$ savings in the last year (\$)	\$2,250,000.00	The projected annual savings after achieving this goal are: \$2,250,000
5.	Determine the plant's annual revenue or \$ sales (\$)	\$200,000,000	The plant's annual sales revenue is, \$200,000,000
6.	Determine the plant's annual net profit (\$)	\$20,000,000	The plant's annual profit is \$20,000,000
7.	Determine the plant's margin on sales \$ by dividing annual net profit by annual revenue (\$)	10.0%	
8.	Divide the savings (Step 4) by the margin (Step 7) to identify equivalent sales \$ required to provide the same impact on the "bottom line" (\$)	\$22,500,000	
Optional (Equivalent Units of Sale)			
9.	Determine price per unit / size of average sale (\$/unit)	\$10,000	
10.	Divide equivalent sales \$ (Step 8) by unit price (Step 9) to identify equivalent unit sales	2250	

Projects Summary

Energy Savings	Target (USD)	Implemented (USD)
One Time Savings	\$160,000	\$120,000
El Savings	\$8,000	\$6,000
	Target (USD)	Implemented (USD)
	980	735

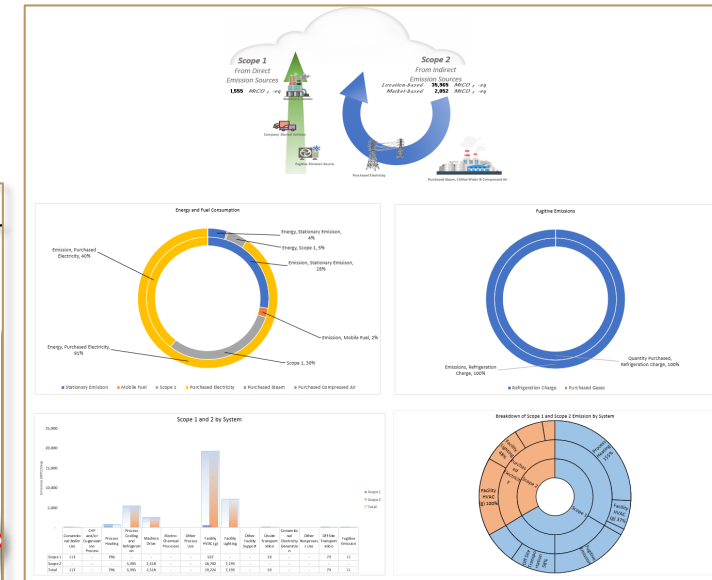
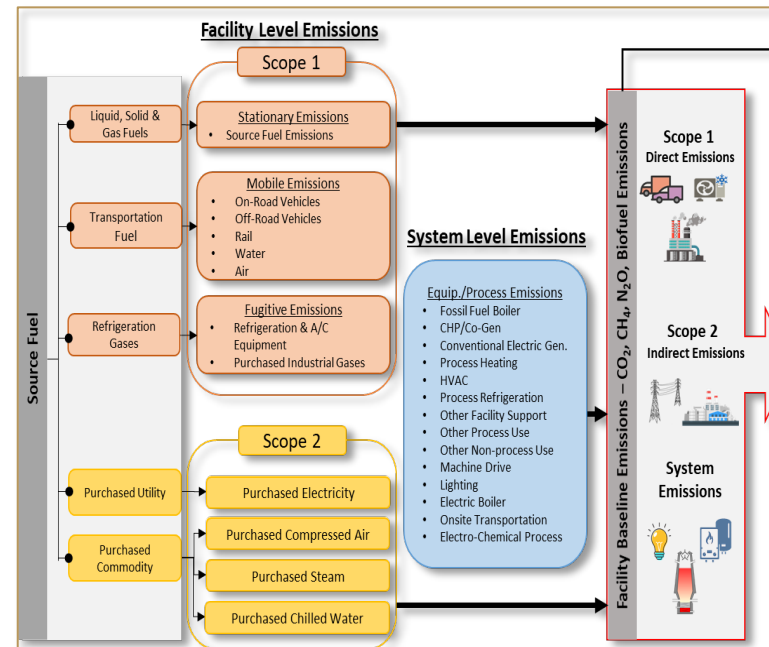
Implementation Results - Thermometers

The "Prize" of the annual energy reduction of 3% is \$2,250,000 or sales of \$22,500,000 or increased revenue of \$22,500,000 or sales of \$22,500,000

- Collection of tools to help projects implementation and communicate success
- 15 different MS Excel tools focused on different stages of implementation
 - Program level
 - Pre-identification
 - During Identification
 - Post-identification
- Tools to justify projects, track implementation progress, conduct GAP analysis to focus implementation efforts

Plant Carbon Footprint and Decarbonization Assessment Tool

- Enables users to create and analyze baseline emissions for facility and at system level
- Scope 1 –
 - Stationary, Mobile & Fugitive
- Scope 2 –
 - Purchased Electricity (Location & Market based),
 - Other Purchased Utilities (steam, chilled water, compressed air)
- Future Updates
 - Provide users the ability to evaluate decarbonization scenarios and perform techno-economic analyses
- MS Excel-based tool

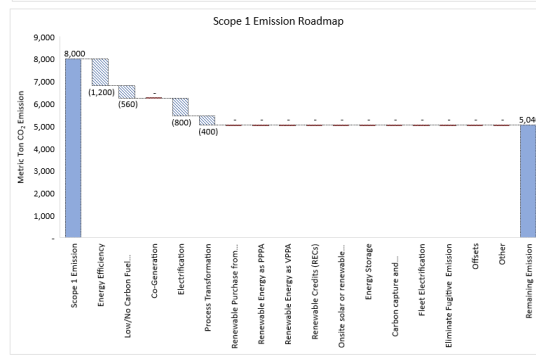
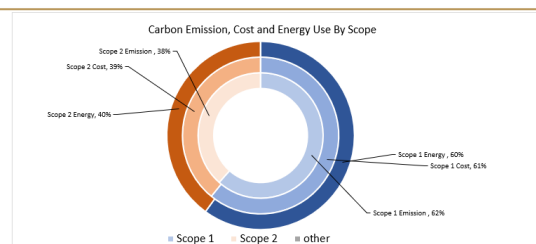


Find this tool at
<https://energyefficiency.ornl.gov/tools-training/>

Decarbonization Action Plan Tool

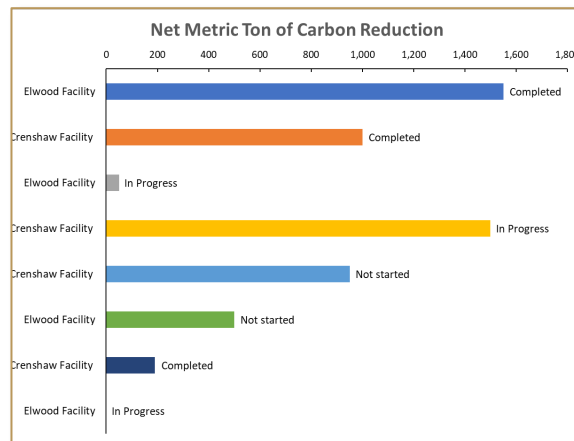
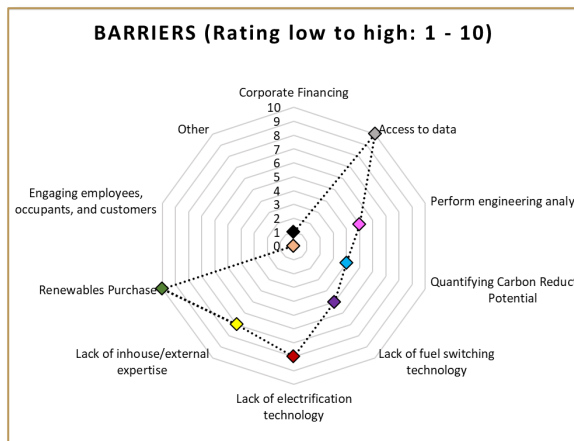
Showcase Plant Name	Elwood Facility
Scope of Emission	Description
Scope 1 Emission	
Stationary Emission	15,000
Natural Gas	15,000
Mobile Emission	-
Fugitive Emission	-
Scope 2 Emission	10,000
Purchased Electricity	10,000
Other	

Pillars of Decarbonization	Opportunity	Barrier	Scope 1 % Carbon Reduction	Scope 2 % Carbon Reduction
Energy Efficiency			15%	30%
Low/No Carbon Fuel Switching			7%	
Co-Generation				
Electrification			10%	-20%
Process Transformation			5%	
Renewable Purchase from Utility				10%
Renewable Energy as PPA				15%
Renewable Energy as VPPA				
Renewable Credits (RECs)				30%
Onsite solar or renewable energy generation				20%
Energy Storage				
Carbon capture and sequestration				
Fleet Electrification				



Aids industrial partners in visualization of Scope 1 and Scope 2 emissions at corporate and facility level.

- Outline corporate and facility level decarbonization roadmap
- Identify barriers faced on their journey to low carbon future
- MS Excel-based tool



Find this tool at
<https://energyefficiency.ornl.gov/tools-training/>

Upcoming SWIFt Resources

New Additions: Wastewater Energy Management Toolkit

Based on the work done during SWIFT, these new documents, tools, and resources are designed to support wastewater facilities beyond SWIFT's time.

To learn more or access available SWIFT recordings and material go to:

<https://bptraining.ornl.gov/swift/>



Advanced Energy Conservation and Resource Recovery Upgrades Implementation Strategies



Wastewater Technical Reports

Energy Capture, Energy Efficiency, Advanced Data Management, and Resource Recovery



Decarbonization Roadmap for WRRF



50001 Ready Strategic Energy Management Sample Plan



Wastewater Treatment Energy Management Data Tool

Opportunities for Wastewater Facilities

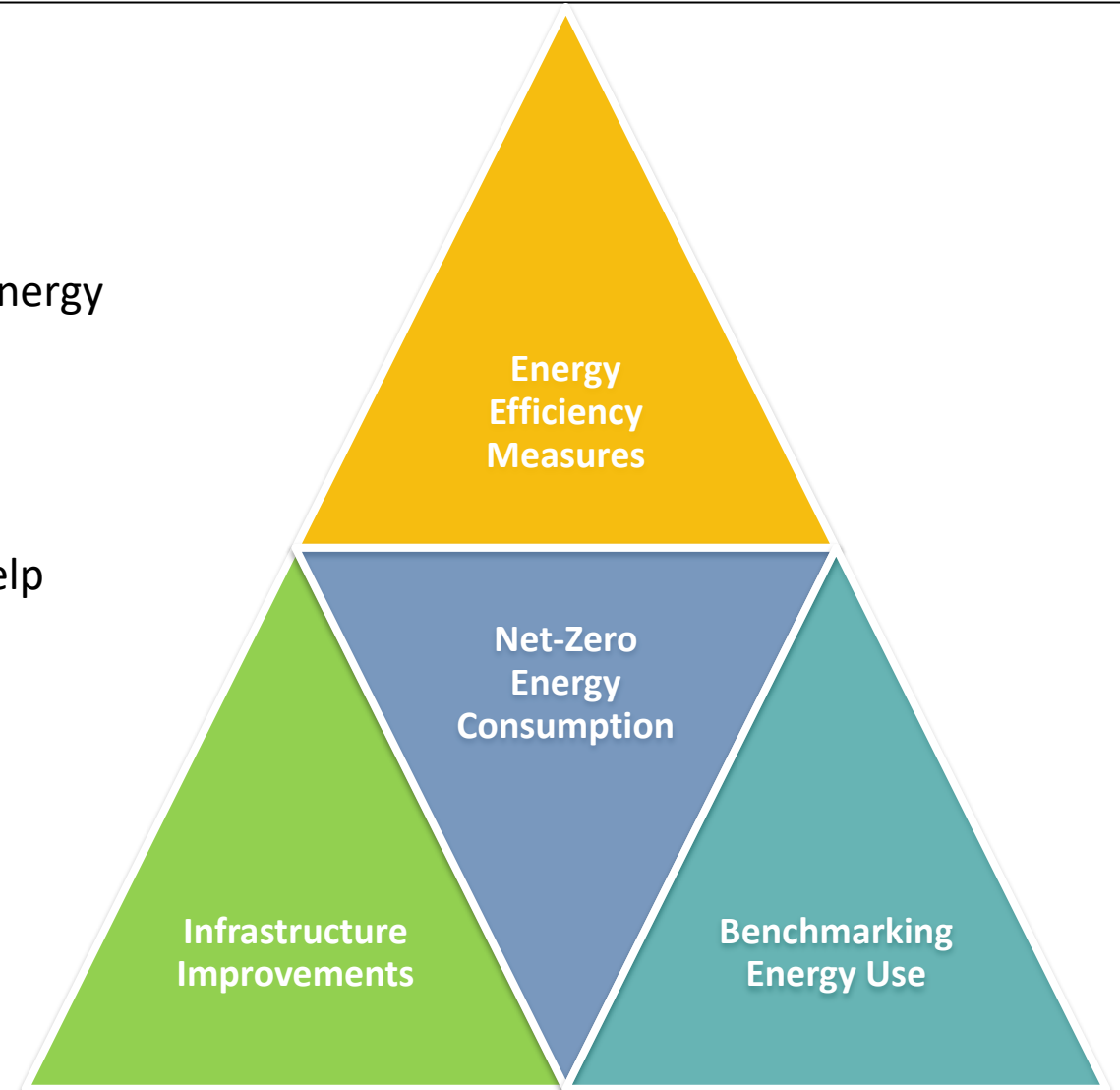
Net-Zero Energy VIPLNT Series

Launching this Fall 2024

Designed to help wastewater treatment facilities achieve net-zero energy consumption through energy efficiency measures, infrastructure improvements, and benchmarking energy use.

This series will operate with the intention of helping wastewater treatment facilities realize tangible changes and developments to help their facility achieve energy neutrality.

The VIPLNT series will host sessions with subject-matter experts and provide opportunities for peer-exchange and engagement.



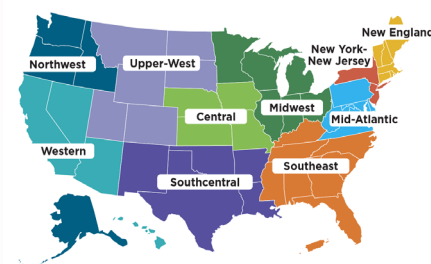
One-on-One TA

Work with our extended team.



Industrial Assessment Centers

Free assessment that identifies energy saving recommendations. IACs typically identify more than \$130,000 in potential annual savings opportunities.



Onsite Energy TAPs

As leading experts in CHP (as well as microgrids, heat to power, and district energy) Onsite Energy TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact.



Wastewater Infrastructure Resilience

Provides systems level modeling which integrates network structure, operations, and performance to quantify how utilities are impacted by disruptions.

Continuing on with DOE's Better Plants Program

Voluntary and free to participate

Partners set long-term strategic goals

DOE works with you to achieve your goal



Why Partner with Better Plants?

Technical Assistance

1



National Recognition

2



Peer-to-Peer Networking Opportunities

3



Access to DOE and National Lab R&D

4



Wastewater Specific Partners



If you are interested in joining Better Plants, please visit

[Join | Better Buildings Initiative \(energy.gov\)](https://www.energy.gov/better-buildings-initiative)

Or reach out to betterplants@ee.doe.gov



Thank You for Joining

Questions?



Follow us on Twitter
@BetterBldgsDOE



Better Buildings Solution Center
<https://betterbuildingssolutioncenter.energy.gov/>



General Inquiries
stateandlocal@ee.doe.gov



Program Support
sharman@ornl.gov
lemarpl@ornl.gov

Thank you for joining us!
For more information, contact:



Nina Wuerch

U.S. Department of Energy, SCEP

Christina.Wuerch@hq.doe.gov



Naushita Sharma

Oak Ridge National Laboratory

sharman@ornl.gov