Unlocking Energy Efficiency for Small Wastewater Treatment Plants

(Tuesday, May 20, 2025)

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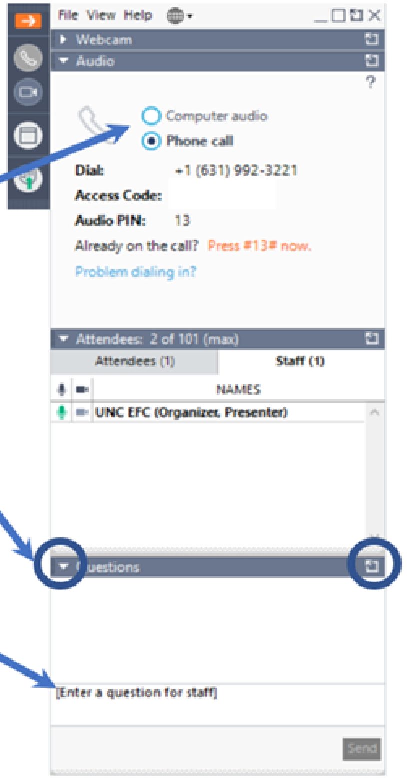

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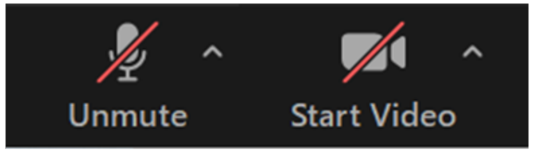

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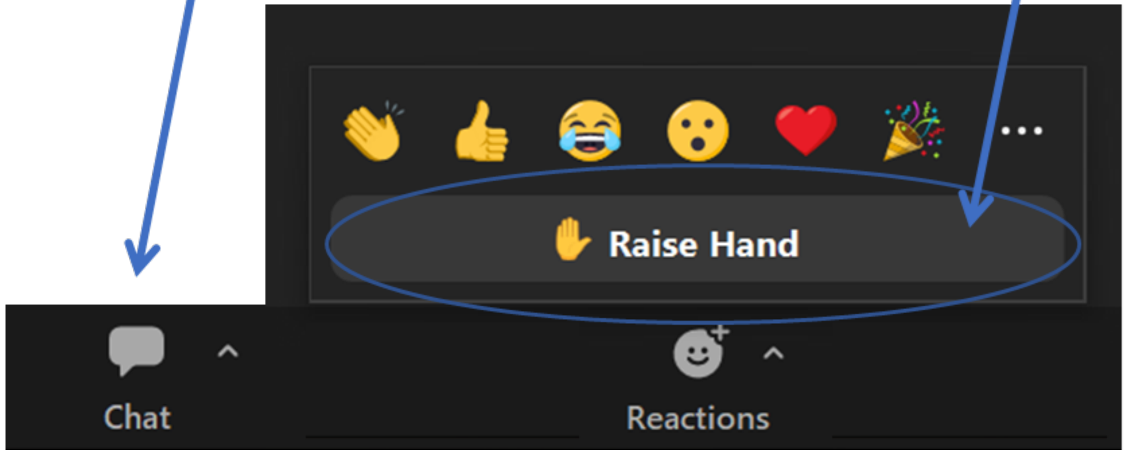

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To receive a certificate:

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If you have questions or need assistance, please contact smallsystems@syr.edu.

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About Us

The **Environmental Finance Center Network (EFCN)** is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and water infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S, including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.

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Small Systems Technical Assistance

Drinking water, wastewater, and/or stormwater systems serving <10,000 people. Wider variety of topics and issues covered.

- Educational resources & trainings, plus technical assistance around U.S.: efcnetwork.org
- For technical assistance within Region 3, email or call Danish Kumar dkumar18@umd.edu (301) 405-9945

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Today’s Speakers

ENVIRONMENTAL FINANCE CENTER

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Webinar Outline

1. Introduction
2. Energy 101 for WWTP
3. Energy Audit
4. Energy Efficiency Strategies
5. Success Stories
6. Next Steps
7. Question & Answer

Energy in WWTP

Small WWTP

- There are 17,544 publicly owned treatment works (POTW) serving 270.4 million Americans, or 82 percent of the population (2022 Clean Watersheds Needs Survey)
- Close to 73% of POTW are small, designed for less than 1 MGD (2022 Clean Watersheds Needs Survey)
- The number of people living in the U.S. served by POTWs with advanced treatment increased from less than 4% in 1972 to about 42 percent in 2022 (2022 CWNS)

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Energy use of WWTP

- WWTPs consume up to 3-4% of U.S. electric load and consume more than 30 billion kWh annually, which equates to about $2 billion in annual electric costs.
- WWTP Energy Use Accounts For 30% To 40% of the total operation and maintenance cost of the facility
- This adds over 45 million tons of greenhouse gases annually.

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Energy use of Small WWTP

Electricity Required

Used at every stage: collection, pumping, aeration, solids handling

The energy use of small WWTP is 3000-6000 kWh/MGD, which is typically higher than larger facilities

High Consumption

This high energy consumption can rapidly escalate costs, often making utility expenses one of the largest operational burdens for the operators

Critical Infrastructure

These plants rely on the grid, making them vulnerable to fluctuating energy prices and power outages that can disrupt critical services

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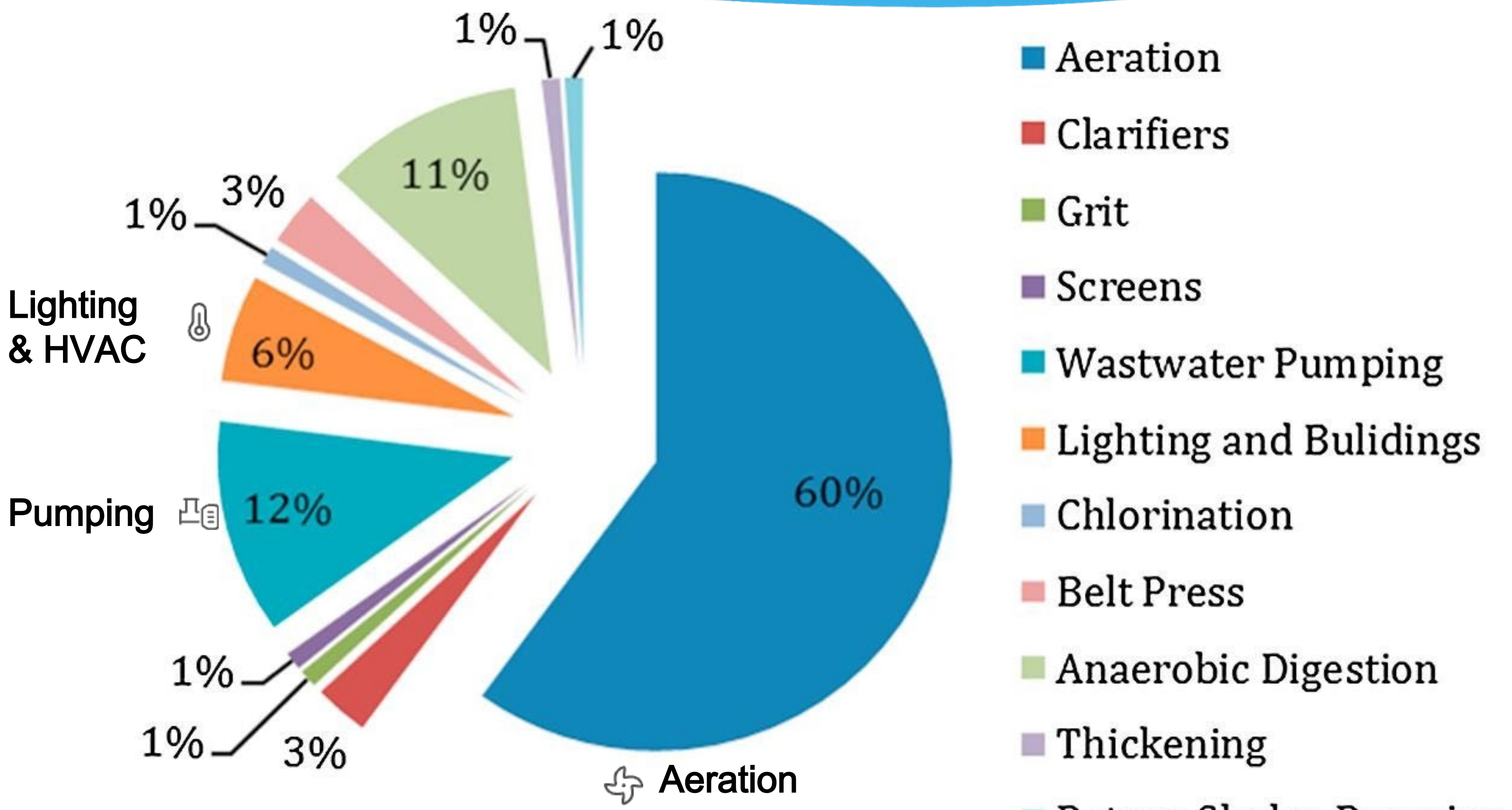
Key Energy Consumption Areas



Why Energy Matters for Small WWTPs

Stringent Requirements

Advanced treatment needs more energy

Resource Recovery

Biosolids treatment adds complexity

Aging Infrastructure

Leads to inefficiency and higher volumes

Electricity Rates

Power cost inflation impacts operations

Budget Impact

30-60% of small system budgets

Resource Challenges

Limited funding, staffing, technical resources

Financial Sustainability

Efficiency critical for long-term viability

Influent Variability

Changes in wastewater composition affect treatment needs

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Benefits of Energy Efficiency

Treatment Quality

Maintained or improved with efficiency upgrades

Cost Savings

Up to 30% reduction in energy costs possible

Safety Standards

Upheld while reducing energy consumption

Operational Improvements

Better reliability, less maintenance, longer equipment life

Regulatory Compliance

Met through smart controls and monitoring

Environmental Impact

Lower greenhouse gas emissions, supports climate goals

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Energy 101

Energy Fundamentals

Energy

The capacity to do work, measured in kilowatt-hours (kWh) or British Thermal Units (BTU).

Power

The rate at which energy is used, measured in kilowatts (kW).

Energy Use Intensity (EUI)

It is a metric used to express the energy consumption of the plant relative to the volume of wastewater it treats.

Kilowatt -hour (kWh)

One kilowatt of power used for one hour. A 10-kW pump running for 5 hours uses 50 kWh.

EUI for WWTP

Commonly tracked as energy use per unit of kWh/MGD or biochemical oxygen demand (BOD) per MGD

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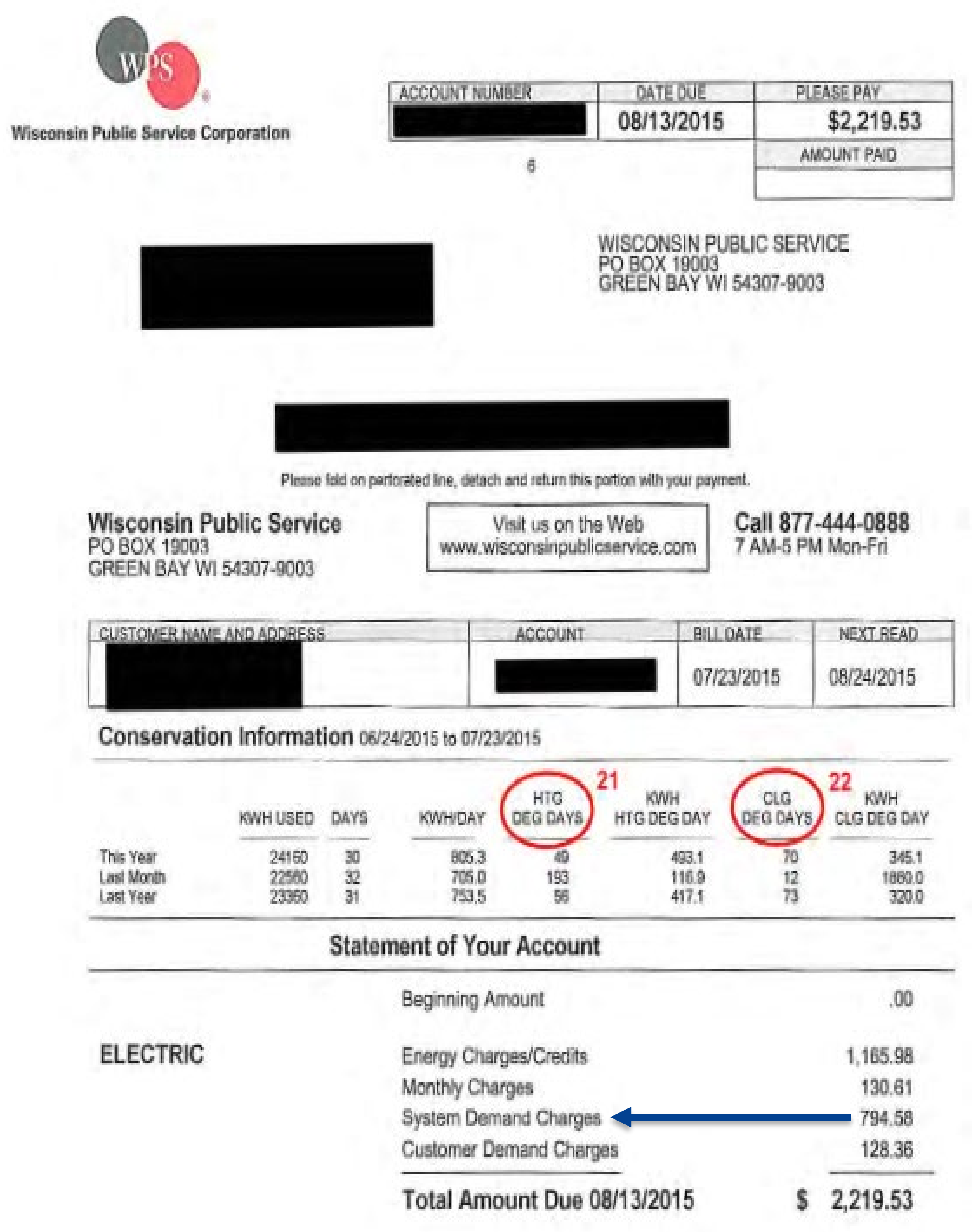
Understanding your Energy Bill

Get a copy of your monthly bill and review it to understand the information it provides.

Contact and get to know the energy provider account representative for your facility.

Determine what rate schedule your energy provider has applied to your facility.

Meet with your account representative to assess if this rate schedule is the most appropriate for your facility.



Wisconsin Public Service Corporation

ACCOUNT NUMBER	DATE DUE	PLEASE PAY
[redacted]	08/13/2015	$2,219.53
		AMOUNT PAID

6

[redacted]

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CUSTOMER NAME AND ADDRESS	ACCOUNT	BILL DATE	NEXT READ
[redacted]	[redacted]	07/23/2015	08/24/2015

Conservation Information 06/24/2015 to 07/23/2015

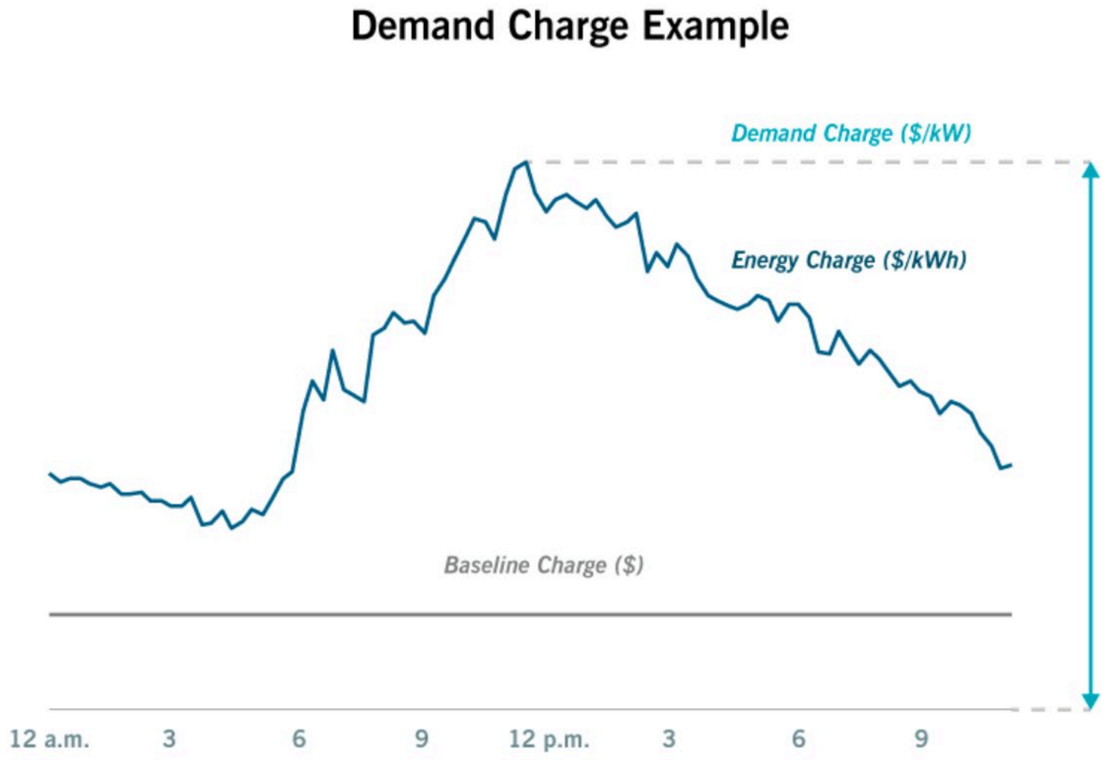
	KWH USED	DAYS	KWH/DAY	HTG DEG DAYS 21	KWH HTG DEG DAY	CLG DEG DAYS 22	KWH CLG DEG DAY
This Year	24160	30	805.3	49	493.1	70	345.1
Last Month	22560	32	705.0	193	116.9	12	1880.0
Last Year	23360	31	753.5	56	417.1	73	320.0

Statement of Your Account

	Beginning Amount	.00
ELECTRIC	Energy Charges/Credits	1,165.98
	Monthly Charges	130.61
	System Demand Charges	794.58
	Customer Demand Charges	128.36
	Total Amount Due 08/13/2015	**$ 2,219.53**

Understanding Demand Charges

- Demand Charges are based on maximum power draw (kW) during a billing period — not total energy consumed (kWh).
- WWTPs may be charged based on the highest 15-minute interval of electricity use each month.
- Often range from $5–$15 per kW/month but can be higher depending on the utility.



Efficiency vs. Conservation

Term	Definition	Example
Energy Efficiency	using less energy to accomplish the same task	LED lights, VFDs, high-efficiency blowers
Energy Conservation	practice of using less energy	Turning off lights, reducing run times

Steps to Improve Energy Efficiency

Assess Current Energy use

- Use Self-assessment and energy audits

Develop Management Plan

- Create roadmap for improvements

Upgrade Equipment

- Install VFDs,
- high-efficiency motors/pumps
- SCADA Systems

Operational Changes

- Shift equipment's to off-peak hours
- Using real time data to make decisions

Renewable Integration

- Add solar
- biogas capture & utilization

Energy Audit

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What Is an Energy Audit?

- **Energy audit** is part of the overall energy management and is an official examination and verification of energy accounts and records

Analyze

Systematically examine how energy is used in your facility.

Benchmark

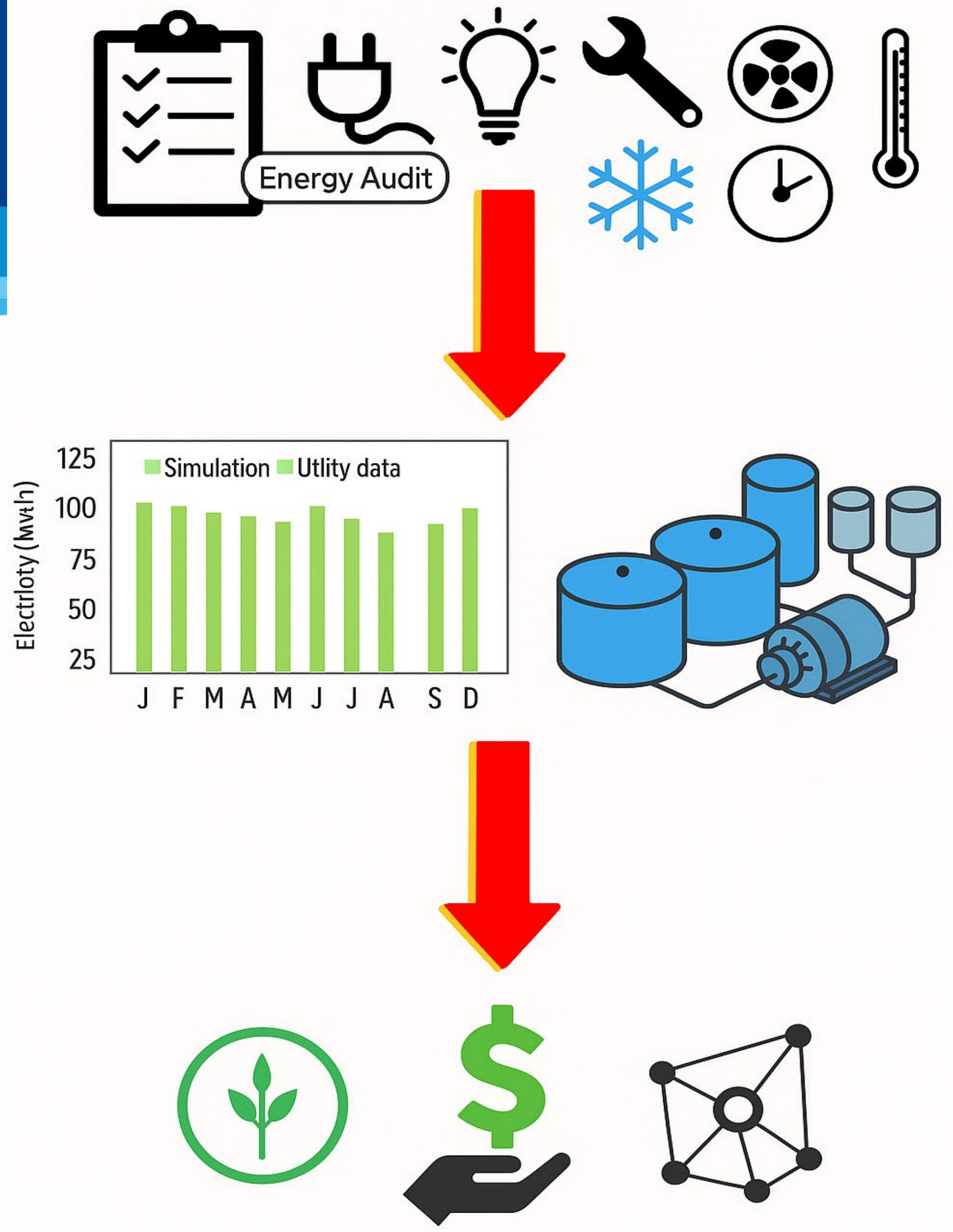
Compare performance to similar facilities.

Identify

Pinpoint Energy Saving Opportunities

Prioritize

Use data to make informed upgrade decisions.



Benefits of Energy Audits

Cost Savings

Reduce operational expenses through improved efficiency.

Environmental Impact

Lower carbon footprint and support sustainability goals.

Performance Tracking

Benchmark using kWh per million gallons treated.

Strategic Planning

Guide future upgrades and justify funding requests.

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Starting Your Energy Audit

Understand	Understand Your Billing
Know	Know how you're charged for energy, including demand charges and time-of-use rates.
Document	Document Facility Processes
Map	Map flows, requirements, and major equipment specifications.
Inventory	Inventory Equipment
List	List all significant energy users with their technical specifications.
Assess	Assess Inefficiencies
Identify	Identify outdated equipment, poor controls, and process bottlenecks.

Types of Energy Audits

ASHRAE Level 3

Investment-grade, in-depth engineering analysis

ASHRAE Level 2

Detailed assessment by process/equipment

ASHRAE Level 1

Walk-through survey with basic measurements

Self-Assessment

Basic review using excel or free online tools

Energy Audit Tasks defined by ASHRAE

1. Collect and analyze historical energy consumption data
2. Study the WWTP's processes and operational characteristics
3. Identify potential modifications to reduce energy consumption and costs
4. Perform an engineering analysis of the identified modifications
5. Prepare a rank-ordered list of recommended energy efficiency measures
6. Prepare a comprehensive report documenting the analysis process and findings

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Benchmarking Your Facility's Energy Performance

Standard Metrics

Use kilowatt-hours per million gallons (kWh/MG) processed as your primary efficiency metric, allowing for standardized comparison across facilities of different sizes and configurations.

Tracking Frequency

Monitor energy usage monthly to identify seasonal patterns and immediately spot abnormal consumption. Compare year-over-year data to evaluate long-term improvement trends.

Cost Monitoring

Track both total facility energy costs and process-level energy consumption. Breaking down usage by process (pumping, aeration, disinfection) helps identify specific improvement opportunities.

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Energy Audit Tools

EPA Energy Use Assessment Tool

Free Excel-based tool for utility bill analysis and equipment review.

Energy Star Portfolio Manager

Online benchmarking tool to compare against similar facilities.

Wastewater Energy Management Toolkit

Collection of resources, best practices and innovative approaches for energy management

NYSERDA Toolkit

Comprehensive resource for energy audit tools and energy management best practices

Obtaining Professional Energy Audits

Industrial Assessment Centers

Department of Energy-funded university programs offering free comprehensive energy audits

Energy Service Companies

ESCOs often provide preliminary audits at reduced cost as part of their performance contracting development process

Utility Partnerships

Many electric utilities offer subsidized or free energy assessments as part of their demand-side management programs

REAP Program Audits

USDA funding for third-party energy assessments specifically tailored to small, rural water utility needs

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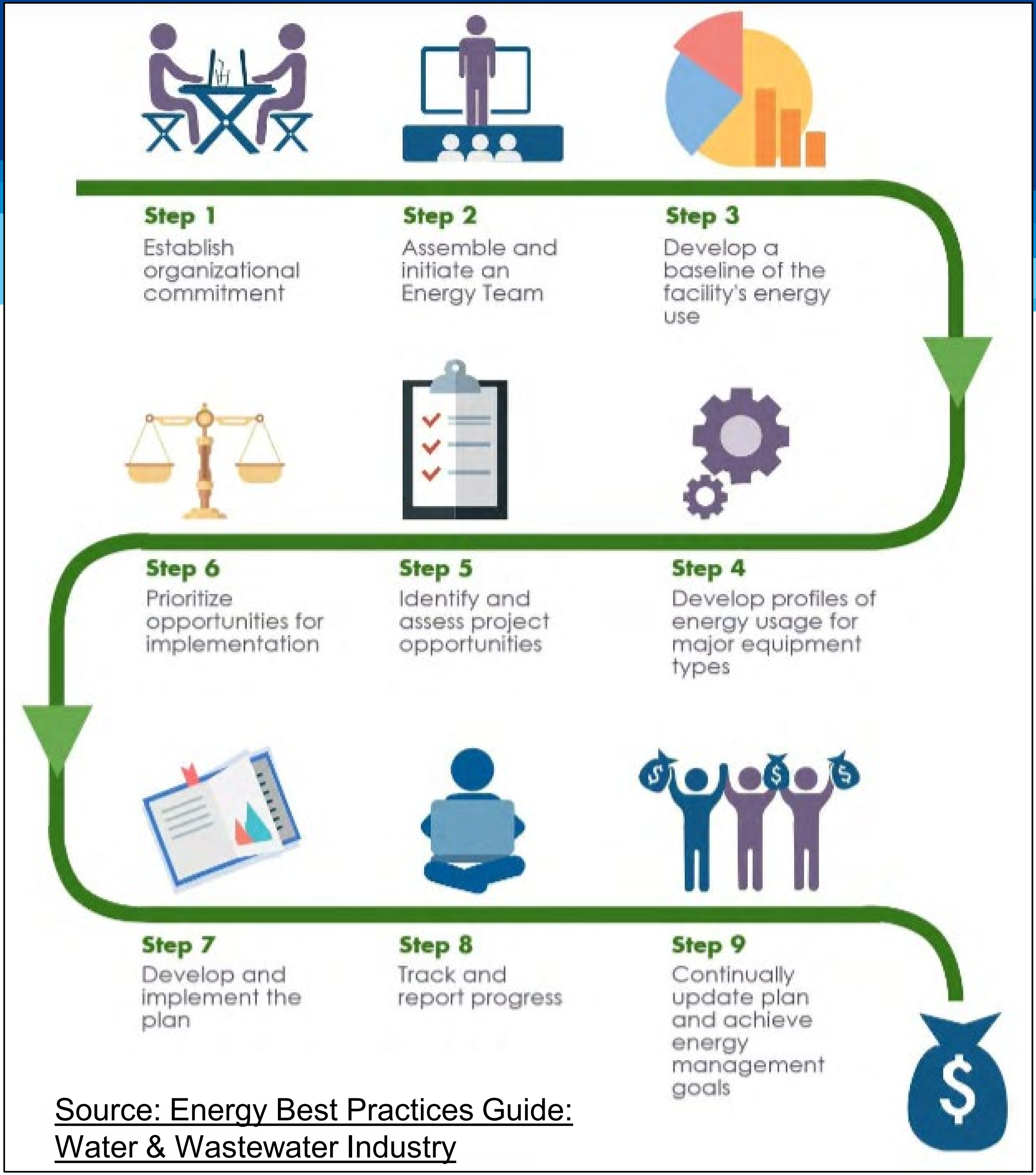

Source: Energy Best Practices Guide: Water & Wastewater Industry

Energy Data Management: Step-by-Step Approach

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Energy Efficiency Strategies

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Optimizing Aeration Systems

Real-Time Oxygen Monitoring

Install sensors with IoT systems to match blower operations with actual oxygen demand, preventing energy waste from over-aeration.

Diffuser Upgrades

Replace coarse-bubble with fine-bubble diffusers to reduce energy consumption by 30-50% while improving oxygen transfer efficiency.

Aeration Optimization

Fine-tune dissolved oxygen setpoints and implement automated DO control. Modest adjustments can reduce blower energy use by 10-15% with minimal investment and no impact on treatment quality.

High-Efficiency Blower Technologies

Turbo Blowers

Modern high-speed turbo blowers feature advanced magnetic bearings that eliminate friction losses and oil lubrication requirements. These units deliver 20-40% energy savings compared to conventional positive displacement blowers.

Multistage Centrifugal Blowers

These blowers excel in applications requiring consistent airflow at moderate pressure. They feature precision-engineered impellers that minimize turbulence and energy losses throughout the compression cycle.

WWTP replacing conventional blowers with turbo units, can reduce aeration energy consumption by 30% while improving process control capabilities. The project can achieve payback in under 4 years.

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Equipment Upgrade Opportunities

High-Efficiency Motors

Replace standard motors with NEMA Premium® or IE4-class models to achieve 2-8% energy savings per motor. Focus on continuously running equipment for maximum ROI.

Variable Frequency Drives

Install VFDs on pumps and blowers to match output with actual demand, reducing energy use by 20-50% depending on load variability and duty cycles.

Right-Sized Pumping Systems

Replace oversized pumps with properly sized alternatives that achieve wire-to-water efficiency above 80%. Pair with VFDs for maximum operational flexibility.

LED Lighting Retrofits

Convert to LED lighting throughout the facility to reduce lighting energy consumption by up to 90%. Add motion sensors in low-traffic areas for additional savings.

Equipment Type	Typical Useful Life
Pumps & Motors	10–15 years
Blowers	10–15 years
Lighting (LED)	10–15 years
HVAC Systems	15–25+ years
Control Systems	10–15 years

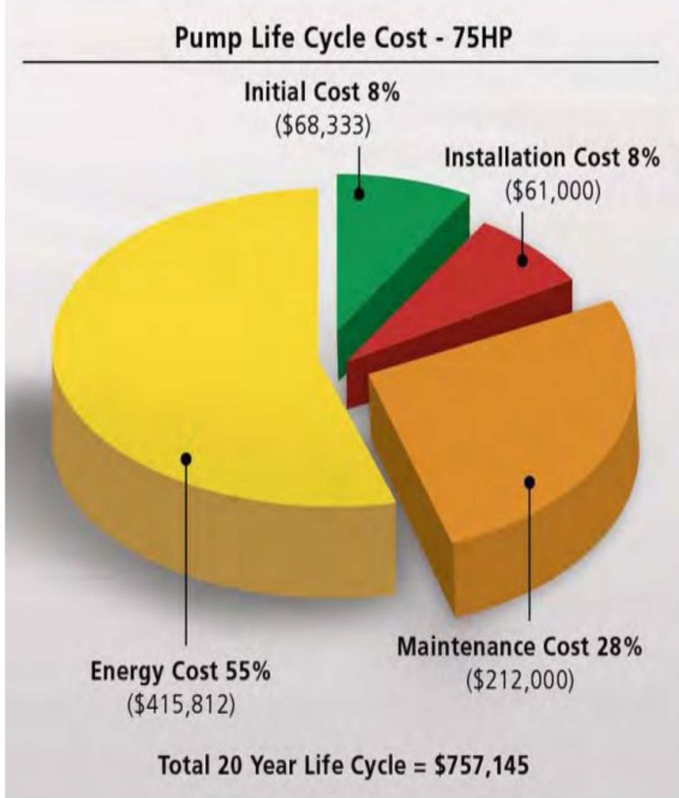
Equipment Upgrade Opportunities

Energy Lesson: Aeration Design

	Transfer Rate (# O_2/HP·hr)
Coarse Air Bubble	1.5
Fine Air Bubble	3.3
Mechanical Aeration	3.9
Fine Air Bubble w/Full Floor Coverage & High Efficiency Blowers	6.6

Source: Sate Energy Conservation Office, Texas, 2018

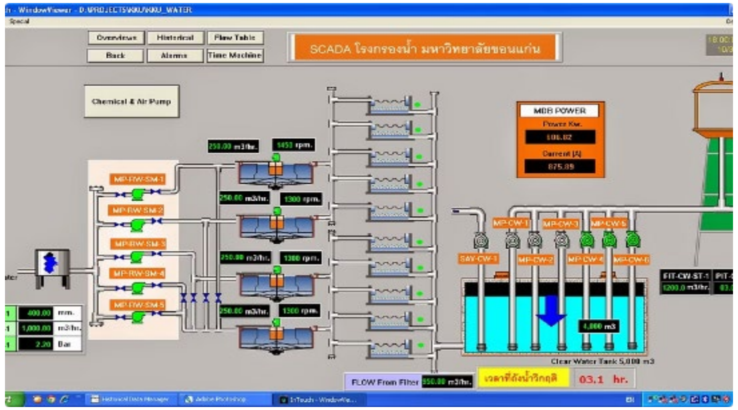
Energy Lesson: Life Cycle Cost for a Pump



Energy Lesson

Buy the most energy efficient pump possible.

Process Control Improvements

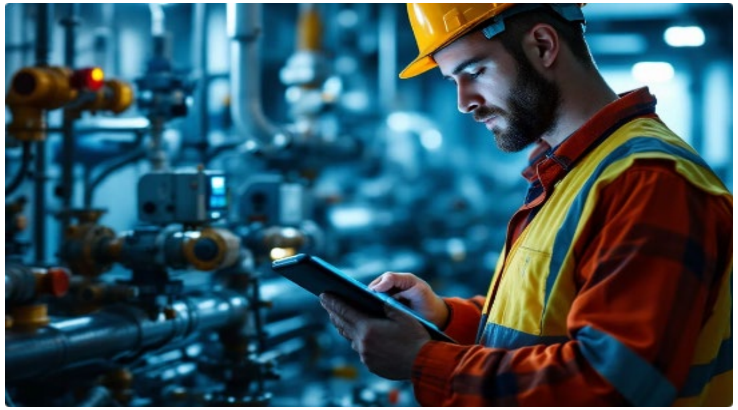


SCADA Implementation

Modern supervisory control and data acquisition (SCADA) systems provide operators with real-time visibility into plant performance. These systems enable precise control of treatment processes, minimizing energy waste while maintaining compliance with discharge permits.

Sub-Metering

Having sub-meters throughout the facility allows operators to track energy consumption by individual process. This granular data highlights inefficient equipment and processes, creating a roadmap for targeted improvements with measurable results.



Automated Control Systems

Automated controls maintain optimal operating conditions regardless of influent variability or weather conditions. These systems reduce manual adjustments, prevent human error, and ensure consistent treatment efficiency.

Using SCADA for Energy Monitoring

Data Collection

Integrate power monitoring with existing SCADA systems to collect real-time energy usage data from key processes

Analysis

Use automated reporting tools to identify consumption patterns, anomalies, and opportunities for adjustments

Optimization

Implement automated control strategies that maintain treatment performance while minimizing energy use

Verification

Track and document energy savings to validate efficiency improvements and justify future investments

Optimizing Chemical Processes for Energy Savings

UV Disinfection

- More energy-efficient and cost-effective than chlorination/dichlorination over 7 years
- Eliminates safety risks from storing chlorine gas
- Use high-efficiency bulbs to minimize energy consumption

Alkalinity Management

- Lye addition for alkalinity is costly and energy-intensive
- Optimizing denitrification can reduce or eliminate the need for added alkalinity

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Heat Pumps for Facility Buildings

- Heat pumps are electric space conditioning equipment that provide both heating and cooling in buildings.
- They function at higher efficiencies than conventional space conditioning equipment's, providing the same level of conditioning but using less energy.

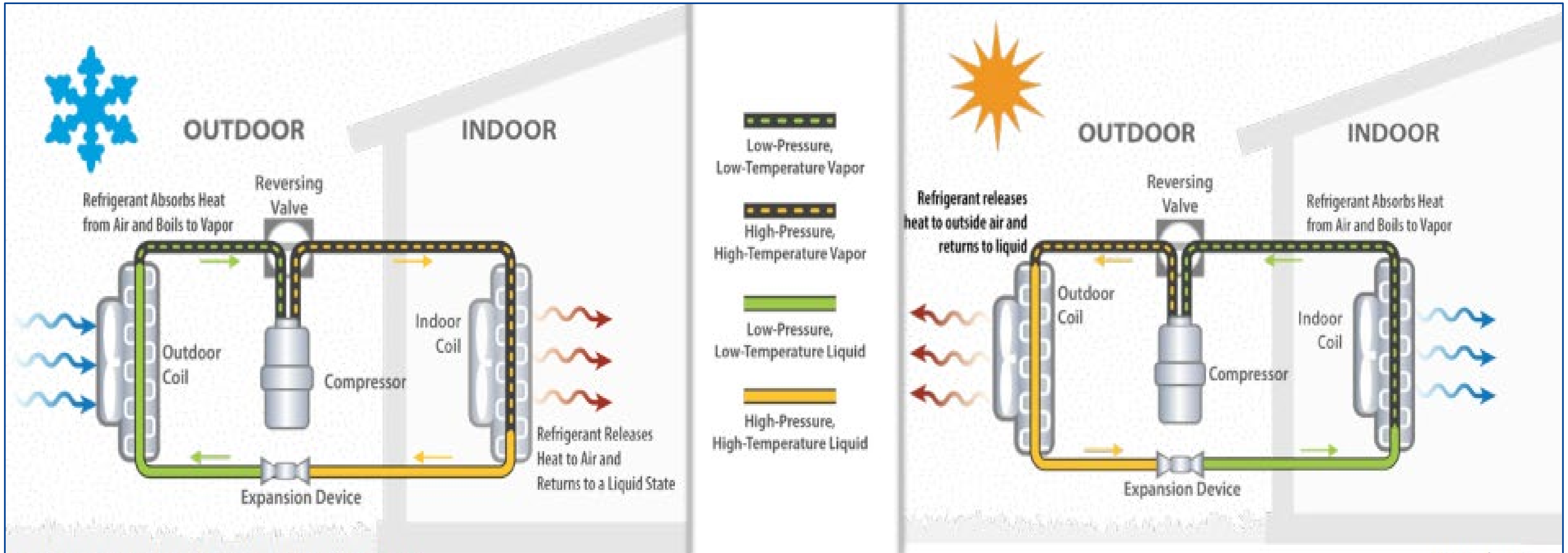

Figure depicts the air-to-air heat pump refrigeration cycle.

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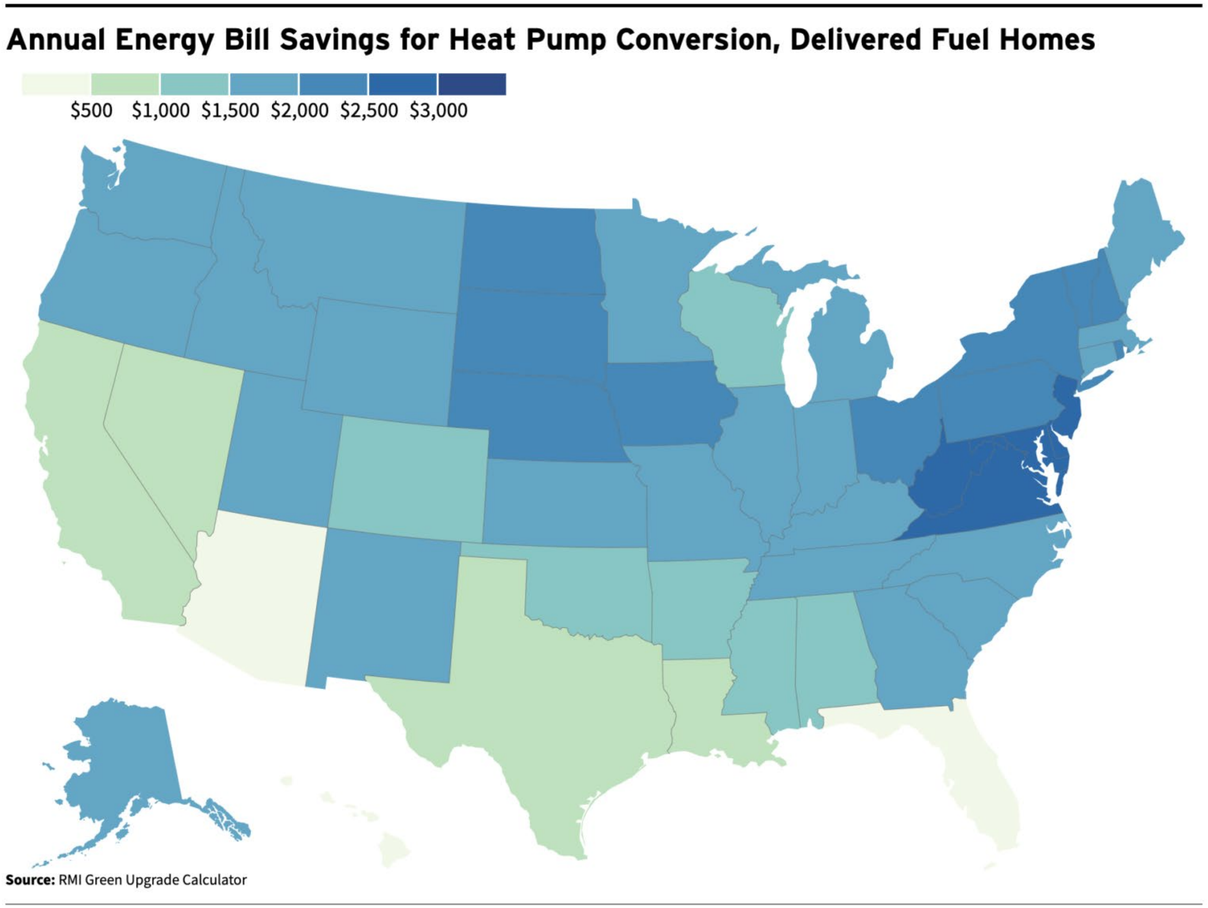
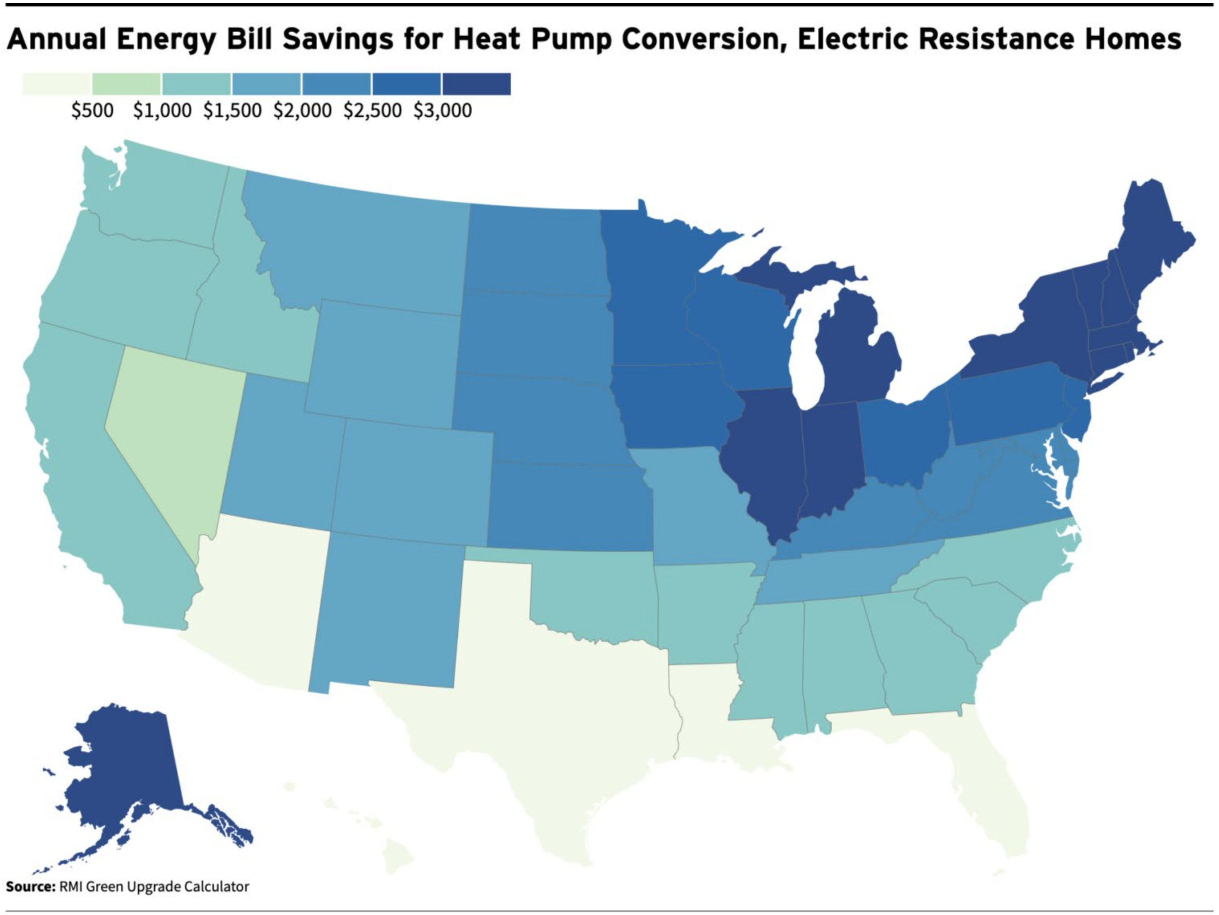
Heat Pumps Cost Savings





Renewable Energy Integration

Biogas Recovery Systems

Anaerobic digesters convert wastewater sludge into methane-rich biogas that can fuel combined heat and power (CHP) systems. Modern digester designs maximize gas production through optimized mixing and temperature control.

- Typical biogas yield: 0.8-1.0 m^3 per kg of volatile solids reduced
- CHP electrical efficiency: 35-40%
- Heat recovery potential: 45-50% of fuel energy

Solar Photovoltaic Arrays

WWTPs typically have abundant open land or roof space ideal for solar installations. Ground-mounted systems offer the highest energy density and easiest maintenance access.

- Typical capacity: 5-10 watts per square foot of array
- Annual production: 1,000-1,300 kWh per kW installed
- System lifespan: 25 years with minimal maintenance
- Cost: 2000-3000$/kW

Available Funding Sources

Federal Programs

EPA Clean Water State Revolving Fund (CWSRF) provides low-interest loans for energy efficiency upgrades.

Tax Incentives

The Inflation Reduction Act (IRA) includes tax credits for renewable energy projects. These credits can cover up to 30% of qualified expenditures.

Utility Programs

Many utilities offer custom incentives for large energy users like WWTPs.

Performance Contracts

Energy Savings Performance Contracts (ESPCs) allow facilities to implement upgrades with no upfront capital. The energy service company guarantees savings that cover the project costs over a defined term, typically 10-15 years.

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Implementation Roadmap

Start with benchmarking

Establish your baseline metrics and identify key improvement areas

Pursue no-cost audits

Leverage IACs, utility programs, or REAP funding for professional assessments

Implement strategically

Balance quick wins with long-term investments for sustained savings

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Prioritizing Projects: ROI Analysis

Project Type	Typical Payback	Annual Savings	Key Considerations
LED Lighting	1–5 years	$1K–$3K	Quick ROI; utility rebates often available
VFD Installation	2–5 years	$5K–$20K	Cuts motor energy use by 20–50%
DO Control Systems	3–7 years	$5K–$20K	Optimizes high-energy equipment for smarter operation
Turbo Blowers	3–7 years	$40K–$200K	Major savings, but high capital investment
Solar PV	7–15 years	50–90% of electric bill	Grants/tax credits can significantly reduce upfront costs

Simple payback calculation: Payback (years) = Initial Cost ÷ Annual Energy Savings.

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Success Stories

Town of Crested Butte

Project Overview

- Town of Crested Butte operates a 0.6 MGD oxidation ditch wastewater treatment plant that serves a small mountain community.
- Conducted energy audit through a Government program to identify low- and no-cost energy efficiency opportunities.

Key Actions Recommended

- Replace underutilized Pump No. 1 with a more efficient unit
- Address excessive inflow and infiltration (I&I) during snowmelt season
- Replace non-functional **DO sensor** and **integrate with VFD** for better control
- Cycle off mixers during aerator operation to reduce redundant energy use
- **Replace aging surface aerator with more efficient model**
- **Deactivate one UV bank and optimize bulb replacement practices**
- Retrofit piping to bypass an idle, energy-wasting ATAD tank
- **Improve sludge transfer system to minimize blower operation time**

Town of Crested Butte

Next Steps

- **Implement Priority Short-Term Actions** (mixer cycling, DO sensor replacement, UV optimization)
- **Pursue Long-Term Upgrades** with external funding (e.g., CWSRF, USDA RD)
- **Develop an Energy Management Plan (EMP)**
- **Benchmark Using EPA Portfolio Manager**
- **Conduct I&I Study and Engage Community** in water conservation initiatives

Table 2. Energy Savings Recommendations

Process	Recommendations	Savings (kWh - % energy - $/year)
Influent Pumping/Headworks	Use Pump No.1 during low flow (ST)	4,300 - 10% - $150
	Conduct I&I study (LT)	14,000 - 35% - $550
	Replace Pump No.1 (LT)	8,700 - 20% - $350
Aeration/Oxidation Ditch	Turn mixers off when aerator operates (ST)	45,900 - 90% - $1,750
	Replace DO meter (ST)	19,800 - 10% - $750
	Connect new DO meter to SCADA/ Replace aerator (LT)	123,000 - 40% - $4,700
UV Disinfection	Remove one UV bank from service/ Determine if bulbs can be removed (ST)	32,000 - 50% - $1,200
Solids Handling	Retrofit piping to feed sludge directly from thickened sludge tank to centrifuge (LT)	23,500 100% - $1,000
ST = short-term, LT- long-term		

Source: https://docs.nrel.gov/docs/fy12osti/53341.pdf

Carthage WWTP

Project Overview

- In 2017, Carthage WWTP (330,000 GPD avg. flow) joined the TN Water & Wastewater Energy Efficiency Partnership.
- **A no-cost operational change** —reducing aerator runtime in a redundant digester—led to major energy savings.

Key Actions Taken

- Site assessment identified that the **second digester's aeration was unnecessary full-time.**
- Staff reduced its operation from **24 hours/day to 6 hours/day** starting April 2017.
- Aerator operation was manually adjusted by plant staff as part of daily duties.

Results

- **>85,000 kWh/year electricity savings**
- 14% monthly electricity reduction despite 15% increase in flow
- 19% drop in kWh/MG and $/MG
- **>$7,000 annual cost savings**
- **11% peak demand reduction**
- $0 implementation cost

Next Steps

- Use savings to **install timers for automated aerator control** and further improvements.

Wetumpka WWTP

Project Overview

- Wetumpka's Wilako WWTP (avg. 1.8 MGD) joined EPA Region 4 and ADEM's Energy Management Initiative (EMI).
- Reduced high energy use from aeration through low-cost operational optimization.

Key Actions Taken

- **Shut down one of two aeration basins** (previously underutilized).
- Adjusted operations to run **2 of 12 aerators + 2 mixers** for 18 hours/day.
- Introduced **anoxic conditions for 4–6 hrs/day** by lowering DO setpoints.
- All changes implemented manually with no capital cost.

Results

- 24% energy savings (460,000 kWh/year)
- **$70,000/year cost savings**
- 390+ tons/year CO_2 reduction
- 12 tons/year effluent nitrogen reduction (62%)
- Effluent quality maintained ($CBOD_5$ < 2 mg/L, TSS ~3 mg/L, NH_4-N < 0.04 mg/L)

Other Benefits

- Process resilience enhanced (e.g., managing I&I with storage lagoons)
- Additional improvements planned: lighting upgrades, VFDs, diffuser replacements

City of Flagstaff Water System

Project Overview

- Identified energy conservation measures through a city-wide audit
- Supported by Grant from Arizona WIFA under EPA's Green Project Reserve

Key Actions Recommended

- **Replace inefficient pumps, blowers, and boosters**
- Operate pumps at Best Efficiency Point (BEP)
- **Monitor power usage and demand charges in real time**
- Implement leak detection and maintenance programs
- **Improve staff training on energy efficiency and rate structures**
- Review pressure zones and evaluate micro-turbine feasibility

Major Results

- Average efficiency increase: From 49% → 71%
- Total estimated cost: $1.48 million
- APS rebate: ~$500,000
- **Annual energy savings: $347,000**
- Payback period: ~2.45 years average

Example savings:

- **Blowers E: $113,963 saved/year (efficiency 35–40% → 69%)**
- Well A2: $40,588 saved/year (efficiency 42% → 69%)
- Total upgrades across 12 facilities

Next Steps

Best Practices

Start with a Comprehensive Energy Audit

Use professional or self-assessment tools to benchmark current usage and identify the highest-impact opportunities

Aggressively Pursue Financial Incentives

Seek utility rebates, grants, and principal forgiveness programs that can cover up to 30 - 50% of implementation costs

Focus on High -Impact Systems

Prioritize aeration, motors, drives, and process controls which typically represent the largest energy consumers

Develop a Culture of Efficiency

Integrate energy management into routine operations and decisions at all levels of the organization

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Implementation Steps

Conduct Initial Assessment

Use EPA tool to identify your facility's biggest energy users and opportunities. This establishes your baseline and helps prioritize efforts where they'll have maximum impact.

Develop Funding Strategy

Research and apply for applicable utility incentives, state grants, and federal funding programs. Contact your utility representative to identify available rebates for specific equipment upgrades.

Implement & Monitor

Begin with quick-win projects while planning longer-term improvements. Install sub-metering to track specific process energy use and verify savings from implemented measures.

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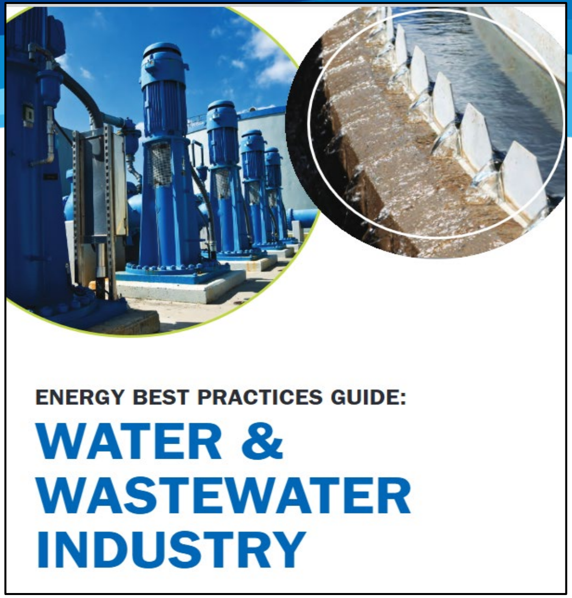
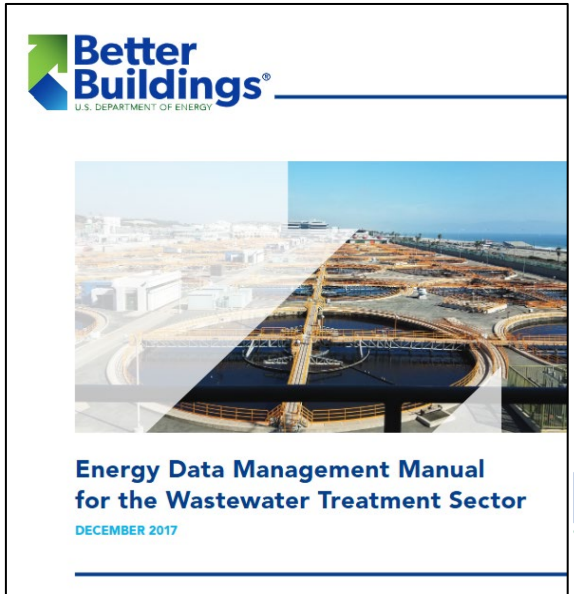
<u>Energy Best Practices Guide</u>: Provides information and resources to assist water/wastewater facility management and staff in identifying and implementing opportunities to reduce energy use.



<u>Energy Data Management Manual for the Wastewater Treatment Sector</u>: Provides practical guidance for small WWTPs on tracking and managing energy performance to support cost-saving energy management programs.



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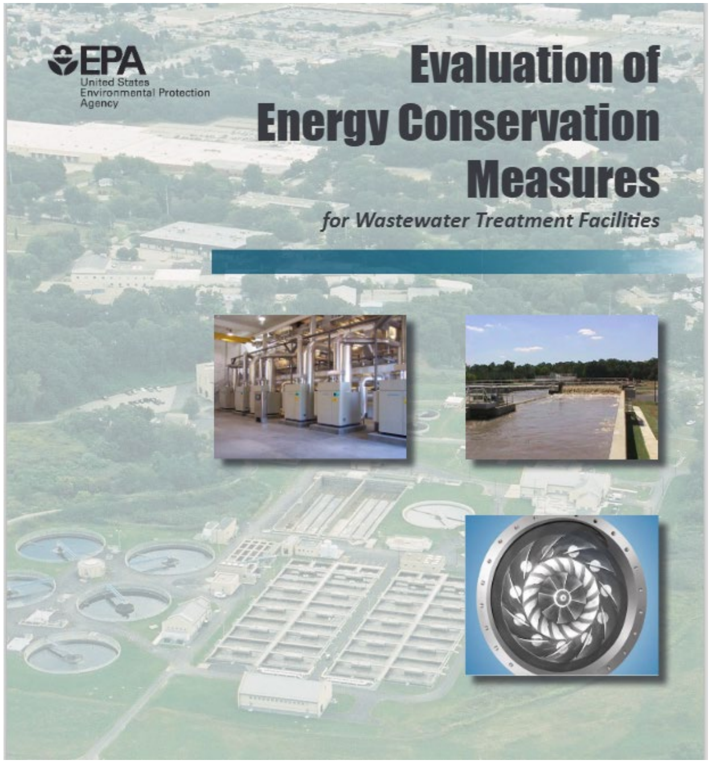
Evaluation of Energy Conservation Measures: Provides performance and cost-benefit information for projects like efficient equipment replacement and operational improvements with reasonable payback periods. It focuses on both established and innovative/emerging ECMs and includes case studies of wastewater treatment facilities that have implemented ECMs, detailing their energy savings and costs.



Resources-Portfolio Manager

- **Property Information**
  - Monthly Energy use for all fuels (kWh, therms, etc.)
  - Average Daily Influent Flow (gpd or MGD)
- **Plant data:**
  - Building square footage
  - Average Influent BOD - average over 12 months (mg/l)
  - Average Effluent BOD - average over 12 months (mg/l)
  - Plant Design Flow Rate - treatment design (MGD)
  - Trickle Filtration Process (yes/no)
  - Nutrient Removal (yes/no)

Metrics Summary

Metric	Dec 2017 (Energy Baseline)	Dec 2021 (Energy Current)	Change
ENERGY STAR Score (1-100)	Not Available	Not Available	N/A
Energy Cost ($)	90,479.79	83,802.43	-6,677.36 (-7.40%)
Water/Wastewater Site EUI (kBtu/gpd)	4.39	3.78	-0.61 (-13.90%)
Water/Wastewater Source EUI (kBtu/gpd)	12.29	10.59	-1.70 (-13.80%)
Water/Wastewater Weather Normalized Site EUI (kBtu/gpd)	4.39	3.78	-0.61 (-13.90%)
Water/Wastewater Weather Normalized Source EUI (kBtu/gpd)	12.29	10.59	-1.70 (-13.80%)
Water/Wastewater - Weather Normalized Site Electricity Intensity (kWh/gpd)	1.3	1.1	-0.20 (-15.40%)

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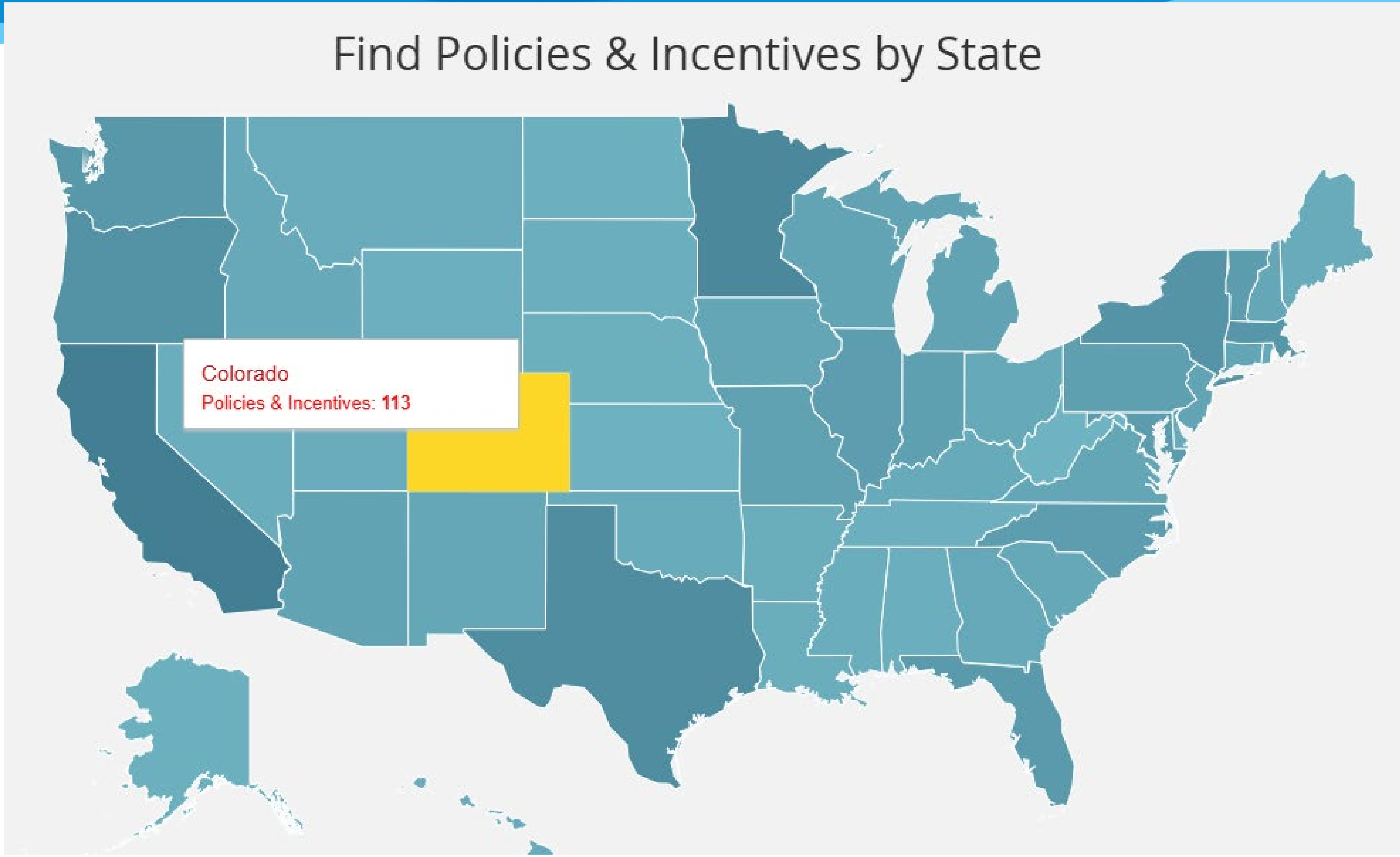
Database of State Incentives for Renewables & Efficiency



Source: https://www.dsireusa.org/

Contacts

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