WRF 4973 Fact Sheet: ID 1740

Strategy: Energy Savings

Reduce Process Power Demand

Blowers Are a Key Power-Consuming Process.
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Improve Efficiency with New/Clean Diffusers.
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This fact sheet focuses on strategies that will reduce the power demand of a water resource recovery facility (WRRF) while still meeting process requirements. This includes strategies to reduce the energy demand by making changes to a process that still meet the process objectives and adjusting equipment to improve energy efficiency.

Processes can be modified to reduce energy demand while still maintaining the process objectives by either reducing the process load or directly reducing the process's energy demand. Examples of strategies that reduce process load and/or energy demand include implementing chemically enhanced primary treatment (CEPT) to divert more biochemical oxygen demand (BOD) away from a process's bioreactors (reducing the aeration demand), recovering gas in anaerobic digestion, operating mixers at a reduced operating time (or lower power input), reducing the dissolved oxygen (DO) set point for nitrification while maintaining complete nitrification with a more efficient oxygen transfer rate, implementing aeration control schemes (ammonia-based aeration control [ABAC], ammonia vs. NO_x [AvN], etc.) that minimize aeration while maintaining process objectives, and reducing internal mixed liquor recycle (IMLR) flows to the minimum rate needed to meet the process objective.

The energy efficiency of a process's equipment can also be improved with modest investment. Conducting a return-on-investment analysis can help determine the attractiveness of these strategies. Examples of this approach include adding instrumentation and controls (I&C) systems to minimize energy use while maintaining performance (e.g., IMLR flow, ABAC, AvN, etc.) or increasing the aeration diffusers' transfer efficiency by replacing old diffusers and/or adding more diffusers for full floor coverage. See the Additional Information section for more strategies and additional details.

Tracking and managing the power demand of a WRRF can help staff identify more opportunities for energy savings. While tracking the energy use of a WRRF can be complicated, it can be simplified by identifying and using key performance indicators (KPIs). These KPIs can be analyzed over a set amount of time to determine the current, relative energy-efficiency performance of a WRRF (as a whole or in individual power-consuming centers) and identify areas of potential improvement when it comes to the energy efficiency of a WRRF.

Energy rate structures typically include different unit price usage rates throughout the day to discourage on-peak energy use. The peak power demand during a set period (month, day, 15 minutes, etc.) often determines the unit price for energy for a longer period. Strategies that avoid high energy usage during times of peak energy demand can result in a lower average energy price rate. These types of strategies include scheduling maintenance activities to avoid using energy-demanding equipment during peak energy rate periods, scheduling and managing the diurnal demand using flow equalization, and implementing many other strategies.

Fact Sheet Application Checklist

R = fact sheet relevant to item
PR = fact sheet is potentially relevant to item depending on application, existing conditions, etc.

Category		Intensification
		Chemical addition
		Carbon management
	R	I&C strategies
		Sidestream mgmt.
	R	Energy savings
		Chemical savings
	R	Operational savings
		Other means of NutRem
Nutrient	R	Ammonia
	R	NOx
	R	TN
	R	Ortho-P
	R	TP
Scale (design flow)	R	Small (<1 mgd)
	R	Medium (1–10 mgd)
	R	Large (>10 mgd)

Goal		Improve reliability
		Reduce nutrient
	R	Reduce O&M cost
Group	R	Optimize existing CNR
	R	Optimize existing TNR
		NutRem in secondary plant
Process		Small
		Pond
	R	Fixed film (secondary)
	R	Conventional act. sludge (CAS)
	R	Nitrifying act. sludge (NAS)
	R	Conventional NutRem (CNR)
	R	Tertiary NutRem (TNR)
		Other

CAS = conventional activated sludge (BOD only)
NAS = nitrifying activated sludge (without denitrification)
CNR = conventional nutrient removal no chemical/no filter, etc.
TNR = tertiary nutrient removal with chemical, filter, etc.

Technology Summary Evaluation

Footprint	3	Compared to conventional (1 = much smaller; 3 = conventional; 5 = much larger)
Development status*	4–5	Technology ranking based (LIFT) see below*
Energy use	1–2	Scale 1–5: 1 = use much less; 3 = use similar to conventional; 5 = use much more
O&M cost	2	Scale 1–5: 1 = cost much less; 3 = cost similar to conventional; 5 = cost much more
Material/consumables	1	Scale 1–3: minimal = 1; some = 2; significant = 3 (e.g., UV lamps/membranes)
Chemical use	1	Scale 1–3: minimal/none = 1; some = 2; significant = 3 (e.g., chemical process)

* Technology ranking based on Leaders Innovation Forum for Technology (LIFT) Water Research Foundation (WRF) Technology Development Level (TDL) definitions:
1 = bench research and development
2 = small-scale pilot
3 = full-scale pilot (demonstration)
4 = pioneer stage (production and implementation)
5 = conventional

Descriptions/Evaluation

Strategy	Reduce process power demand
Description	This fact sheet contains strategies to reduce the energy demand of a WRRF for nutrient removal, focusing on strategies that optimize the operation of the treatment process and equipment. Process strategies include changes in control set points (for DO, internal recycle flows, etc.) and adjusting equipment operation to operate at the point of optimal equipment efficiency for the flow and load variations.
Application	These strategies are focused on the major power-consuming processes at a WRRF, which are typically the following: • Aeration blowers • Pumps • Ultraviolet (UV) disinfection • Process settings and controls • Dewatering reject (recycle) water impacts • Mixing
Constituents removed	None: these energy-saving strategies should maintain treatment performance
Development status*	The energy optimization strategies generally fall in LIFT TDLs 4–5.
O&M considerations	Implementation of these strategies may have some positive or negative impact on staffing. If staff effort increases, the associated benefits need to outweigh the cost. For example, the energy to clean aeration diffusers must be less than the cost savings from the resulting improved aeration performance.
Benefits	Reduce cost and power consumption. Extend equipment life by operating in ideal range.
Limitations	None
Design considerations	Performance criteria are set for a specific strategy. Generally, some minor design is required.
Potential fatal flaws	None
Footprint requirements	None
Residuals	No change in residuals
Cost considerations	Some investment may be required for equipment refurbishing and replacement. A life-cycle cost analysis is recommended to determine if the return on investment is acceptable. Energy rebates and other programs may be available to fund the investment required.
Past experience	None
Publications	Reardon, D. 1998. “Energy Usage Wastewater Treatment Plants.” Waterworld, August 31. U.S. Department of Energy. 2019. “Energy Data Management Manual Wastewater Treatment.” DOE/EE-1700 Better Buildings, U.S. Department of Energy, December 2017. WEF. 2017. “Operation of Water Resource Recovery Facilities, MOP 11.” Water Environment Federation (WEF).
Related fact sheets	1701: Reduce Energy Consumption Overview 1710: Optimize Available Equipment 1901: Optimize Operation and Maintenance
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Note

* Technology ranking based on LIFT WRF TDL definitions:
1 = bench research and development
2 = small-scale pilot
3 = full-scale pilot (demonstration)
4 = pioneer stage (production and implementation)
5 = conventional (https://www.waterrf.org/sites/default/files/file/2019-07/LIFT%20Scan%20Application-LIFT%20Link%2BHub_0.pdf : accessed September 2020)

Additional Information

The focus of this fact sheet is on strategies that will reduce the power demand to provide energy savings while still meeting process requirements. This entails using process equipment more effectively, so their power draw is reduced, or installing more energy-efficient equipment that will maintain process performance. Some strategies may require a modest investment that requires a life-cycle analysis (LCA) to determine their attractiveness.

KPIs can help WRRF staff track and manage energy use. It is best to establish WRRF-specific target KPIs and, based on those, set a target for energy consumption. Direct comparison metrics with other WRRFs are rarely useful, because WRRFs are operated under different permit conditions, environments, site constraints, and other factors. However, comparing current KPIs with past performance of the same WRRF (as a whole or in individual power-consuming centers) provides a more appropriate measure and comparison of operational energy efficiency.

Table 1 below provides additional information regarding the strategies that can be used to reduce process-related energy at a WRRF.

Table 1. Optimization Process Strategies That Reduce Power Demand.

Sort	Process Strategy	Strategy Objective	Example	Related Fact Sheets
1	Divert BOD away from biological nutrient removal (BNR)	Divert BOD demand to anaerobic digestion for gas production (energy recovery) and reduce demand on BNR. Keep in mind that BNR requires organics.	• CEPT • Optimize primary clarifier operation	1150, 1301, 1320
2	Improve oxygen transfer efficiency	Reduce the amount of oxygen that needs to be transferred into the liquid to meet the oxidation demand.	• Reduce operating DO • Rely on denitrification to reduce oxygen demand • Clean diffusers • Install additional diffusers • Replace with new diffusers	1101, 1740
2	Optimize BNR recycle flows	Reduce/adjust IMLR to minimize pump energy while meeting denitrification objectives.	• Reduce IMLR flows • Add I&C to control IMLR recycle to optimal rate	1740

Sort	Process Strategy	Strategy Objective	Example	Related Fact Sheets
6	Reduce overmixing	Reduce mixing input to meet minimum requirements while maintaining process performance	• Implement intermittent mixing (with controls or timers) • Use hydraulic mixing from IMLR pumped flow instead of mixers • Replace mixers with smaller units	
7	Pumping efficiency	Reduce pumping energy requirement by reducing pump head. Optimize pump efficiency.	• Modify pipe fixture or routing to reduce pump head • Raise wet well level • Install “jockey pump” to cover low flow demands • Reducing pumping during peak energy demand charge periods	1710
8	Aeration equipment efficiency	Reduce blower energy requirement by reducing blower header pressure. Optimize blower operation efficiency.	• Reduce operating header pressure • Optimize blower operation to cover entire operating range • Install “jockey” blower to cover operating range	1101
9	Automate process controls	Control high-energy-consuming equipment	• Automate DO control • Modified Ludzack-Ettinger (MLE) control • Return activated sludge (RAS) control	1501, 1510, 1560
10	Improve effluent transmittivity	Increase ultraviolet transmittance (UVT) to reduce UV dose required to meet disinfection goals	• Optimize secondary clarifier performance for lower total suspended solids (TSS) • Improve oxidation of organics in liquid (increase solids retention time [SRT])	1101, 1130
11	Treat and manage reject water (sidestreams)	Reduce the recycle load returned to headworks to reduce the nutrient load. Alternatively, manage the return load variation to provide a reduced and constant load to liquid treatment.	• Manage reject water return flows to avoid shock loading to WRRF • Remove nitrogen (N) in reject water by adding nitrification or total nitrogen (TN) reduction treatment • Remove phosphorus (P) in reject water with chemical addition or by recovering P	1601, 1610, 1620, 1630

Sort	Process Strategy	Strategy Objective	Example	Related Fact Sheets
15	Track KPIs	Establish energy-based KPIs WRRF-wide or individual unit processes and monitor performance	• Determine KPIs for unit process and for WRRF as a whole • Use past performance as starting point/base • Establish goal for KPI • Track progress and adjust	See Section 4.1.4 in report

Abbreviations

ABAC	Ammonia-based aeration control
AvN	Ammonia vs. NO_x (aeration control)
BNR	Biological nutrient removal
BOD	Biochemical oxygen demand
CAS	Conventional activated sludge: BOD removal only
CEPT	Chemically enhanced primary treatment
CNR	Conventional nutrient removal
DO	Dissolved oxygen
I&C	Instrumentation and controls
IMLR	Internal mixed liquor recycle
KPI	Key performance indicator
LCA	Life-cycle analysis
LIFT	Leaders Innovation Forum for Technology (now RIC and RISE)
mgd	Million gallons per day
MLE	Modified Ludzack-Ettinger
N	Nitrogen
NAS	Nitrifying activated sludge
NO_x	Oxidized nitrogen (nitrate + nitrite)
NutRem	Nutrient removal
O&M	Operations and maintenance
P	Phosphorus
RAS	Return activated sludge
RIC	Research & Innovation Committee
RISE	Research and Innovation for Strengthening Engagement
SRT	Solids retention time
TDL	Technology Development Level
TN	Total nitrogen
TNR	Tertiary nutrient removal
TP	Total phosphorus
TSS	Total suspended solids
UV	Ultraviolet
UVT	Ultraviolet transmittance
WRF	The Water Research Foundation
WRRF	Water resource recovery facility