SCE DRET Findings
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DR15.18: Demand/Response System for Wastewater Aeration Using On-line Off-gas

COST SAVING OPPORTUNITIES AT WATER RESOUCE RECOVERY FACILITIES DURING DEMAND RESPONSE EVENTS

Water resource recovery facilities (WRRFs) typically receive the highest loading flowrate (water to be treated) when the cost of energy is also the highest. The overlap between the peak flowrate and the most expensive energy price intensifies both the cost of treatment of water and the concurrent greenhouse gas (GHG) emissions. With recent advances in sensors, monitoring equipment and modeling software, cost saving opportunities at water resource recovery facilities during demand response (DR) events can more reliably be predicted.

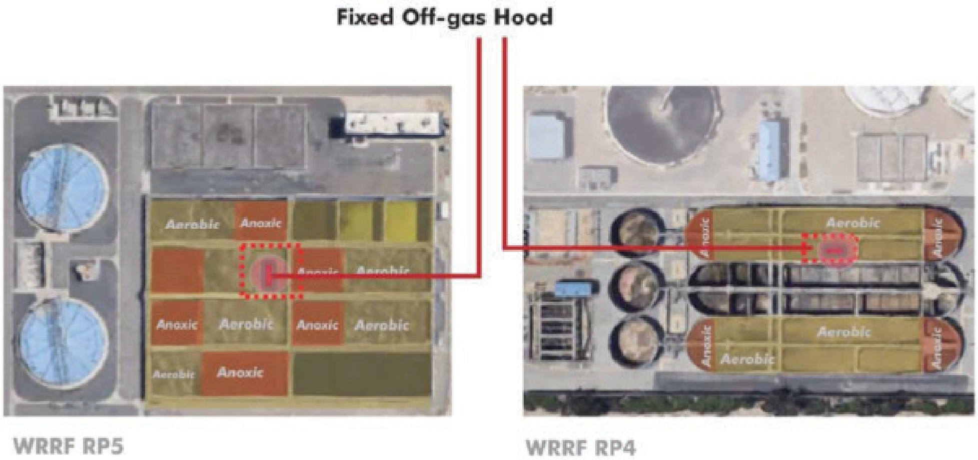

Figure 1: Schematic of IEUA RP-4 and RP-5 showing the characterized secondary treatment reactors. The red dots represents the off-gas hood approx. location where the aeration efficiency indicators were measured during the 12-month period

Two Inland Empire Utilities Agency (IEUA) water resource recovery facilities (RP-4 and RP-5) were the basis of understanding process conditions associated with seasonal and daily dynamics and identifying process control strategies for optimized energy efficiency. A tailored model for the plants under study was developed from the collected data. From this, the simulated wastewater facilities are now available to further investigate alternative strategies, or a combination of them, for reducing energy consumption during a peak demand hours.

INTRODUCTION

What is this technology?

Efficient Air Package

Continuously capturing the aeration efficiency dynamics was possible using the developed demand/response system for wastewater aeration efficiency monitoring. The system includes an innovative on-line off-gas analyzer. The developed on-line analyzer not only outperforms previous versions of analyzers with new capabilities and a compact design, it also automates the data collection and analysis process by sending and processing data continuously. Continuous monitoring of the efficiency enables further control, can improve plant performance, and supports decision-making by providing critical information regarding the most convenient aeration strategy saving methods to implement in WRRFs.

The aeration efficiency was monitored continuously using a telemetry system which is located inside the off-gas analyzer and connected via Ethernet to the Opto22 automated controller. The signal from the Opto22 unit is transmitted via a CAT-6 cable to a modem for transmission. The modem is mod. ALC MW41TM LINKZONE HOTSPOT, relying on a GSM cellular network for transmittal. The modem receives the signal and relays it via static IP, a necessary detail for I/O direct remote connection.

Seasonal, monthly, and daily dynamics concerning aeration efficiency were successfully captured using the telemetry system. The long-term characterization of the aeration tanks enabled the compilation of enough data to maximize the reliability of cost saving projections using commercial modeling software.

The facility was then modeled using a simulator reproducing the exact same conditions, treatment train characteristics, intrinsic dynamics, and energy tariff structures (e.g., time-of-use (TOU) rates, energy usage, and peak power demand charges).

What We Did?

Twelve months of intensive sampling and monitoring were conducted to obtain the dynamics of the main aeration efficiency indicators as well as plant operating and performance data, averages which were used to calibrate the WTTP model, a commonly used process simulator in the consulting industry. The influent and other required operating parameters were obtained from the plant personnel together with some plant historical records.

Reactors at IEUA RP-4 facility were modeled using a commercial simulator, and steady state and dynamic modeling was conducted for each alternative. The WWTP model was developed with 9 CSTR in series in a Denitrification-Nitrification-Denitrification-Nitrification (D-N-D-N) configuration. The geometry and diffuser characteristics were carefully implemented to mimic RP4 plant conditions.

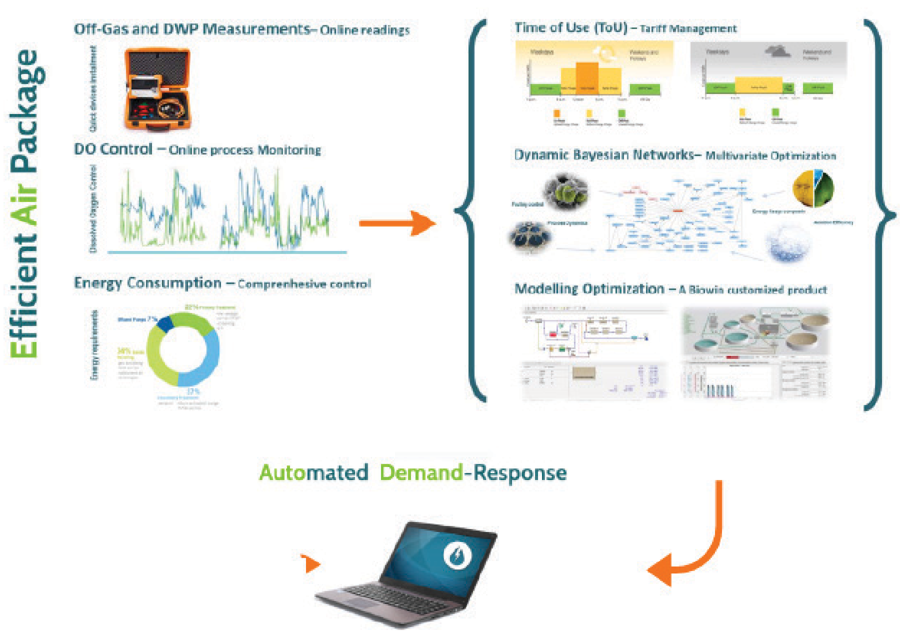

Figure 2: Schematic of the emerging demand/ response product for wastewater aeration monitoring using an on-line off-gas analyzer

FINDINGS

Four main operational strategies impacting the total amount of oxygen required were applied to the constructed model. The set of selected strategies targeted potential changes in the current aeration practices and were aimed at maximizing aeration cost-savings while maintaining the effluent quality, thus providing the required basis for cost comparisons between strategies and the combination of them.

REDUCE THE CURRENT DO SETPOINT OF 2.5MG/L WITHOUT PRODUCING A LOWER QUALITY EFFLUENT
The results show that while just decreasing the DO to 2.3mg/L, savings close to 4% could potentially be obtained, and the use of more aggressive lower DO setpoints could maximize cost-savings up to 19%.

INTERMITTENT AERATION DURING PEAK HOURS TO ENHANCE MIXING AND INCREASE AERATION SAVINGS
The simulations of this strategy resulted in cost-savings improvements close to 18% for almost all the seasonal periods. The simplicity of this strategy plus the potential savings obtained should position this strategy as one of the most promising operational strategies to gradually implement at RP-4.

DELAYING THE AMMONIA PEAK On the other hand, delaying the ammonia peak also resulted in cost-savings close to 12% independently of the season or DO setpoint applied. Although an interesting strategy from the cost saving point of view, some investment or skilled personnel may be required to deploy such a strategy. Therefore, further studies are required to better define and understand how avoiding the peaks of the main oxygen consumer could further reduce the aeration requirements.

INFLUENT FLOWRATE EQUALIZATION STRATEGIES Finally, the implementation of influent flowrate equalization strategies could not be fully explored due to some technical limitations which the co-authoring team expects to overcome in the following weeks. Therefore, the detrimental effect of the amplification phenomena occurring during on-peak periods (higher energy costs when aeration efficiency is the lowest) will be further explored in the upcoming final report.

Table 1: Summary of Aeration Strategies

DELTA DO	DO SETPOINT [O2 MG/L]	AERATION SAVINGS (%)
Strategy #1: DO Setpoint		
0.0	2.5	0.0
0.2	2.3	3.7
0.4	2.1	7.8
0.6	1.9	11.8
0.8	1.7	15.2
1.0	1.5	19.1
Strategy #2: Intermittent Aeration		
0.0	2.5	17.3
0.2	2.3	17.3
0.4	2.1	18.0
0.6	1.9	18.5
0.8	1.7	18.1
1.0	1.5	19.9
Strategy #3: Ammonia Equalization		
0.0	2.5	12.2
0.2	2.3	12.0
0.4	2.1	11.9
0.6	1.9	12.8
0.8	1.7	11.0
1.0	1.5	11.3
Strategy #4: Flow Equalization		
0.0	2.5	8.5
1.0	1.5	7.8

CONCLUSIONS

What We Concluded?

• Site-specific data is necessary for accurate quantification of the cost-analysis and potential savings for the different aeration-associated strategies.

• The results showed decreasing the DO from 2.5 mg/L to 2.3mg/L can result in average of 4% in aeration cost savings. The use of lower DO setpoints (1.5 mg/L) could maximize cost savings up to 22% while maintaining the effluent quality.

• Two operational strategies (e.g., intermittent aeration and ammonia equalization) resulted in an average cost savings close to 15-20% when compared to current operational strategy.

• The theoretical implementation of flow equalization will result in savings close 15%. Nevertheless, this strategy will fail to be feasible during some periods of year and further investigations are required before being recommended.

These Findings are based on the report "Demand/Response System for Wastewater Aeration Using On-line Off-gas," which is available from the ETCC program website, https://www.etcc-ca.com/reports.

Lessons Learned

Telemetry System Deployment

The telemetry system relies on a modem whose lifespan is affected by high temperatures. To prevent the accumulation of moisture within the analyzer gas sensors chamber, a moisture absorber that incorporated a heating system was installed in the OTE analyzer at RP-4. However, the heating system affected the lifespan of the telemetry modem and required replacement of that modem within six months.

To solve this thermal challenge, the team reconfigured the analyzer and the modem was thermally shielded. The entire enclosure was covered with an aluminum shield. From the experience gained from the OTE analyzer at RP-4, the team implemented an improved thermal design for the DR analyzer at RP-5 (see Figure 3 below).

To guarantee the autonomous operation of the unit, a ground-fault circuit interrupter, GFCI, was installed. Ground faults were likely to occur due to the condensation during some moist winter nights. In such an event, the current will switch to the installed solar panel connected to a chargeable battery pack located in an additional enclosure without interrupting operation.

Figure 3: image of the DR analyzer at IEUA RP-5, in its current configuration. The solar panels on the left wall and on the top were installed to charge the battery pack for autonomous analyzer operation.

Flow Equalization Strategy Savings

The simulation of the equalization tanks was performed using a constant alpha due to the incapacity to predict the impact of the equalization tanks on the aeration efficiency indicators. The initial simulations were run using a constant alpha factor of 0.5, which resulted in higher costs than the baseline. The observed negative values in winter for case studies 3 and 4 highlighted the importance of understanding the real and dynamic variations of mass transfer in each scenario. Therefore, the flow equalization scenario needs to be reviewed considering a dynamic alpha that can better represent the actual value of these kinds of systems or strategies. Similarly, no summer data was used as the results were still showing inconsistencies.