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Wastewater Treatment Smart Tip

Using SCADA to Improve and Assess Operations

Brief Introduction to SCADA Systems and Energy Efficiency

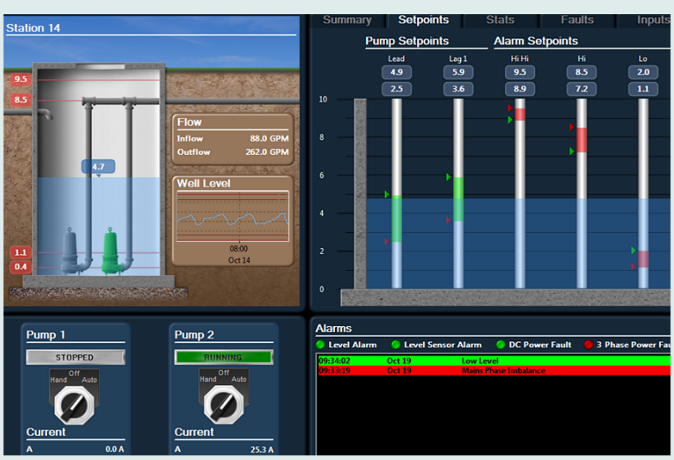
A Supervisory Control and Data Acquisition (SCADA) system is an assemblage of computer and communications equipment designed to work together for the purpose of gathering, monitoring, and analyzing data in real time. In modern and cost-effective wastewater treatment plants (WWTPs), processes such as aeration, chemical feeds and sludge pumping are usually controlled by an operating system integrated with online probes and sensors which provide data-driven actions. In 2014, the U.S. Electric Power Research Institute reported that integration of better control and optimization can potentially generate 10 to 20% saving in energy consumption (Copeland, C. Energy-Water Nexus: The Water Sector's Energy Use. (2014). Congressional Research Service).

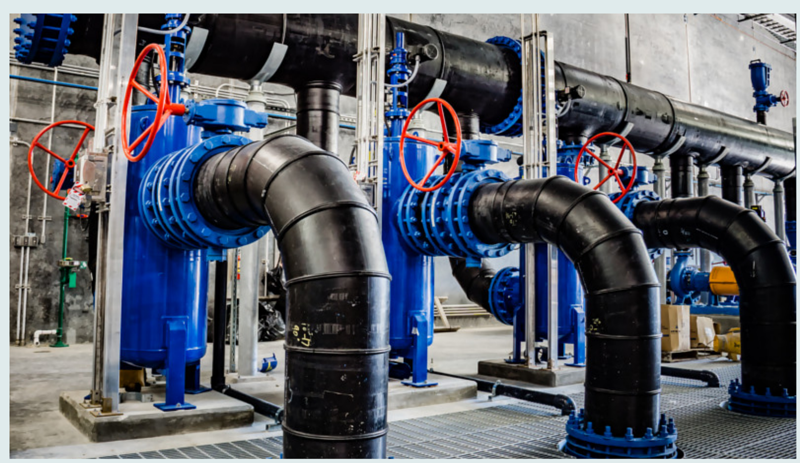
Tracking Performance in a SCADA System

The integration of a full SCADA system is a means for plant operators to deeply understand the functionality of the WWTP including the inputs and resulting outputs, process steps, cycle times, and modes of operation. SCADA systems provide a visual interface between the plant operator and the process which can allow for analysis of operations to determine normal and abnormal events. In many plants, SCADA use is limited to basic monitoring and reactive control of systems. However, they are capable of much more.

Data tracked through a SCADA system can serve as an operational benchmark by identifying key performance indicators and provides operators with the ability to set target performance levels. With that in mind, operators can easily track a plant's performance by analyzing the following parameters:

Influent Loading (water flow rate vs. air flow rate)
For an activated sludge process, BOD removal and nitrification require a theoretical mass of oxygen to be introduced in the system. However, the demand for oxygen is not always constant and varies with influent flows and BOD loading. Therefore, monitoring the plant influent flow is crucial to gauge the amount of air needed to maintain good BOD and nitrogen removal. Flow monitoring allows for basic airflow adjustments to run at reduced speed when flow rates and influent loading are lower, thus resulting in significant energy savings.





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Tracking Performance in a SCADA System (cont.)

Blower Discharge Pressure
Blowers produce air flow, and the discharge pressure is the system resistance to the flow at a given submergence level. This variable is an indicator of how much air the blower needs to provide to overcome the discharge pressure and maintain aeration requirements. Blowers keep air moving until the back pressure exceeds the blower's capability. Tracking of air pressure offers operators the capability to monitor the operating status of blowers and distribution system. For instance, an increase in pressure could be indicative of diffuser fouling or inlet filter fouling, and such issue can be addressed before it causes energy waste and blower damage.

Equipment Runtime
Runtime is a very important parameter for energy disaggregation, which allows operators and engineers to separately analyze the energy use for individual equipment or processes. This is extremely beneficial in achieving and maintaining energy efficiency. Run-time monitoring and management allows for optimizing equipment as well as detecting potential equipment malfunctions. A good example would be using a pump curve and runtime data to calculate an expected plant flow rate. This expected flow value can then be compared to the actual flowrate to yield information regarding the efficiency of the pump, potential clogs, and flow restrictions within the system. Deviations from expected flow can trigger maintenance alarms to notify staff of a potential issue.

Dissolved Oxygen (DO)
DO concentration in the aeration tank is an important process control parameter that has a great effect on the treatment efficiency, operational cost, and system stability due to its direct impact on the effluent quality with respect to nutrient removal. Low DO concentration can negatively affect effluent water nutrient levels or promote growth of unwanted microorganisms, while a high concentration can result in over-aeration or problems in the settling of sludge due to shearing of flocs and re-suspension of inert materials. Therefore, real-time DO monitoring can indicate the effectiveness of biological treatment. In a SCADA application, changes in DO are sensed and the SCADA system is used as a feedback control loop which signals the system to increase or decrease the speed of blowers, open and close valves to push air to parts of the process that need it and throttle back where demand is low. These actions can save 25% to 40% of aeration system energy compared to manual control. Monitoring DO over time can reveal issues with operational control, as well. DO that doesn't settle at a setpoint can indicate poor control loop design, which will increase wear and tear on control valves and blower systems. A well-tuned DO control loop will vary little from the desired setpoint except when large changes in demand occur.

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Tracking Performance in a SCADA System (cont.)

Nitrate and Ammonia Levels

A SCADA system that directly monitors the chemical concentrations of nitrate and ammonia in the aeration basins can allow the DO setpoint to be dialed down even lower than with a DO probe alone. This feedback provides a direct measurement of the efficiency of anoxic processes. These parameters can help ensure optimal nutrient levels and plant permit compliance. Some plants may use the online ammonia reading to control the aeration blowers in combination with the DO sensors to better tune the control loop. This type of control tends to minimize excessive DO in the aeration tank and prevents excessive DO in RAS flows while still ensuring that sufficient oxygen has been added to achieve full nitrification and denitrification. Cascade ammonia/nitrogen and DO control can generate approximately 9% of energy cost savings.

pH Measurement

Measurement of pH indicates the acidity or alkalinity of the influent and process basins. Inappropriate levels can negatively affect the required chemical or microbial reactions for nutrient removal. SCADA systems use data collected from pH transducers to make comparisons with the desired values and consequently take corrective actions to maintain optimal nutrient removal. For plants with enhanced nutrient removal, pH that is swinging away from setpoints can indicate poor phosphorus removal, as this process frees up alkalinity to maintain pH in the nitrification process.

Additional Considerations for Further Energy Efficiency

Equipment Monitoring

SCADA systems offer the capability to monitor the operating conditions of mechanical equipment within the plant. Operators have access to pressure setpoints for blowers, power monitoring, vibration sensors, runtime, etc. Using this information, operators can drive and improve maintenance. For instance, in DISC aerator applications, submergence level is crucial to achieve good air to water mixing. Power monitoring of individual pieces of equipment, coupled with historic tracking of energy, can reveal wear and tear that causes energy use to increase.

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Additional Considerations for Further Energy Efficiency (cont.)

Historical Data

SCADA systems also have the capability to log historical process variables to help operators capture changes in the process impacting efficiency and energy use. Operators can use historical data to identify trends, predict outcomes, and respond to changing conditions by analyzing current with past data. These variables can include influent flow, waste and return activated sludge flow, digester temperature, dissolved oxygen, etc. An example of how this data could be used to manage plant energy use would be by analyzing trends between current and past pump speed and gallons per minute flow output. With this information, operators can deduce whether the pump is performing efficiently or whether the pump needs tuning, impeller replacement, or other maintenance.

Remote Monitoring

Remote monitoring helps maintain efficiency and communicate issues. Remote systems can notify operators of issues and serve as means to enable remote maintenance to reduce downtime with early fault detection, alarming, and quick response time to reduce downtime. Furthermore, accessing the plant data remotely eliminates the need for periodic manual maintenance checks, thus reducing labor costs.

Artificial Intelligence

SCADA, with integrated system modeling capability, can compare current operation to optimized operation, and identify issues, automatically correct, or alert maintenance to investigate. This reduces the human effort and error involved in data tracking and calculations. SCADA systems with AI can run control algorithms based on mathematical modeling and computer simulation to optimize aeration in advance of large upsets like I&I flows, adjust return and waste sludge flows to provide optimal biomass for the incoming loading for treatment, and much more. This has become a helpful tool in the analysis of each part of wastewater treatment and its effectiveness. While implementing AI can be a high-capital project, the long-term benefits can significantly reduce energy consumption to treat wastewater, and better maintain those savings over time.

What Makes an Effective SCADA System?

Analyzable

The SCADA can identify root causes of issues by monitoring components throughout the treatment process. In addition, some SCADA systems have statistical packages incorporated which can use online analysis of the real time data to detect system changes or issues. For instance, SCADA systems can identify opportunities for instrument re-calibration or imminent failures of various sensory components.

Flexible

SCADA systems can easily be updated with future expansions or technology. This would include open-source code over proprietary systems, long-term operational support, and contractor longevity for consistency in programming when updates are made.

Stable

Stability of a SCADA system is based around proper tuning of the system to avoid rapid, large fluctuations in process variables like aeration airflow or pump speeds, typically referred to as hunting. A SCADA system should adjust to a disruption, and within a short period, reach and maintain a setpoint for all associated processes without hunting.

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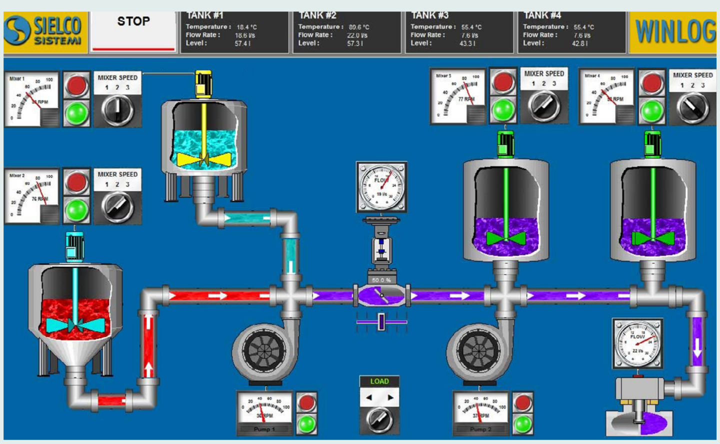
Summary of SCADA Benefits

Sophisticated SCADA systems are incorporated with a set of tools capable of displaying process data through which a plant's operating conditions can be observed and analyzed. Data can then be used to track and evaluate the plant's performance and allow for the detection of subtle changes throughout the treatment such as faulty equipment, leaks, overflows, or chemical imbalance. Moreover, SCADA systems can provide operators with the ability to effectively develop measures to assess the WWTP's energy balance and identify strategies to improve energy efficiency. Specific measures include reductions in energy costs through more efficient processes, shifting of loads to off-peak hours, reductions in maintenance costs by adopting preventive maintenance as opposed to reactive maintenance, and increases in effective capacity through optimization of processes. Also, SCADA systems can allow for remote monitoring which facilitates quick intervention and eliminates costly lags in system functionality. Some systems can be tied into auto-paging and auto-dialing which automatically notifies operators of a problem.

New SCADA systems can implement AI as a further advantage, thus, increasing response times and process stability in the face of large or unpredictable upsets like heavy rainfalls or slugs of biological loading. Continuous optimization of the process to an idealized AI model also better maintains long-term efficiency of processes.

Integrating such system might seem costly at first, but SCADA allows operators to reduce resource use and costs. In addition, the proper use data-driven operations has a significant impact on understanding and accurately optimizing the overall treatment process, especially energy-intensive processes which can yield positive returns on investments in process control technology.



Have a Question About the Public Water Infrastructure Program?
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WHO WE ARE

SEDAC provides energy assessments, education and technical assistance. This program is in partnership with the U.S. Dept. of Energy Sustainable Wastewater Infrastructure of the Future (SWIFT) accelerator for energy efficiency in wastewater treatment, and a partner for the Public Water Infrastructure Energy Efficiency Program with the Illinois EPA Office of Energy

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