U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
ADVANCED MANUFACTURING OFFICE

Flexible Distributed Energy and Water from Waste for the Food and Beverage Industry

Robust Waste-to-Value Solution Using Advanced Monitoring and Controls

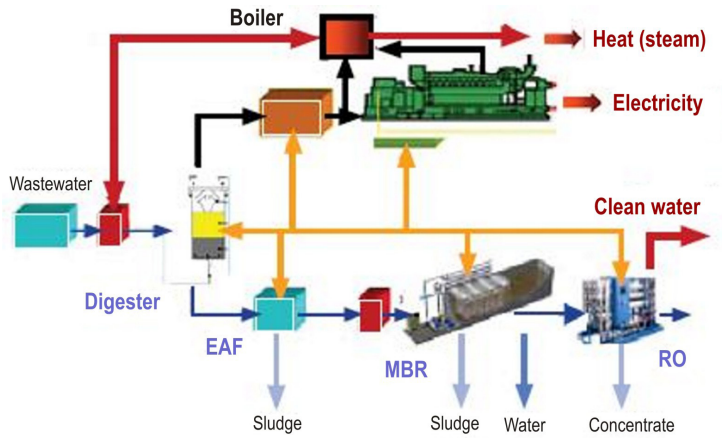
Introduction

Waste-to-value is a promising and comprehensive wastewater processing solution being pursued by GE that recovers valuable energy and purified water from the abundant wastewater generated and currently discharged in many industries. A key challenge to the successful implementation and commercialization of this technology is its low overall operational system stability and reliability, indicated by frequent system upsets and costly shutdowns for maintenance. As shown in the figure to the right, the overall system consists of multiple components, including pretreatment, anaerobic digestion, aerobic reaction, filtration and gas processing, and combustion in a boiler and/or gas engines, all operating together in an integrated system. Frequent and often unknown variations in operating conditions and wastewater feed composition create upsets in individual components, which when unmitigated, grow into system-level upsets and associated shutdowns and costly repairs.

This project sought to address this challenge through the development of an automated monitoring and supervisory controls solution to improve the overall system robustness, targeting up to a 90% reduction in unmitigated process upsets. The monitoring and controls solution will improve operation efficiency and reduce operating costs by 5-10% or more. It was implemented in a pilot plant in order to validate the overall system performance improvement.

Benefits for Our Industry and Our Nation

According to the U.S. Census Bureau, there are approximately 30,000 food and beverage plants in the United States that were estimated to consume approximately 1 quadrillion Btu of energy in 2008. This amounts to 4% of total manufacturing energy end use, while generating emissions totaling 24.4 million metric tons of carbon. Roughly 375 of these plants are very amenable to a complete waste-to-value solution because of factors that include the high organic content in the plants' effluent waste streams. It is estimated that a comprehensive waste-to-value solution for a typical large food and beverage plant holds the promise for displacing up to 25% of fossil-based energy while recovering and recycling up to 90% of the water in the waste stream. This has the effect of reducing greenhouse gas emissions by up to 13,000 tons per year. The total energy and water savings for a typical plant is estimated to be approximately $4 million per year.



Waste-to-value plant recovers energy through anaerobic digestion and purifies the water to desired purity for reuse, moving through filtration, an aerobic membrane bioreactor (MBR), and reverse osmosis (RO). Predictive monitoring and supervisory controls are key to achieving the robust and flexible operation of the integrated plant. *Illustration courtesy of GE Global Research*

Applications in Our Nation's Industry

The immediate application of the waste-to-value technology will be in the food and beverage industry. As the technology matures and demonstrates its value for this initial target industry, it can subsequently be expanded to other industries with similar high-organics wastewater effluent, such as biofuels, pulp, and paper.

Project Description

This project developed a systematic model-based predictive monitoring and supervisory control solution for the early detection of abnormal process variations and potential upsets in a waste-to-value wastewater processing system. The monitoring and control solution mitigates the impact of any detected variations through automated corrective action, aiming to reduce the occurrence of severe upsets by up to 90%. It also enables improved operating efficiency and reduces operating costs. The predictive monitoring and supervisory controls solution was demonstrated in a wastewater treatment plant at an Anheuser-Busch facility in California.

Barriers

- Limited online sensing for detecting variations in feed and operating conditions
- Limited understanding of the cause-effect relationships in individual components and the overall system
- Slow and complex dynamics in bioreactors impacted by input and process variations
- Manual operation with inadequate automation for coordinated operation of process components

Pathways

In Phase I, a predictive model-based online monitoring and supervisory controls solution was developed. Controlled anaerobic digestion lab experiments were conducted to complement available field data from existing customer sites in order to develop and validate a real-time predictive model of the overall system. The predictive model formed the basis for online virtual sensing of key unmeasured process variables and developed rules for early detection of potential upsets. A feed-forward/feedback supervisory control solution was developed to mitigate the impact of detected variations and to coordinate the operation of all process components. The developed monitoring and control solution was initially tested on a controls hardware platform. In Phase II, a full-scale pilot project was implemented at a wastewater treatment plant at an Anheuser-Busch facility so that its performance benefits could be validated.

Milestones

Phase I

- Gathering of system-level requirements
- Validation of system models
- Simulation of monitoring and control algorithm followed by implementation and validation of control hardware

Phase II

- Implementation of developed monitoring and controls solution at pilot plant
- Stable operation of pilot plant and evaluation of control solution's impact on system operation

Achievements

- An integrated monitoring and supervisory control system for industrial waste-to-value systems was developed and demonstrated in a pilot project
- Developed system is capable of identifying and controlling process disturbances, improving overall system stability
- Pilot plant operation helped identify further development needs to improve certain data analysis capabilities and ruggedness of the monitoring instrumentation

Commercialization

One of the project partners, GE Water & Process Technologies, is actively pursuing the implementation and commercialization of waste-to-value technology and thus already has a wide customer base in the food and beverage industry. GE is in a unique position to bring to market and expand upon a comprehensive solution because of its expertise and ownership of key process equipment and chemicals for water processing, power generation, and state-of-the-art controls solutions. The Phase II pilot plant technology demonstration proved that the monitoring and control solution is a viable product for future commercialization, but that further development work is needed to improve the monitoring instrumentation and certain data analysis capabilities.

Project Partners

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Project final report available at
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