

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

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

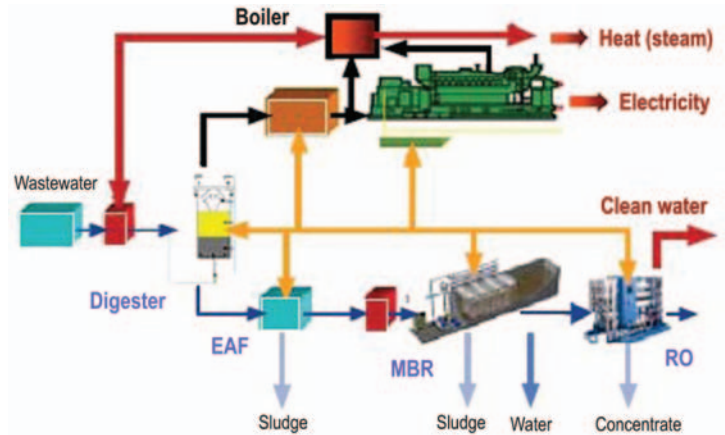
#### Introduction

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 below, 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 seeks 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. Also, the monitoring and controls solution will improve the operation efficiency and reduce the operation cost by 5-10% or more. The developed predictive monitoring and controls solution will be 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



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.*

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.

#### 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

The goal of this project is to develop 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 developed monitoring and control solution would also mitigate the impact of any detected variations through automated corrective action, aiming to reduce the occurrence of severe upsets by up to 90%. The monitoring and controls solution will also enable improved operation efficiency and reduce operation cost. The developed predictive monitoring and supervisory control solution will be subsequently demonstrated in a pilot plant at a customer site.

## 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 will be developed. To this end, controlled anaerobic digestion lab experiments will be 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 will form the basis for online virtual sensing of key unmeasured process variables and develop rules for early detection of potential upsets. A feed-forward/feedback supervisory control solution will be developed to mitigate the impact of detected variations and to coordinate the operation of all process components. The developed monitoring and control solution will initially be tested on a controls hardware platform. Finally, in Phase II of the project, the solution will be applied in a full-scale pilot plant at a customer site and its performance benefits will be validated.

## Milestones

This project started in January 2009.

Phase I (Completed 2009-2010)

- 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 (scheduled for 2011)

- Implementation of developed monitoring and controls solution at pilot plant
- Stable operation of pilot plant and quantified impact

## 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 will alleviate current concerns regarding process reliability, allowing for accelerated implementation and commercialization in the food and beverage industry.

## Project Partners

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