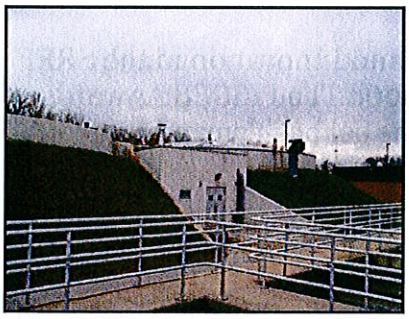
PROJECT DESCRIPTION

As concerns for energy efficiency become more prevalent, cities nationwide are considering alternative power projects. The City of West Lafayette was ahead of the trend with its Digester Renovation with Alternate Power Sources Project at its Wastewater Treatment Plant (WWTP). The plant was in need of major upgrades to its solids handling process. Covers on both anaerobic digesters were over 20 years old and in need of replacement, and the sludge heating and mixing systems were in poor condition and only able to heat one digester at a time. In addition, gas produced by the digestion process was being flared to the atmosphere, resulting in greenhouse gas emissions and a wasted energy source.



Old Digester Facility

The City took a proactive approach to "going green" by incorporating a co-generation system and a fats, oils, and grease (FOG) receiving facility for producing renewable energy as part of the needed digester improvements. The project had lofty goals with regards to reducing electrical and natural gas consumption and generating revenue.

The original digester process used natural gas to fuel the boiler for heating sludge to the necessary temperature to promote biological reactions, and the gas produced as a byproduct of these reactions was flared to the atmosphere. The new system utilizes a combined heat and power system (CHP), using this gas to fuel microturbines to produce electricity for the plant as well as recovering waste heat from the microturbines to heat the digester sludge, thereby reducing use of natural gas for the boiler. Adding FOG and food waste to the digesters has increased digester gas production, further increasing the production of renewable power. The current gas production is sufficient to power two 65 kW microturbines for use as alternate power with provisions for adding two more in the future. The City is considering adding another CHP technology, internal combustion engines, to work in conjunction with the microturbines when the process is expanded.

New Digester Facility

This would put the plant in the unique position of having the capability to compare the performance of the microturbines and engines using the same gas.

By utilizing new fixed covers for the digesters to replace the old floating covers, an additional 4 feet of digester volume was realized, increasing the usable volume by 18% and providing sufficient capacity for a population growth of 25% within the service area. This saved the City more than one million dollars over building a third digester.

The project earned the City the US EPA's Performance and Innovation in the SRF Creating Environmental Success (PISCES) award in 2006. The PISCES Awards highlight successfully designed projects that further the goal of clean and safe water with exceptional planning, management, and financing.

ENVIRONMENTAL BENEFITS

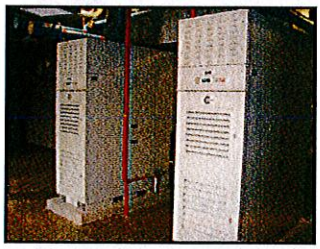
Green – having positive environmental attributes; supporting or protecting the environment; environmentally friendly

Sustainable – capable of being maintained without exhausting natural resources or minimal long-term environmental impacts

Renewable Energy – an energy resource that is replaced rapidly by natural processes

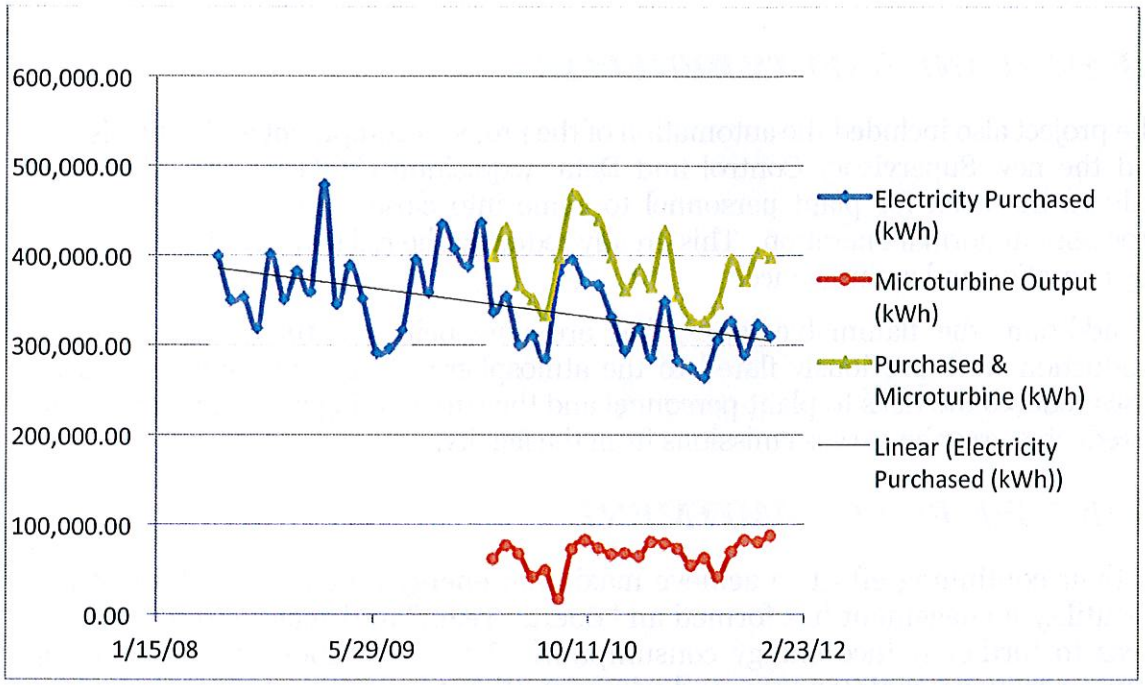
These terms can all be used to describe the City of West Lafayette's Digester Renovation with Alternate Power Sources Project. While these terms have become commonplace, this project hits at their very heart – utilizing a renewable energy source that is readily replenished and reducing the use of finite fossil fuels and their associated carbon footprint.

Based on 22 months of plant operations data from March 2010 to December 2011, the microturbines are producing an average of 18% of the WWTP total electricity usage per month that would otherwise come from non-renewable sources. And this production is trending upward; the average of the last 12 months of the data period was 19%, and there have been several recent months where it reached 20% or higher. The graph below illustrates the declining trend in the purchased electricity at the WWTP since the project was completed.



Microturbines

The utility also reduced its natural gas consumption during this time period by almost 60% when compared to a similar time frame a few years ago (prior to construction) by using waste heat from the co-generation system for sludge heating instead of the boiler which is fueled by natural gas.



The City also receives up to several tons of cafeteria food waste from Purdue University almost every day and adds it to the digesters to further increase gas production. This waste was previously hauled to a landfill for disposal. Hauling FOG and food wastes from local sources to the WWTP reduces hauling distance, frees up landfill space, and provides additional environmental benefits such as reduced carbon footprint. The expansion of FOG and food waste receiving will increase gas production, provide more renewable power, and generate even more savings.

The City has been recognized as a "Green Power Partner" by the US EPA. The Green Power Partnership is a voluntary program that encourages organizations to buy or generate green power to reduce the environmental impacts associated with purchased electricity use. The EPA defines Green Power as electricity generated from renewable energy resources providing the highest environmental benefit, such as solar, wind, geothermal, biogas, biomass, and hydroelectric sources. On-site green power is produced at the WWTP rather than at central power plants, producing no net increase in greenhouse gas emissions.

HEALTH AND SAFETY BENEFITS

The project also included the automation of the project's equipment and controls, and the new Supervisory Control and Data Acquisition (SCADA) control system reduces the need for plant personnel to come into close contact with parts and processes in normal operation. This greatly reducing the risks involved with day-to-day operation and maintenance.

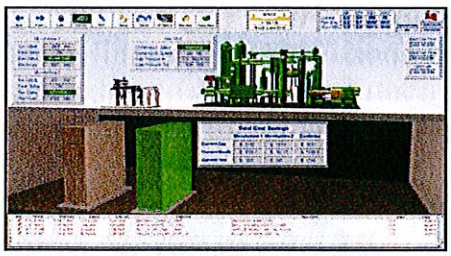
In addition, the flammable gases that are now being captured for electricity production were previously flared to the atmosphere. The containment of these gases reduces the risks to plant personnel and the surrounding environment as well as reducing greenhouse gas emissions from the facility.

MANAGEMENT COMMITMENT

In their continuing effort to achieve maximum energy efficiency at the WWTP, the utility management has formed an "Energy Team" to discuss and implement ideas to further reduce energy consumption. This team consists of staff from plant operations, maintenance, and administration to ensure potential savings in all aspects of the facility are recognized.

The involvement of employees in developing and implementing ideas for energy efficiency has given them a sense of pride and ownership in the facility. They are continuously searching for ways to reduce energy consumption, improve operations, and establish the facility as an innovative leader in the industry. And Utility management encourages their involvement and gives support and recognition of viable ideas for improvement.

Management has also expanded the SCADA control system to track and display the energy produced by the microturbines on a monthly and annual basis. The system also tracks the savings incurred by not purchasing this electricity. This allows both management and employees to see in real time the impact that their efforts have on the facility.



Microturbine SCADA Screen

Before the project was implemented, many efforts were made to inform the community about the proposed project and anticipated energy savings. Utility management, along with the design engineer, attended several meetings including City Council meetings and public hearings in order to educate people on the benefits to be realized by the project. Users of the City's sewer system would see an increase in their monthly fee to assist the City in repaying the State Revolving Fund (SRF) loan obtained for the project, and the Utility wanted to be

sure the public was as informed as possible about the need for this increase as well as the associated benefits.

TRANSFERABILITY

This project serves as a model for other municipalities considering similar projects with their anaerobic digesters. With the growing desire to be stewards of the environment, wastewater utilities will likely consider environmentally sensitive benefits when evaluating future upgrades, and this project shows that with the right changes, "going green" can be both economically and environmentally beneficial.

The City of West Lafayette is proud of this innovative and forward-thinking project and welcomes other municipalities to the plant to view first-hand the finished product and learn about the benefits realized since implementation. There have been a number of visits from other communities considering utilizing their digester gas for energy production.

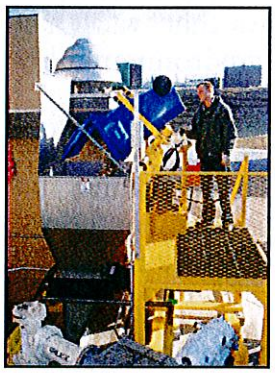
The Utility has also produced flyers informing the community of the project and encouraging individual households to pick up free collection bottles at the WWTP to recycle used cooking oil, fats, and grease in lieu of disposing of them down home drains. The flyers discuss the benefits of recycling these materials including reduced clogging, landfill wastes, and City electric costs for treatment and describe how the facility will utilize the container contents to produce electricity. The flyers and collection bottles were distributed at City Hall, the WWTP, and the Farmer's Market. Flyers were also developed and sent directly to grease haulers in the area which describe the benefits to the haulers as well as the community of bringing their loads to the WWTP instead of hauling to a landfill. These flyers are included at the end of this application.

Along with these efforts, the Utility also presents monthly Green Power reports to the Board of Works and the City Council keeping them informed of the performance of their new digester system and other efforts at energy efficiency. These reports are also made available to the public on the City website.

INNOVATION

While digester gas has historically been used to fuel boilers and combustible engines to drive dedicated pumps or blowers, the use of gas to produce electricity is a relatively new application in the municipal wastewater field. Electricity is a much more versatile form of power which can be used throughout the facility for a variety of equipment.

FOG receiving facilities are also a new concept at WWTPs, with the West Lafayette facility being among only a handful in the country although many communities have begun investigating the feasibility and benefit to their plants in conjunction with cogeneration. In order to take advantage of existing structures, the new FOG receiving facility reused an abandoned wet-well/dry-well pump station which was modified to accept and handle FOG. This type of facility had not been previously installed in a cold weather climate, so considerations were made to prevent the FOG contents from solidifying at cooler temperatures, and the plant has had no problems with this. The FOG is mixed in the wet well and conveyed through an insulated piping system to the digesters.



Food Waste Receiving Station

The City further enhanced its dedication to "going green" by installing electric vehicle charging stations. Electricity generated by the microturbines will be used to power the City's future electrical vehicle fleet.

Electric Car Charging Stations

ECONOMIC BENEFITS

In 2011, the microturbines produced an average of 70,000 kW-hours of electricity per month which is approximately 18% of the WWTP's total usage. This has resulted in a monthly savings of approximately $4,924 for the plant and is equivalent to the electricity used by 75 homes every month. The utility also reduced their natural gas consumption in 2011 by approximately 51% (21,500 ccf) as compared to the year prior to construction by using waste heat from the co-generation system for sludge heating. The utility realized a total savings of nearly $30,000 in natural gas costs for this period.

The savings realized by this project will only increase as electric and natural gas rates rise in the future. With the addition of more microturbines or engines, approximately 25% of the plant's future power needs will be supplied by the methane-generated electricity using the cogeneration system.

The addition of the FOG receiving facility also generates tipping fees, a new revenue source for the utility. Commercial customers haul waste grease from restaurants to the WWTP for disposal rather than out of town, reducing trucking distance and its associated secondary carbon footprint. At the maximum capacity of 12,000 gallons received per weekday, FOG receiving could generate $280,000 in revenue annually.

The overall project cost for the digester renovation was approximately $10.4M for engineering, construction, and legal fees, with most of this cost associated with needed process improvements not directly associated with the cogeneration facilities. As the numbers show above, the City already sees a very real return every month with electricity savings, natural gas savings, and the addition of the tipping fees for receiving the FOG and food wastes. This savings will only increase as the system is expanded.

Public perception has been extremely positive due to the environmental benefits and projected financial savings associated with the project which will help minimize future rate increases due to operation and maintenance at the plant as well as future projects as the facility expands. Plant management is very proactive in promoting the environmental and economic benefits resulting from the work at the plant, and they are eager to inform and share their knowledge with their citizens and other WWTP's.

This project secured the employment of design engineers and numerous trades of construction workers during construction.

The Digester Renovation with Alternate Power Sources project is a true "waste to energy" project, providing significant environmental benefits while also providing economic benefits to the City of West Lafayette and its rate payers.

Environmental and Economic Benefits Summary

Electricity

January 2011 – December 2011

- *Total Electricity Used – 4,465,000 kWh*
- *Electricity Produced by Microturbines – 844,300 kWh*
- *% of Total Electricity Produced by Microturbines – 18.9%*
- *Savings - $59,100 per year → $4,925 per month*

Natural Gas

January 2007 to December 2007 (Before Construction)

- *Natural Gas Consumed – 68,700 ccf*

January 2011 to December 2011

- *Natural Gas Consumed – 27,400 ccf*
- *Decrease in Natural Gas Consumption – 41,300 ccf → 60%*
- *Savings - $46,600 per year → $3,900 per month*

HOME OF PURDUE UNIVERSITY

CITY OF WEST LAFAYETTE

Anaerobic Digesters and Co-Generation

At The West Lafayette Wastewater Utility

Anaerobic Digestion

- Process in which volatile organic solids are broken down by anaerobic bacteria.
- Anaerobic microorganisms live in an environment containing no free oxygen. They obtain their oxygen by breaking down chemical compounds which contain oxygen.
- Anaerobic bacteria need to be kept warm to function efficiently. The contents of our digesters are heated to around 100°F.

Benefits of Anaerobic Digestion:

- Pathogen Destruction
- Solids and Mass Reduction
- Reduced Vector Attraction
- Digested Sludge Can Be Used as Crop Fertilizer
- Methane Gas Production

Wastes Treated In Our Anaerobic Digesters:

- **Primary Sludge**
  - Sludge From Wastewater Settled in Primary Clarifiers
    - Average 30,000 Gallons/day pumped to Digesters

- **Thickened Secondary Waste Sludge**
  - Excess Activated Sludge That Must Be Removed From System
    - Average 8,000 Gallons/day pumped to Digesters

- **Fats, Oil & Grease**
  - Average 1,500 Gallons/day pumped to Digesters
    - Grease Waste from Hauling Companies
    - Cooking Oil from City's Collection Program

- **Food Waste**
  - Purdue University Dining Halls
    - Average 1,600 pounds/day pumped to Digesters

Equipment Overview

Anaerobic Digester Tanks (2):

- **Volume:**
  - 520,000 Gallons Each
  - 1,040,000 Gallons Total

- **Detention Time:**
  - Average 20 Days

Microturbines (2):

- **Capstone C65 Microturbines:**
  - Each Can Produce Up to 65 kW of Electricity
  - Combustion of Digester Gas Turns Turbine to Produce Electricity

- **Heat Exchanger Add-On**
  - Captures Heat Produced During Gas Combustion and Exchanges it into a Water Loop
  - Captured Heat Used to Heat Digester Contents in Water-to-Sludge Heat Exchangers
  - "Co-generation" – Combined Heat and Power Generation

Digester Pumping:

- **Mixing Pumps (2)**
  - Mixes Contents of Digester Tanks

- **Hot Water Pumps (2)**
  - Pumps Hot Water From Microturbines to Water-to-Sludge Heat Exchangers, in a Loop

- **Recirculation Pumps (2)**
  - Pumps Digester Contents Through Water-to-Sludge Heat Exchangers To Maintain 100F
  - Heat Exchangers Use Captured Heat from Microturbines

- **Transfer Pumps (2)**
  - Pumps Digested Sludge to Biosolids Holding Lagoon