Final Technical Report

Project Title:	Managing Dairy Waste Inputs in Morrisville's Hard-top Plug-flow Anaerobic Digester
Award Number:	DE-FG36-05GO85008
Recipient:	SUNY Morrisville State College
Project Location:	Dairy Complex, Morrisville State College, Morrisville, NY 13104
Project Period:	June 30, 2005 to December 31, 2006
Date of Report:	March 20, 2007
Written by:	Dr. Walid H. Shayya
Subcontractors:	Dr. David Palmer, Cow Power Company, Project Consultant Paul Yaman Construction, Primary Construction Contractor
Cost-Sharing Partners:	New York State Energy Research and Development Authority (NYSERDA) New York State Department of Agriculture and Markets SUNY Morrisville State College
Project Contact(s):	Dr. Ray Cross, Institutional Representative (phone: 315-684-6044, email: crossrw@morrisville.edu) Dr. Walid Shayya, Principal Investigator (phone: 315-684-6526, e-mail: shayyaw@morrisville.edu) Mr. John Angerosa, Business Contact (phone: 315-684-6061, e-mail: angerojj@morrisville.edu)
DOE Project Team:	Mr. Gene Petersen, DOE Field Project Officer Mr. Michael Schledorn, DOE Contract Specialist Mr. Chad Schell, DOE Project Monitor

Executive Summary

The state of New York through the New York State Energy Research and Development Authority (NYSERDA) has developed a suite of digester projects throughout the state to assess the potential for anaerobic digestion systems to improve manure management and concurrently produce energy through the production of heat and electrical power using the biogas produced from the digesters. Dairies comprise a significant part of the agribusiness and economy of the state of New York. Improving the energy efficiency and environmental footprint of dairies is a goal of NYSERDA. SUNY Morrisville State College (MSC) is part of a collection of state universities, dairy farms, cooperatives, and municipalities examining anaerobic digestion systems to achieve the goals of NYSERDA, the improvement of manure management, and reducing emissions to local dairy animal sites.

The Dairy Complex at MSC was built in 2001 with a free-stall barn that houses more than 200 milking cows. Several new additions to the dairy complex were made over the past four years, including two barns for heifers, dry cows, and bred heifers (constructed in 2004); two new calf barns (one constructed in 2004 and a second scheduled for completion in 2007); and a show barn (built in 2006).

The process for siting a digester system at the MSC's free-stall Dairy Complex was initiated in 2002. The project involved the construction of an anaerobic digester that can accommodate the organic waste generated at Dairy complex located about a mile southeast of the main campus. Support for the project was provided through funding from the New York State Energy Research and Development Authority (NYSERDA) and the New York State Department of Agriculture and Markets. The DOE contribution to the project provided additional resources to construct an expanded facility to handle waste generated from the existing free-stall dairy and the newly-constructed barns. Construction on the project was completed in 2006 and the production of biogas started soon after the tanks were filled with the effluent generated at the Dairy Complex. The system has been in operation since December 17, 2006. The generated biogas was consistently flared starting from December 20, 2006, and until the operation of the internal combustion engine/generator set were first tested on the 9th of January, 2007. Flaring the biogas continued until the interconnect with the power grid was approved by NYSEG (the electrical power provider) and the combined heat and power generation (CHP) system was authorized to start on February 27, 2007. The system has been in operation since February 28, 2007, and is generating 45 to 50 kW of electrical power on continuous basis.

The completed project will ultimately allow for investigating the facility of utilizing organic waste from a dairy operation in a hard-top plug-flow methane digester with the ultimate goal of reducing environmental risk, increasing economic benefits, and demonstrating the viability of an anaerobic methane digestion system. Many benefits are expected as a result of the completed project including our better understanding of the anaerobic digestion process and its management as well as the facility to utilize the methane digester as a demonstration site for dairy producers, farmers, and organic waste producers in New York State and the Northeast. Additional benefits include helping current and future students in dairy science and technology, agricultural business, environmental sciences, agricultural engineering, and other disciplines develop better understanding of underutilized biomass alternative energy technologies, environmental conservation, environmental stewardship, and sustainable agriculture.

Project Scope and Objectives

The project scope involved the construction of a dual-chamber, hard-top concrete tank, anaerobic, methane digester that can accommodate larger flows of dairy waste from the free-stall dairy complex and the newly-constructed heifer and calf barns on the campus of SUNY Morrisville State College. Support for the project was provided through funding from the New York State Energy Research and Development Authority (NYSERDA) and the New York State Department of Agriculture and Markets. The DOE contribution to the project provided resources to construct an expanded facility to handle waste from the existing free-stall dairy and the newly-constructed heifer and calf barns.

The specific objectives of the project included the following:

- Modify the existing designs to handle additional capacity of dairy waste.

- Determine that the modified designs do not adversely impact the steady-state operation of the methane digester operating on animal wastes generated at Dairy Complex.

The project objectives were met as outlined in the next section of this report. As such, the DOE share of the work was successfully completed following the construction of the facility and its successful operation using the generated dairy waste streams at MSC's Dairy Complex.

Project Accomplishments

The overall objectives of the project were achieved in early December 2006 after the construction on the system was completed and all of the mechanical and electrical components were installed. However, a slight delay was encountered after the startup process of the system was initiated and before the system became fully operational. Amongst the issues that delayed the operation of the system was the time it took for both sides of the digester to be filled with effluent from the Daily Complex. In addition, the digester had to be seeded with anaerobic microorganisms and heated to approach the optimum mesophilic temperature conditions of 98ºF. The production of sufficient amounts of biogas as reflected through the measurement of gas lines pressure became the next obstacle that had to be overcome. This requirement was imposed by the manufacturer of the combined heat and power generation system (GenTec) as it essential to have enough biogas being generated by the system before a representative of the company could visit the site to start the engine after finalizing the installation of mechanical/electrical equipments (ICE, system controllers, and electric interconnect). The visit ultimately took place on the 9th of January, 2007. The final obstacle was to receive final approval from NYSEG, the electrical power provider, for the operation of the system given the required interconnect with the power grid. Final approval for the operation of the system was received from NYSEG on the 27th of February and the regular operation of the system commenced at 6:30 a.m. on the 28th of February, 2007.

Summary of Project Activities:

Below is a list of major activities completed during the entire period of DOE funding on the digester project:

- The revised design of the methane digester project as prepared by the consultant was used to award the construction contract to a local company. The design prepared by Cow Power Company and Tiry Engineering included completed drawings and design documents that involve the construction of the two-chamber tank (90'x37'x12') along with associated below-grade manure transfer piping, tanks, manholes, and valves. It also included the designs for the construction of a building (36'x36') for housing the combined heat and power (CHP) generation system.

- The construction contract was awarded to Paul Yaman Construction in early August, 2005, and the contractor mobilized to the site on Wednesday – August 3, 2005.

- Site preparation and excavation for the construction of the tank was completed during the week of August 8, 2005 (Figure 1).

- The poured concrete foundation and floor slab of the dual-chamber tank were completed in early August, 2005, along with the required floor insulation (Figures 2, 3, and 4). The poured concrete walls of the digester as well as the interior walls that separate the two chambers were then finished in early September, 2005. Each of the two sides of the digester included another wall that separates the digester tank from a smaller grit chamber where the primary heat exchanger were eventually located for heating the influent waste stream (Figures 5, 6, 7, 8, and 9). The access ports to the two chambers of the digester were formed during the week of September 26, 2005. The construction on the interior of the digester (including the grit chamber) and access ports was completed in early October, 2005. During the same period, the CHP building foundation was excavated, the holes for the posts dug, and the posts of the CHP building erected

- The pre-cast concrete planks were installed on the 10th of October, 2005 (Figure 10). The joints of the concrete planks were then sealed (Figure 11). The forms for the top concrete coat and the baffle close to the location of the outlet bay were also completed towards mid October, 2005 (Figure 12).

- The heat loop inside each of the two chambers of the digester (Figure 13) as well as the heat exchangers inside the grit chamber of each side of the digester (Figure 14) were installed during the week of the 10th of October, 2005.

- The 4"-concrete top coat and the access ports to the two sides of the digester were poured during the week of the 17th of October, 2005 (Figure 15).

- The outside of the walls of the digester as well as the digester's top were insulated using polyurethane. In addition, a coating of poly-urea was applied to protect the insulation from UV light damage (Figure 16).

- The 12" effluent pipe from the outlet bay of the digester to a location near the existing manure storage tank was installed.

- The inside of the top of the digester was finished and coal tar epoxy coating was applied on November 4th, 2005, to seal the interior of the two chambers of the digester.

- The slab for the outlet bay of the digester was formed and poured during the week of November 7, 2005 (Figure 17). The walls of the outlet bay of the digester were formed and poured during the week of November 14, 2005 (Figure 18).

- The framing of the equipment building was completed in early November, 2005, along with the roof and most of the exterior siding of the building (Figures 19 and 20).

- The installation of insulated steel pipes for heated water that would connect the thermal skid inside the CHP building to the two maintenance loops and the two heat exchangers in the digester was completed on November 21, 2005 (Figure 21). The trench was then backfilled after pressure-testing the pipes for leaks.

- The back-fill and packing of the soil behind the outside walls of the digester was started on the 28th of October, 2005. The back-fill and packing of the soil behind the outside walls of the digester as well as the area surrounding the CHP building was completed during the week of the 26th of November, 2005 (Figures 23).

- The cement floor of the CHP building was poured on the 22nd of November, 2005.

- A trench (Figure 24) was dug on the 6th of December, 2005, between the existing manure storage tank and the influent side of the digester. A 4" Schedule 80 PVC pipe was then installed to connect the manure storage tank to the digester so that a pump can be used to move the influent to the digester.

- Several mechanical and electrical components (excluding the engine and the boiler) were delivered to the site during the week of November 28th, 2005, and stored in the CHP building.

- The finishing of the interior walls and ceiling of the CHP building was started in mid December, 2005. Construction on the building was completed in early January, 2006.

- A 300,000 Btu/hr output boiler system was delivered to the site in January, 2006. The boiler was acquired from Performance Engineering as a research donation.

- The engine/generator set was delivered to the site on Friday – April 21, 2006 (Figure 25).

- The existing 3-day storage was subdivided into two compartments (Figure 26). About two-thirds of the original volume of the tank continues as an influent tank while the remaining one-third will now serve as a receiving tank of the effluent from the digester. The subdivision of the tank was accomplished through an 8" concrete dividing wall. The profile of the existing manure storage tank allowed for its subdivision without the need to stop the flow of scraped manure from the barn and wash water from the milking parlor.

- A bypass of the footbath was constructed during the week of April 17, 2006. The bypass involved the installation of 6" PVC pipe (used to intersect the existing drain pipe in the dairy barn) that connected to the 36" effluent pipe from the digester (located between the CHP building and the digester), thereby completely bypassing the digester. The 36" effluent pipe that was already installed along the SW side of the digester (and as far as the west corner of the influent side of the digester) was extended to reach the new effluent compartment of the existing storage tank (Figure 27).

- Arrangements of the various mechanical and electrical components of the system were made within the CHP building followed by making several connections (Figure 28).

- The flare system was partially installed and the biogas lines were connected to the CHP building during the middle of May, 2006. Construction of the flare mount and gas line supports on the top of the digester were completed in the middle of July, 2006 (Figures 29 and 30).

- The unit heaters for heating the equipment building were connected to the system in July, 2006 (Figure 31).

- Control wiring was connected to several equipments in the equipment building in July, 2006 (Figures 32 and 33).

- The internal combustion engine exhaust and radiator set were installed in early August, 2006 (Figures 34 and 35).

- The entire heat loop of the system was tested for leaks after connecting the heat and maintenance loops to the thermal skid. Some leaks were discovered in the thermal skid. These were corrected by the supplier of the mechanical equipment (GenTec) in mid August, 2006.

- The area surrounding the digester and existing manure pit was graded. Followed that, a layer of top soil was spread over the entire disturbed construction site (including the digester) and the seeding and mulching of the area was completed (Figures 36 and 37).

- A polyurethane layer and a poly-urea coating were applied to the inside of the digester on the 29th of August, 2006 (Figure 38). The polyurethane-polyurea applications were made to the ceiling of the digester as well as the inside walls of both chambers to a level of about a couple of feet below the liquid line in the tank. These applications were intended to provide a gas-tight digester.

- The digester was filled with water and pressure-tested for leaks. The tests revealed a drop of less than 0.15 inches of water column per hour, an acceptable criterion which is below the 0.25-inch threshold set within the design manual as the upper limit for an acceptable test.

- The propane tank (Figure 39) to be used by the boiler for heating the digester during startup was installed during the week of 11th of September, 2006. This followed the installation of lines from the propane tank to the equipment building.

- The installation of the stack on the boiler was completed during the week of September 18, 2006 (Figures 40 and 41).

- The aluminum covers at the effluent side (Figure 42) of the digester were installed by the mechanical subcontractor along with the aluminum plate cover at the access port.

- The process of digester startup was initiated on the 21st of September, 2006. By the end of September, the influent that was pumped into the grit chamber of the SW side of digester reached up to a level of few inches below the baffle on the effluent side. Since the permanent pump that was ordered to allow for moving the influent from the storage tank to the digester was not installed yet, a temporary 6" PVC pipeline was installed to pump the influent using an existing tractor-driven (originally used to pump the influent from the 3-day storage concrete tank to the tanker to spread manure on college fields following the daily-haul method).

- The heating of the digester was started on October 11, 2006, following a visit by Gen-Tech which allowed for the connection of the boiler to the thermal skid and the heating of the digester with hot water generated through the burning of propane. The boiler was run at a temperature of about 100ºF until October 23, 2006, when it was discovered that a water leak in the system required the cessation of heating of the SW side of the digester. It took about a week to fix the problem! During that time, the temperature in the digester dropped from an average of about 90ºF to an average of 84ºF.

- The acidity and temperature of the digester were checked on daily-basis starting from October 17, 2006. Temperature readings were taken at multiple locations along the length of the digester with some being collected from the bottom of the tank through a devised sampler that was put together from a ¾" PVC pipe and fittings. While the temperature readings varied some, the pH of the samples stayed within the range of 7.0 and 7.9.

- Plastic tubing was installed to allow the venting of biogas from the two manometers on SE wall of the equipment building to the exterior of the building. The tubing will be used to sample gas from the digester as well as vent gas while the digester is being filled with manure.

- A total of 100 lb of inoculant (called Propriety Inoculant Material, PIM) was added on the 1st of November, 2006, at four locations within the SW side of the digester. The PIM was obtained from RCAg Industries, Inc., of Rochester, NY, as a research donation to assess the efficacy of the anaerobic microorganisms present in the PIM in starting the anaerobic digestion process within the digester. Within six days of the application of PIM, the biogas pressure (Figure 43) in the digester developed from about 0.5 inches of water column to 6.6 inches as measured on November 7, 2006.

- The gas pressure in the digester dropped to less than 0.5" on the 9th of November, 2006, following the increase of temperature in the digester to an average of 108ºF. This was the result of attempting to find the right temperature setting on the boiler to provide an optimum temperature of 98ºF within the digester. Within a couple of days of attempting to address this problem, the temperature in the digester returned to the 96-103ºF range and the pressure increased again to about 6 inches as measured on November 15, 2006. The correction of the temperature was accomplished by reducing the heat setting on the boiler to 100ºF as well as the addition of influent (Figure 44).

- Using the Dräger tubes, the CO_2 concentration of the biogas was measured at 55-60% on the 15th of November, 2006, while the presence of methane was ascertained qualitatively. The measurements were repeated several times since then and the readings were comparable. H_2S concentrations were also measured using the Dräger tubes and were within the 1000 ppm range.

- The process of installing an electric pump to load manure into the digester was completed on November 28, 2006. The process involved the installation of an electric control box (Figure 45), the fabrication and installation of a platform (Figure 46), and the actual installation of the pump (Figures 47 and 48) which took place after the influent compartment of the existing manure storage tank was emptied and cleaned during the morning of the 28th of November, 2006.

- The process of filling the NE side of the digester was started on the 29th of November, 2006. Half of the collected manure was conveyed to the NE side of the digester with the remaining half being fed to the SW side of the digester that had been producing biogas for about four weeks. Part of the effluent from the SW side of the digester was also pumped into the NE side of the digester to provide the inoculant to startup the anaerobic digestion process as well as fill up the NE side of the digester as quickly as possible. Meanwhile the biogas pressure in the SW side of the digester was measured at 10.5 inches on December 4, 2006.

- The installation of monitoring equipment on the system were finalized in early January 2007. The equipment included several thermocouples along with the remaining control wiring to gas meters and thermocouples on the ICE/generator skid.

- The steady production of biogas started soon after the two sides of the digester were filled with the effluent from the dairy complex. The digester has been in operation since December 17, 2006. The generated biogas was consistently flared starting from December 20, 2006 and until the internal combustion engine/genset was started briefly on the 9^{th} of January, 2007. Flaring the biogas continued until the interconnect with the power grid was approved and the combined heat and power generation (CHP) system was authorized to start on February 27, 2007. The system has been in operation since February 28, 2007. It has been consistently generating electrical power close to the system's capacity of 50 kW since that date.

Problems Encountered and Ways Addressed:

Among the many problems encountered during the construction phase of the project (most of them minor), three problems stood out as major resulting in marked delays on the project. These problems along with the ways they were resolved are listed below:

- The digester had to be tested for air-tightness following construction based on a test delineated in the design manual. It involved the filling of each side of the digester with water and pressure-testing it for leaks. The first test was conducted on the NE side of the digester on November 21, 2005. The test revealed a major leak near the baffle that is located close to the outlet bay on the effluent side of the digester. After re-applying a sealant to where leakages were observed, the SW side of the digester was filled with water and pressure-tested for leaks on November 28, 2005. A leak similar to the one observed on the NE side of the digester was discovered between the baffle located close to the outlet bay and the walls. Both leaks had to do with an error in pouring the baffle with the top of the digester instead of the digester walls and without including a groove to tie the baffle to the walls. An approach was devised amongst the contractor, engineer, and consultant to resolve this matter and the baffles were eventually sealed. This, however, did not result in the successful completion of pressure tests as additional tests revealed additional leakages through the top of the digester. This issue was ultimately resolved through the applications of the polyurethane layer and a poly-urea coating to the inside of the digester on the 29^{th} of August, 2006. The polyurethane-polyurea applications were made to the ceiling of the digester as well as the inside walls of both chambers to a level of about a couple of feet below the liquid line in the tank. These applications allowed for the eventual resolution of the problem.

- The second issue dealt with the unexpected delays in the projected delivery date of the stirling engine which was part of the original awarded contract on the project. The impetus behind approving the inclusion of the stirling engine over the traditional internal combustion engine (ICE) included the novelty of the developed unit which was expected to hit the market in 2005. In addition, several additional advantages played into the decision since the stirling engine was slated as an ideal unit for applications that include corrosive biogas. Moreover, the unit's cost was expected to be relatively comparable to the cost of a equivalent ICE while the lack of contact between the biogas and the moving parts of the engine was another advantage. The supplier of the engine was originally slated to have the unit delivered to the contractor by the end of November, 2005. The deadline was pushed back to early 2006. This would have resulted in pushing back the timeline for digester startup. Avoiding the startup of a digester in the middle of winter in Central NY became the only viable alternative. However, the supplier of the stirling engine indicated once again that the unit will not be available until August, 2006. As this was an unacceptable delay on the delivery of this important piece of equipment, discussions amongst the GenTec, the contractor, the consultant, and the college ensued to find a viable solution to the problem. The issue was finally resolved and an industrial-grade 50-kW internal combustion engine was identified as being a suitable replacement. The engine is German-made (MAN) and was delivered to Martin Machinery (the supplier of the CHP system and heat exchangers, located in Latham, Missouri) in late February, 2006, for fitting. The engine/generator set was assembled and the specifications of the revised package were forwarded to the project consultant and contractor for final approval. Once it was determined that the assembled package meets design specifications, approval was given to have the system shipped to Morrisville.

- The influent side of the digester was dug-up on October 24, 2006, to fix a leak that was discovered in one of the six Schedule 80 PVC valves installed on the insulated steel pipes that feed the main and maintenance heat loops inside the two sides of the digester. Once dug up, a decision was made by the college to replace all of the six PVC valves with brass valves and to build a wooden box around the valves to make them more accessible (if warranted in the future) as well as protect the valves from being in direct contact with the soil. After the valves were installed, the boiler was turned back on October 30, 2006.

Products Developed

- A poster (a copy is included at the end of this report) was presented on the project during NYSERDA's "Innovations in Agriculture Conference" held between the 29th and 30th of March, 2006, in Syracuse, NY.

- A slideshow was developed to present an overview of the project and delineate the progress made on the construction phase. The slideshow is accessible online at the following address: http://people.morrisville.edu/~shayyaw/DigesterPresent.htm. It was last updated on February 15, 2007.

- A webpage on the digester was developed and posted to the world-wide web on the 17th of August, 2006. The webpage is accessible under the link "http://www.morrisville.edu/Academics/Ag_NRC/AgrScience/html/Digester.htm".

- A new professional-looking website on alternative energy projects at Morrisville State College was developed by the college webmaster and posted to the web on the 18th of September, 2006. The website focuses primarily on two projects: the methane digester and a 10-kW wind turbine (developed under a separate project) located at the college's Dairy Complex. The new website is available under the "Technology" link which is accessible from the home page of the college website at the address http://www.morrisville.edu. The main page on "alternative energy" can also be accessed directly using the following url: http://www.morrisville.edu/alternativeenergy/default.aspx (a printout of the page is included at the end of the report).

Figure 1. Site excavation for the foundation of the dual-chamber digester tank (picture taken on August 9, 2005).

Figure 2. Form of the bottom of the tank (picture taken from near the north-east side of the tank on August 16, 2005).

Figure 3. Concrete-pouring of the floor of the tank (picture taken on August 23, 2005).

Figure 4. Closeup of the grit chamber section (15.3' long) of the tank showing ½ of the 4" Sch. 80 bottom of the chamber (picture taken on August 23, 2005).

Figure 5. Preparation of form of the outside walls of the digester (picture taken from the near N-W corner of the tank on September 6, 2005).

Figure 6. Completed half of the walls of the digester (picture taken from near the N-E corner on September 12, 2005).

Figure 7. Form on the south-west wall of the digester showing the location of one of three wall penetrations on each side of the tank (picture taken on September 12, 2005).

Figure 8. Completed walls of the digester showing both the influent (near side of the picture) and effluent sides of the digester (picture taken on September 30, 2005).

Figure 9. Close-up of one of the chambers of the effluent-side of the digester (picture taken on September 30, 2005).

Figure 10. Laying of a pre-cast concrete plank on the NE chamber of the digester (picture taken on October 10, 2005, from near the NW wall of the digester, i.e., influent side).

Figure 11. Sealing of the top of the planks covering the NE chamber of the digester (picture taken on October 10, 2005).

Figure 12. View of the access ports section of the digester top before pouring the 4" concrete top coat (picture taken on October 14, 2005).

Figure 13. View of the maintenance heat loop near the wall of NE grit chamber (picture taken on October 14, 2005, inside the NE chamber of the digester).

Figure 14. View of the heat exchanger inside the NE grit chamber (picture taken on October 14, 2005, showing one of the two access tubes that penetrate through the top).

Figure 15. View of the SE wall of the digester (the effluent side of the tank) after the 4" concrete top coat was poured (picture taken on October 20, 2005).

Figure 16. View of the NE side of the digester after the top and the outside walls were insulated with a layer of 2.5" of polyurethane (picture taken on November 11, 2005).

Figure 17. View of the SE wall of the digester showing the slab for the outlet bay and the openings for the cover plates on the effluent side (picture taken on November 11, 2005).

Figure 18. View of the outlet bay (picture taken from a point close to the East corner of the digester on November 17, 2005).

Figure 19. Completed frame of the combined heat and power (CHP) building (picture taken on November 11, 2005, showing a part of the siding of the SW side of the CHP).

Figure 20. View of the back and the SW side of the CHP building (picture taken on November 17, 2005).

Figure 21. View of the insulated pipes that connect the CHP to the maintenance loops and heat exchangers (picture of the NE side of the digester taken on November 21, 2005).

Figure 22. View of the completed backfill on the SW side of the digester (picture taken on November 21, 2005).

Figure 23. A view of the back (SW) side of the CHP building after the backfill was completed (picture taken on November 28, 2005).

Figure 24. View of the 4" influent pipe to the digester (picture taken on December 6th showing the pipe's location in relation to the SE side of the existing manure storage tank).

Figure 25. View of the delivered ICE/generator skid in the CHP building (picture taken on April 21, 2006).

Figure 26. View of the divided manure storage tank taken from near the north corner (picture taken on April 21, 2006).

Figure 27. View of the S-W wall of the effluent compartment of the storage tank showing the outlet location of the effluent pipe from the digester (picture taken on May 2, 2006).

Figure 28. View of the partially connected thermal and ICE/generator skids inside the CHP building (picture taken on May 23, 2006).

Figure 29. View of the installed gas lines from the two chambers of the digester to the flare (picture taken on July 20, 2006).

Figure 30. View of the installed gas lines from the digester to the equipment building (picture taken on July 20, 2006).

Figure 31. Inside view of the equipment building showing the two stainless gas lines from the digester and hot water lines to one of the heaters (picture taken on July 20, 2006).

Figure 32. View of a control panel inside the equipment building (picture taken on July 20, 2006).

Figure 33. View of the installed system controller inside the equipment building (picture taken on July 20, 2006).

Figure 34. View of the ICE-exhaust connected to a muffler mounted on the outside of the SE wall of the equipment building (picture taken on August 7, 2006).

Figure 35. View of the installed radiator on a pad SE of the equipment building (picture taken on August 7, 2006).

Figure 36. View of the effluent side of the digester (picture taken on October 2, 2006).

Figure 37. View of the digester and equipment building (picture taken on October 2, 2006).

Figure 38. Inside view of the digester after the applications of polyurethane/polyurea to seal the gas chambers on both sides of the digester (picture taken on August 30, 2006).

Figure 39. View of the propane tank installed near the SE side of the equipment building (picture taken on September 22, 2006).

Figure 40. View of the installed boiler (left) and thermal skid (picture taken inside the equipment building on September 22, 2006).

Figure 41. View of the installed boiler exhaust which was anchored to the northeast side of the equipment building (picture taken on September 22, 2006).

Figure 42. View of the effluent side of the digester showing the installed aluminum covers (picture taken on September 15, 2006).

Figure 43. View of the manometer showing the biogas pressure in the SW side of the digester (picture was taken on November 4, 2006).

Figure 44. View of the thermostat on the boiler showing a setting of 134ºF (picture was taken on November 4, 2006).

Figure 45. View of the installed pump control panel taken on November 3, 2006.

Figure 46 View of NW corner of the subdivided 3-day storage tank in preparation for the installation of the electric pump (picture taken on November 28, 2006).

Figure 47. View of NW wall of the subdivided 3-day storage tank as the pump is being installed (picture taken on November 28, 2006).

Figure 48. Another view of NW chamber of the 3-day storage tank as the pump is being installed (picture taken on November 28, 2006).

SYSTEMS APPROACH TO STUDYING AND DEMONSTRATING ANAEROBIC DIGESTION

Close-up of one of the chambers from the effluent side of the digester (9/30/05)

Digester and equipment building while under construction (11/21/05)

"We are learning more about tomorrow's technologies and sharing what we learn."

- James Van Riper, Interim Provost

Morrisville State College, Morrisville, NY

Objectives:

The overall objective of the project is to design and construct an anaerobic digester to treat dairy manure (generated at the freestall dairy complex) and other organic waste produced on the campus of Morrisville State College (MSC) and to use the generated biogas to run a combined heat and power generation system. Other objectives include the collection of data on the various components of the system; the analysis of the collected data and the reporting of results; the utilization of the project for demonstration purposes; and the use of the facility within any pertinent educational program offered by MSC.

Description of System:

Anaerobic digestion can minimize odor, generate biogas, and allow more effective nutrient use by crops. To realize the potential energy, environmental, and cost-saving benefits of anaerobic digestion, farmers need information to evaluate the energy, labor, land, and equipment costs. The anaerobic digester project at Morrisville State College involves the design and construction of a heated, hard-top plug-flow anaerobic digester. The digester will biologically treat dairy manure and other organic waste generated on campus to produce a stable effluent with improved physical, chemical, and biological characteristics. In the system, biogas (about 60% methane) will be produced, captured, and combusted to generate heat and power using a 50kW engine generator set. A boiler that runs on either biogas or propane will also be used to heat water during the startup phase of the system and anytime the engine generator set is not running. The methane digester system is sized to treat manure from over 350 milking cows and generate about 300,000 kWh per year from the recovered biogas.

The project is being funded by NYSERDA and the New York State Department of Agriculture and Markets, with additional support through U.S. Representative John McHugh, and from the U.S. Dept. of Energy's Office in Golden, CO. Construction on the project started in August 2005 and is expected to be completed in early April 2006. The system will be started soon thereafter.

Outcome:

This NYSERDA project will generate data on the effectiveness of an internal combustion engine for converting biogas to energy; will track and evaluate project data, costs, and benefits; and will use the digester system in Morrisville State College's academic programs to transfer information to others considering anaerobic digestion systems.

Further Information:

Dr. Walid Shayya, Morrisville State College, 315-684-6526, shayyaw@morrisville.edu
Tom Fiesinger, Project Manager, NYSERDA 518-862-1090 x 3218 twf@nyserda.org

Cornell University

NYSERDA's 6th Innovations in Agriculture Conference
Innovations in Agriculture

NYSERDA

MORRISVILLE STATE COLLEGE School of Ag & Natural Resources :: Dept. of Agricultural Science, Business, & Dairy

Anaerobic Digester

Digester Construction Slide Show

NYSERDA's 6th Innovations in Agriculture Poster

Sampling, Testing, & Evaluation Plan (STEP) - Draft

Anaerobic digestion can minimize odor, generate biogas, and allow more effective nutrient use by crops. To realize the potential energy, environmental, and cost saving benefits of anaerobic digestion, farmers need information to evaluate the energy, labor, land, and equipment costs.

The anaerobic digester project at Morrisville State College involves the design and construction of a hardtop plug-flow digester. The digester will biologically treat dairy manure and other organic waste generated on campus to produce a stable effluent with improved physical, chemical, and biological characteristics. In the system, biogas (about 60% methane) will be produced, captured, and combusted to generate heat and power using a 50kW engine generator set. A boiler that runs on either biogas or propane will also be used to heat water during the startup phase of the system and anytime the engine generator set is not running.

The methane digester system at Morrisville State College is sized to treat manure from over 350 milking cows and generate about 300,000 kWh per year from the recovered biogas. The project is being funded by NYSERDA and the New York State Department of Agriculture and Markets, with additional support through U.S. Representative John McHugh, and from the U.S. Dept. of Energy's Office in Golden, Colorado. Construction on the project started in August 2005 and is expected to be completed in August 2006. The system will be started soon thereafter.

The digester project at Morrisville State College will generate data on the effectiveness of an internal combustion engine for converting biogas to energy; will track and evaluate project data, costs, and benefits; and will use the digester system in Morrisville State College's academic programs to transfer information to others considering anaerobic digestion systems.

Welcome | Faculty and Staff | Academic Programs | Courses | Facilities
Student Club | News | Contact Info | Request Information | Admissions
Home Page | Previous Page | School Web Site | MSC Home Page

Department web site designed and maintained by Dr. Walid Shayya. Last modified: October 08, 2006.

MSC Home | Academics | Admission | Athletics | Student Life | Technology | Offices and Services

MORRISVILLE STATE COLLEGE

Alternative Energy

Alternative Energy

Wind Turbine

Methane Digester

For More Information:
Dr. Walid H. Shayya

Ph: (315) 684-6526
Fax: (315) 684-6125
134 Marshall Hall

E-mail Address:
shayyaw@morrisville.edu

School of Agriculture and Natural Resources

Anaerobic Methane Digester

Anaerobic digestion can minimize odor, generate biogas, and allow more effective nutrient use by crops. To realize the potential energy, environmental, and cost saving benefits of anaerobic digestion, farmers need information to evaluate the energy, labor, land, and equipment costs.

The anaerobic digester project at Morrisville State College involves the design and construction of a hardtop plug-flow digester. The digester will biologically treat dairy manure and other organic waste generated on campus to produce a stable effluent with improved physical, chemical, and biological characteristics. In the system, biogas (about 60% methane) will be produced, captured, and combusted to generate heat and power using a 50kW engine generator set. A boiler that runs on either biogas or propane will also be used to heat water during the startup phase of the system and anytime the engine generator set is not running.

The methane digester system at Morrisville State College is sized to treat manure from over 350 milking cows and generate about 300,000 kWh per year from the recovered biogas. The project is being funded by NYSERDA and the New York State Department of Agriculture and Markets, with additional support through U.S. Representative John McHugh, and from the U.S. Dept. of Energy's Office in Golden, Colorado. Construction on the project started in August 2005 and is expected to be completed in August 2006. The system will be started soon thereafter.

The digester project at Morrisville State College will generate data on the effectiveness of an internal combustion engine for converting biogas to energy; will track and evaluate project data, costs, and benefits; and will use the digester system in Morrisville State College's academic programs to transfer information to others considering anaerobic digestion systems.

Digester Construction Slide Show - (HTML PowerPoint)
NYSERDA's 6th Innovations in Agriculture Poster - (PDF)
Sampling, Testing, & Evaluation Plan (STEP) - Draft - (PDF)

Morrisville State College • P.O. Box 901 • Morrisville, NY 13408 • 1-800-258-0111 • www.morrisville.edu