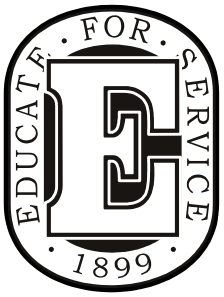

Elizabethtown
COLLEGE

Project Name:
Establishing Rural Biomass Energy Conversion as a Source of Energy

Solicitation Number: USDA-GRANTS-031803-001

May 14, 2003

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Establishing Rural Biomass Energy Conversion as a Source of Energy

Technical Summary

This proposed project demonstrates how Elizabethtown College, a large consumer of electricity in a rural area, can develop a network of methane biogas digesters to be operated on nearby farms to meet 40% of their energy needs (i.e. Elizabethtown College's base demand is 1500 kW). To meet this goal, several areas of research are anticipated:

- Organizational and institutional issues will be explored to determine the optimum institutional structure for "wheeling" electricity from rural biogas digesters to Elizabethtown College.
- Biomass producers (animal manure and food wastes) from farms and food processing facilities within 10 miles of Elizabethtown College will be identified.
- A methane biogas anaerobic digester and 80 kW generator will be installed at the Brubaker Farms to produce electricity for its own consumption and to sell to Elizabethtown College.
- Technical research will be carried out by Siemens Corporation and Carrier Corporation to gather product data from diagnostic monitoring of digesters in a network and testing and monitoring micro-turbines.
- TeamAg will develop and analyze land management practices for utilizing nutrients from digested manure and food wastes to grow crops.

The knowledge gained from this research project will encourage other partnerships between rural-based, large energy consumers and farms for methane biogas production. This project will demonstrate how institutions based in rural areas can obtain electricity from a network of biogas digesters from animal manure and food wastes. New technologies being developed at Siemens Corporation and United Technologies Corporation will be tested and researched for generating and transmitting electricity. TeamAg and Elizabethtown College faculty, staff, and students will gain experience with biomass technology which they can use as they develop other biogas generators to serve their electric needs.

This project will establish an organizational structure to utilize technical innovation to allow Elizabethtown College to establish a network of methane biogas producers to produce electricity for their use. The outcome of this research project will be a business entity with the technical, financial, organizational structure and capability to develop other methane biogas digesters to supply electricity for Elizabethtown College.

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Establishing Rural Biomass Energy Conversion as a Source of Energy

Part I: Technical Proposal

1. Project Description

A Partnership of Agriculture, Higher Education and Technology

Many years ago alchemists tried unsuccessfully to find a way to convert lead into gold. Current technology allows us to achieve what alchemists could not by turning material of lesser value to a material of higher value. The process does not involve turning lead into gold, but converts cow manure into electricity. This proposal creates collaboration between Elizabethtown College, Brubaker Farms, Siemens Corporation, United Technologies Corporation, and TeamAg to provide a clean, effective alternative to generate electricity while reducing odors created by spreading of manure from farming operations. In accomplishing this, the team will be doing something alchemists never thought of and improving the environment as part of the conversion process.

Elizabethtown College is located in Lancaster County, Pennsylvania—the county with the highest value in agricultural production (non-irrigated) in the United States. Much of this value comes from dairies and other livestock facilities.

According to data from Penn State University's ORSER (Office for Remote Sensing of Earth Resources), in the seven zip code areas surrounding Elizabethtown College, a radius of approximately 10 miles, there are approximately 44,000 cattle, 84,000 hogs, and 19,000,000 chickens which produces 4,400 tons of manure daily, with the potential of producing 4,000 kW. This supply of manure can be a valuable resource for Elizabethtown College's energy requirements while reducing objectionable odors created by the current land application of manure on fields.

The Problem

This project addresses a variety of problems facing livestock producers, and provides a source of green energy for Elizabethtown College. Housing development in Lancaster County, and in particular around the Mount Joy and Elizabethtown area is encroaching on existing farmland. Farmers frequently have to deal with neighbors who object to odors from manure. Increasing environmental regulations also place greater burdens on livestock producers for effective manure management. At the same time, producers are looking for ways to increase income and reduce costs.

Elizabethtown College buildings consume 12,000,000 kWh of electricity and 26,000 MCF of natural gas each year. During 2002, $702,000 and $251,000 was spent by the College on electricity and natural gas respectively. Besides being concerned with these rising costs, the College is committed to finding sources of clean, green energy to demonstrate environmental stewardship to their students and members of the community.

The Initial Solution

Technology exists, in the form of biogas methane digesters, to reduce the undigested material in manure by 50% resulting in significant decrease in the odor of spread material. A methane digester can be thought of as an extension to a cow's digestive system over a 20-day period, continues the anaerobic digestion of manure in a continuous process which converts the manure to a gas made up of methane, carbon dioxide and hydrogen sulfide**;** water and solids. The processed manure, having been subjected to twenty days of 99-degree temperatures, is nearly free of pathogens, free of fly larva and weed seeds, and can be spread on fields with significantly reduced odor. Methane, the major component of natural gas, is burned in micro-turbines or internal combustion engines to produce electricity and heat. The farmer uses some of the electricity and the heat is used to support the digester operation and to warm animal living areas. This proven technology is operating in many farming areas.

However, growth of this technology has been limited by economics, as the farm cannot use all of the electricity that can be generated by the combustion of the methane and cannot sell the excess to the local utility at a cost close to the current value of electricity.

The Vision

The vision for this project is to create a synergy between Elizabethtown College--a large consumer of electrical energy--and nearby farms to convert large amounts of manure to electricity through methane biogas digestion. This project will establish the groundwork for the following vision to be accomplished within ten years:

> ***Elizabethtown College will obtain all of its base demand of electricity (1500 kW) from methane biogas production from neighboring farms and food processing facilities. The success of this project will be extended to other institutions and large consumers of energy who will partner with farms to purchase electricity from their methane biogas digesters.***

Expected Outcomes and Benefits

This project will have the following expected outcomes and benefits:

- Creates an economically viable digester/cogeneration facility at Brubaker Farms in Mount Joy producing electricity and heat.
- Demonstrates the cost-effectiveness of methane biogas digesters from a network of neighboring farms for a large electrical consumer.
- Researches management, organizational and ownership issues for the operation of an educational institution partnering with local farms and industry to produce electricity.

- Demonstrates the economic viability of a digester, which produces biogas from food and yard waste.
- Demonstrates new technology—micro turbines-- provided by Carrier Corporation for the combustion of biogas to produce electricity.
- Demonstrates how Siemens' Apogee Go Technology can be used to monitor and operate biogas digesters and electric generating equipment to ensure efficient operation.
- Provides an educational and internship experience for Elizabethtown College Business and Engineering students.
- Links the educational process to the planned construction of a Science Building at Elizabethtown College to present real time information about the digester/cogeneration facility to students, faculty, staff and visitors.
- Provides a continuing educational opportunity for Elizabethtown College students, farmers, and members of the community to learn about environmentally friendly green power generating processes and equipment.

Project Timeline

This project will be implemented over a three-year period beginning on January 1, 2004 and ending on December 31, 2007.

2. Statement of Work

This section describes the specific tasks to be undertaken within the project, the responsible parties involved, and the success criteria for monitoring progress.

Task 1: <u>The Organizational Research</u>: Elizabethtown College will establish a legal entity to "wheel" electricity from neighboring methane biogas digesters to be consumed by the college. Other organizational issues such as ownership structure, financial, and business processes will also be addressed to determine the optimal "win-win" solution for energy producers and energy consumers.

Elizabethtown College will explore and understand the state regulations governing "wheeling" electricity, and negotiate with PP&L, its electrical supplier, to create an entity that can transmit electricity from producers to the College.

Elizabethtown College will research organizational structures for this new business opportunity. Other potential methane-based electric producers will be invited to work with the college to determine the best arrangements for this business structure. Financing arrangements for funding future methane biogas digesters will also be explored with banks and other financial institutions.

Success Criteria: Understanding the regulations of "wheeling" electricity, high participation of potential producers, and completed financial arrangements for funding further methane biogas digesters.

Task 2: Inventory of Resources: TeamAg, Inc. in collaboration with Elizabethtown College faculty and interns will undertake a technical feasibility study of biomass producers within a 10-mile radius of Elizabethtown College.

TeamAg, Inc. through its relationships with livestock producers and agri-businesses will identify livestock operations within a 10-mile radius of Elizabethtown College, which are well suited for developing methane biogas digesters. Food processing companies in this area will also be contacted to determine the feasibility of establishing methane biogas digesters, to digest food wastes.

Elizabethtown College student interns will be hired to assist in this study and will work together with TeamAg to produce a report which identities potential sites for methane gas digesters, either from manure or food wastes.

This study will also study the economics and other factors to determine what size of dairy/livestock operation is best suited to have its own digester, and whether a digester can be shared by several smaller producers.

Success Criteria: Enough methane biogas digesters will be identified within 10 miles of Elizabethtown College, which can produce 5,000,000 kWh of electricity each year. Preliminary feasibility studies will be developed for the most promising sites.

Task 3: Demonstration: Brubaker Farms will install a methane biogas digester in their manure management system.

Brubaker Farms, located in Mount Joy, Pennsylvania, is a dairy currently milking approximately 540 Holstein dairy cows. Currently all the milking and dry cows totaling approximately 700 head are located at the main farm where the milking facilities are located. The anaerobic digester will be constructed at this location to utilize the manure created by the milking and dry cows. A number of heifers and calves are located at the same site and manure from these animals could also potentially be used to feed the digester.

Currently a round concrete manure storage is used to provide some storage for the manure and the milk house wastewater. The round concrete manure storage no longer provides enough storage for Brubaker Farms to properly execute their nutrient management plan so a new lined manure storage pond is being constructed. Once the manure storage pond is complete the round concrete manure storage will be retrofitted into an anaerobic digester.

The design of the methane digester/cogeneration facility will be prepared by TeamAg, select professional sub-consultants, and engineering interns from Elizabethtown College. As part of the design process, TeamAg will evaluate the current technologies for generating electricity to determine which technology is optimal for maintenance-free and efficient electric generation.

The tank will be retrofitted with a heat exchanging system using process heat generated by the combustion of methane gas to produce electricity to warm the media to the proper temperature to maximize microbial growth and biogas production. The heat exchanging system will be controlled with a temperature control and monitoring system supplied by Siemens Corp.

A gas collection system including tank cover, piping, gas conditioning equipment, and micro turbine will be installed to collect the biogas from the digester for combustion by the micro turbine to generate electricity. United Technologies/Carrier Corp will supply the micro-turbine and heat recovery system.

A qualified electrical engineer will be contracted to design the electrical interconnection system to the power grid in accordance with PPL requirements.

Success Criteria: All necessary equipment will be secured and installed and construction will be completed so that the system will be able to begin to generate biogas, electricity and process hot water.

Task 4: <u>Technology Research:</u> The methane digester, electric generating equipment, and monitoring system be tested over a one-year period.

Digester systems are dynamic variable systems that require a startup and troubleshooting period to bring the system to a steady state condition. United Technologies Corp./Carrier Corp., Siemens Corp., TeamAg staff, Brubaker Farms and other technical consultants will collaborate to troubleshoot any problems that may be encountered during startup to ensure equipment compatibility and quick startup. Technical consultants will work with TeamAg to continue assisting and advise in monitoring and managing the digester to maximize gas production. The data derived by the operation of the digester and electrical generation system will provide guidance and information for the design and operation for future methane digesters and power generation systems.

Success Criteria: The digester system will be brought to a steady state condition and all subcomponents will be operating within their design parameters.

Task 5: <u>Research on Land Management Practices:</u> TeamAg, Inc. soil scientists and nutrient management specialists will study land management practices to

optimize nutrients being land applied from digesters of manure and other biomass which may be used in this project.

Manure is the primary source of nutrients for crops grown by Brubaker Farms. All most the entire crop production grown is utilized as feed for the cows. Upon completion of the digester the digested manure will be land applied to supply nutrients to the crops. TeamAg staff will study the digested manure to characterize any changes in nutrient values, nutrient availability, physical components, and any other properties that might affect crop growth.

Success Criteria: Findings and recommendations will be supplied to Brubaker Farms to ensure proper nutrient management as per Brubaker Farm's nutrient management plan. Other potential farms and food-processing facilities will also use this information for the land application of the agricultural wastes being processed by the digesters.

Task 6: <u>Business Plan</u>: TeamAg and Elizabethtown College will prepare a business plan to develop approximately 20 other methane biogas digesters.

Towards the end of the project, based on what has been learned from the earlier tasks, TeamAg and Elizabethtown College will develop a business plan for expanding the proposed entity to develop 20 other methane biogas digesters in the proximity of the college. This business plan will be used to promote investment, seek loans from financial institutions, and obtain grants. It will include marketing, management, financial, and public relations components.

Success Criteria: The proposed entity will have a sound financial and management foundation to develop other sites.

Part II: The Statement of Capabilities

1. Project Organization and Structure

Elizabethtown College entered the 21st century in a position of strength as a leading force in higher education in Pennsylvania. With record enrollment and firmly established business, education, biology, engineering, honors and biotechnology programs, to name a few, the College continues to improve and expand its programs and facilities and is consistently ranked as one of America's finest regional colleges.

The college has an enrollment of 1,741, offers 40 majors, has a full time faculty of more than 110, enrolls students from more than two-thirds of the United States and enrolls students from more than 40 foreign countries.

A collaboration of specialists led by Elizabethtown College's Director of Facilities Management will coordinate the implementation of this project. Faculty members and students in the Biology, Physics and Engineering and Business Departments will participate in this project.

Elizabethtown College Facilities staff will coordinate the work of the team members during all phases of this project. They will also assist in the installation of the electrical generation and distribution system; coordinate the selection and employment of student interns and directly manage the development of the entity to wheel electricity from Brubaker Farms to Elizabethtown College.

2. Collaborating Specialists Identified and their Roles of Responsibility

- TeamAg, Inc. is an agricultural consulting company consisting of agricultural engineers, soils scientists, nutrient management planners, and natural conservation specialists located in Ephrata, PA. During 2002, TeamAg, Inc. designed 30 manure management systems for farms in New York and Pennsylvania. TeamAg, Inc. will provide overall technical support for the project and obtain other outside consultants as required for the successful implementation of the project, such as electrical engineers for making the interconnection to the electric grid. TeamAg, Inc will also act as a facilitator to seek collaborative working relationships between livestock producers—potential electricity producers—and Elizabethtown College—the major consumer of the electricity produced. TeamAg engineers will design and provide quality assurance for the methane bio-gas digester, obtain permits and prepare or amend nutrient management plans as required. John Williamson, P.E. will be design engineer and project facilitator.

- Brubaker Farms is a 700-cow dairy located 4 miles from Elizabethtown College in Mount Joy. This partnership consists of Luke Brubaker and his two sons, Mike and Tony. The farm has received numerous awards for environmental stewardship, including the 2001 Dairy Stakeholder Pacesetter Award, 2000 National Environmental Stewardship Award. They will have the overall responsibility of managing the manure system and hiring contractors for constructing the methane gas digester.

- Siemens Corporation has agreed to participate in the grant and funding of the matching funds, as they are Elizabethtown College's temperature control contractor. They supplied Elizabethtown College's Apogee DDC temperature control system, which could be extended to monitor the operation of the digester, the cogeneration and electrical supply system.

- United Technologies Corp/Carrier Corporation has agreed to participate in as a member of the team as they are the premier supplier of micro-turbine equipment that would burn the methane to produce electricity and heat.

3. Key Personnel

The following are brief descriptions of the key personnel working on this project:

Joseph P. Metro - Director of Facilities Management, Elizabethtown College

Education: BS Naval Science Electrical/Mechanical Engineering, 1966
M.B.A. Bloomsburg, University of Pennsylvania

Experience: Extensive experience in the facilities management field in higher education, K-12 and industry. Previously worked in facilities management for International Salt at Bloomsburg Area School District, Bloomsburg University, Cornell University, Mankato State University (Minnesota), Cranbrook Educational Community (Michigan). In all of his positions a major focus has been on the conservation of recourses and minimizing the impact of institutional facilities on the environment. While doing this he has installed two backpressure cogeneration systems, managed numerous renovation projects focusing on providing state of the art facilities which operate very efficiently. He has developed and presented a process to determine the cost of operating facilities in a constant state of usefulness in which they support the programs they house while not incurring deferred maintenance backlog. His philosophy is to provide facilities which properly support the learning, living and outreach programs of the College with the smallest impact on the environment and to exercise a stewardship roll for those who will follow him in managing the institution's facilities.

John R. Williamson, P.E. –Design Engineer and Project Facilitator.

Education: Masters Regional Planning, Cornell University, 1987
Masters Engineering (Agriculture), Cornell University, 1979
BS Civil Engineering, Ohio State University, 1973

Experience: 2002-2003: Vice President TeamAg, Inc, designing manure management systems
1999-2001: Manager Engineering Services, Brubaker Consulting Services, designing manure management systems
1975-1999: Various positions with Mennonite Central Committee in Nepal, Indonesia, and Akron, PA.

Sean Sweeney Junior Engineer and Nutrient Management Planner

Education: BS Agricultural & Biological Engineering, Minored in Environmental Engineering, The Pennsylvania State University, 2002

Experience: 2003: Junior Engineer and Nutrient Management Planner TeamAg Inc
5/02-11/02: Penn State Agricultural Safety and Health, Technician
5/01 - 9/01: Greater Lebanon Refuse Authority, Engineering Intern

5/00 - 9/00: Pennsylvania Department of Environmental Protection
Engineering Intern

Mike Brubaker Brubaker Farms Partner
Education: BS Agriculture Business Management, Penn State University, 1989
Experience: Full time farming for 14 years.
Member of Township Planning Commission

David Andiorio Siemens Corporation Account Engineer
Education: Penn State University 1969-1972
Experience: Barber Coleman Control Electrician 1978-1990
Siemens Account Engineer 1996-present

4. Description of Collaboration and Participation in the Project

Synergy will develop from the rich mixture of people and organizations collaborating on this project. This project brings together a diverse group of entities that already have a strong commitment to the conservation of natural resources. Brubaker Farms, Siemens Corporation, United Technologies Corp/Carrier Corporation, TeamAg, and Elizabethtown College will come together bringing their expertise and knowledge to develop a network of methane biogas digesters to supply electricity for Elizabethtown College.

Part III: The Cost Proposal

1. Project Budget:

Task and Sub-Tasks:		Estimated Costs	
Task 1: Organizational Research			**$ 20,000**
Task 2: Inventory of Resources			**$ 26,800**
TeamAg Planner	$	3,200	
TeamAg Nutrient Mgt. Specialist	$	4,800	
Elizabethtown College Student Interns	$	8,000	
Elizabethtown College Faculty	$	10,800	
Task 3: Demonstration			**$ 383,400**
Retrofitting Existing Concrete tank	$	90,000	
Mixing Tank	$	20,000	
Micro turbine	$	128,400	
Equipment building	$	10,000	
Piping, pumps	$	10,000	
Interconnection Costs	$	50,000	
Engineering Design & Permitting	$	35,000	
Start-up & Operation Tech. Advising	$	30,000	
Monitoring Equipment	$	10,000	
Task 4:Technology Research			**$ 14,320**
TeamAg Engineer	$	8,320	
Outside Technical Consultant	$	4,000	
Testing Services	$	2,000	
Task 5: Research of Land Management Practices			**$ 18,500**
Nutrient Management Specialist	$	18,000	
Soil Testing	$	500	
Task 6: Business Plan			**$ 11,400**
Management Consultant	$	8,000	
Elizabethtown College Faculty	$	3,400	
Total			**$ 474,420**

2. Contributions of Resources from Participating Entities:

	E-town College	Brubaker Farms	UTC/Carrier Corp	Siemens Corp	Grant	Total
Task 1: Organizational Research	$ 20,000					$ 20,000
Task 2: Inventory of Resources	$ 18,800				$ 8,000	$ 26,800
Task 3: Demonstration		$ 40,000	$ 32,000	$ 10,000	$ 301,400	$383,400
Task 4:Technology Research					$ 14,320	$ 14,320
Task 5: Research of Land Management Practices					$ 18,500	$ 18,500
Task 6: Business Plan	$ 3,400				$ 8,000	$ 11,400
Contributions	**$ 42,200**	**$ 40,000**	**$ 32,000**	**$ 10,000**	**$ 350,220**	**$474,420**

3. Summary of Proposed Resources by Statement of Work Task

i. The various staff will be involved in this project:
Design Engineer/Planner—244 hours; Total Cost: $16,920
Junior Engineer /Nutrient Mgt. Specialist—280 hours; Total Cost: $16,800

ii. Total cost for travel- There will be no travel costs since all work is local.

iii. Proposed equipment, supplies or other major expenses over $5,000:

Retrofitting Existing Concrete tank	$ 90,000
Mixing Tank	$ 20,000
Micro turbine	$ 128,400
Equipment building	$ 10,000
Piping, pumps	$ 10,000
Interconnection Costs	$ 50,000
Engineering Design & Permitting	$ 35,000
Start-up & Operation Tech. Advising	$ 30,000
Monitoring Equipment	$ 10,000

iv. The total of all direct costs: $474,420.

v. The total of all indirect costs: Elizabethtown College will be administrating the project and these costs have not been included.