THE CENTER FOR

Rural Pennsylvania

JUNE 1995

MEDIUM- AND SMALL- SCALE METHANE DIGESTERS FOR LIVESTOCK MANURE DISPOSAL IN LANCASTER COUNTY

212 LOCUST ST., HARRISBURG, PA 17101 PHONE (717) 787-9555 FAX (717) 772-3587 WEBSITE WWW.RURALPA.ORG

Medium- and Small- Scale Methane Digesters for Livestock Manure Disposal in Lancaster County

Completion Report
June 1, 1995

submitted by

Robert E. Graves
Professor
Agricultural and Biological Engineering Department
The Pennsylvania State University

Executive Summary

Three Pennsylvania farmers, a Lancaster county conservation district staff member and an agricultural engineer from Penn State participated in a study tour of China to investigate Chinese biogas production techniques for potential application to small and medium size farms in Pennsylvania. The Center for Rural Pennsylvania provided support toward the farmers' travel and subsequent activities of the team in Pennsylvania relative to use of controlled anaerobic digestion for odor control and production of biogas. Travel funds were also supplied by Penn State, USDA, conservation districts, agricultural banks, producer groups and the trip participants. Because of farm size and climate differences many of the very successful Chinese methods can not be directly transferred to Pennsylvania farms.

Plans to participate in the design and construction of biogas units on two of the participant's farms were dropped because of inadequate financing. A mini-digester similar to the small Chinese family digesters was designed using a precast septic tank and other common construction components. No cooperator could be found to install this unit. A cooperative project for the design and construction of a demonstration digester suitable for 50 cows was explored with The Milton Hershey School, Hershey Foods Co. and Agway. A preliminary design was developed but the project was dropped due to funding difficulties.

There is a high level of interest within the agricultural community in using biogas technology to reduce odors from liquid manure systems and produce energy. Odor problems increase as more people, more animals and more liquid manure storages come closer together. Obstacles to more widespread adoption of this process include the present need for individual design, high construction costs, operation requirements, difficulty of financing, and electric utility buy back policies. The team has discussed many of these issues and this report offers suggestions for ways to address these needs.

Areas for possible legislative attention include guaranteed loans to encourage private sector participation in financing biogas units, establishing a reward structure to encourage construction and successful operation of biogas production units and setting reasonable state wide standards for interconnection of biogas powered generating systems with electric suppliers.

Medium- and Small- Scale Methane Digesters for Livestock Manure Disposal in Lancaster County
Completion Report
June 1, 1995

In August 1993, a team of six agriculturist visited the Peoples Republic of China to study China's agricultural biogas program. The team consisted of three Pennsylvania farmers, a Lancaster county conservation district staff member, an agricultural engineer from Penn State and a USDA veterinarian. (Information about these team members can be found in appendix II). The Center for Rural Pennsylvania provided funds towards the costs of the farmer's travel to China as part of the *Medium- and Small- Scale Methane Digesters for Livestock Manure Disposal in Lancaster County* project. Travel arrangements and costs during the three week trip in China were the responsibility of the Chinese government as part of an agreement with the USDA Office of International Cooperation and Development (USDA OICD). Travel funds were also supplied by Penn State, USDA, conservation districts, agricultural banks, producer groups and the trip participants.

The Chinese were reported to have a program that has resulted in development of low cost biogas production units that have been placed on millions of small farms. This contrasts with U.S. biogas technology which has been limited to larger farms because of cost and complexity of the biogas production and utilization units. An earlier trip to China had briefly exposed two of the participants to this technology. Arrangements were made through USDA OICD for the team to visit China and study the Chinese biogas production program. The team visited operating units and met with scientists and field staff responsible for development of the technology and for training of local teams in installation and operation of the units. Operating units were observed on farms and related establishments in three southern provinces of China. The team also visited the Biogas Research Center at Chengdu which directs the program, provides education and develops new designs and construction methods. A complete report on the trip is found in Appendix I. The publicity surrounding the team's planned trip to China and its subsequent reporting increased interest and public awareness of this technology for odor control of liquid manure.

The close proximity of farms and people in southeastern Pennsylvania has resulted in an increase in conflicts caused by odor and other nuisance conditions attributed to stored manure. Manure storage, especially liquid manure, is rapidly increasing as farmers respond to pressures to improve environmental protection measures on animal farms. Controlled anaerobic decomposition of liquid manures results in the production of biogas (a low-grade natural gas type fuel) and a relatively nuisance free liquid effluent. Fertilizer nutrients from the manure are retained in the liquid effluet. Biogas production technology that is successfully used on several larger Pennsylvania farms is too costly for dairy and swine farms sized to allow a single family to provide the majority of the labor. The primary goal of this project was to determine if Chinese technology and techniques could be adapted to Pennsylvania conditions. Simpler lower cost technology would allow many more farms access to this form of odor control. A system suitable for smaller farms including those that do not use electricity but find liquid systems advantages because of reduced hand labor is desirable. Traditional bedded manure storage and handling systems that are mechanized with electric gutter cleaners and tractor loaders are not well suited to farms that do not use electricity or tractors.

The team soon learned that Chinese technology and methods could not be directly translated to Pennsylvania conditions. The typical small Chinese digester was developed and operated to utilize the manure generated by a family of three or four humans, 10 to 30 pigs, some chickens and perhaps other organic refuse from food preparation or crop production. Rural residents in China do not enjoy a readily available supply of energy. The primary purpose for these units was to provide cooking gas and, in some cases, illumination gas for rural residents. The warm climate and minimal requirements for productivity allowed digesters with no heating systems. A "small"

Chinese farm is much smaller than a "small" Pennsylvania farm. The units might be compared in size, cost and complexity to a septic tank system. The effluent from the units was used for crop fertilization or discharged into fish ponds, open drainage ditches or streams. The sludge was used to fertilize crops. Medium-size Chinese digesters were of a size to be applicable to Pennsylvania farms. However, the operation of these with no external heating and with a goal of producing cooking gas is inconsistent with Pennsylvania climate and farming conditions. See Appendix III for more detail on Chinese small and medium digesters.

The Chinese are to be admired for their development, deployment and utilization of small biogas production units. They are rapidly improving the life of rural residents by making a convenient fuel available to rural residents. The Chinese mini or family digesters were:

- simple to build and operate
- effective for providing families with cooking gas and illumination
- designed to allow local construction and operation
- self-regulating with no mechanical or electrical parts
- 1000 - 2000 gallons in size
- unheated
- inconsistent in operation depending on ambient temperature and feed stock

Ideas learned from the Chinese can be incorporated into biogas production units in Pennsylvania. No major cost reductions in biogas production units designed to produce electricity will result from technology learned in China. Discussions with the Chinese and observations of their systems helped the team to focus on possibilities of simpler digesters designed and operated with a goal of odor control versus maximum energy production.

Summary of Team Activities

The goals of the team and this program included:

- Observe and learn about Chinese biogas efforts.
- Use Chinese technology to modify existing U.S. methods to develop less expensive and complicated biogas production systems.
- Participate in design, construction and operation of demonstration digesters on farms operated by two of the team members.
- Increase general awareness of biogas production technology as a means for odor control for small and medium size farms.
- Provide guidance to legislative and other decision makers concerning biogas technology and appropriate government or private actions or programs to encourage its adoption.
- Following the trip, it was decided that it would be desirable to design a family or mini-type digester for application on a farm in Pennsylvania with limited livestock.

The team did not accomplish all of these goals but many positive accomplishments resulted from this project.

- The team visited China and completed a comprehensive study of the small-scale biogas program operated through the Chengdu Biogas Institute and provincial and village governments. Design and education information was obtained. Contacts for future cooperative work were made.

- Documented and reported on the Chinese program in a written report (Appendix II) and public meeting attended by 100 interested participants (see Appendix V).

- Developed a design for a mini-digester using readily available construction methods and components (see Appendix IV). The mini-digester would be loaded with manure from animals on a small scale or part time farm. The resulting low odor effluent would be used for fertilizer and the biogas could be used for operation of a small internal combustion engine, heating, cooking or lighting. No cooperator was located to install this digester so the project was dropped and remaining funding returned.

- The trip and its publicity provided a focal point for renewed interest and discussion concerning biogas on Pennsylvania farms.

- Defined major obstacles to more widespread adoption of biogas technology.

- The College of Agricultural Sciences has provided [redacted] resources to update biogas education materials and programs.

- The Natural Resources Conservation Service participated in education programs and helped several farmers investigate biogas production.

- The Pennsylvania Department of Environmental Resources and Pennsylvania Energy Office have cooperated in aspects of the project.

- A group was formed to investigate a cooperative demonstration biogas production unit applicable to small farms with no electricity at The Milton Hershey School. Hershey Foods Company and Agway also participated in this project. Sufficient funds were not assembled to complete this project (See Appendix VI).

- With the help of Larry Lentz of the Center for Rural Pennsylvania, an exploratory meeting was held with the Pennsylvania Utility Commission and Pennsylvania Department of Agriculture to discuss issues surrounding sale of electricity from biogas units to power companies (Appendix IX).

- A technical paper was prepared for and presented at the 1993 Northeast Agriculutral and Biological Engineering Conference (See Appendix VII).

- Various news releases and articles and a professional meeting paper were generated (See Appendix VIII).

- Several public programs were presented by various team participants.

Obstacles To Widespread Biogas Production In Pennsylvania

The obstacles to more widespread adoption of biogas technology on Pennsylvania farms remains the same as before the project. However, the obstacles and how they might be addressed are better understood.

The major obstacles to biogas adoption are:

- cost and complexity of biogas units
- need of individual designs for each unit
- cost and availability of competent design assistance
- electricity buy back requirements and pricing policies
- reluctance of lending institutions to finance biogas projects

Actions to Encourage Biogas Adoption

Biogas production is an appropriate and effective method for odor control in areas where animal agriculture and non-farm development coexist. It also offers the possibility of production of a useful product (biogas) to help offset the costs of operation. The monetary value of odor control is difficult to quantify. Education programs, materials and demonstrations can help inform farmers and those working with farmers of the potential value of this practice. The cost benefit relationship on most Pennsylvania farms will not provide sufficient revenue to pay for this technology. Government and private sector assistance can help to encourage adoption of this technology.

Well placed demonstration units at private or public farms, as called for in the Anaerobic Manure Digesters Act can help familiarize potential participants in design, financing, construction, and operation of biogas units. This may include more use of existing on-farm biogas units and expertise in addition to construction of new units. At this time, design and construction for biogas units must be customized to individual farms. There is little foreseeable salvage value for units that do not function as desired. Need for individual design and difficulty of recovering investment for failed systems further increases the cost and hampers the adoption of this practice.

Any subsidy program should consider the problems and successes with similar programs. In particular, mechanisms are needed to encourage private participation and to reward successful system operation versus just paying for construction. Following are characteristics that should be considered for inclusion in a program to assist farmers in adopting biogas production technology.

- Encourage private sector participation in design, financing, construction, and operation of biogas units.
- Provide financial assistance for design, construction, and operation of biogas units.
- Reward designers, suppliers and operators of units that operate successfully. This could be in the form of premiums for sale of power from biogas units, decreased interest or forgiveness of principle on loans related to successful performance, incentives to designers and suppliers who participate in successful systems.
- All parties that stand to benefit from government funding should have some investment in the system. This could be deferred profits or incentives for designers and suppliers and a required percentage of cost of project to be made up of farm funds.

- Include provisions for innovation to explore new ideas and methods.
- Include an oversight committee consisting of farmers, elected or appointed government personnel, university or extension personnel, private sector suppliers and financial personnel.
- Contain safeguards to help protect participants from unqualified designers and suppliers attracted by government money.

Federal and state regulations require power companies to buy electricity from independent power producers (IPPs). However, requirements placed on IPPs for switch gear, metering and safety equipment are at the discretion of each power company. The variation in equipment required by power suppliers is often seen as a major obstacle to adoption of biogas production by the farm community. Legislative action to institute consistent statewide requirements for connection of IPPs to any power supplier would help to level the playing field. Changes or even elimination of legislative requirements covering mandatory purchase of power are being considered at both state and federal levels.

Lending insitutions need to know the affect a biogas unit will have on a farm's cash flow. A clear understanding of the revenue that can be gained from sale of excess power to utilities is an important part of this anaylsis.

Summary

Controlled anaerobic digestion of manure with subsequent production of biogas is a reasonable solution to minimize odor problems from stored manure for many farms in Pennsylvania. Most of the cost savings and standardization in design used by the Chinese are not directly applicable to Pennsylvania conditions. The need for individual design, the high costs of construction and required operation skills have resulted in reluctance by farmers and financial institutions to pursue this practice. Actions can be taken to help farmers with the design, construction and operation of these units. Any programs must encourage public/private sector partnerships, provide screening of designers and farms, and reward successful operation not just subsidize design and construction costs.