REVIEW OF CURRICULUM CONTENT AND PROGRAMS FOR ANAEROBIC DIGESTION EDUCATION AND TRAINING

Prepared for

THE NEW YORK STATE
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Executive summary

The development of the anaerobic digestion (AD) industry requires financial, physical and human resources. In New York State, financial and physical resources have been mobilized to finance and build ten anaerobic digesters on dairy farms. The objective of this report is to make recommendations for the development of human resources as the groundwork for the creation of technical AD coursework which can lead to the development of a robust and comprehensive anaerobic digestion industry.

A needs analysis was completed to identify important curriculum content areas. Many concepts naturally coalesced to form key subject areas. An analysis of target audiences was completed, and similarly, audiences with closely related interests emerged. In this way the need for distinct courses, directed at different groups, became apparent.

In order to expedite the curriculum development process, a comprehensive search for educational materials related to anaerobic digestion was completed. The results of this search are organized in the matrices provided at the end of this report. Materials of interest (referenced in the matrices) are included in the Appendix. The search found that no program in NYS *completely* addresses the key content identified, but that a number of institutions have coursework and facilities of significant relevance. Outside of NYS, many related resources were discovered through universities, government agencies, and organizations, both in the United States and abroad. Of note are two already developed courses, one at Madison Area Technical College in Madison, Wisconsin and another at the International Biogas and Bio-energy Competence Center (IBBK) in Germany. These were the only groups offering courses that were specifically designed for adult learners in the AD industry.

Allied industries like wastewater treatment; heating, ventilation and air conditioning (HVAC); combined heat and power (CHP); natural gas; landfill gas; solar power; and wind power also have components that can be replicated in the development of an AD curriculum. Developments and advancements in these industries provide insight into human resource development processes and provide models and delivery methods for a

similar curriculum for an AD audience which shares many similar needs and educational materials.

Delivery approaches for AD curriculum and their possible contribution to workforce development were evaluated. These, in conjunction with the analysis described above, were used to formulate eight recommendations. Outlines of three recommended courses are given, along with rough cost estimates for their development. Additionally, market research was initiated by contacting stakeholder organizations to obtain an assessment of member interests in AD courses.

A letter was sent to 29 New York organizations across a broad sector related to the dairy industry, both public and private to gain their feedback on the recommendations of the report. Specific thoughts were sought on the three technical courses relative to perceived needs and interests of the respective group. From ten direct responses the results indicated a generally positive response to the proposed three technical courses, subject of course to specifics of time of offering and cost.

The following recommendations are made related to AD training and education.

1. Develop three technical short courses that will provide educational training to people involved in the planning and implementation of Dairy AD systems as well as those managing already constructed and operating systems.
2. Develop a one-day public relations workshop for media, farm neighbors, regulators, government officials, renewable energy enthusiasts and all other interested parties to cover the basics of anaerobic digestion.
3. Form discussion groups that allow professionals in the industry to discuss AD, troubleshoot digester problems and share resources.
4. Develop a website that provides access to course materials and pertinent information (some free of charge, while others for a nominal fee). The website may, in the future, provide distance learning opportunities and an online discussion forum.

5. Assess the potential for the development of a New York Biogas/Bioenergy Association that will coordinate training and education.
6. Communicate with cooperative extension programs, agricultural organizations (NY Ag Society, Dairy Practices Council, NEDPA, Farm Bureau, etc), NYWEA, NABCEP, IREC, landfill gas associations, waste management associations and the International Biogas & Bio-energy Center (IBBK) regarding the recommendations made in this report. Solicit input from these organizations about the development of courses and their member interest in such programs.
7. Consider certification programs as the industry matures and a need is recognized.
8. Encourage colleges and universities to conduct research and teaching on anaerobic digestion.

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1. Introduction

Anaerobic digestion (AD) is an effective way to manage dairy manure by addressing the principal problems of odor and environmental control while offering an opportunity to create power, heat, and valuable by-products. In New York State, the expansion of this technology is hindered by the lack of a well-developed industry that spans the range of expertise from feasibility analysis to design, construction, operation and maintenance. Increasingly, there is a need for knowledgeable professional personnel in these areas. Because relevant education and training is, at best, limited, there is an urgent need to develop capacity-building programs.

2. Key curriculum content

Key facts, concepts, understandings, skills, and capabilities important for successful digester design, operation and maintenance fall into seven categories: feasibility, financing and insurance, design, construction and installation, operation and maintenance, safety, and public relations and general information. An outline of the key components is given below, and Matrix 1 lists the anticipated audience for each component.

1. Feasibility
    - 1.1. Feasibility basics
    - 1.2. Technical feasibility study writing
    - 1.3. Site feasibility
    - 1.4. Economics and sensitivity to key assumptions
    - 1.5. Analysis of value-added ventures
    - 1.6. Funding options
    - 1.7. Business plans/risk assessment
    - 1.8. Laws, regulations, and permits
    - 1.9. Public relations
2. Financing and insurance
    - 2.1. Financing
    - 2.2. Government funding

2.3. Emission/carbon credits

2.4. Tax credits

3. Design

3.1. Selection of the digester design

3.2. Geographic location

3.3. Fundamentals of microbiology

3.4. Farm characteristics, site feasibility

3.5. Herd make-up

3.6. Feeding practices and feed composition

3.7. Characteristics of manure and other inputs

3.8. Nutrient transformations

3.9. Energy, her, material balances

3.10. Type of digester

3.11. Operating temperature and digester heating

3.12. Digester design and optimization

3.13. Manure collection/handling system

3.14. Influent handling and mixing system

3.15. Influent handling and mixing system

3.16. Effluent handling system

3.17. Solids retention time

3.18. Hydraulic retention time

3.19. Digester loading rate

3.20. Viability of microorganisms

3.21. Solid separation/reclaimed solids/composting/bedding

3.22. Gas collection and flare

3.23. Options for biogas use

3.24. Combined heat and power generation (CHP)

3.25. Digester location

3.26. Control system and automation

3.27. Monitoring and instrumentation

3.28. Appropriate subsystem sizing

3.29. Ability to expand operations

4. Construction and installation

4.1. Digester construction

4.2. Materials for construction

4.3. Manure collection/handling/mixing/storage systems

4.4. Gas collection and flare

4.5. Engine

4.6. Combined heat and power (CHP)

4.7. Electrical

4.8. Pumps and plumbing

4.9. Separator

5. Operation and maintenance

5.1. Selecting the digester operator

5.2. Digester startup

5.3. Record keeping

5.4. Maintenance requirements and schedules

5.5. Scheduled overhauls

5.6. Troubleshooting

5.7. Warranties and parts replacement

5.8. Engine servicing/heat exchanger

5.9. Pumps and plumbing

5.10. Electrical

5.11. Handling settled solids

5.12. Routine care/oil change

5.13. Monitoring/performance evaluations

6. Safety

6.1. Hazards identified

6.2. Best practices established

6.3. Safety reports

6.4. Electrical safety

6.5. Engine safety

6.6. Manure/food waste handling

6.7. Gas and hydrogen sulfide

7. Public relations/general information

7.1. Who needs to know about digester plans?

7.2. Digester basics

7.3. Environmental and odor reduction benefits

7.4. Community impact

3. Target audiences

The audiences recommended to receive training and education are listed below. These target audiences are organized with respect to key curriculum content in Matrix 2.

Dairy producers

Agricultural professionals

Government and university extension employees

Environmental management planners

Engineering firm employees

University and secondary level educators

Independent professionals, including engineering, planning, and veterinarian

Digester operators and managers

Digester construction, installation, and service contractors

Component manufacturer employees

Utility company employees

Investors and lenders

Government agency employees

Insurance company employees

Food processing industry employees

Media

General public

Neighbors

4. Institutions, their programs in NY, and the degree of coverage of these programs.
NY institutions and organizations that provide training or educational services related to anaerobic digestion are presented in Matrix 3: Schools in NY. Six educational institutions that provide training or educational services related to some aspect of anaerobic digestion were found in NY State.

5. Existing institutions in New York providing related coverage.
Institutions in NYS that provide related coverage are listed in Matrix 4: Related NYS Programs. A total of 12 institutions were identified. Only a few programs exist that specifically address AD systems. It is therefore necessary to look at how educational services in other industries can be adapted to fit an AD workforce's training needs. Related AD industries are wastewater treatment, heating, ventilation and air conditioning (HVAC), natural gas, landfill gas, solar power and wind power. Because the solar and wind industries are newly expanding, they offer a unique model of workforce development. In the absence of appropriate existing services, AD specific programs may have to be developed.

Within NYS, wastewater treatment courses like advanced wastewater treatment, pumps & electrical maintenance, electrical safety, laboratory testing, and mechanical maintenance can be adapted to at least partially meet the needs of an AD workforce. Many of these courses are focused on preparing students for New York State Department of Environmental Conservation wastewater treatment certification. There are four levels of certification (Grades 1, 2, 3, and 4), each requiring specific courses and previous education requirements (*1*). Great Lakes Laboratory in Buffalo, Hudson Valley Community College, SUNY Ulster, New York Water Environment Association, Albany County Cooperative Extension, New York City Department of Environmental Protection, SUNY Morrisville, SUNY Ulster, and Westchester County DEP all have coursework to prepare students for each level of certification (Matrix 4- Related NY Programs). The Environmental Training Center at Morrisville has an anaerobic digestion module that is taught as part of an existing course.

HVAC is a mature industry with established training and certification programs. HVAC training curriculum includes key concepts important to AD like selection of system components, heat exchangers, cooling coils, heat pumps, energy conservation, heat recovery, thermal storage, techniques for improving energy use, importance of energy conservation, description of heat recovery systems, and operation and performance criteria of coils, fans, pumps, and filters. New York State HVAC training programs are offered at secondary and post secondary schools like Branford Hall Career Institute and Technical Career Institute, and also through basic self-study courses available on the Internet. Training schools can be accredited by one of three agencies- HVAC Excellence, the National Center for Construction Education and Research (NCCER) and the Partnership for Air Conditioning, Heating, and Refrigeration Accreditation (PHARA)(*2*). In addition, many organizations have curriculum guides posted on their websites.

The HVAC industry has developed "entry level" certification exams for those students with less than a year of experience. Higher level certification can be obtained through the Refrigeration Service Engineers Society (RSES), HVAC Excellence, The Carbon Monoxide Safety Association (COSA), Air Conditioning and Refrigeration Safety Coalition, North American Technician Excellence, Inc. (NATE), and others(*2*). Certification is a way for employers to measure competence and for skilled workers to increase advancement possibilities. HVAC Excellence provides three levels of certification; employment ready, professional level, and master specialist(*2*). North American Technician Excellence provides certification for service technicians and installation technicians. A technician then specializes in one area, for example, oil heating. To receive certification as an oil heating technician, one must pass both the installation technician test and then the specialty oil heating test.

The US Solar (photovoltaic (PV) and solar thermal) industry presently employs over 20,000 workers, and by 2020 this number is expected to climb to 150,000 (*3*). Workforce development for this industry is underway in NYS, with seven accredited solar training centers offering education (see Appendix and Matrix 4-Related NY Programs). Hudson Valley Community College, one of the abovementioned programs, has adapted its

Electrical Construction and Maintenance Department to include PV training. Hudson Valley also hosted a conference specifically geared toward educators in the renewable energy field (see Appendix). Solar training programs in NYS are designed to prepare students for the North American Board of Certified Energy Practitioners (NABCEP) entry level certification exam. Accreditation of training programs is done by the Institute for Sustainable Power, using ISPQ international standards(*4*). In NYS, verification of ISPQ standards is being completed by the Interstate Renewable Energy Council(*5*).

NABCEP certification for solar electric practitioners targets the contractor responsible for PV panel installation. Certification is voluntary and is not intended to prevent qualified individuals from installing solar products(*4*). Certification is intended to(*4*):

> *identify qualified professionals and add a national credential to their portfolio, to ensure recognition of expertise, to assist manufacturers in identifying qualified dealers and installers, to enhance credibility and prestige, to provide a vehicle for professional development, to establish professional practice standards, to protect the public and increase safety of installed systems, and to enable professionals to stay current.*

NABCEP's philosophy is that certification programs should only be created if a significant number of stakeholders agree that a certification program would be beneficial. The NABCEP's credentialing and certification programs were preceded by task analyses to identify specific knowledge and skills required by energy practitioners. The task analysis for photovoltaic system installers and solar water system installers are included in the Appendix.

The task analysis for small wind turbine (under 100kW) installers and maintenance professionals is underway (*4*).

National corporations, like Caterpillar and GE, are also active in NYS. These groups build biogas engines, have experience in anaerobic digestion, and provide educational services related to proper engine use and maintenance (Matrix 5- Allied Industries, Biogas Engines). The natural gas industry also has educational services like pipeline welding and safety, gas technician training, natural gas vehicle training, and other courses that are transferable to AD-CHP training programs. In Denmark, where the natural gas

industry is developed and supported by a qualified workforce, many skilled gas workers have been employed in biogas plants.

Although many of the discussed industries have established certification exams, this approach is not necessarily suitable to AD at this time. It is more important to start with solid education and training programs instead of building an immediate hurdle over which new practitioners must jump. It is informative to see that most industries do indeed work towards certification and accreditation. This, however, should not be misconstrued as reason to immediately adopt certification in the nascent AD industry.

6. Institutions and programs beyond NY State.

Institutions and programs beyond NYS are provided in the following Matrices: Matrix 5- Allied Industries, Matrix 6- US Schools, Matrix 7- US Government, Matrix 8- Other Organizations and Matrix 9- Europe. Information about these organizations was taken directly from the websites provided.

Resources in allied industries beyond NYS are identified in Matrix 5. Wastewater treatment courses on activated sludge/anaerobic digestion, lab testing, pump operation, mechanical maintenance and other applicable subjects have been identified. The National Environmental Training Center for Small Communities offers tailored training programs; curriculum development and a training package on anaerobic digestion (see Appendix). The Environmental Resource Training Center at Southern Illinois University and other wastewater education facilities also offer pertinent training courses. Other industries with applicable training materials such as HVAC, natural gas, biogas engine providers (GE and Caterpillar), solar, wind, and CHP have also been identified. The matrices do not attempt to catalog all training activities related to these industries. Of note is that the Midwest CHP Application Center has held two workshops dedicated to the integration of CHP with digester technologies.

Schools that offer training directly relating or adaptable to AD-CHP systems are identified in Matrix 6. Of note is an Anaerobic Digester Technician course taught at

Madison Community College (MACC). This course was developed with a grant from the National Science Foundation. Course curriculum has been solicited and is under review per agreement with MACC.

US Governmental Agencies that offer resources related to AD training are presented in Matrix 7.

Other relevant organizations are presented in Matrix 8. The renewable energy industry, responding to increased demand for such technologies, has begun to build a technical workforce. Nationally, the effort to do so has been led by the Partnership for Environmental Technology Education (PETE) and the Advanced Technology Environmental Education Center (ATEEC)(*6*). With funding from the Department of Energy, PETE has developed and put into operation the C4 Program for Energy Management Technicians. This curriculum has been developed for community colleges and technical schools and leads to a one year certificate(*7*). The Interstate Renewable Energy Council (IREC) is a non-profit organization with members from state agencies, national laboratories, industry and academia. It was developed to address the need to expand the renewable energy market. The Interstate Renewable Energy Council (IREC) "supports market-oriented services targeted at education, coordination, procurement, the adoption and implementation of uniform guidelines and standards, workforce development, and consumer protection."(*8*) The IREC provides a course catalog with renewable energy courses across the country. PETE, ATEEC and IREC are organizations that have experience building renewable energy programs and some of their curriculum may be directly transferable to AD.

Information on European groups is presented in Matrix 9. Contact was made with Michael Köttner of the International Biogas and Bio-energy Competence-centre (IBBK) who is interested in working out an agreement to share their training resources. IBBK has developed a course module for biogas plant operators, which have been taught for four years in Germany. IBBK is capable of developing specialized training courses. IBBK is

planning a meeting in Canada (not yet scheduled) during 2007 and it will be useful to maintain contact and to consider possible attendance at this upcoming meeting in Canada.

7. Methods for effective training and education.

Outlined below are viable mechanisms for meeting the educational needs of an AD-CHP industry. The appropriateness of these training methods is discussed in relation to anaerobic digestion.

University coursework

With increased attention on renewable energy, many four year colleges and universities have begun to offer renewable energy courses. Some offer Bachelors degrees in Renewable Energy. These institutions provide an opportunity to teach the fundamentals of microbiology, engineering design, AD economic analysis, material and nutrient balances and to do research on anaerobic digestion.

Technical college coursework

The HVAC, Solar, Wind, etc. rely on technical colleges to train their workforce. At these technical schools, renewable energy courses are being taught as extensions of existing curriculum. One could imagine courses on anaerobic digestion being integrated into existing coursework. For example, a certificate of knowledge could be provided to those who specialize in "Maintenance of Biogas Engines," or other AD-related subjects. Technical colleges may be a way to institutionalize these programs and ensure lasting workforce development.

Workshops and short courses (classroom, online, or home study)

For farmers and on-farm digester operators who are not inclined to leave the farm for extended periods, workshops and short courses are more appropriate than university or technical college courses. For a workshop approach to be effective, however, there has to be adequate incentive for attendance. In the case of wastewater treatment, courses prepare students for a certification exam and are attended for this reason. Courses may be offered in a classroom, online or as a home study packet. One approach to short course

development is to create flexible training modules. Combining appropriate modules allows courses to be tailored to specific audiences. Some modules, like CHP, are important to other industries. If a CHP module were created, it could be easily used in other workforce development programs.

Necessary supporting resources (DVDs, movies, on-line materials, packets, case studies, software, etc) should always be provided to students taking short courses. For a Digester Technician course, take-home materials could include a Startup and Operations Guide for Technicians, Safety Protocol Guide, and Subsystem Equipment Manual and other relevant references. There is question as to whether materials should be provided free to those who do not enroll in a course. The debate stems from the thought that providing free materials will discourage people from participating in onsite training courses. This should be weighed against the fact that some farmers will not enroll in courses anyway, and that all attempts should be made to give them access to needed materials. Internet-based delivery of information can be an effective mechanism (either for cost or freely available) to meet educational and training opportunities in such cases.

Farm tours

Farm tours and information sessions are an effective way to inform the general public, interested farmers, and government figures about anaerobic digestion. Presentations are usually less technical in nature and are intended as an overview of the system, its benefits, and economics. Farm tours will have to be tailored so that bio-security is not compromised.

European study tours

Study tours are underway in Europe, allowing professionals in the biogas industry to survey various technologies and see them in action. In September of 2006, IBBK held an International Biogas Study Tour in Germany and Austria. Similar study tours and workshops on the "Progress in Biogas" are planned for 2007.

There is opportunity for US participation in European tours, workshops and training courses. In Europe, training courses have already been offered to people from China, France, Italy and Canada. Participants obtain a certificate from these courses, which has official recognition. The IBBK is planning a workshop in Canada and has expressed interest in involving US participants. Canada has already held one workshop in April of 2006, titled "Organic Inputs and Renewable Energy: Learning from the European Biogas Model" (See Appendix).

Conferences

Conferences provide a forum for information exchange and allow involved parties to remain up-to-date on advances in technologies. The US Composting Council, for example, held a conference that included presentations on technologies for the treatment of organic waste. AD-CHP fits appropriately into the framework of such conferences. Conferences support the industry by promoting transfer of technology and increasing publicity.

Discussion groups

Encouraging dialog and information exchange between stakeholders can be accomplished with the creation of discussion groups. This allows individuals to share experiences, resources, and information. The European Anaerobic Digestion Network has accomplished this using an online system where thirteen member countries exchange technical information, plan events and network (See Matrix 9).

News stories

Featured stories appearing on the local news, press releases, and workshops for the news media are strategies to address public interest in AD.

8. Recommendations

The development of the Dairy AD industry requires that programs be created for diverse audiences using a variety of approaches. This is due to the fact that AD systems are complex and that the adoption of AD requires political will, farmer dedication and a

trained workforce. Based on the target audiences, key content areas and methods of material delivery identified in this report, we recommend that the following steps be taken.

1. Develop three technical short courses that will provide educational training to people involved in the planning and implementation of Dairy AD systems as well as those managing already constructed and operating systems. These courses are:

    a. Feasibility of Farm Anaerobic Digesters (1 day)
    b. Implementation of AD System from Planning and Design to Construction (2-3 days)
    c. Technician's Start-Up and Operation Guide (2-3 days)

    A description and outline of each course is provided in section 11 of this report. The audience will be primarily adult learners, which in turn dictates the length of each of these courses. Efforts should be made to integrate elements into existing coursework at technical schools and colleges. With time, stand alone classes may emerge. Thus, the development of an AD curriculum should reflect the need for materials that can be used by colleges and universities.

2. Develop a one-day public relations workshop for the media, farm neighbors, regulators, government officials, renewable energy enthusiasts and all other interested parties. Such a workshop covers the basics of anaerobic digestion and is intended to raise awareness about the environmental benefits of anaerobic digestion, encourage positive media attention on AD and provide informational materials to interested parties.

3. Form discussion groups (including list servers) that allow professionals in the industry to discuss AD issues, troubleshoot digester problems and share resources.

4. Develop a website that provides access to course materials and pertinent information (some free of change, while others for a nominal fee). The website may, in the future, provide distance learning opportunities and an online discussion forum.

5. Assess the potential for the development of a New York Biogas Association as either a subsidiary of an existing organization such as NYS Agricultural Society, Dairy Practices Council, NEDPA, or as a "Coalition of Stakeholders." A New York Biogas/Bioenergy Association would be the coordinating body that oversees and fosters the development of the industry.

6. Communicate with cooperative extension programs, agricultural organizations (NY Agricultural Society, Dairy Practices Council, NEDPA, and Farm Bureau), NYWEA, landfill gas associations, waste management associations and the International Biogas and Bioenergy Center (IBBK) regarding the recommendations made in this report. Also, solicit input from these organizations about the development of short courses and obtain member interests in these proposed programs.

7. Consider certification programs as the industry matures and a need is recognized. Certification programs could be administered through an organization with a stake in the industry or by the a proposed "New York Biogas Association". For certification to have an impact, it should be recognized at a regional and national level.

8. Encourage colleges and universities to conduct research and teaching on anaerobic digestion.

9. Response to letters sent to stakeholders

A letter was developed and sent to 29 organizations related to the dairy industry and allied groups. The purpose was to seek feedback on the report (sent to the respective

organization) to ensure that the recommendations were consistent with perceived needs to develop a robust anaerobic digester industry in New York. The organizations receiving the letter were:

NYS Department of Ag. and Markets
New York Power Authority
New York Independent System Operator (NYSISO)
New State Agribusiness Association
NYS Department of Environmental Conservation
NYS Department of Health
NYS Natural Resources Conservation Service
NYS Soil and Water Conservation Committee
NYS Association of Food Protection
NYS Milk Promotion Advisory Board
NYS Cheese Manufacturers Association
NY Farms!
New York State Education Department
NY Association of Agricultural Educators
Pride of New York
The New York State Agricultural Society
NY Farm Bureau
Northeast Dairy Producers Association
DairyLea
DairyOne
Upstate milk cooperative
American Diary Association and Dairy Council
New York Dairy Practices Council
NYWEA
New York State Association for Solid Waste Management
New York State Cattle Health Assurance program
National Milk Producers Federation
Air & Waste Management Association
Solid Waste Association of North America

We received 10 direct responses to a set of questions addressed in the letter (attached to this report). The questions were:

1. Do the proposed three courses address the needs of your constituents? What additions or subtractions to the content would you suggest?

2. If the three courses were offered, how much interest would your member base have in participating?

3. Does the suggested length and schedule of the particular course seem appropriate?

4. What is the preferred delivery method: home study, online course, farm tour, or workshop/short course?

5. What need, if any, do you perceive for development of a certification program for digester operators?

6. What additional recommendations would you suggest to advance the development of the AD industry?

The responses are summarized as:

a. Efforts to further the use of AD as a method to produce electricity are welcomed. The proposed curriculum appears to be a comprehensive approach to provide information to a number of vital audiences.
b. Dairy farmers are always looking for new and innovative ways to improve farming. Dairy farmers seem interested in AD but is there a good return?
c. Possibly the NRCS CIG source would be a viable place for funding the development of courses.
d. Appeared to be interest among ag teachers in NYS to attend one or more of the courses. Also, interest among faculty at the "AG & Techs". Suggestion that the one-day course would be very appropriate for the Ag Teacher Professional Development Workshop that is scheduled each year in June.
e. Feeling that the proposed educational program and materials have national application.
f. Believe there would be interest by NRCS field staff.
g. Perception that a workshop format would be best delivery mechanism supplemented by Internet information.

Discussions with Mr. Peter Sheehan of NABCEP (North American Board of Certifying Energy Professionals) suggest that there might well be a possibility to collaborate with this organizations to develop and implement quality credentialing and certification programs for practitioners, as well as in development and presentation of AD courses.

Another potential collaborator in the development and delivery of the AD courses is IREC (Interstate Renewable Energy Council). IREC supports services targeted at education, coordination, procurement, the adoption and implementation of uniform

guidelines and standards, workforce development, and consumer protection for renewable energy.

10. Cost estimates

Approximate costs for development and delivery of the three recommended courses were estimated (Table 1). For all but the first course (Feasibility of Farm Anaerobic Digesters), a high and low estimate was made based on two- and three-day courses. To calculate the expected time needed to develop the curriculum, the expected course length was scaled by 20. The cost per hour was set at $50, and the cost of delivering the course was assumed to be $1,500 dollars per day. The capital cost of manuals, original workbooks and class materials was also included, although it is assumed that the cost of developing these materials is part of the cost of coursework development. Overhead was set at 20%. The result of these estimates is that the course Feasibility of Farm Anaerobic Digester course will cost roughly $12,600, Implementation of AD System from Planning and Design to Construction will cost between $25,200 and $36,600, and Technician's Start-Up and Operation Guide will cost between $27,600 and $39,000.

Table 1. Estimated costs of the three proposed anaerobic digestion courses.

Section	Feasibility of Farm Anaerobic Digesters (1 day)	Implementation of AD System from Planning to Design to Construction (2-3days)	Technician's Start-Up and Operation Guide (2-3 days)
Course time (hr)	8	16-24	16-24
Coursework development time (hr)	106	320-480	320-480
Coursework development cost	$8,000	$16,000-$24,000	$16,000-$24,000
Manuals, original workbooks, and class materials	$1,000	$2,000	$4,000
Delivery cost	$1,500	$3,000-$4,000	$3,000-$4,000
Overhead cost	$2,100	$4,200-$6,100	$4,600-$6,500

Total cost	$12600	$25200-$36600	$27600-$39000

Notes: Cost values were calculated by making the following assumptions: The time required to develop the curriculum is 20-fold as great as the course time, the cost of course development is $50/hr, the cost of course delivery is $1500/d, and overhead is 20%. All costs are in US$.

11. Course Outlines

Feasibility of Farm Anaerobic Digesters

Course description. This course will provide students with the tools they need to: evaluate the feasibility and economics of a dairy farm digester system, conduct a risk assessment and sensitivity analysis on key assumptions, explore funding options**,** be aware of the time-frame and effort required to complete an AD project, understand the environmental benefits that an AD system provides, and evaluate the feasibility of a digester system on any given farm.

Audience. This course is geared toward dairy producers, professionals seeking Continuing Education Units, agriculture consultants, environmental management planners, local authorities, utilities, public officials, regulators, policy makers, insurance companies, venture capitalists and the financial sector.

Approach. This one-day course will provide learners with case studies that will be analyzed during the course; relevant resources on grant writing, funding opportunities and applicable laws; and software for evaluating the feasibility of projects.

Skill sets/competencies. After completing this course, learners should be able to:

1. Explain the course objectives
2. Describe the basic biological and chemical reactions that take place in anaerobic digesters, and their importance
3. Recognize the fundamental components of anaerobic digestion systems and their functions
4. Quantify the effects of site characteristics on the feasibility of developing an anaerobic digestion system
5. Perform a feasibility study for the development of an anaerobic digestion system
6. Predict the cost and revenue generation from an anaerobic digestion system

7. Quantify the effect of uncertainties or variability in assumptions on economics of anaerobic digestion systems, and quantify risks associated with anaerobic digesters
8. Identify potential sources of funding for the development of an anaerobic digestion system
9. List and describe laws, agreements, permits, and codes that are relevant to anaerobic digester development and operation
10. Produce an implementation time table for the development of an anaerobic digestion system

Performance standards. Performance will be assessed through a written examination.

Course Outline

1.Introduction and course objectives
2.Basics of anaerobic digestion
- 2.1. Digester microbiology
- 2.2. Digester chemistry and physics

3.Overview of the AD system
4.Site feasibility
- 4.1. Herd make-up
- 4.2. Manure quantity and composition
- 4.3. Feeding practices
- 4.4. Compatibility of existing structures
- 4.5. Site layout, geographic location
- 4.6. Farm goals, objectives, and plans

5.Feasibility studies
- 5.1. Importance of a feasibility study
- 5.2. Performing an AD feasibility study
- 5.3. Using FarmWare and other software

6.Business plan and economic considerations
- 6.1. Capital costs
- 6.2. Total annual costs
- 6.3. Return on investment
- 6.4. Return on assets
- 6.5. Expected life of capital investments
- 6.6. Organic waste tipping fees
- 6.7. Emissions credits
- 6.8. Carbon credits
- 6.9. Tax credits

7.Risk assessment and sensitivity analysis on key assumptions
- 7.1. Price of electricity/fossil fuels
- 7.2. Food waste inputs
- 7.3. Present and future environmental regulations
- 7.4. Pathogen reduction
- 7.5. Digester performance
- 7.6. Price changes in system inputs and outputs

8.Funding
    8.1. Federal and state grants
    8.2. Support mechanisms
    8.3. Technical grant writing-applying for funding
9.Laws, regulations, agreements, permits, and codes
    9.1. Animal by-product legislation
    9.2. Nutrient management and land application guidelines
    9.3. Zoning codes
    9.4. Regulations on biogas plants and gas handling
    9.5. Net metering
    9.6. Air-quality regulations of distributed generation sources (NYSERDA section 222-1)
    9.7. USDA anaerobic digester standards
    9.8. EPA Air Quality Compliance Agreement
    9.9. Possible future emissions standards
10.Implementation timetable

Implementation of Anaerobic Digestion Systems from Planning and Design to Construction

Course description. This course prepares learners to implement and run an AD system from the planning and design phase to operation and maintenance. It focuses on the design of AD systems; how to successfully interact with a designer so that the farms needs are met; basic operation and maintenance; analysis of value added options; and outreach to the local community.

Audiences: This course is aimed at dairy producers who have made the decision to pursue anaerobic digestion on their farms, engineering companies, dairy advisors, university personnel in animal agriculture, extension staff, professionals seeking continuing education units, agricultural professionals, environmental management planners, manufacturers and suppliers of subsystem parts, contractors and service providers.

Approach: This is a two-to-three day short course. A course workbook is provided.

Skill sets/competencies. After completing this course, learners should be able to:

1. Explain the course objectives
2. Describe differences in available anaerobic digestion system designs, and identify designs suited for particular farm characteristics
3. Describe the basic biological and chemical reactions that take place in anaerobic digesters, and their importance
4. Explain the basic components of digester system operation
5. Explain the basic components of digester system maintenance
6. Describe the nutrient transformations that take place within a digester, and quantify the effect of waste importation on a farm nutrient budget
7. Identify sources of revenue that can be generated using an anaerobic digestion system
8. Describe essential components of anaerobic digester system management

9. Describe practices for maintaining safety during digester operation and maintenance
10. Understand approaches for dealing with residual solids resulting from anaerobic digestion
11. Explain the impact of anaerobic digestion on pathogen levels

Performance standards. Performance will be assessed through a written examination.

Course Outline

1. Introduction and course objectives
2. Design
    - 2.1. Selecting the digester designer
    - 2.2. Farm characteristics
        - 2.2.1. Site design, site considerations, adaptability of existing structures
        - 2.2.2. Herd size and make-up
        - 2.2.3. Farm needs, goals, objectives, and plans
    - 2.3. Characteristics of manure and other inputs
    - 2.4. Digester type
    - 2.5. Manure collection, handling, influent storage
    - 2.6. Effluent and separated solids handling
    - 2.7. Materials for construction
    - 2.8. Design flexibility
    - 2.9. Energy utilization options
3. Introduction to digester microbiology and chemistry
4. Operation basics
    - 4.1. Selecting the digester operator
    - 4.2. Digester startup, testing, and shutdown
    - 4.3. Monitoring and instrumentation
    - 4.4. Performance evaluations
    - 4.5. Troubleshooting
    - 4.6. Subsystem operation
        - 4.6.1. Engine
        - 4.6.2. Flare
        - 4.6.3. CHP
        - 4.6.4. Electrical
        - 4.6.5. Biogas handling
    - 4.7. Record keeping
5. Maintenance basics
    - 5.1. Servicing
    - 5.2. Parts replacement
    - 5.3. Overhauls
    - 5.4. Warranties
    - 5.5. Digester cleaning
6. Nutrient management plan
    - 6.1. Nutrient transformations

- 6.2. Assessment of additional waste inputs
- 6.3. Management of residuals

7. Value added ventures
   - 7.1. Waste heat
   - 7.2. Assessing biogas composition and other uses
   - 7.3. Digested solids, separating solids, and composting
   - 7.4. Long term contracts
   - 7.5. Food waste inputs
     - 7.5.1. Quantity and type of waste and effect on effluent composition
     - 7.5.2. Effect on quantity of biogas and subsystem sizing requirements
     - 7.5.3. Land base requirements
     - 7.5.4. Proximity of input waste to farm
     - 7.5.5. Regulations of food waste handling and handling and processing
   - 7.6. Interfacing with existing system

8. Management
   - 8.1. Compliance
   - 8.2. Budgets
   - 8.3. Public relations/ outreach
     - 8.3.1. Involving appropriate authorities
     - 8.3.2. Neighbor relations and community education

9. Safety
   - 9.1. Identify potential hazards
   - 9.2. Establish best practices
   - 9.3. Safety reports
   - 9.4. Emergency action plan

10. Economics and financing
    - 10.1. Costs
    - 10.2. Revenue sources
    - 10.3. Financing sources

11. Management of pathogens
    - 11.1.1. Effect of anaerobic digestion on pathogen levels
    - 11.1.2. Design options for pathogen control

Technician's Start-Up and Operation Guide

Course description. This course prepares the learner to operate a Dairy AD System. It covers system design; biological and chemical processes of anaerobic digesters; proper daily operation; preventative and corrective maintenance of mechanical, gas, and electric components; troubleshooting digester performance issues; record keeping; and safety.

Audience. This course is targeted at the person in charge of operating and maintaining a digester. This may be the farmer, farm employee or an off-farm technician. Although the course is designed to train digester operators, a number of different audiences may be interested in attending, including wastewater facility operators, service contractors, equipment suppliers, safety professionals, dairy cooperative representatives, and professionals seeking continuing education credits.

Methods. This is a two-to-three day course. Manuals on operational protocol, maintenance schedules, safety, equipment, instrumentation and controls will be provided to course participants.

Skill sets/competencies. After completing this course, learners will be able to:

1. Describe the course objectives
2. Identify the basic types of anaerobic digesters, basic anaerobic digestion system components, and describe their function
3. Describe the fundamental biological and chemical reactions that take place within an anaerobic digester, and their importance
4. Operate an anaerobic digester system
5. Implement digester maintenance procedures
6. Describe practices for maintaining safety during digester operation and maintenance
7. Understand the relevant regulations that relate to digester startup and operation
8. Successfully interact with the public in describing anaerobic digestion systems

Performance standards. Performance will be assessed through a written examination.

Course Outline

1. Introduction and course objectives
2. AD system overview
    2.1. Digester types
    2.2. Manure collection, handling, influent storage
    2.3. Digester loading
    2.4. Mixing (if applicable)
    2.5. Hydraulic retention time
    2.6. Solids retention time
    2.7. Heat transfer, heating system, digester heating
    2.8. Fluid flows
    2.9. Effluent handling and solids separation
    2.10. Use of reclaimed solids
    2.11. Biogas handling, treatment, and use
    2.12. Subsystem setup
        2.12.1. Engine-generator set
        2.12.2. Electrical hookup
        2.12.3. Net metering and distributed generation
        2.12.4. CHP, combustion heat recovery system
        2.12.5. Biogas handling
        2.12.6. Flare
3. Introduction to biological and chemical processes
    3.1. Microbiology and anaerobic digestion
    3.2. Digester chemistry
    3.3. Nutrient transformations
    3.4. Pathogen destruction
4. Operations
    4.1. Control system and automation
    4.2. Monitoring and instrumentation
    4.3. Record keeping
    4.4. Electrical/mechanical/biological systems
    4.5. Standard performance evaluation
        4.5.1. Biogas production rating
        4.5.2. Energy production efficiency
        4.5.3. Engine-generator set efficiency
        4.5.4. CHP efficiency
        4.5.5. AD parasitic heat rating
        4.5.6. AD parasitic electrical power
        4.5.7. AD heat energy rating
        4.5.8. Heat recovery efficiency
        4.5.9. AD unit insulation rating
    4.6. Troubleshooting digester symptoms
        4.6.1. Decrease in gas production
        4.6.2. Decrease in pH

- 4.6.3. Decrease in methane/carbon dioxide ratio
- 4.6.4. Increase in volatile compounds

4.7. Testing

- 4.7.1. Manure moisture content
- 4.7.2. Temperature- infrared temperature sensors
- 4.7.3. pH
- 4.7.4. Gas composition
- 4.7.5. Loading rate
- 4.7.6. Hydraulic retention time
- 4.7.7. Nature of influent and effluent
- 4.7.8. Changes in animal diet

5. Maintenance

5.1. Maintenance requirements and schedules (preventative and corrective)

5.2. Routine care and troubleshooting

- 5.2.1. Engine generator set of mincro-turbine
- 5.2.2. Compressors
- 5.2.3. Piping
- 5.2.4. Filters
- 5.2.5. Pumps
- 5.2.6. Valves
- 5.2.7. Mixers, agitators
- 5.2.8. Biogas blowers/compressors
- 5.2.9. Solid-liquid separator, screw press
- 5.2.10. Electrical
- 5.2.11. Scheduled overhauls

5.3. Warranties

5.4. Servicing

5.5. Parts replacement

5.6. Digester cleaning

6. Safety

6.1. Identification of hazards

6.2. est practices

6.3. Electrical safety

6.4. Engine safety

6.5. Biogas safety

6.6. Hydrogen sulfide safety

6.7. Manure and organic waste handling safety

6.8. Emergency actions plan

7. Laws, regulations, agreements, permits, and codes

8. Public relations

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14. **Letter to Stakeholders**

Date

Dear XXXXX:

I am writing to share the progress report from a NYSERDA supported project to assess the availability of educational and training opportunities for anaerobic digestion (AD) and to assess the need for development of an anaerobic digestion (AD) curriculum. We solicit your input on this report. The primary objective of the project was to present recommendations for the development of human resources in support of the AD industry in New York. With ten AD systems operating on NY dairy farms and with more in the planning stages, the need to develop educational and training programs to support these systems and future ones is apparent. An assessment of key curriculum content, target audiences, existing institutional programs, and methods for effective training and education are presented in the enclosed report, recently submitted to NYSERDA.

In addition to the application of AD systems for manure management for odor control and to meet environmental concerns, a number of value-added opportunities exist for significant combined heat and power development. The Renewable Portfolio Standard (RPS) in New York includes AD systems under the Customer-Sited Tier Program. Thus, we seek feedback from the dairy industry and related groups on this report in order to

ensure that our recommendations are consistent with needs to develop a robust AD industry. Our recommendations are to:

1 .Develop three technical short courses that will provide educational training to people involved in the planning and implementation of Dairy AD systems as well as those managing already constructed and operating systems. These courses are:

a. Feasibility of a. Farm Anaerobic Digesters (1 day)
b. Implementation of AD System from Planning and Design to Construction (2-3 days)
c. Technician's Start-Up and Operation Guide (2-3 days)

A description and outline of each course is provided in section 10 of the report. The audience will be primarily adult learners, which in turn dictates the suggested length of these courses. Also, efforts should be made to integrate elements into existing coursework at technical schools and colleges. Over time, stand alone classes may emerge. Thus, the development of an AD curriculum should reflect the need for materials that can be used by colleges and universities.

2. Develop a one-day public relations workshop for the media, farm neighbors, regulators, government officials, renewable energy enthusiasts and other interested parties. Such a workshop will cover the basics of anaerobic digestion and is intended to raise awareness about the environmental benefits of anaerobic digestion, encourage positive media attention on AD and provide informational materials to interested parties.

3. Form a discussion group that allows professionals in the industry to discuss AD issues troubleshoot digester problems and share resources.

4. Develop a website that provides access to course materials and pertinent information (some free of change, while others for a nominal fee). The website may, in the future, provide distance learning opportunities and an online discussion forum.

5. Assess the potential for the development of a New York Biogas Association as either a subsidiary of an existing organization such as NYS Agricultural Society, Dairy Practices Council, NEDPA, or as a "Coalition of Stakeholders." A New York Biogas Association could become the coordinating body that oversees and fosters the development of a robust industry.

6.Consider certification programs as the industry matures and a need is recognized. Certification programs could be administered through an organization with a stake in the industry or by the proposed "New York Biogas Association". For certification to have an impact, it should be recognized at a regional and national level.

7. Encourage colleges and universities to conduct research and teaching on anaerobic digestion.

As a stakeholder in the dairy industry directly or indirectly, your input regarding these recommendations and the proposed three technical courses outlined in the report is important. To assist and help guide your response we have developed a few questions, which you may find useful, but please feel free to submit your comments and thoughts in any other format as well.

1. Do the proposed three courses address the needs of your constituents? What additions or subtractions to the content would you suggest?

2. If the three courses were offered, how much interest would your member base have in participating?

3. Does the suggested length and schedule of the particular course seem appropriate?

4. What is the preferred delivery method: home study, online course, farm tour, or workshop/short course?

5. What need, if any, do you perceive for development of a certification program for digester operators?

6. What additional recommendations would you suggest to advance the development of the AD industry?

Educational programs are only effective if they deliver key information to the right audiences in a timely and user friendly manner. For this reason, your response is essential to guide development of educational and training programs, which can lead to building an effective AD industry. Iain Clark will follow up with you by a phone call within approximately three weeks, if we have not heard from you, to see if you have any questions or need further information.

Thank you very much for participating in this important endeavor.

Sincerely,

Norman Scott
Professor