AC 2011-1596: DEVELOPMENT AND IMPLEMENTATION OF A CERTIFICATE IN ENERGY AND ENVIRONMENTAL MANAGEMENT

Andrew L. Gerhart, Lawrence Technological University

Andrew Gerhart, Ph.D. is an Associate Professor of Mechanical Engineering at Lawrence Technological University. He is actively involved in ASEE, the American Society of Mechanical Engineers, and the Engineering Society of Detroit. He serves as Faculty Advisor for the American Institute of Aeronautics and Astronautics Student Chapter at LTU, chair for the LTU Leadership Curriculum Committee, director of the LTU Thermal Science Laboratory, coordinator of the Certificate in Energy & Environmental Management and Certificate/Minor in Aeronautical Engineering, and member of the ASME PTC committee on Air-Cooled Condensers.

Robert W Fletcher, Lawrence Technological University

Robert W. Fletcher joined the faculty of the Mechanical Engineering Department at Lawrence Technological University in the summer of 2003, after several years of continuous industrial research, product development and manufacturing experience.

Dr. Fletcher earned his Bachelor of Science Degree in Chemical Engineering from the University of Washington, in Seattle, Washington, a Master of Engineering in Manufacturing Systems from Lawrence Technological University, in Southfield, Michigan, and the Master of Science and Ph.D. degrees in Chemical Engineering focusing on Electrochemical Engineering, both from the University of Michigan, in Ann Arbor.

He teaches a number of alternative energy courses and is leading LTU's efforts to establish a full energy engineering program that addresses both alternative and renewable energy systems, as well as energy conservation and optimization of traditional energy systems. He also is the Director of the Alternative Energy program at Lawrence Tech.

Development and Implementation of a Certificate in Energy and Environmental Management

Abstract

Energy management and the related environmental issues are becoming major cost factors throughout industry. Therefore the demand for energy and environmental managers has risen. In addition, the rapid emergence of global industrial energy demands have promoted the necessity for advanced education in the field to help energy producers and users maintain sustainable operations. The few current energy certificate programs are quite broad, but unfortunately they lack the environmental issues that must be addressed and the technical depth that a university can offer. Consequently, Lawrence Technological University developed and implemented a program to become a certified energy and environmental manager.

As mentioned, the Certificate in Energy and Environmental Management (CEEM) combines a knowledge base of not only energy management, but also the management of environmental impact. Based on benchmarking of other energy management certificates, feedback from an Industrial Advisory Board, and advice from CEEM alumni working in the industry, the CEEM requires successfully completing two 3 credit hour courses (45 meeting hours each) that include multiple real-world projects, successful completion of a certification exam that is not simply multiple choice, and 12 months of work experience or training in the energy management and/or environmental management field. Completion of these steps will properly assess a candidate's knowledge and ability to apply the subject matter. The paper will explain the development of the certificate, requirements for student admission, and details of the course content and project work. Examples of the experiential component required to earn the CEEM will be included. In addition, the success of the program will be explained via the employment record of students upon graduation from the CEEM program.

1. Introduction

If you were to ask a group of grade school children what are the major problems facing the Earth and its people, you will likely hear two top answers: energy resources and pollution (or environmental issues stemming from energy use). Worldwide concern continues to grow for our depleting supply of fossil fuels, the related increasing cost of fuels, and the reduction of emissions (particularly greenhouse gases and carbon footprint). While there are many solutions to these problems being addressed, no solution has yet taken a foothold over energy derived from fossil fuels with their consequent emissions. While the research and development community continues to work on alternatives, world citizens have the obligation to reduce the use of energy and manage it wisely; we must get the most out of what we have until a cost-viable and energy-capacity-equivalent alternative is available. Significant reductions in energy usage can be gained through wise energy management, and these reductions can be realized with existing technology. Thus, the demand for competent energy and environmental managers has been steadily increasing.

Six years ago only two certification program existed to become an energy manager, and neither were/are offered from a fully accredited university. Today there are at least 10 energy management certification programs, but in 2005, Lawrence Technological University launched the first energy management certification program by an accredited university and the first that was energy *and* environmental management. Lawrence Tech is accredited by the Higher Learning Commission of the North Central Association, and Lawrence Tech's A. Leon Linton Department of Mechanical Engineering, which houses the CEEM is accredited by ABET, Inc. formerly known as the Accreditation Board for Engineering and Technology.

2. Development

In the Fall of 2004, Lawrence Tech faculty were approached by leaders in the energy and energy management industry (who also held the Association of Energy Engineers' Certificate in Energy Management® – AEE's CEM) with encouragement to develop a certificate in energy and environmental management. Their reasons were many fold. They recognized that they needed to hire many energy managers in the near future; they wanted them to be trained locally. They also wanted an applied training program – something that was hands-on and required the completion of real-world projects. They wanted the program to embrace more topics than the traditional CEM®, and therefore wanted an inclusion of energy-related environmental impact, preparedness, awareness, and emergency response. Finally, they wanted a certificate that was administered by an accredited university, with all of the benefits that entails, such as rigorous admission policies, full-length semester courses, highly qualified instructors, support staff, and numerous resources. Lawrence Tech met all of these criteria; in fact, the institution's motto is "Theory and Practice," and its mission statement is "To develop leaders through innovative and agile programs embracing theory and practice." Due to Lawrence Tech's reputation, it was understood that the institution would deliver a practical and applied program with all of the necessary theoretical instruction to create a well-rounded graduate.

One of the first major steps was to determine if we had the appropriate resources. Six full-time faculty had a background in thermal-fluid science and energy generation (now seven full-time faculty). In addition, Lawrence Tech had a plethora of qualified and dedicated adjunct faculty who work in the thermal-fluids and energy industry and teach those subjects. Lawrence Tech also has an energy laboratory, a thermal science laboratory, and multiple energy-related "living" laboratories including an active array of solar panels and a LEED Silver-certified building with a geothermal energy system and living green roof.

An energy management industry advisory board was created that included energy managers from such companies as Johnson Controls, DTE Energy Services, Detroit Edison, Ford Motor Company, Daimler Chrysler, and the State of Michigan Energy Office. Meetings with the faculty and advisory board set the stage for the topics that should be covered, the format of the certification requirements, and the admissions/eligibility requirements for the students.

There were a few missteps during development and piloting. One was to offer the foundation course's (Energy and Environmental Management 1) 45 classroom hours over six and a half meeting periods. The meeting day was Saturday. The reason for the format was that full-time working students and those with a substantial commute would not have the course spread over

the traditional 16 weeks and during weekdays. When the first offering of the course was operated in this manner, it was the classic "drinking water through a firehouse." While the students performed quite well, they knew that attention span and retention of material was suffering during the course. The instructors also noted that the "soak-time" between sections of material was limited and deemed detrimental. Therefore, the students had to do much more review than for a normally-scheduled course. Fortunately, all of the class periods were videotaped and posted on the course website. The courses are now all scheduled over the traditional 16-week semester. The course only meets once per week in the evening which accommodates the working student and those with a commute.

A bad idea that was never implemented and ultimately rejected was to allow an applicant to attempt the certification exam without having taken coursework. Because of the desire to have an applied training program, it was proposed that the students that did not take the course would be required to pass not only a written competency exam, but also an in-depth project-based assessment. It was decided that a single project would not insure the depth and breadth desired of the graduates, while multiple projects within a course could. All certificate candidates would be required to complete the coursework.

3. Eligibility and Admissions Requirements

We believe it is important that the students admitted to the Energy and Environmental Certificate program have a firm theoretical training and background in physical sciences and engineering. As opposed to a purely management certificate, we want the program to be engineering-oriented in nature. With that said, to be admitted, an applicant must have a four-year degree in engineering or physical science or be licensed as a Professional Engineer. (For this reason, the certificate is known as a graduate certificate at Lawrence Tech – one in which the student already holds a college degree or equivalent). The student must have earned college credit in thermodynamics or thermal sciences and calculus-level mathematics. If an applicant has not been actively using thermodynamics principles for more than approximately five years, the student is strongly recommended to complete a refresher course in Thermodynamics (or related) before beginning the energy management coursework.

4. Curriculum requirements and details of the course work

Between U.S. engineering colleges, undergraduate and graduate engineering degree requirements usually follow a standard. Undergraduate degrees are roughly 120 to 135 credit hours (under the semester system) and graduate degrees are typically 30 to 40 credit hours. Certificate requirements, on the other hand do not follow a standard, and often are not even consistent within the same institution. For example at a particular college, some certificates require no credit hours at all but instead require a certain grouping of electives already built into the total hours within a degree, and other certificates require 18 credit hours beyond a degree. A sampling of certificates in energy management at colleges and universities reveals a wide range of required total credit hours. One program is zero credit hours, but instead requires completion of a six week program. Other programs range from 2 credits hours up to 40 credit hours. The programs with the higher credit hour requirements are at the community colleges and are often integrated into a broader degree in energy. At Lawrence Tech, the typical graduate certificate is

six courses, or 18 credit hours. The CEEM is the exception. It instead entails only two courses, or 6 credit hours, and a 12 month practicum (i.e., 12 months of experiential learning).

Specifically, the requirements to earn the CEEM are as follows:

- Completing the EGE 5303 Energy and Environmental Management 1 course with a minimum grade of B.
- Completing the EGE 5323 Energy and Environmental Management 2 course with a minimum grade of B.
- Completion of a written assessment/exam (i.e., the certification exam) with a score of 70% after completion of the EGE 5303 course (or at the discretion of the certificate administrators, completion of the EGE 5303 Final Exam with a B grade or better).
- Documentation of 12 months experience and/or training in the field of energy management and/or environmental management.

The main reason for this course/practicum format over the traditional course-based-only certificate is the desire for more of a practical and hands-on certification process. Another reason is so that the students can custom tailor portions of their certificate, within the approval of the faculty advisor. One student may desire an additional focus on control systems while another student may lean toward modifying energy-inefficient HVAC systems.

The 12 months experience and/or training component can include a variety of different learning structures. It can include seminars, workshops, research projects, additional coursework, internships, co-ops, actual full-time employment in industry, LEED training/certification (or similar training), or even service learning. One such service learning opportunity available in Southeastern Michigan is a non-profit organization that provides energy audits to non-profit organizations such as churches. The audits are largely performed by youth that are led and guided by trained adults. One of Lawrence Tech's students spent a substantial amount of time with this program performing audits, guiding/training the youth, and even training other adult guides. The students must identify/seek the experiences/training on their own, although the instructors and advisors regularly post available opportunities. The coordinator of the certificate should approve the experience/activity before the student begins to ensure that credit will be granted. While exact numbers have not been determined, the majority of the students fill the 12 month requirement with on-the-job projects or through internships. Second most popular choice is seminars and workshops to fill out their 12 months. Only a few have taken additional courses. Documentation of the 12 months experience can include letters from employers, pay stubs, receipts accompanied by official programs from workshops or seminars, and in the case of co-ops and additional coursework, official academic transcripts. Besides the two courses in energy and environmental management, Lawrence Tech offers a variety of courses in energy systems, alternative energy, green architecture, and sustainability (as do many of the surrounding community colleges).

Pertaining to the certification exam, the faculty and the industry advisory board agreed that the open book, multiple answer format of the AEE CEM® program was less than desired where some sections of the exam can be chosen over others (i.e., entire sections of the exam can be skipped). Therefore the CEEM exam is a closed-book competency exam based heavily on the material learned in EGE 5303 course, which as stated is application based with multiple real-

world projects. The exam typically is administered during the final exam period of the EGE 5303 course and therefore takes two hours to complete. The exam mostly consists of problem solving (i.e., computation) and short essays, although a few multiple choice problems/questions are included.

For the coursework, EGE 5303 must be completed first during a separate semester from EGE 5323 (i.e., EGE 5303 is a prerequisite for EGE 5323). Following the traditional academic year, the coursework spans from late August through early May (including a semester break). Candidates can be completing the 12 months practicum during or after coursework. Thus it takes about a year minimum to complete the certificate.

EGE 5303 – Energy and Environmental Management 1
For Energy and Environmental Management 1 topics include:

- Review of the current state of energy generation, distribution, and usage
- Definition of fundamental energy terms and parameters
- Codes and standards
- Energy economics and accounting
- Strategies for improving efficiency
- Energy generation technologies and systems
- Introduction to facilities (building envelope, building systems, building energy services)
- Major process equipment
- Major building systems
- HVAC equipment
- Insulation
- Lighting systems
- Indoor air quality
- Power plant management
- Public and private utilities
- Power distribution systems
- Energy consumers and consumption
- Energy auditing and accounting
- Electrical system optimization
- Waste heat recovery
- Cogeneration
- Control systems
- Thermal storage
- Renewable systems
- Environmental issues, regulations, and standards
- Environmental impact assessment
- ISO 14001
- Defining LEED
- Emergency preparedness planning.

Besides standard classroom instruction, the students go on site visits, are visited by special guest lecturers, and complete four projects. In detail, the projects are as follows:

1) Preparation of an "Energy Conservation Plan" with the following aspects: identifying opportunities, determining an action plan, calculating the savings, written report.

2) Working in a team of two students perform an actual energy audit with the following aspects: energy audit scope & plan, walk-down & information gathering, analysis, recommendations, written report.

3) Preparation of an Environmental Impact Assessment with the following aspects: identifying the environmental aspects, identifying the potential pathways, making assumptions with respect to dispersions, identifying who will be impacted, identifying the extent of the impact, written report.

4) Preparation & Presentation of an "Environmental Emergency Preparedness Plan." Assigned to a team of 2 to 4 students, the objective is to simulate teamwork during an emergency and determining priorities. Aspects include: accident scenario, short term priorities, short term actions, internal & external communication & coordination, bringing the accident under control, assessing the impact, preparing the plan and presentation.

For the projects, students are loaned typical equipment for monitoring, measuring, and assessing energy use and loss.

In addition to the projects and classroom instruction, the students complete multiple individual homework assignments and an individual technical presentation pertaining to a topic in energy or environmental management of their choosing. Presentations are 20 minutes long with a question and answer session.

With all of the topics covered, site visits, guest lectures, projects, and homework, one may wonder how all of this will fit into a single 3 credit hour course. First, many of the course topics do not need much classroom time. All of the admitted students have a degree in engineering or physical science so many topics are review or relatively easy to grasp for these students. Second, some topics are not presented in depth. The students will either learn more about a particular topic during their project work or will get more coverage in the second course. Third, a few of the site visits take place outside of allotted classroom hours. Finally, the projects are completed outside of class. We have found that all of the course objectives can be successfully met within the single semester.

Typical grading distribution of assignments is as follows: 20 min technical presentation – 10%, Energy Conservation Plan – 10%, Energy Audit – 20%, Environmental Impact Assessment – 15%, Environmental Emergency Preparedness Plan – 15%, Homework Problems – 10%, Final Exam – 20%.

The textbook is *Guide to Energy Management* by Capehart, Turner, and Kennedy.[1] Other useful textbooks are reserved in the library for the energy management students.[2, 3, 4, 5]

EGE 5323 – Energy and Environmental Management 2
Energy and Environmental Management 2 builds upon the foundation of topics, issues, and techniques established in the first course, EGE 5303. Topics include:

- Introduction to energy computer modeling simulation projects (using eQUEST®)
- Computer modeling schematic design – building envelope
- Computer modeling – building system and plant development
- Energy monitoring and base-line development utilizing regression analysis (using METRIX®)
- Energy Measurement and Verification (M&V), International Performance Measurement and Verification protocol (IPMVP)
- Energy and atmosphere – ASHRAE Energy Performance
- Outdoor air quality requirement and monitoring
- Indoor environmental quality – minimum indoor air requirement and calculation
- Environmental thermal comfort design and verification

As deduced from the topics, this second course is very practical and industry-oriented. The students ultimately complete two major projects. First they prepare a preliminary computer model energy audit and perform sample calculations for each individual energy measure. Later, they complete a team-based comprehensive detailed building computer model energy audit with a written and oral report.

In addition, each student individually chooses a technical journal article related to energy management or environmental management and presents the findings to the class.

5. Results

The CEEM graduates have contributed to a wide range of industries including development/manufacture of energy control and monitoring equipment, health care facilities (hospitals, nursing homes, and rehabilitation centers), educational organizations (elementary, secondary, universities, school districts), churches, automotive efficiency, and various facilities both large and small (business and office, commercial, industrial, and retail center).

As of the publishing of this paper, 36 students have earned the Certificate in Energy and Environmental Management. (Note that by the conclusion of the Fall 2010 Semester, 74 students had completed the EGE 5303 Energy and Environmental Management I course over the seven times it had been offered, although not all of those students were intending to complete the CEEM. In other words a few of those students were taking the CEEM-required course as a Mechanical Engineering degree elective only.) Some of the 36 students completed an earlier iteration of the requirements wherein students were required to complete only one course, but needed 18 months of experience and/or training instead of 12 months. The following results are a reflection of both sets of students.

An anonymous survey was conducted of those that have earned the CEEM. Of the 33 that had completed the CEEM by December 2010, 19 responded. While this sample size is too small to

make any firm conclusions, the survey outcomes are presented here to give the reader an idea of the results up to this point. (Note that 84.2% of the respondents were required to only take one course with the 18 months of practicum.)

First the background of the graduates was investigated. Five respondents were already working in the energy, energy management, or environmental management when they applied to the program. Of the remaining 14 students, 11 (or 57.9% of the total respondents) were seeking to change their career to energy, energy management, or environmental management when they applied to the program. Of those 11 seeking to change their career, 5 acquired a job in the energy, energy management, or environmental management field during their CEEM work or after earning their CEEM. One graduate did not have a job as of January 2011, but had two interviews within the previous two weeks. Another graduate appears to have received a job while working on the CEEM, and received a promotion upon completion.

On a scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree, the graduates were asked to rate the statement, "The CEEM prepared me for a job in energy management." The average rating was 4.05 with 68.4% agreeing and 21.1% strongly agreeing. The one graduate who disagreed explained his response in his comments. "Employers are looking for [AEE's] CEM…and did not know what the LTU CEEM was all about…." The graduate also implied that adding a co-op or internship would help.

On the same scale, graduates were asked to rate the statement, "The amount of work required to earn a CEEM was appropriate." The average rating was 3.68 with 73.7% agreeing or strongly agreeing. One of the graduates who disagreed commented that he wanted *more* hands-on work! Another graduate who agreed to the statement loved the practical experience and wanted more to supplement the coursework. The authors are encouraged to add more.

Next, the graduates were asked to complete the statement, "The level of material that we covered in the course(s) was…." On a scale of 1 to 5 with 1 being too easy and 5 being too advanced, the average rating was 2.53 with 57.9% claiming the material was "just right." The authors are aiming for a 3.0, but the relatively low rating is likely due to the fact that the CEEM students have an engineering or physical science degree and have completed calculus-level mathematics courses. Their point of reference is rather difficult courses, compared to management-type courses that require no more than basic algebra. One graduate had an intriguing/encouraging comment: "Easy enough to encourage continuation toward completion, difficult enough to learn a good portion of material, practical enough to be useful."

On a scale of 1 to 5 with 1 being strongly disagree and 5 being strongly agree, the graduates were asked to rate the statement, "I got what I wanted out of the CEEM program (in other words, the program met my expectations)." The average rating was 4.0 with 47.4% agreeing and 31.6% strongly agreeing. One graduate commuted over 140 miles (280 miles round-trip) each week and strongly agreed that he got what he wanted from the CEEM program. One graduate that disagreed was expecting more coverage of alternative energy and LEED topics.

Finally the graduates were asked "How would you rate your experience in the CEEM program?" On a scale of 1 to 5, with 1 being unsatisfactory and 5 being excellent, the average rating was 4.26 with nearly half (47.4%) rating it "excellent."

The graduates were asked to comment on what they liked about the program, what they would change, and any other comments/observations. Four of the graduates mentioned that the CEM is the industry standard, and the CEEM is having "recognition-trouble." Some community colleges and at least one university has partnered with AEE's CEM to administer the CEM exam. Moving forward, this is a consideration, but possibly the CEEM (and other alternate energy management certificates) need stronger promotion. One graduate commented that having an industry expert as the course instructor was of great benefit. Another graduate commented, "One of the most helpful aspects of the course was Excel spreadsheets that were distributed to class members by the instructor - valuable tools for the trade. I think the instruction seemed relevant because it came not from a full time teacher, but from a professional whose primary job was working in the trade for which the class was taught." A third student commented, "First, the LTU campus was amazing with the geothermal wells and the way the buildings show the pipes. Second, the teacher…was so excited about everything he shared with us and was so extremely knowledgeable. He still forwards job leads and extends his encouragement to contact him with any questions, even after the class is over. He was a window into the possibilities of a CEEM career." Five students commented on their fondness for the practical, real-world projects. Only one student noted that the environmental management material should be reduced and replaced with more energy management.

As a final note, one graduate, even though he responded that he did not acquire a job in energy after graduating, commented that he actually did get a somewhat energy-related job, but considers it more automotive in nature.

6. Conclusion

Overall, the CEEM program can be viewed as successful. While the CEEM is rigorous in nature and complete in its coverage of important topics necessary for success, competing with the long-established and highly recognized CEM from AEE continues to be a challenge. While time may overcome this challenge, pro-active measures are likely required. One graduate sent an email with the following suggestion: "My experience in the program is excellent in teaching the students what they need to know. The problem I have encountered in the working world is that it does not have enough exposure. There also needs to be better cooperation and mutual respect between CEMs and CEEMs.

"My suggestion is to try and find a grant, sponsors or resources to form a CEEM organization like other professional organizations to provide mentoring to students, continuing education for CEEMs, a jobs board, newsletters and for networking all on a web site. This might require membership dues but overall I think this would be helpful to gain further exposure about the program."

A further step, beyond the CEEM, would be a degree program. Lawrence Tech already has a Master of Science in Mechanical Engineering with an energy concentration, as well as a graduate

certificate and minor in Energy Engineering. In addition, Lawrence Tech has architectural courses in energy management and sustainability, and a new degree in Architectural Engineering. The resources are available, but the market may not be. Here is one graduates' comments:

"The CEEM program could be expanded to a Masters program in energy/environmental management/sustainable engineering, incorporating courses in alternative energy, passive solar, sustainable construction (Civil), BIM, and energy software, with track options such as hydraulics or architectural. I recommend that a proposed Masters program would be interdisciplinary in nature, including some joint engineering and architectural courses, which would be in keeping with the integrated nature of design build projects."

A good suggestion and perhaps the wave of the future for energy managers.

Acknowledgements
The authors would like to thank Jamal Aboueljoud for his outstanding commitment to teaching the courses, Michael Cooper (adjunct professor), the CEEM industry advisory board, the former and active Mechanical Engineering Department Chairs (Steve Howell, Greg Feierfeil, and Badih Jawad) for their support, and the thermal-fluids faculty that helped to develop the certificate program.

References

1. Capehart, B.L., Turner, W.C., Kennedy, W.J. 2006. Guide to Energy Management. 5th Ed. The Fairmont Press, CRC Press.
2. Thumann, A. and Mehta, D.P. 2001. *Handbook of Energy Engineering*. 5th Ed. The Fairmont Press, Marcel Dekker.
3. Thumann, A. and Younger, W.J. 2003. *Handbook of Energy Audits*. 6th Ed. The Fairmont Press, Marcel Dekker.
4. Rubin E.S. 2001. *Introduction to Engineering & The Environment*. McGraw-Hill.
5. Marriott B.B. 1997. *Environmental Impact Analysis: A Practical Guide*. McGraw-Hill.