AC 2010-1255: A GRADUATE CERTIFICATE IN EFFICIENT ENERGY TECHNOLOGY

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A GRADUATE CERTIFICATE IN EFFICIENT ENERGY TECHNOLOGY

Abstract
The paper presents the design of a graduate certificate in Efficient Energy Technology (EET) in the Engineering Technology (ET) programs. The certificate aims to prepare professionals in an area that is extremely critical for the survival of humanity and our civilization. The curriculum is designed to deal with all aspects related to source and consumption of energy. The intended audience comprise of post-baccalaureate students in Engineering Technologies and the working supervisor/manager/professional who hold baccalaureate in other technology fields. The certificate courses introduce the concepts and technology of harvesting energy from sun, wind and other alternative sources, thermoelectric, electrochemical, bio-photosynthetic and hydrogen based energy systems. The certificate consists of 12 credit hours, equivalent of four courses: 1) Solar Engineering Systems, 2) Wind and Alternative Energy Technology, 3) Energy Networking and 4) Energy Neutral Living.

Courses in the certificate can be delivered in traditional classroom/distance learning formats. Each course comprises of three components: a) content, b) critical review of current research papers and c) project. The course content consists of study of sources of energy and current methods of conversion to useful forms. In the second component, the students are required to read, and critically analyze two current research papers in the related field of renewable energy technology. In the third component, students prepare design of projects that are targeted to needs of the local community. Project design is the capstone activity involving literature search and application of multiple learned concepts and techniques. The paper will share the experiences of offering two of these courses at Purdue University Calumet.

The paper also shows that how classroom learning can be enhanced by making available to learners the classroom lecture in audio /video/pdf format from anywhere and at all times on demand. This technology, called the Lecture_on_Demand (LoD) technology, enables the distant, absent and not attentive students, the experience of the classroom environment beyond the physical classroom. Furthermore, the students can concentrate on learning and not be distracted by having to take notes in the classroom. The lecture can be made available asynchronously or broadcast synchronously on the internet. A demonstration of LoD technology can be viewed on http://ecet.calumet.purdue.edu/~jpagrawa/tech581_ses/local/lecture_on_demand_demo.wmv
I. PROGRAM OBJECTIVE

The Efficient Energy Technology (EET) certificate aims to prepare professionals in an area that is extremely critical for the survival of humanity and our civilization. The curriculum is designed to educate all aspects related to source and consumption of energy. The intended audience comprises of post-baccalaureate students in Engineering Technologies and the working supervisor/manager/professionals who hold baccalaureate in other technology fields. The certificate courses introduce the concepts and technology of harvesting energy from sun, wind and other alternative sources, thermoelectric, electrochemical, bio-photosynthetic and hydrogen based energy systems.

II. STATEMENT OF NEED

The following figure 1 sums up the justification for the proposed program of study. Energy from sun in a single year far exceeds the accumulated life-time energy content in other forms of energy from coal, oil, gas (fossil fuel) and uranium. Energy from sun is also several times more than the annual consumption of energy by mankind at the point in time. Solar radiation along with secondary solar resources such as wind, wave power, hydroelectricity and biomass accounts for most of the available renewable energy on earth. Generation of present day energy from fossil fuel and electricity are approximately 1/3rd efficient. Consumption of energy in the present day technology is also suboptimal. A great amount of effort and education is required to tackle the source-to-destination issues in energy. The proposed course aims to prepare students for the today’s as well as tomorrow’s energy technologies.

![Energy scenario](https://example.com/figure1.png)

Fig. 1 Energy scenario (courtesy Dr. Quaschning[1] for the figure).

The need for this program is supported by the long term occupational predictions in the energy related profession [1].
Employment of environmental science and protection technologists and technicians is expected to grow *much faster than the average*; these workers will be needed to help regulate waste products; to collect air, water, and soil samples for measuring levels of pollutants; to monitor compliance with environmental regulations; and to clean up contaminated sites. Over 80 percent of this growth is expected to be in professional, scientific, and technical services as environmental monitoring, management, and regulatory compliance increase.

Only 16.2% of adults in Lake County, Indiana, have obtained a BA or higher degree, compared with 19.4% for the state overall. According to the 2000 census data, only 5.5% of adults 25 or older in Lake County have attained a graduate or professional degree [1]. Compared with a 7.2% rate for graduate and professional degrees in the state, and 8.9% for the nation, the region is below both state and national averages [2]. Since the Technology Graduate program at Purdue University Calumet campus has of today a student population of more than 100 in a short span of 2 years, coupled with the high awareness about opportunities in energy sector, there is a great likelihood that the enrollment in the EET program will meet or exceed the expectation of 15-25 students per year.

The courses in the certificate may be offered as classroom based in campus, on-line or hybrid courses, or a combination. The target audience for this program comprise of holders of a baccalaureate degree in electrical, mechanical, chemical, civil and environmental engineering technologies and/or the engineering/technology supervisor/manager who holds a baccalaureate in another area. The certificate shall require 12 credit hours, taken for a letter grade.

### III. COURSES

There are four important constituents of energy sector which the educators must focus on when designing the curriculum for the certificate program in Efficient Energy Technology, as depicted in Fig. 2:

1. Sources of energy: primary and secondary
2. Conversion of energy from sources to final energy

3. Transport, storage and management of delivery network

4. Consumption (of the useful energy) Management

The primary energy is the original unprocessed form of energy such as the crude oil, coal, uranium, sunlight, wind, tidal waves etc. The final energy is the form of energy in which it reaches the end user, such as the gas, fuel, petrol, electricity, water or steam or hot air. Useful energy is the form of energy used by the end user, such as light, radiator heat, motion or vehicles.

Above constituents can be addressed in following four courses:
A. ECET 511 - Solar Energy Systems
B. ECET 521 – Wind and Alternative Energy Technology
C. ECET 531 – Energy Network
D. ECET 541 - Energy Neutral Living

The first two courses cover the topics of the sources of energy, conventional or renewable, availability, convertibility, durability of supply of energy, the conversion technology, efficiency and economics. The third course provides the technology of making a smart grid of generators, storages and consumers under the management of a networking (grid management) body. The fourth course addresses the issues of enhancing the efficiency of consumption and reduction of waste. It is needless to say that the present day efficiencies are very poor and the waste product management at both the generation and consumer side is not only poor but is neglected.

Fig. 2 Constituents of Energy Education

3.1. ECET 511 – Solar Energy Systems

3.1.1. Course Description
An introduction to energy from sun, technology and design of photovoltaic systems, solar thermal systems, solar lighting systems and solar-bio systems. The topics will also cover the energy storage using hydrogen and new advancements in the solar technology.
Course Pattern: class 3, credit 3.

3.1.2. Course Outcomes
After successfully completing this course, the student should know:
1. Why and how to harness the energy from sun.
2. Design solar cell based energy systems.
3. How to design solar to thermal conversion systems
4. How to utilize solar radiance in lighting.
5. How to store sun-derived energy.

3.1.3. Teaching Modules

Module 1: Solar Energy from Sun
Module 2: Solar Electrical (Photovoltaics)
Module 3: Solar Thermal
Module 4: Solar Lighting
Module 5: Energy Storage
Module 6: Solar Bio/Ecology Systems

3.1.4. Simulation

Uses TRYNSIS 16 which is a transient systems simulation program, capable of simulating user-specified energy systems subject to weather data and other time-dependent forcing functions. TRNSYS is highly modular. Main applications include: solar systems (solar thermal and photovoltaic systems), low energy buildings and HVAC systems, renewable energy systems, cogeneration and fuel cells. The simulation exercises in the summer offering 2009 were selected from the Trynsis simulation exercises:

1. Solar Combisystems (a demo)
2. A Simple Solar Domestic Hot Water System
3. Solar Industrial Process Heating (IPH) System
4. Swimming Pool Air Conditioning Simulation
5. Building Integrated Photovoltaics
6. Photovoltaic-Powered Solar Domestic Hot Water System
7. PV/Hydrogen System
8. Hydrogen Fuel Cell Powered Car

3.1.5. Critical Review Assignments

Students are required to read a few research papers or patents on modern technology and advancements. They are required to submit their own technical summary, analysis and critical comments. These reviews aim at challenging the students to think and have a critical aptitude of analyzing and looking for omissions by the authors and, therefore, the opportunities to do research or search topic for their term papers or end-term design projects.

Critical Review Assignment 1:

Read the paper and prepare your critical review the keeping following points in your view:

1. Is the presented material scientifically solid?
2. Did the authors miss any thing, or concept or in error?
3. Do you think, is it feasible?
4. Read one prominent reference and try to support or criticize the authors.

Critical Review Assignment 2:
Black Silicon is between 100 and 500 times more sensitive to light than standard silicon. Prepare a powerpoint presentation on "Black Silicon" technology and promise it offers for energy generation.

You may use following resources but look for more on your own:
http://www.sionyxinc.com/technology.html
Your presentation must have at least 10-15 slides.

Technical Summary Assignment3:
Read literature and articles on Internet on, “Day lighting Using Tubular Light Guide Systems”. Write a technical summary in your own words of the current state of technology, its benefits and feasibility in a short paper of not more than five pages.

3.1.6. Design Project

Design project is the corner stone of this class. This is where the students apply all the learned principles and acquire the knowledge of components and subsystems available from the various vendors in the industry. The student is required to prepare the design of a solar energy system in the neighborhood area, select components and devise the plan for execution. A written report and power-point presentation are required at the end of this course. The design projects in the summer 2009 are listed below:
1. Solar cooking involving conduction/convection/radiation or combination (three projects)
2. Solar energy from artificial/natural photosynthesis process (two projects)
3. Thermoelectric Hybrid power generation
4. Building a home solar power project
5. Minimization of energy consumption and also lower carbon footprint
6. Solar energy from thermochemical process (two projects)
7. Thermoelectric Hybrid power generation

3.1.6. Grading Distribution
Test (40%), Homework (15%), Critical Review (15%) and Design Project (30%)

3.1.7. Textbook and References
3. Solar Energy Technology Advances - G. N. Tiwari

3.2. ECET 521 – Wind and Alternative Energy Technology

3.2.1. Course Description
An overview of the major fuels and their energy content is presented. The environmental and economic consequences of using the existing mature (example fossil fuel based) energy generation technologies along with the concepts of sustainability provide the basis for the consideration of alternative energy systems. The course introduces atmospheric science and weather before bringing on the core topic of energy from wind farms. Other renewable energy sources are discussed and assessed such as the biomass and biofuels, industrial and agricultural residues and wastes, biofills, geothermal energy, tidal and ocean waves.

Wind issues discussed are the energy content of wind, the Betz limit, and the design and control of wind turbines. A brief review of organic chemistry provides students with an understanding of the bio-sources of fuel and their energy content. Methods of energy extraction from biomass sources including gasification, pyrolysis, anaerobic digestion, biogas, landfills and fermentation are discussed. The course concludes with integration of various alternative energy technologies into a system for producing a continuous uninterrupted and constant power stream.

3.2.2. Simulation and Design Project
AnemoScope \(^5\) provides a fully integrated solution, combining state-of-the-art mesoscale and microscale wind models with advanced visualization, pre/post processing, and analysis on laptop computer. AnemoScope allows users to determine ideal location to install wind turbines, incorporate localized terrain and land-use data. AnemoScope uses two advanced meteorological models—Environment Canada's MC2 and MS-Micro to calculate and predict wind flow patterns over a given landscape. The design project requires a paper design of a wind farm with complete system and component specifications. An alternative simulation software is WindFarm\(^6\).

3.2.3. Textbook and References

3.3. ECET 531 – Energy Network

Course Description
Energy must be storable and portable when production from intermittent sources, renewable or conventional, does not match energy consumption locally or in a wider
region. Energy must be delivered through a smart grid anywhere and at anytime on the need basis using standard based interfacing and interoperability. The smart grid enables energy management both on the source and load sides. In this way, the energy production can be maintained at a constant level more efficiently and at lower costs. The topics to be introduced are energy storage using batteries, hydrogen, and other methods and transportation network and load leveling techniques and fault detection and management.

3.3.1. Simulation and Design Project
Software tools will be used to simulate grid connections and energy network management strategies. The tool is not yet identified.

3.4. ECET 541 –Energy Neutral Living

Course Description
This course examines the economics and issues related to improving efficiency and minimization of waste in energy consumption in the three sectors; home, transport and communication. The topics cover the design issues and metrics of consumption, peak load, and annual use, hydrogen economy, green building, importance of integrated design, principles of orientation, thermal envelope, renewable energy systems that produce (positive), as well as mechanical, electrical and ventilation systems, innovative approaches of Green Roofs/Green Walls and Greening Cities, approaches to the design of efficient electric lighting both indoor and outdoor.
Course Pattern: class 3, credit 3.

3.4.1. Simulation and Design Project
Software tool will be used to create the environmentally optimal building designs based on building Information modeling (BIM) in a virtual environment for optimizing resource and material usage. The tool is not yet identified. A written report and power-point presentation are required at the end of this course.

IV. COURSE OFFERINGS AND EXPERIENCES

4.1. Course Offerings
The courses on Solar Energy Systems was offered and taught in the Summer 2009 semester as a graduate on-line course. The enrollment was eleven students. The Wind/Alternative Energy Course is offered in Spring 2010 as the graduate course in regular class format with an enrollment of ten students. The Energy Network course was offered as Battery Technology in Spring 2009 as the graduate course in regular class format with an enrollment of twelve students. The fourth course on Energy Neutral Living is planned to be offered in future.

4.2. Student and Faculty Feedback
Feedback was sought from students using the following questions and they were asked to provide suggestions for improvements:
1. Did you like the course on the Solar Energy Systems as a whole?
2. Did you find the course subject interesting?
3. Was the course difficult to follow?
4. Do you feel your background knowledge was sufficient for the course?
5. How you think this course would help you in future?
6. Would you have liked mathematics more or less than presented in the class?
7. Did you find student presentations useful (as a presenter and as a listener)?
8. Were the home assignments well designed and helpful in learning the subject?
9. How did you like the course delivery on the web?
10. Which part of the course you like the most?
11. Do you want more conventional mid-term tests?
12. Any suggestions making the course more alive and efficient?

Out of nine responses, five expressed satisfaction on the course contents and the assignments. They were also confident that this course has given them the necessary foundation principles and knowledge of the prevailing technology. Two students suggested visit to research industry/lab and presentation of more practical design examples. All nine students suggested to give two mid-term examinations and picking the best score. A few students complained about the grading system and requested a clearer picture about the weight of each assessed component on the final grade.

The suggestions and review by colleagues was also sought to determine the usability of the course. The colleagues were presented the course material and were also invited to peak in the web class forum discussions. Suggested questionnaire for faculty colleagues is given below:

1. How do you think this course will help the overall educational objectives of the graduate program in Technology (Engineering if you are an engineering faculty)?
2. What could be improved?
3. Do you think if this class can be brought in the undergraduate level?

Two colleagues in the Engineering Technology faculty at Purdue University Calumet provided the feedback. In summary, both expressed satisfaction that the foundation knowledge will be very helpful to the students. One of them suggested a trip to Discovery Park in West Lafayette campus of Purdue University and if possible to national labs in the Chicago area. All suggestions were adapted and will be used in future offerings.

V. LECTURE-ON-DEMAND DELIVERY

The Lecture-on-Demand (LoD)[25] is a method of connecting the instructor and learner through Web that enhances the learning experience. It offers a new paradigm in classroom instructional delivery and/or outreaching to distant and non-traditional
learners. The LoD technology is a low-cost solution and enables the instructor to assume full command of the teaching-learning process. In the LoD method, the production and delivery are all done by the instructor himself without any complicated gear and without any assistance. The instructor has flexibility of recording the lecture in a studio or in the real classroom with students in the synchronous manner or in studio or at home or elsewhere. The instructor uploads the lecture in totality (video+audio+pdf) on a website and the learners have access to it at all times and from anywhere on the synchronous and asynchronous basis. Students have access to the teaching material off the classroom for repeated viewing, and for learning on their pace. It is a great help to those who missed out in the classroom, came late or did not show at all.

Software to record the screen capture and audio, Windows Media Encoder (WME) is downloadable free for Microsoft user systems. The WME software allows selection of the quality of the video/audio recording on a wide range of resolution. The file size for optimum recoding quality is approximately 500 Kbits per minute of recording. A lecture of 75 minutes is recorded typically in a 35 Mbits file. Learners will require a high-speed broadband connection for complete download, else it may be streamed live on Internet. After the live streaming of lecture, it can be uploaded on the class website for asynchronous experience on 24x7 basis.

We normally save power-point file with annotations into a pdf file using a pdf creator in the print mode for uploading it to the class website for asynchronous viewing by students. I have also found that writing on the Tablet screen in the class or in prerecording environment, is more liked by students, because it is a gradual presentation and the material is absorbed by students in at a reasonable pace. In pre-prepared files, absorption of the subject matter is little more difficult.

VI. SUMMARY

The paper has presented the design of a graduate certificate in Efficient Energy Technology (EET). The curriculum is designed to cover all aspects from the source to destination of energy. The certificate consists of 12 credit hours, equivalent of four courses. The targeted audience comprise of post-baccalaureate students in Engineering Technologies and the working supervisor/manager/professionals who hold baccalaureate in other technology fields. These courses are intended to be offered both in the classroom instruction as well as on the distance learning basis via web-instruction. Students are at first overwhelmed by the amount of new information, but love to work through the simulation exercises. Come critical reviews and design project and they have lot of questions, but learn a great deal and enjoy while surfing for components and existing technology and practices. The distance-learning students were at first apprehensive of on-line lectures, but later they expressed satisfaction that they did not miss the classroom at all.

References:


