June 12, 2008

MEMORANDUM

TO: Herbert Rabin
    Interim Dean, A. James Clark School of Engineering

FROM: Phyllis Peres
    Associate Provost for Academic Planning and Programs

SUBJECT: Proposal to add an informal area of specialization in Sustainable Energy Engineering to the Professional Master of Engineering degree (PCC log no. 07073)

    On May 2, the Senate Committee on Programs, Curricula and Courses approved your proposal to add an informal area of specialization in Sustainable Energy Engineering to the Professional Master of Engineering degree. A copy of the approved proposal is attached.

    The approval is effective immediately. The Clark School should ensure that the change is described in the Graduate Catalog and in all relevant descriptive materials, and that all advisors are informed.

CWR/

Enclosures

cc: Carmen Balthrop, Chair, Senate PCC Committee
    Sarah Bauder, Office of Student Financial Aid
    Reka Montfort, University Senate
    Barbara Hope, Data Administration
    Denise Nadasen, Institutional Research & Planning
    Anne Turkos, Archives
    Linda Yokoi, Office of the Registrar
    Mary Ann Ottinger, Graduate School
    Gary Pertmer, A. James Clark School of Engineering
    George Syrmos, Office of Advanced Engineering Education
    Paul Easterling, Office of Advanced Engineering Education
THE UNIVERSITY OF MARYLAND, COLLEGE PARK
PROGRAM/CURRICULUM PROPOSAL

DIRECTIONS:
- Provide one form with original approval signatures in lines 1 - 4 for each proposed action. Keep this form to one page in length.
- Early consultation with the Office of the Associate Provost for Academic Planning & Programs is strongly recommended if there are questions or concerns, particularly with new programs.
- Please submit the signed form to Claudia Zecior, Office of the Associate Provost for Academic Planning and Programs, 1119 Main Administration Building, Campus.
- Please email the rest of the proposal as an MSWord attachment to pcc-submissions@umd.edu.

DATE SUBMITTED 03/25/08
PCC LOG NO. 07073

COLLEGE/SCHOOL ENGR

DEPARTMENT/PROGRAM OAEE

PROPOSED ACTION (A separate form for each) ADD X DELETE ____ CHANGE ____

DESCRIPTION (Provide a succinct account of the proposed action. Details should be provided in an attachment. Provide old and new sample programs for curriculum changes.)

Creation of an academic option in Sustainable Energy Engineering to the existing Professional Master of Engineering program through the Office of Advanced Engineering Education.

Creation of an on-line option in Sustainable Energy Engineering to the existing Professional Master of Engineering program through the Office of Advanced Engineering Education.

JUSTIFICATION/REASONS/RESOURCES (Briefly explain the reason for the proposed action. Identify the source of new resources that may be required. Details should be provided in an attachment.)

See attached.

APPROVAL SIGNATURES - Please print name, sign, and date

1. Department Committee Chair GEORGE SYMES 3-25-08
2. Department Chair GEORGE SYMES 3-25-08
3. College/School PCC Chair K. WERELEY 3-25-08
4. Dean SAHIN 4/10/08
5. Dean of the Graduate School (if required) CHEN 6/12/08
6. Chair, Senate PCC ALHABA 6/12/08
7. Chair of Senate
8. Vice President for Academic Affairs & Provost
Proposal for approving an academic option in Sustainable Energy Engineering to the existing Professional Master of Engineering program and an on-line option in Sustainable Energy Engineering to the existing Professional Master of Engineering program through the Office of Advanced Engineering Education

Sustainable Energy Engineering (SEE) will be a new academic option in the Professional Master of Engineering (ENPM) program that combines curriculum from Mechanical Engineering, Chemical and Biomolecular Engineering, Nuclear Engineering, Reliability Engineering, and Systems Engineering within the Clark School. The curriculum as laid out below will consist of six core courses and four elective courses. The student will select from three elective sets, whichever fits his/her needs, and will take courses from that elective set with the approval of his/her academic advisor. Drawing upon the Clark School’s strengths in energy engineering through UMERC (University of Maryland Energy Research Center), we will be able to offer working engineers and technical professionals access to the coursework and faculty at the forefront of energy science and technology.

The high interest in SEE locally and the lack of an equivalent option available from other top engineering schools nationwide necessitate offering SEE on-line nationally and internationally. In its on-campus form, a student is awarded the Master of Engineering degree in the SEE option after having completed ten 3-credit courses via our Distance Education Technology and Services (DETS) office in the Clark School of Engineering. Many of the courses needed to complete the degree program have already been recorded and we expect to have the additional courses web-cast in the near future.

Therefore, we propose an on-line option to the existing Professional Master of Engineering program in Sustainable Energy Engineering (MEEE) leading to a Master of Engineering degree. The faculty who teach for the on-campus program will also teach for the on-line program. The standards of good practice observed for the on-campus program will apply equally to the on-line version. In particular, faculty support and resources for learning will be provided by the DETS office to our on-line students.

Like all of the academic options offered through OAEE, the campus-based and on-line SEE options will be administered through OAEE, making sure that the necessary student services are provided. All content will be provided by the participating academic units making sure that both commitment to support the programs and academic excellence are in place. Evaluation and assessment of the programs will be performed by both the participating academic units and OAEE, and their delivery through the DETS office will ensure a state-of-the-art accessibility of the associated courses.
Master of Engineering in Sustainable Energy Engineering

Curriculum
Consist of six core courses with different elective sets developed to allow the student to focus on their individual needs.

SPECIALIZATION CORE (6 courses)
ENPM 624 Renewable Energy Applications (3) Prerequisite: undergraduate thermodynamics and undergraduate heat transfer. Thermodynamics and heat transfer analysis of renewable energy sources for heating, power generation and transportation. Wind energy, solar thermal, photovoltaic, biomass, waste burning and OTEC. Broad overview of the growing use of renewable energy sources in the world economy with detailed analysis of specific applications. (Treado)

ENME 706 Impact of Energy Conversion and the Environment (3)
This course begins with a review of the energy flow diagram of the US and discusses the current status of energy production, transportation and consumption. This is followed by an introduction to environmental issues that are caused through energy conversion: Ozone depletion, global warming and air quality issues. Based on this background information, the students then develop, through classroom discussions, student presentations and lectures, alternative energy conversion concepts, assess their performance in design projects, and evaluate the potential environmental, infrastructure and cost impacts. The course focuses extensively and in considerable detail on the understanding and application of the latest energy conversion technologies. The objective of the course is to a) provide understanding of conventional and sustainable energy production and utilization and b) to identify areas where research and development is needed to move the world toward a sustainable energy future. This course reviews the major sources and end-uses of energy in our current society as well as treating the sources and end-uses that are expected to become important in the near term. Renewable energy sources will be highlighted with a focus on projections for a sustainable energy future. The course will provide an overview of the major energy flows and the issues associated with production and end-use. Major current sources of energy include fossil fuel, hydroelectric, nuclear power, and wind energy. Major end-use categories include industrial uses, transportation and buildings. The course will introduce a range of innovative technologies and put them in the context of the current energy infrastructure. These will include fuel cells, hybrid cars, advanced nuclear reactor designs, combined cycle power plants, photovoltaics and other current topics. Attention will also be devoted to societal and regulatory aspects of energy production and use. (Jackson, Radermacher)

ENPM 622 Modern Power Generation I - Stationary Power Applications (3) Prerequisite: undergraduate thermodynamics and heat transfer. Thermal engineering of modern power generation systems. Cycle analysis of various modern power generation technologies including gas turbine, combined cycle, waste burning, and cogeneration. Energy storage and energy transport. (Keating)

ENPM 808G Modern Power Generation II - Mobility Applications (3) This course presents the scientific and engineering basis for design, manufacture, and operation of thermal conversion technologies utilized for mobility power generation. The interface between fuel combustion chemistry and generated power are addressed. The practical aspects of design and operation of various alternatives for power are compared. The impact of choices with regard to power and fuel alternatives as well as air pollution potential is also considered. (Keating)

ENCH 808/ENPM 808 Advanced Fuel Cells and Batteries (3) (NEW COURSE)
Reducing or eliminating the dependency on petroleum is a major element of US energy research activities. Batteries are a key technology for todays and tomorrow’s electronic devices and electrical hybrid vehicle. Fuel cells are a key element in a future hydrogen economy, offering the potential to revolutionize current power technologies and to solve the major energy security and environmental challenges that face America today. Fuel cells and batteries are in massive and rapidly growing demand as the power source for stationary systems, portable devices and electric vehicles. Fuel cells and batteries are efficient, vibration free, noiseless, environmentally friendly alternatives to conventional energy sources. The lecture will start from the basic electrochemical thermodynamics and kinetics, with emphasis on electrochemical techniques, fundamental principle of batteries and fuel cells, mass transport processes and performance of various battery and fuel cell technologies. Fuel cell and battery design, system integration, synthesis of electrode materials and catalysts will
be presented. A survey of the cutting-edge technologies for fuel cells and batteries will also be discussed. Students will have an opportunity to tour the Fuel Cell and Battery Lab in Chemistry Building. (Wang)

**ENCH 808/ENPM 808 Photovoltaics: Solar Energy (3)** (NEW COURSE)
The total usable solar energy flux at the Earth's surface is by some estimates more than enough to meet current world energy needs. However, harnessing this source in a fashion that is economically competitive with other sources of energy presents many challenges. This course will emphasize the following topics: basic physics of light/material interactions, recent laboratory scale developments in photovoltaic and photoelectrochemical technologies, manufacturing of photovoltaic materials, and photovoltaic systems design and integration with existing power generation/distribution infrastructure. Additional topics to be covered include solar heating, solar thermal power generation and photoelectrochemical hydrogen generation. Upon completion of the class students will be able to calculate electrical power, thermal power, or hydrogen production rates, at the device scale. At the systems level, students will be able to use thermodynamic efficiency to perform an economics based comparison, and will also be able to assess system reliability and perform a lifecycle analysis on the system. (Adomaitis, Ehrman)

**NUCLEAR Elective Set (4 courses)**

**ENNU 450 Nuclear Reactor Engineering I (3)**
Elementary nuclear physics, reactor theory, and reactor energy transfer. Steady-state and time-dependent neutron distributions in space and energy. Conduction and convective heat transfer in nuclear reactor systems.

**ENNU 455 Nuclear Reactor Engineering II (3)**
General plant design considerations including radiation hazards and health physics, shielding design, nuclear power economics, radiation effects on reactor materials, and various types of nuclear reactor systems.

**ENNU 465 Nuclear Reactor Systems Analysis (3)**
Power reactor (BWR, PWR, HTGR) system design and analysis. System specifications and modes of operation. Plant documentation (PSAR, FSAR, etc.). Piping and instrumentation drawings. Theory and application of pump and piping calculations. Steam power plant cycles and calculations. Steam plant equipment (turbines, heaters, condensers, etc.) analysis.

**ENNU 480 Reactor Core Design (3)**
Design of nuclear reactor cores based on a sequence of standard computer codes. Thermal and epithermal cross sections, multigroup diffusion theory in one and two dimensions and fine structure flux calculations using transport theory.

**ENNU 485 Nuclear Reactor Thermalhydraulics (3)**

**ENNU 490 Nuclear Fuel and Power Management (3)**
Physics and economics of the nuclear fuel cycle utilizing existing design codes. Mining, conversion, enrichment, fabrication, reprocessing processes. Effects of plutonium recycle, in-core shuffling, fuel mechanical design and power peaking on fuel cycle costs.

**ENNU 605 Radiation Sciences (3)**
Nuclear structure and radioactivity; ionizing and non-ionizing radiation; energy deposition and radiation dose; radiation interactions; sources of radiation; radiation chemistry; applications of radiation - accelerators, activation analysis, industrial and medical uses; radiotio radiation processing and manufacturing.

**ENNU 610 Radiation Transport (3)**
Characterization of radiation fields and sources; radiation interactions; photon and neutron response functions; deterministic transport theory - the transport equation, approximations, discrete ordinates, integral transport method; Monte Carlo methods - stochastic variables, simple analog Monte Carlo calculation, variance reduction methods, non-analog methods.

**ENNU 648H Special Problems in Nuclear Engineering: Advanced Nuclear Physics and Engineering (3)**
Nuclear physics, reactor theory, and reactor energy transfer. Steady-state and time dependent neutron distributions in space and energy, Elementary single and two phase flow, principles of reactor safety.

**ENNU 655 Radiation Engineering (3)**
Prerequisite: permission of both department and instructor.
An analysis of such radiation applications as synthesizing chemicals, preserving foods, control of industrial processes, design of irradiation installations. E.G., Cobalt 60 gamma ray sources, electronuclear machine arrangement, and chemonuclear reactors.

**ENERGY SYSTEMS Elective Set (4 courses)**

**ENPM 641 Systems Engineering Principles (3)**
Prerequisite: permission of department.

**ENPM 642 System Modeling and Analysis (3)**
Prerequisite: ENPM 641 and permission of department. Basic system types are defined and fundamental concepts, such as system state,
inputs, outputs and disturbances are discussed. Modeling methods and computer-aided systems engineering (CASE) formal structures and computer-aided systems engineering (CASE) tools for solving practical systems related problems. Quantitative techniques are presented and applied, including Petri nets, basic probabilistic and stochastic tools, Markov processes, queuing theory, simulation, and the fundamentals of decision and risk analysis.

**ENME 635 Energy Systems Analysis**
The course discusses Rankin cycles from traditional power plants to move, two-, multi-stage absorption cycles and vapor compression cycles with pure and mixed working fluids and gas turbine cycles. Student projects are designed to foster the understanding of opportunities and challenges in energy system integration focusing predominantly on conventional and well-established energy conversion technologies. (Radermacher)

**ENPM 654 Energy Systems Management (3)** Covers the application of energy efficient technologies, analysis procedures and implementation techniques, including lighting, motors, energy conservation and demand side management. The course will cover the latest innovation in energy efficient equipment and applications, primarily in the buildings and industrial areas. Topics will include both new installations and retrofit activities, with emphasis on methods for evaluating the energy and cost savings potential of different design options or equipment alternatives.

**ENPM 623 Control of Combustion Generated Air Pollution (3)** Analysis of the sources and mechanisms of combustion generated air pollution. Air pollution due to internal combustion engines, power generation and industrial emissions. Techniques to minimize and control emissions. Acid rain, ozone, plume analysis, scrubbing, filtering.

**ENPM 627 Environmental Risk Analysis (3)** The fundamental methodology for analyzing environmental risk is described with examples for selected applications. Key elements of the environmental risk methodology include: (1) source term and release characterization, (2) migration of contaminants in various media, (3) exposure assessment, (4) dose-response evaluation, (5) risk characterization, and (6) risk management. Also included will be an introduction to uncertainty analysis and environmental laws and regulations. This course intends to provide students with the basic skills and knowledge needed to manage, evaluate, or perform environmental risk assessments and risk analysis.

**ENPM 635 Design and Analysis of Thermal Systems (3)** Prerequisites: Undergraduate thermodynamics and heat transfer. The focus of this course deals with the numerical evaluation of the inevitable trade-offs associated with any thermodynamic or heat transfer system. A distinction will be made between workable and optimal systems. For workable systems problems, several laborious manual solutions will be required to ensure that the physics of the system and solution techniques are well understood. A primary analytical tool that will be used for system simulation and evaluation will be an engineering equation solver (EES) program. Although no computer language will be required for simulations, prior experience with windows and spreadsheets will be helpful. Optimal system analysis will include one calculus method and one search method. Applications will include power and refrigeration systems, electronics cooling, distillation columns, dehumidifying coils, and co-generation systems. Student performance will be based largely on manual and computer based take-home problems, some of which will include system performance modeling.

**ENPM 651 Heat Transfer for Modern Applications (3)** Prerequisite: ENPM 635 or equivalent. Advanced course in heat transfer application analysis. Extends the introductory treatment by utilizing fundamental relationships to obtain numerical solutions to real-world applications. Course will include the full range of thermal system analysis but will focus largely on heat transfer aspects.

**ENPM 808K Applied Thermodynamics (3)** The course focuses on an analytical system performance technique known as Availability or Exergy Analysis, which is based on the 2nd Law of Thermodynamics. It focuses on traditional power and refrigeration systems. Non-traditional power generation systems are considered by way of a special project of each student's choice. It will include an engineering description of the state-of-the art of the selected topic (e.g., wind or solar power, fuel cell, etc.) and a second law performance analysis of a prototype system which will be presented to the class. In addition to the power system topics, the availability analysis will be applied to combustion and psychrometric processes.

**ENERGY RELIABILITY Elective Set (4 courses)**

**ENRE 445/446 Applied Reliability Engineering I&II**
Combined course including: fundamental understanding of how things fail, probabilistic models to represent failure phenomena, life-models for non-repairable items, reliability data collection and analysis and applicable quality techniques. Distribution functions such as the normal, Weibull, exponential, binomial, and gamma are explored. System modeling and analysis, designing for reliability, reliability testing, reliability in manufacturing, and reliability management. Fault tree analysis, RBD, and cut sets are covered along with sneak circuits, time-on-test plots and acceptance testing.

**ENRE 602 Reliability Analysis**
Principal methods of reliability analysis, including fault tree and reliability block diagrams; Failure Mode and Effects Analysis (FMEA); event tree construction and evaluation; reliability data collection and analysis; methods of modeling systems for reliability analysis. Focus on problems related to
process industries, fossil-fueled power plant availability, and other systems of concern to engineers. (Modarres, Mosleh)

**ENRE 620 Mathematical Techniques for Engineers**
Basic probability and statistics. Application of selected mathematical techniques to the analysis and solution of reliability engineering problems. Applications of matrices, vectors, tensors, differential equations, integral transforms, and probability methods to a wide range of engineering problems. (Bernard, Modarres, Smidts)

**ENRE 670 Risk Assessment for Engineers**
Why study risk, sources of risk, probabilistic risk assessment procedure, factors affecting risk acceptance, statistical risk acceptance analysis, psychometric risk of lately a new loan the more you do you of him and him who me in the you really want new in the end of on of the the design to the mom to acceptance, perception of risk, comparison or risks, consequence analysis, risk benefit assessment. Risk analysis performed for light water reactors, chemical industry, and dams. Class projects on risk management concepts. (Mosleh, Modarres)