ENERGY AND MINERAL ENGINEERING (EME)

EME 501: Design Under Uncertainty in Energy and Mineral Systems

3 Credits

This class is designed to present a broad range of tools for evaluating energy projects, technologies, and systems. Topics will include project evaluation methods (NPV, discounting), tools for decision/design under uncertainty (Monte Carlo simulation, decision trees, lattices, real options), optimization (linear programming, stochastic programming), and economics/markets/regulation (review of microeconomics, market failures, regulation, and market design). Students will focus both on the intuition and appropriate application of the various methods and theories.

EME 504: Foundations in Sustainability Systems

3 Credits

Theoretical background of sustainability issues and studies of sustainability systems.

EME 510: Health and Safety Engineering

3 Credits

Develop the ability to use scientific and engineering principles to evaluate and control health and safety hazards in the workplace.

EME 511: Interfacial Phenomena in Energy and Mineral Systems

3 Credits

The boundary between two phases, the interface between the phases (referred to as the "interface") has very different properties from that of the bulk phase and such interfaces are important in a variety of energy, chemical, and mineral engineering processes. The interface may control transport between the phases, e.g., liquid-liquid extraction, reaction at the interface, e.g., heterogeneous catalysis, or accumulation of a component from one of the bulk phases, e.g., adsorption. All of these are examples of interfacial phenomena relevant to energy conversion, mineral extraction, and oil recovery processes. Course topics are drawn from physical and interfacial chemistry to address engineering and applied science needs in fuel science, fossil fuel recovery, renewable fuel processing, mineral processing, environmental science, and health. Topics include interfacial forces, phase behavior, adsorption/desorption, reaction kinetics, and solution chemistry. The applications of these subjects in various fields such as reservoir engineering, fuel science, mineral separations, reacting flows, and water systems will also be covered.

EME 521: Mathematical Modeling of Energy and Mineral Systems

3 Credits

This class develops the understanding of methods of modeling used for important physical and chemical phenomena involved in energy and mineral engineering systems. These include both separate and mixed solid (solid mechanics) and fluid (computational fluid mechanics) systems, including reactive components. The emphasis is on finite element methods but also includes other continuum methods (LBM, SPH), integral methods, and discontinuum methods. Students will develop working programming modules of simple-through-complex models of interactive physical systems and research materials on some form of computational methods.

Prerequisite: EGEE 510

EME 522: Computational Methods for Electric Power Systems Analysis

3 Credits

This course covers the formulation of and solution methods for a full range of economic-engineering investment and operations problems for electric power systems. Application problems include economic dispatch, unit commitment, optimal power flow, generation capacity expansion, transmission expansion, and modeling of competitive electricity markets. Solution methods include linear programming, mixed integer programming, decomposition methods for stochastic programming (e.g., Lagrangian Relaxation, Benders Decomposition), and mixed complementarity problems, with an emphasis on numerical implementation.

RECOMMENDED PREPARATIONS: It is recommended that students be familiar with or have taken EME 501, IE 505, or an equivalent graduate-level course in math programming.

EME 523: Stochastic Optimization Methods of Energy and Environmental Systems

3 Credits

This course covers the theory and implementation of computational methods for stochastic simulation and stochastic optimization, with an emphasis on algorithms and implementation. The course emphasizes the quantitative analysis or numerical modeling of complex systems in fields such as civil, environmental, energy, mechanical, and industrial engineering or energy, environmental, and natural resource economics. Topics include Monte Carlo simulation, quasi-random and pseudo-random sampling methods, Markov Chains, Dynamic Programming, Approximate Dynamic Programming, and Stochastic Programming decomposition techniques.

RECOMMENDED PREPARATIONS: It is recommended that students be familiar with or have taken EME 501, IE 505, or an equivalent graduate-level course in math programming.

EME 524: Machine Learning for Energy and Mineral Engineering Problems

3 Credits

This course provides an overview of the application of machine learning algorithms to problems in energy and mineral engineering. The course addresses the strengths and weaknesses of various machine learning approaches, as well as appropriate testing and validation techniques for these complex models. Topics include machine learning applications in regression, classification, design optimization, and risk analysis. An emphasis of this course is for students to apply these methods to specific research problems of interest. Students with some background in statistics, but no previous formal training in machine learning algorithms will find this course most useful.

RECOMMENDED PREPARATIONS: Students are recommended to have had some previous basic training in statistics and experience with at least one programming language.

EME 525: Theory and Practice of Policy Analysis for Engineers

3 Credits

The course provides a broad introduction to analytical methods commonly used in science, technology, and energy policy analysis.

EME 526: Solar Utility and Portfolio Management

3 Credits

EME 526 covers the theoretical frameworks and quantitative methods for evaluating and designing solar resource projects. Methods will include quantitative solar resource measurement, forecasting, uncertainty quantification, dynamical systems modeling, and game theoretic models. Students will compare and assess alternative theoretical and quantitative approaches in terms of their ability to address a range of important objectives, including economic, technical constraints, robustness to uncertainty, varying risk preferences of stakeholders, and other ethical and cultural considerations. The course utilizes data sets and modeling resources drawn from actual case studies to provide students context in which to apply and evaluate the methods.

EME 527: Stochastic Modeling of Spatial Variability in Energy and Environmental Systems

3 Credits

This course covers the theory, methods, and implementation of modeling spatial variability and uncertainty with special consideration of the structure of energy, natural resource, and environmental system models. The course draws heavily upon geostatistical methods, and covers random functions, Semivariograms, Kriging, spatial simulation, and data assimilation into spatial simulation models.

EME 531: Thermodynamics of Energy and Mineral Systems

3 Credits

This course presents linear and non-linear irreversible thermodynamics as a means to explore the coupling between physicochemical, kinetic, and transport processes. Linear irreversible thermodynamics will be illustrated by well-known and practical phenomena such as Seebeck effect (thermocouple), Peltier effect (dehumidifier), Soret effect (thermal diffusion), etc. Non-linear irreversible thermodynamics will be used for demonstrating the phenomena of bifurcation, self-organization, and dissipative structures that take place in nature and human society. The self-organizing economy will also be discussed to show how the far-from-equilibrium thermodynamics can be applied to some economic phenomena.

EME 541: Electrochemical Science and Engineering Fundamentals

3 Credits

Fundamentals of electrochemical science and engineering based on electrochemical thermodynamics and kinetics. EME 541 Electrochemical Science and Engineering Fundamentals (3) The course focuses on the fundamental concepts of electrochemical science and engineering based on thermodynamics and kinetics. The course provides a synopsis of a variety of electrochemical systems and processes and shows their applicability for a number of industrial applications.

EME 551: Safety, Health and Environmental Risks in Energy and Mineral Production

3 Credits

In the energy and minerals sector, safety, health, and environmental concerns have increased in importance to engineering, operations, and applied research. Contemporary experience has demonstrated that the integration of these priorities into the conceptualization, development, and management of energy and mineral technologies is essential. This course will begin with a few case studies of high-profile disasters to foster a broad understanding of the similar managerial, organizational, behavioral, and technical factors that led to these disasters. The balance of the course will be devoted to study of effective approaches to analyzing, mitigating, and managing risk (qualitative and quantitative), behavioral/psychological dimensions (e.g., cognitive workload and risk biases), and the application and validation of interventions to achieve goals. The intent of this course is to give students an understanding of the challenges and successful approaches that should be part of every project and operation.

EME 570: Catalytic Materials

3 Credits

Preparation and characterization of solid catalytic materials and the relationships between their surface, defect, and electronic properties and catalytic activity. MATSE (EME) 570 Catalytic Materials (3)This course covers the preparation and characterization of solid catalytic materials, and the relationships between the surface and electronic properties and pore structure of the materials and their catalytic activity and selectivity. The course includes the following materials: zeolites and molecular sieves; metals and alloys; metal oxides; metal sulfides; and other catalytic materials. Also included are the major applications of catalytic materials in chemical and petroleum industries and in other manufacturing industries for environmental protection. This course can be grouped into three parts: (1) introduction to catalysis and analytical techniques; (2) synthesis and characterization of catalytic materials; and (3) catalysis at surfaces of solid materials. The course is suitable for a broad spectrum of students in energy and mineral engineering, materials science and engineering, fuel science, chemical engineering, chemistry, solid -state science, and environmental engineering.

Prerequisite: CHEM 452 or similar course in chemical, materials or energy sciences and engineering
Cross-listed with: MATSE 570

EME 580: Interdisciplinary Team Project in EME Systems

3 Credits

Problem-based, integrative, and collaborative learning to solve interdisciplinary problems on energy and mineral systems based on engineering and business principles. EME 580 Integrative Design of EME Systems (3) The role of energy and minerals in society is increasingly important with increasing environmental constraints, transitioning energy policies, supply disruption, and international pressure on climate change compliance and competition for energy. Both conventional (fossil fuels) and renewable energy sources are being explored. This course will enable energy and mineral engineering students to collaboratively integrate their knowledge and experiences in addressing common problems. The typical problems will address issues with the production, processing and utilization of fossil and renewable energy and the associated environmental, health and safety, and business management issues.

Students will utilize their engineering and business principles to optimally recover, process and utilize conventional and unconventional energy in an environmentally friendly, safe and economical manner. Complete problem solutions must include a synthesis of methods to identify, recover, transport, and utilize the energy source. A quantitative approach, including mechanistic, thermodynamic, fluid flow, and kinetic analysis of proposed options must be considered, together with a preliminary economic analysis.

Prerequisite: EME 500

EME 581: Research and Geostatistics Methods

3 Credits

Presents methods essential for the conduct and analysis of scientific research and spatial characterization in energy and mineral engineering disciplines.

EME 590: Colloquium

1-3 Credits/Maximum of 3

Continuing seminars that consist of individual lectures by faculty, students or outside speakers on energy and mineral engineering issues.

Cross-listed with: PNG 590

EME 596: Individual Studies

1-9 Credits/Maximum of 12

Creative projects, including nonthesis research, that are supervised on an individual basis and which fall outside the scope of formal courses.

EME 597: Special Topics

1-9 Credits/Maximum of 12

Formal courses given on a topical or special interest subject which may be offered infrequently.

EME 597B: Geomechanics

2 Credits

Discussion of current and foundational research contributions in Geomechanics including ongoing work by current students

EME 597C: Creating University/Industry Collaboration

2 Credits

This course will provide students hands-on experience designing research programs to address external market needs that will lead to enhanced Penn State / external collaboration. Classroom lectures will cover topics important for design a new technology program.

EME 600: Thesis Research

1-15 Credits/Maximum of 999

Thesis research culminating into the doctoral degree in Energy and Mineral Engineering.

EME 601: Thesis Preparation

0 Credits/Maximum of 999

Thesis research after successful comprehensive exam culminating into the doctoral degree in Energy and Minerl Engineering.

EME 801: Energy Markets, Policy, and Regulation

3 Credits

Structure and function of energy markets; existing and emerging environmental regulations; decision-making by energy companies.

EME 802: Renewable and Sustainable Energy Systems

3 Credits

An overview of renewable energy technologies and sustainable energy system analysis.

EME 803: Applied Energy Policy

3 Credits

Provides in-depth exploration of energy policy development, implementation, and assessment at multiple governmental and corporate scales with emphasis on energy markets.

EME 805: Renewable Energy and Nonmarket Enterprise

3 Credits

Industry perspective on the resources, technologies, engineering approaches and externalities involved in deploying renewable energy businesses profitably and sustainably.

EME 807: Technologies for Sustainability Systems

3 Credits

This course examines strategies and applications of sustainable technologies in manufacturing, energy, water, transportation, food, and building systems.

EME 810: Solar Resource Assessment and Economics

3 Credits

Methods, economic criteria, and meteorological background for assessing the solar resource with respect to solar energy conversion technologies.

EME 811: Solar Thermal Energy for Utilities and Industry

3 Credits

Applications of solar thermal energy (STE) including district heating/cooling (buildings), industrial process heating, fuel synthesis, desalination, and materials processing.

Prerequisite: EME 810

EME 812: Utility Solar Power and Concentration

3 Credits

Technical and theoretical background for utility scale solar energy conversion technologies to generate electric power.

Prerequisite: EME 810