Rutgers University, Department of Electrical and Computer Engineering

COURSE SYLLABUS

14:332:402 Sustainable Energy: choosing among options
Prof. Paul Panayotatos

The course is comprised of three parts:

- An introductory part that provides “just in time” analysis tools such as energy formulas and physics, engineering economics, thermodynamics and sociopolitical analysis tools.
- A section of analysis of all the major non-renewable sources and
- A section of analysis of all the major renewable sources.

Pre-Requisite and Co-Requisite Courses: None. This course is multi-disciplinary, but a maturity level in science and engineering is necessary.

Pre-Requisite by Topic: None beyond senior level standing in any SOE department

Textbook & Materials:

- Power Point presentation handouts and lecture notes

References:

- Internet resources to which students will be directed by the instructor such as the sites of, The World Bank, the Energy Information Administration, the World Research Institute, the Intergovernmental Panel on Climate Change etc.
- If smart classroom is available, in-class internet searches for fast-changing technological and policy aspects relating to the material.

Overall Educational Objective: To demonstrate multi-disciplinary strategic thinking in a sustainable development context taking into account diverse constraints

Course Learning Outcomes: A student who successfully completes this course will
1. Understand the desirability of establishing sustainability in the context of energy generation
2. Appreciate the complexity of the problem and the interactions between the various components of the global ecosystem
3. Understand the tradeoffs between environmental impact, resource depletion and economic development
4. Understand the technical basics of each of the major non-renewable and renewable sources of energy.
5. Understand the extent of the environmental impact and resource depletion of each of the major non-renewable and renewable sources of energy.
6. Be able to apply this knowledge in gauging different options for specific scenarios.

How Course Outcomes are Assessed:

Homework (20%)
Mid-Term Exam (30%)
Final Exam (50%)

N = none    S = Supportive    H = highly related

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<tr>
<th>Outcome</th>
<th>Level</th>
<th>Proficiency assessed by</th>
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<tbody>
<tr>
<td>(a) an ability to apply knowledge of Mathematics, science, and engineering</td>
<td>S</td>
<td>HW Problems, Exams, Lecture Discussion</td>
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<td>(b) an ability to design and conduct experiments and interpret data</td>
<td>N</td>
<td></td>
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<tr>
<td>(c) an ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability</td>
<td>H</td>
<td>HW Problems, Exams, Lecture Discussion</td>
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<td>(d) an ability to function as part of a multi-disciplinary team</td>
<td>H</td>
<td>Multidisciplinary student body: Lecture Discussions</td>
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<td>(e) an ability to identify, formulate, and solve ECE problems</td>
<td>S</td>
<td>HW Problems, Exams, Lecture Discussion</td>
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<td>(f) an understanding of professional and ethical responsibility</td>
<td>H</td>
<td>HW Problems, Exams, Lecture Discussion</td>
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<td>(g) an ability to communicate in written and oral form</td>
<td>H</td>
<td>HW Problems, Lecture Discussion</td>
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<td>(h) the broad education necessary to understand the impact of electrical and computer engineering solutions in a global, economic, environmental, and societal context</td>
<td>H</td>
<td>HW Problems, Exams, Lecture Discussion</td>
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<td>(i) a recognition of the need for, and an ability to engage in life-long learning</td>
<td>H</td>
<td>Home-work, discussions during lectures</td>
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<td>(j) a knowledge of contemporary issues</td>
<td>H</td>
<td>HW Problems, Exams, Lecture Discussion</td>
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<td>(k) an ability to use the techniques, skills, and modern engineering tools necessary for electrical and computer engineering practice</td>
<td>S</td>
<td>HW Problems, Exams</td>
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<tr>
<td>Basic disciplines in Electrical Engineering</td>
<td>S</td>
<td>HW Problems, Exams</td>
</tr>
<tr>
<td>Depth in Electrical Engineering</td>
<td>N</td>
<td></td>
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<tr>
<td>Basic disciplines in Computer Engineering</td>
<td>N</td>
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<tr>
<td>Depth in Computer Engineering</td>
<td>N</td>
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<tr>
<td>Laboratory equipment and software tools</td>
<td>N</td>
<td></td>
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<tr>
<td>Variety of instruction formats</td>
<td>H</td>
<td>Lecture, office hour discussions, use of internet resources; if in smart-classroom also in-class internet searches</td>
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Topics Covered week by week:

Lectures 1&2: Introduction
Sustainable Energy; Defining Energy-Scientific and Engineering Foundations; Aspects of Energy Production and Consumption; National and Global Patterns of Energy Supply and Utilization; Environmental Effects of Energy; Confronting the Energy-Prosperity-Environmental Dilemma; Mathematical Representations of Sustainability

Lecture 3: Estimation and Evaluation of Energy Resources
Units of Measurement, Energy and Power; Comparison of Different Forms of Energy; The Energy Lifecycle; Estimation and Valuation of Fossil Mineral Fuels, Especially Petroleum; Lessons for Sustainable Development

Lectures 4 & 5: Technical Performance: Allowability, Efficiency, Production Rates
Relation to Sustainability; An Introduction to Methods of Thermodynamic Analysis; The Importance of Rate Processes in Energy Conversion; Chemical Rate Processes; The Physical Transport of Heat; Use and Abuse of Time Scales; Energy Resources and Energy Conversion

Lectures 6-8: Local, Regional, and Global Environmental Effects of Energy
How Energy Systems Interact with the Environment; Adverse Environmental Effects Over Local and Regional Length Scales; Global Climate Change: Environmental Consequences over Planetary-Length Scales; Attribution of Environmental Damage to Energy Utilization; Methods of Environmental Protection; Environmental Benefits of Energy; Implications for Sustainable Energy

Lectures 9 & 10: Project Economic Evaluation
Introduction; Time Value of Money Mechanics; Current versus Constant-Dollar Comparisons; Simple Payback; Economy of Scale and Learning Curve; Allowing for Uncertainty; Accounting for Externalities; Energy Accounting; Modeling Beyond the Project Level

Lecture 11: Energy Systems and Sustainability Metrics
Introduction and Historical Notes; Energy from a Systems Perspective; Systems Analysis Approaches; Measures of Sustainability; Drivers of Societal Change; Some General Principles of Sustainable Development

Lectures 12 &13: Fossil Fuels and Fossil Energy
Introduction; The Fossil Fuel Resource Base; Harvesting Energy and Energy Products from Fossil Fuels; Environmental Impacts; Economics of Fossil Energy; Some Principles for Evaluating Fossil and Other Energy Technology Options; Emerging Technologies; Why Are Fossil Fuels Important to Sustainable Energy

Lecture 14: Midterm Exam

Lectures 15 &16: Nuclear Power
Nuclear History; Physics; Nuclear Reactors; Nuclear Power Economics; Reactor Safety; Different Reactor Technologies; Advanced Reactors; Nuclear Power Fuel Resources; Fuel Cycle; Fusion Energy; Future Prospects for Nuclear Power

Lectures 17 & 18: Generally on Renewables & Biomass
Introduction and Historical Notes; Resource Assessment; Environmental Impacts; Technology Development and Deployment; The Importance of Storage; Connecting Renewables to Hydrogen; The Future for Renewable Energy
Characterizing the Biomass Resource; Biomass Relevance to Energy Production; Chemical and Physical Properties Relevant to Energy Production; Biomass Production: Useful Scaling Parameters; Thermal Conversion of Biomass; Bioconversion; Environmental Issues; Economics; Enabling Research and Development; Disruptive Technology

Lectures 19 & 20: Geothermal Energy
Characterization of Geothermal Resource Types; Geothermal Resource Size and Distribution; Practical Operation and Equipment for Recovering Energy; Sustainability Attributes; Status of Geothermal Technology Today; Competing in Today's Energy Markets; Research and Development Advances Needed; Potential for the Long Term

Lecture 20 & 21: Hydropower
Overview; Hydropower Resource Assessment; Basic Energy Conversion Principles; Conversion Equipment and Civil Engineering Operations; Sustainability Attributes; Status of Hydropower Technology Today

Lectures 22 & 23: Solar Energy
General Characteristics of Solar Energy; Resource Assessment; Passive and Active Solar Thermal Energy for Buildings; Economic and policy issues; Solar Thermal Electric Systems-Concentrating Solar Power; Power tower-central receiver systems; Parabolic troughs; Dish systems

Lectures 24 & 25: Solar Photovoltaic (PV) Systems
Semiconductor device physics fundamentals; Performance limits and design options; Silicon-based cells (crystalline and amorphous); Thin-film cells; Concentrator cells; Current status and future potential of PV; Sustainability Attributes; Prognosis

Lecture 26 & 27: Ocean Waves, Tide, and Thermal Energy Conversion
Introduction; Energy from the Tides; Energy from the Waves; Energy from Temperature Differences; Economic Prospects; Environmental and Sustainability Considerations; The Ocean as an Externalities Sink; Current Status and Future Prospects

Lecture 28: Wind Energy
Introduction and Historical Notes; Wind Resources; Wind Machinery and Generating Systems; Wind Turbine Rating; Wind Power Economics; Measures of Sustainability; Current Status/Future Prospects

Computer Usage: Homework Assignments
Laboratory Experiences: None
Design Experiences: Homework assignments which have some design component
Independent Learning Experiences: Homework involves information searches. Material is highly subject to updating and change; internet resources crucial.

Contribution to the Professional Component:
(a) College-level mathematics and basic sciences: 0.25 credit hours
(b) Engineering Topics (Science and/or Design): 1.5 credit hours
(c) General Education: 1.25 credit hours

Prepared by: Paul Panayotatos
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