COLUMBIA UNIVERSITY
Department of Earth and Environmental Engineering

Proposed Course: EAEE E4190 – Photovoltaic Systems Engineering and Sustainability
Instructor: Prof. Vasilis Fthenakis, Tel: (212) 854-8885, Email: vmf5@columbia.edu
Class: S.W. Mudd 1127
Date: Fall 2014 –Mondays 1:10 AM- 3:40 PM

Course Description
A systems approach on solar energy utilization, involving the study of resources, generation, demand, storage, transmission, economics and policies. Study of current and emerging photovoltaic technologies, with focus on basic sustainability metrics (e.g., cost, resource availability, and life-cycle environmental impacts) for large scale of PV integration. The status and the potential of 1st and 2nd generation photovoltaic technologies (e.g., crystalline and amorphous Si, CdTe, CIGS) and emerging 3rd generation ones. PV-grid integration and storage options to overcome the intermittency constraint.

Points: 3 **Prerequisites:** Senior standing or instructor's permission
Rationale: The photovoltaic industry is one of the fastest growing industries world-wide and the demand for sustainable and clean energy will continue. Employment in the PV industry is expected to be strong for years to come as the U.S. is embarking in efforts to promote clean and secure energy production. The proposed course is designed to provide a basic understanding of PV fundamentals, technologies, research, engineering and deployment challenges/prospects and prepare students of applied science and engineering for working in this growing energy industry and for continuing in more advance studies. In addition the course teaches basic sustainability concepts that apply across various technologies and disciplines. The instructor articles on PV large-scale growth and sustainability, life cycle analysis and recycling, will supplement the text of this course. Students of business, economics and international affairs with a basic understanding of physics are also welcome and course projects will be custom made according to their background.

Topics Covered: Energy fundamentals, systems analysis, sustainability, resource availability, fundamentals of semiconductor physics, 1st, 2nd and 3rd generation solar photovoltaic technologies, grid integration, manufacturing processes, direct and external costs, large scale deployment, life cycle analysis, end-of-life management and recycling.

Textbook:
Konrad Mertens, Photovoltaics Fundamentals, Technology and Practice, Wiley, 2014
(Supplemented by the instructor's articles and handouts)

Some Pertinent Journals & Magazines
Photon magazine; Home power magazine, Progress in Photovoltaics Research and Applications; Solar and Wind magazine

Grading:

Quizzes	15 points
Homework assignments	15 points
Mid-term Exam	35 points
Project /Presentation/ Oral exam	35 points

There will be four home assignments and an in-class mid-term examination. The final examination will constitute of the presentation of a term-paper on a topic that can be selected by the student and approved by the instructor. Students are required to a) submit a formal written work-plan by October 13, 2014, b)

submit Weekly Progress reports every week starting October 20th, c) submit a final Report by December 8th, and make a formal presentation to the class of the results of their work on December 15th.

Topics Covered Each Week

DATE	
9/8	1. PV Technology Overview, Markets, Global Trends, Prospects *Instructor Slides & Energy Policy Paper, Chapter 1 of textbook*
9/15	2. a. Introduction to Sustainability of Photovoltaics b. Introduction to Life Cycle Analysis *Instructor Slides & Papers*
9/22	3. Solar Irradiation Data and Conversions –*Chapter 2 of the textbook & Slides*
9/29	4. Fundamentals of semiconductors; photovoltaic modules –*Slides, Chapter 3 of textbook*- QUIZ1
	a. How solar cells work Chapter 4 of textbook
	b. PV modules, arrays, systems
10/6	5. PV system sizing and grid integration –*Slides, Handout, Chapter 6 of textbook*
10/13	6. Silicon-based photovoltaics –*Slides, Handout, Chapter 5 of textbook*
	a. Production of MG-Si, poly-Si and crystalline (Siemens, FBR)
	b. Module manufacturing
	c. Waste management; Recycling
10/20	7. Thin-film photovoltaics –Slides, Instructor's J VAc review article, Chapter 5 of text
	a. CdTe & CIGS vapor transport processes –QUIZ 2 unannounced
	b. a-silicon and thin-film Si plasma deposition
	c. R&D Needs
10/27	Mid-term exam
11/3	Academic Holiday
11/10	8. 3rd generation photovoltaics –Slides
	a. III/V concentrators
	b. nanostructured, organic cells
11/17	9. Electricity Storage - QUIZ 3
	a. How much storage is needed? –Slides, Handout
	b. Batteries –Chapter 7.3
11/24	10. Sustainability /Life Cycle Environmental impacts (energy payback times, toxic and greenhouse gas emissions) –Simapro projects review
12/1	11. Sustainability - Solar Grand Plan: Resource Availability/End-of-Life/Recycling (goals, needs, technologies, programs, infrastructure, R&D needs)
12/8	12. a) Energy Sustainability Analysis b) Review of technology and cost-reduction programs (e.g., SunShot) QUIZ 4 Project Reports DUE
12/15	Final examination -In class presentations of reports