Yale University  
School of Forestry and Environmental Studies  
Fall Term 2016

FES 814   MGT 563  

Energy Systems Analysis

Room: SOM Evans Hall, room 4420 till October 24, 2016 and room 4200 thereafter  
Time: Monday 2.30 - 5.20 pm (weekly)  
       Wednesday 6.00 – 9.00 pm on September 14 and September 28, 2016.

Instructor: Shonali Pachauri: (shonali.pachauri@yale.edu)  
TF-1: Amir Mehr: (amir.mehr@yale.edu)  
TF-2: Lynsey Gaudioso: (lynsey.gaudioso@yale.edu)  
TF-3: Melissa Legge: (melissa.legge@yale.edu)

Office hours: Mondays 9.00-12:00, or by scheduled appointment.  
380 Edwards Street, Room 302, Tel: 432-0060

This 3 credit lecture course offers a systems analysis approach to describe and explain the basics of energy systems, including all forms of energy (fossil and renewable), all sectors/activities of energy production/conversion, and all end-uses, irrespective of the form of market transaction (commercial or noncommercial) or form of technology (traditional as well as novel advanced concepts) deployed. Students gain a comprehensive theoretical and empirical knowledge base from which to understand energy-environmental issues. Special attention is given to introduce students to formal methods used to analyze energy systems or individual energy projects and to discuss also traditionally lesser-discussed elements of energy systems.

The deepening theme in the 2016 ESA class will be energy access in developing countries and will be covered by a dedicated class session. Active student participation is encouraged, including participation in class activities and exercises and student debates and discussions. Professional modules (held Wednesday evenings in addition to regular Monday classes) complement and deepen topics covered in class. Completion of 3 problem sets, a written mid-term, and a final written exam are mandatory. Given the large class size, dates of mid-term and final exams are fixed. Students are advised to plan their travels accordingly.

Registration (deadline: September 05) via Canvas is absolutely mandatory. Non registered students will not be admitted to class.
Course Objectives

- Develop comprehensive overview and understanding of energy systems, i.e. the interaction of social, economic, technological, and regulatory forces shaping energy demand and supply
- Gain an understanding of main data sources and methods used to analyze energy systems and their strengths and weaknesses
- Get introduced to major analytical concepts and tools used in energy systems and policy analysis
- Develop basic analytical skills to master energy conversions and other calculus needed for elementary energy policy or project analysis.

Organization, Assignments and Evaluation

The course consists of lectures given by the instructor. Class learning is complemented by self-study in form of required reading and solving 3 problem sets. Active student participation is encouraged. Additional professional modules (scheduled as extra class events on Wednesdays 6-9 pm) complement regular Monday classes and offer a forum for development of professional and analytical skills. Timely delivery of the three problem sets as well as successful completion (minimum of 70%) of (written) mid-term and final exams are required for a positive class grade. Auditors are allowed only under most exceptional circumstances and have to participate in all classes, complete all class assignments (i.e. the 3 problem sets) and the mid-term exam and are dispensed only of the final exam.

All class material, including all reading assignments are available at the ESA class website (via Yale's Canvas Server).

Readings (in reading order):


Additional background reading and introductory-level reading for the two climate change classes are also posted on the class server, but are not listed separately here.

**Grading will be based on:**

45% Problem sets  
25% Mid-term exam  
30% Final exam
FES 814a - Energy Systems Analysis (ESA)

Class Sessions:
Monday 2.30-5.20 pm, SOM Evans Hall, room 4420 till October 24, 2016 and room 4200 thereafter
Wednesday 6.00 – 9.00 pm on September 14 and September 28, 2016 (rooms tbd)

September 5: Labor Day, class does not meet
(make-up class: Wednesday, October 5)
Deadline for ESA student registration via Canvas.
Non-registered students will not be admitted to class.

September 12: Class Overview: (introduction by instructor, self-introduction of students, class logic and logistics). Introduction to Energy Systems: (definitions, system boundaries, types of conversions, heating values, emission factors, energy balances and statistics).
Required reading: Energy Primer
Material: 814_0 and 814_1

September 14: Professional Module 1: Basic calculus for ESA problem sets (room tbd): Student- and TF-led “reminder” of high school calculus with on-hands training on your own laptop, including: Basic Excel features and functionalities; growth rates and discounting; elasticities, etc. Voluntary participation on a need basis!

Required reading: Energy Primer
Material: 814_2

September 26: Fundamentals of Energy Systems II: (energy systems constraints - comparison metrics [chain calculations, direct and indirect energy requirements, system comparisons] - energy, economic and environmental calculus).
Required reading: Energy Primer
Material: 814_3
Problem set 1 distributed.

September 28: Professional Module 2: Energy data: Sources, uncertainties, analytical insights and pitfalls (room tbd): (Introduction by Instructor -- student presentations -- wrap-up by instructor).

October 3: Energy Systems Determinants 1: Demand (Overview of main determinants [demographic, economic, social/cultural, policy], overview of main demand categories, orders of magnitude, and specific determinants)
Material: 814_4

October 5: (Make-up class for Labor Day room tbd)
Energy Systems Determinants 1: Demand (continued)
(Synopsis of main analytical tools to analyze energy demand in economics, industrial ecology, engineering, and social science.)
Material 814_5

October 10: Energy Systems Determinants 2: Supply (Overview of main determinants [geology, technology, economics, policy] and resource inventory methodology and numbers, discussion of supply vs. environmental constraints framing resource availability).
Required reading: Rogner et al., GEA Chapter 7, Energy Resources
Material: 814_6

October 17: Energy systems determinants 3: Environment (Taxonomy of major environmental problems of energy production and use and strategies to address them: local - regional - global).
Required reading: Holdren/Smith, Energy, the Environment and Health
Material: 814_7
Problem set 1 due
Problem set 2 distributed

October 24: Wrap-up/catch-up class (1.5 hrs)
Mid-term written exam (90 min after class, place t.b.d.)

October 31: Energy Access in Developing Countries (definitions and measurement of access, estimating benefits of access, determining costs of expanding access, business models and policies for increasing affordability, emissions impacts of traditional energy carriers)
Material: 814_8
November 7: An introduction to energy models: (What is a model and what it is useful for - main types of models used for energy policy analysis [top-down versus bottom-up] - typical systems boundaries and input data - example of a macro-economic energy-environmental model [DICE] and of engineering, bottom-up model [MESSAGE]).
Material: 814_9
Problem set 2 due,
Problem set 3 distributed.

November 14: Financing Energy Investments: Guest lecture by Bill Ellis.
(Date to be confirmed).
Material: 814_10

November 21: Fall recess (no class)

November 28: Climate change 1: The basics (science and energy basics of climate change, impacts, and mitigation, overview of policy dilemmas: intra- vs. intergenerational equity (who causes and who suffers, who pays and who benefits) - uncertainty and policy delay vs. technological inertia and policy acceleration).
Material: 814_11
Problem set 3 due

December 5: Climate change 2: Insights from climate and policy models from a developing country perspective (overview of key concepts, their representation in models, and major policy insights, incl. multiple GHG species, radiative forcing, integration of climate with other policy objectives, climate as a co-benefit of other energy and development policies, implications for other energy goals of climate policy).
Material: 814_12

December 12: Reading week (no class)

December 19: Final Written Exam