73-428/19-624
The Transformation of Energy Markets
T/Th 1:30 – 2:50 pm, Scaife Hall 219

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About the course
The following is the little blurb that was published in the course catalog:

> Crude-oil and natural gas deregulation are widely-cited success stories, while the electric power industry has become the poster child for advocates of a strong government role in energy markets. This course will blend the tools of economics and engineering to assess the successes and failures of energy-market commoditization. Why are markets for oil and natural gas considered to be "well-functioning," while electricity markets are not? What constraints does technology place on the economic goal of competition?
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> The course will consider markets for, and the technological idiosyncrasies of, petroleum, natural gas, and electricity. Topics to be covered include the economics of resource extraction, volatility in futures markets for oil and natural gas, the rise and fall of OPEC, power systems engineering and economics, and the special problems inherent in creating markets for wholesale electric power. We will contrast the performance of electricity markets in California, the Northeastern U.S., and Britain. Additional topics may include consumer response to volatile energy prices, renewable portfolio standards in electric power generation, coal and nuclear technologies, and the possibility of supply shortages in oil and natural gas.

As you can see, this is essentially an energy economics course, with a good bit of history and engineering thrown in. The course is intended to be a broad survey of the oil, natural gas, and electric-power industries, with a focus on "commoditization," – the change in industry behavior and organization based on regulation and vertical integration to behavior and organization based on trading and markets. This course was designed to be appropriate for upper-level economics and engineering students. This differs from a typical energy-economics course in that we will be spending quite a bit of time discussing the technology of energy commodities and their underlying physical properties. Engineers and economists have long lived in blissful ignorance of one another; my hope is that you will leave this class realizing that such ignorance leads to poor policy decisions.

Prerequisites
Formally, students who registered under 73-428 are expected to have taken calculus-based microeconomic theory and macroeconomic theory (73-200 and 73-251). Students who registered under 19-624 are expected to have taken a basic economics course (73-100 or its equivalent), and should also be familiar with differential calculus.

This means that I expect every student in this course to be familiar with calculus-based microeconomics (producer and consumer theory). If you have never seen supply and

demand curves before, you will find the economic material much more difficult, although I will be running a brief refresher during the first week of classes.

Required readings and texts
There is no required text for this course, mainly because a worthwhile text for a course like this does not exist. I will write up notes for most sections of the course, to be supplemented by outside reading. All of the readings for this course (my notes as well as outside sources) will be available online, either through blackboard or through Hunt Library's e-reserves. I will provide explicit URLs for all the reserve readings so that you don't have to go fishing through the list every time I want you to read something. If you have trouble accessing the e-reserves, please let me know as soon as possible.

In particular, we will be reading large portions of *Flipping the Switch: The Transformation of Energy Markets* by Samuel A. van Vactor. In addition to being the inspiration for the name of this course, the book provides a good overview of transactions cost economics and how industrial and institutional arrangements have influenced commoditization in the energy industry. I will give you each a copy of the manuscript three-hole punched. Since I'm not making you buy a textbook, I will ask that you buy a large three-ring binder for this book, my lecture notes, and other readings which I'll hand out.

I have set up a blackboard site for this course. Reading lists, homework assignments, and solutions can be accessed through blackboard or my web site for this course: http://www.andrew.cmu.edu/~sblumsac/energy/energy.html. If you have trouble accessing the blackboard site or my course site, please let me know.

Course requirements
1. Class time: This course will spend roughly half the time in lecture mode and half the time in discussion mode. When we are in discussion mode, I expect you to participate actively, and especially to ask questions if there are things you don't understand. Particularly in the energy industries, important issues often have two (or three or four…) sides, and no consensus exists on the "right" answer or approach. If you can come away from the readings with a general idea of what the debate is all about, then we will have some excellent discussions in class. On days when there will be substantive discussion in class, I will expect each student to independently (without consulting others) prepare a short review of each reading to be handed in at the end of class. A few sentences on each reading is fine. Your reviews can consist of discussion topics based on the readings, questions about the readings, or other things that come to mind. Each set of reviews will be worth five points, and will be graded on a binary scale. If you hand it in, you get five points, and if you don't hand it in, you get zero points. I will let you know when you will need to prepare these reviews to hand in.

2. Homework: There will be seven homework assignments throughout the semester. There will be three types of problems on the homework assignments. The first type are problems that everyone in the class is expected to complete. The second type are economics-specific questions that only those students signed up for 73-428 will be

expected to complete. The third type are engineering-specific questions that only those students signed up for 19-624 will be expected to complete. If you are signed up for 73-428 and wish to do the engineering-specific questions (or vice versa), then you will get extra credit for doing so (and I encourage you to at least try these problems). In other words, it can help you but cannot harm you.

Homework is due at the beginning of class on the specified due date. Each assignment will be graded on a 100-point scale; graded assignments and solutions will be available one week after the due date; the solutions will be posted on blackboard. Homework handed in after the specified due date will be penalized by ten points for every day it is late. I will not accept homework handed in after the solutions have been posted. I will allow you to work in small groups on the homework (less than four people), but the work you hand in must ultimately be your own. If you worked with others on a homework problem, you must let me know by writing down the names of the others you worked with when you hand in your homework. I will not accept assignments handed in by groups (everyone must write up and hand in their own paper).

I don't care if your homework is typed or handwritten, but if I can't read your writing, then I'll ask you to re-do the assignment. I expect your answers to the homework problems to be clearly written and well-reasoned. If there is mathematics or calculation involved, I expect to see your work. All graphs *must* be clearly labeled, including axes.

3. Papers and exams: There will be two short exams during the course of the semester. I have no final exam planned for this class. In lieu of a final exam, I am assigning a paper, to be done in groups, which will be due on the last day of class. The paper will consist of a discussion of energy markets in a country other than the United States. Those of you with an interest in developing countries, this is your chance. More details on the group paper will be forthcoming. We will probably use our allotted final-exam time for group presentations based on the papers.

Grading
Your grade in this class will be broken down as follows:
Homework: 30% (this includes the formal assignments and the "talking points")
Exams: 30%, split equally between both exams
Group Project: 30%
Class participation: 10%

Syllabus
Here is an approximate syllabus for the course. I will let you know well in advance if there are radical changes.

I. Energy and the Macro-Economy (2 classes)
Topics: Types of energy. Sources of energy and energy conversions. Consumption of energy. Energy intensity of production and consumption across countries. The relationship between energy and GDP.

II. Microeconomics Refresher (2 classes)
Topics: Calculus-based producer and consumer theory. Substitutes and complements. Perfect competition, monopoly, and oligopoly. Economies of scale. Market power.

III. Transaction Cost Economics (3 classes)
Topics: Coasian transaction cost economics. Rationales for vertical integration. Asset specificity in commodities and infrastructure. Measurement of transaction costs (bid/ask spreads). Futures markets and new contract development.

IV. Introduction to the Economics of Exhaustible Resources (2 classes)
Topics: Gray's model and Hotelling's formalization. Adelman's Rule. Hubbert's logistic decline curve. Empirical tests of the Hotelling hypothesis. The reserve-production ratio

V. Introduction to the Oil and Gas Industries (2 classes)
Topics: Petroleum extraction and refining. Quality of oil. API Gravity. Natural gas extraction and transportation. Oil is heterogeneous but easily transportable. Gas is homogenous but transportation is difficult. Industry structures.

VI. Markets for Oil and Gas (3 classes)
Topics: History of the oil and gas liberalization in the United States. The rise and fall of OPEC as a dominant presence in world oil markets. Who, if anyone, has market power in oil markets, and how do we know? Development of futures markets and the real legacy of Enron. Implications of asset specificity on financial and physical market efficiency.

VII. The Future of Oil and Gas (1 class)
Topics: Are we running out of oil or gas? LNG and unconventional sources of oil. Drilling in ANWR.

VIII. Introduction to the Electric Power Industry (1 class)
Topics: Size and scope of the electric power industry. Generation technologies. Generation mix. Vertical integration in electricity. Markets for coal. Nuclear power technologies and economics.

IX. Power Engineering and Power Systems Economics (3 classes)
Topics: Kirchoff's Laws. AC and DC Power Flow. Real and Reactive Power. Optimal Power Flow. Transmission Losses. Merit-order Dispatch and congestion management. Centralized and De-centralized dispatch

X. Regulation and Deregulation of Electricity (3 classes)
Topics: Rate of return Regulation. The Averch-Johnson Effect. Power Pools, Centralized Spot Markets, and Bilateral Markets. Deregulation. PUHCA, PURPA, EPAct. The California Power Crisis. Performance of Futures Contracts in Electricity. Electricity deregulation in Britain and Australia.

XI. What Makes Electricity So Difficult? (3 classes)
Topics: Transaction-Cost Explanation and Asset Specificity. Market-Structure Explanation. Measuring Market Structure in Electricity. The Constraints of Physics. Retail Competition and Demand-Side Response. How far can we push electricity deregulation?

XII. Providing Electricity in an Emissions-Constrained World (2 classes)
Topics: Renewable portfolio standards. Wind power. Will nuclear power rise again? Emerging technologies (photovoltaic, fusion, CCS). What are the limits to reducing carbon emissions?