ESD.934, 6.974

Engineering, Economics and Regulation of the Electric Power Sector

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Homework HW4. Optimization models & microeconomics

Question 1. A simple generation Unit Commitment model.

In this question, we will consider a highly simplified unit commitment model to determine which power plants to connect to the system (unit commitment, UC) and what output power to operate at (economic dispatch, ED) during each time period.

In Simpleland, the electricity demand follows a repeating daily pattern at two levels: A Low level of D_L = 1000 MW for T_L = 20 hours, followed by a high level of D_H = 1500 MW for T_H = 4 hours, and so on.

Simpleland electric power company has 3 generation units as described in the table below:

	Rated Capacity	Technical Minimum	Variable Cost	Startup Cost
Plant Name	P_{max}, MW	P_{min}, MW	C_{var}, \$/MWh	C_{su}, \$/start
Papa Bear	1500	1200	10	\$40,000
Mama Bear	1200	500	20	\$10,000
Baby Bear	600	100	30	\$3,000

a) Write the complete set of equations of the UC+ED problem using either mathematical notation or words.

b) Give the optimal solution to this problem (you should be able do it by inspection, after all this is Simpleland). If you wish, you could write and solve a computer model for this problem, but it is not required.

c) What is the marginal cost of electricity at each one of these two periods? Do all generation units recover their total costs with the dispatch schedule and the prices that you have computed? If not, is this acceptable and what solution do you propose?

d) Simpleland experiences a population boom, and load increases to D_L = 1200MW, D_H = 1800MW. Repeat parts b&c for this case.

e) The Olympics and World Cup overlap and TV watching extends long into the night, increasing the duration of the peak period, T_H to 8 hours (at the post-boom demand levels). Repeat parts b&c for this case.

f) The Simple PUC (Public Utility Commission) decides to deregulate the electric sector and convert to an open market using simple bids (pairs of variable cost and output level only). Assume that each generator was sold to a separate operating company. The

Olympics are over, but the population is still increased. What is the resulting dispatch profile? Repeat part c for this case.

Question 2. The dilemma of the peaking generation plants.

<Recommended: Read page 58 and following ones of P. Joskow, "The difficult transition to competitive electricity markets in the US", 2003

Step 1: Create the annual load duration curve (or some reasonable approximation) for the system you have chosen. In some cases annual reports will show this figure directly, in other cases you can construct one based on a year of hourly load data. Hourly data is often readily available on market operator's websites. In addition, for the US, some historic data is available through FERC form 714 at: http://www.ferc.gov/docs-filing/forms/form-714/data.asp

Note: *Do not spend much time with this*. If you have difficulty obtaining a full year of data, estimate one based on a few representative days from various seasons of the year. If you have difficulty finding the information, consider estimating it based on a different similar system or invent one. In all cases, clearly cite your data sources and approximations.

Step 2: Using the following data:

1. The load duration curve from Step 1.
2. The annual capital cost of a competitive ("best technology") peaking unit. Use $100,000/MW per year unless you happen to have a better value (in this case indicate your sources). If you want to learn how to obtain this cost, read the document in the reference material: "Fixed Cost of a Best New Entrant Peaking Plant", Single Electricity Market Committee of Ireland, 2009, http://www.allislandproject.org/
3. The estimated cost for the average demand of loss of electricity supply (5,000 $/MWh). Assume that this is the market price of electricity whenever there is not enough generation to meet all the demand.

Answer the following questions:

a. Describe the resulting dilemma of the peaking units from the complementary viewpoints of the potential investor in a peaking plant, the consumer and the regulator:
    - Investor: Under which conditions would the investor be willing to build a new peaking plant? Do you think that investing is a reasonable decision?
    - Regulator: Would a regulator be satisfied with a market that functions under an energy-only pricing rule? Is an acceptable level of investment to be expected? Do you think that generators should be allowed to bid whatever price they want or should they be mandated to bid variable costs strictly (under threat of abuse of market power)? Would it be a good idea to establish a price cap of 1,000 $/MWh to the market electricity price?
    - Consumer: Should the regulator protect consumers somehow or do you think that consumers would prefer to protect themselves against high prices and power shortages, without any regulatory intervention? How could they protect themselves?

b. Any suggestion to address this dilemma?

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