Review Problems

May 29, 2017

This is not an exhaustive list. In particular, the material on the effect of transmission lines are covered towards the end of the quarter and are not listed here. Any other material covered in homework **may** be on the final. Nor does it mean that every possible problem covered here would be on the final. It's to be used a fresher. In fact, it is probably a safe bet that at least one topic in this review will not be on the final and at least one topic not here will be on the final.

Problem 1. Economic Dispatch.
A small system is supplied by 3 generators. The cost of each are given by

$$C_1 = 250 + 5P_1 + 0.05P_1^2$$
$$C_2 = 100 + 10P_2 + 0.06P_2^2$$
$$C_3 = 150 + 8P_3 + 0.07P_3^2$$

Suppose the load is equal to 700 MW and there are no limits on the generators. Find the economic dispatch (i.e., the output of generators). Find the Lagrange multiplier.

Problem 2. Economic Dispatch.
A small system is supplied by 2 generators. The cost of each are given by

$$C_1 = 100 + 5P_1 + 0.05P_1^2$$
$$C_2 = 30P_2, \text{ where } P_2 \leq 200$$

Suppose the load is equal to 500 MW and there is no limit on generator 1. Find the economic dispatch (i.e., the output of generators). Find the nodal price.

Problem 3. Economic Dispatch.
A system is supplied by three generators. The cost characteristics are:

$$C_1 = 300 + 12P_1 + 0.05P_1^2 \quad P_1 \leq 250MW$$
$$C_2 = 250 + 13P_2 + 0.05P_2^2 \quad P_2 \leq 250MW$$
$$C_3 = 150 + 11P_3 + 0.08P_3^2 \quad P_3 \leq 200MW$$

1. Find the optimal economic dispatch when the total load is 600 MW. Find the nodal price.

2. Suppose the generator limits are changed to $P_1 \leq 200MW$, $P_2 \leq 240MW$, and $P_3 \leq 200MW$. The load is still 600 MW. What is the economic dispatch? What is the nodal price?

Problem 4. Unit commitment.
Consider the 3 generators with the characteristics given in Tab. 1, they must satisfy the load requirement in Tab. 2.

Unit	P_{min}	$P_{\max}$	Marginal cost (\$/MWh)	Min up time (h) (\$)	No-load cost (\$)
1	120	200	30	3	300
2	50	100	20	2	150
3	30	50	40	1	100

Table 1: Information for problem 4.

Hour	1	2	3
Load	150	120	160

Table 2: Information for problem 4.

Assume at the beginning of the problem all generators are off.

1. Write down the formulation of the unit commitment problem.

2. Suppose we impose a 10 MW reserve requirement. Write the new unit commitment problem.

Problem 5. Linear programming.
Solve the following linear programming problem:

$$\begin{aligned}
\max\ & x + 2y \\
\text{s.t. } & x \geq 0 \\
& y \geq 0 \\
& 2x + y \geq 2 \\
& x - 2y + 6 \geq 0 \\
& x + 3y \leq 15 \\
& x - y \leq 5 \\
& y \leq 4
\end{aligned}$$

Problem 6. Supply and demand.
The demand curve, in terms of quantity q (MW) as a function of the **price (\$/MW)** is given by

$$\pi = -0.01q + 4$$

find:

1. The level of consumption at $\pi = 3\$/MW$, the consumer surplus, demand charges and the revenue received by the suppliers.

2. If the price is increased by 10%, what is the new revenue received by the producer?

3. Suppose the **production cost** is given by

$$C = 0.001q^2 + 1.3q,$$

find the equilibrium price and the social welfare at this equilibrium.

Problem 7. Electricity market.
Consider a system with three generators with the following cost functions:

$$\begin{aligned} C_A &= 15 + 1.4P_A + 0.04P_A^2 \\ C_B &= 25 + 1.6P_B + 0.05P_B^2 \\ C_C &= 20 + 1.8P_C + 0.02P_C^2 \end{aligned}$$

the system also has option to buy energy at 8.20 $/MW from the market and must satisfy a 350 MW load. In addition, the system has the opportunity to sell at 10.20 $/MW to another load. What is the optimal generation amount, amount bought, and amount sold to maximize the net profit?