Power Systems Economics: Homework #3

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3.2

Given: The rules of the Syldavian electricity market stiplate that all participants must trade energy exclusively through the Power Pool. However, the Syldavia Aluminum Company (SALCo) and the Northern Syldavia Power Company (NSPCo) have signed a contract for difference for the delivery of 200 MW on a continuous basis at a strike price of 16$/MWh.

A) Trace the flow of power and money between these companies when the pool price takes the following values: 16$/MWh, 18$/MWh, and 13$/MWh

i) 16$/MWh

At a pool price of 16$/MWh, the **Power Flow** would be that NSPCo would simply produce the 200W and sells it to the pool, and, after this, SALCo would then buy the 200MW from the pool. For the **money flow of the pool**, it would simply be $200MW * 16\$/MWh = \$3200$ sold into the pool, and the same amount, $3200 bought from the pool. This also, therefore, means that the **money flow of the contract** is $0 since no money was exchanged under the contract for difference.

ii) 18$/MWh

At a pool price of 18$/MWh, the **Power Flow** would be that NSPCo would simply produce the 200W and sells it to the pool, and, after this, SALCo would then buy the 200MW from the pool. For the **money flow of the pool**, it would simply be $200MW * 18\$/MWh = \$3600$ sold into the pool, and the same amount, $3600 bought from the pool. This pool price, however, would mean that the contract would come into effect, as the pool price is $2 above the contract strike price. This means that NSPCo would then pay the difference of prices so that SALCo, in effect, pays only $16/MWh. Therefore, NSPCo would pay SALCo is...

$$(\text{Pool Price} - \text{Strike Price}) * \text{Quantity} = (18 - 16) * 200 = \$400$$

iii) 13$/MWh

At a pool price of 13$/MWh, again, NSPCo would simply sell the 200MW to the pool, and SALCo would buy from said pool the 200W. The **money flow**, this time, would be simply $200*13 = 2600$ bought from the pool, and also sold to the pool. The pool price, however, is again not te same as the strike price, meaning that their will be a money flow from the contract of difference, BUT, instead of NSPCo paying, it would be SALCo. Specifically SALCo would pay NSPCo...

$$(16 - 13) * 200 = \$600$$

B) What happens if during one hour the Northern Syldavia Power Company is able to deliver only 50 MWh and the pool price is 18$/MWh?

If NSPCo can only deliver 50MWh's to the pool, and SALCo still buys that 200 MWhs from the pool, SALCo would pay to the pool still the total of $18 * 200 = \$3600$ while NSPCo would only sell to the pool $18 * 50 = \$900$. SINCE, the contract of difference *doesn't care* about how much NSPCo actually produces, and is only based on strike price and the pool price, NSPCo would still be obligated to pay the difference (since the pool price is above the strike price) of contract. This means, NSPCo would need to pay...

$$(18 - 16) * 200 = \$400$$

C) What happens if during one hour the Syldavia Aluminum Company consumes only 100 MWh and the pool price is 13$/MWh?

Now, if SALCo only buys 100MW in an hour, this, again, does not matter, and the money flow and such would be VERY VERY similar to that of part B. The contract of difference was set up only on a *purely financial basis*, meaning *even* if SALCo doesn't consume the actual amount of electricity they said they would buy, SALCo/NSPCo would need to pay the difference (depending on the pool price). In this case, since the pool price is below the strike price set, SALCo will pay NSPCo the following:

$$(16 - 13) * 200 = \$600$$

3.4

Given: The operator of a centralized market for electrical energy has recieved the bids shown in the table below for the supply of electrical energy during a given period.

Company	Amount (MWh)	Price ($/MWh)
Red	100	12.5
Red	100	14.0
Red	50	18.0
Blue	200	10.5
Blue	200	13.0
Blue	100	15.0
Green	50	13.5
Green	50	14.5
Green	50	15.5

A) Build the supply curve

To build the supply curve we simply need to sort the companies from ascending order of price and find out the cumulative amount that it would quantify. That would be the following table...

Company	Amount (MWh)	Price ($/MWh)	Cumulative Amount (MW)
Blue	200	10.5	0 - 200
Red	100	12.5	200 - 300
Blue	200	13.0	300 - 500
Green	50	13.5	500 - 550
Red	100	14.0	550 - 650
Green	50	14.5	650 - 700
Blue	100	15.0	700 - 800
Green	50	15.5	800 - 850
Red	50	18.0	850 - 900

B) Assume that this market operates unilaterally, that is, that the demand does not bid and is represented by a forecast. Calculate the market price, the quantity produced by each company and the revenue of each company for each of the following loads: 400MW, 600MW, 875MW.

i) 400 MW

At a load of 400MW, the demand would fall within Blue's 13.0$/MWh and would mean the market price is **13.0$/MWh**. This woud therefore mean the following profits for the following companies:

- Blue: Produces 200MW from 10.5$/MWh bid, and 100MW from 13.0$/MWh bid $\therefore$ Revenue $= 300 * 13 = \$3900$.
- Red: Produces only 100MW $\therefore$ would have a revenue of $100 * 13.0 = \$1300$.
- Green: Produces 0 MW $\therefore$ Revenue $= \$0$.

ii) 600 MW

A load of 600 MW, the market price would fall into Red's **\$14.0/MWh** bid.

- Blue: Produces $200 + 200 = 400$MW $\therefore$ Revenue $= 400 * 14.0 = \$5600$.
- Red: Produces $100 + 50 = 150$MW $\therefore$ Revenue $= 150 * 14.0 = \$2100$.
- Green: Produces 50MW $\therefore$ Revenue $= 50 * 14.0 = \$700$.

iii) 875 MW

A load of 875 MW, the market price would fall into Red's **\$18.0/MWh** bid.

- Blue: Produces $200 + 200 + 100 = 500$MW $\therefore$ Revenue $= 500 * 18.0 = \$9000$.
- Red: Produces $100 + 100 + 25 = 225$MW $\therefore$ Revenue $= 225 * 18.0 = \$4050$.
- Green: Produces $50 + 50 + 50 = 150$MW $\therefore$ Revenue $= 150 * 18.0 = \$2700$.

C) Suppose that instead of being treated as constant, the load is represent by its inverse demand curve, which is assumed ot have the following form:

$$D = L - 4 * \pi$$

where D is the demand, L is the forcasted load, and π is the price. Calculate the effect that this price sensitivity of demand has on the market price and the quantity traded.

i) 400 MW

Now, to find the equilibrium demand we simply plug in the equiblibrium price we found above as well as the load wanted.

$$D = 400 - 4 * 13.0 = 348\text{MW}$$

This would then mean the following from the revenues of each company...

- Blue: Produces $200 + (348 - 300) = 248$MW $\therefore$ Revenue $= 248 * 13.0 = \$3224$.
- Red: Produces $100 = 100$MW $\therefore$ Revenue $= 100 * 13.0 = \$1300$.
- Green: Produces $0 = 0$MW $\therefore$ Revenue $= 0 * 13.0 = \$0$.

ii) 600 MW

Now, to find the equilibrium demand we simply plug in the equiblibrium price we found above as well as the load wanted.

$$D = 600 - 4 * 14 = 344\text{MW}$$

BUT, UH OH, that demand is not in the range of the strike price of 14.0\$/MWh, therefore we should try the strike price right below it, or 13.5\$/MWh:

$$D = 600 - 4 * 13.5 = 346$$

This, is in the correct range, and would then mean the following from the revenues of each company...

- Blue: Produces 400MW $\therefore$ Revenue $= 400 * 13.5 = \$5400$.
- Red: Produces 100MW $\therefore$ Revenue $= 100 * 13.5 = \$1350$.
- Green: Produces 46MW $\therefore$ Revenue $= 46 * 13.5 = \$621$.

iii) 875 MW

Now, to find the equilibrium demand we simply plug in the equiblibrium price we found above as well as the load wanted.

$$D = 875 - 4 * 18.0 = \cancel{803\text{MW}} \rightarrow D = 875 - 4 * 15.5 = 813\text{MW}$$

This would then mean the following from the revenues of each company...

- Blue: Produces 500MW $\therefore$ Revenue $= 500 * 15.5 = \$7750$.
- Red: Produces 200MW $\therefore$ Revenue $= 200 * 15.5 = \$3100$.
- Green: Produces 113MW $\therefore$ Revenue $= 113 * 15.5 = \$1751.50$.

Picture of Code Output

Python Script Output Verification

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Building the Supply Curve (Merit Order)
  Company  Amount  Price  Cumulative_Amount
0    Blue     200   10.5                200
1     Red     100   12.5                300
2    Blue     200   13.0                500
3   Green      50   13.5                550
4     Red     100   14.0                650
5   Green      50   14.5                700
6    Blue     100   15.0                800
7   Green      50   15.5                850
8     Red      50   18.0                900

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Analyzing Fixed Demand Scenarios

Scenario: Demand is fixed at 400 MW
  -> Market Price: $13.00/MWh
     - Blue: Produces 300 MWh, Revenue: $3900.00
     - Green: Produces 0 MWh, Revenue: $0.00
     - Red: Produces 100 MWh, Revenue: $1300.00

Scenario: Demand is fixed at 600 MW
  -> Market Price: $14.00/MWh
     - Blue: Produces 400 MWh, Revenue: $5600.00
     - Green: Produces 50 MWh, Revenue: $700.00
     - Red: Produces 150 MWh, Revenue: $2100.00

Scenario: Demand is fixed at 875 MW
  -> Market Price: $18.00/MWh
     - Blue: Produces 500 MWh, Revenue: $9000.00
     - Green: Produces 150 MWh, Revenue: $2700.00
     - Red: Produces 225 MWh, Revenue: $4050.00

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Analyzing Scenarios with a Demand Curve

Scenario: Forecast Load (L) is 400 MW
  -> Market Equilibrium: Price=$13.00/MWh, Demand=348.00 MW
     - Blue: Produces 248.00 MWh, Revenue: $3224.00
     - Green: Produces 0.00 MWh, Revenue: $0.00
     - Red: Produces 100.00 MWh, Revenue: $1300.00

Scenario: Forecast Load (L) is 600 MW
  -> Market Equilibrium: Price=$13.50/MWh, Demand=546.00 MW
     - Blue: Produces 400.00 MWh, Revenue: $5400.00
     - Green: Produces 46.00 MWh, Revenue: $621.00
     - Red: Produces 100.00 MWh, Revenue: $1350.00

Scenario: Forecast Load (L) is 875 MW
  -> Market Equilibrium: Price=$15.50/MWh, Demand=813.00 MW
     - Blue: Produces 500.00 MWh, Revenue: $7750.00
     - Green: Produces 113.00 MWh, Revenue: $1751.50
     - Red: Produces 200.00 MWh, Revenue: $3100.00

[nix-shell:~/Documents/School/Classes/Fall25/EEL4298/HW/hw3]$
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