

Problem #2

Prices For Investment in an Ideal World

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Nodal Prices (CLP) Are Much Criticized

- Most critics have not read an economics book.
- They notice that sometimes there is a shortage, and prices go up above **some** marginal costs.
- They believe this is unfair.
- They do not consider fixed costs or investment.
- Some examples assume (accidentally) that stupid investments have been made in the past. CLPs provide excess profits when there is a shortage of capacity.

PSE, Ch. 5-5

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CLPs Are Not the Complete Answer

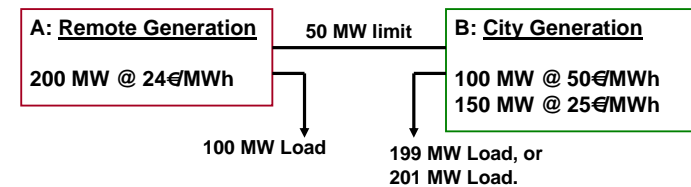
- While most criticisms of CLPs are confused, you should not assume CLPs can solve all problems.
- But, the problems with CLPs can be understood with careful economic analysis.
- There is no need to invent Electricity Economics.

- Here is an example of a criticism published in "the Electricity Journal." It is understandable, but still quite silly.

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Locational profits



199 MW City Load $\rightarrow P_A = 24 \text{ €}, P_B = 25 \text{ €/MWh}$.

200 MW City Load $\rightarrow P_A = 24 \text{ €}, P_B = 50 \text{ €/MWh}$.

So the City needs 2 more MWh, and these cost $25 + 50 = 75 \text{ €}$. But, the city must pay $(201 \times 50) - (199 \times 25) = 5075 \text{ €}$ more. Why should they pay 5000 € extra?

PSE, Ch. 5-5

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Locational profits

- Anti-CLP Complaints:
 - Consumers should only have to pay production costs.
 - Nodal prices are monopoly prices
 - Nodal prices make no sense!
 - They are just prices made up by Bill Hogan.
- Anti-CLP mistakes:
 - The computed prices assume no market power.
 - They were not invented by Bill Hogan.
 - Generation costs are not only fuel costs.
 - Prices are for not only for dispatch. But, also investment.

What is the investment signal?

- The remote generators are paid €24/MWh
- 50 MW of remote generation is not used.
- → Do not build any remote generation.
- → Retire some remote generators.
- Given the transmission system and the load, this is the correct signal.

Investment in the city

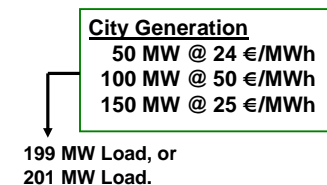
- Sometimes the 25 € generators make no profit.
- Sometimes they make 25 € / MWh profit.
- Would this cover the fixed cost of a new generator?
- It depends on the % of time making 25 €
- If the price is 50 € for half the time, and Type D generator can be build for less than $\frac{1}{2} \times 25 \text{ €} \times 8760 = 109,500 \text{ €} / \text{MW}$, then investors will build more Type D generators.

The same example without transmission

Same* “crazy prices.”

No transmission lines.

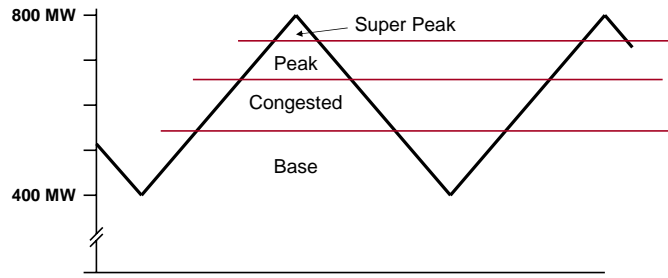
The CLPs are just normal competitive prices.



Complaints about CLPs (nodal prices) are complaints about standard competitive prices.

* There is one difference, when the price is 50 €, the 24-€ generation makes all the profit that was paid to the transmission line in the previous example.

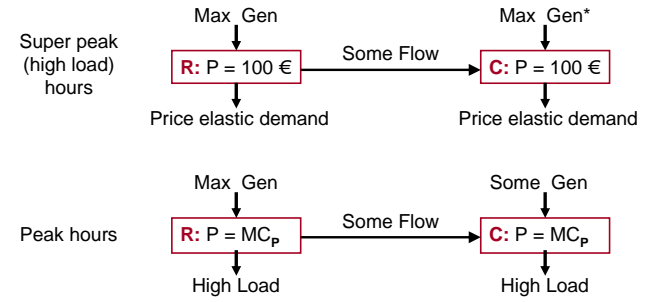
Four demand conditions (at each Location)



The system will experience 4 qualitatively different demand conditions.

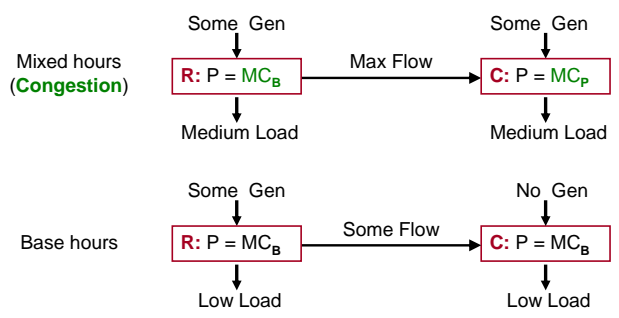
- Supper peak → All capacity in use.
- Peak → peakers set the price in both locations.
- Congestion → different prices in different locations.
- Base → Only base load capacity in use. A low price everywhere.

A Qualitative Solution (part 1)

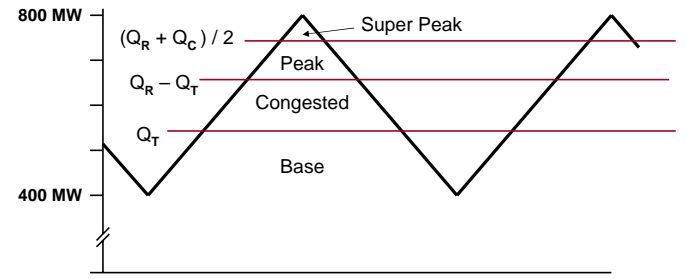


*Max Gen in the city will be less than Max Gen in the remote location.

A Qualitative Solution (part 2)



Demand Boundaries (at 1 Location)



Max total generation = $(Q_R + Q_C)$. Max load per location = $(Q_R + Q_C) / 2$.

When City Load < Line Limit, Q_T , then all City power can be imported.

The line can only be congested when the remote location has enough surplus capacity to congest the line: $(Q_R - L) > Q_T$, which $\rightarrow L < (Q_R - Q_T)$.

Three Zero-Profit Conditions

- As investors build more generation and more transmission line, their profits decrease. When profits go negative they stop investing.

$$T \times (P - MC) - FC = 0. \quad (\text{Zero Profit})$$

where T = the % of time with price P.

- Short-run production profits pay for investment.
- One condition for each type of investment:
(1) City Gen, (2) Remote Gen, (3) Transmission line.

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1. City Generation (Peakers)

- City generators (peakers) only make short-run profit when $P > MC_p \rightarrow$ during super-peak hours.
- $T_{SP} \times (100 - MC_p) - FC_p = 0.$
Where T_{SP} = percent of super-peak time
- $T_{SP} = FC_p / (100 - MC_p)$
 $T_{SP} = 10 / (100 - 60) = 25\%.$
- $T_{SP} = 25\% \rightarrow (Q_R + Q_C) / 2 = 700 \text{ MW}$, because Load $> 700 \text{ MW}$ 25% of the time. (See demand graph.)

$$Q_R + Q_C = 1400 \text{ MW}$$

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2. Remote Generation (Baseload)

- Remote (baseload) generators make the same short-run profit as peakers (FC_p) during super-peak hours plus this much more: $T_{SP} \times (MC_p - MC_B)$.
- During peak hours they make: $T_p \times (MC_p - MC_B)$.
- Setting their net revenue = to their fixed costs:
 $(T_{SP} + T_p) \times (MC_p - MC_B) + FC_p = FC_B$
- $(T_{SP} + T_p) = 20 / (60 - 20) = 50\%.$
- $T_p + T_{SP} = 50\% \rightarrow (Q_R - Q_T) = 600 \text{ MW}$, because Load $> 600 \text{ MW}$ 50% of the time. (Also see the Demand-Boundary slide.)

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3. Transmission Investment

- A transmission line investors makes profit only when the line is congested (in an ideal world with no market power etc. and line owners are paid the congestion rent).
- Transmission rent = City Price – Remote Price
- $T_M \times (MC_p - MC_B) - FC_T = 0.$
Where T_M = percent of mixed time (with congestion)
- $T_M = 10 / (60 - 20) = 25\%.$
- $T_M = 25\% \rightarrow Q_T = 500 \text{ MW}$, because $600 \text{ MW} > \text{Load} > 500 \text{ MW}$ only 25% of the time. (Also see the Demand-Boundary slide.)

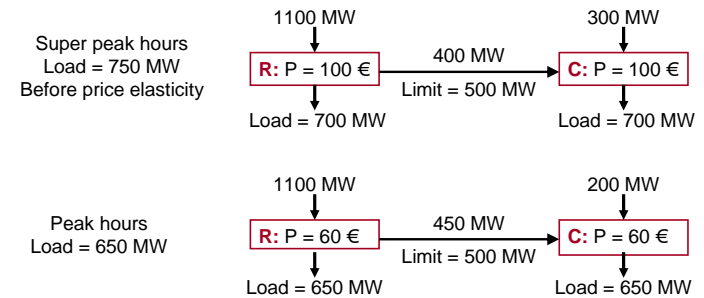
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Solving for all investment quantities

- $Q_T = 500$ MW
- $(Q_R - Q_T) = 600$ MW $\rightarrow Q_R = 1100$ MW
- $Q_R + Q_C = 1400$ MW $\rightarrow Q_C = 300$ MW
- The values for T_{SP} , T_P , and T_M , tells us when the four different load conditions occur.
- We know the CLPs are equal to marginal cost.
- This is the complete solution.

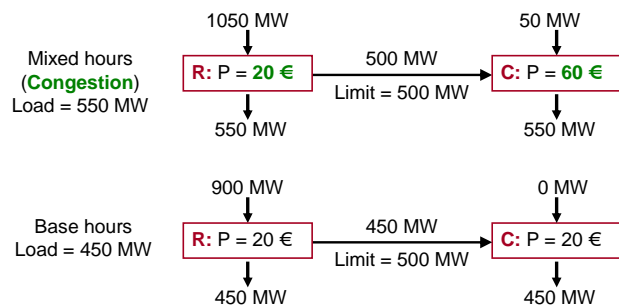
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A Quantitative Solution (part 1)



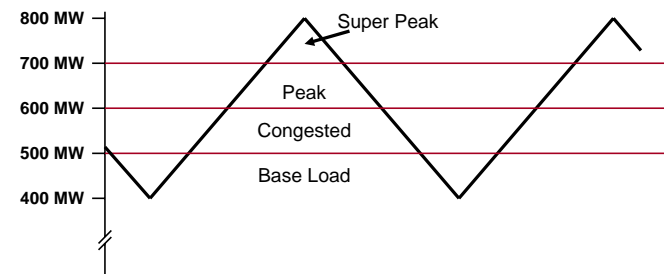
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A Quantitative Solution (part 2)



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Demand Boundaries (at 1 Location)



Max total generation = 1400 MW \rightarrow Max load per location = 700 MW.

When City Load < Line Limit, Q_T , (500 MW) all City power is imported.

The line can only be congested when the remote location has enough surplus capacity to congest the line: $(1100 - L) > Q_T$, which $\rightarrow L < (1100 - 500)$.

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Things to Note (1)

- Everything works perfectly.
- Consumers get their electricity at long-run average cost and at short-run marginal cost.
- Investors cover cost including a risk adjusted rate of return—but no more.
- When the City needs 1 MW of City generation, all consumers must pay 60 €/MWh even though the other 1001 MW is produced for 20 €/MWh.
- If these CLPs are “improved” electricity will cost consumers more in the long run.

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Things to Note (2)

- In the real world, things do not work so well.
- Some Problems:
 - Consumers don't see the price,
 - Transmission and generation costs are more complex and violate the assumptions of a competitive market.
 - There is market power, mainly in the supper peak hours, and in the transmission markets.
- Competitive Locational Prices (CLPs) are not the problem.
- Non-existent CLPs and nodal prices != CLPs are the problems.

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Things to Note (3)

- Congestion (maximum line use) does not happen during the super peak or the peak hours.
- Very often this is the case in the real world.
- The super peak hours last much too long in the model, but the amount of profit generated during those hours is about right.
- Super-peak hours pay all generators enough to cover the fixed costs of a peaker. That's about 1/3 of all short-run profits.

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Problems:

1. How much lower would profits of City capacity be, per MWh of capacity, if investors built 350 MW of capacity instead of 300?
2. How much lower would profits of transmission be, per MWh of capacity, if investors built 550 MW of transmission instead of 500?
3. If the transmission owner were a monopolist, and generation investors still built 1100 MW and 300 MW, how much transmission would be built?

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Solution 1:

Profits of City capacity if investors built 350 MW of capacity instead of 300?

The extra 50 MW will allow load to increase 25 MW in each location before the super peak begins.

This reduces the duration of the super-peak by 25%, so the short-run profits of peakers is reduced 25%.

Short-run profit in equilibrium = $FC = 10 \text{ €/ MWh}$, which is $10 \times 300 = 3000 \text{ €/ h}$.

This is reduced to 2250 €/ h , and capacity is increased to 350, so the short run profit per MWh of capacity falls to 6.43 €/ MWh , for a reduction of 3.57 €/ MWh .

Consequently, total profit is $- 3.57 \text{ €/ MWh}$.

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Solution #2:

What would profits of transmission be if investors built 550 MW of transmission instead of 500?

In equilibrium, congestion begins when load increases from 500.01, so that the city is importing as much as the line can carry.

Congestion ends when remote load reaches 600.01 because at that time, the 1100 MW of country capacity is only enough to export $1100 - 600.01 = 499.99 \text{ MW}$.

With 550 MW of transmission, congestion begins when the load reaches 550, and ends when the power available for export from the remote region drops to $550 = 1100 - L$. So it ends when L is 550.

So with a line capacity of 550, the transmission investor makes no profit.

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Solution #3:

If the transmission owner were a monopolist, how much transmission would be built?

If the transmission line were only 400 MW it would be congested down to minimum city load of 400 MW, and up to a load of 700 MW because remote export = $1100 - 700 = 400 \text{ MW}$ at that load.

With a 399 MW line, the city will run out of capacity at $399+300 \text{ MW}$ of load, which is 1 MW sooner than in equilibrium (at 700 MW).

Guess that capacity will be less than 400 and test that guess.

$$\text{SR profit / MW} = T_1 (60 - 20) + T_2 (100 - 20),$$

where T_1 = the time before $L = 300 + Q_T$

and T_2 = the time after T_1 and before $L = 1100 - Q_T$.

(at this point, the remote location runs out of capacity)

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Solution #3 continued:

$$T_1 = (300 + Q_T - 400) / 400$$

$$T_2 = \min(1, (1100 - Q_T - 400) / 400) - T_1$$

$$\text{Profit} = [T_1 (60 - 20) + T_2 (100 - 20)] \times Q_T - 10 \times Q_T$$

This is easier solved numerically.

$$Q_T = 300 \text{ MW},$$

$$T_1 = 50\%$$

$$T_2 = 50\%$$

$$\text{Profit} = 15,000/\text{h} = 50 \text{ €/ MWh}$$

Of course this would not last, as more generation would be built in the city.

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