Market Power in Electricity Market

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ELECTENG 703: Advanced Power Systems
Auckland University
October 03, 2007

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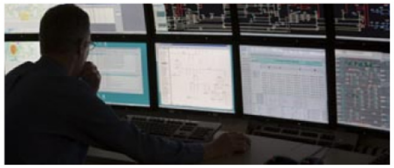
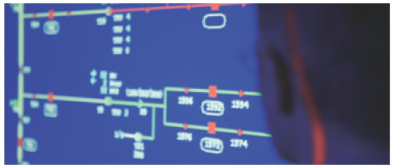




SYSTEM OPERATOR

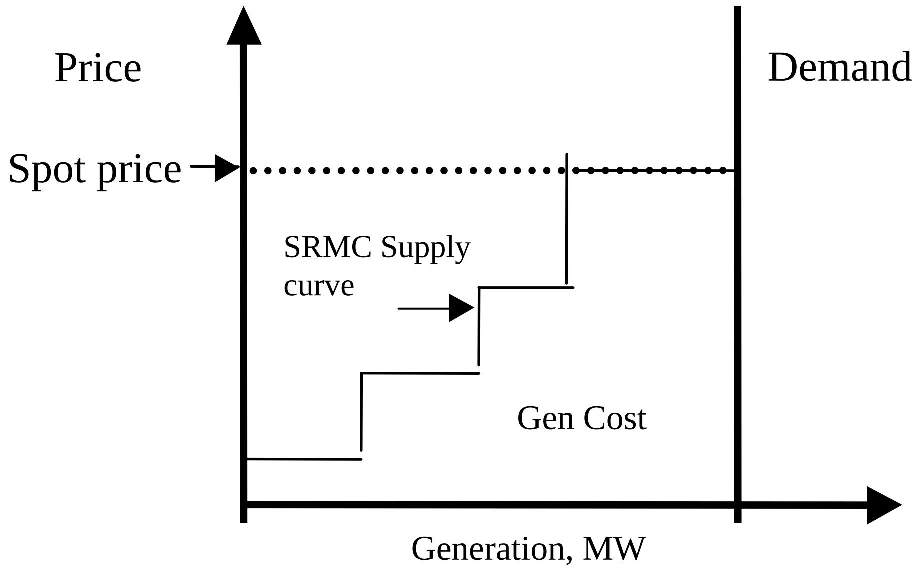
Generation Cost savings: Optimal dispatch model

Minimise: *Total Generation cost function*

Subject to:

Power flow in each circuit must be ≤ Thermal capacity of the circuit

Total supply = total demand plus loss

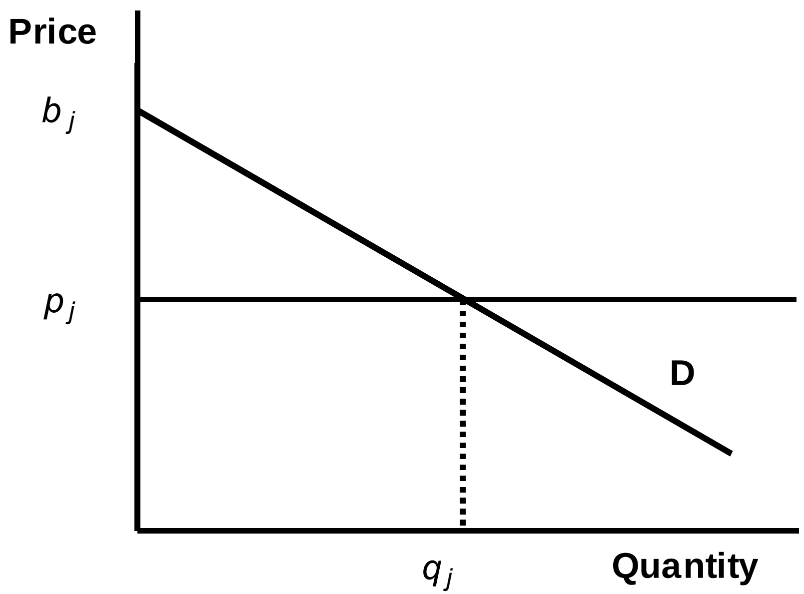


Supply and Demand Curve for any half-hour

Generation cost = Dispatch obtained by solving the model * SRMC

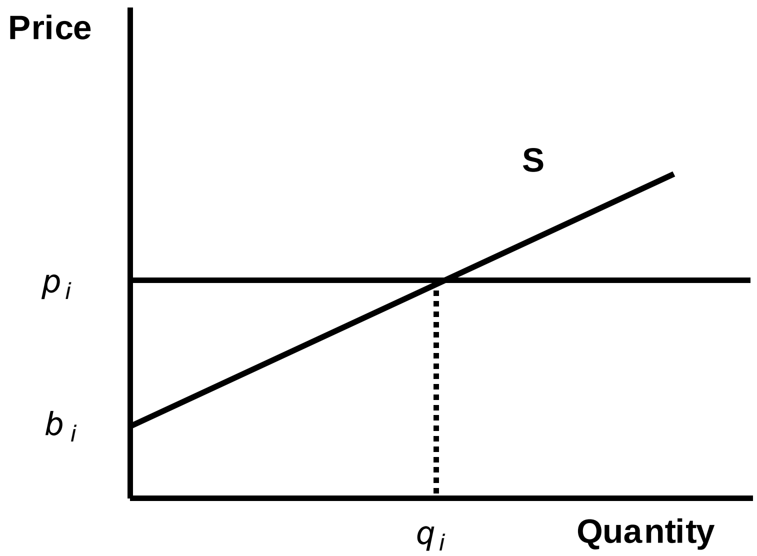
Generation cost saving = Generation cost $_{\text{without inv}}$ - Generation cost $_{\text{with inv}}$.

Consumer Surplus



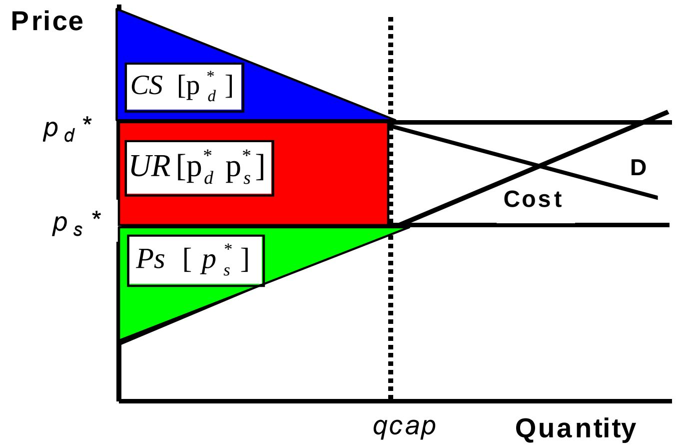
Consumer surplus for consumer j at the price p_j

Producer Surplus



Producer surplus for producer *i* at the price p_i

Surplus in a Constrained Network

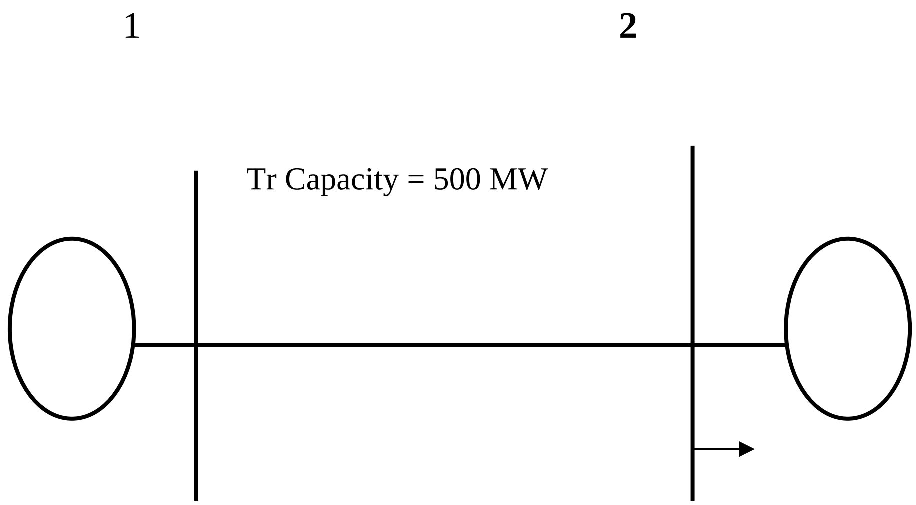


Different surpluses in a constrained network

Figure shows an equilibrium for a system in which there is one producer and one consumer connected by a single transmission link with capacity qcap.

The price at the demand is greater than the price at the supply node. The producer will receive profits equal to PS_s^* consumers will receive value represented by CS_d^* and the un-subscribed revenues, represented by the area $UR[p_d^*, p_s^*]$ is defined as the congestion rent.

Two Node Network with No Loss

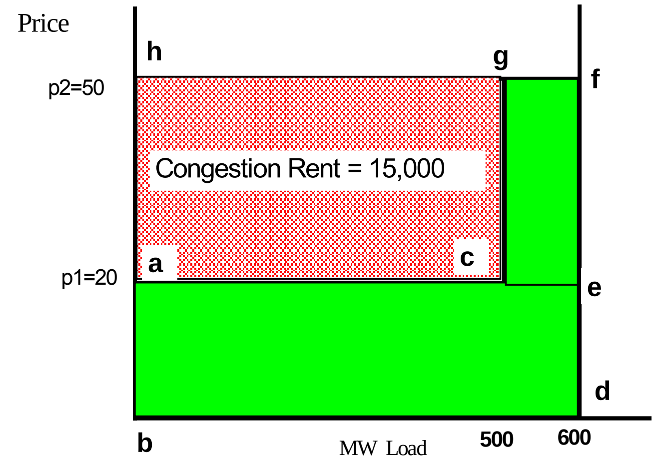


Gen 1 Capacity = 1000 MW
Marginal cost MC1 = $20/ MWH

Demand = 600 MW
Gen2 Capacity = 1000 MW

Marginal cost MC2 = $50/ MWH

Two node, loss less network



No transmission Congestion

Spot price (system marginal price) at node 1 & 2

$\rho_1 = \rho_2 =$ \$20 / MWH.

Total generation cost = area "abde" = 600 *20= \$12000

Total bill paid by the customer = area "abde" = 600*20 = 12,000

With Transmission Congestion for a transmission capacity = 500 MW

Since transmission line is congested, a marginal electricity demand at node 2 can be met only by using expensive power generated at node 2.

Marginal price at node 2, ρ_2 = 50 /MWH.

Total generation cost =area "abdfgca" 500 * 20 + 100*50 = \$15,000.

Total bill paid by the customer = area "bdfh" = 600*50 = 30,000

Cost of Congestion = area "cefg" = 15000 – 12000 = \$3000 & Congestion Rent = area "acgh" = 30,000 - 15,000 = \$15,000

Market Power

Definition

Ability to

- Profitably *Altering Prices* *away* from the competitive price level
- Restrict output below competitive level *(withholding)* for a sustained period [*Financially* by bidding high or *physically* by curtailing output]

Due to

- Market Concentration
- Transmission Congestion

Effect of Market Power

- Transfer of wealth from customers to suppliers
- Dead weight loss to society

Monitoring Market Power

- Current Methods Include: HHI Index, and the Lerner Index
- HHI index
  - DOJ, FERC uses this index to identify the effect of merger on market power.
  - Based on Market Share

HHI (Herfindahl - Hirschman Index)

$$HHI = \sum_{i=1}^{N} \alpha_i^2$$

$$\alpha_i = \frac{q_i}{Q} = \text{Market Share of supplier } i$$

HHI ranges between 0 and 10,000

Example: A=20%, B=40%, C=30%, D=10%. Then HHI = 3000. What does it mean?

As per FERC, USA;

HHI < 1000, Market is not concentrated

HHI <1800 but >1000, Market is moderately concentrated

HHI >1800 Market is concentrated

What about NZ ?

Four Factors that HHI Ignores

A. Demand Elasticity

$$Demand\ Elasticity = \frac{\%change\ in\ demand}{\%change\ in\ \Pr ice} = \frac{dQ}{dP}.\frac{P}{Q};$$

All demand elasticities are negative (- ve sign dropped)

B. Style of competition

C. Forward contracting

D. Geographic extent of the Market

2. Lerner Index (Ramsey pricing)

Max: Utilities to consumers - production cost

$$= \int_0^q p(x).dx - \int_0^q c(x).dx$$

Subject to

$$pq - \int_0^q c(x).dx = 0; \theta$$

$$L = \int_0^q p(x).dx - \int_0^q c(x).dx + \theta.[pq - \int_0^q c(x).dx]$$

Using, $c(x) = MC = \lambda$

$$\frac{\partial L}{\partial q} = p - \lambda + \theta.[p - \frac{dp}{dq}q - \lambda] = 0$$

Using $e = \frac{dq}{dp}\frac{p}{q}$,

$$\frac{p - \lambda}{p} = \frac{\alpha}{e}$$

$$\alpha = \frac{\theta}{1 + \theta}$$

The expression $\frac{p - \lambda}{p}$ is known as Lerner Index and expressed as a ratio of difference in Price to marginal cost and the price

1) $\alpha = 0$ corresponds to $p = \lambda$ and results into competitive price

2) $\alpha = 1$ corresponds to $p = \frac{\lambda}{1 - \frac{1}{e}}$ and results into Monopoly price

LI for Cournot Oligopoly

- LI index in terms of individual market share

$$L_X = \frac{p-\lambda}{p} = \frac{s_i}{e} \text{ where market share, } s_i = \frac{q_i}{Q}$$

- Average LI index in terms of HHI Index

$$Average\ L_X = \frac{p-\lambda}{p} = \frac{HHI}{e} \text{ where } HHI = \sum_{i=1}^{N} s_i^2$$

Capacity Pricing

- As a general rule, in models with capacity constraints, Firms make positive profit and market price > marginal cost.
- For rigid capacity constraint, marginal cost c upto q(capacity) and then = *infinity*.
- Rationing
  - Efficient Rationing
  - Proportional Rationing

Conjectural Variations

- Consider a 3-firm oligopoly, and assume they produce and sell a single homogeneous product at the same market price P.
- Let Z_1, Z_2, Z_3 be the output of firms 1, 2, and 3.
- Total output = Z where, $Z = Z_1 + Z_2 + Z_3$
- Industry demand function, $P = P(Z) = P(Z_1, Z_2, Z_3)$

Total revenue for firm i,

$$TR_i = P.Z_i \qquad i = 1,2,3$$

$$= TR_i(Z_1, Z_2, Z_3)$$

Total Profit for firm i,

$$\pi_i = TR_i - TC_i(Z_i); \quad i = 1,2,3 \quad \text{(xx)}$$

$TC_i =$ Total cost function of the firm i

Assume each firm maximises its own profit, differentiate (xx) wrt each firm's output and set to zero;

$$\frac{d\pi_1}{dZ_1} = \frac{dTR_1}{dZ_1} + \frac{dTR_1}{dZ_2}.\frac{dZ_2}{dZ_1} + \frac{dTR_1}{dZ_3}\frac{dZ_3}{dZ_1} - \frac{dTC_1}{dZ_1} = 0 \quad \text{(x1x1)}$$

$$\frac{d\pi_2}{dZ_2} = \frac{dTR_2}{dZ_2} + \frac{dTR_2}{dZ_1}.\frac{dZ_1}{dZ_2} + \frac{dTR_2}{dZ_3}\frac{dZ_3}{dZ_2} - \frac{dTC_2}{dZ_2} = 0 \quad \text{(x2x2)}$$

$$\frac{d\pi_3}{dZ_3} = \frac{dTR_3}{dZ_3} + \frac{dTR_3}{dZ_1}.\frac{dZ_1}{dZ_3} + \frac{dTR_3}{dZ_2}\frac{dZ_2}{dZ_3} - \frac{dTC_3}{dZ_3} = 0 \quad \text{(x3x3)}$$

We can solve the above 3 equations, if we know:

- either the functional form,
- Or, the values of the derivatives

$$\frac{dZ_1}{dZ_2}, \frac{dZ_1}{dZ_3}; \frac{dZ_2}{dZ_1}, \frac{dZ_2}{dZ_3}; \text{and} \frac{dZ_3}{dZ_1}, \frac{dZ_3}{dZ_2}$$

These derivatives are called conjectural variations. Various oligopoly models can be developed on the assumptions of these conjectured variations.

Cournot Gaming

Based on Quantity, rather than Price

Example with Duopoly (G1 and G2)

Assume, Homogeneous Product, same market price and cost of production =0,

Demand curve: $P = 12 - Q$

Assume $Q = q1 + q2$; then $P = 12 - (q1 + q2)$

Profits are $\Pi_1 = (12-(q1 + q2))^* q1$; and $\Pi_2 = (12-(q1 + q2))^* q2$;

Note Π_1 depends not only upon q1 but also on q2 and vice versa. And sum of profits depend upon q1 and q2 both. Thus we confronted with a 2-person, non-constant-sum game.

- In Cournot model, G1 regards q2 constant and G2 considers q1 constant and thus each of the terms is ZERO

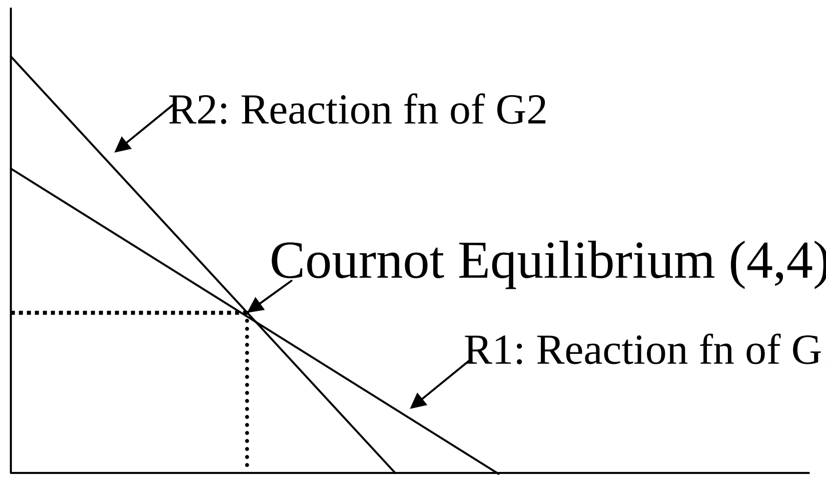
$$\frac{dq_1}{dq_2} \; and \; \frac{dq_2}{dq_1};$$

- *Therefore* $MR_i = MC_i$

- *For profit maximisation, Differentiate profit functions wrt q1 and q2.*

Q1=6-0.5 q2   Reaction function of G1

Q2=6-0.5 q1   Reaction function of G2



Any point on R1 gives the value of Profit maximising output of G1as a function of q2.

q1 = 4, and q2 = 4 is the Cournot equilibrium.

Acknowledgements

Mr. Kieran Devine

General Manager, System Operator, Transpower

Mr. Doug Goodwin

Manager, Development Group

System Operator, Transpower