Engineering, Economics & Regulation of the Electric Power Sector

ESD.934, 6.974

Session 11
Module D.4

Generation & wholesale markets
Market power

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Study material *(1 of 2)*

- Kenneth Rose, "Market power in the emerging competitive electric supply industry" *<Quasi-tutorial paper on market power in electricity markets in the US context>*
- Udi Helman, "Market power monitoring and mitigation in the US wholesale power markets", Energy 31 (2006) pp. 877-904 *<excellent revision of market power issues in the US context. A bit more complex to read, but a more complete view>*

Study material *(2 of 2)*

- FERC Order 697-A *<on the conditions to allow market-based rates, depending on market power mitigation issues. Very technical in legal terms. Just to have an idea of the terminology and the issues involved when examining market power in actual systems>*

"Material for this transparency has been borrowed from Bernard Tenenbaum, from FERC in the USA.

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Readings

- The Brattle Group, "Review of PJM's Market Power Mitigation Practices", 2007 <short & easy to read>
- OFFER, "Power pool consultation", 1999 <enquiry by OFGEM of potentially anti-competitive behaviour of the UK market agents>

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Outline

- Definitions
- Regulation
- Metrics
- Models
  - Monopolistic market power
  - Oligopolistic market power
- Mitigation of market power

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Definitions

Market power
Definition

- *"Market power is the ability to affect the market price profitably"*
  - the standard for the normal price is the competitive equilibrium price
  - the regulatory viewpoint: how much market power is a matter of concern?
  - market power depends mostly on the structure, not on the rules in a competitive market
    - However, some intervenionist *(i.e. limitations on the functioning of the market)* regulatory measures can mitigate market power
  - Distinguish between the existence of market power & the exercise (abuse) of market power

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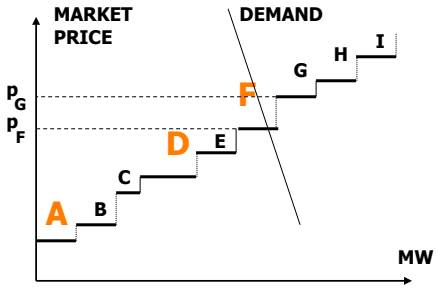
How can market power be exercised?



If plants A, D & F belong to the same generation company, removal of plant F (by bidding higher) increases the system price from P^F to P^G and the benefits to the company may increase

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Horizontal market power (*)

- Horizontal MP exists when a supplier or group of suppliers is able to influence the price of a product for their benefit
  - The typical case is when a firm has a large share of the market & faces competition by smaller firms
    - However, size & market share alone are not synonymous with market power, although they help

(*) Source: K. Rose, "Electricity competition: Market power, mergers and PUHCA", NRRI, Ohio State University, 1999.

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Other types of market power

Vertical market power (*)

- Vertical MP exists when a transmission or distribution owning company can favor itself or its own affiliate in the provision of a competitive service
  - This is a barrier of entry that prevents other suppliers to have access to customers
  - These barriers may be price (e.g. an excessive network fee) or just difficulties to access the network
  - Vertical MP allows a single supplier or group of suppliers a significant strategic advantage in terms of access to customers that other suppliers will not be able to obtain

(*) Source: K. Rose, "Electricity competition: Market power, mergers and PUHCA", NRRI, Ohio State University, 1999.

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How market power can be exercised?
(Art. 82 of the EC Treaty)

"Any abuse by one or more undertakings of a dominant position within the common market or in a substantial part of it shall be prohibited as incompatible with the common market in so far as it may affect trade between Member States.

Such abuse may, in particular, consist in:

a) directly or indirectly imposing unfair purchase of selling prices or unfair trading conditions:

b) limiting production, markets or technical development to the prejudice of consumers;

c) applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage;

d) Making the conclusion of contracts subject to acceptance by other parties of supplementary obligations which, by their nature or according to commercial use, have no connection with the subject of such contracts"

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Always remember that …

"When structure is not conducive to competition, the regulator and pool operator will find themselves unsuccessfully chasing after conduct. The solution is not a better rule, but a change in structure"(*)

(*) From "Governance & regulation of power pools & system operators", Barker, J., Tenenbaum, B. & Woolf, F., World Bank, 1997.

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Regulation

US regulation

- **FERC** has a statutory obligation under the Federal Power Act 1935 to ensure that individual State Regulatory Commissions manage liberalization to ensure that wholesale prices remain "just and reasonable"
  - Before an electric utility could be allowed to sell at wholesale market prices, any market power has to be adequately mitigated
  - And the authorization can be withdrawn (& regulated prices will be used instead) if "there is any change in status that would reflect a departure from the characteristics the Commission has relied upon in approving market-based pricing"

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EU regulation *(1 of 2)*

- The perspective of **defense of competition**: Articles 81 & 82 of the EU Treaty examine mergers & acquisitions, as well as anticompetitive behavior; however, they do not limit market power ex ante
- **Electricity Directives** aim to remove the barriers to create a competitive market, without (apparently) seeing the need to ensure that the resulting market structures were sufficiently competitive before introducing liberalization

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EU regulation *(2 of 2)*

- **Electricity Directive 2003/54/CE** establishes that "Member States will create adequate instruments to prevent abuses of dominant position"
  - Within the electricity sector, Member States have applied diverse regulatory mechanisms to reduce or mitigate market power ex ante (price caps, virtual power sales, restrictions to investment, forced divestitures, mandatory contracts, etc.)

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The "relevant market"

(EU Commission, 1997)

"A relevant product market comprises all those products &/or services which are regarded as interchangeable or substitutable by the consumer, by reason of the product' characteristics, their prices & their intended use.

The relevant geographic market comprises the area in which the undertakings concerned are involved in the supply & demand of products & services, in which the conditions of competition are sufficiently homogeneous and which can be distinguished from neighboring areas because the conditions of competition are appreciably different in those areas"

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The "relevant market"

(US Dept. of Justice & Federal Trade Commission)

The SSNIP test (Small but Significant & Non-transitory increase in price):

"A market is defined as a product or group of products & a geographic area in which it is produced or sold such that a hypothetical profit-maximizing firm, not subject to price regulation, that was the only present and future seller of products in that area likely would impose at least a "small but significant & non-transitory" increase in price, assuming the terms of sale of all other products are held constant. A relevant market is a group of products and a geographical area that is no bigger than necessary to satisfy this test"

("US Horizontal Merger Guidelines,1997)

(In the US a "small" price increase is normally defined as 5%, while in the EU is 5-10%)

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Metrics

Different metrics for different tasks

- Ex-ante versus ex-post analysis
- Long-term vs. short-term analysis
- System-level market power vs. local market power
- Horizontal market power vs vertical market power

➔ Here the focus will be on horizontal concentration in generation in wholesale markets

Based on a presentation by D. Newbery, Athens, October 2005

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Tools for detection of market power

- **Structural Indices**
  - – Concentration ratios and HHI
  - – Residual Supply Index
  - – Residual Demand Analysis
- **Indices of behavior**
  - – Bid-Cost Margins (e.g. Lerner Index)
  - – Net Revenue Benchmark Analysis
- **Simulation Models**
  - – Competitive Benchmark Analysis
  - – Oligopoly Models

Based on a presentation by D. Newbery, Athens, October 2005 21

Metrics of market share

- Concentration ratios
  - C1: share of largest firm
    - C1 > 20% can be a concern, but it depends on the amount of spare capacity
  - C3, C4 total share of top 3 or 4 firms
- Available capacity, with or without imports
- Shares of production

Based on a presentation by D. Newbery, Athens, October 2005 22

Herfindahl-Hirschman index

- Herfindahl-Hirschman index (HHI)

$$HHI = \sum_i (s_i)^2$$

where

  - s_i is the market share in per unit of supplier i (output of supplier i divided by total supply)
  - in regulatory documents HHI is usually multiplied by 10000 (i.e. s_i is expressed in percentage; a market with 5 agents of equal size has a HHI of 2000)
- HHI is a very crude measure of what may actually happen in the market

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Herfindahl-Hirschman index
Detail

- If N = 1 (monopoly) ➔ HHI = 10,000
- If N -> ∞ (atomistic competition) ➔ HHI -> 0
- It is sometimes accepted that
  - HHI < 1,000 indicates adequate competition
  - HHI > 1,800 indicates inadequate competition

- **Static HHI:** On the basis of installed / available capacity
- **Dynamic HHI:** On the basis of real production or sales

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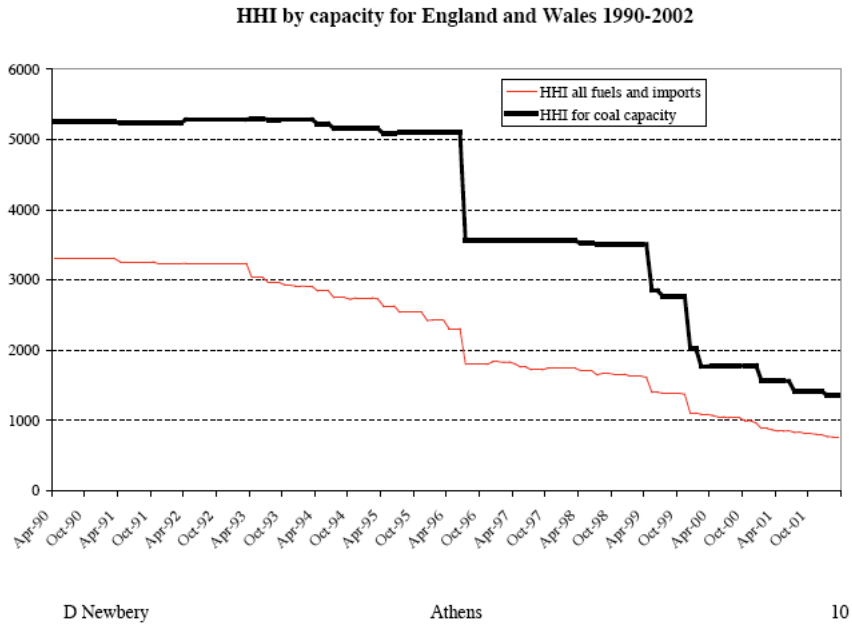

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Residual Supply Index

- RSI = $\frac{\text{(total capacity – firm's relevant capacity)}}{\text{total demand}}$
- There is a pivotal supplier if RSI < 100%
- Strengths
  - Takes into account demand side conditions
  - Suited for dynamic analysis
  - Applicable at local as well as system level
- Weaknesses
  - Ignores
    - Potential of correlated behavior (among time periods)
    - Demand elasticities
- Application: Pivotal Supplier Screen in USA

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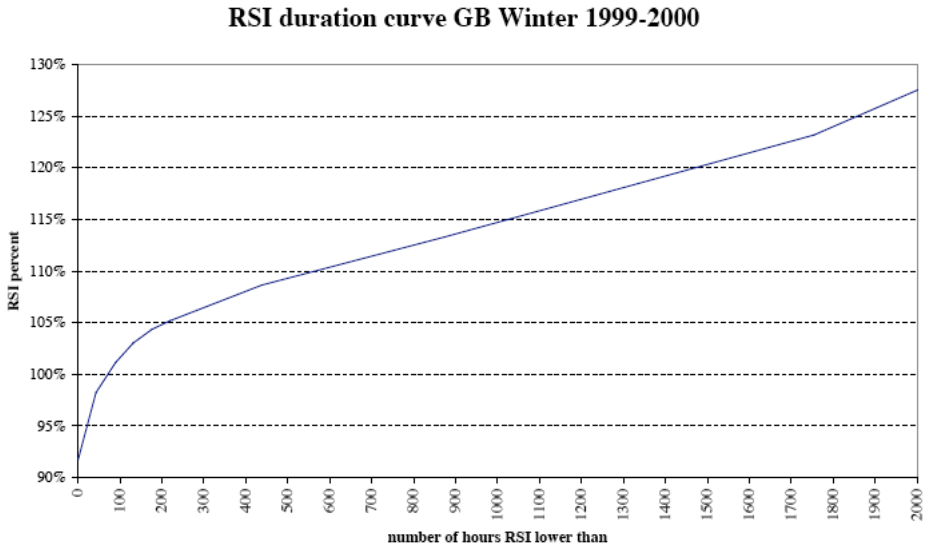

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Lerner index

- Lerner index L

$$L = (P - MC)/P$$

where

- P is the market price when the production agents exercise the complete market power that they have
- MC is the market price under perfect competitive conditions *(i.e., if the agents do not exercise any market power that they might have)*

  (In microeconomic textbooks MC in the computation of L is typically defined as the marginal cost of the supplier at the margin under the same production dispatch with which P was calculated. Then L happens to have nice mathematical properties, but it is meaningless)

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Lerner index
Detail

- Analysis of market prices
  - Lerner Index measures the mark-up of prices over marginal costs, as a percentage of prices (on the assumption that, in competition, prices equal marginal costs)

    Lerner = (P – MC)/P
- However:
  - difficulties in estimating costs and marginal costs accurately
  - prices higher than marginal costs may just signal scarcity (and may persist until new capacity enters in operation)

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Models

Market power
Models

- The following 4 conceptual models will be considered
  - Perfect competition
  - Perfect monopoly
  - Cournot
  - Cournotist behaviour with supply curve bidding

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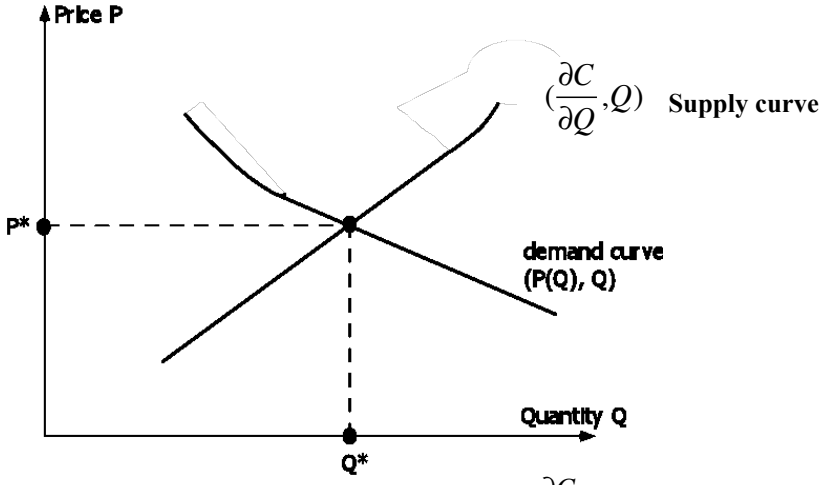
Power market models
Perfect competition



System price P(Q) equals the marginal supply cost $\frac{\partial C}{\partial Q}$

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Power market models
Perfect monopoly (1)

- One firm faces the entire demand
- The firm's benefit is

$$B(Q) = P(Q).Q - C(Q)$$

benefit = revenue - production cost

- Benefit maximization

$$P(Q) + Q.\frac{\partial P}{\partial Q} = \frac{\partial C}{\partial Q}$$

marginal revenue = marginal cost

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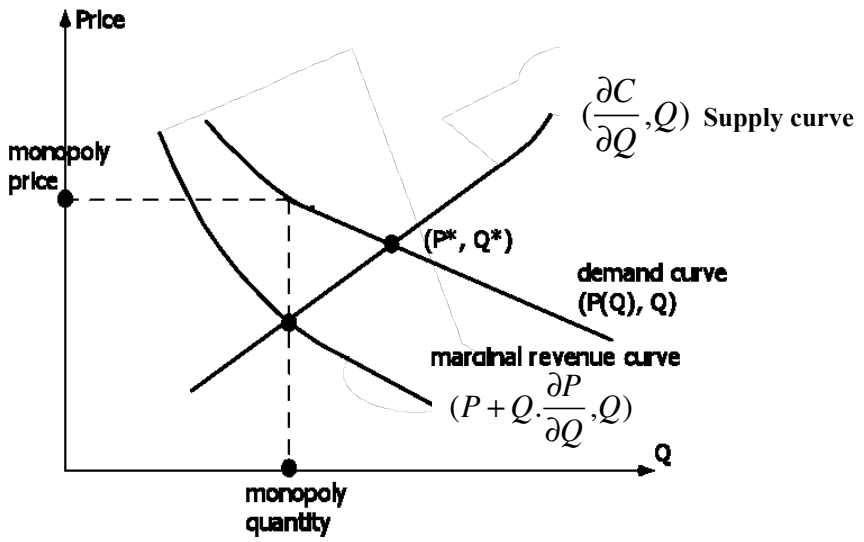

Monopolist withholds capacity in order to maximize profit, since the inframarginal capacity is paid now a higher price

Power market models
Perfect monopoly (2)

- Lerner index of a perfect monopoly. Since

$$P + Q.(\partial P/\partial Q) = \partial C/\partial Q = MC$$

$$1 + (Q/P).(\partial P/\partial Q) = MC/P$$

$$1 - 1/e = MC/P$$

$$\mathbf{L = 1/e}$$

where e is the elasticity of the demand

$$e = - (P/Q).(\partial Q/\partial P)$$

Note that MC is defined on the basis of the derivative of the production cost of the unit at the margin *in the oligopolistic equilibrium, which is not the competitive price. This choice renders this metric useless.*

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Power market models
Oligopoly

- Some firms have some control on the price
- Firms have two strategic variables: price and quantity
- Different models have been used to describe oligopolistic behavior

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Power market models
The Cournot model (1)

- Firm k is assumed to know the demand curve & the outputs Q_i of rival firms
- The strategy of firm k is similar to the perfect monopolist ➔ choose optimum output level Q_k and price $P(\Sigma Q_i)$ so that its benefit is maximized

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Power market models
The Cournot model (2)

- The benefit of firm k is

$$B_k(Q_k) = P(\Sigma Q_i).Q_k - C_k(Q_k)$$

benefit = revenue - production cost

- Benefit maximization

$$P(\Sigma Q_i) + Q_k.\, \partial(P(\Sigma Q_i)/\partial Q_k) = \partial C_k/\partial Q_k \rightarrow Q_k^*$$

marginal revenue = marginal cost

Note that only a price setter firm can manipulate P with its output Q_k

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Power market models
The Cournot model (3)

- Lerner index for the oligopolistic firm k

$$P(\Sigma Q_i) + Q_k.(\partial P(\Sigma Q_i)/\partial Q_k) = \partial C_k/\partial Q_k$$

$$1 + (Q_k/P).(\partial P/Q_k) = MC_k/P$$

$$1 + (Q_k/\Sigma Q_i).(-1/e) = MC_k/P$$

$$\mathbf{L_k = s_k/e}$$

where s_k is the market share $Q_k/\ \Sigma Q_i$ of supplier k

- Limitation: Note that L_k does not depend on the mix of units of firm k

Note that MC is defined on the basis of the derivative of the production cost of the unit at the margin *in the oligopolistic equilibrium, which is not the competitive price.*

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Power market models
The Cournot model (4)

- HHI index for the oligopolistic firm k

The average Lerner index is

$$Av(L) = \Sigma s_i.L_i = \Sigma (s_i)^2/e = HHI/e$$

$$\mathbf{Av(L) = HHI/e}$$

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Power market models
The Cournot model (5)

- Other properties of the Cournot model
  - The Cournot equilibrium is a Nash equilibrium when bids are expressed only as quantities (no supplier would want to modify its bid Q_k, given the bids of the remaining agents)
  - The Cournot model describes satisfactorily the actual behavior of agents in an oligopolistic market, in particular in the medium term

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The Cournot model with forward contracts

- Assume that firm k does not anticipate that today's market price will affect the price of contracts in the future *(myopic strategy or contracts are very long-term, e.g. > 5 years)*
- The benefit of firm k with a contracted quantity QC_k at a contracted price PC_k is

$$B_k(Q_k) = P(\Sigma Q).(Q_k - QC_k) + QC_k.PC_k - C_k(Q_k)$$

- The Lerner index now becomes

$$\mathbf{L_k = ss_k/e}$$

where $ss_k=(Q_k - QC_k)/ \Sigma Q_i$

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The Cournot model with supply-curve bidding (1)

- In most markets the bids have to be sent as blocks of energy at a price, i.e. as a supply curve
- Under this rule the agents are able to achieve the same Cournot equilibrium if they bid blocks of energy at marginal cost (or below) until $Q = Q_k^*$ and a very high price for $Q > Q_k^*$

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The Cournot model with supply-curve bidding (2)

- If demand is uncertain, the optimal value of Q_k^* will depend on the demand level ➔ the optimal cournotist bidding strategy is the supply curve (price, quantity) that passes by all these points
  - If all agents bid following this strategy, firm k will see a "residual demand curve" (i.e. the original demand less the supply curves of all competitors) with higher elasticity *(i.e. flatter)* ➔ market power has been reduced
- If there is scarcity of supply to meet demand, all the supply curves are very steep near the equilibrium point ➔ the "residual demand curve" is also steep ➔ better opportunity to exercise market power

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A difficulty
Sensitivity of realistic models ???

- Hogan
  - **'Due to the central role of assumptions, the margin of error may well be larger than the magnitude of the effect that one is attempting to measure'**
- Neuhoff "The devil is in the details"
  - **'Clever choice of reasonable assumptions can be used to replicate any observed price; this is a generic problem with over-parameterized models'**
- Smeers
  - **'Models are not currently capable of providing the degree of legal and regulatory certainty that the importance of ex-ante remedies requires'**

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Mitigation of market power

Market power
Mitigation measures

- **Elasticity of demand**
- **Avoidance of situations with scarcity of supply**
- **Divestiture &/or virtual sales**
- **Volume of forward contracts / bid caps**
  - voluntary (not a real limitation factor)
  - mandatory (load to be supplied at a regulated price, mandatory volume of contracted capacity)
  - Recovery of stranded costs "by differences" have a similar effect
- **Uncertainty in demand**
- **Long-term consequences**
  - Contestability of new entrants
  - Demand elasticity (in the long-run)
  - Regulator response

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Remedies for market power
(US Department of Energy, 2000)

- Market monitoring
- Creation of a bidding trust for certain assets
- Contracts for differences & call options
- Requirements *(to generators)* for transmission upgrades
- Interconnection requirements for open access
- Price caps for end-use customers
- Limitations on variance of bid prices
- Denial of market-based rates

Source: "Horizontal market power in restructured electricity markets", Office of Economic, Electricity & Natural Gas Analysis, Officie of Policy, US DOE, March 2000

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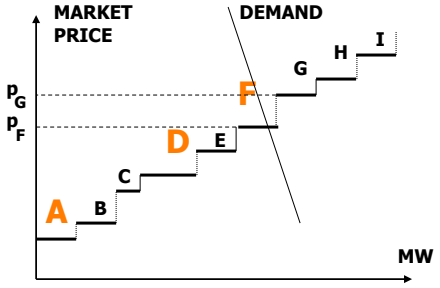
How can market power be exercised?



If plants A, D & F belong to the same generation company, removal of plant F (by bidding higher) increases the system price from P^F to P^G and the benefits to the company may increase

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Detail *(mitigation of market power)*
Long-term contracts

- Margin of oligopolist if plant F **is not** removed: $Q_A.(P_F-CV_A)+Q_D.(P_F-CV_D)$
- Margin of oligopolist if plant F **is** removed: $Q_A.(P_G-CV_A)+Q_D.(P_G-CV_D)$
- Margin of oligopolist if Q_A is contracted at P_{con} & plant F **is not** removed: $Q_A.(P_{con}-CV_A)+Q_D.(P_F-CV_D)$
- Margin of oligopolist if Q_A is contracted at P_{con} & plant F **is** removed: $Q_A.(P_{con}-CV_A)+Q_D.(P_G-CV_D)$

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Detail *(mitigation of market power)*
Virtual power sales

- Measure to mitigate market power when there is excessive horizontal concentration (e.g. Alberta, France, Spain)
- Ownership of physical assets remains with the original owner
- But the commercialization of the output of the plants is offered in a competitive open auction. Possibilities
  - The energy that is produced by some prescribed plants
  - An option to buy energy from the company up to a prescribed capacity & for a prescribed time

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Case example

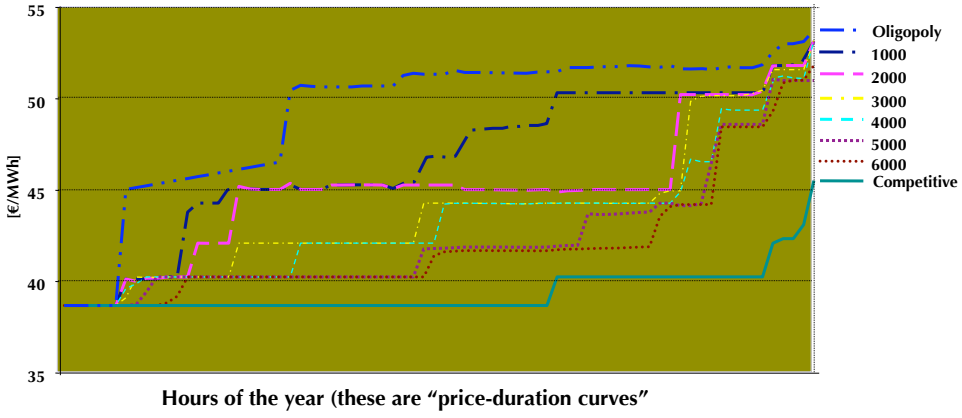
Source:
Pérez-Arriaga, J.I., Batlle, C., Vázquez, C., Rivier M., Rodilla, P., "*White Paper on the reform of the regulatory framework of electricity generation in Spain", Instituto de Investigación Tecnológica (IIT), Comillas University, July 2005. Available at http://www6.mityc.es/energia/archivos/LibroBlanco.pdf*

Case example: Proposal for regulatory reform of the Spanish electricity wholesale market (White Paper, July 2005)

- The proposal of the White Paper
  - Limit on the amount of effective production capacity that is free from long-term commercial commitments
  - Available regulatory instruments
    - Divestiture, virtual power sales, long-term contracts, virtual power contracts
    - Besides other more traditional regulatory measures

Quantitative analysis of the impact of long-term contracts

- Market prices diminish as the level of long-term contracting grows



Hours of the year (these are "price-duration curves"

Proposed implementation

shoulder

Indicative effective capacities & quotas

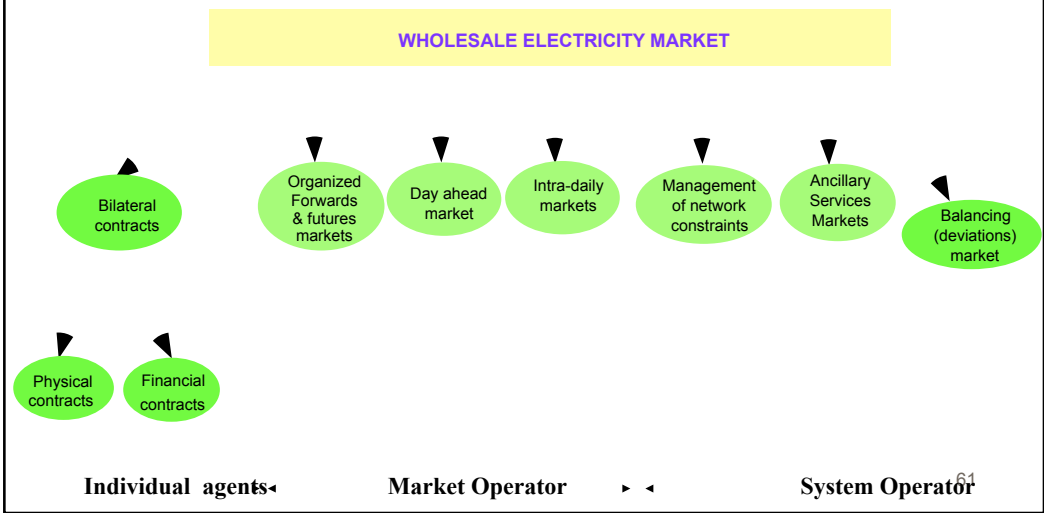
- Maximum effective production capacity for each agent

shoulder	**19%**
peak	**22%**

- Effective production capacity of each generation company in the short-term markets (in %)

Llano							
Total	EN	IB	UF	HC	VI	GN	OT
2005	68	86	100	100	100	100	100
2008	68	73	100	100	100	100	100
Punta							
Total	EN	IB	UF	HC	VI	GN	OT
2005	67	70	100	100	100	100	100
2008	68	64	100	100	100	100	100

Possible transactions in the wholesale market



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