Electricity Markets: Summer Semester 2016, Lecture 10

Tom Brown, Mirko Schäfer

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Frankfurt Institute of Advanced Studies (FIAS), Goethe-Universität Frankfurt
FIAS Renewable Energy System and Network Analysis (FRESNA)

{brown,schaefer}@fias.uni-frankfurt.de

FIAS Frankfurt Institute for Advanced Studies

Preface: Competitive bidding

Why markets?

We've learned that the optimal rates of generation and consumption in an electricity system can be obtained from an optimisation process under constraints. Given enough information and control power, an omniscient system operator could perform this optimisation and achieve an economically efficient use of the resources.
But experience shows: incentives with respect to productive efficiency, innovation and customer responsiveness tend to be much higher in competitive markets.

Market mechanism

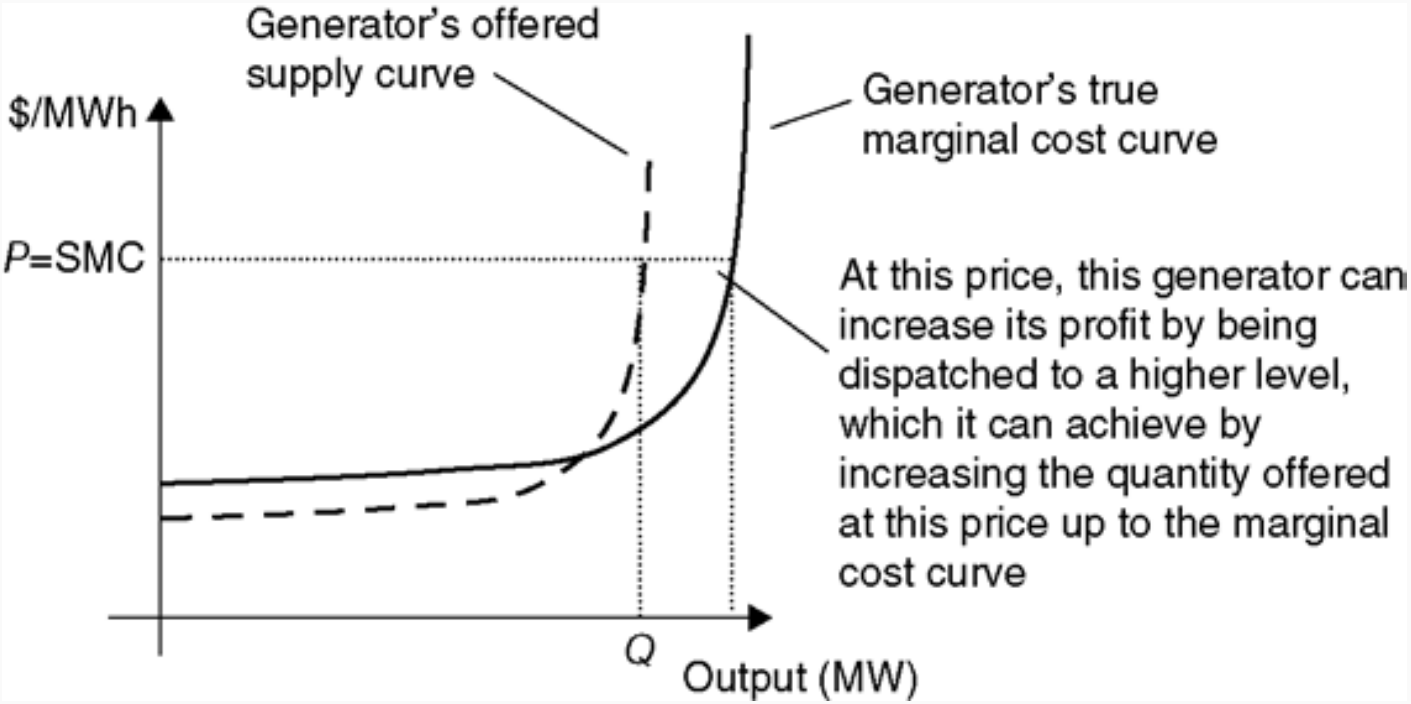
We assume that the market operates as follows:

- Market participants send key supply/demand information to a central system operator
- From this information, the system operator computes the optimal dispatch (which maximises total economic wellfare). The output is a rate of production or consumption for every market participant, and a set of prices for the different price zones.
- The market participants receive the key information about the market outcome from the system operator and adjust their rate of production or consumption accordingly.

Economic game: What information (supply and demand curves) do the market participants report to the system operator?

Optimal dispatch through competitive bidding

A price-taking generator has an incentive to truthfully reveal its marginal cost of production.



Source: Biggar & Hesamzadeh

Problems in practice

- Market power (some market participants may have influence over the market price)
- Limits on prices
- Limits on the frequency of the market process
- Startup costs, minimum production levels,...
- Limits in the communication of the supply and demand information

Market power in electricity markets - basic concepts

Definition of market power

- Definition in *Economics* by Samuelson and Nordhaus (19th edition, 2010):
  "Market power signifies the degree of control that a single firm or a small number of firms have over the price and production decisions in an industry."
- We use the following definition: We say that a generator has market power if by changing its rate of production, it can affect the wholesale market price it is paid. Analogously, a load has market power if by changing its rate of consumption, it can affect the wholesale market price it has to pay.

The residual demand curve

Assume that the market price is a function of the rate of generation of a generator. We call this function the residual demand curve $P^{RD}(Q)$. Other things in the market being equal, this curve shows the relation of the market price P which is paid to the generator, depending on its rate of generation Q.

We assume

$$\frac{dP^{RD}}{dQ} < 0 \ ,$$

i.e. an increase of production lowers the market price paid to the generator.

Maximising short-run profits

The generator chooses a level of output which maximises its short-run profit:

$$\max_{Q} \left[P^{RD}(Q)Q - C(Q) \right] \ .$$

First-order condition:

$$P^{RD}(Q^*) + Q^* \left. \frac{dP^{RD}(Q)}{dQ} \right|_{Q=Q^*} = C'(Q^*) \ .$$

The left side of this equation is the marginal revenue curve. The profit maximising rate of production is where the marginal revenue is equal to the marginal cost.

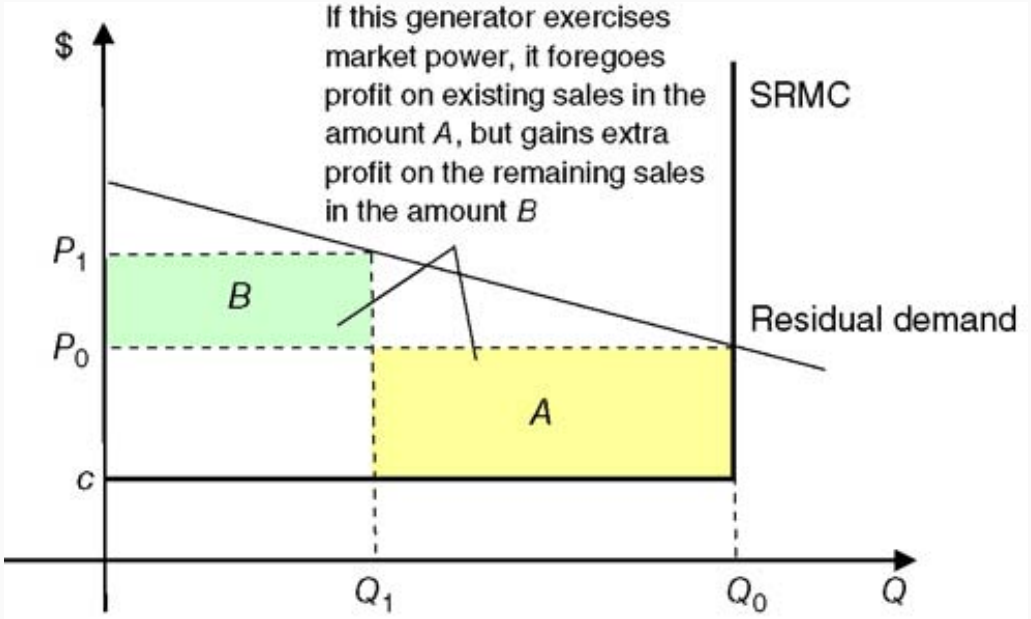
The price-volume trade-off

$$P^{RD}(Q^*) + Q^* \left. \frac{dP^{RD}(Q)}{dQ} \right|_{Q=Q^*} = C'(Q^*) \, .$$

The residual demand curve $P^{RD}(Q)$ has negative slope: price-volume trade-off between a lower spot price for a larger volume, or a higher spot price for a lesser volume.

The price-volume trade-off: example

Generator with a constant short-run marginal cost c and market power:



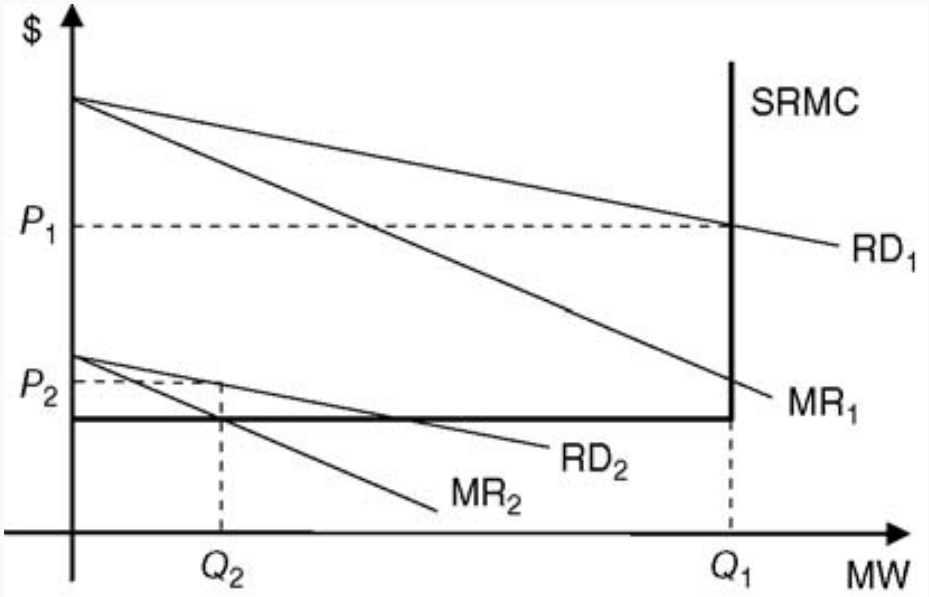
Generator will choose to produce at a lower rate of production if area B is larger than area A (depends on various factors).

Source: Biggar & Hesamzadeh

Optimal rate of production

Marginal revenue equal to short-run marginal cost of production:

$$P^{RD}(Q^*) + Q^* \frac{dP^{PR}}{dQ^*} = C'(Q^*) \ .$$



Source: Biggar & Hesamzadeh

A generator exercises market power if the profit-maximising price-quantity (Q, P) is not on the marginal cost curve.

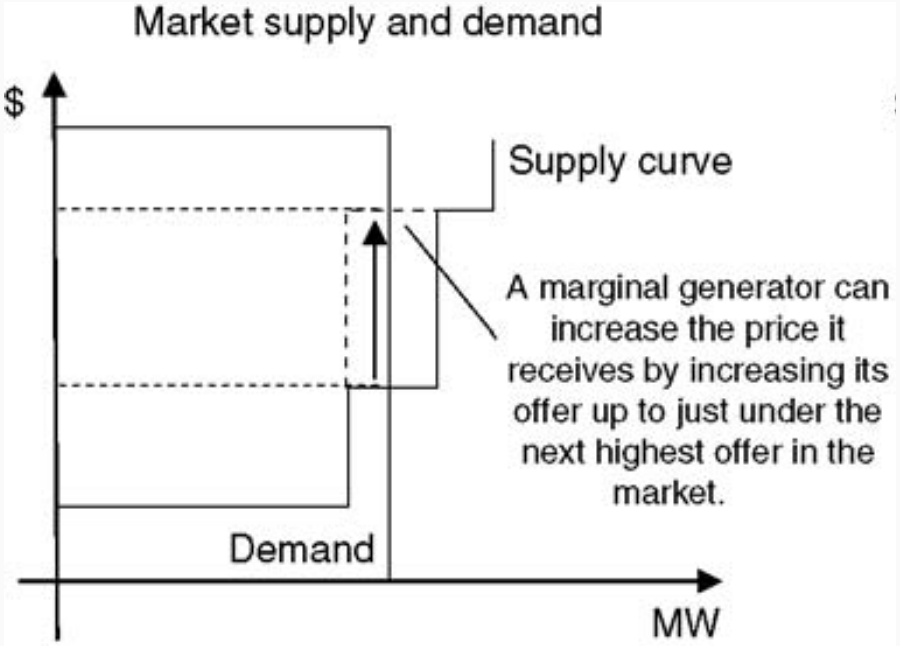
Withholding of production capacity

Reduction of the quantity offered to the market at a given price, or increase of the price at which the generator is prepared to produce at a given rate of output.

- Economic withholding: submission of an offer curve leading to a dispatch with a price-quantity combination above the generators marginal cost curve.
- Physical withholding: making some proportion of the plant physically unavailable

Pricing up and the marginal generator

- Marginal generator: generator(s) whose offer directly affects the wholesale spot price at a given point in time.
- Pricing up: Raise the offer just below the next-highest offer which is in the market



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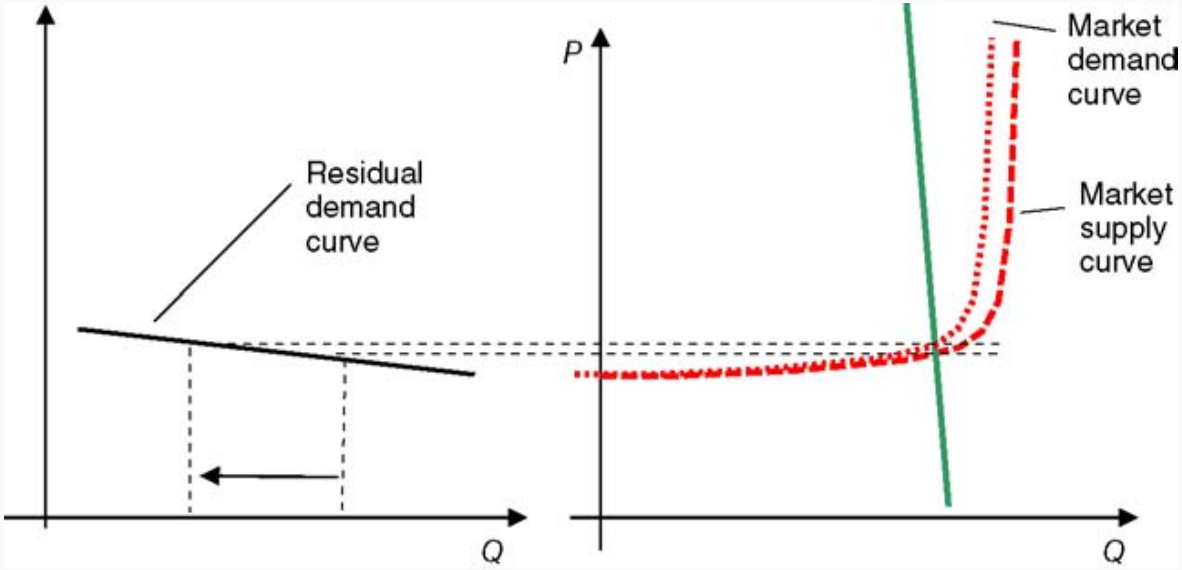
The shape of the residual demand curve

Assumption: the residual demand curve is the marked demand less the supply of all other generators.

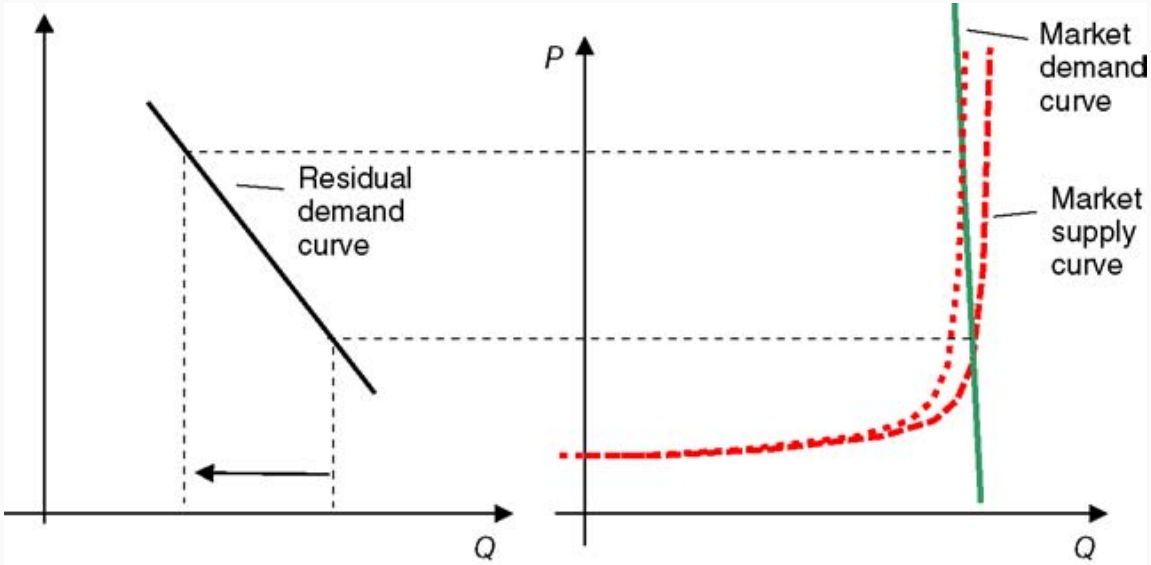


Off-peak situation: reduction of the output can be covered by spare capacity of other generators; only modest amount of increase in the local market price.

Source: Biggar & Hesamzadeh

The shape of the residual demand curve

Assumption: the residual demand curve is the market demand less the supply of all other generators.



Peak situation: other generators are running at or very near their capacity; a single generator can have substantial market power.

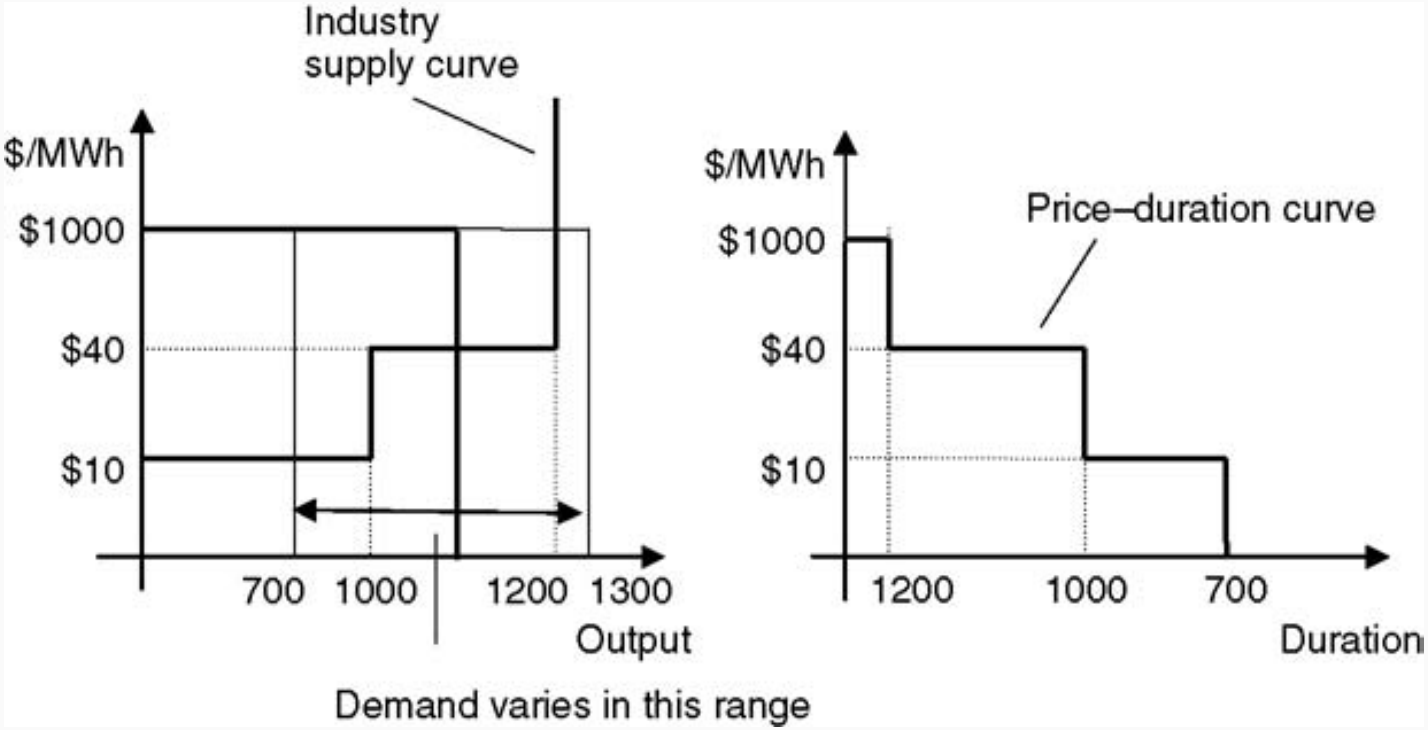
Source: Biggar & Hesamzadeh

Market power: example

Example

- Total generation capacity of 1200 MW, of which 1000 MW has marginal cost 10 €/MWh, and 200 MW has marginal cost 40 €/MWh.
- Demand is inelastic up to 1000 €/MWh. It varies between 700 MW and 1300 MW. Above the price of 1000 €/MWh demand is zero.

Market outcome in a competitive industry



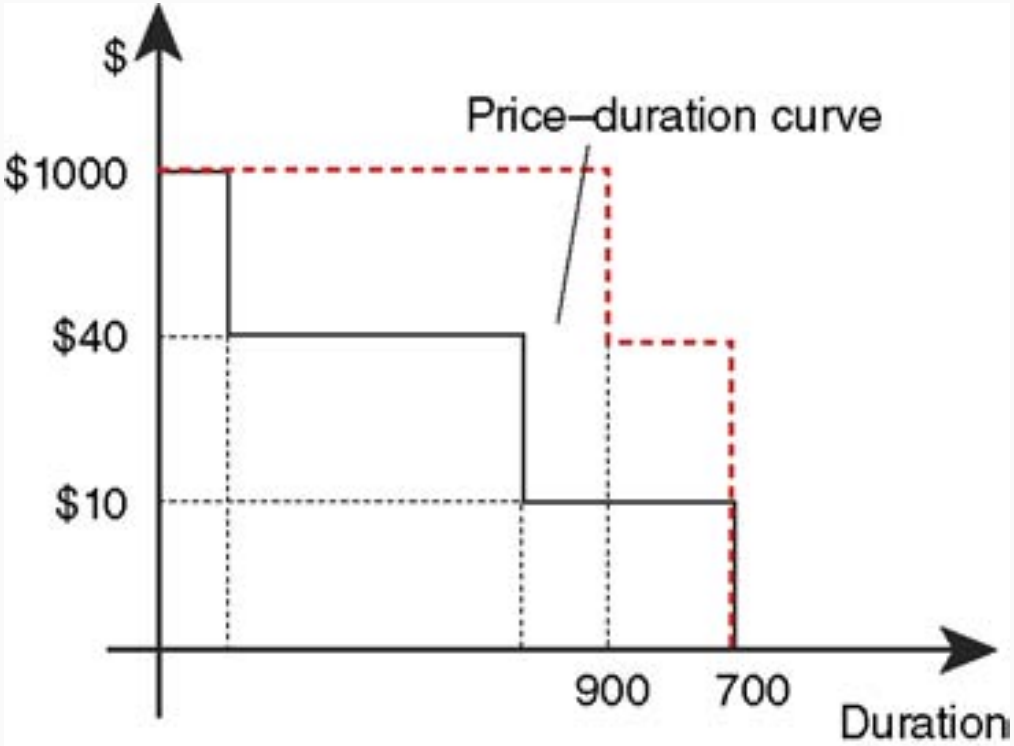
Source: Biggar & Hesamzadeh

One dominant generator

Assume that out of the 1000 MW generation capacity with marginal cost 10 €/MWh, there is a single generator with 300 MW, and the remaining 700 MW are so small that they are effectively price takers.

If demand is larger than 700 MW, this single (dominant) generator can affect the price. By providing just the demand above 700 MW or 900 MW, it can rise the price to 40 €/MWh or 1000 €/MWh, respectively.

One dominant generator



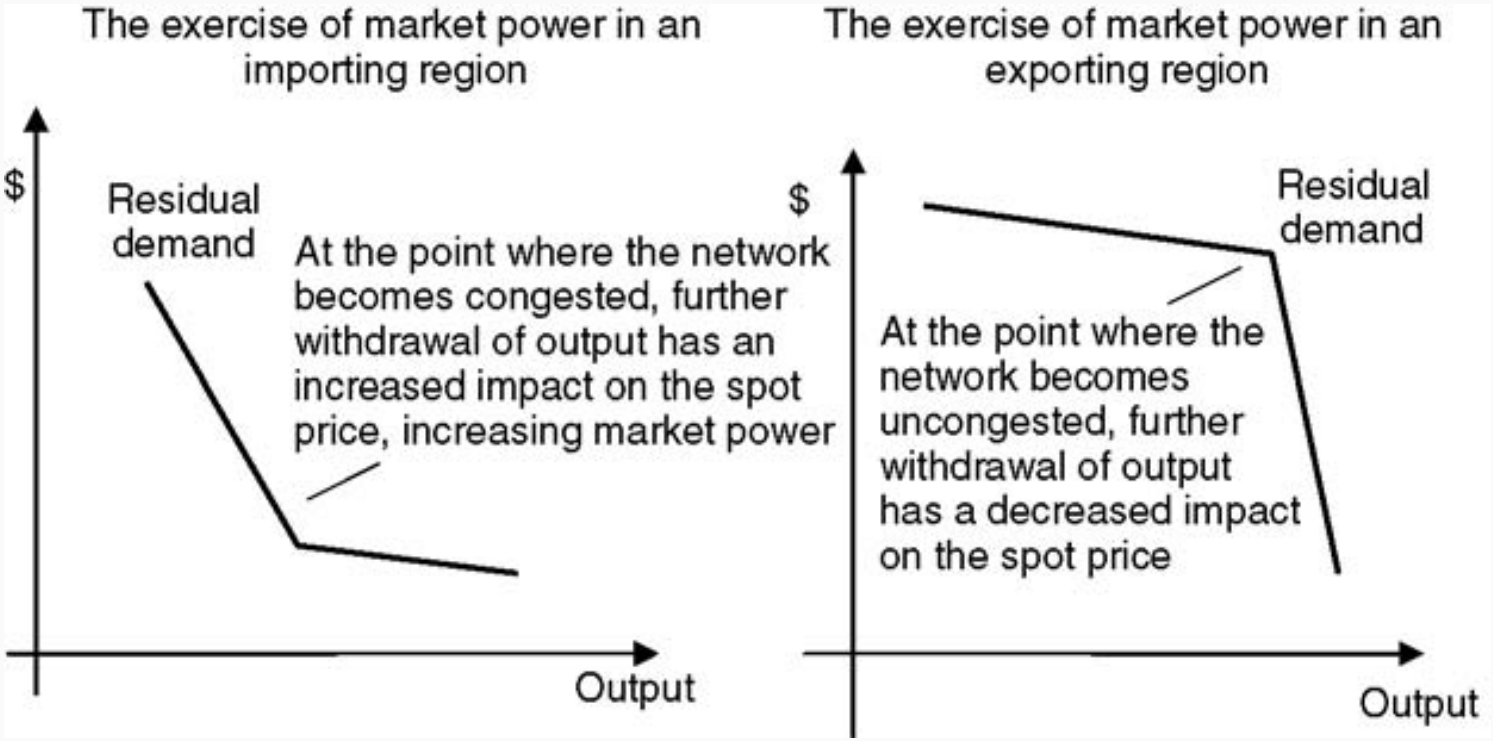
Source: Biggar & Hesamzadeh

Market power and network congestion

The influence of transmission constraints

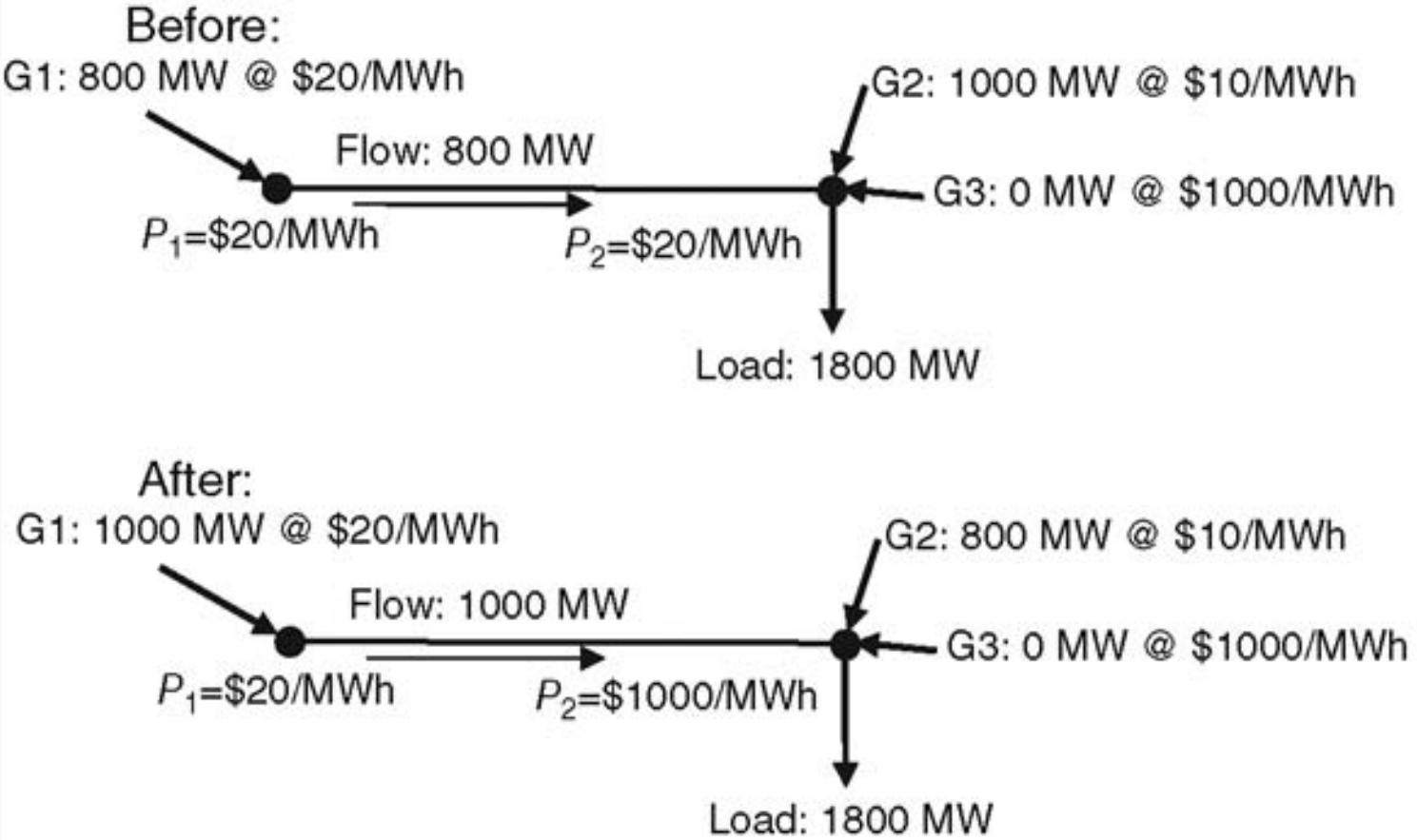
We've learned that in a peak situation many generators run at their capacity and cannot respond to capacity withholding with an increase of their own production.
Similarly, transmission constraints can prevent other generators to respond to capacity withholding (that is, the geographic scope of the market and thus number of competing generators is reduced).

Market power and network congestion



Source: Biggar & Hesamzadeh

Example



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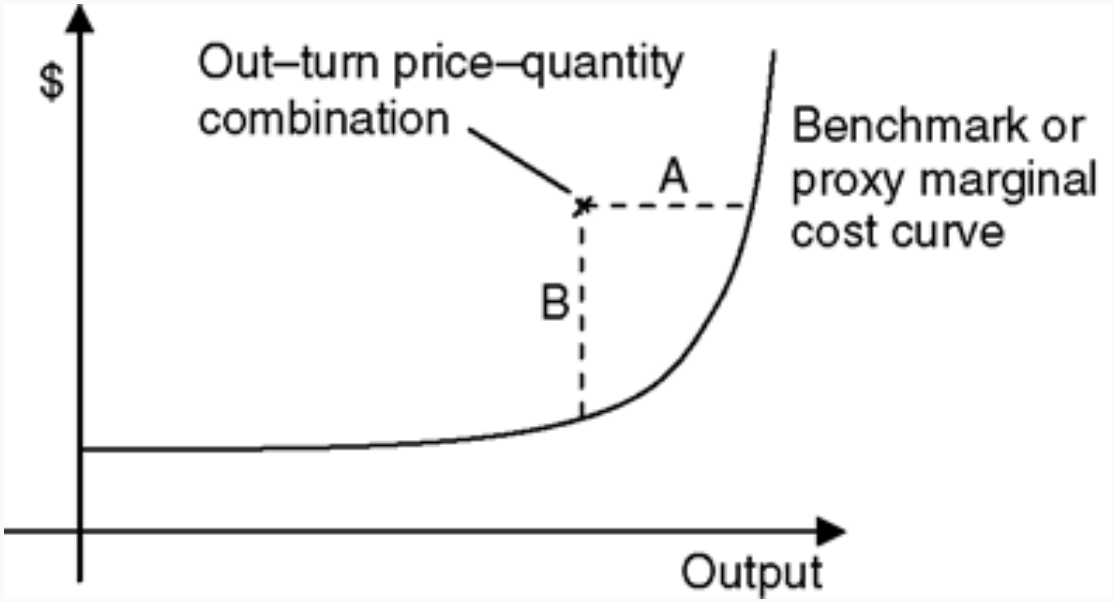
Detecting market power and policies

Examination of market outcomes in the past

Detection of market power: compare a generator's offer curve (price-dispatch quantity combination) to its marginal cost curve.



Source: Biggar & Hesamzadeh

Price-cost margin studies

Lerner index:

$$L = \frac{P - SRMC}{P} \ .$$

Here P is the spot price and $SRMC$ is the short-run marginal cost.
Theory:

$$P^{RD}(Q^*) + Q^* \frac{dP^{RD}}{dQ^*} = C'(Q^*)$$

$$\Rightarrow \quad \frac{P^{RD} - C'(Q^*)}{P^{RD}} = -\frac{Q^*}{P^{RD}} \frac{dP^{RD}}{dQ^*} = \frac{1}{\epsilon^{RD}} \ .$$

Policies to reduce market power

- Reduce market concentration
- Increase the responsiveness of demand to the wholesale price
- Reduce network congestion
- Increase average hedge levels
- Price caps
- Bidding control

Example

Sector Inquiry into Electricity Generation and Wholesale Markets

Report in accordance with Section 32e (3) of the German Act against Restraints of Competition – ARC (*Gesetz gegen Wettwerwerbsbeschränkungen - GWB*). • January 2011

Summary

Source: Bundeskartellamt

Example

The Decision Division has come to the conclusion that on the basis of the applicable auction mechanism and the given market circumstances, **the undertakings which are addressees of Sections 19 and 29 ARC and Art. 102 TFEU** (only ***dominant*** undertakings) are **in principle not allowed to offer at a price exceeding their marginal costs unless** the undertaking can demonstrate that a corresponding mark-up is **necessary in order to cover** its ***total average costs*** based on its entire power plant portfolio.

Source: Bundeskartellamt

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`http://fias.uni-frankfurt.de/~brown/courses/electricity_markets/`