

Price regulation in the energy sector: introduction

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ERRA Price Regulation and Tariffs Course

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Energy prices are (still) high on the political agenda – 2013 in ...



Bulgaria

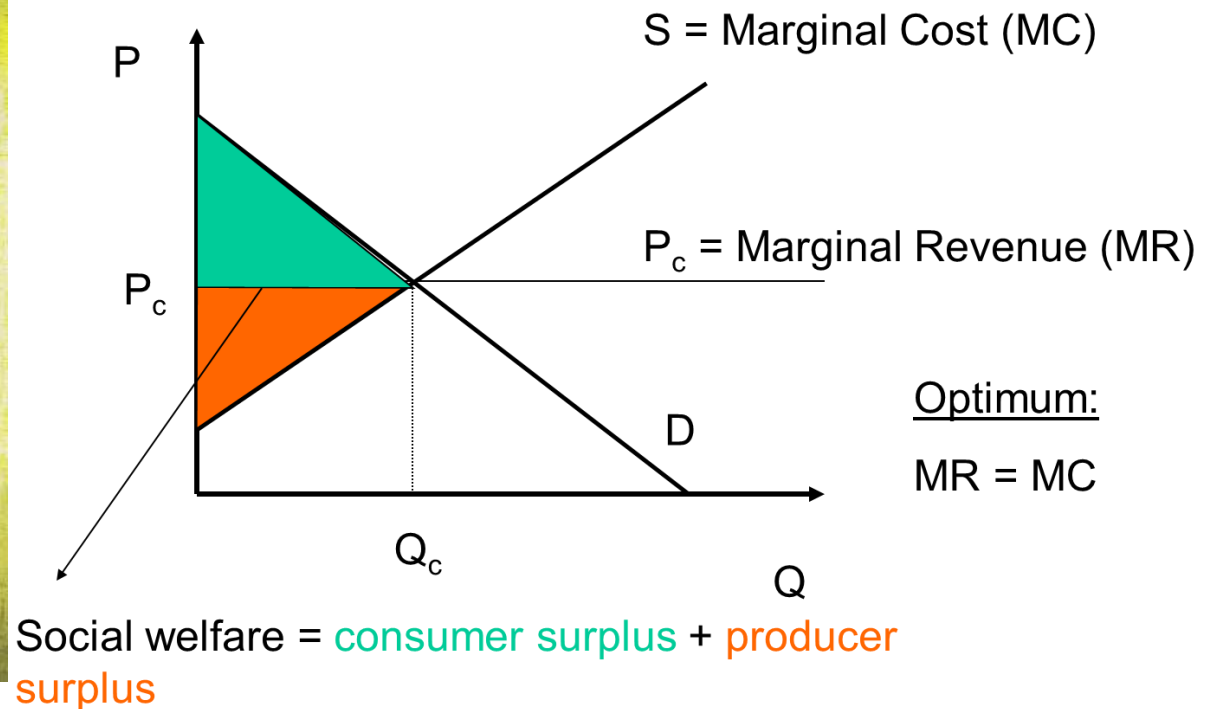
and



Hungary

Who does regulate energy prices?

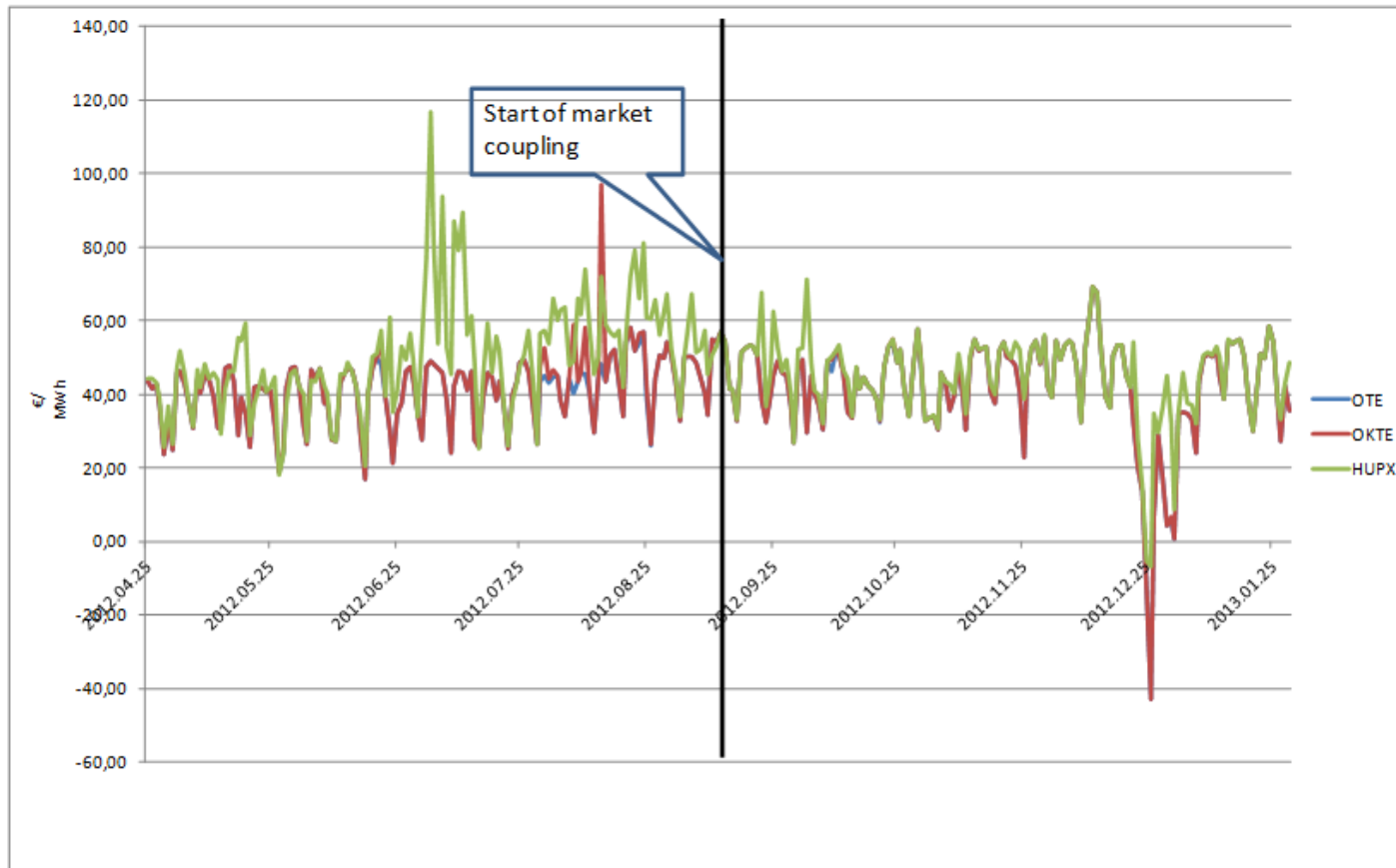
Isn't it the market?



It can be if the conditions for an efficient market prevail!

Who does regulate wholesale electricity prices on the recently coupled Czech-Slovak-Hungarian electricity market?

Figure 1. Next day baseload prices on the relevant exchanges before and after market coupling



Source: HUPX, OKTE

Hourly changes in electricity supply and demand!

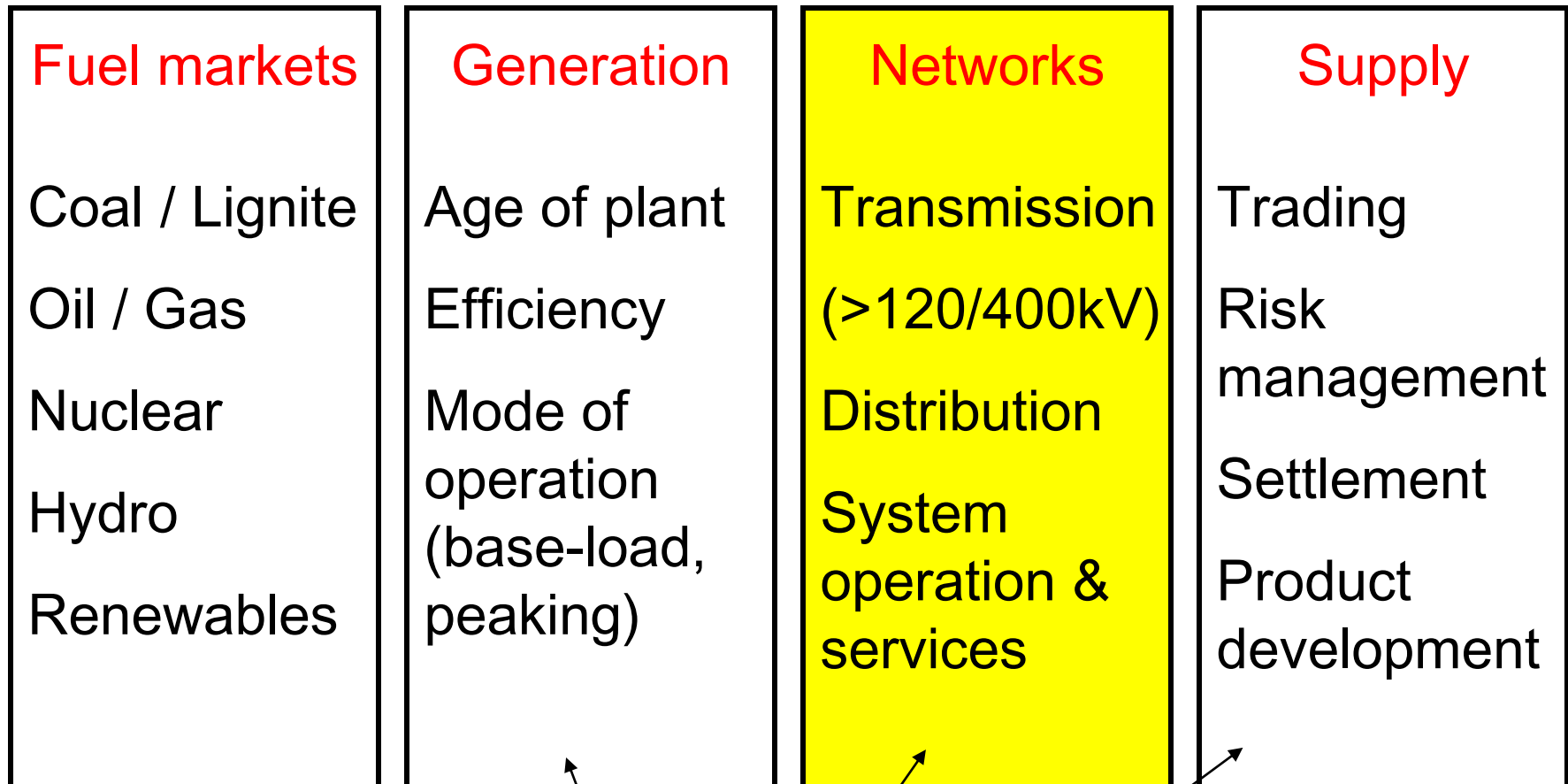
Regulation substitutes the market in case of monopolies



Energy price regulation comes with monopoly positions!

What to regulate?

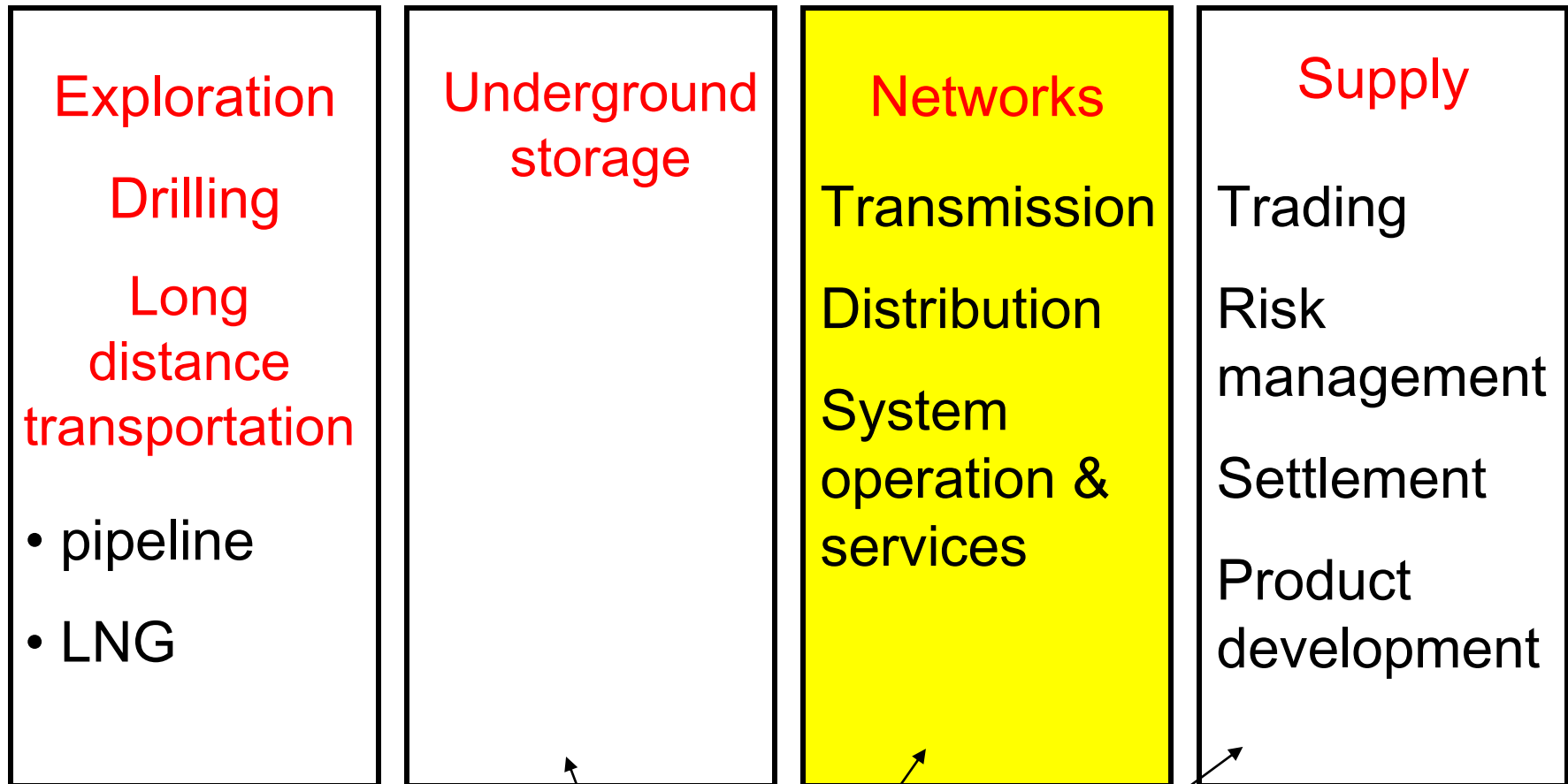
The value chain of electricity supply



Price regulation?

What to regulate?

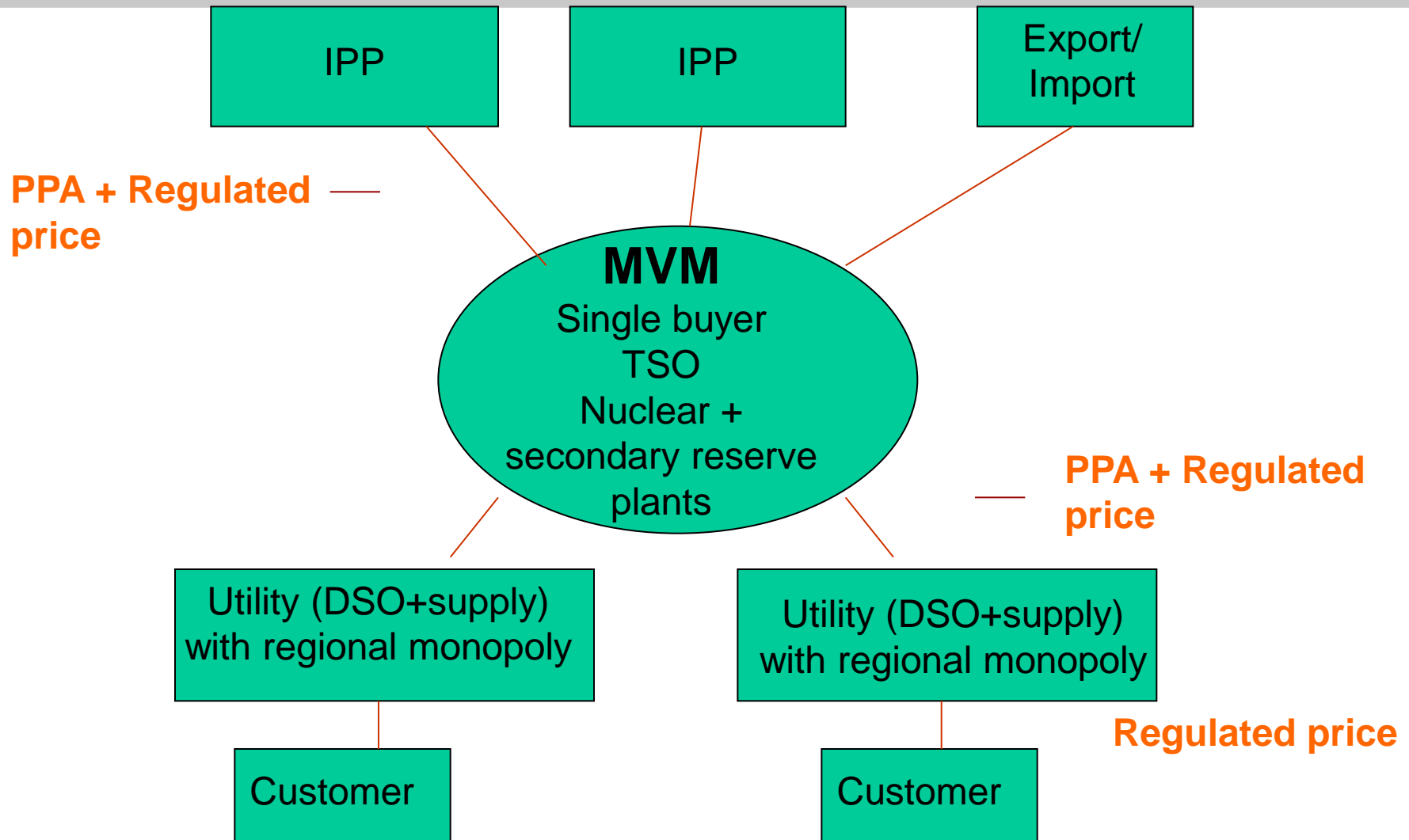
The value chain of natural gas supply



Price regulation?

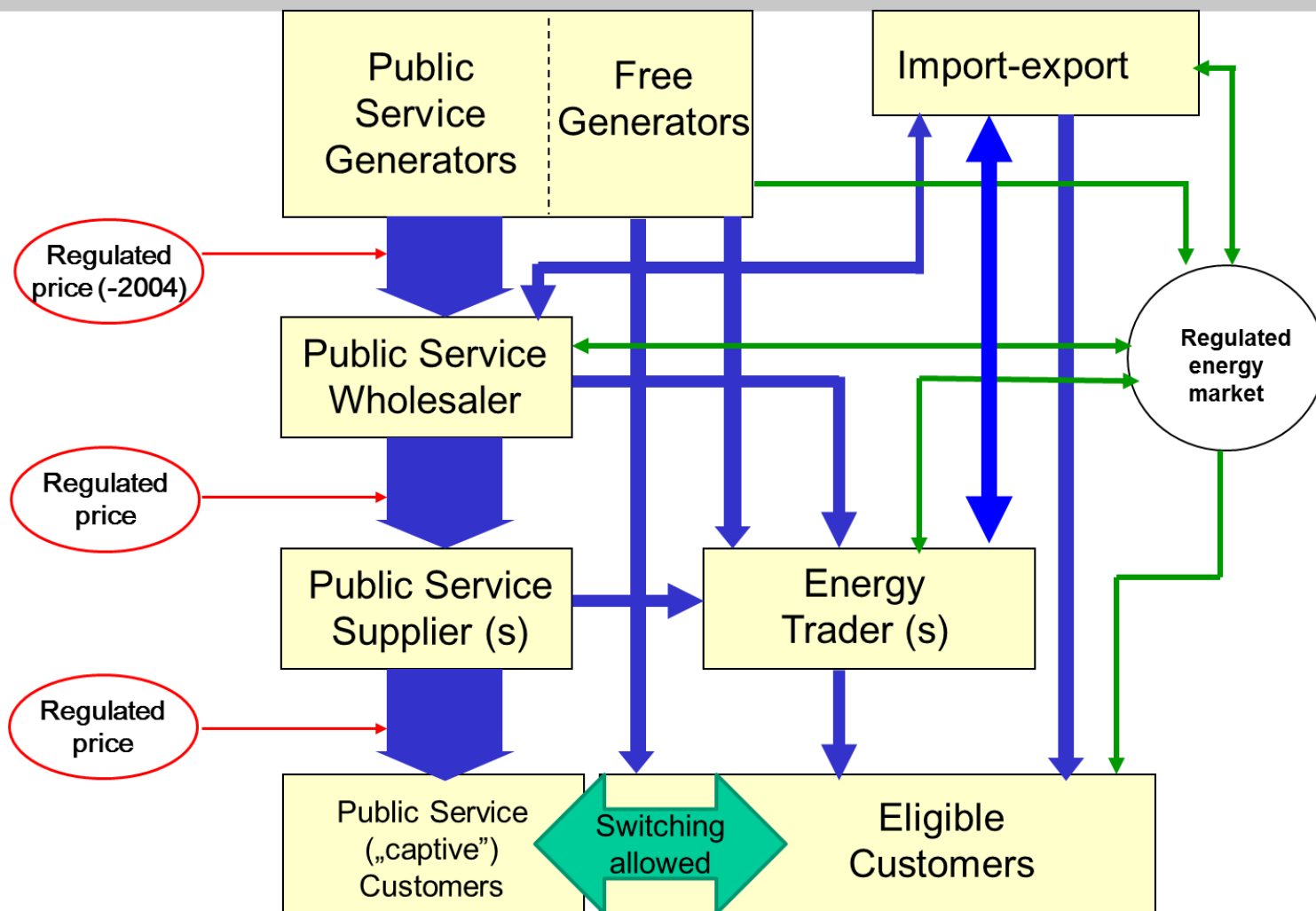
- Scope for price regulation is market model dependent!
 - integrated utility model – full price control
 - full liberalization – only network access pricing
 - hybrid models: network access pricing + regulated price option for certain end customer groups
- Additional price regulatory tasks:
 - renewable energy pricing
 - social tariff setting
- Market analysis might be needed
 - potentially competitive activities (natural gas storage)
 - players with significant market power

The Hungarian single buyer model in electricity, 1994 - 2003



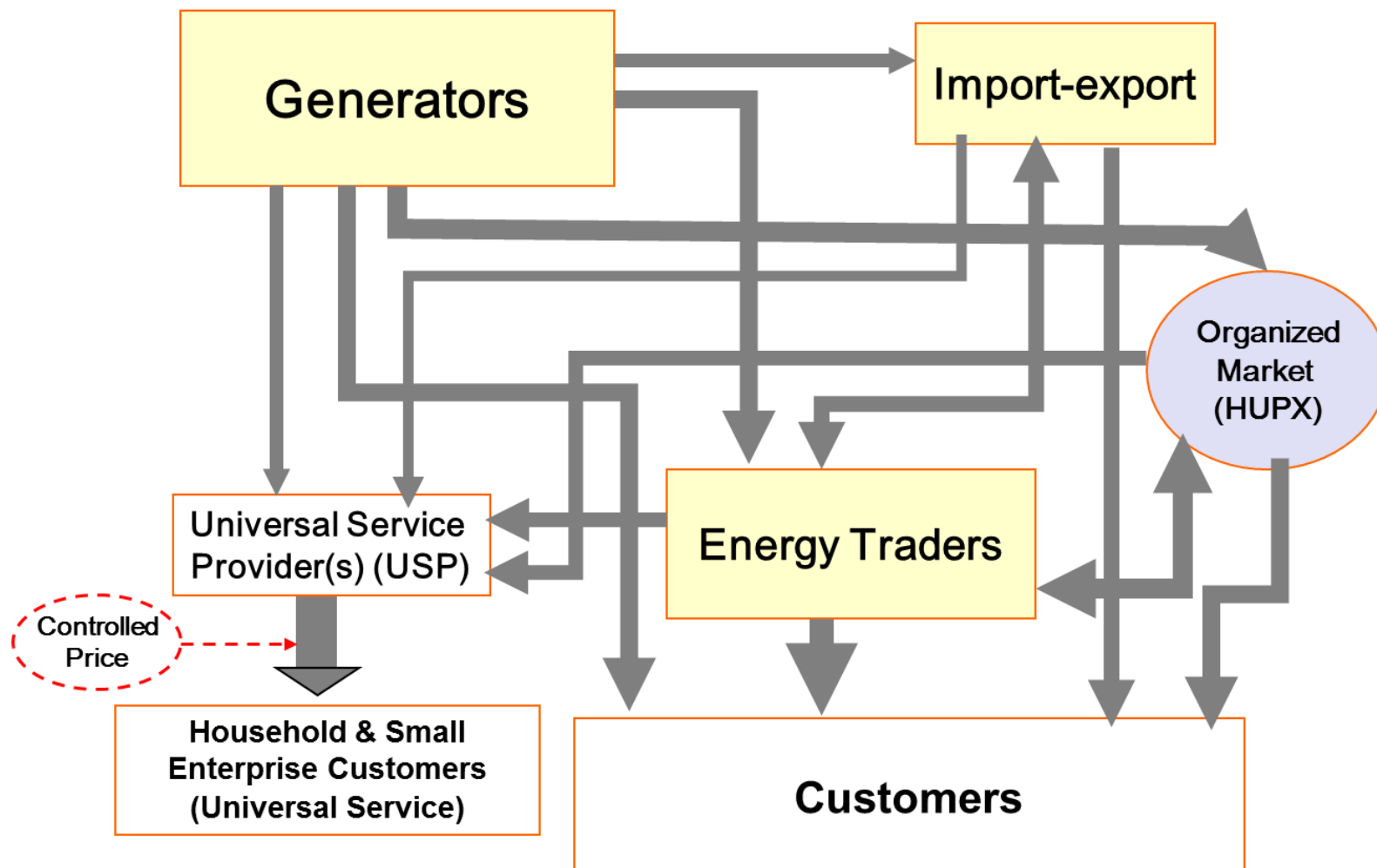
No need for regulated access tariffs to the network!

The first phase of liberalization: the hybrid model in Hungary, 2003 - 2008



+ Regulated access tariffs to the network!

The present competitive electricity market model in Hungary (since 2008)



- Basic economic principles of ,good' price regulation
- Major steps in regulated tariff setting and alternative price regulation methods
- Network access tariffs
- Social tariffs
- Practice to calculate simple regulated tariffs

Three major steps of price regulation

(1) Establishing the Revenue Requirement



Cost and asset review. Which are the justified costs related to the regulated activities?

(2) Tariff Design



The allocation of costs to regulated activities and customer groups.
Forecasts of future activities.
Setting variable and / or fixed tariffs

(3) Price Control Framework



How do tariffs adjusted over time?
What kind of economic incentives price regulation applies?

Rate of return regulation

- Determining the revenue requirement
- Frequent cost review and price adjustments
- Cost review can be requested by either party
- All prices controlled by regulation
- Tightly controlled profits
- Weak incentives for cost reduction

Incentive regulation

- Determining the revenue requirement
- Infrequent cost reviews, automatic price paths in between
- Interim cost review requests not possible
- Limited pricing flexibility for the company
- Loosely controlled profits
- Strong incentives for cost reduction

The basic theme of energy price regulation

Annual Revenue Requirement (ARR) = Total justified costs

Price_t * electricity sold = FC + VC (justified)

Price_t = (FC + VC) / electricity sold
(\$/kW and/or \$/kWh)

Price_{t+1} = Price_t * ?

VARIATIONS

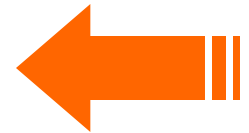
The economics of price regulation

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Course director

March 5 – 8, 2013, Budapest

- Basic concepts in the economics of price regulation
 - demand, consumer surplus, production cost structure, natural monopoly, allocative efficiency, welfare, why regulate?
- Single product natural monopoly
 - marginal and average cost pricing, price discrimination, non-linear (two-part and block) tariffs, optional tariffs
- Multiproduct monopoly
 - fixed cost allocation, FDC and Ramsey prices

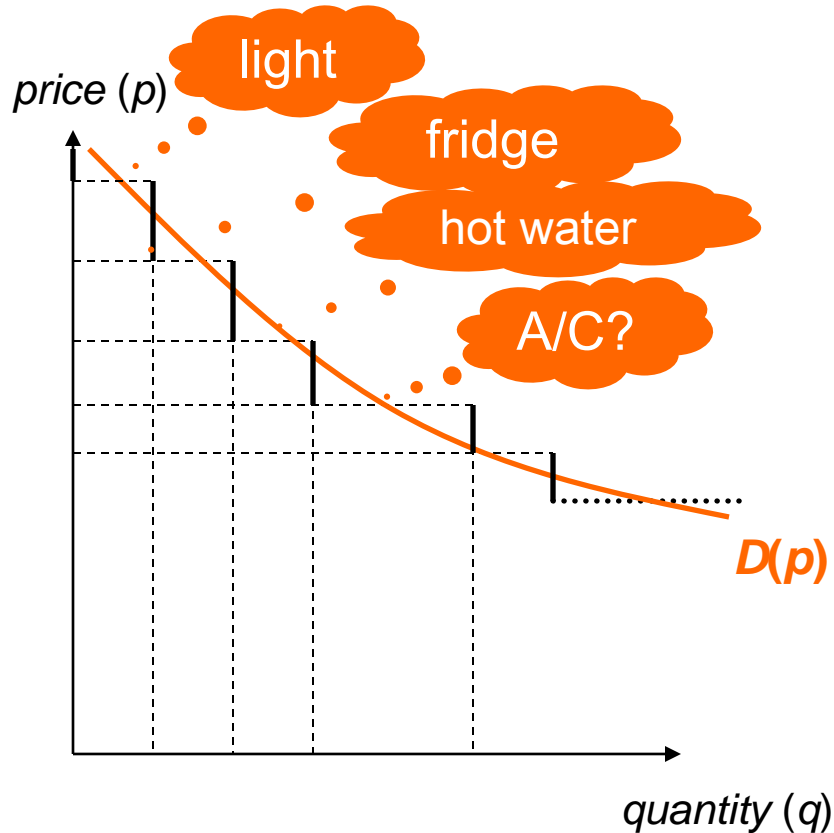
- Cost coverage
- Economically efficient production and consumption structure
- Motivation for improvements in operation
- Social fairness
- Transparency, stability and reliability
- Promotion of favored technologies
- Minimum required regulatory intervention



- Discussion of economic issues related to price regulation
- Main concern throughout: EFFICIENCY
- Normative analysis
 - how regulation *should be* done (not how it *is* done) from an economic point of view
- Strong simplification of reality needed
 - to isolate the main factors influencing company and consumer behavior, and
 - to retain tractability for the tools of economic theory
- Intuition and general ideas instead of exact prescriptions

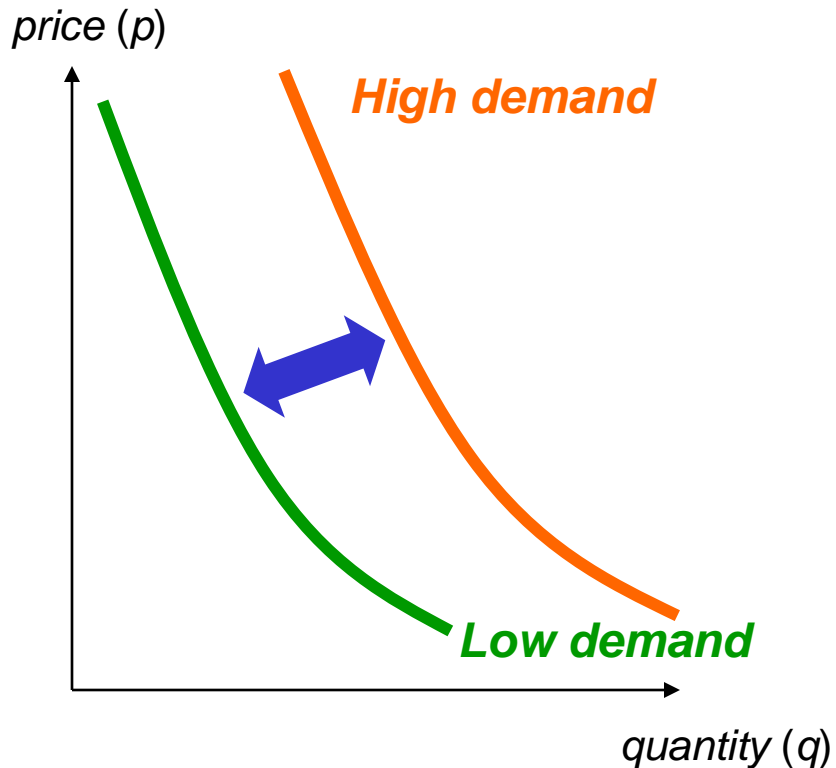
- People have an idea how much of a product they want to consume, depending on:
 - their needs
 - the time of day
 - the weather
 - their **income**
 - the neighbors' consumption
 - **the price of the product**
 - marketing and advertising
 - how much they consumed last time
 - ...
- We are interested in the effect of the relevant and measurable factors

Basic concepts: demand



With many consumers or large quantities, the demand schedule is approximated by a continuous curve.

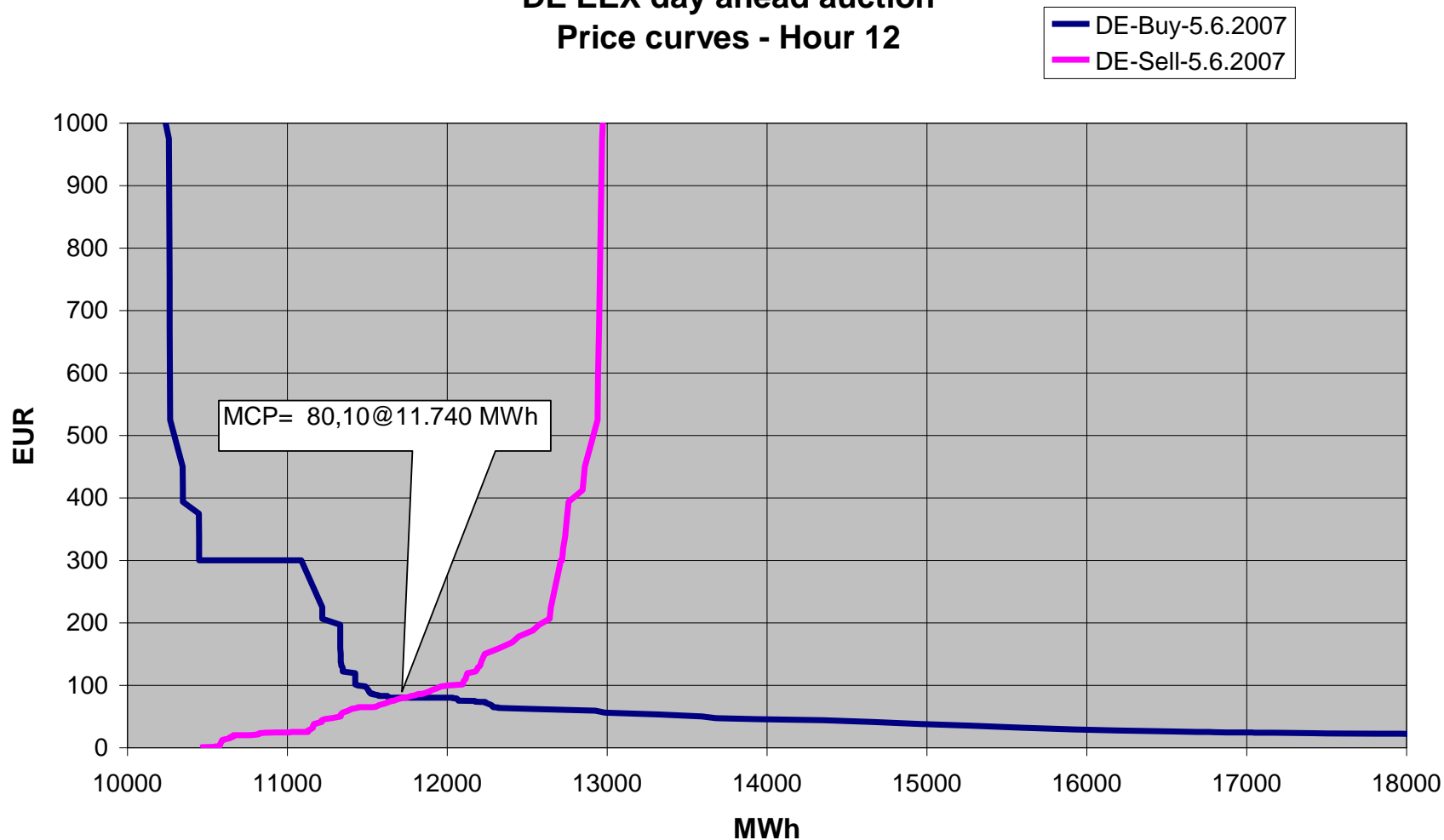
- For any quantity, there is a maximum unit price that consumers are willing to pay
- For any given price, there is a maximum quantity that consumers are willing to purchase
- The lower the price, the higher the demanded quantity
- This relationship is captured by the downward-sloping demand curve



- Consumption is influenced by many factors at the same time
- In two dimensions, only one effect can be displayed
- The other effects **shift** the demand curve in or out
- Demand shifters
 - ▶ good vs bad weather
 - ▶ high vs low income
 - ▶ daytime vs nighttime
 - ▶ in-fashion vs out-of-fashion
 - ▶ little vs a lot of marketing
 - ▶ ...

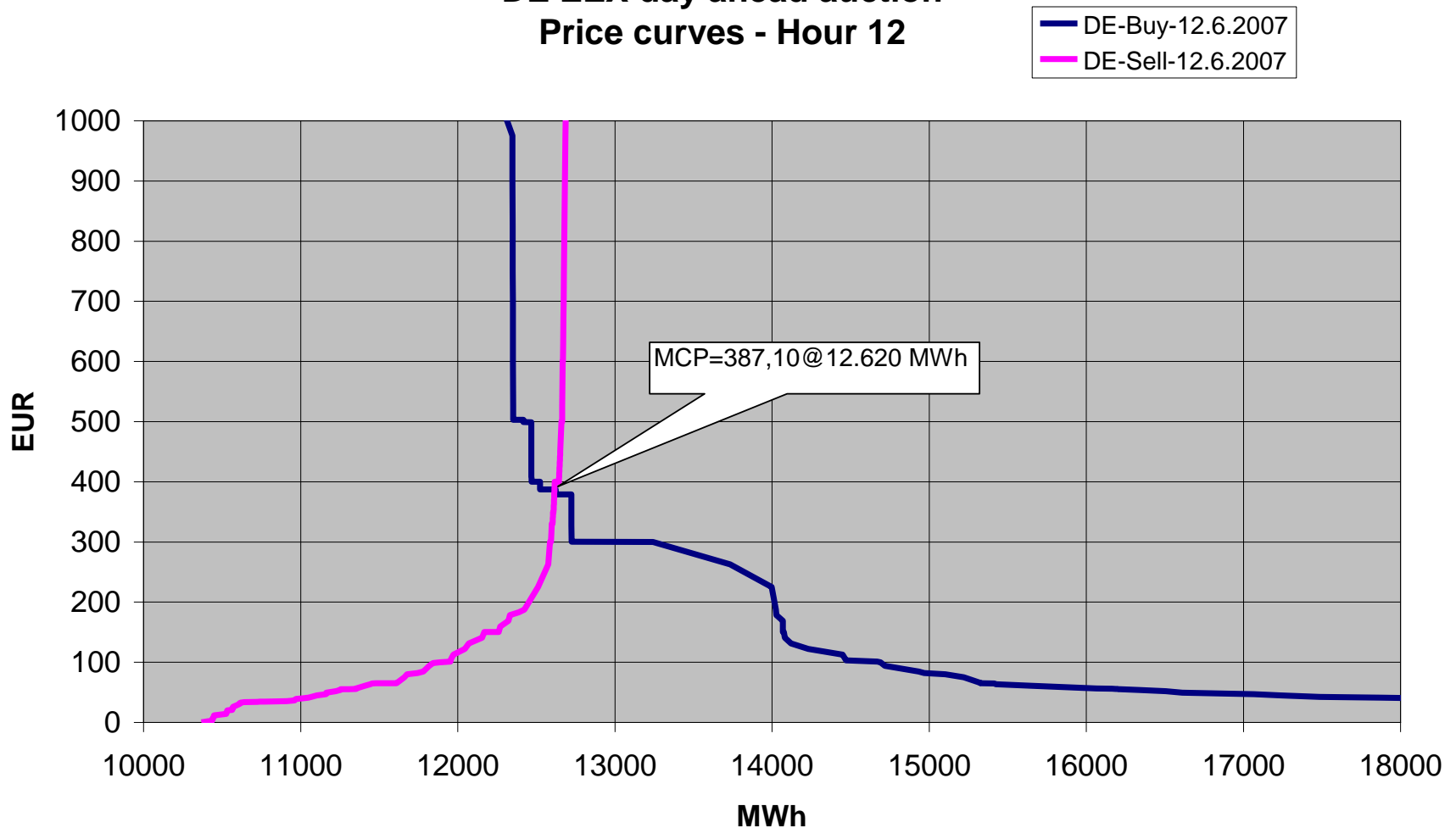
Example: Electricity demand on EEX (1)

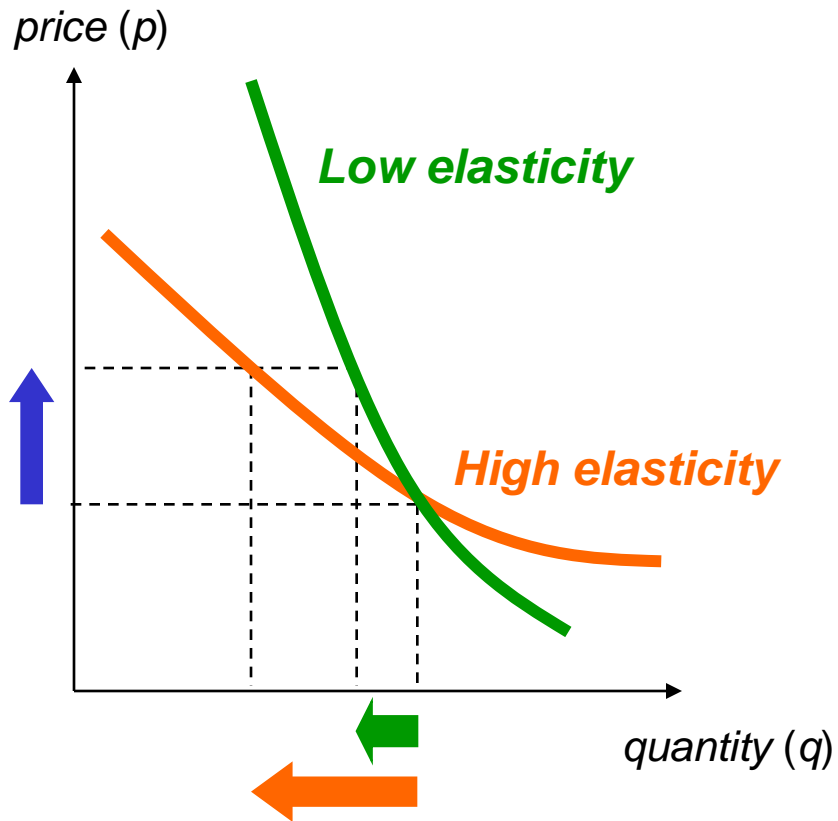
DE EEX day ahead auction Price curves - Hour 12



Example: Electricity demand on EEX (2)

DE EEX day ahead auction Price curves - Hour 12

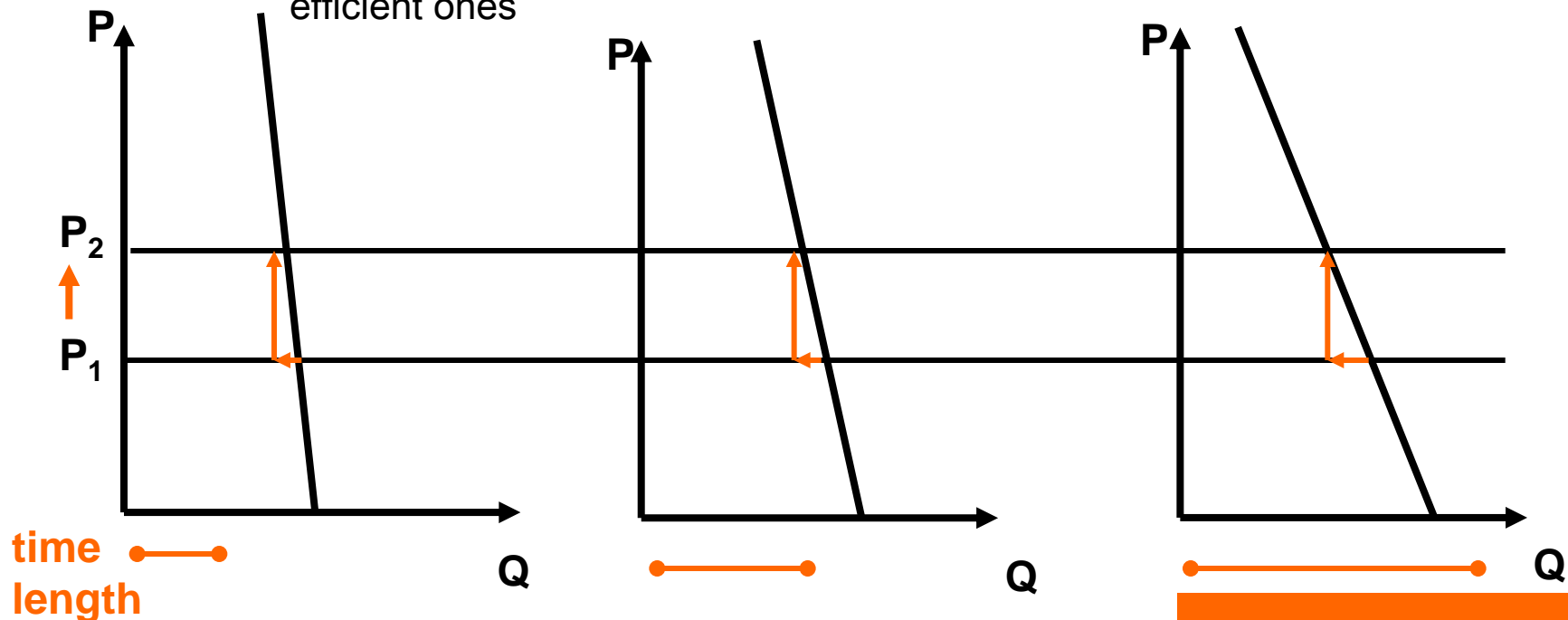




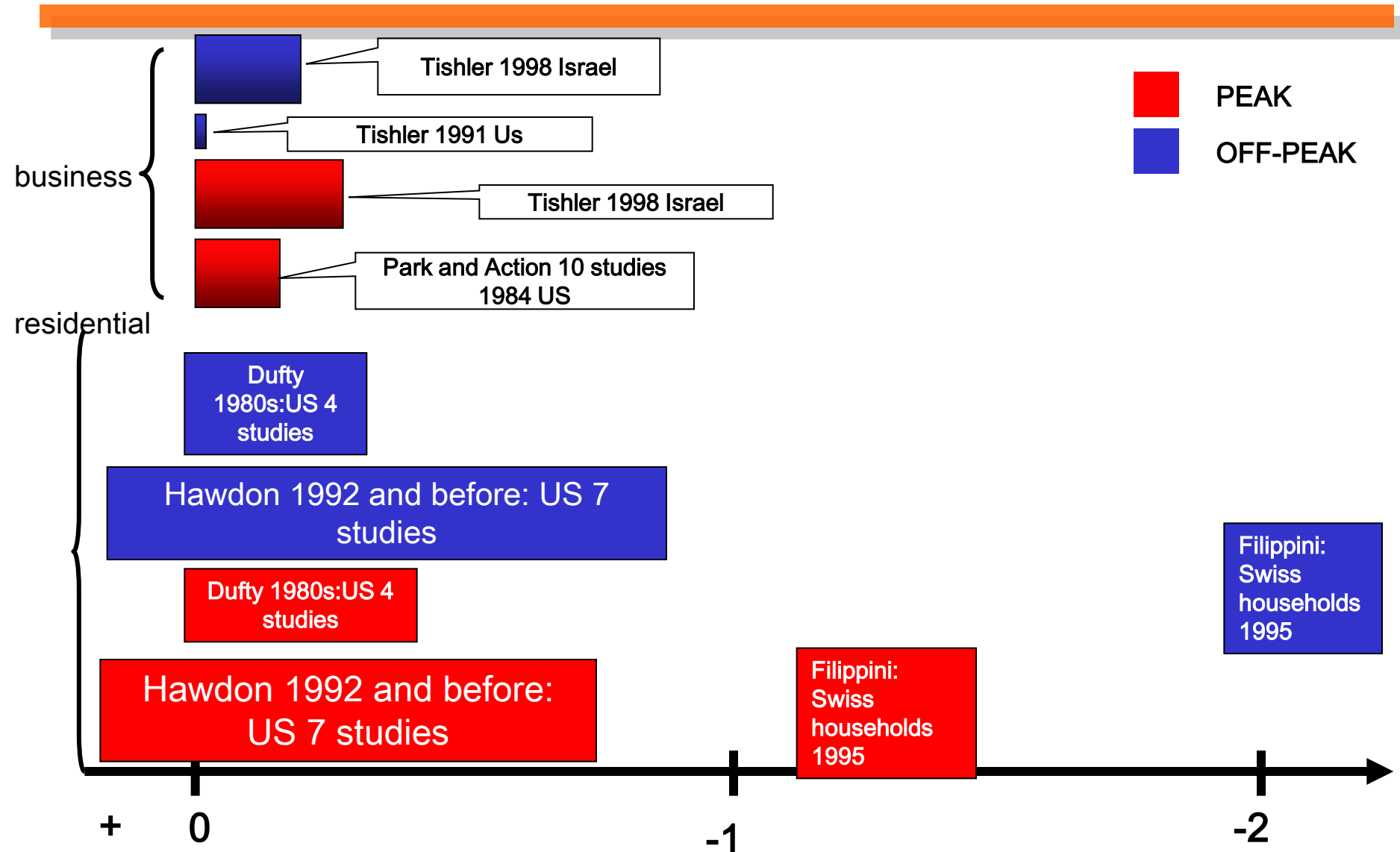
- How does consumption react to a change in price?
- If the same price change induces a greater fallback in consumption, demand is more **elastic**
- Demand elasticity depends on substitution possibilities
 - e.g. how feasible it is to substitute natural gas for electricity
- Income elasticity can be defined similarly
- Other influences on demand elasticity
 - good vs bad weather
 - high vs low income
 - daytime vs nighttime
 - **time horizon**
 - ...

Demand elasticity: the time dimension

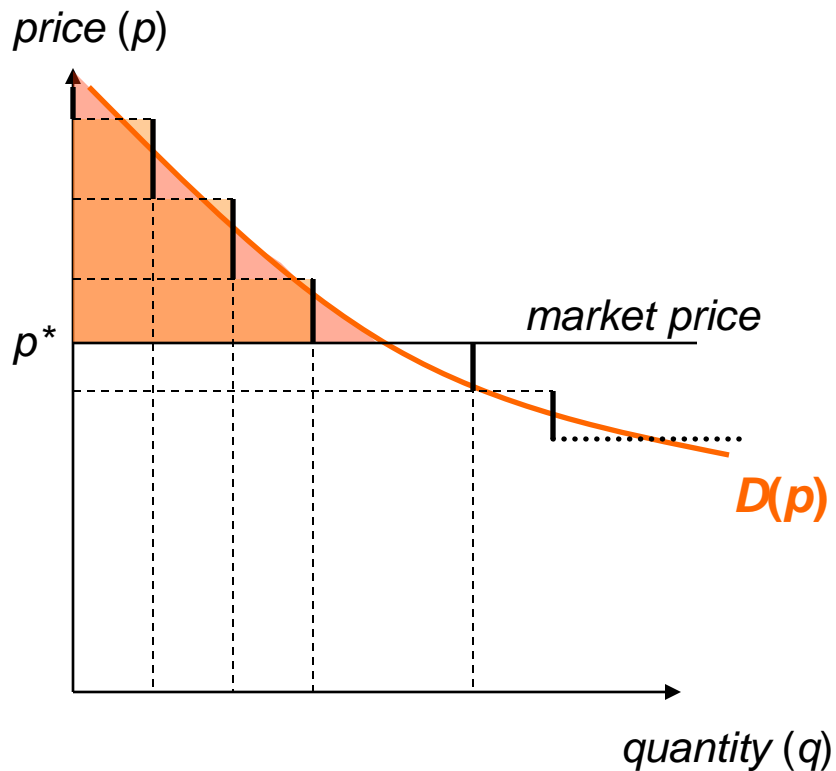
- Magnitude of demand response depends on the time available for reaction:
 - Short term: Changing the use of current appliances
 - e.g. turning down the air conditioner
 - Long term: Changing the appliances
 - e.g. buying new appliances and changing the old ones to more energy efficient ones



A few price elasticity estimates



Basic concepts: surplus



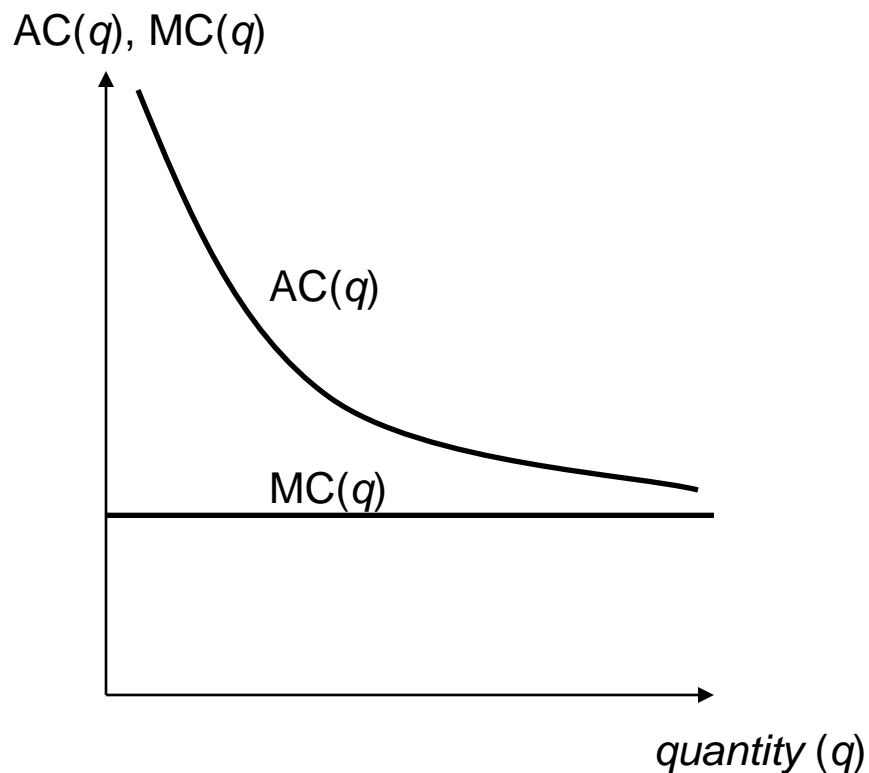
With many consumers or large quantities, consumer surplus still equals the area below the demand curve and above the price level.

- The difference between what the consumers are *willing to pay* for a product („reservation price” – embodied by the demand curve) and what they *have to pay* („market price”) is called **consumer surplus**
- If consumer surplus increases, consumers are better-off, and vice versa
- Thus, consumer surplus is an appropriate measure of the well-being of consumers

- By and large, production costs $[C(q)]$ can be divided into two groups:
 - fixed costs: FC [e.g.: capital equipment]
 - variable costs: $VC(q)$ [e.g.: total fuel cost]
- The cost of producing the next (or last) unit:
 - marginal cost: $MC(q)$ [e.g.: fuel cost of the next kWh of electricity]
- Average production cost:
 - total cost divided by quantity: $AC(q)$ [e.g.: average cost of producing 1 kWh of electricity]

Example: simplified cost structure of an electric utility

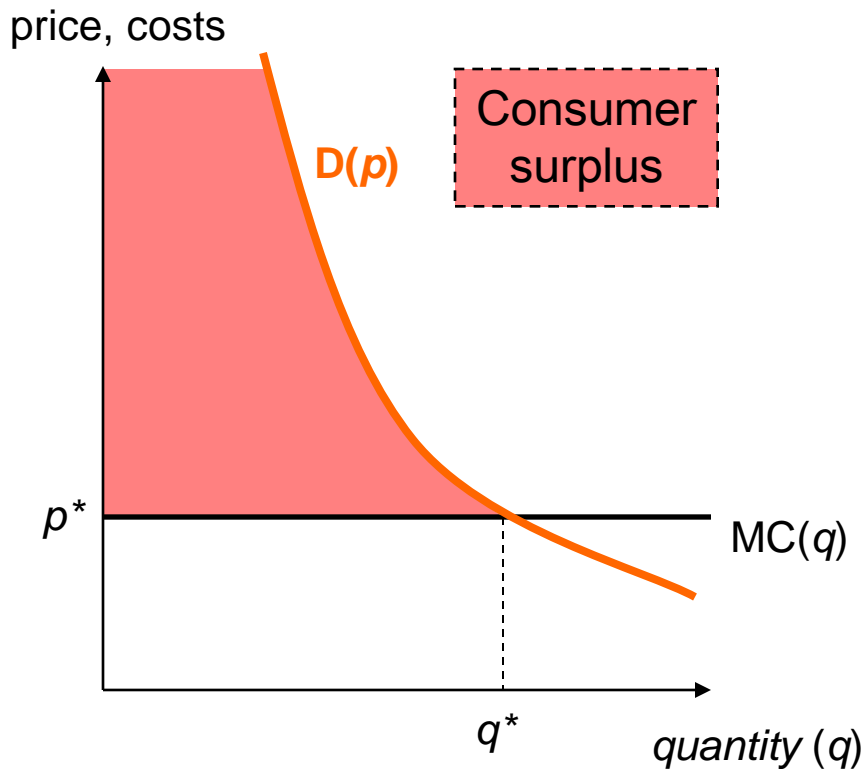
- Time interval: one year
- Fixed costs (79.5 m\$)
 - Cost of capital (35.0 m\$)
 - Asset Base \times WACC
 - Depreciation (20 m\$)
 - OPEX (fixed part: 24.5 m\$)
- Marginal costs (33.15 \$/MWh)
 - Cost of electricity (30 \$/MWh)
 - Network loss (3.15 \$/MWh)



- If fixed costs are large relative to variable costs, then $AC(q)$ is decreasing and above $MC(q)$
- Decreasing average costs imply economies of scale in production
- Demand can be satisfied most economically by a single company
- E.g.: network services (water, gas, electricity)

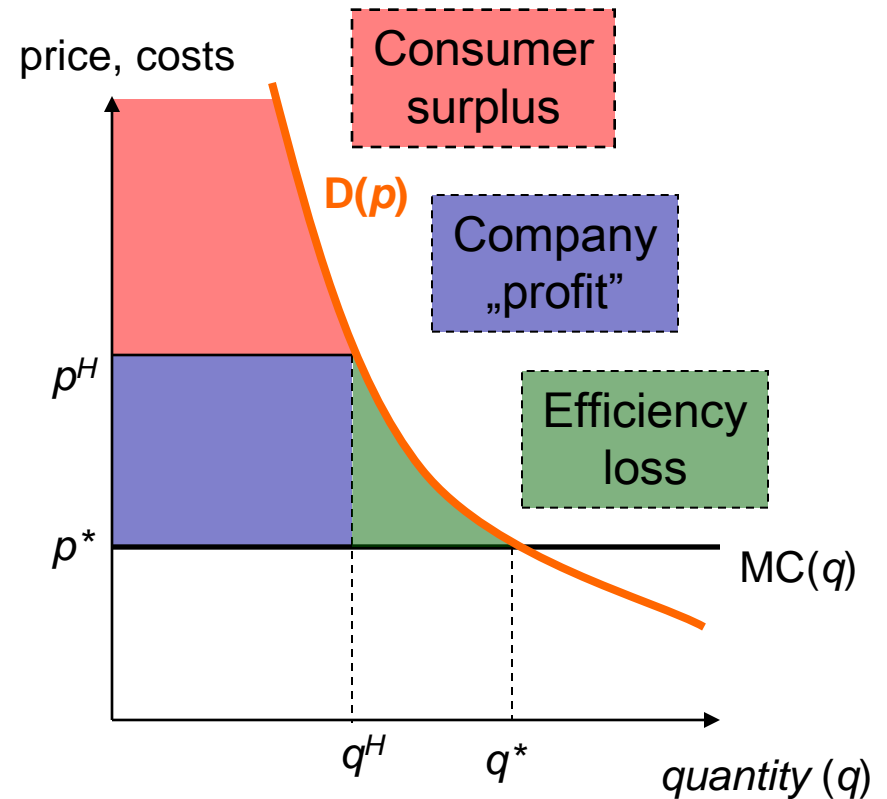
- Definition:
 - ▶ *Production and consumption levels are (allocatively) efficient, if no party can be made better off without hurting any other party, considering the current production possibilities.*
 - ▶ E.g.: if some consumers could be made better off (theoretically) without a decrease in company profits and without a decrease in other consumers' surplus, then we have an inefficient allocation of resources.

Basic concepts: allocative efficiency



Efficient price

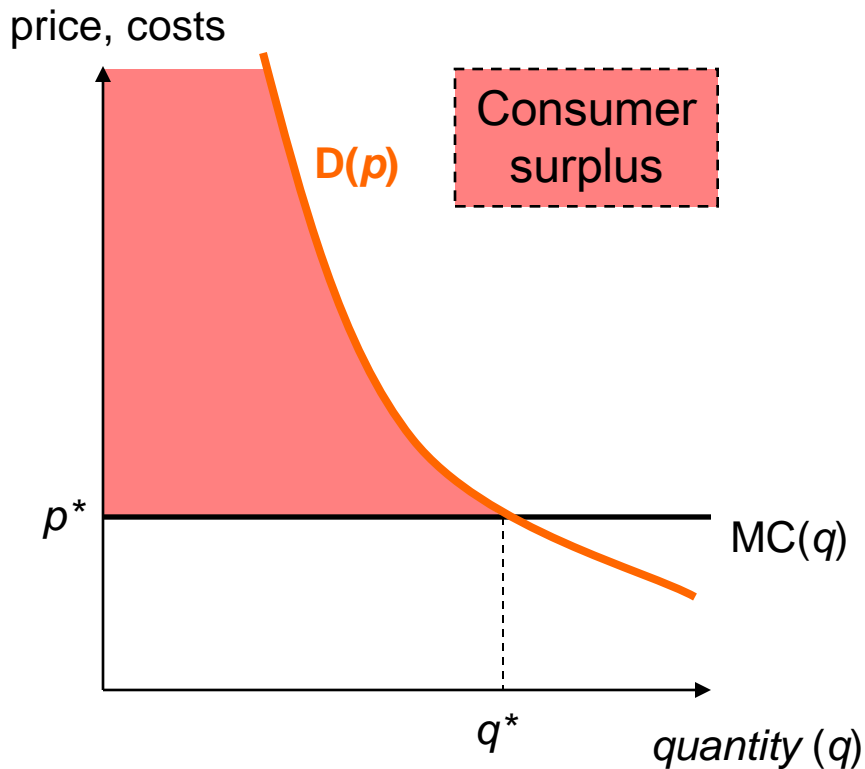
$$p^* = MC(q)$$



Inefficiently high price

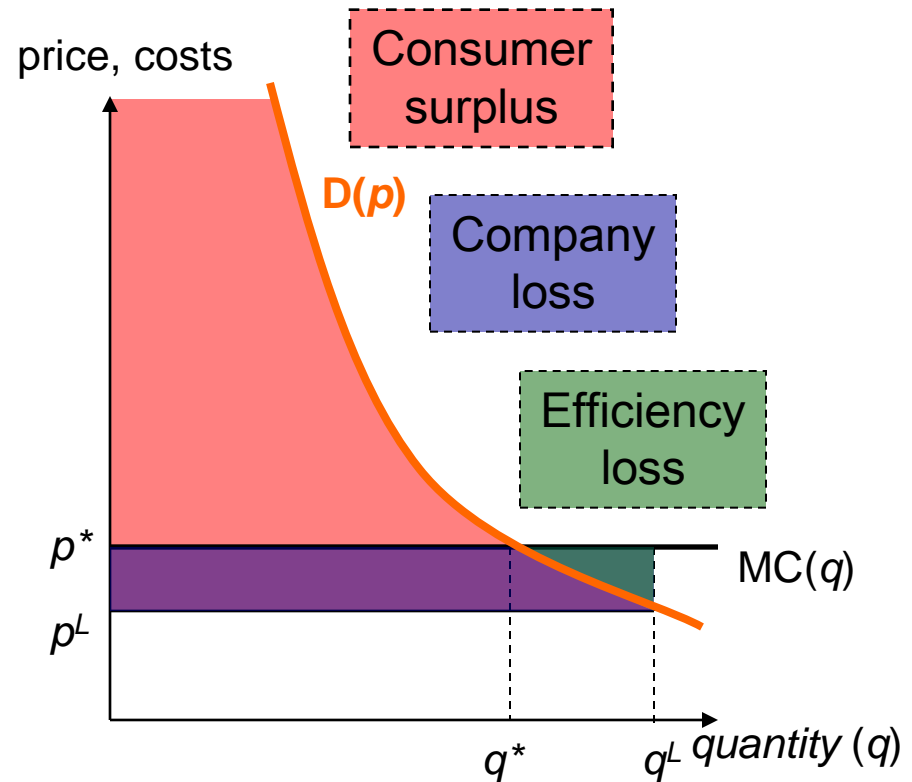
$$p^H > MC(q)$$

Basic concepts: allocative efficiency



Efficient price

$$p^* = MC(q)$$



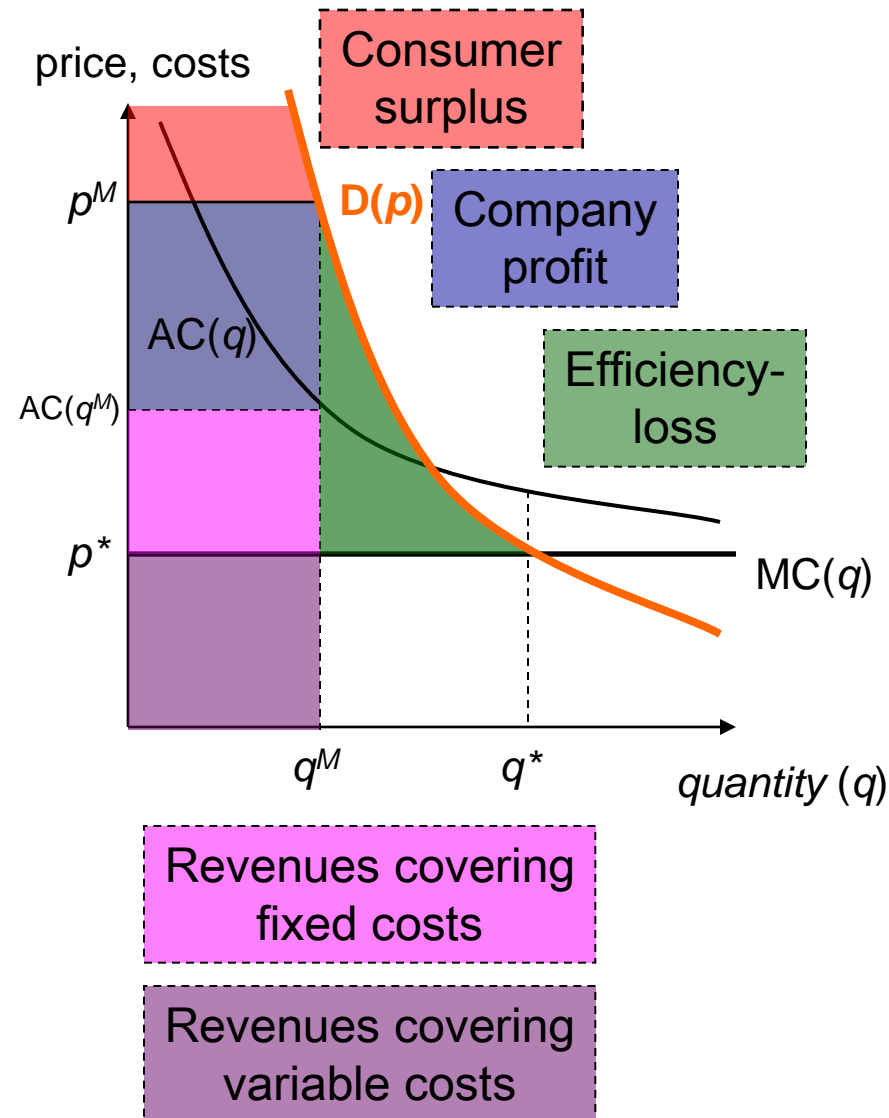
Inefficiently low price

$$p^L < MC(q)$$

- Socially efficient production level requires the unit **price to equal the marginal cost** of producing the last unit of output
 - ▶ if $p > MC$, then another unit can be produced for MC and sold for some price between p and MC – to the benefit of both the consumers and the producers
 - ▶ if $p < MC$, then the last unit produced was worth less to the consumers than it cost the firms to produce – both would be better-off if the production of that unit was cancelled and the consumers were compensated by some small amount from the avoided loss of the firms

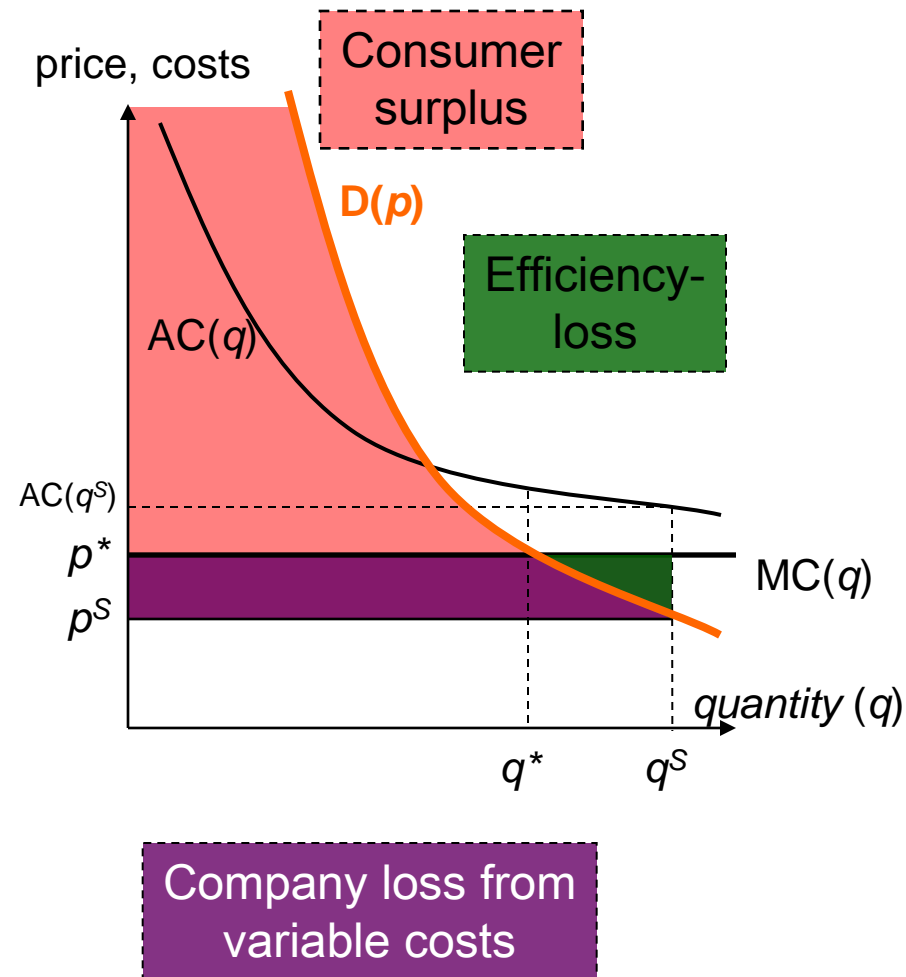
- Producers' „well-being” is measured by profits
 - Profit (π) = Revenues – Costs = $p \times q - C(q)$
- Consumers' well-being is measured by consumer surplus:
 - the area between the demand curve and the price level
- A single measure for the well-being of „society” would combine both:
 - Welfare = Consumer surplus + $\alpha \times$ Profits
- Consumer surplus may be valued higher than producers' profit: $\alpha < 1$
 - this distributional concern is usually present in policy applications
 - as a consequence, economic profit (monopoly rent) is a sign of a suboptimal welfare level (it could be re-allocated to consumers)
 - therefore, regulation justifiably aims for the reduction of economic profits (i.e. prices) to benefit the consumers

Basic concepts: why regulate?



- If left unregulated, natural monopolies set prices high to maximize profits
- High prices:
 - decrease the total surplus to be divided between the firm and the consumers (efficiency-loss)
 - redistribute available total surplus towards the company (profit)
 - decrease welfare overall
- Thus, **price setting by natural monopolies must be limited!**

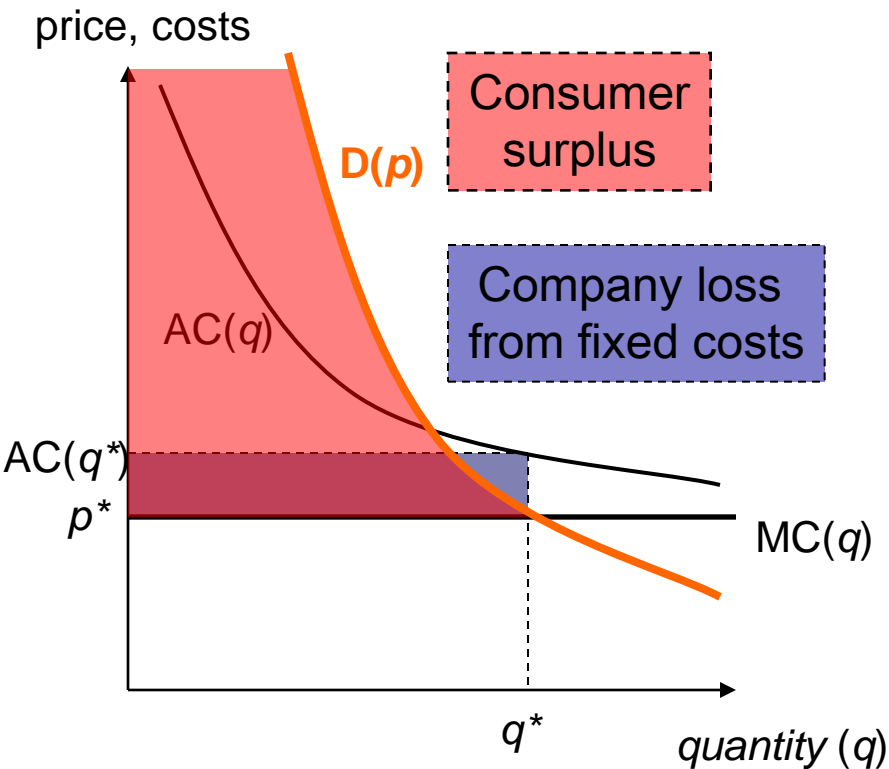
Basic concepts: why regulate?



- It may also be the case that monopoly prices are oversubsidized historically
- Low prices:
 - ▶ decrease the total surplus to be divided between the firm and the consumers (efficiency-loss)
 - ▶ redistribute available total surplus towards customers (from taxpayers?)
 - ▶ decrease welfare overall
- Thus, **inefficiently low prices must also be corrected!**

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Marginal cost pricing




Total revenues: $TR(q^*) = p^* \times q^*$

Total costs: $C(q^*) = AC(q^*) \times q^*$

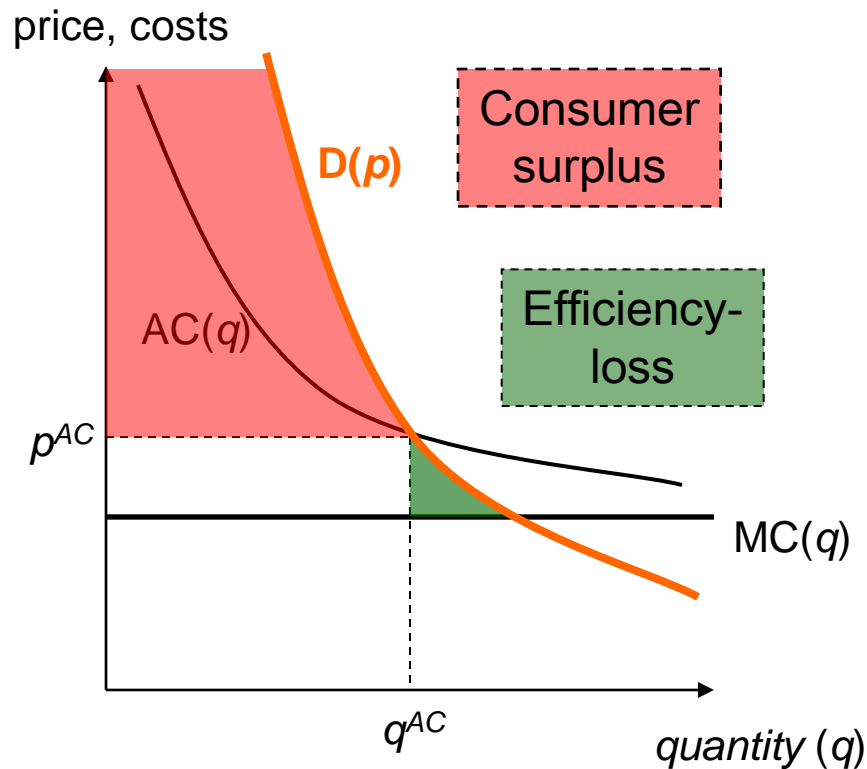
Profit: $\pi = TR - C = [p^* - AC(q^*)] \times q^* < 0$

- Efficiency requires:
 $p^* = MC(q^*)$
- Welfare is maximized
 - first-best solution
- But: fixed costs are not recovered through prices
 - the monopolist makes a loss
- The firm must be compensated with lump-sum transfers by the regulator
 - may be implicit if monopolist is state-owned
 - is it fair to taxpayers?
- Transfers from the regulator to the monopolist may not be politically feasible

Example: marginal cost pricing

- Total consumption (*suppose*): $Q = 10.98$ [TWh]
- Cost structure: $C = 79.5 + 33.15 \times Q$ [m\$]
- Regulated price equals the marginal cost of service:
 - $p = 33.15$ \$/MWh
- Company revenues: $R = p \times Q = 364.1$ m\$
- Costs: $C = 79.5 + 33.15 \times Q = 443.6$ m\$
- Profit: $R - C = -79.5$ m\$ (loss!)
 - fixed costs are not recovered by MC pricing!
- Remedies:
 - state subsidy (usually not a good idea)
 - higher regulated price 
 - fixed energy charge component

Average cost pricing



$$\text{Total revenues: } TR(q^{AC}) = p^{AC} \times q^{AC}$$

$$\text{Total costs: } C(q^{AC}) = AC(q^{AC}) \times q^{AC}$$

$$\text{Profit: } \pi = [p^{AC} - AC(q^{AC})] \times q^{AC} = 0$$

- Since profits cannot be negative:
 $p^{AC} = AC(q^{AC})$
- Welfare is maximized subject to non-negative profit level
 - second-best solution
- Consumers fully finance the service
- But: price level is inefficiently high
- Consumption decreases relative to efficient level
- Some consumers may be „priced out of the market”
- Deadweight-loss must be incurred
- **How significant is this efficiency loss?**

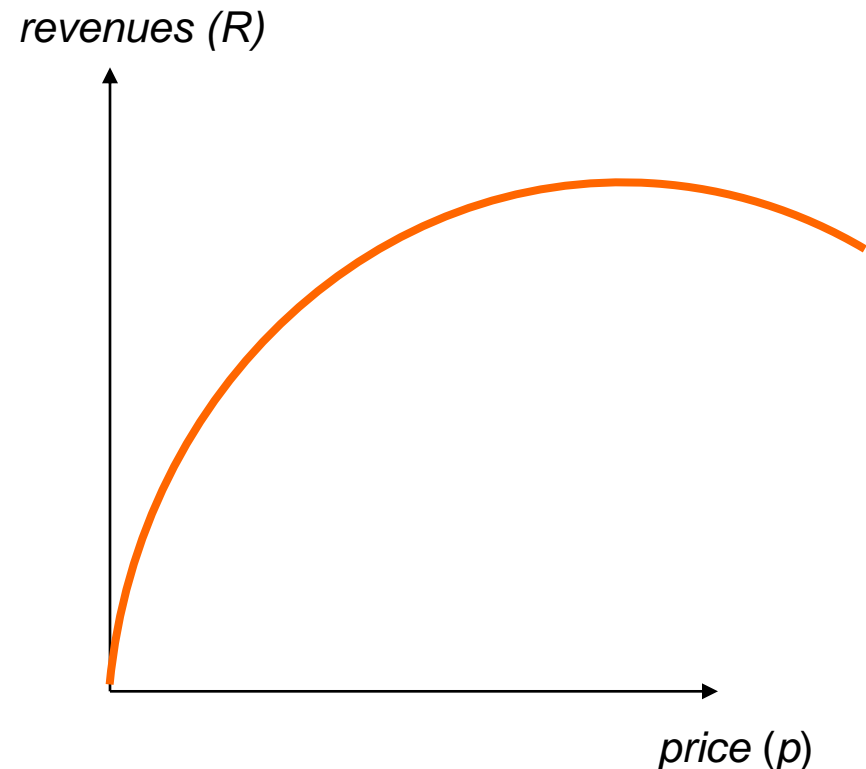
Example: average cost pricing (1)

- Increase the price to cover fixed costs
- Consumption will fall!
- Exact cost coverage is a „moving target”
- Treat the regulated price (p) as an unknown variable
- Total sales (assumed demand function):

$$Q = 14.1 \times 10^6 - 94,000 \times p$$

- Revenues:

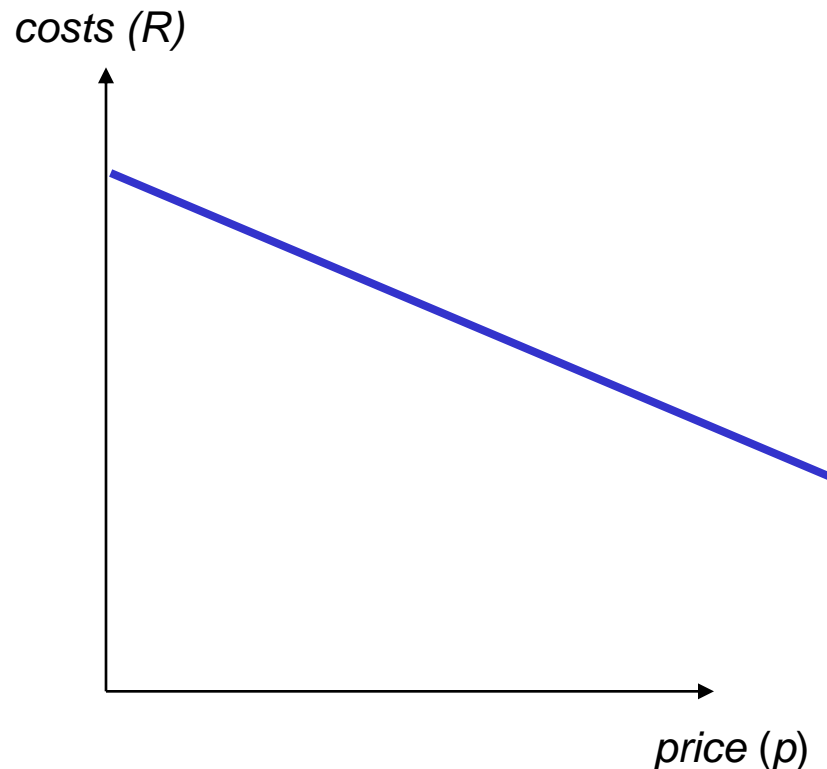
$$R = p \times Q = 14.1 \times 10^6 \times p - 94,000 \times p^2$$



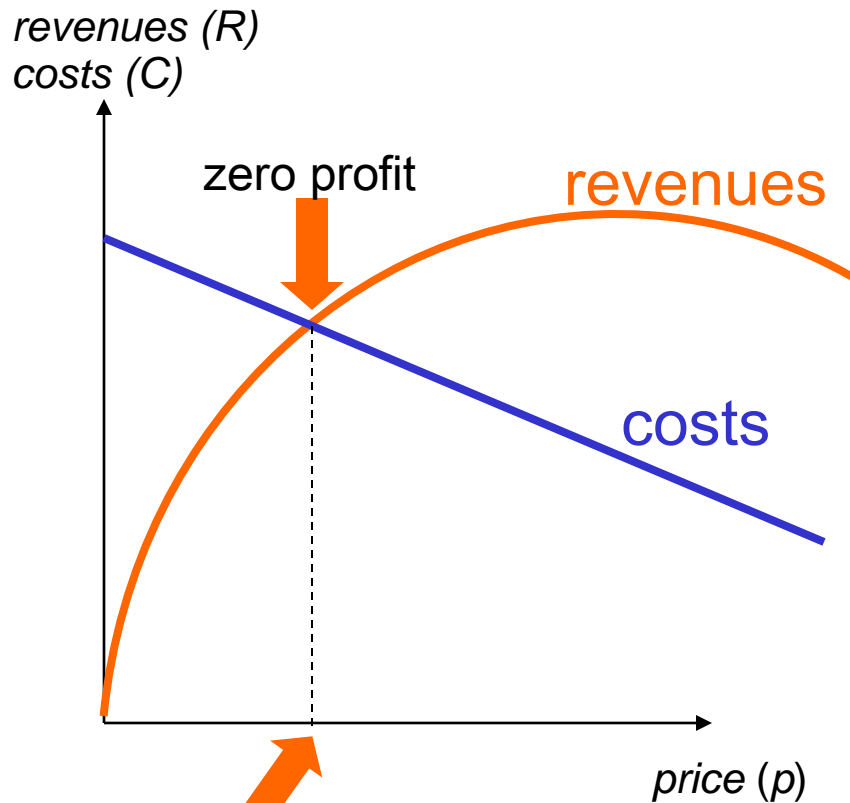
Example: average cost pricing (2)

- Costs:

$$\begin{aligned} C &= 79.5\text{m} + 33.15 \times Q = \\ &79.5 \times 10^6 + 33.15 \times (14.1 \times 10^6 - 94,000 \times p) = \\ &546.9 \times 10^6 - 3.1 \times 10^6 \times p \end{aligned}$$



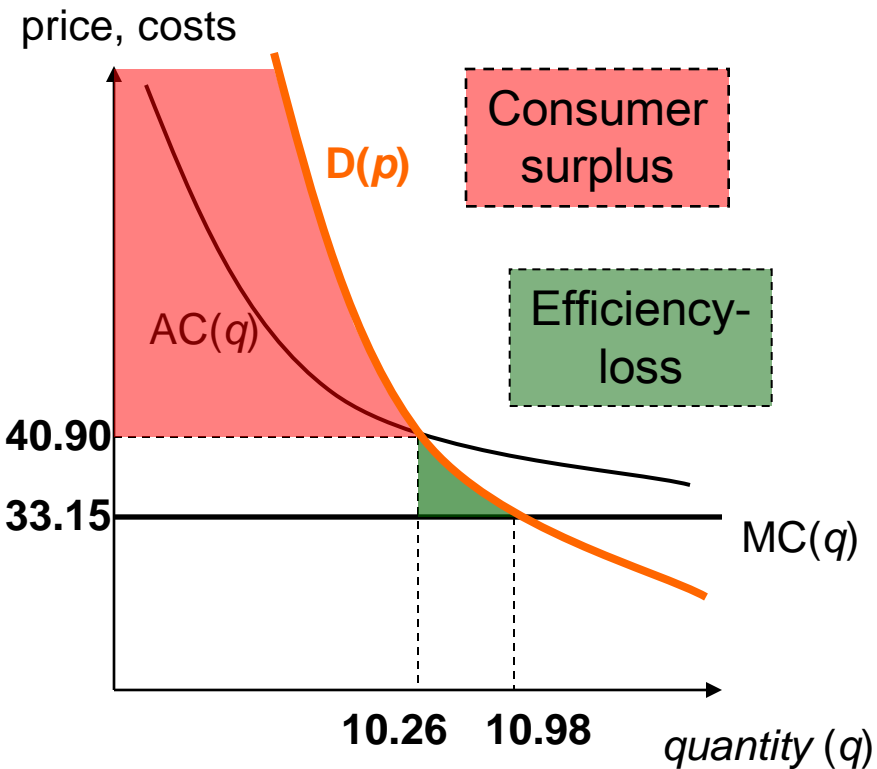
Example: average cost pricing (3)



$p = 40.90 \text{ \$/MWh}$

➡ Consumption: $Q = 10.26 \text{ TWh}$

Example: average cost pricing (4)



- How significant is the efficiency loss?
- Area of the triangle measuring the efficiency loss:

$$\text{Eff.L.} = 0.5 \times 0.72 \text{ TWh} \times 7.75 \text{ \$/MWh}$$

2.79 m\$

- This is the amount of „welfare” lost to society when regulated prices rise above marginal costs

What if the second-best is not good enough?


- Possibility of transfers to make up for losses?
 - regulators generally don't write checks to industry firms
 - financing fixed costs from general tax revenues also causes inefficiencies (inherent in the tax system)
- Is it necessary to have a single price for all quantities purchased?
 - non-linear pricing schemes
 - two-part tariffs, optional tariffs
- Is it necessary to have a single price for all consumers?
 - price discrimination

- Unit prices can be decreased below average costs, if we introduce other charges to make up for lost profit
- Two-part tariffs include a **fixed charge**, ...
 - subscription fee, membership fee, connection charge, etc.
- ... and a **unit price**
- Fixed charge should be designed to recover the costs of service provision not compensated for by marginal cost pricing (typically: fixed costs)
- Unit price can then be lowered to equal marginal costs

Example: Two-part tariffs

- Time interval: one year
- Cost structure:
 - $C(Q) = 33.15 \times Q + 79,500,000$ [\$]
 - $MC = 33.15$ [\$/MWh], $FC = 79,500,000$ [\$]
- 500,000 consumers
- Fixed connection charge: 159 [\$/consumer]
- Energy price: 33.15 [\$/MWh] (vs. $p_{AC} = 40.90$ [\$/MWh])
 - This price structure always results in **zero profits and efficient allocation**, *as long as no consumers are „priced out of the market” by the fixed charge*

Example: Two-part tariffs (cont'd)

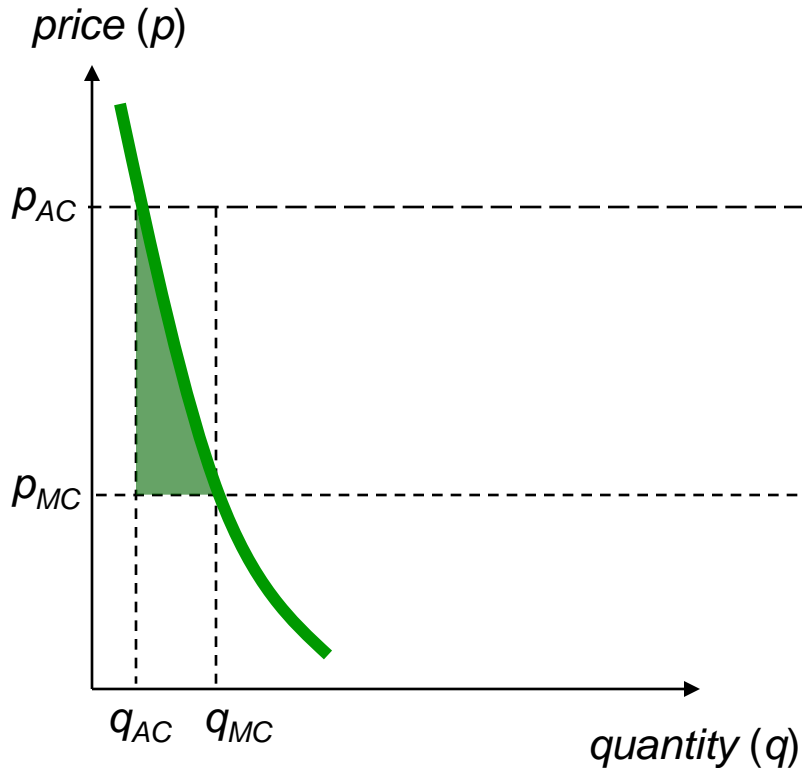
- What happens if 10,000 consumers who would have been willing to pay the average cost price of 40.90 \$/MWh choose to drop out of the market because of the fixed connection charge?
- Cost structure remains the same:
 - $C(Q) = 33.15 \times Q + 79,500,000$ [\$]
 - $MC = 33.15$ [\$/MWh], $FC = 79,500,000$ [\$]
- 490,000 consumers
- Fixed connection charge: 162 [\$/consumer] 
- Energy price: 33.15 [\$/MWh] (vs. $p_{AC} = 40.90$ [\$/MWh])
- Two-part tariff is not efficient any more!
 - 10,000 consumers could be supplied at marginal cost and would be willing to pay even more than that, but this isn't happening

- Both result in zero economic profit for the monopoly
- Two-part tariffs are always efficient (a better choice) if consumers do not leave the market because of the high fixed charge
- Otherwise, the relative efficiency of the two pricing schemes depends on the details of the demand function
 - how many and what kind of consumers leave the market due to the fixed charge?
- Trade-offs can be made between the two extremes: higher unit price in return for lower subscription fees

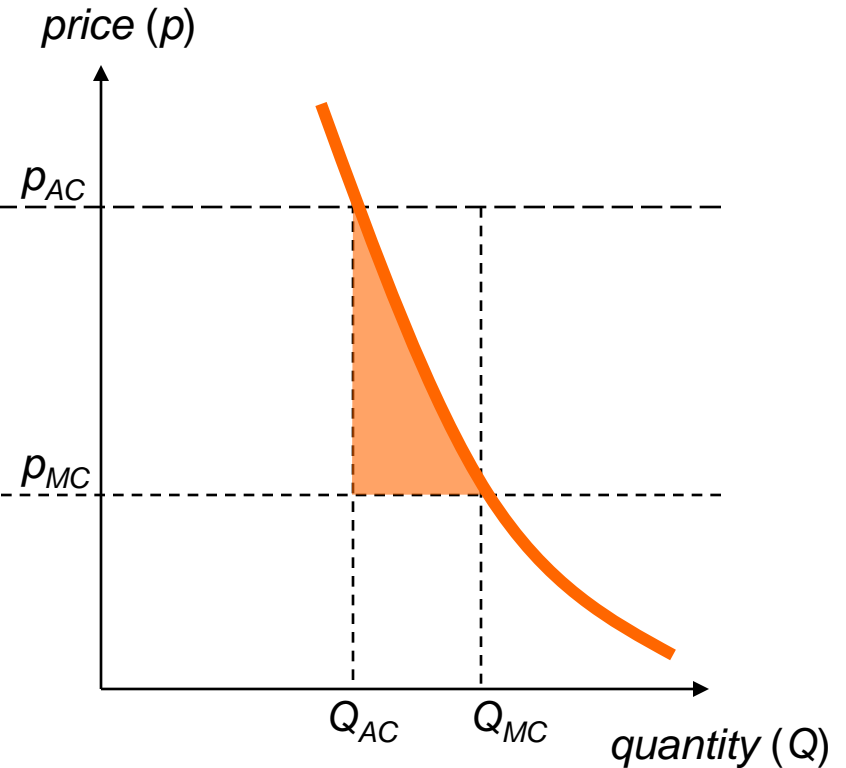
- Consumers have generally different consumption needs
- Some of them may benefit from two-part tariffs with marginal cost pricing, while others would rather choose higher unit prices but no fixed charge
- Both schemes (and their combinations) can be designed to recover the costs of service provision for the monopoly
- Why not make the choice optional for consumers?
 - Consumers can only benefit from more options to choose from
 - The firm is no worse-off, if options are well-designed
- Optional tariffs may take different forms
 - high fixed charges and low unit price vs. low (zero) fixed charges and high unit price
 - block tariffs with lower unit charges for higher consumption levels
 - combinations of fixed charges and block tariffs
- Industry to learn from: telecommunications

Example: Optional tariffs (1)

Small consumer



Large consumer

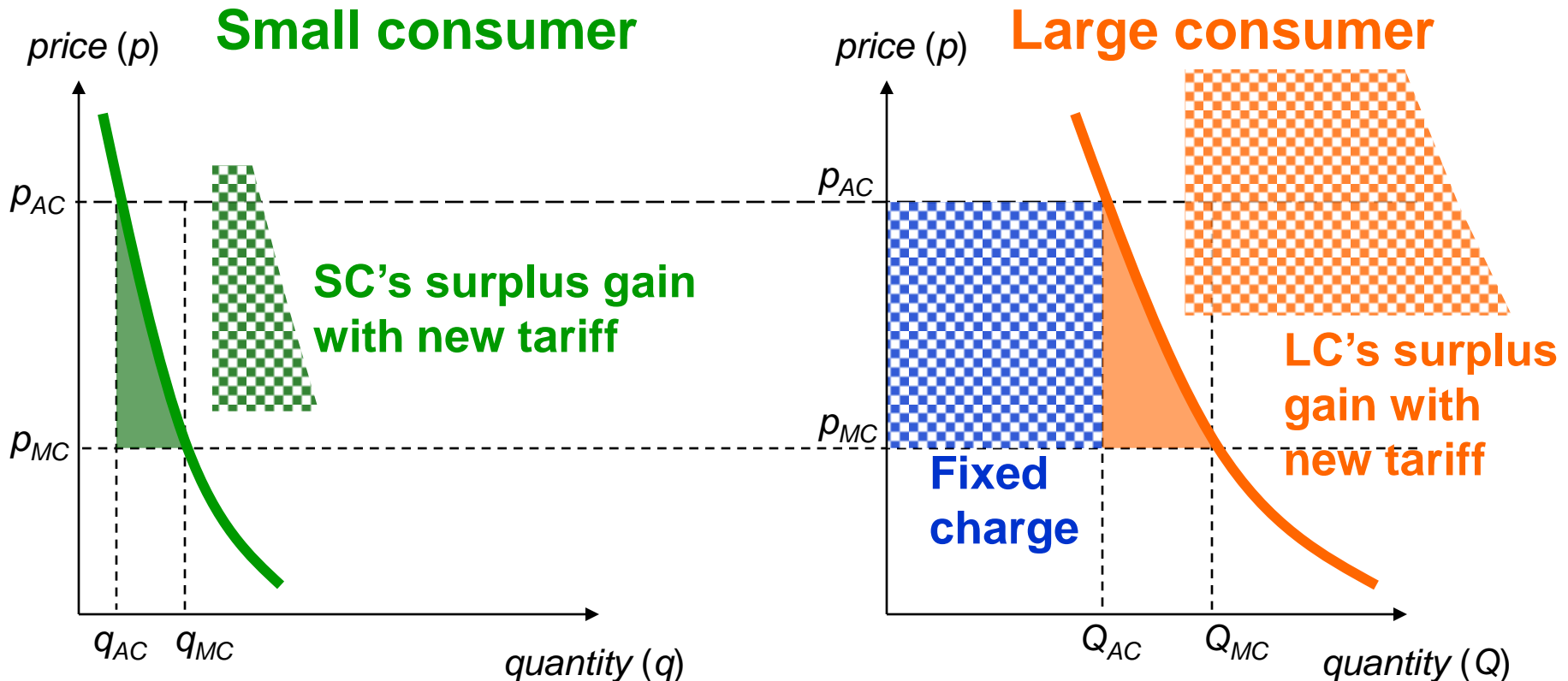


Starting point: everyone pays a single, average-cost price.

Plan: introduce an **optional two-part tariff** to increase efficiency.

Example: Optional tariffs (2)

Two-part tariff: consumers may choose the option of paying the marginal cost price, in return for also paying a fixed charge equal to $(p_{AC} - p_{MC}) \times Q_{AC}$



Example: Optional tariffs (3)

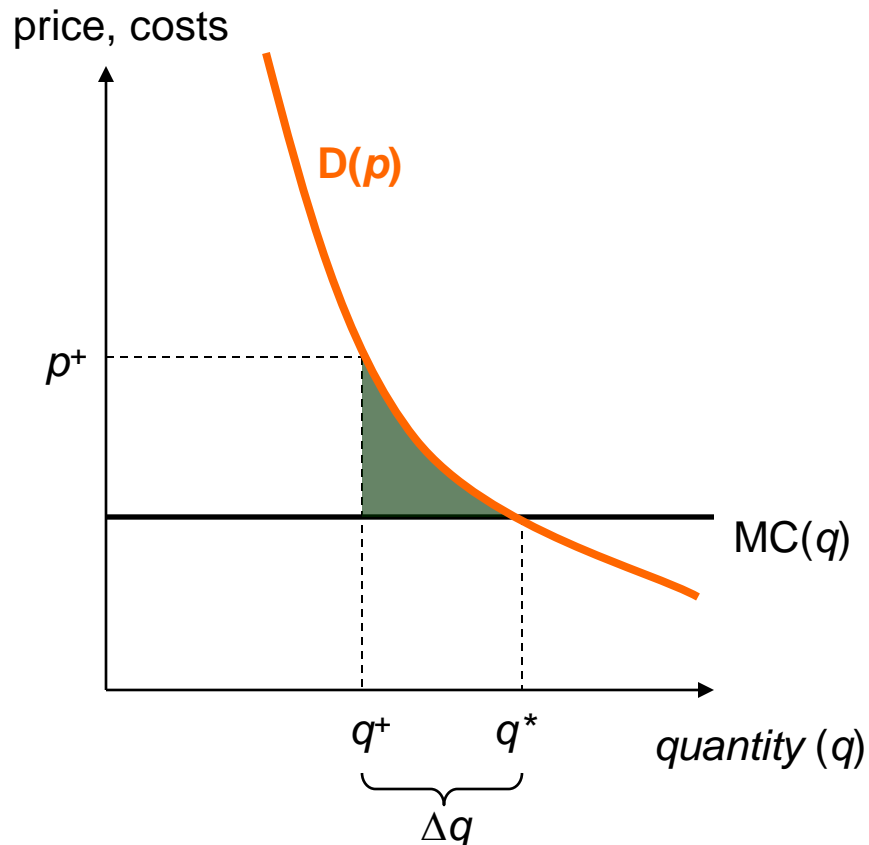
- Small consumers are strictly better off with the original simple average-price tariff
 - will not switch to the new pricing scheme
 - their surplus remains the same
- Large consumers are strictly better off with the new optional two-part tariff
 - will switch to the new pricing scheme
 - their surplus increases
- Company profit remains the same as before
- We have reached an unambiguous welfare improvement
 - welfare gains of large consumers could be shared with small consumers

- Definition: different consumers pay different prices
 - based on unobserved characteristics
 - non-linear pricing, optional tariffs
 - (second-degree price discrimination)
 - consumers self-select to most beneficial schemes
 - based on observed characteristics
 - voltage level, legal form, geographical area, income level
 - (first- or third-degree price discrimination)
 - prices are mandated, but combination with optional tariffs also possible
- Useful to increase allocative efficiency
- Often also used as a tool of social policy
 - redistributive purposes, cross-subsidization
 - efficiency vs. equity trade-off may arise

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- **Multiproduct monopoly**
 - fixed cost allocation, FDC and Ramsey prices

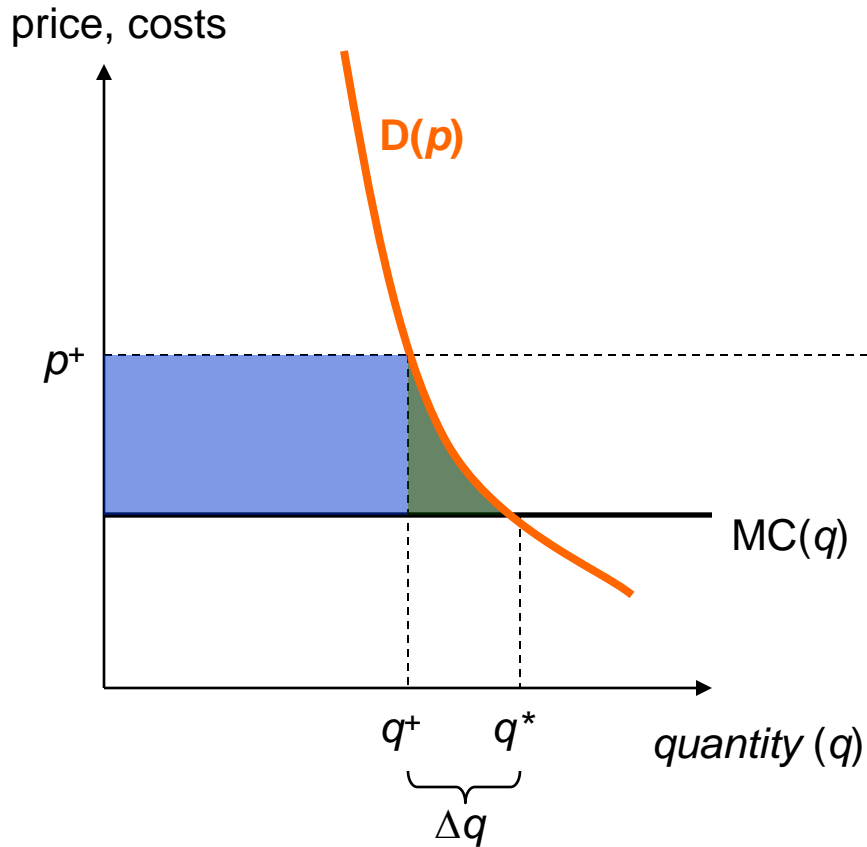
- Single-product firms are rare
 - e.g.: electricity is a different product at 3am and at 11am
- Large fixed costs still pose a problem for efficient (marginal cost) pricing
- Additionally, a significant part of fixed costs cannot be squarely attributed to any of the products
- Main issue regarding multiproduct monopolies:
To what extent should we assign the recovery of non-attributable fixed costs to each product?
 - e.g.: how should average capital costs be divided between peak and off-peak electricity?

- Fully Distributed Cost pricing has been used historically
 - the only objective: total revenues cover total costs
 - ad hoc criteria for fixed cost assignment to products
 - based on variable or attributable costs, consumed quantities, product revenues, employed workers, etc.
 - no obvious choice of weighting method
 - efficient price structure only approximated by chance
- **Efficient prices** (subject to the zero profit constraint) **cannot be set without detailed knowledge of the demand side!**

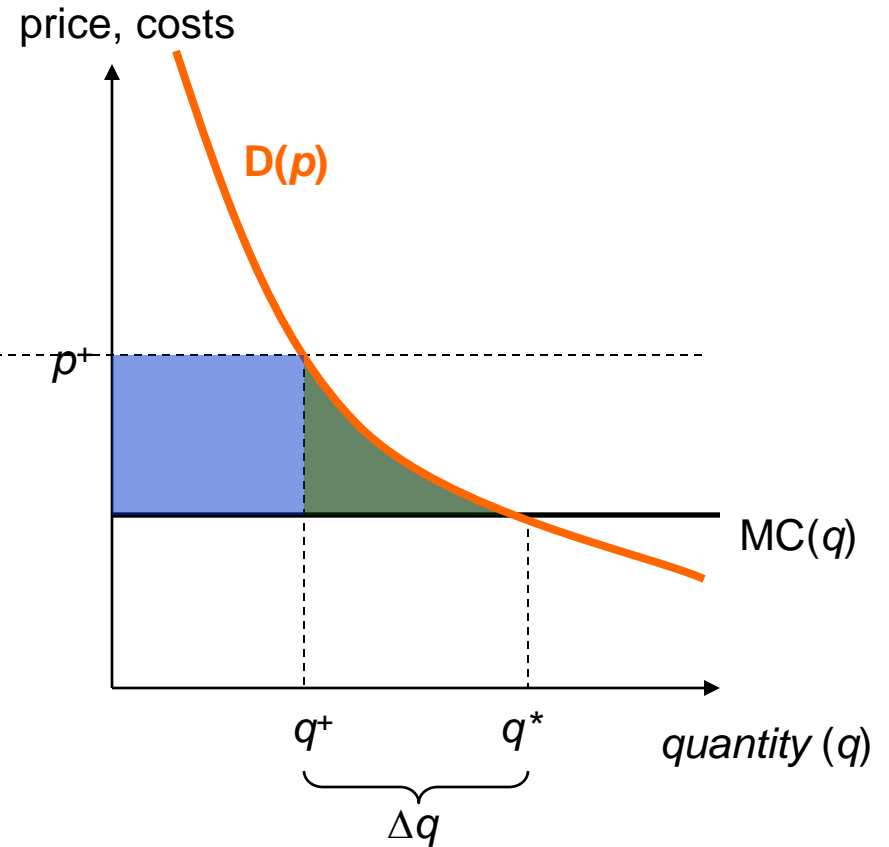


- The idea is to minimize total deadweight-losses (DWLs) subject to zero profits
- DWLs arise when prices exceed marginal costs
- DWLs are proportional to
 - the excess of price over marginal costs
 - the reduction in quantity demanded (Δq)
- Δq is determined by the *elasticity* of the demand function

Ramsey-pricing



Inelastic demand



Elastic demand

- Price-cost mark-up should be inversely proportional to demand elasticity in each product market
 - the more elastic product market should be operated with a lower (percentage) mark-up on costs and vice versa
- Second-best optimum (much like AC-pricing)
- Efficiency losses inevitable, but minimized
- Determining exact prices is computationally intensive
- Very detailed knowledge of demand functions needed
 - totally unrealistic assumption
- Not practical to apply strictly, but intuition is useful
- Conflicts with equity may arise
 - small consumers usually have less elastic demand

- With linear pricing, the best we can do is Ramsey-prices
- Non-linear pricing schemes applied to single product monopolies are also relevant for multiproduct firms
- Main issue is the same:
 - how to reconcile the need to ensure non-negative profit levels for the company with the drive towards allocative efficiency (marginal cost pricing)?
- Comments regarding two-part and optional tariffs apply here as well

- Economic inefficiency is a measurable welfare loss to society, therefore it is a justifiable aim of price regulation to minimize this loss
- Information on consumer demand is important for assessing economic efficiency
- Efficiency is enhanced by bringing unit prices closer to marginal costs of service
- More sophisticated (two-part, optional) tariff design helps achieve more efficient outcomes
- Fixed cost allocation should also be carried out with an eye on tariff setting efficiency

THANK YOU FOR YOUR ATTENTION!

REKK was established at the Corvinus University of Budapest in December, 2003. The mission of REKK is to contribute to the creation of working energy markets and the establishment of efficient regulation by carrying out applied research, training and quality consultancy activities for all those interested persons and organizations that are active in the field.

We think that the experiences that Hungary and some other Central and Eastern European countries have gained through the restructuring and re-regulation of their energy markets are valuable and relevant for all transition economies. This is why the Centre intends to put a special emphasis on the research and dissemination of the regional experience and intends to become a regional research and training centre.

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