

# Market Power - Analysis of the Nordic electricity system using the Balmorel model

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# Historical background

- Transition to more market based national systems during 1990's:
  - Norway, Sweden, Finland, Denmark
- Previous Nordic international trade based on bilateral arrangements, now supported by Nord Pool

# Understanding the Nordic power system

- Traditional understanding based on assumption of minimising of total costs of production (“marginal cost pricing”, or “minimisation of sum of consumers’ and producers’ surplus”)
- E.g.: key result for Danish integration: “hydro power levels prices as much as permitted within transmission conditions”
- “Same as perfect competition”

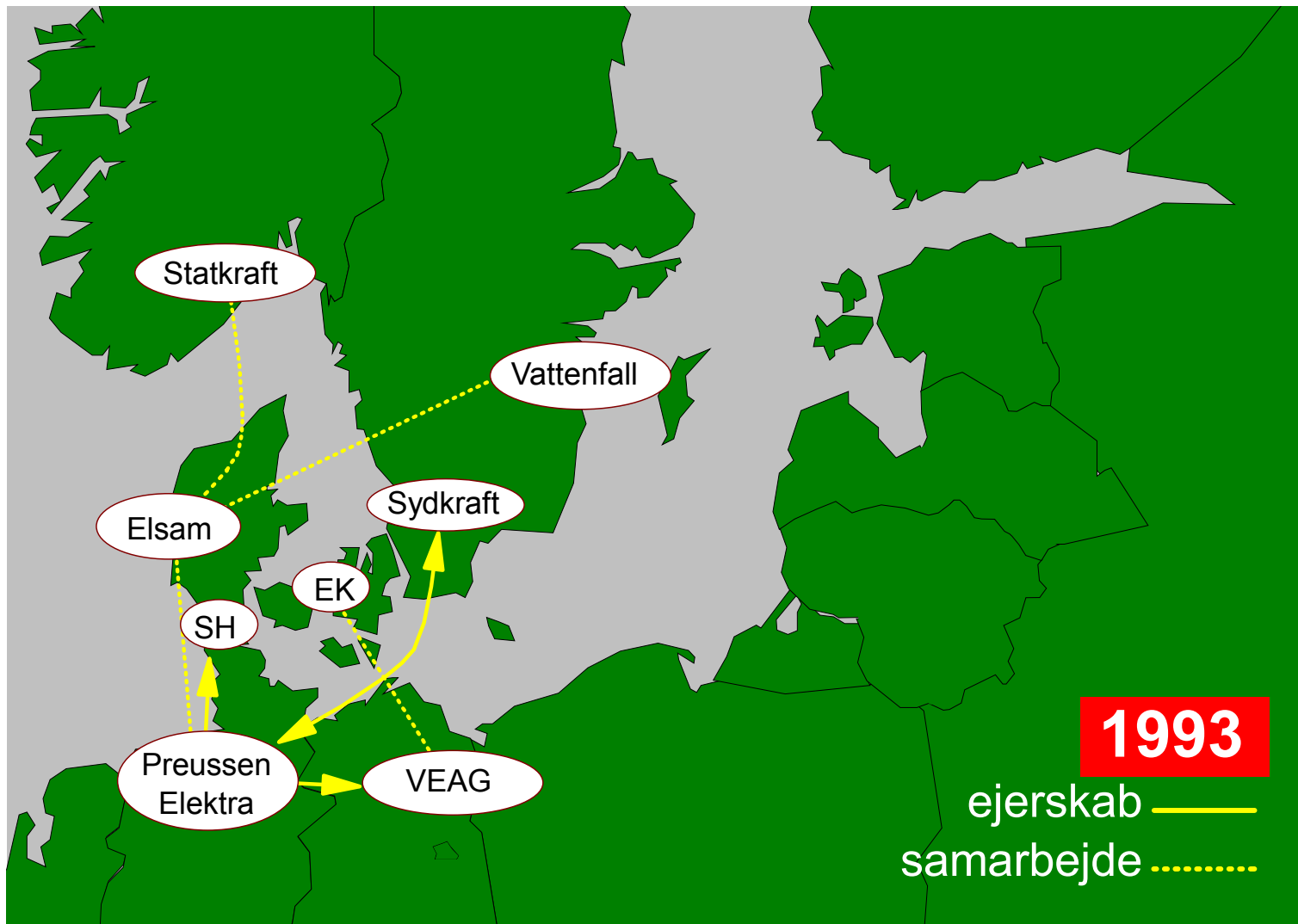
# Why question this?

- Always necessary to question basic assumptions
- Economic efficiency at stake
- In particular, the System Operator has responsibilities for market functioning

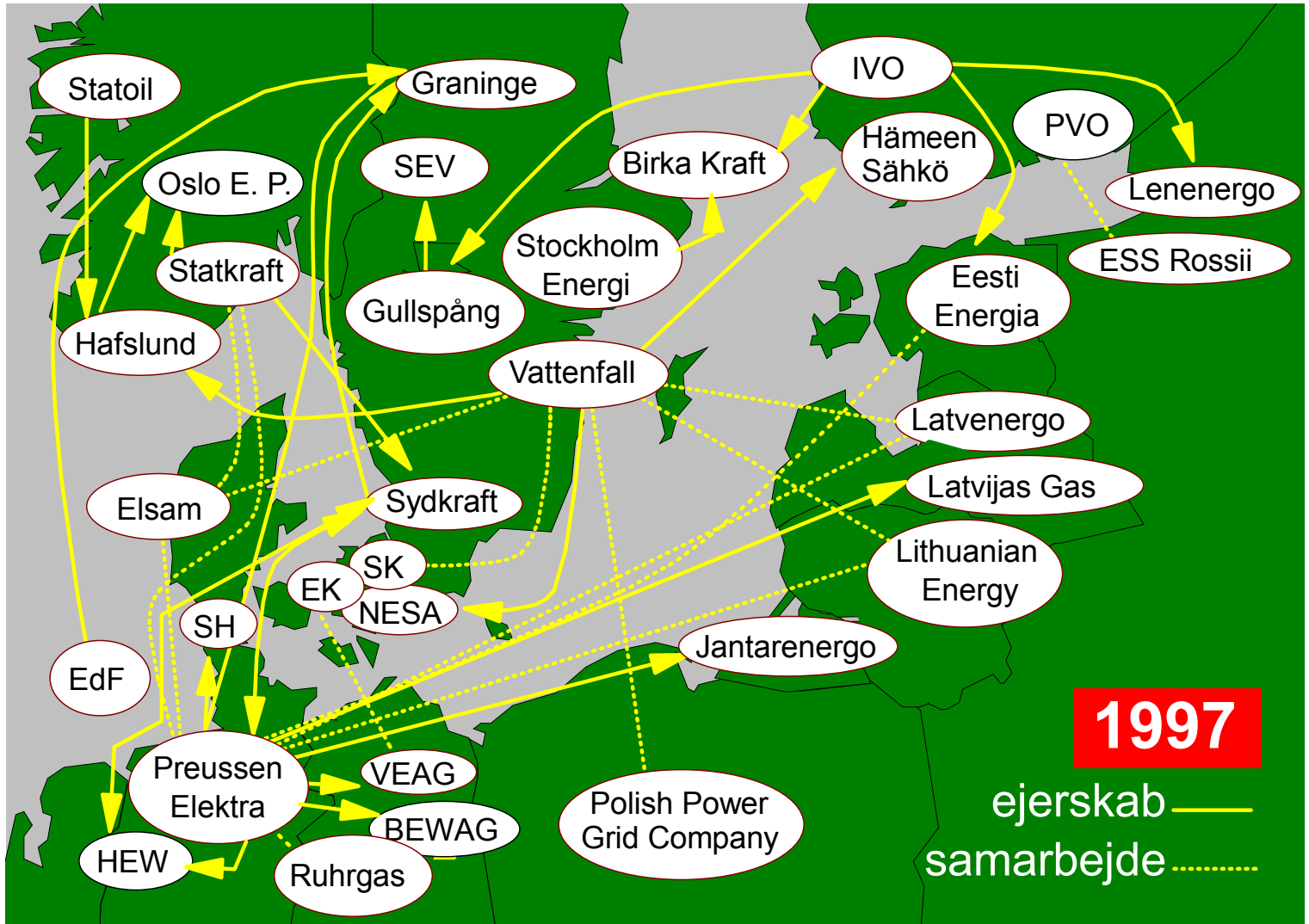
# Challenge to previous understanding: market power

Forms of market power:

- Horizontal power: 'large' production companies. (NB: transmission constraints)
- Vertical power: control over several links in the chain from production to consumption



From IRP97, Elkraft-samarbejdets integrerede ressourceplanlægning



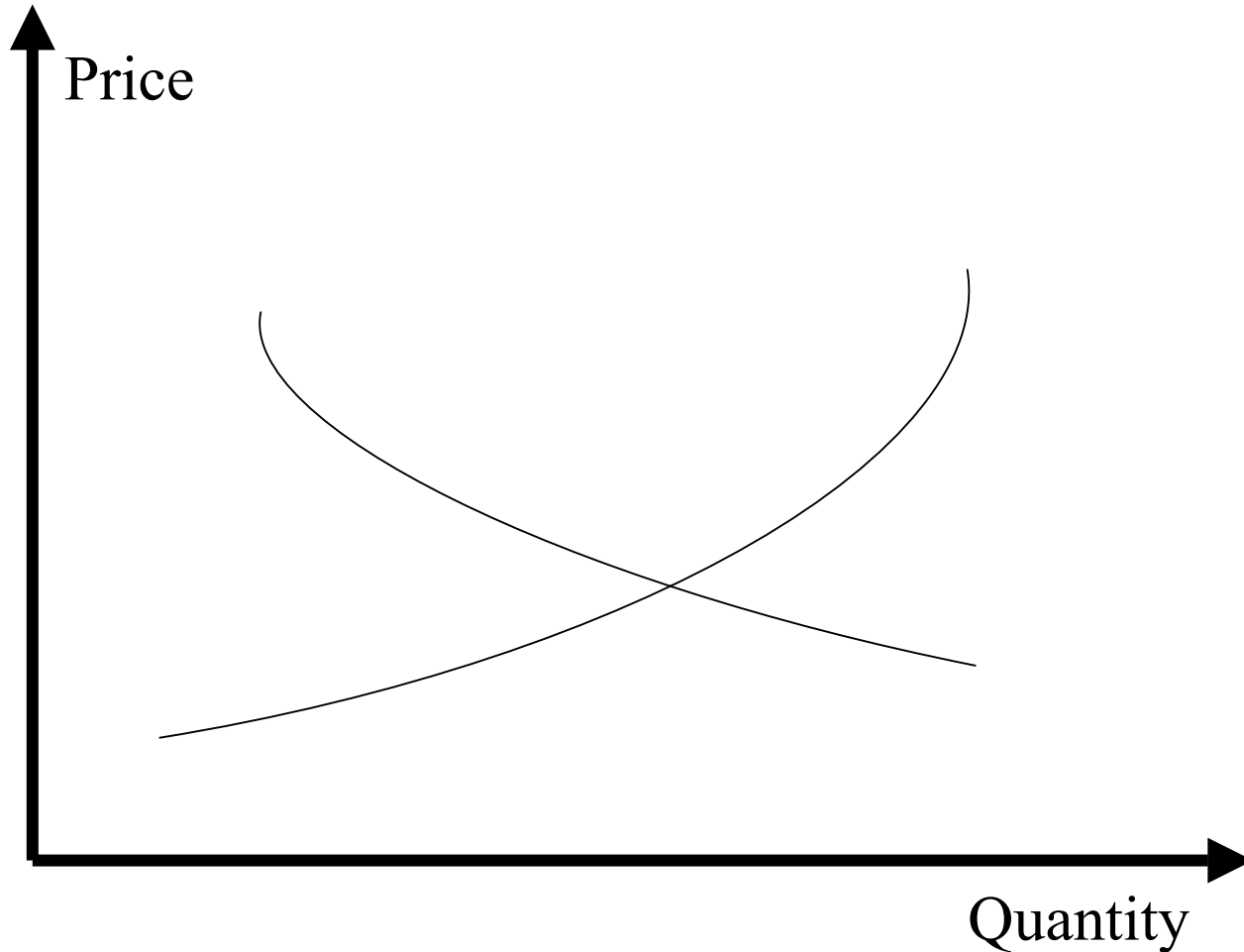
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# 'The liberalisation process'

- Unbundling: separation of production, transmission, distribution, 'system services'
- Providing access to transmission network
- (Some places breaking up large production companies)

# 'Perfect competition'

Electricity offered at production cost, the price will be the cost of marginal unit

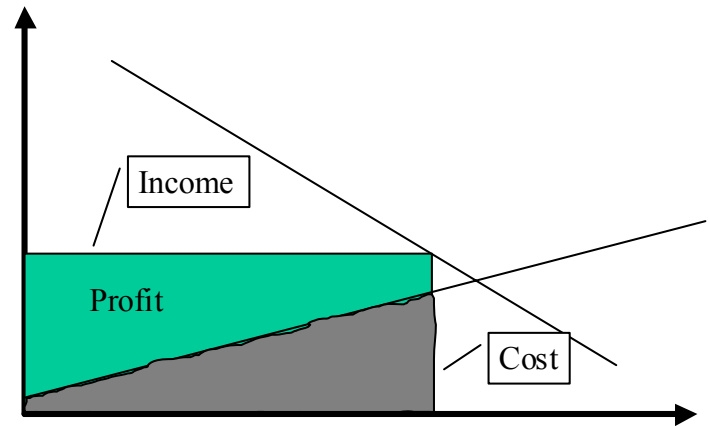
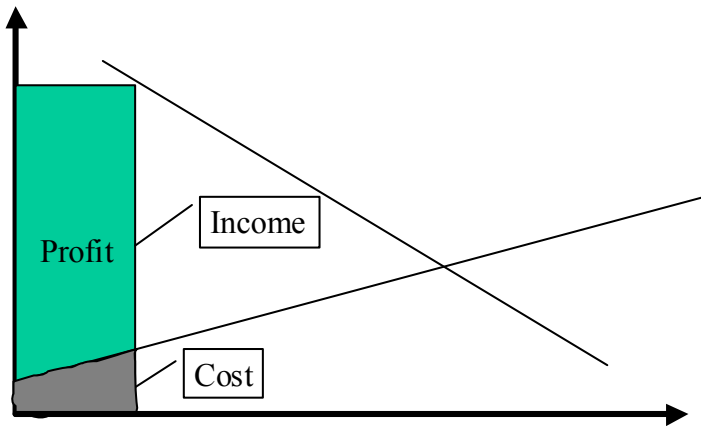


# Alternatives

- Monopoly
- Cournot
- Bertrand
- Supply Function Equilibrium
- Auction models
- ...
  
- (NB: transmission constraints!)

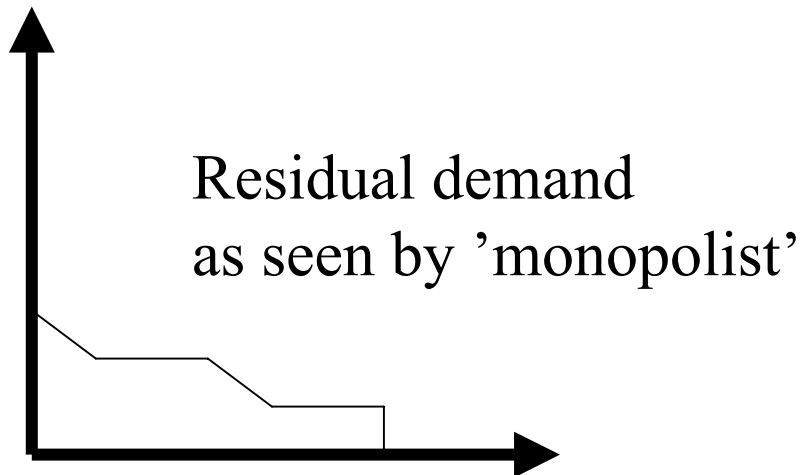
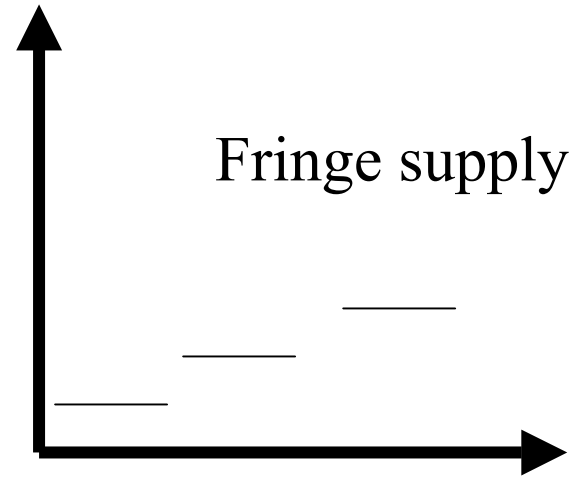
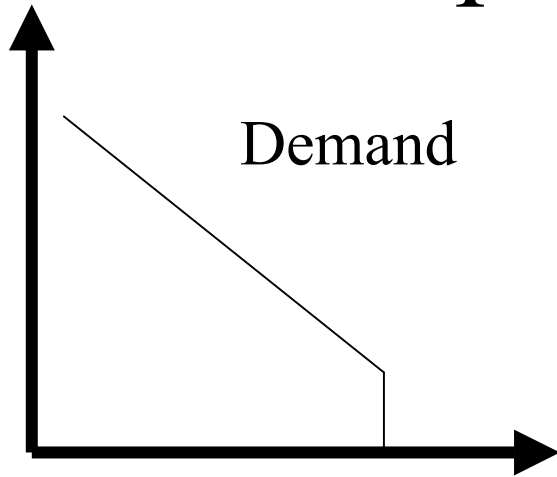
# Monopoly

Adjust quantity to maximise profits:  
 $\max[pd(p) - c(d(p))]$



Prices are higher and total production lower than in marginal cost pricing

# 'Monopoly' with fringe producers



# Cournot competition

- Each individual firm adjusts quantity offered to maximise its profit; other firms' quantities given
- Limiting cases:
  - One firm: monopoly
  - Infinitely many firms: marginal cost pricing
- Fringe firms may be included
- Prices are higher and total production lower than in marginal cost pricing

# Supply Function Equilibrium

- Each firm chooses for each price a quantity to supply
- In general many Nash equilibria, but with uncertainty this is reduced
- May be generalised to *conjectured* supply function equilibrium

# Nordic contributions

- Anderson, Amundsen, Bergman, von der Fehr, Skytte, ...
- Halseth: Market power in the Nordic electricity market (1998)
- Fristup: Oligopolistic Competition on Electricity Markets (1999)
- Amundsen and Bergman: Will Cross-Ownership Reestablish Market Power in the Nordic Power Market? (2000)
- Fleten and Lie: A stochastic Cournot model of the Scandinavian electricity market (2000)
- ECON (for Eltra and Elkraft): Storebæltsforbindelsen og markedsrett i dansk kraftsektor (2000)
- Kromann: Imperfect Competition in the Nordic Electricity Markets (2001)

# Nordic conclusions?

- ”... market power ... could be used to raise the electricity price substantially above marginal costs...” (Kromann 2001)
- ”Markedsmaktproblemer kan oppstå i de danske markedsområdene ... opptrer sannsynligvis ikke ofte ... ” (ECON 2000)
- ” ... the problem of market power mainly turns on Vattenfall. The company may only manipulate through reduced production in nuclear plants ... for many reasons unrealistic ...” (Halseth 1998)

# What then?

- A number of approaches and experiment exist
- No clear conclusions on how to model
- No clear conclusions on market power or not
- ... but still a relevant topic!

# How to formulate mathematically?

- Optimisation for monopoly (single objective)
- Stationarity more general:
  - the KKT conditions for the whole system imply KKT conditions for any single firm
- If both quantity and price in model formulation then in general mixed complementarity (MCP) formulation necessary

Assume profit maximising firms:

What should characterise a 'solution' or 'equilibrium' point?

- If attained, no motivation for any individual firm to leave it (Nash equilibrium)
- If not attained, some process (to be defined) should converge to such point
- Unique?

# How to solve?

- Analytical solution: assume smooth, convex, etc. functions and use paper and pencil
- Numerical solutions: use standard code:
  - optimisation: abundant and potent
  - MCP: less so

# Present modelling

- Ambition: we end up with:
  - a numerical model with 'real' data
  - incorporating transmission system
- Starting point:
  - Monopoly with fringe firms in one region
  - Transmission links to other regions in which there is marginal cost pricing
  - Balmorel model

# The Balmorel model

- Models the electricity and CHP sector in the Baltic Sea Region
- Suited for energy and environmental policy analysis
- Developed under the Danish Energy Research Program 1999-2001
- Developed by Elkraft System, Risø, AKF and partners along the Baltic Sea
- Open for anyone to inspect, use and modify
- Further information at [www.Balmorel.com](http://www.Balmorel.com)

# Status

- Base version of Balmorel model ('perfect competition') exists
- Monopoly with fringe firms in one region implemented in 'stand-alone' version, not verified
- To be integrated into Balmorel
- Analyses to be performed