Supply Security, Capacity Payments and Electricity Spot Market Prices

Eirik S. Amundsen and Lars Bergman

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Key aspects of the electricity market

- The electricity supply industry has four segments:
  - Generation
  - Transmission
  - Distribution
  - Retailing (Supply)
- The system has to balance in real time
- Typical contracts between suppliers and final consumers are designed as options

The Nordic electricty market

- A common power exchange (Nord Pool) and no border tariffs
- National system operation
- Background data
  - Annual consumption close to 400 TWh
  - Almost 50% hydropower and 25% nuclear power
  - National production systems differ significantly

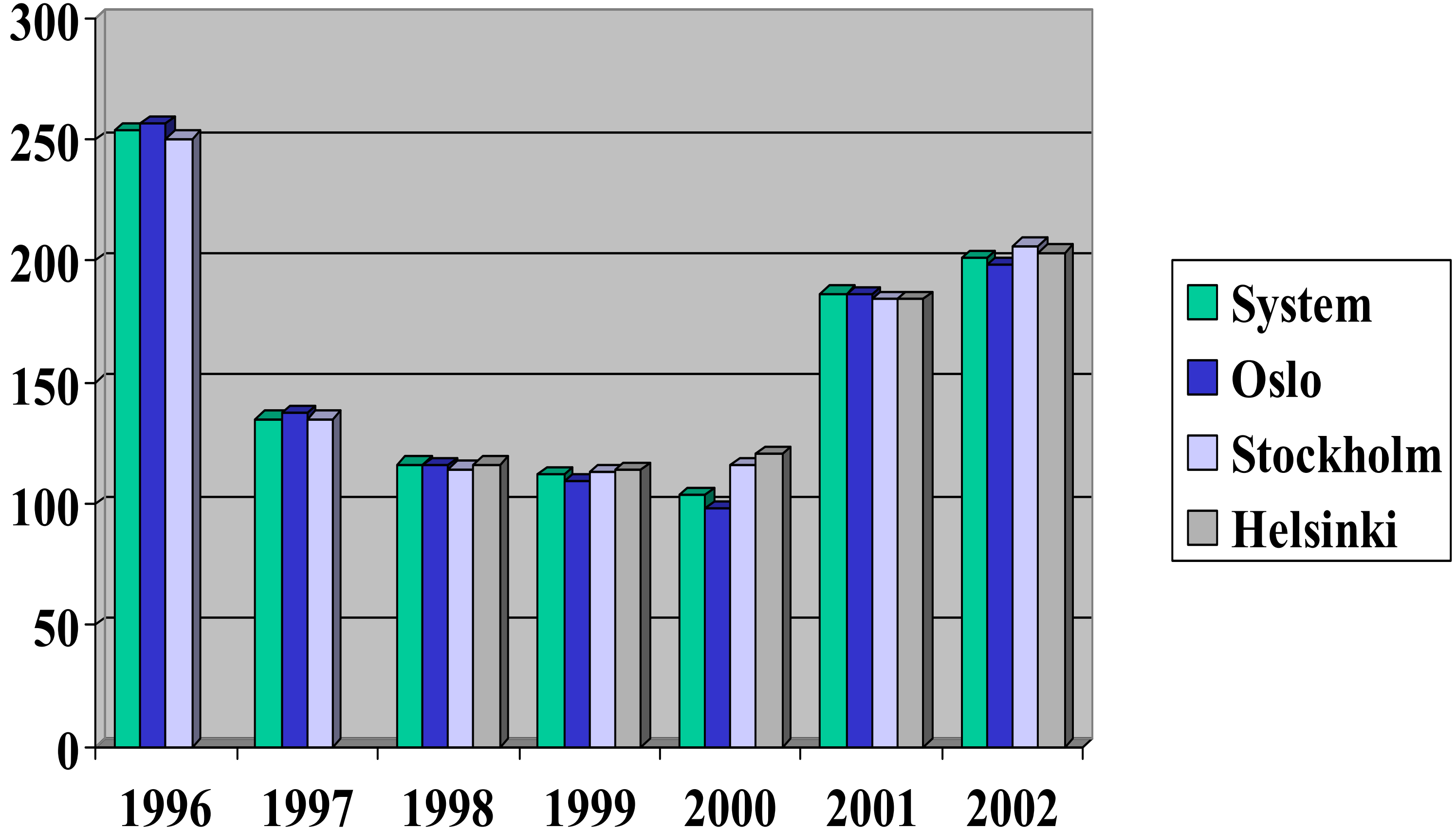
Markets

- “Physical” markets
  - “Markets” for bilateral long-term contracts
  - Elspot (Nord Pool) [Day-ahead]
  - Elbas (Finland and Sweden) [Hours ahead]
  - Regulation markets (national) [Real time]
- Purely financial markets
  - Eltermin and Eloption (Nord Pool)
  - Market for CFD:s (Nord Pool)
  - OTC markets

Wholesale spot market prices

- Elspot *system price*
  - Hourly price determined in a unit price auction
  - Determined on the assumption that transmission capacities are sufficient
- Elspot *area prices*
  - Hourly prices for all price areas (predetermined, maximum 9)
  - Division of the market into price areas determined by expected power flows and available transmission capacities

System and area prices 1996-2002 NOK/MWh



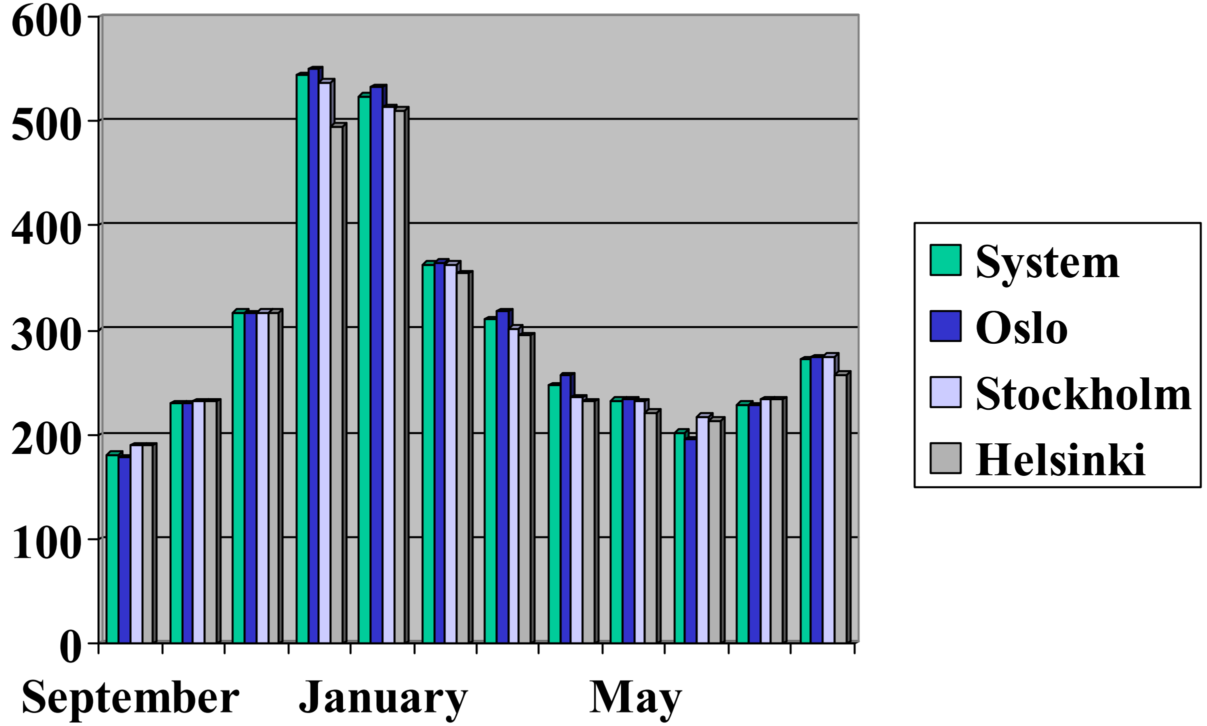
Observations on market power

- The national wholesale markets are concentrated, but the integrated market is not
  - In general small differences between system and area prices
- Increasing concentration and vertical integration between generation and retailing in Sweden
  - Trade margins have increased, partly reflecting previously underestimated costs and partly market power

Impact of supply shocks

- Several extreme years since the ”new” market opened in 1996
  - Extremely large hydropower supply in 2000
  - Extremely small hydropower supply in 2002
- Yet the market has continously cleared, and generators and retailers have been sufficiently well hedged to prevent disastrous financial consequences of low and high wholesale prices

System and area prices 2002-2003
NOK/MWh



A sequence of ”physical” markets:
Some implications for generator behaviour (1)

- The forward (bilateral and spot) markets close before the real-time market opens
- The suppliers plan production and/or power purchases on the basis of the expected real-time demand of their customers, but the actual demand is uncertain
- The suppliers are financially responsible for the (aggregate) deviation between the expected and actual real-time demand of their customers

A sequence of ”physical” markets:
Some implications for generator behaviour (2)

- The generators may commit capacity for honouring forward market contracts, or keep it available for bidding in the real-time market
- As result the spot and real-time markets are interdependent
- Spot and real-time market interdependence may affect the standard measure of market power (Lerner index)

A simple model of generator behaviour

p = *Price*

x = *Production*

X = *Capacity*

c = *Marginal and average cost*

f, r = *Index for spot and real-time market*

s = *Index for "state of the world"*

ρ = *Probability of state of the world*

μ= *Demand for balancing power (positive or negative)*

φ = *Expected rate of capacity utilisation*

π = *Profit*

A simple model of generator behaviour (cont.)

$$\pi = p_f x_f - c x_f - \sum_s \rho_s p_r^s \mu_s + \sum_s \varphi_s (p_r^s - c)\left(X - x_f\right)$$

with necessary condition

$$\frac{\partial \pi}{\partial x_f} = p_f - c - \sum_s \varphi_s (p_r^s - c) = 0$$

Side-track: Apparent market power

- Assume for simplicity that expected and real-time demand coincide so that no balancing power is needed
- Then the spot market price p_f will exceed the marginal cost, and the Lerner index will be positive
- In addition part of the available capacity will be withheld
- Thus, although the market is perfectly competitive it appears that the generators are exercising market power

The demand and supply of reserve capacity

- Important factors on the demand side:
  - The security of supply objectives of the system operator
  - The time lag between the closing of the spot market and real time operations
  - The companies' incentives to be in balance
  - The responsiveness of consumers to scarce supply (pricing in a tight market)
- Important factors on the supply side
  - Expected real-time electricity demand and prices
  - The prices paid to generators that keep reserve capacity available (capacity payments)

The Case for Capacity Payments

- In theory “energy-only” spot and real-time markets could result in efficient operation and supply of (total and reserve) capacity
- Hence there is no need for specific capacity payments
- But this result relies on the assumption that producers and consumers observe the real time market price and make instantaneous adjustments
- In addition perfect knowledge on future prices or their distribution is assumed.
- But in reality firms may be risk averse and thus not willing to keep seldom used reserve capacity even though this is profitable in expected value terms

Provision of reserve capacity: literature

By now quite an abundant literature exists on electricity market design and architecture related to reserve capacity provision (e.g. Schweppe et al. (1978), Joskow and Schmalensee (1983) , Chao and Huntington (1998), Stoft (2002), Wilson (2002))

Practical experiences in Sweden

- Between 1996 and 2000 there were no capacity payments in Sweden
- During this period around 3 000 MW (of a total of 34 000 MW) was mothballed
- As a result the margin between peak demand and installed capacity was reduced from 8 000 MW to 4 000 MW (2 000 MW during a short period)
- In 2001 a temporary capacity payment system was introduced, and 1 000 MW mothballed reserve capacity was made available

The temporary system in Sweden

- The TSO pays generators to keep a certain amount of reserve capacity available
- The reserve capacity should be bid into the market at predetermined prices (twice the operating cost of the units in question)
- The demand side is not involved in the system
- Since the temporary system was introduced peak-load capacity has not been a problem

Objectives in the provision of reserve capacity

- Reserve capacity should be provided at the least cost to society
- This involves both the supply and the demand side
  - The supply side should be involved in order of increasing marginal cost of provision
  - The demand side should be involved in order of increasing marginal willingness to pay for power (demand side management)

Efficient provision of reserve capacity

- Efficient supply of reserve capacity
  - Trade-off between the marginal cost of keeping reserve capacity and the aggregate marginal willingness to pay for reserve capacity
- Efficient use of existing reserve capacity in real time (known demand)
  - Trade off between generation of regulating power and voluntary disconnection

Examples of arrangements for capacity provision

- The PJM ICAP-market (PJM)
  - a long term arrangement designed to induce new investments
  - The SO allocates capacity obligations among the LSE
  - The LSE must secure either physical capacity or capacity credits purchased bilaterally or on the ICAP market (resembles in this respect a system of tradable emission permits)

- ICAP with mandatory call options (Oren, 2000)
  - The seller of the call option can either provide capacity at the strike price or pay the difference between the spot price and the strike price
  - The strike price and duration is set by the agents and not the SO.
  - This allows for risk management

Examples of arrangements for capacity provision (cont.)

- Capacity Subscription and self rationing (Panzar and Sibley, 1978; Chao and Wilson, 1987)
  - Involves the consumer side as consumers subscribe to their anticipated capacity needs
  - Due to a system of fuse-activation consumers have "black outs" in their own home
  - Quality of supply becomes a private good and not a public good
  - A market for reliable supply can be organized where the quantity is endogenized
- The Norwegian RPM-options market

Norway: Market of capacity options

- As of 1. November 2000 the new market for ”regulating power options” (RPM-options) was introduced in Norway
- The market is run by Statnett SF and comes in addition to the other existing power markets (i.e. the Elspot market (Nord Pool), the Eltermin Market (Nord Pool), the Elopsjon (Nord Pool), the Regulating Power Market, RPM (Statnett SF), and the bilateral markets)
- The market invites participation from both generators and consumers (e.g. large consumers in the paper and melting industry)

Norway: Market of capacity options (Cont.)

- Participants signing up in this market must guarantee to deliver (reduce) specific volumes in the Regulating Power Market if called upon.
- Conditions: The RPM- options
  - must be active within 15 minutes after being called upon
  - must be continuously active for at least an hour
  - must be able to be active for at least 10 hours a week.
- Duration of contracts: 3 months and 1 year.

Norway: Market of capacity options (Cont.)

- Acceptance of offers with the lowest price until the desired volume of power is obtained (3 separate price areas)
- All accepted offers are remunerated based on the price of the last accepted offer
- In addition accepted participants are also paid the RPM price according to actual delivery
- The market seems to have functioned satisfactorily (3-4 more than Statnett needed was offered)
- This has resulted in consumers registering in the RPM which was not earlier the case