Electricity Market Developments in the Nord Pool Area

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Norwegian and Nordic electricity market

• One of the first deregulated electricity markets in the world
  – Nordic countries (excl. Iceland): 400 TWh / population 25 mill.
• Energy is traded in the Nordic market
  – Power Exchange: Nord Pool Spot
  – Financial Market: NASDAQ OMX Commodities (from 2010)
• Vertical separation of transmission/distribution and generation
  – By separation of accounts (except for Statkraft / Statnett)
• Competitive supply and demand for power
  – Choose energy supplier
  – No price caps
  – Not even for households
• Transmission and distribution are regulated
Norwegian and Nordic electricity market

Long term contracts: Reduced volume and duration after deregulation

- Contracts offered
  - Fixed price
  - Variable price
  - Spot price

Generation

Nord Pool Spot

- System price (unconstrained)
- Area prices
- 70 – 80 % of Nordic power

Retailers

Energy intensive industry

Consumption

Transmission

TSO (Statnett)
Investments by licenses

≤ 132 kV (>70 companies)
Investments by licenses

≤ 22 kV (>130 companies)
Area concession – rights and obligations

Regional transmission

Third party access to network
Implemented by point tariffs

Distribution
Nord Pool Spot

- Covers
  - Norway, Sweden, Finland, Denmark, KONTEK/Germany, Estonia
- Day-ahead
  - Supplemented by balancing / regulation markets
- Voluntary pool
  - Trades between Elspot areas are mandatory
  - Agents use Nord Pool Spot to determine prices and as a counterpart
- Three kinds of bids
  - Hourly bids – bids for individual hours
  - Block bids – create dependency between hours
    - Non-convexities
  - Flexible hourly bids – sell during hours with highest prices
Regulation of electricity networks - Norway

• Network companies (excl. Statnett)
  − Regional transmission (≤ 132 kV)
    • 75 companies, annual cost 2006 ≈ 3.2 billion NOK
  − Distribution networks
    • 136 companies, annual cost 2006 ≈ 10.5 billion NOK
    • 57 companies with both RS- and D-networks

• Regulation is based on total cost
  − Rate of return regulation from 1993
  − Incentive regulation from 1997 (with minimum returns)

• Annual cost includes value of lost load (VOLL) and cost of capital
  − VOLL = unit prices * lost load (MWh)
  − Linear depreciation (according to accounts)
  − Return on capital = Book values * NVE rate of return
Cost groups – distribution companies

2006 dataset
Incentive regulation

• Incentives for efficient operation, organization, investments
  – Revenue should be independent of the regulated company’s own costs
    • Revenue = cost of the “marginal” company, given the company’s “output” (volume and quality)
    • Profit also depends on the company’s costs

• Sufficient revenue level to attract both financial and human capital
  – Competitive rate of return on invested capital
  – Accept continual “super-profits”

• Time profile of revenues can be an issue
  – Productivity independent of age
    • Real annuity based on new replacement values / catalogue values
    • Ref. annuity versus fixed part payment
Regulation model from 2007

• Revenue cap regulation continued
  – A company’s own cost should not determine its cost norm
    • “Super-efficiency”
  – To allow super-profits for the most efficient companies
    • “Calibration of average efficiency”

• Yardstick-competition
  – Revenue cap based on actual costs and cost norms
    \[ \text{RCap} = C + \rho (C^* - C) = \rho C^* + (1 - \rho) C \]

• How to determine C?
  – Accounts and calculated costs
  – Reference and regulation period

• How to determine C*?
  – Benchmarking models and interpretation of results
DEA benchmarking method

• In DEA different assumptions can be made about
  – Inputs / outputs
  – Economies of scale
  – Super efficiency

• To implement DEA efficiency analyses requires knowledge about the underlying cost structure!
  – Cost groups and cost assessment, especially for calculated cost
  – Cost drivers

• Successful implementation requires reliable data
  – Frontier model

• Need to consider how the DEA results are to be used in the regulation mechanism
  – Calibration of returns
  – Time lags
Sum industry revenue cap (excl. Statnett)

Yardstick revenue cap formula for each company

\[
RCap = \rho \cdot C^{**} + (1 - \rho) \cdot C + CP
\]

\[
CP = 1.6 \cdot r_{NVE} \cdot \text{Investments}_{t-2}
\]

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### The market works well?

Energy not supplied (ENS) in per thousand of the energy supplied (ES) to end users in Norway since 1996
Major developments and challenges

• European integration
  – Tight volume coupling
  – Convergence of algorithms

• Congestion management
  – Zonal pricing and transfer capacities

• Demand response
  – Industry
  – Households
  – Advanced metering and control systems from 2017

• Investments
  – Generation
  – Transmission
European integration

Figure 4.1 – Day-ahead transmission capacity allocations across Europe (updated June 2007)
Congestion Management in the Nordic Power Market

• Inter zonal congestion – Zonal pricing / Market splitting
  – Day-ahead market
  – For the largest and long-lasting congestions in Norway and Sweden and for congestions on the borders of the control areas, including two Danish areas

• Intra zonal congestion – Counter trading / Redispatching
  – The regulation market

• TSOs are regulated
  – Net effect of ZP and CT is passed on to domestic customers

• What is zonal pricing?
  – A “simplification” of nodal prices
    • Fewer prices, good for liquidity and competition in the spot market?
  – Implies some sort of aggregation
    • What is to be aggregated? Prices? The physical network model?
Aggregation models

True network
- "All" nodes included
- "All" lines represented

Price aggregation
- "All" nodes included
- "All" lines represented
- Zones with uniform prices

Physical aggregation
- Aggregate nodes
- Aggregate lines
- Prices for "nodes"
Transfer capacities

• Capacity limits are determined by TSOs and communicated to Nord Pool before market clearing
• Limits are based on
  – Forecasts of supply and demand
  – Imports/exports from the Nord Pool area
  – Security constraints
• Sweden cut 2 / Denmark DK1 cut B
  – Proportional allocation to each connection or group of connections
  – Optimization routine to determine capacity utilization for groups of connections
• Norway west-east connections
  – Hasle corridor heuristic
Figur 3: Diverse fysiske forhold og spotpris i Østdanmark d. 28. og 29. november.


Note: forskellen i Elspot flow og Actual flow i venstre figur på Kontek-forbindelsen, skyldes Energi E2s gamle aftale om at sende 350 MWh i sydgående retning.
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Remedy – more price areas
Challenges winter 09/10

• Very cold
• Long lasting nuclear outages
• Three periods with “sky high” spot prices
  – In some cases followed by large downward regulation in balancing market
• New price areas introduced
• Security constraints violated

⇒ Expert group to consider power system operation
Price spikes winter 09/10

• Very cold, high and inelastic demand, reductions in production and transfer capacities
  – December 17: Low Swedish nuclear power production
  – January 8: Low nuclear power production and low transfer capacity
    • Prices documented to be very sensitive to transfer capacities (Gaia report 2010, NordREG)
  – February 22: Low nuclear power production, low reservoirs and inflow (reduced efficiency in the hydro power system)

• Large price differences, but also missing price signals
  – Large price areas and relaxed security constraints
    • Bergen, Stavanger, Oslo
Transfer capacities from Southern Norway to Sweden and price difference (NVE)
Regulation market:
Down regulation at very high prices (NVE)
Large down-regulation - low RPM prices

• Several explanations for the down-regulation
  – The demand side adapted consumption to high Elspot prices
  – Forecasts of demand were bad under extreme temperatures
  – Suppliers seemed to fear high prices for up-regulation and oversupplied in Elspot
  – Starting of reserves in Sweden – discrete amounts – larger than necessary (partly due to minimum requirements for starting)

• What explains the large price difference?
  – Low elasticities in supply and demand implies a big impact on the Elspot market prices when demand increase
  – The mirror in RPM: Small down-regulations in the RPM results in low prices

• In addition: Energy intensive industry only offered power to the pool after the first spikes
Demand flexibility

• Three important aspects
  – The fundamental possibility to reduce the use of electricity
    • Substitution and income / direct price effect (the budget effect)
  – Incentives to change behavior
    • Real time measuring (hourly) and accounting
    • High transaction costs in frequent adjustment of behavior
      – Automatic price induced power regulation
  – Awareness about the possibilities – information and market
    • Fixed prices do not induce incentives to adjust demand
      – The energy intensive industry did not expect price peaks

• Prices should reflect cost variations and be allowed to vary in time and space so that they trigger
  • Investments in technology to avoid high prices and benefit from low prices
  • Short term flexibility
Investments

- Generation
  - Finland
    - Nuclear power
    - Long term contracts with industry
  - Denmark
    - Wind power
    - Feed in tariffs
  - Sweden
    - Fuel-substitution (mostly biomass)
    - Green certificates
    - Ambition: 17 TWh in 2016

- Norway
  - Small scale hydro power
  - Evidence of "real option behavior"
    - Waiting for the green certificate markets
    - Joint with Sweden from Jan 2012
    - Ambition: 26.4 TWh in 2020

<table>
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<tr>
<th>Current and expected generation fuel mix</th>
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<td>Wind power</td>
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<td>Hydro power</td>
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Actual investment commissioning during 2010 (* Does not include 300 MW capacity in gas-fired mobile reserve plants)
Investments

• Transmission and distribution
  – Massive investment needs
    • 100 bill. until 2020
    • Book value today $\approx 60-65$ bill.
  – Public acceptance