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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

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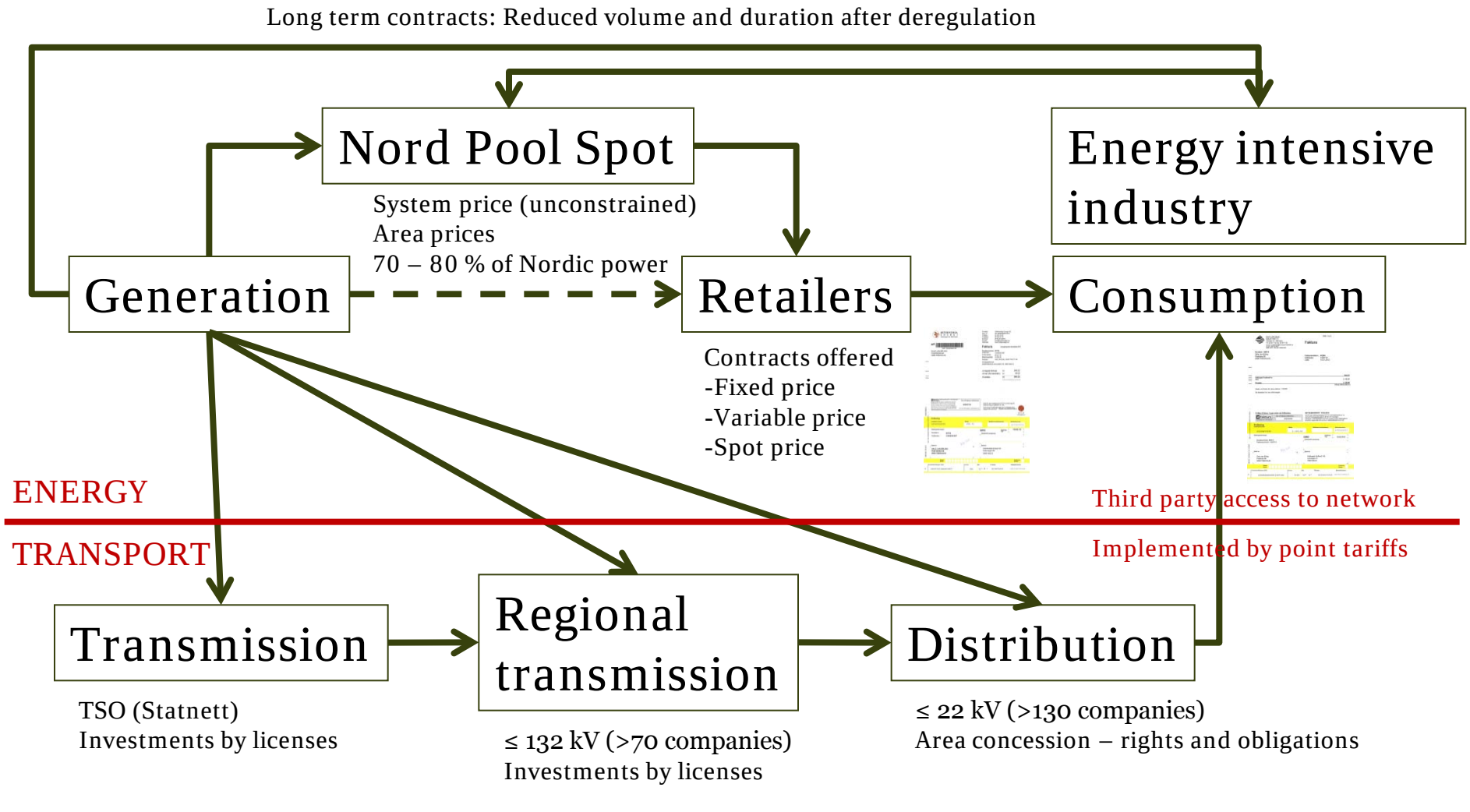
Norwegian and Nordic electricity market



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

Elspot
- Prices
- Volumes
- Capacities
- Flow

Elbas
- Market data
- Initial capacity
- Flow
- Transmission capacity
- Total scheduled flow

Regulating power
- Regulating power per area
- Regulating prices
- Regulating volumes
- Volume of regulating bids
- Special regulation volume
- Automatic activated reserve

Power system data
- Production
- Consumption
- Exchange
- Hydro reservoir

Maps
- Elspot market overview
- Power system overview
- Nordic power system

Downloads

Elspot market overview

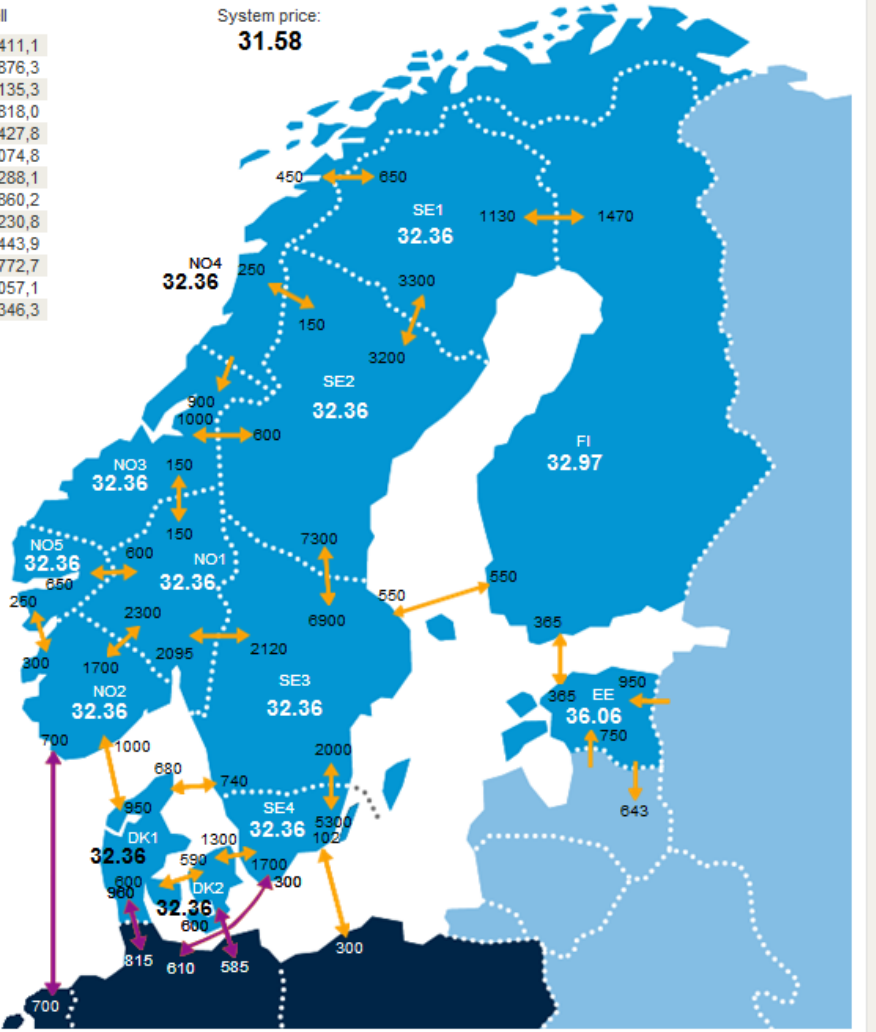
03-03-2012 Resolution 17 - 18 Currency EUR ☑ Capacities ↔ ☐ Flow ↔ ☑ Area Prices

ITVC ↔ ITVC ↔

Elspot volumes

	Buy	Sell
NO1	4 436,0	3 411,1
NO2	2 786,7	4 876,3
NO3	1 343,4	1 135,3
NO4	1 387,1	1 818,0
NO5	1 007,0	1 427,8
DK1	2 595,5	2 074,8
DK2	2 254,2	1 288,1
SE1	1 228,9	3 860,2
SE2	1 774,4	5 230,8
SE3	10 644,5	9 443,9
SE4	3 861,3	772,7
FI	6 712,1	5 057,1
EE	711,3	346,3

System price: **31.58**



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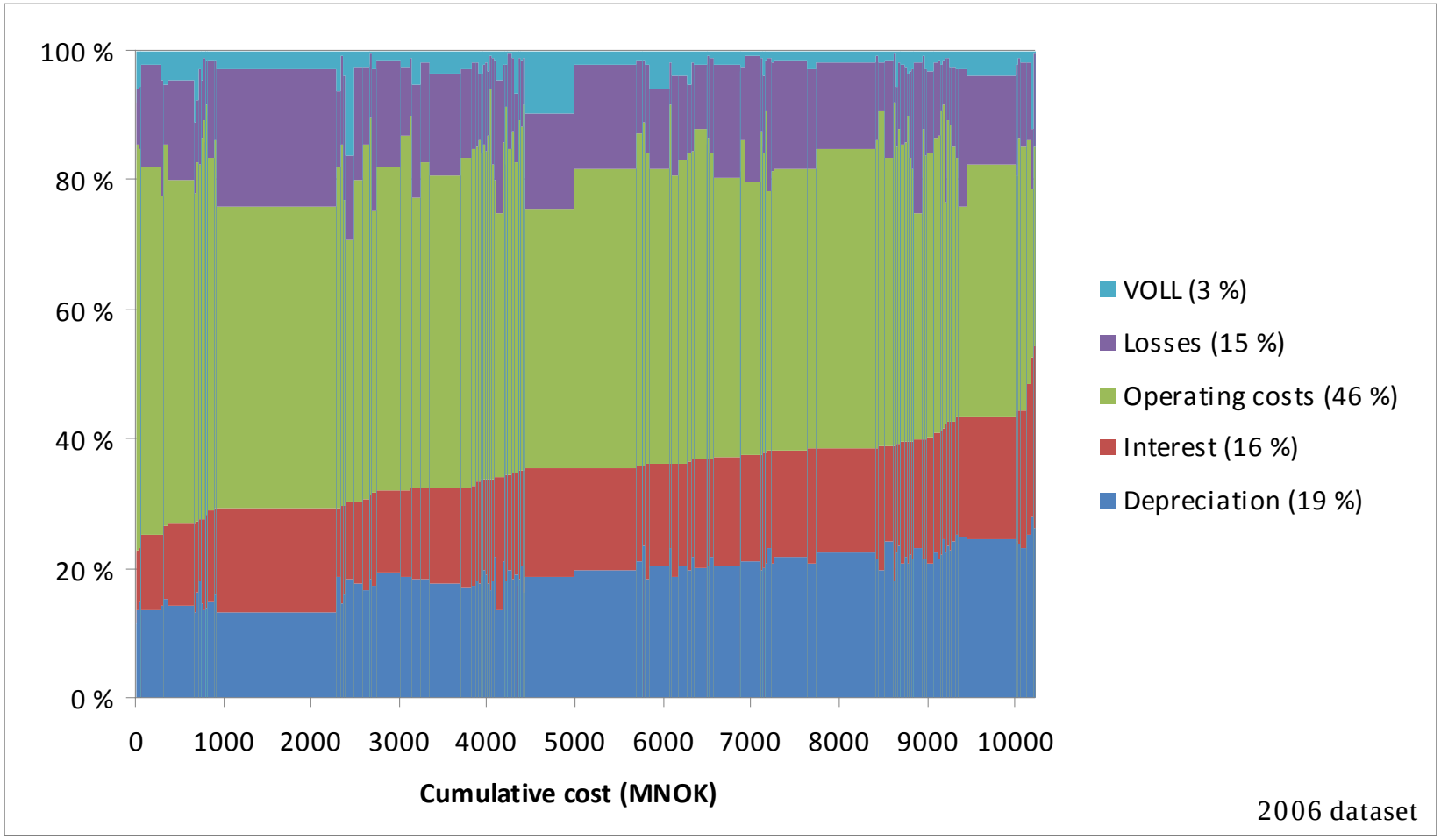
Regulation of electricity networks - Norway

- 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

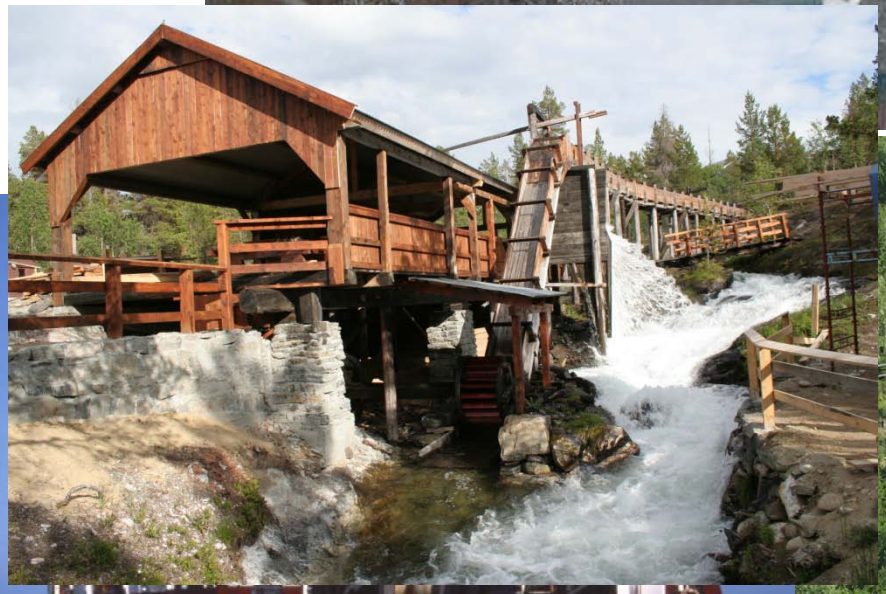


Incentive regulation

- 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
  - $RCap = C + \rho (C^* - C) = \rho C^* + (1 - \rho) C$
- How to determine C?
  - Accounts and calculated costs
  - Reference and regulation period
- How to determine C*?
  - Benchmarking models and interpretation of results



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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

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Sum industry revenue cap (excl. Statnett)

Yardstick revenue cap formula for each company

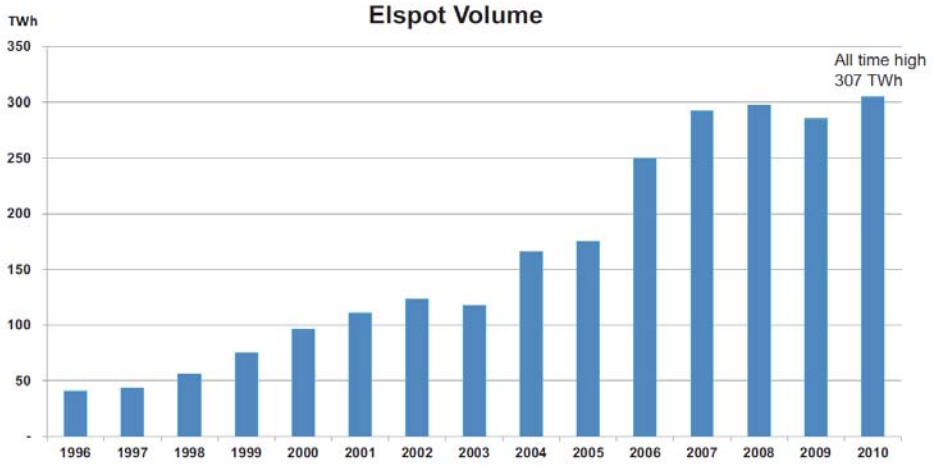
$$RCap = \rho \cdot C^{**} + (1-\rho) \cdot C + CP$$

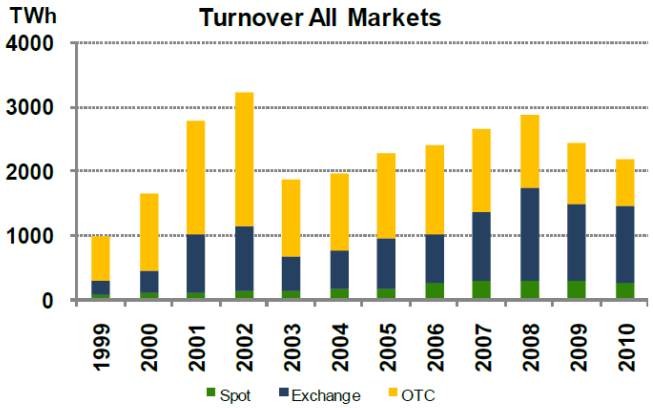
$$CP = 1.6 \cdot r_{NVE} \cdot \text{Investments}_{t-2}$$

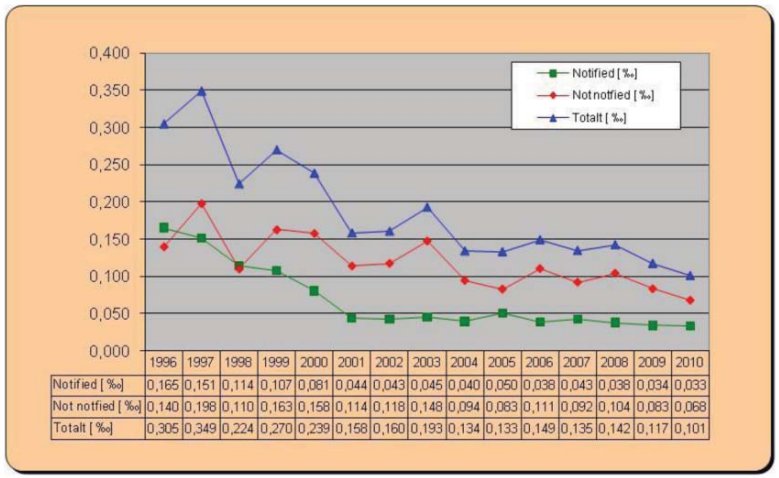
	2007		2008	
	MNOK	**"Profitability"**	**MNOK**	**"Profitability"**
Revenue cap based on DEA eff. scores	12 986	6.54 %	13 848	6.37 %
Effect of adjusting eff. scores (step 2)	599	1.55 %	786	2.01 %
Revenue cap after step 2 adjustments	13 585	8.09 %	14 635	8.38 %
Compensation parameter (step 3)	328	0.85 %	371	0.95 %
Rev. cap before calibration (RCap1)	13 913	8.94 %	15 006	9.33 %
Calibration effect (step 3)	-328	-0.85 %	-372	-0.95 %
Final revenue cap (RCap2)	13 585	8.09 %	14 634	8.38 %

The market works well?

Elspot prices at Nord Pool Spot (EUR/MWh)												
Year	SYS	NO1	NO2	NO3	NO4	NO5	DK1	DK2	FI	SE	EE	KT
2000	12,75	12,06	-	-			16,41	-	14,88	14,24		-
2001	23,15	23,08	-	-			23,74	23,54	22,83	22,86		-
2002	26,91	26,57	26,80	26,80			25,47	28,59	27,28	27,62		-
2003	36,69	37,11	36,66	36,66			33,68	36,80	35,30	36,49		-
2004	28,92	29,40	29,12	29,12			28,80	28,35	27,68	28,08		-
2005	29,33	29,13	29,39	29,39			37,23	33,80	30,53	29,76		59,32
2006	48,59	49,23	48,97	48,98			44,18	48,53	48,57	48,12		49,70
2007	27,93	25,74	29,59	29,43			32,40	33,01	30,01	30,25		36,62
2008	44,73	39,15	51,17	49,81			56,43	56,64	51,02	51,12		63,89
2009	35,02	33,74	35,53	35,53			36,05	39,88	36,98	37,01		33,94
2010	53,06	54,25	50,82	58,04	57,33	51,79	46,49	56,94	56,64	56,82	34,92	-







	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Notified [‰]	0,165	0,151	0,114	0,107	0,081	0,044	0,043	0,045	0,040	0,050	0,038	0,043	0,038	0,034	0,033
Not notfied [‰]	0,140	0,198	0,110	0,163	0,158	0,114	0,118	0,148	0,094	0,083	0,111	0,092	0,104	0,083	0,068
Totalt [‰]	0,305	0,349	0,224	0,270	0,239	0,158	0,160	0,193	0,134	0,133	0,149	0,135	0,142	0,117	0,101

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

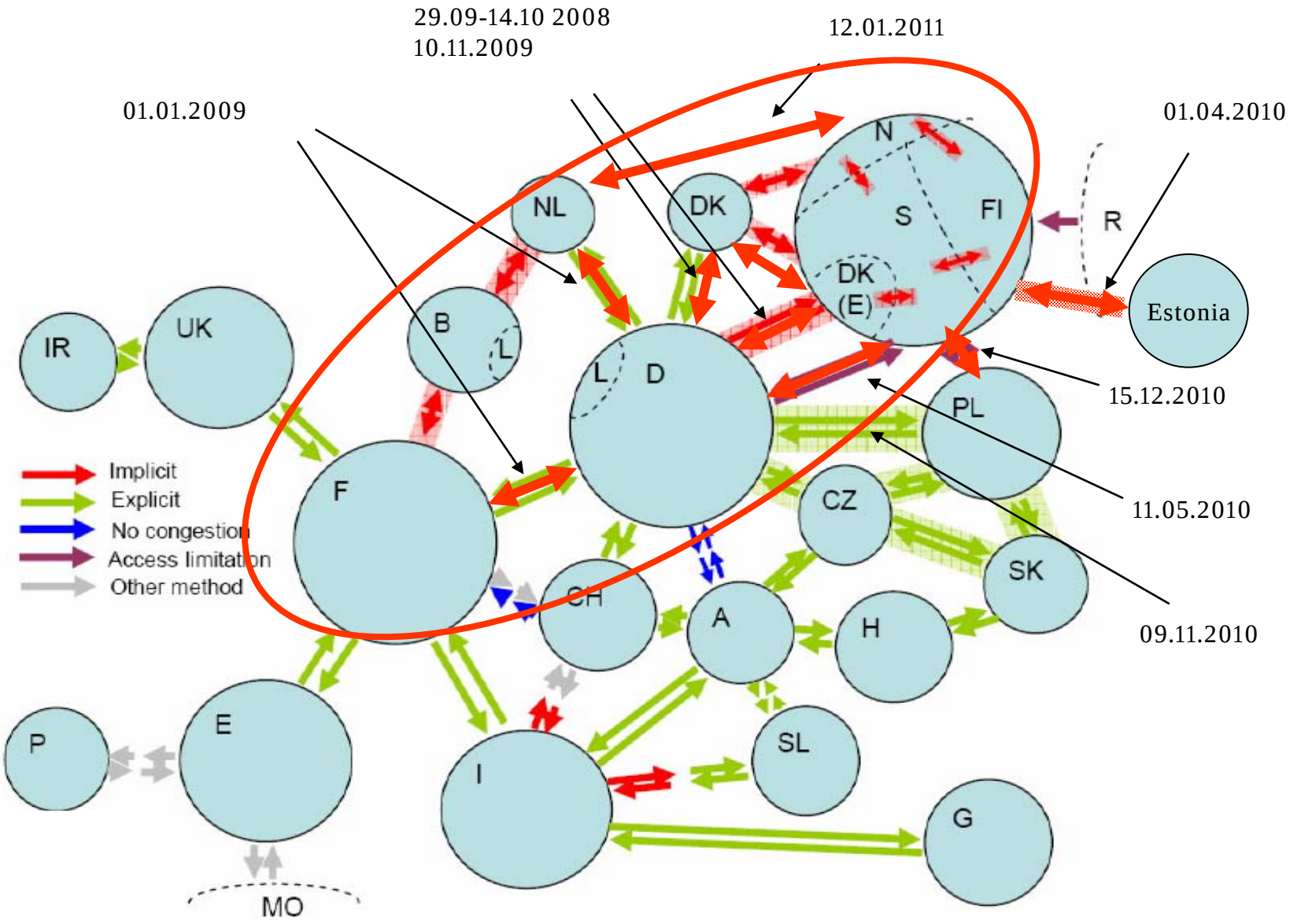


Figure 4.1 – Day-ahead transmission capacity allocations across Europe (updated June 2007)

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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?

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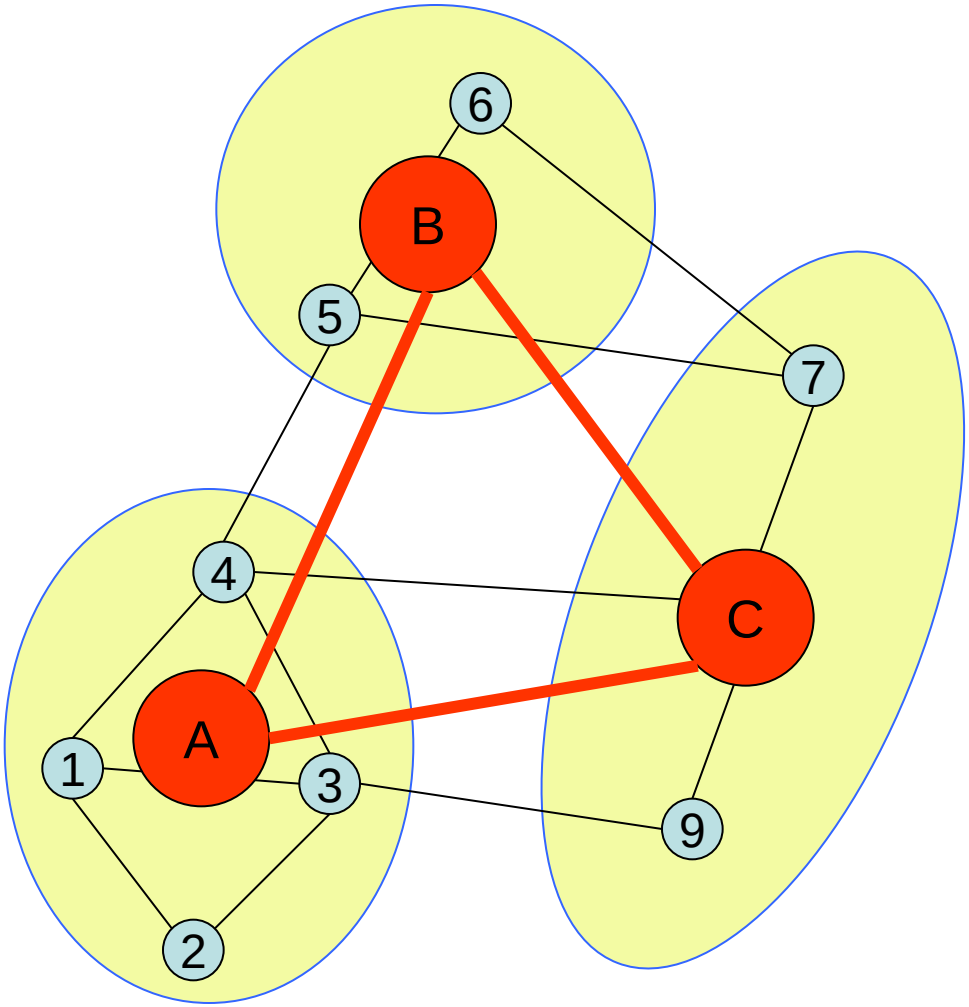
Aggregation models



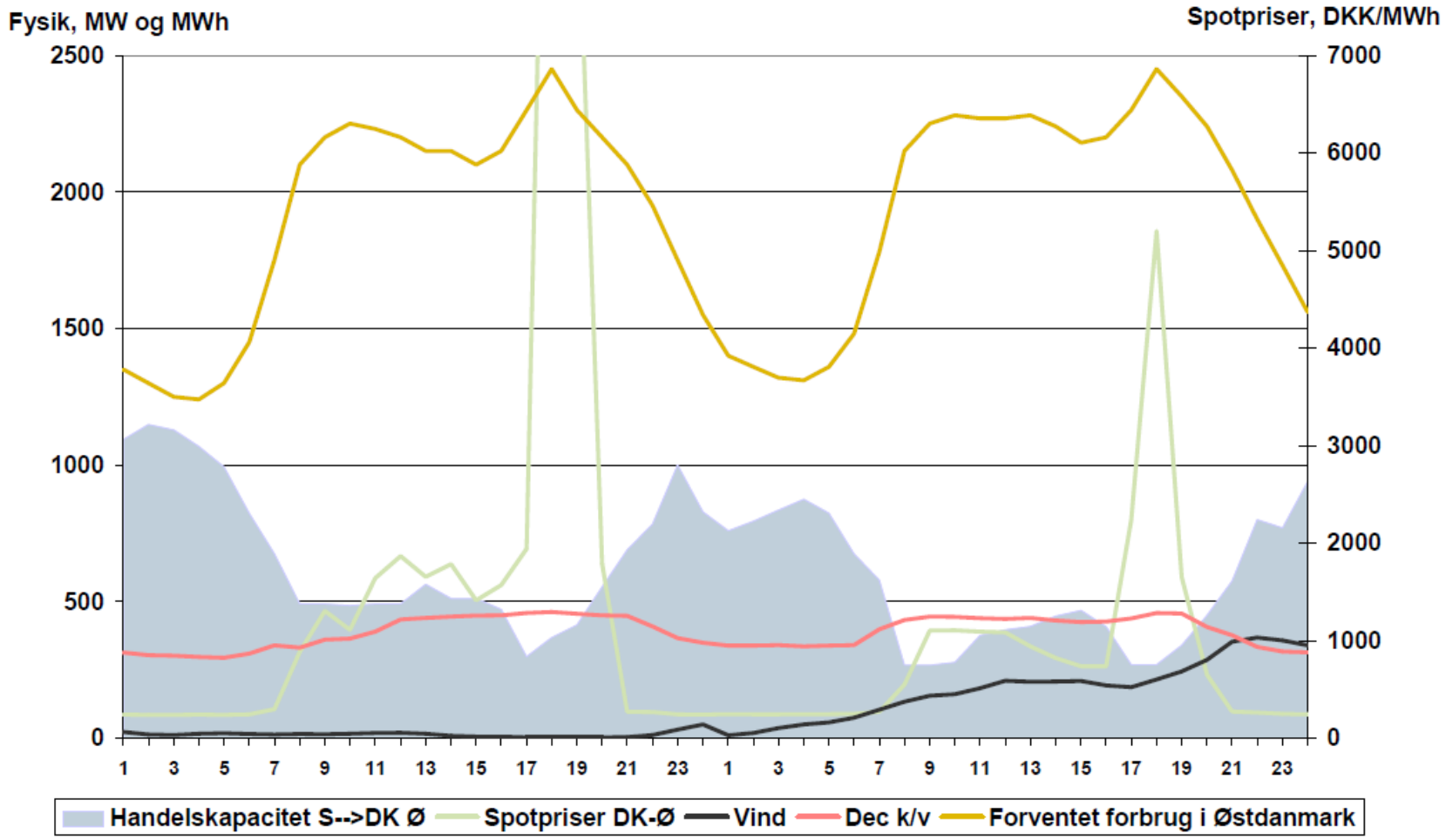
True network
- ”All” nodes included
- ”All” lines represented

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

Physical aggregation
- Aggregate nodes
- Aggregate lines
- Prices for “nodes”

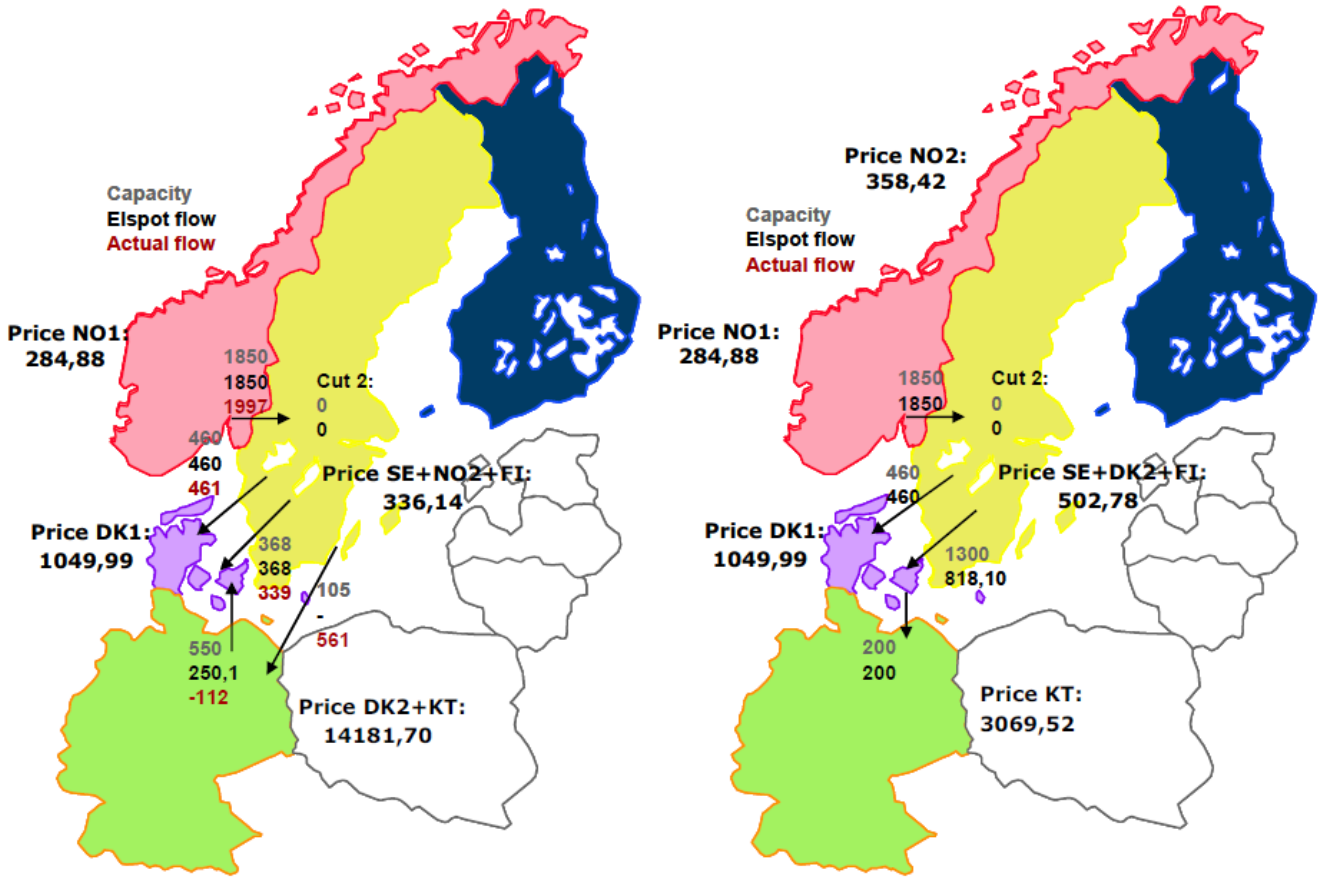
Transfer capacities

- 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.

Nord Pool Spot har udført en række alternative prisberegninger af time 18 den 28. november 2005. Figur 10 viser effekten af fuldkapacitet på Øresundsforbindelsen.



Area	Price Change
NO2	+20
SE+FI	+170
DK2	-13 500
KT	-11 000

Figur 10: Venstre figur: Realiserede spotpriser og flow time 18, 28. november 2005. Højre figur: Elspot simulerede spotpriser med fuld kapacitet på Øresundsforbindelsen. Priser er i NOK/MWh
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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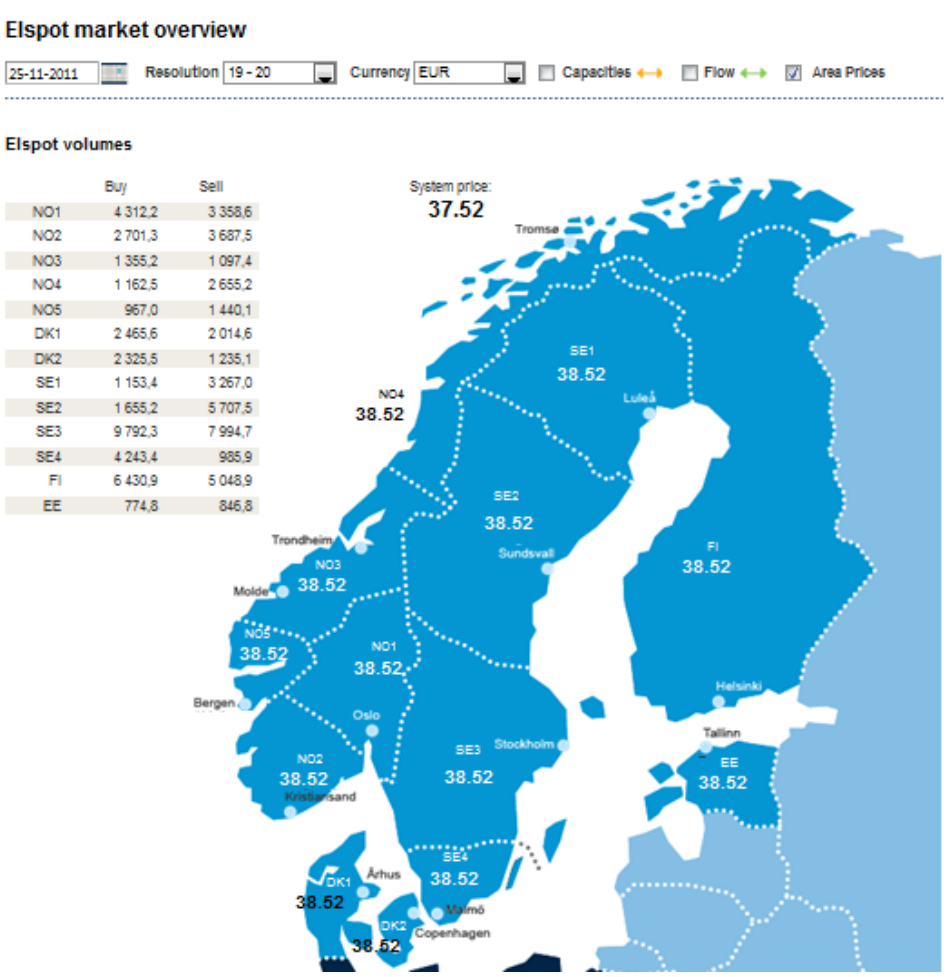
Capacity in MWh/h - 02.12.2010

Date / Time	SE>FI	SE>DK1	SE>DK2	SE>NO1	NO1>SE	NO1>NO3	NO3>NO1	NO2>NO5	NO3>NO4	Cut 2 SE*	Cut B DK1(in)*	Cut B DK1(out)*
Max NTC	2050	680	1300	2095	2145	500	500	1100	200	-	-	-
00-01	1610	150	1300	1745	1200	150	-150	700	0	1928	1340	1320
01-02	1610	150	1300	1745	1200	150	-150	700	0	1601	1340	1320
02-03	1610	150	1300	1745	1300	150	-150	700	0	1601	1340	1320
03-04	1610	150	1300	1745	1300	150	-150	700	0	1801	1340	1320
04-05	1610	150	1300	1745	1300	150	-150	700	0	2144	1340	1320
05-06	1610	150	1200	1295	1000	100	-100	500	0	1112	1340	1320
06-07	1610	150	600	695	700	-100	100	250	0	0	1300	1320
07-08	1060	0	0	95	400	-200	200	250	0	0	1300	1320
08-09	1060	0	0	95	400	-150	150	250	0	0	1300	1320
09-10	1060	0	0	95	500	-150	150	250	0	0	1300	1320
10-11	1060	0	0	95	500	-150	150	250	0	0	1300	1320
11-12	1060	0	0	95	500	-150	150	250	0	0	1300	1320
12-13	1060	0	0	95	500	-150	150	250	0	0	1300	1320
13-14	1060	0	0	95	500	-100	100	250	0	0	1300	1320
14-15	1060	0	0	95	500	-100	100	250	0	0	1300	1320
15-16	1060	0	0	95	500	-100	100	250	0	0	1300	1320
16-17	1060	0	0	95	400	-100	100	250	0	0	1300	1320
17-18	1060	0	0	95	500	-100	100	250	0	0	1300	1320
18-19	1095	48	126	237	600	-100	100	250	0	0	1300	1320
19-20	1277	150	726	837	600	-100	100	250	0	0	1300	1320
20-21	1533	150	1300	1437	700	0	0	250	0	477	1300	1320
21-22	1610	150	1300	1745	700	50	-50	250	0	1006	1300	1320
22-23	1610	150	1300	1745	800	50	-50	500	0	2346	1300	1320
23-24	1610	150	1300	1745	800	50	-50	700	0	3897	1300	1320
Low	1060	0	0	95	400	-200	-150	250	0	0	1300	1320
High	1610	150	1300	1745	1300	150	200	700	0	3897	1340	1320
Sum	31665	1848	14352	19506	17400	-750	750	9200	0	17913	31440	31680

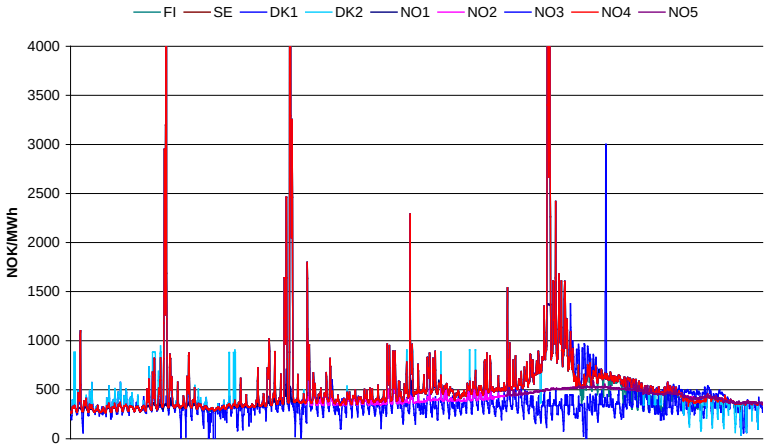
Data updated: 02. Dec. 2010, 13:50 Time is CET (GMT +1)

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

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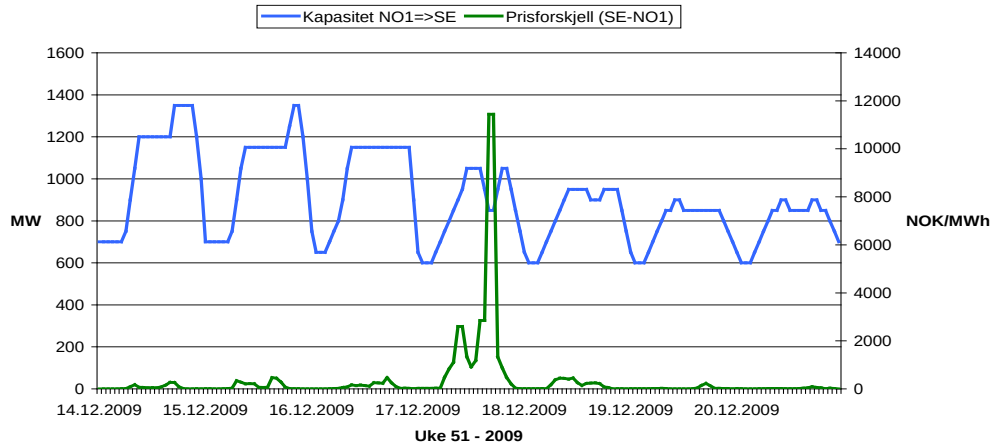
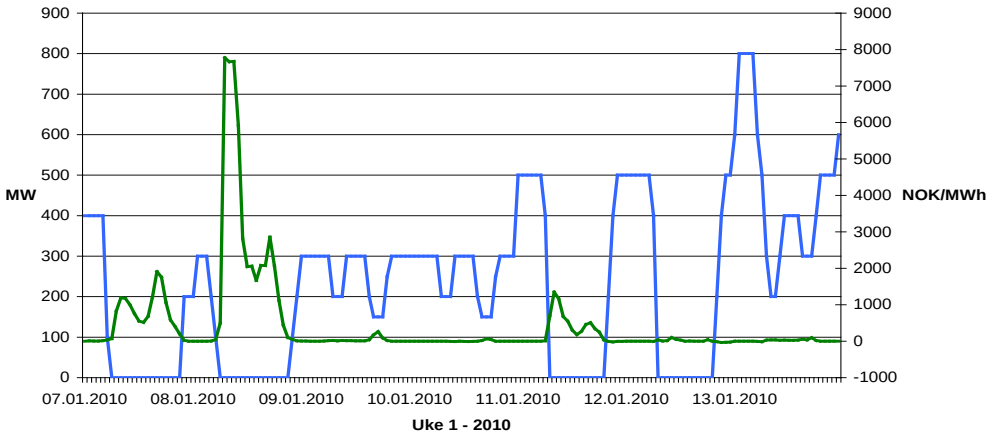
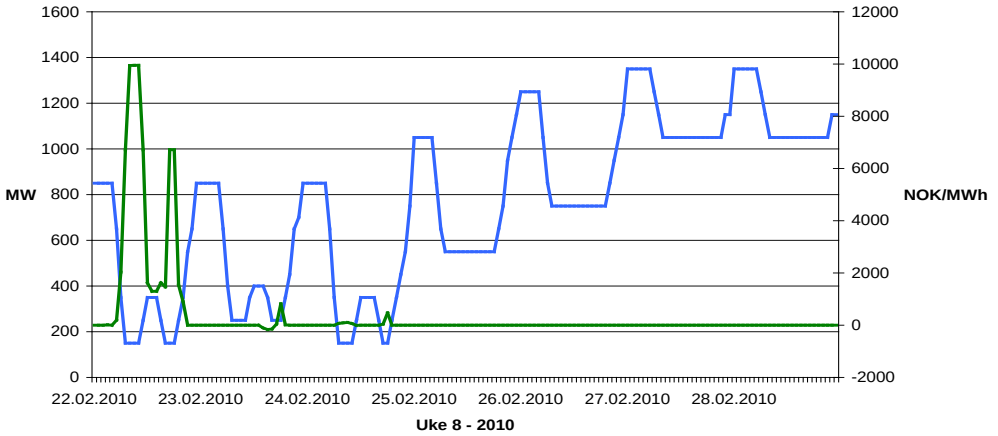
Transfer capacities from Southern Norway to Sweden and price difference (NVE)

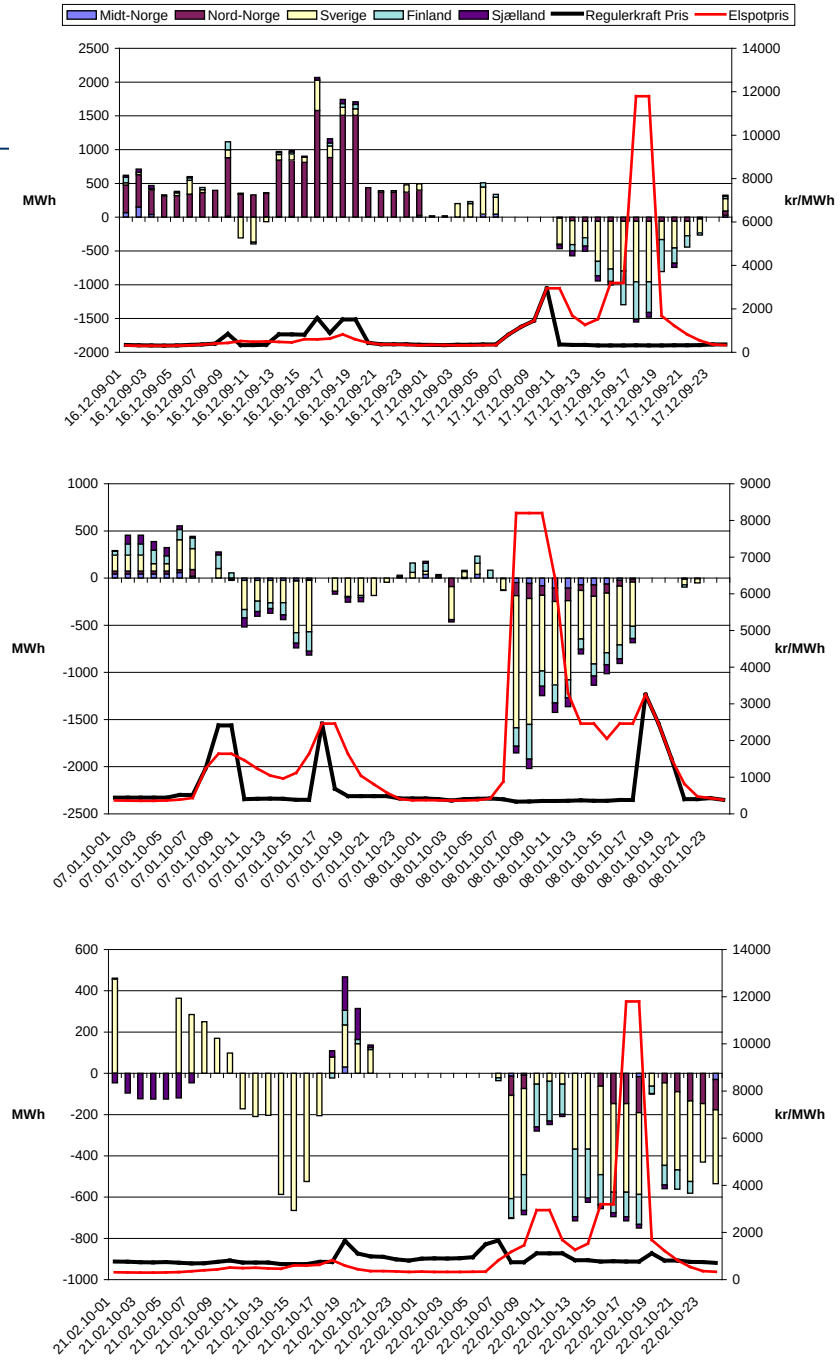






Regulation market:

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

Current and expected generation fuel mix

	Installed capacity 31.12.2010 [MW]	Mean annual generation 31.12.2010 [TWh/y]	Net capacity added in 2010 [MW]	Expected increase in capacity in 2011 [MW]	Under construction on 31.12.2010 [MW]	License/permit given, not yet built [MW]
Wind power	435	1.3	4 MW	100	158	2800
Hydro power	29 954	124.4	240 MW	439	688	1145
Thermal power	1 049*	7.4	280		0	1720

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 ≈ 60-65 bill.
  - Public acceptance