Demand Response in Nordic countries

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Workshop on Demand Side Management

April 18, 2007

Seoul Palace Hotel, Korea

Content

- Nordic Electricity market
  - Development of the Nordic Electricity system
  - Nord Pool market
  - Regulating power market (by TSOs)
- Demand response as TSOs` operating reserves
- Demand response potential in Nordic countries
- DR in large scale industries
- DR at electrically heated customers
- Develoment of automatic meter reading in Finland

Nordic countries

	Population million	Total area km2	Population density persons/km2	Capital
Denmark	5,4	43 094	120	Copenhagen
Finland	5,2	338 000	15	Helsinki
Norway	4,5	324 220	14	Oslo
Sweden	8,9	450 000	19	Stockholm

Deregulation Process in the Nordic countries

1991, ->

Norway

- Unbundling of Statnett and Statkraft
- All customers in competitive market without extra costs
- Unbundling of network businerss and sales on bookkeeping base
- Nordpool in Oslo
- Tight governmental control power plant licensing

1995, ->

Finland

- Unbundling of IVO / IVS, Fingrid in 1997
- In 1995 market opened for 500 kW+ customers, for all customers in 1997 (without extra costs in 1998)
- Unbundling of network businerss and sales on bookkeeping base
- National power exchange EL-EX, integration into NordPool in 1997
- Liberal licensing policy

1996, ->

Sweden

- Unbundling of Vattenfall / Svenska Kraftnät
- Market open for all customers (hourly meters required in the beginning)
- Unbudling of network and sales businesses into separate companies
- NordPool

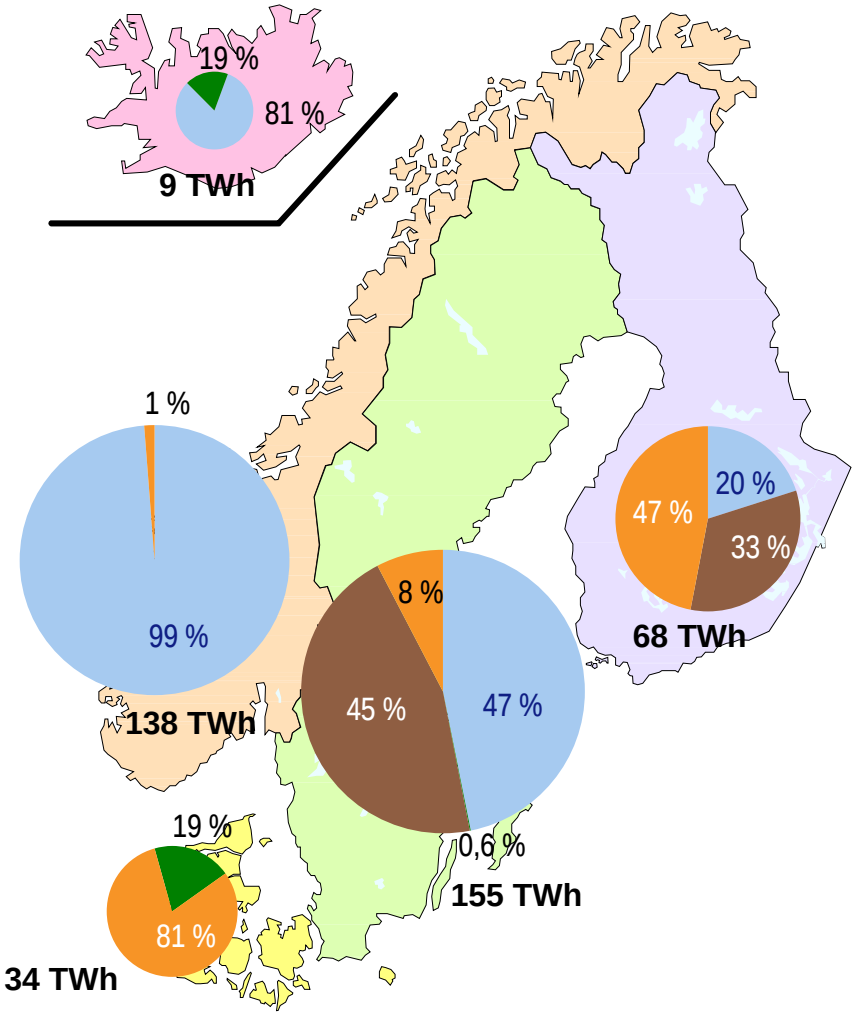
1998, ->

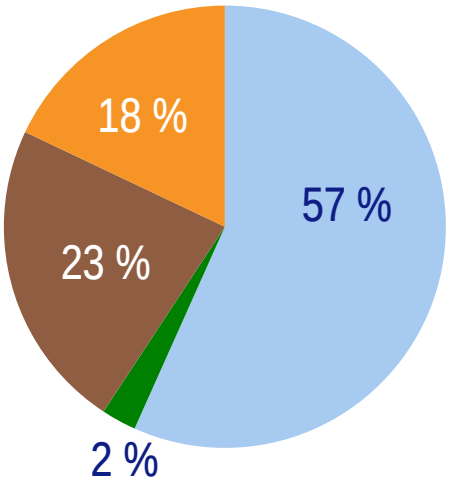
Denmark

- Unbundling of two system operators ELSAM / ELTRA merged into one stateowned company in 2005, Energinet.dk
- Full competition in 2003
- Special support for renewables (wind), CHP, energy savings
- NordPool (1999, 2000)

The Nordic countries are leaders in the deregulation and transcountry trading of electricity

Generation in the Nordic Countries 2005

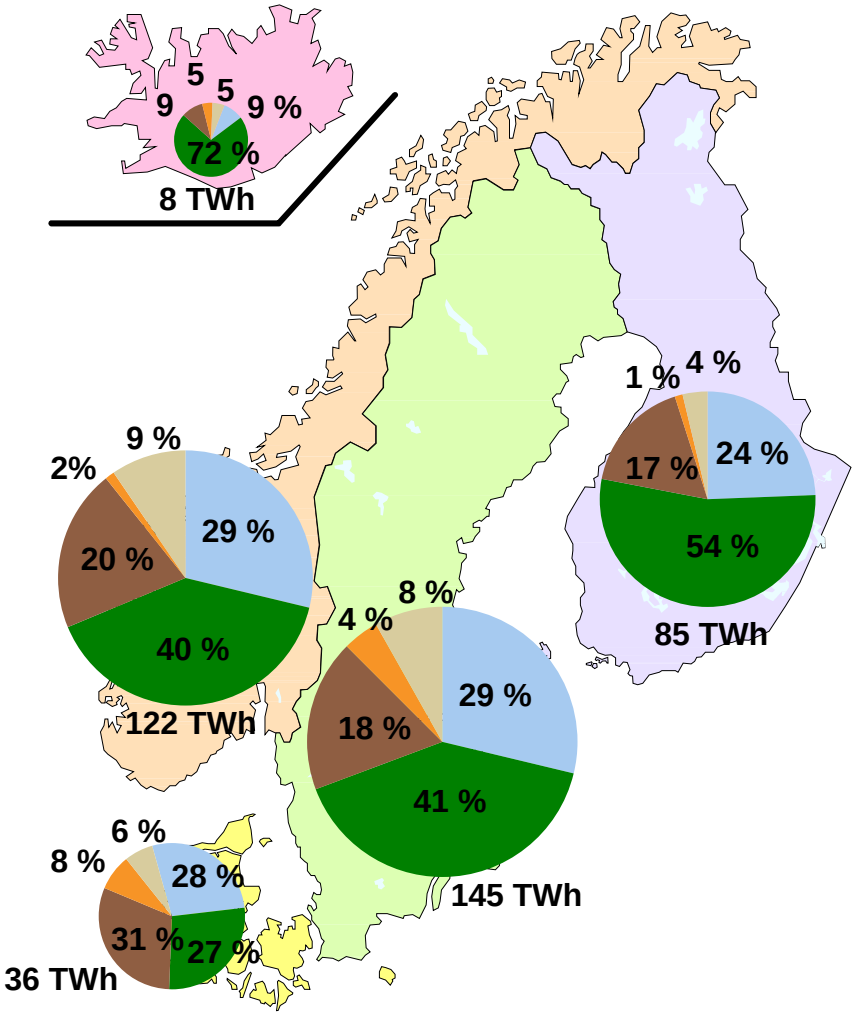




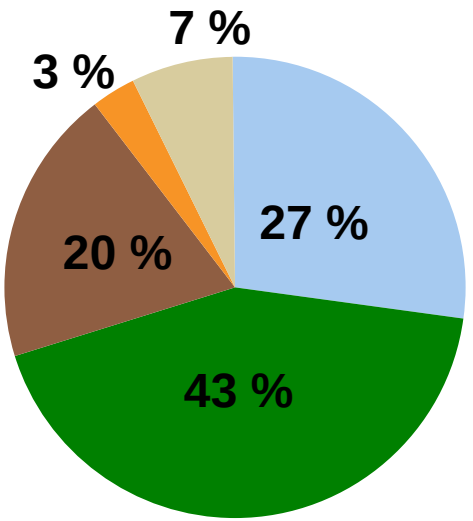
404 TWh

- Hydro power
- Wind and geothermal power
- Nuclear power
- Thermal power

Electricity Consumption 2005



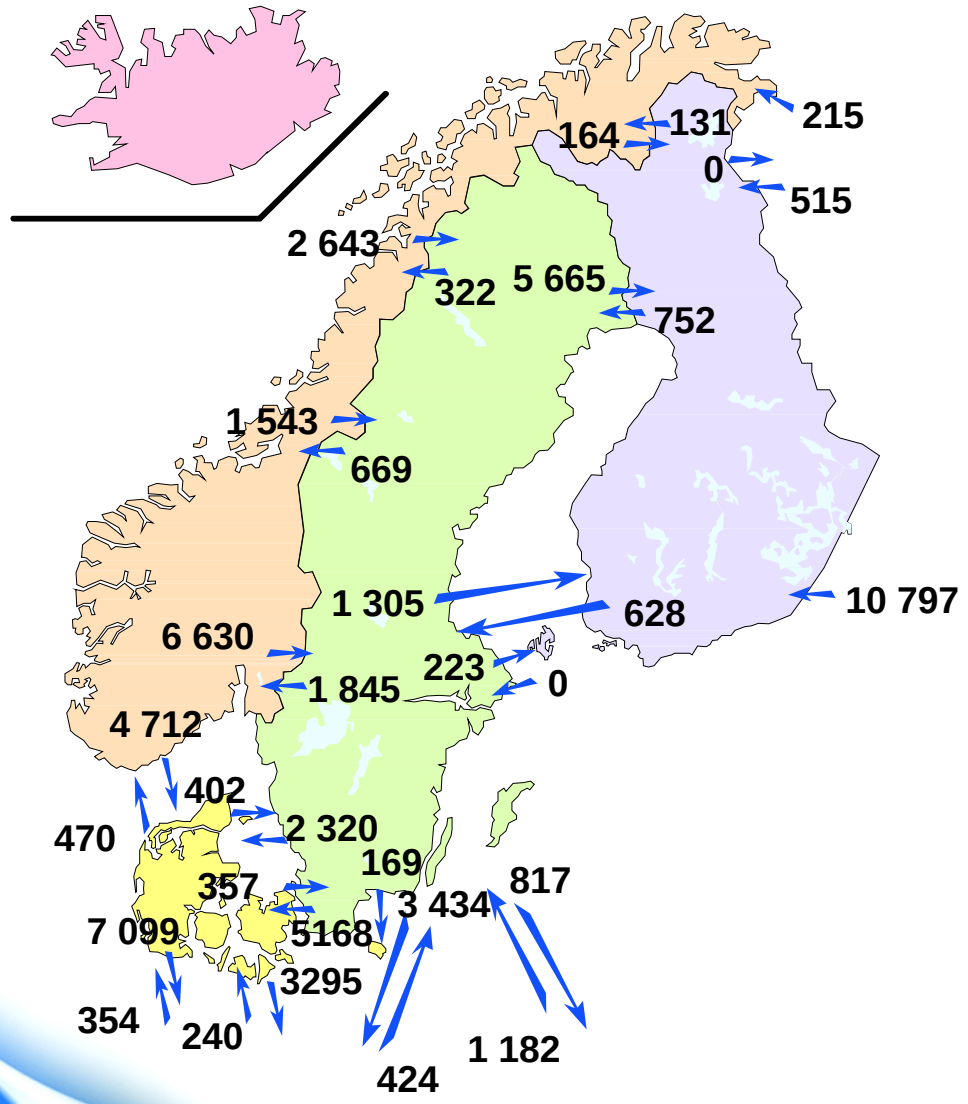
Nordel



396 TWh

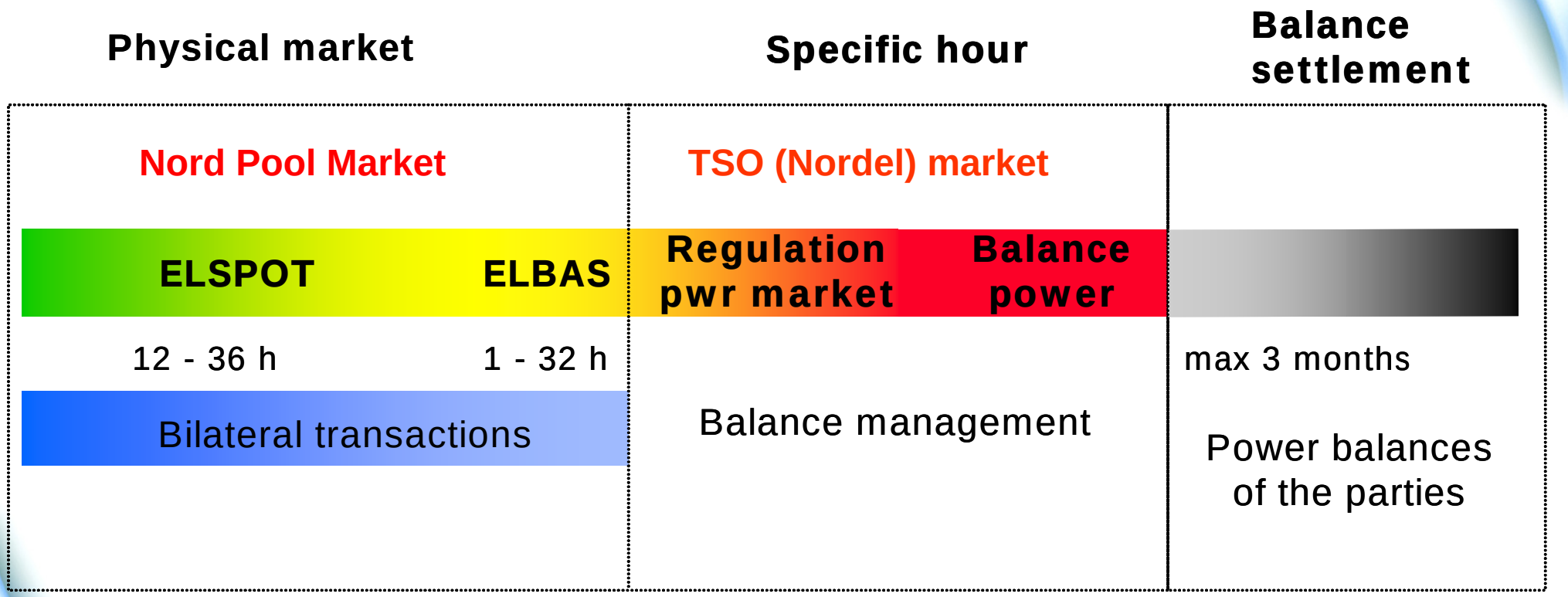
- Housing
- Industry (incl. energy sector)
- Trade and Services
- Other (incl. agriculture)
- Network losses

Exchange of Electricity in the Nordic Countries in 2005, GWh



	Imports GWh	Exports GWh
Denmark	12 998	11 623
Finland	18 669	1 525
Norway	3 652	15 692
Sweden	14 575	21 972
Other counries	13 727	14 645

Physical trade of electricity



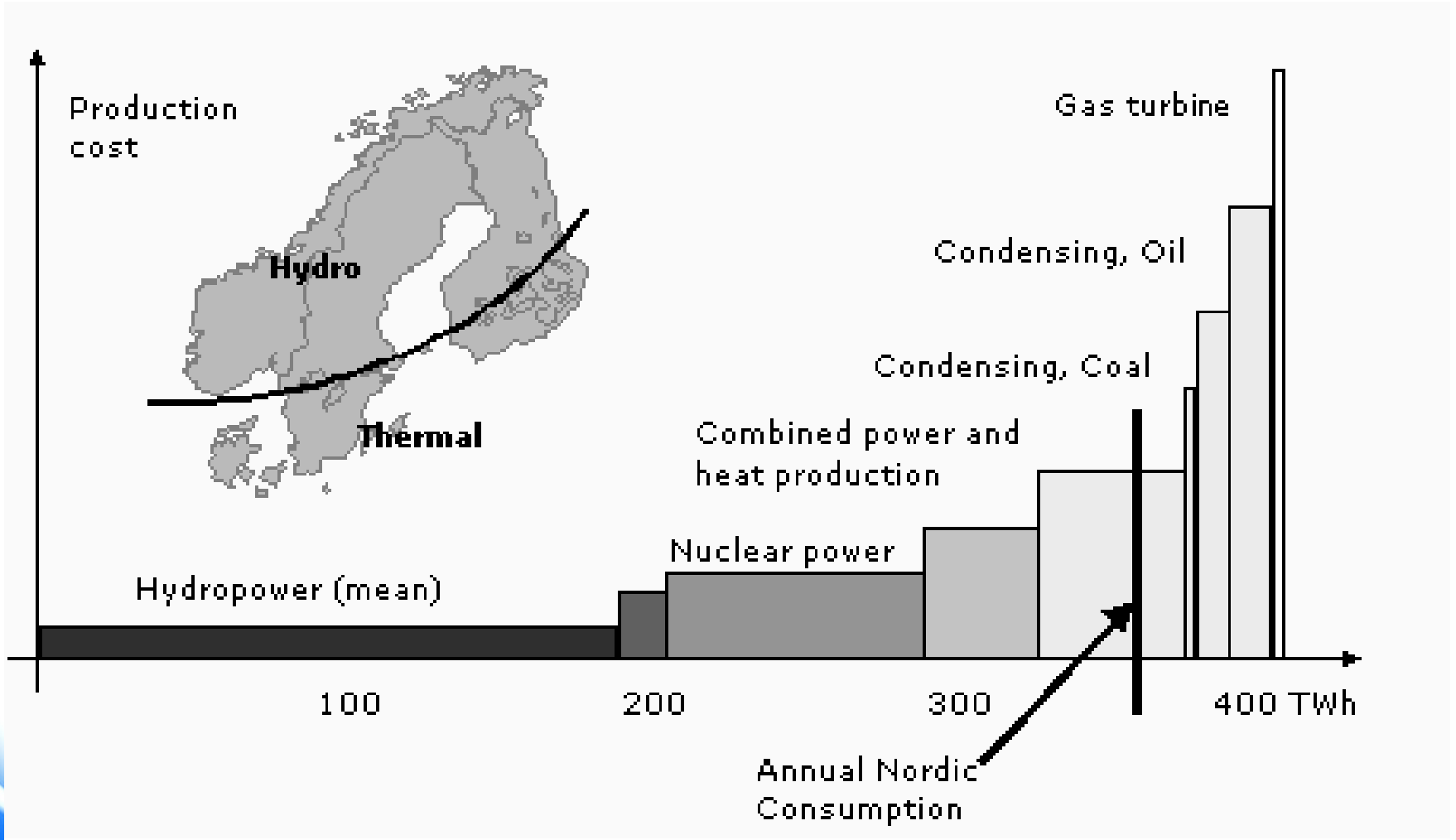
Fixed transactions must be agreed and reported before the specific hour

Common marketplace: Nord Pool

VOLUNTARY MARKET PLACE FOR ELECTRICITY

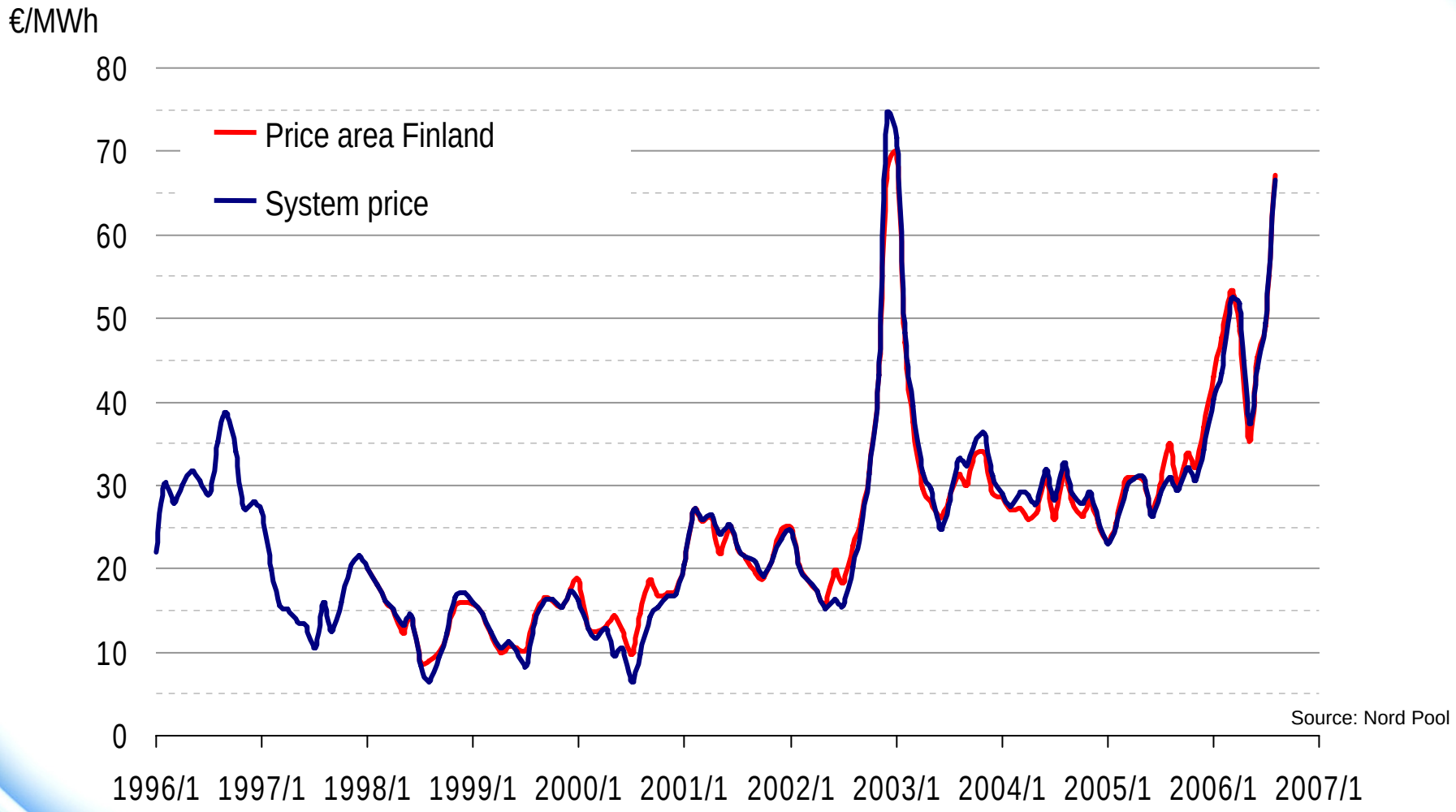
- Founded in 1993 in Norway
- Other countries joined later
- Owned mainly by system operators
- Not all electricity traded through NordPool, but it sets the marketprice
- Several types of products
  - Physical market (daily spot market on hourly bases (Elspot), Hourly market (Elbas)
  - Financial market (Futures and options, standard products until 3 years ahead)
  - OTC and bilateral market

Marginal costs in the Nordic system



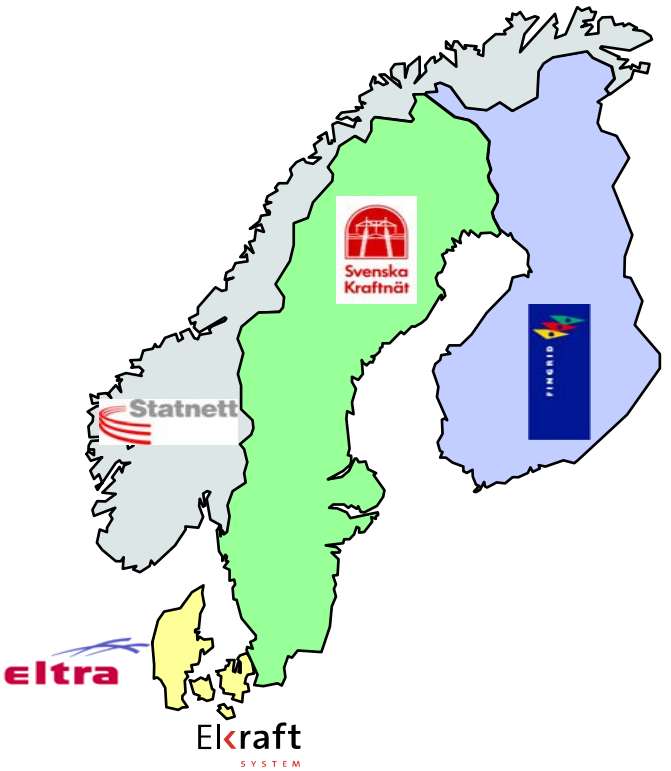
Elspot Prices (Nord Pool)

(monthly average)

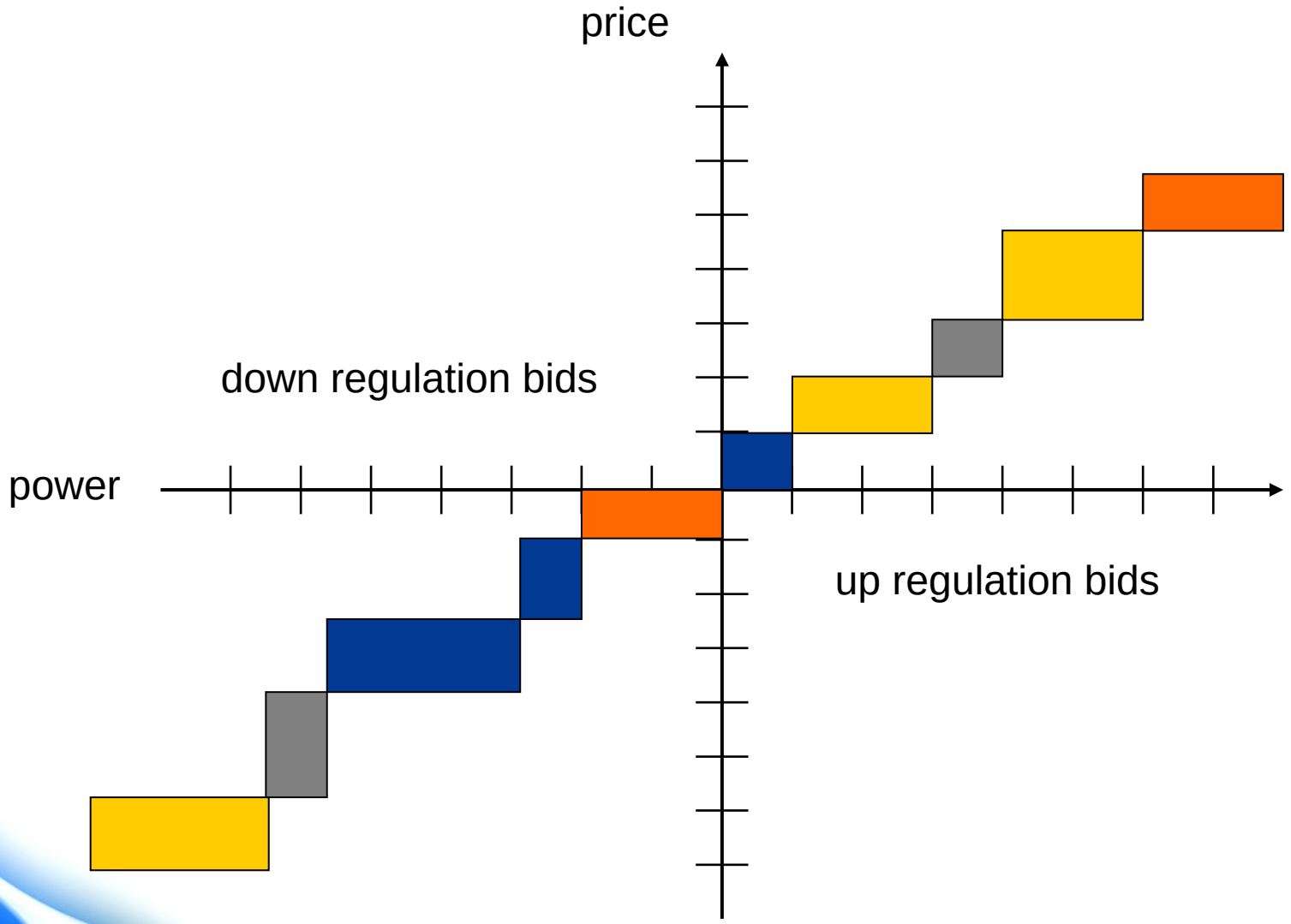


Nordic regulation power market

- TSOs specific balancing market
  => common nordic balancing management
- The Finnish regulation power market is part of the Nordic regulation power market.
- The synchronous area is regulated as a one system



Nordic regulation power market



Pricing of balance power

- The pricing of balance power is founded on Nord Pool Spot price for Elspot price area Finland (Elspot FIN).
- The price of balance power changes on the basis of regulations carried out during the hour.
- A two-price system, i.e. separate prices are specified for the sales and purchase of balance power, is applied to the pricing of balance power.
- Purchase price of balance power = down-regulation price
- Sales price of balance power = up-regulation price

Pricing of balance power

- Each hour is specified to be either an up- or down-regulation hour based on the direction in which more regulations have been carried out, determined on the basis of the volume of energy.
- If the regulations in each direction have an equal volume, both the up-regulation and the down-regulation price is Elspot FIN
- The prices are made available to the Balance Providers two hours after the specific hour

Demand Response as TSOs` operating reserves

DR as TSOs´operating reserves
(activation based on the need of ancillary services)

DR as fast active disturbance reserves

DR as frequency controlled disturbance reserves
– All TSOs (Energinet.dk, Fingrid, Statnett and SvK) have contracted some DR as disturbance reserves.

Reserves for regulating power market
– Fingrid and SvK have practically no DR bids in the regulating power market
– Statnett has RKOM contractors that bid to regulating power market
– Energinet.dk have contracted some volumes.

Capacity payments change the behaviour of market players.

Demand as a Resource in Statnett's Regulating Capacity Options Market (RCOM) Regulating Capacity (Norway)

- **Successful participationfrom large industries:**
  - Predictable revenues
  - Acceptable technical requirements
  - Direct participants in Elspot
  - Large demand units(> 25 MW)

- **Evolutionof demandside attitude:**
  - "Process protection" => "business opportunity"
  - Industries now also submit price flexible bids in Elspot

Finnish Demand Side Operational Reserves

❑ Fingrid has signed contracts with process industry's large customers on disconnectable loads:

– Metal industry (steel works and furnaces)
– Forest industry (groundwood plants and mechanical pulping plants)
– Chemical industry (electrolyses)

❑ The unit size of disconnectable load varies between 15 -60 MW

❑ The needed amount of disconnectable loads are contracted with a competitive bidding procedure on yearly bases

❑ Additional loads can be obtained from reserve owners on weekly basis

Demand response potential in Nordic countries

Estimated DR potential in Nordic countries

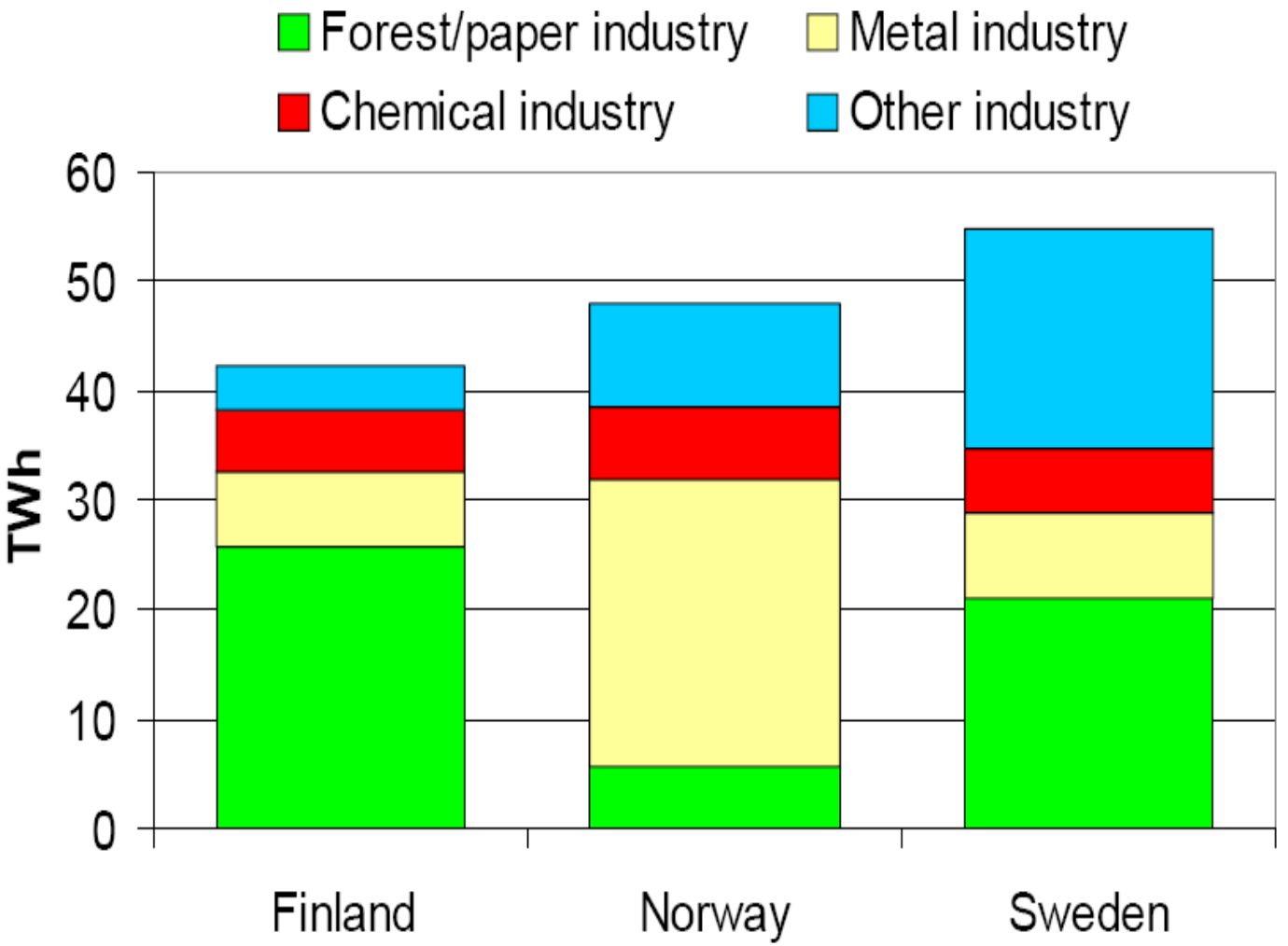
	Denmark	*Finland*	*Norway*	*Sweden*	*TOTAL*
Contracted by TSOs	25	365	1,300	385	2,075
Observed other response	20	140	800	700	1,660
Additional economic and technical potential in the short and medium term	800	2,400	4,600	3,000	10,800
A pessimistic estimate of the total potential	*At least 500*	*At least 2,500*	*At least 5,000*	*At least 4,000*	*At least 12,000*

Source: The background survey "Demand Response in the Nordic Countries"

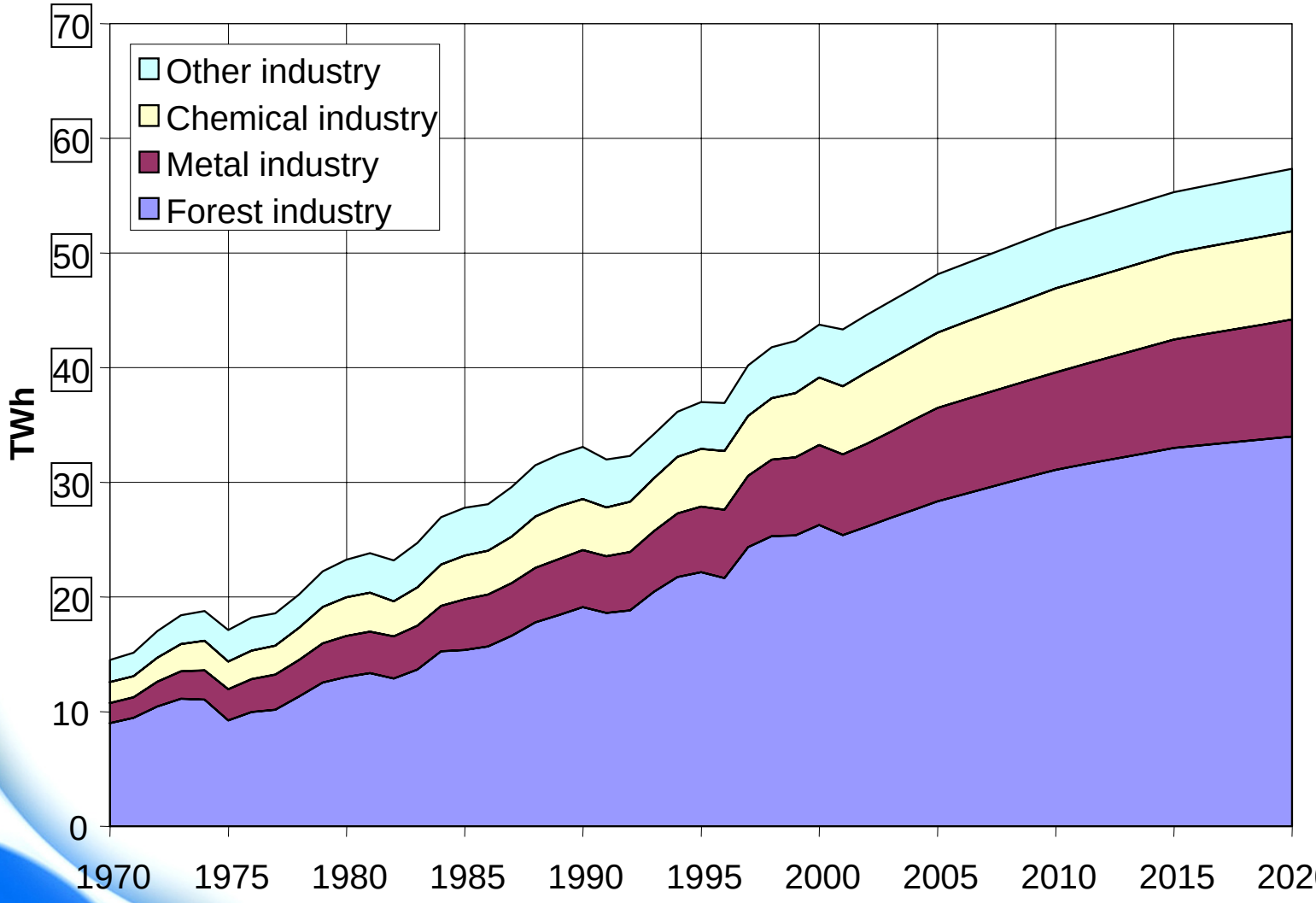
Main potential in large-scale industries and electric heating

DR in large scale industry

Annual Consumption in large Industries



Electricity use in Finnish industry

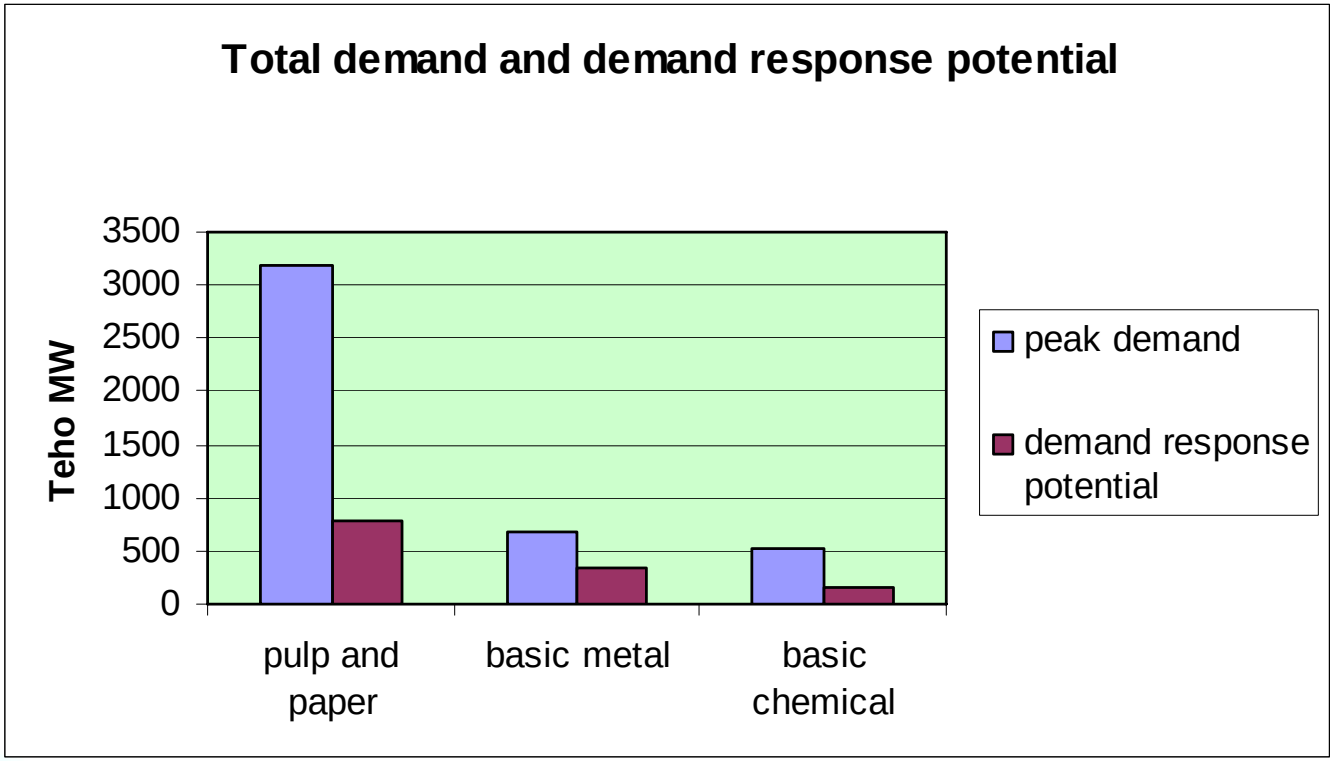


Year 2003

Industry	45 TWh
Services and public	14 TWh
Households	10 TWh
Electric heating	9 TWh
Other	7 TWh
Total	85 TWh

Technical potential of DR in large-scale industry in Finland

- Technical potential of DR (1 280 MW) is about 9 % from the peak power of Finland (14 000 MW)



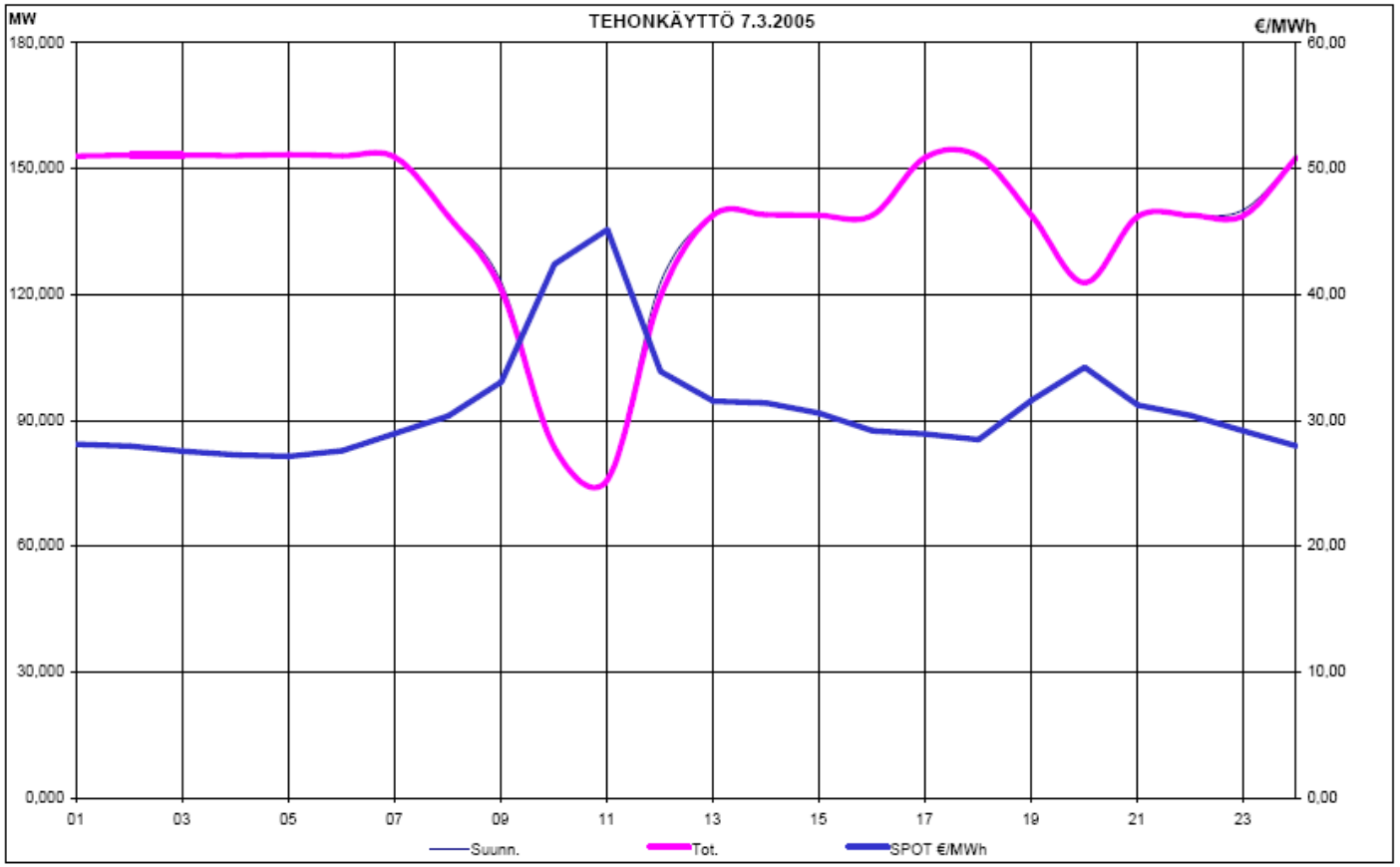
Effect of electricity price on activating Demand Response

Effect of electricity price on activating demand response		
Price limit that activates the response	Response duration	
	max 3 h	**over 12 h**
100 EUR/MWh		
200 EUR/MWh	266 MW	275 MW
300 EUR/MWh	1063 MW	275 MW
500 EUR/MWh	1068 MW	275 MW
1000 EUR/MWh	1169 MW	317 MW

- Price limits and demand response are very sensitive to market fluctuations (product prices)
- Electricity costs in the companies vary from 6 % to 80 % of production costs

Example of DR in a chemical company

One day (7 of March 2005)



Demand

Spot price

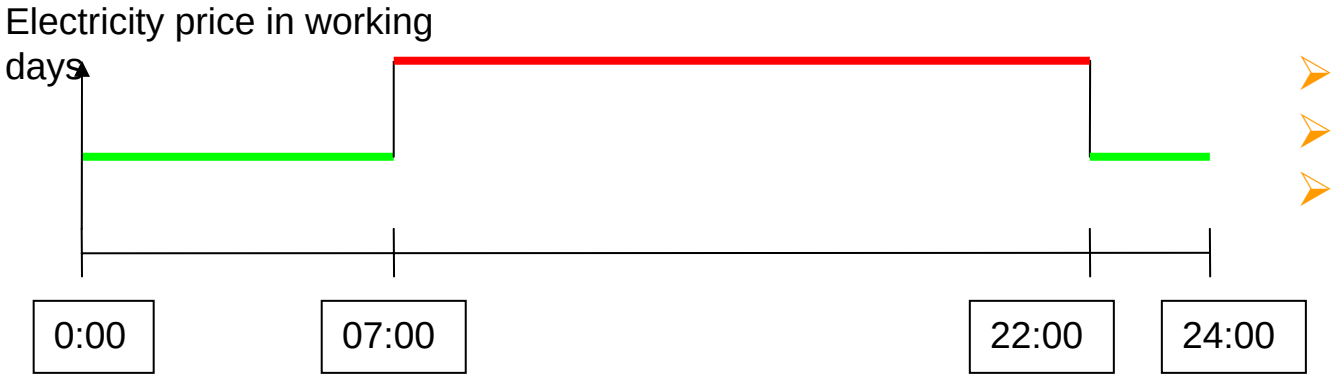
Conclusions

- Total DR potential in Finnish large-scale industry about 1 280 MW (9 % from the Finnish power demand peak)
- DR potential in pulp and paper industry 790 MW (62 %), in basic metal industry 330 MW (25 %) and in basic chemical industry 160 MW (13 %)
- Year 2005 880 MW from the potential is available for electricity market and 400 MW for disturbance reserve
- After the fifth nuclear power unit comes on line (year 2009) 480 MW is available for electricity market and 800 MW for disturbance reserve
- 300 EUR/MWh electricity price activates about 1060 MW DR for electricity markets
- Many barriers to participate on DR: integrated processes, too little storages, risk of equipment faults, opposition of production personnel, new market conditions

DR at electrically heated customers

Demand response of electric heating in Finland
Before the competition

Time of use tariffs are applied long time since the beginning of electric heating in Finland in the beginning of 1970s (with fixed charge depending on the fuse size)



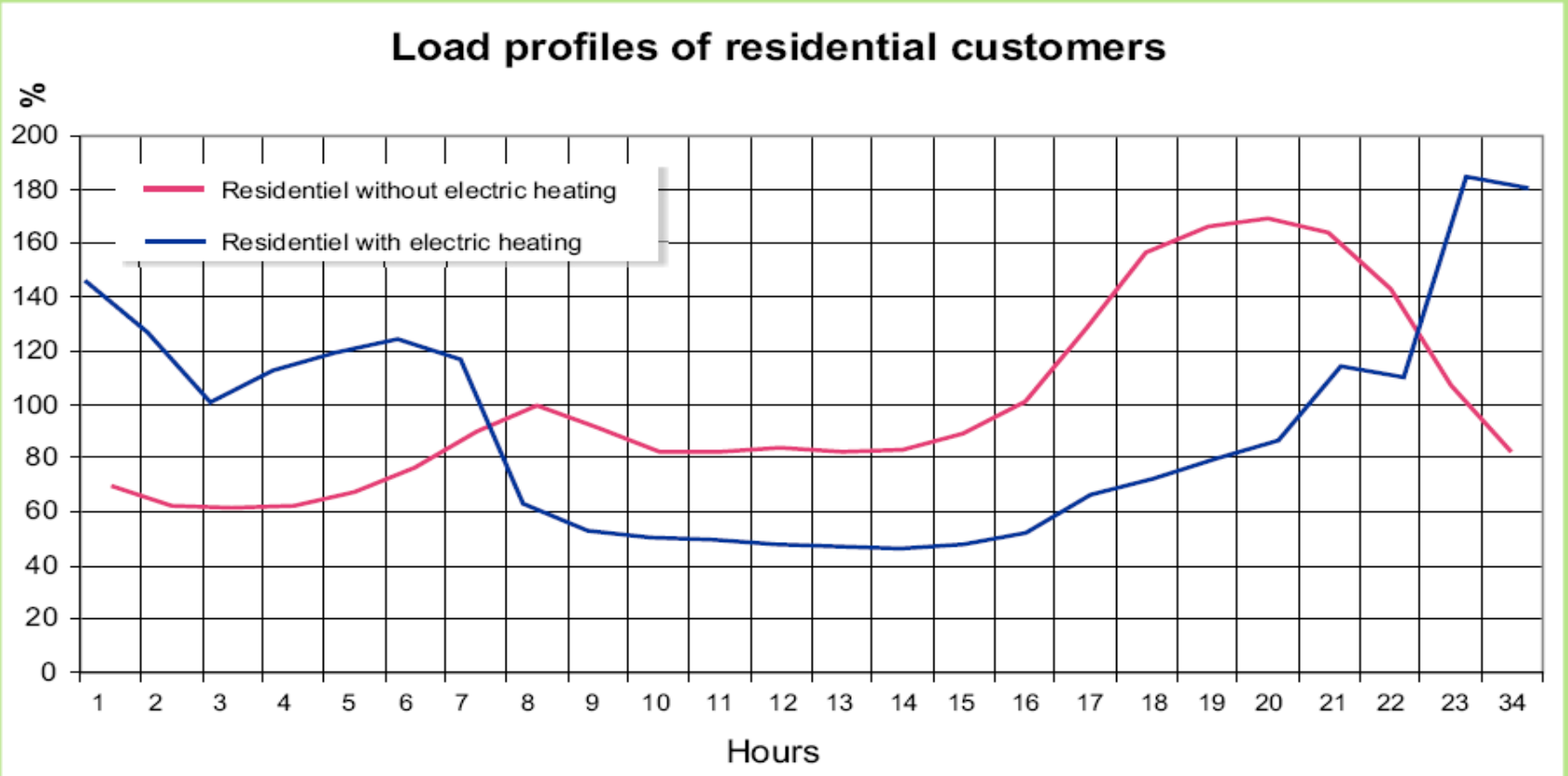
- Typical for working days
- Weekends often low-priced
- Also seasonal (winter – non-winter) variations possible

Development of new technologies:

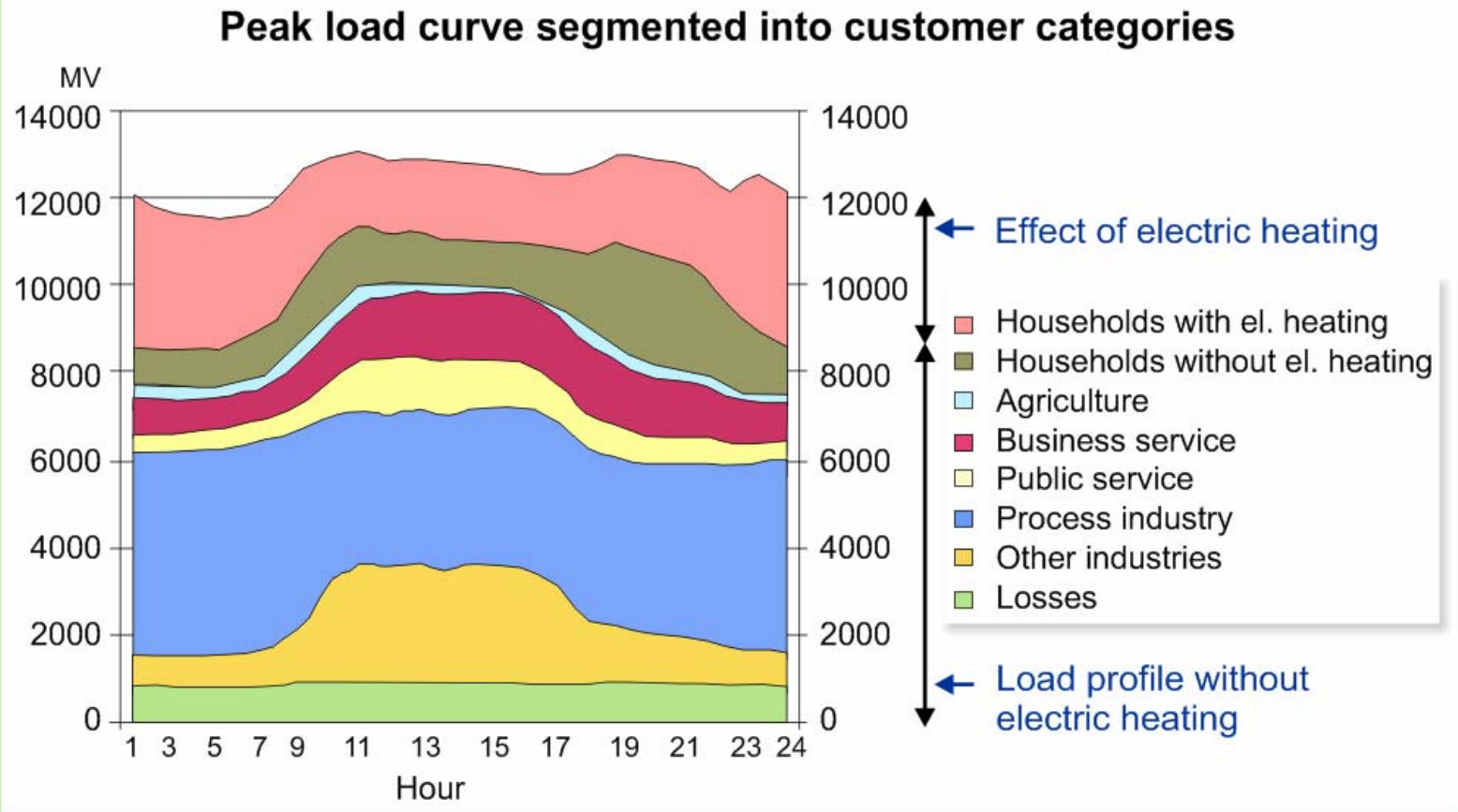
- efficient heat insulation of houses, triple windows, heat recovery from ventilation
- use of meters with 2 – 4 registers for different price zones
- domestic hot water production in night time (heat storage)
- switching off part of heating when sauna (8 – 12 kW) is switched on (to decrease fuse size)
- direct load control of heating loads by using ripple control or DLC (due to the high incentive in whole sale tariffs)
- development of new technical solutions for electric heating (actual heating systems and heating control systems inside the house)

Effect of pricing: Average load profiles of small customers with electric heating
Large share of customers have TOU-pricing

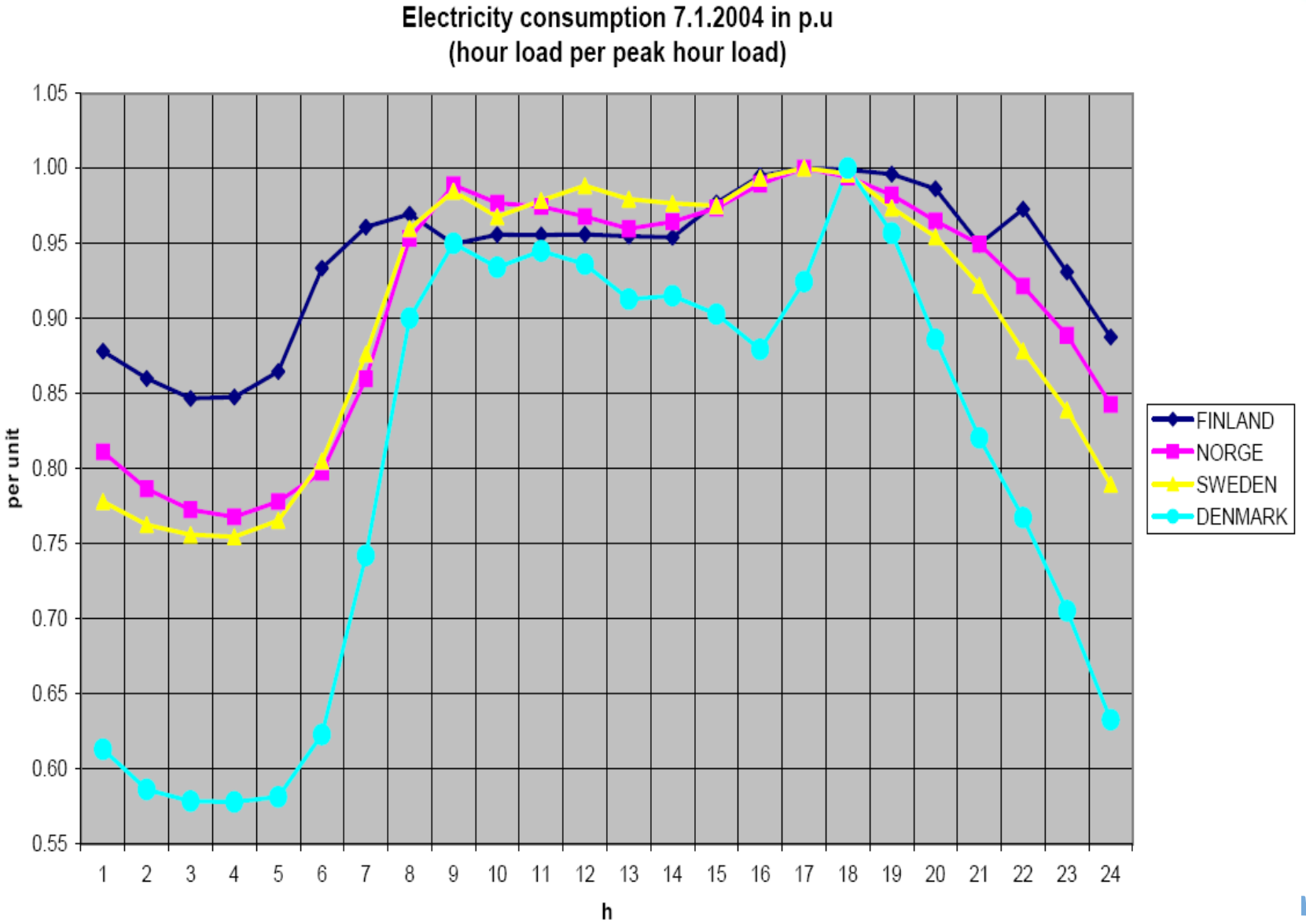
Low price → High price → low price



Effect of demand response of electric heating in Finland



Comparison:Time-of-use tariffs even out the load profile in Finland



Source: Nordpool

Effect of competition and unbundling on DR in electric heating in Finland

Unbundling of network business and retail business of distribution companies

- network tariffs usually still include TOU-structure, may have changes in the future
- retail pricing has different schemes depending on retailer (TOU still applied)
- no incentives for direct load control (disappeared)

New challenges of DR in electric heating in Finland

The potential based on TOU-pricing is already exploited. New ideas needed
Next steps:

- real-time pricing based on the spot-price
- automated meter reading with hourly bases
- new type of load control: selling loads back into the market (aggregators needed)?

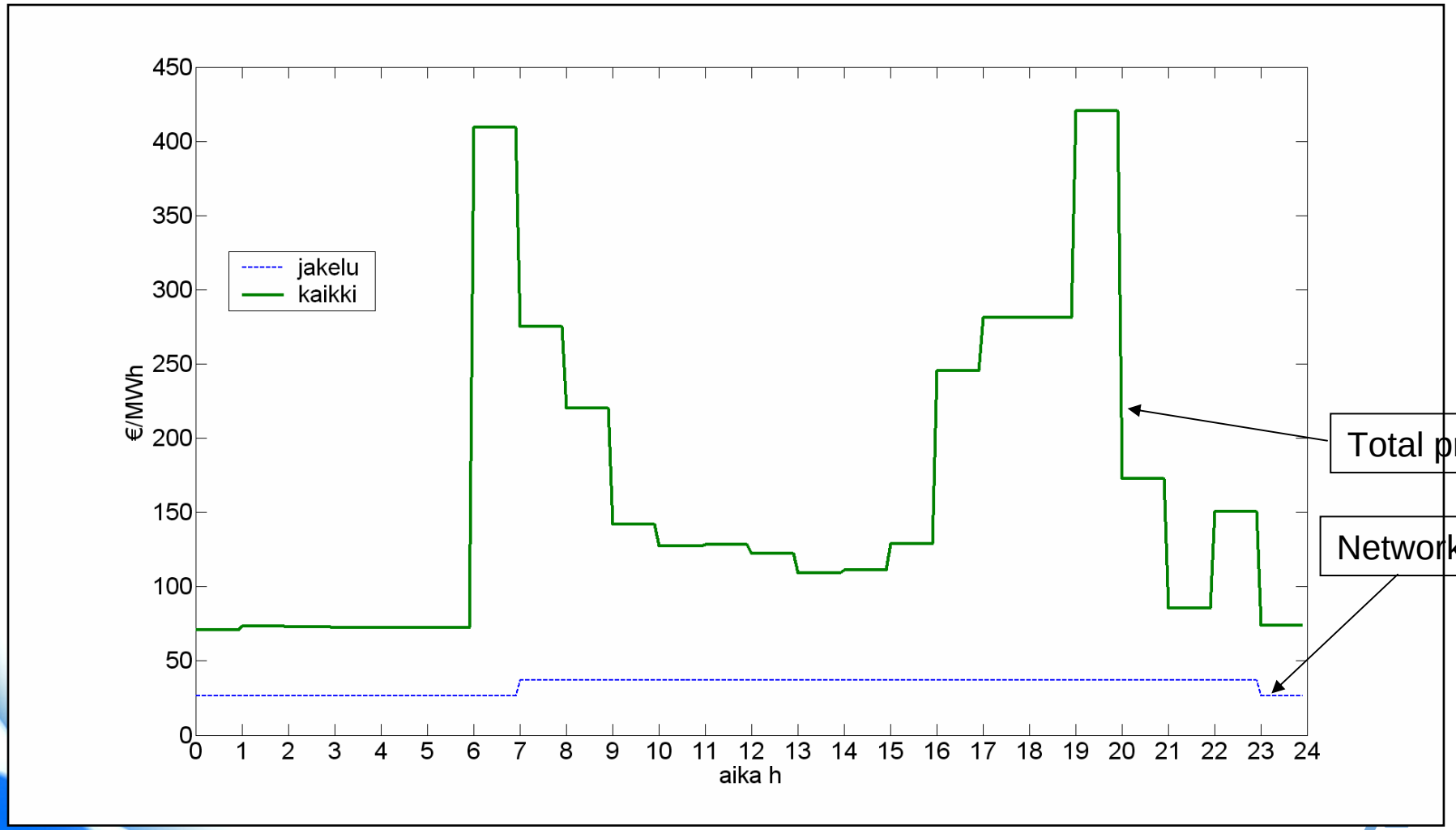
The present status of demand response at small customers with electric heating in Finland

- DSOs installed many direct control systems for electrical heating loads before the electricity market was opened up to competition. These systems have not been used during the competitive electricity market (, because of unbundling, need for new rules and business models, low electricity prices, short management time-horizon, ..)
- Time of use tariffs are still commonly applied for electrically heated houses and cause significant balancing needs at the system level. (2-time or 3-time distribution and/or energy tariffs).
- Electrical heating has significant unused demand response potential, because the system costs have been too high. (about 600 000 electrically heated homes, also many summer houses are electrically heated.)
- Tariffs based on the spot market prices are available even to small customers, but still rarely used. For small customers demand response is still infeasible because of high system costs, especially costs of hourly metering. Also new electricity market legislation is a significant barrier.
- New innovative pricing structures are under discussion at retailes in all Nordic countries

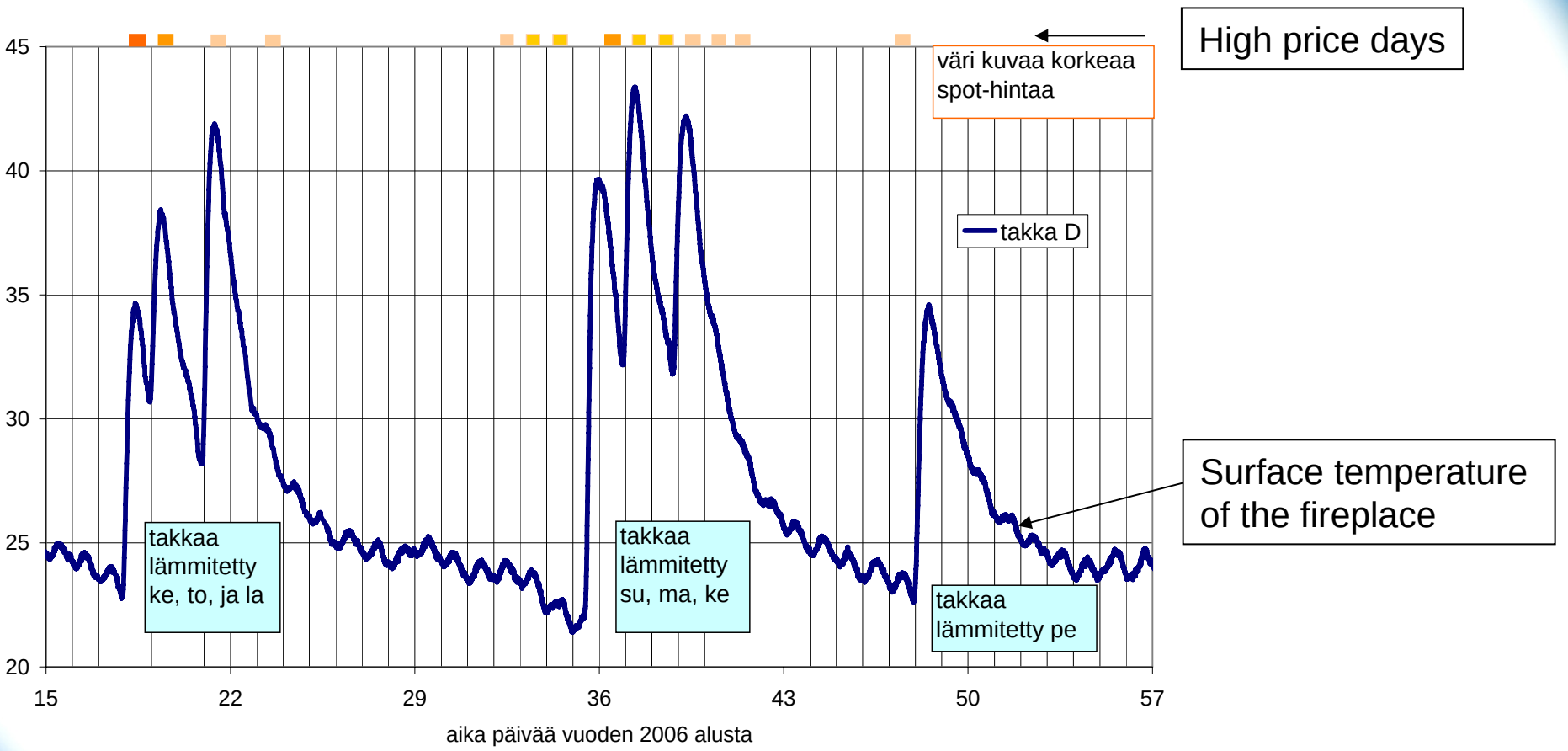
Example: Spot market price based demand response project in Finland

- Field trials of demand response to spot market price based real-time tariffs, 2004-2006
- 5 electrically heated houses
- 5 electrically heated apartments in a row house
- bigger buildings connected in the district heating network, apartment buildings,

Example on high price day, 19.01.2006



Use of fireplace during January 15 - end of February 2006

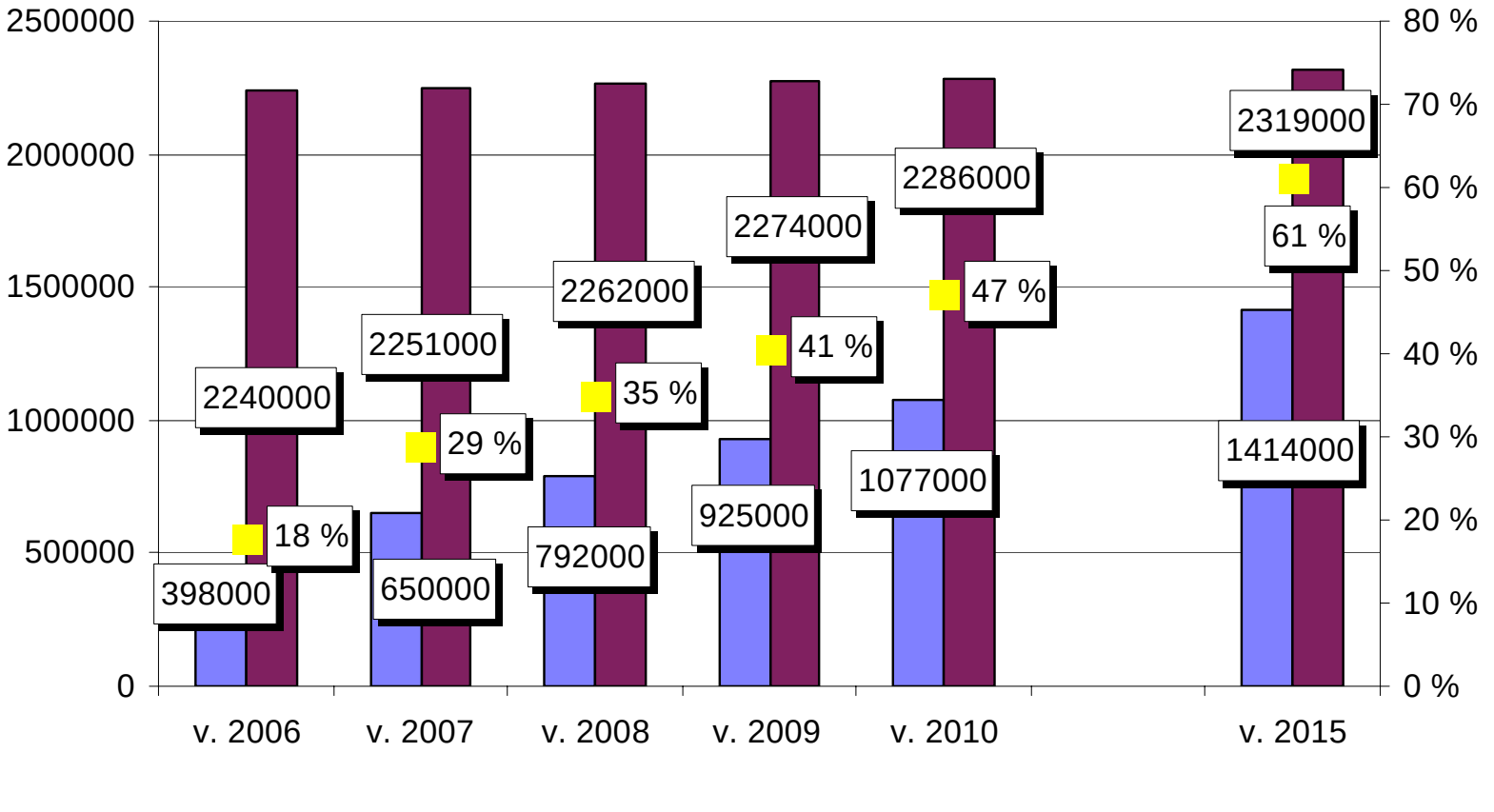


Development of automatic meter reading in Finland (questionnaire to network companies)

(AMR is seen as an essential part in development of DR for small customers)

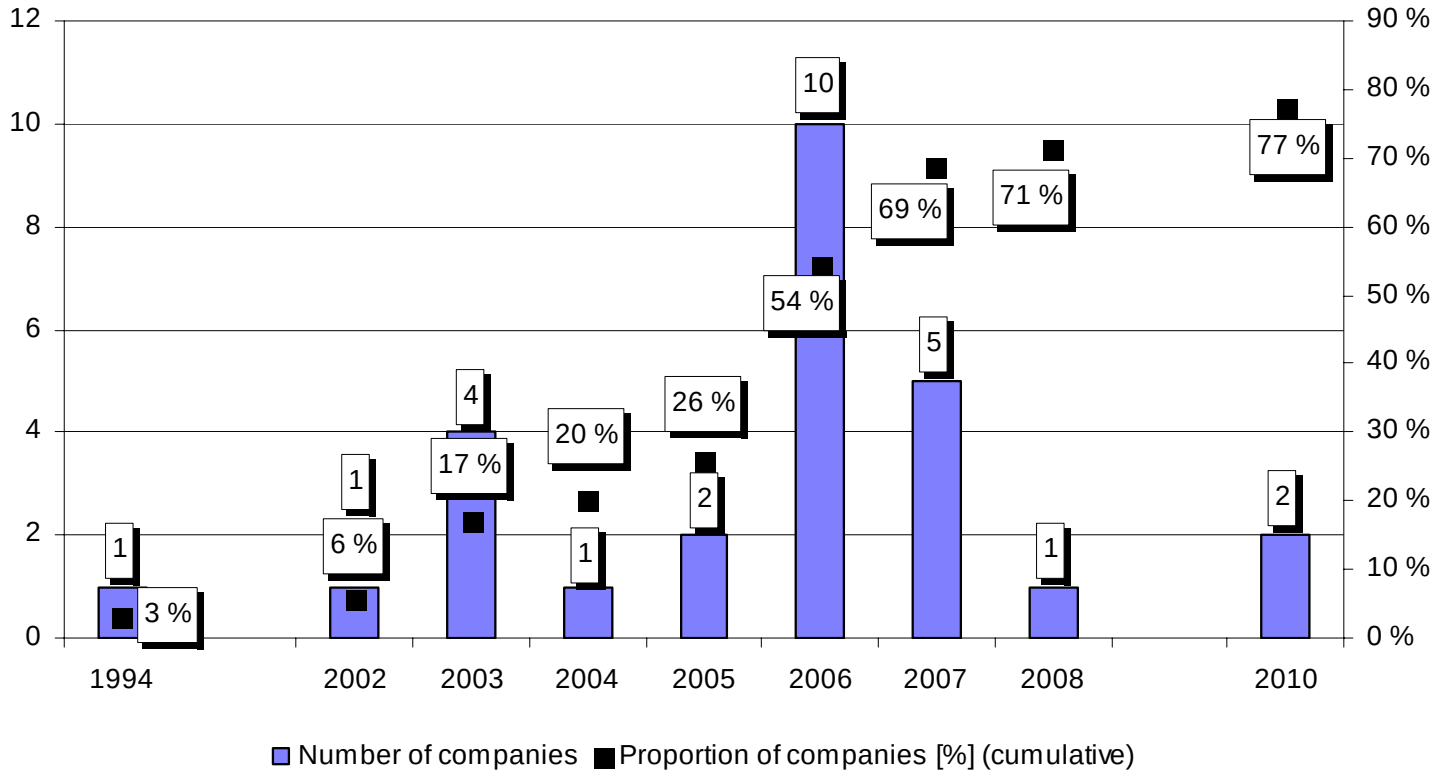
AMR-Questionnaire

The number of AMR small-scale customers and total amount of small-scale customers and proportion of AMR customers of total amount of customers [%]. (Answer was given by 28 companies, 70 %)



Purchase and utilization of AMR

The number of companies annually, when companies have made or will make decisions of purchase of AMR. Answer was given by 27 companies.



Costs of AMR

Investment costs of AMR. (Answer was given by 19 companies, 60 %)

	Urban [€]	Rural [€]
Range	100–250	170–350
Average value	166	215

Operating costs of AMR

	Urban [€]	Rural [€]
Range	0,5–50	5–50
Average value	12	16

Price of AMR [€/piece], when the holding time is 15 years and interest rate is 5 %.

	Urban [€]	Rural [€]
Range	9–51	16–51
Average value	20	27

Thank You