DSM experiences in Nordic countries

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Business from technology

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Content

- Nordic Electricity market
- DSM/Demand Response (DR) as TSOs` operating reserves
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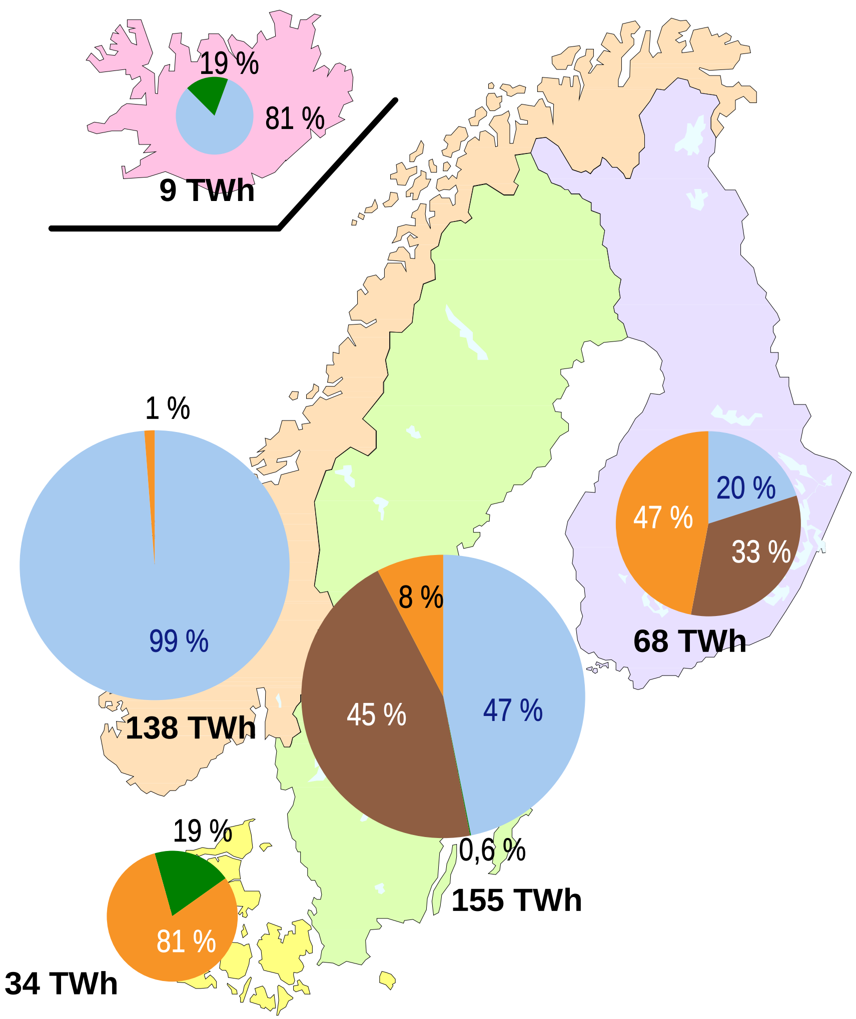
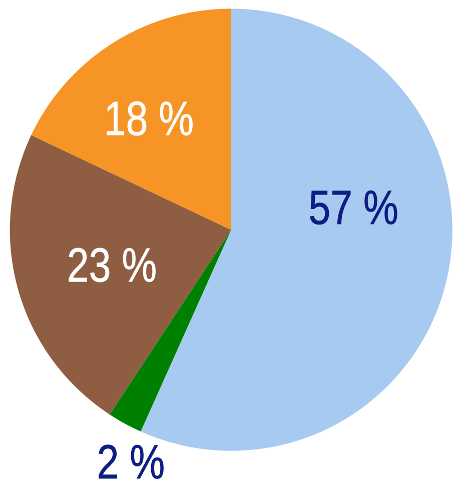
Nordic countries

	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

Generation in the Nordic Countries 2005



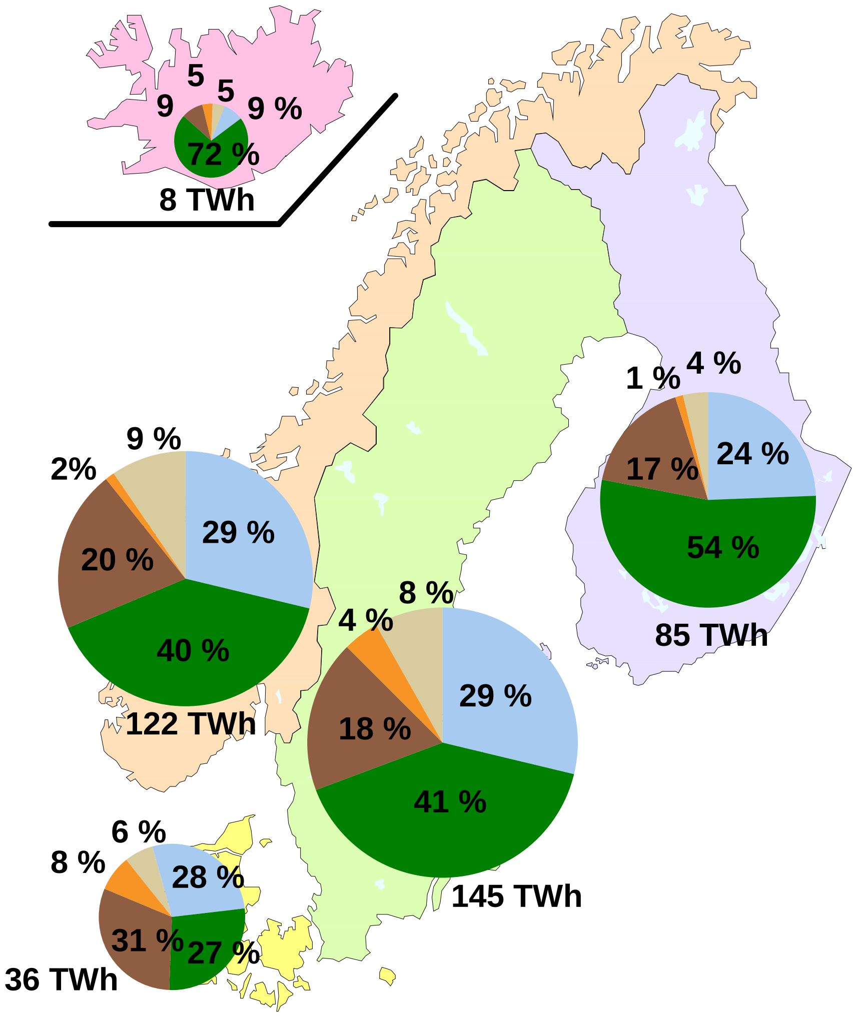
Nordel

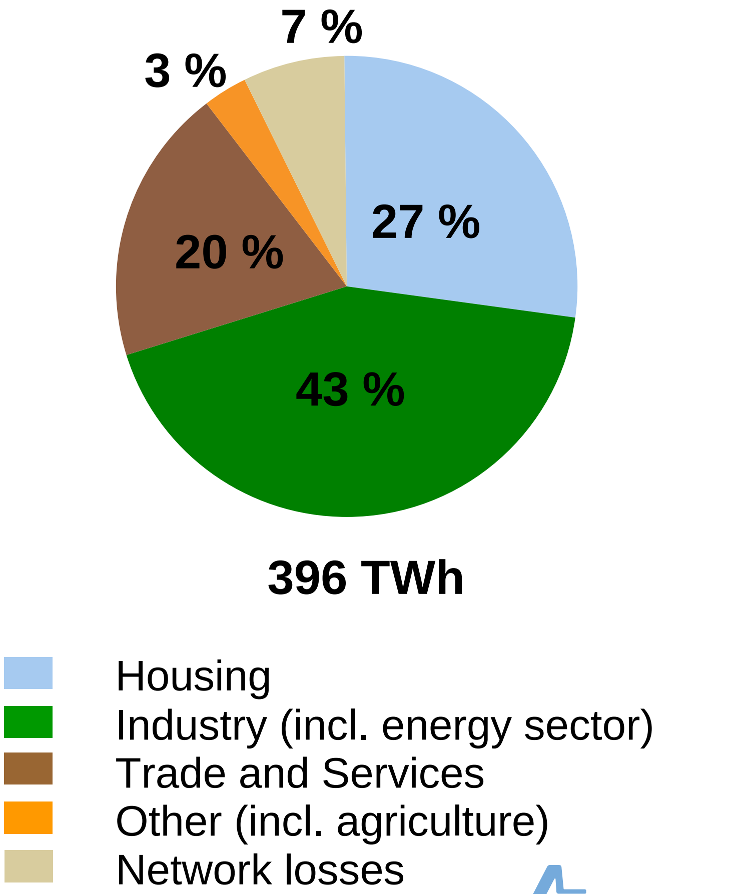


404 TWh

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

Electricity Consumption 2005

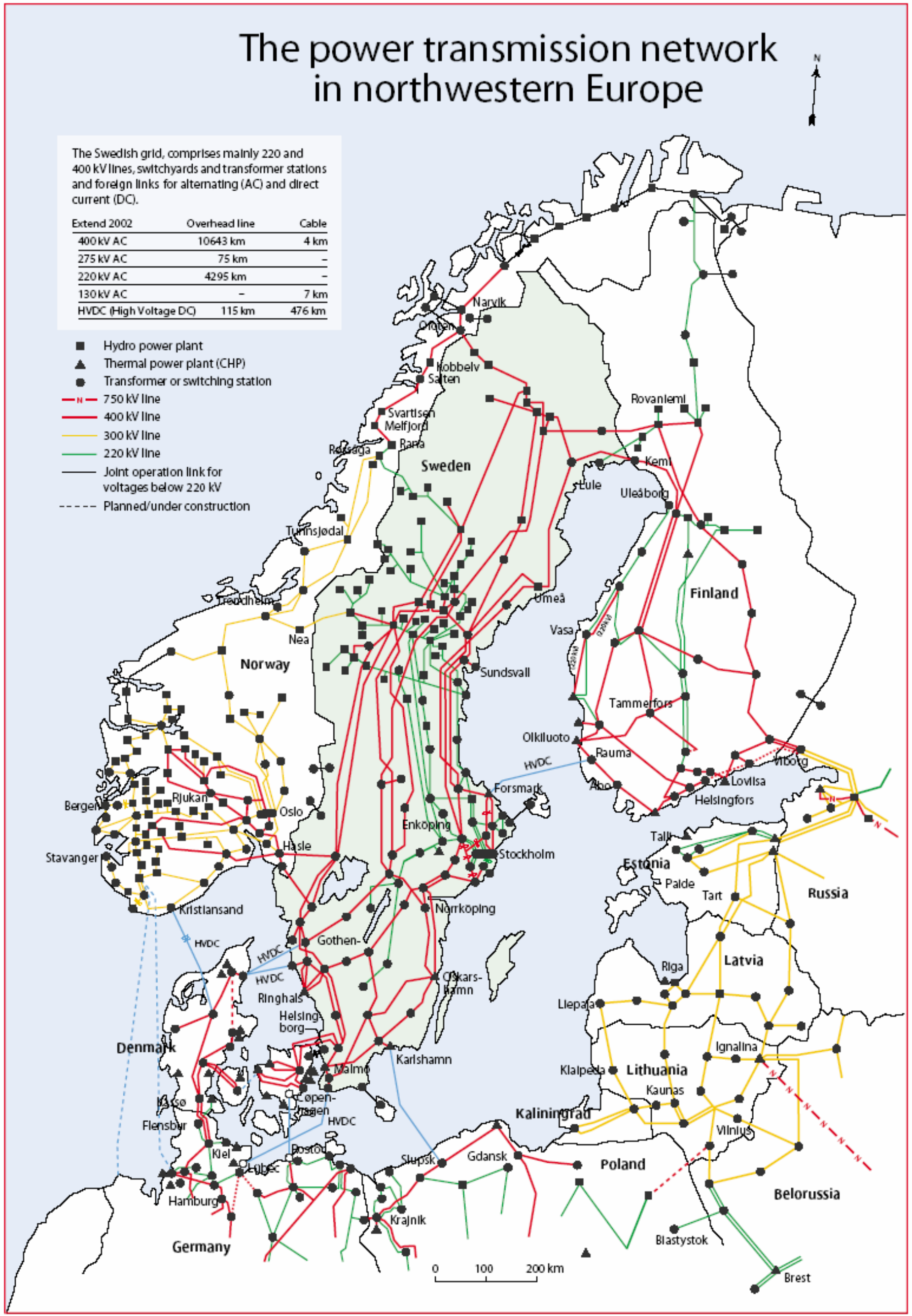




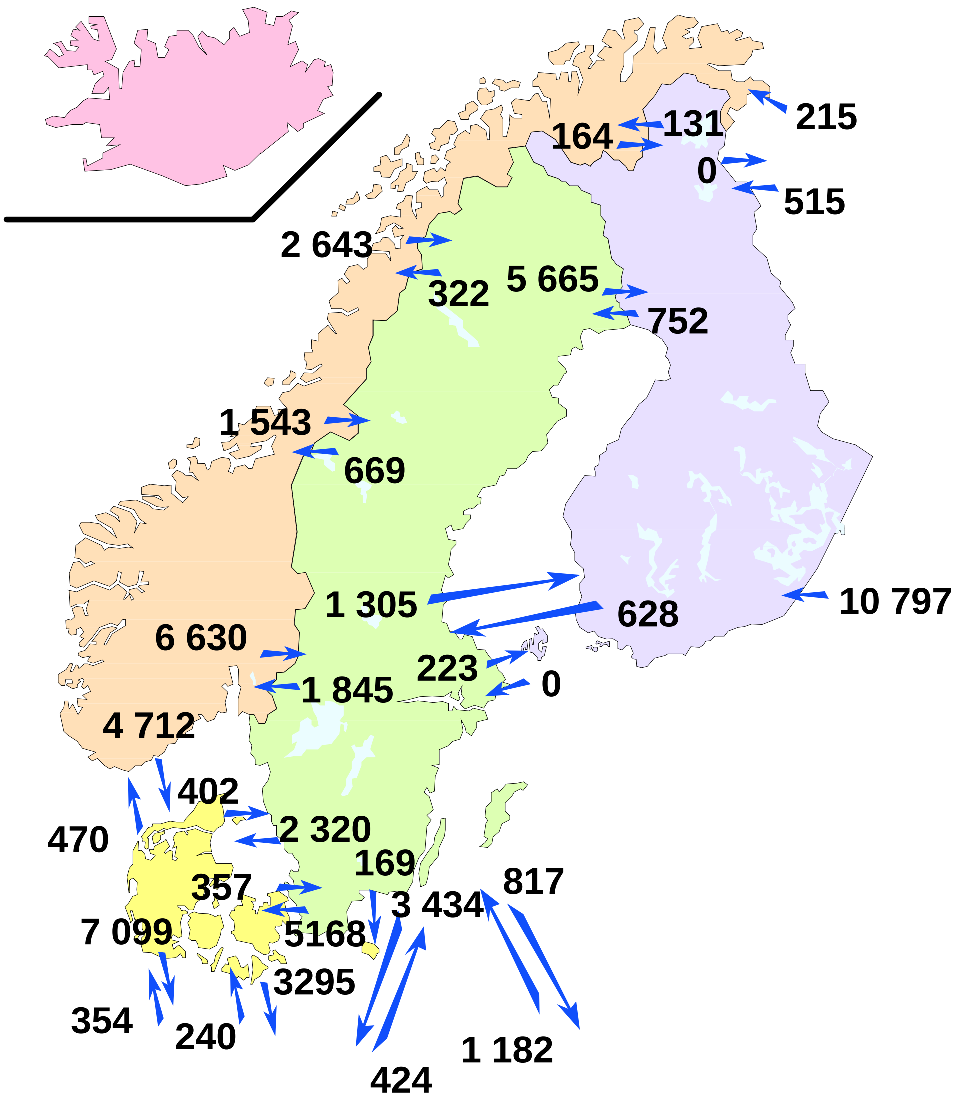
Transmission grid in Nordic countries

Recent development

- 600 MV cable Norway-Netherlands in operation (2007)
- 300 MW cable Finland-Estonia in operation (2007)



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

Physical market

Specific hour

Balance settlement

Nord Pool Market

TSO (Nordel) market

ELSPOT

ELBAS

Regulation pwr market

Balance power

12 - 36 h

1 - 32 h

max 3 months

Bilateral transactions

Balance management

Power balances of the parties

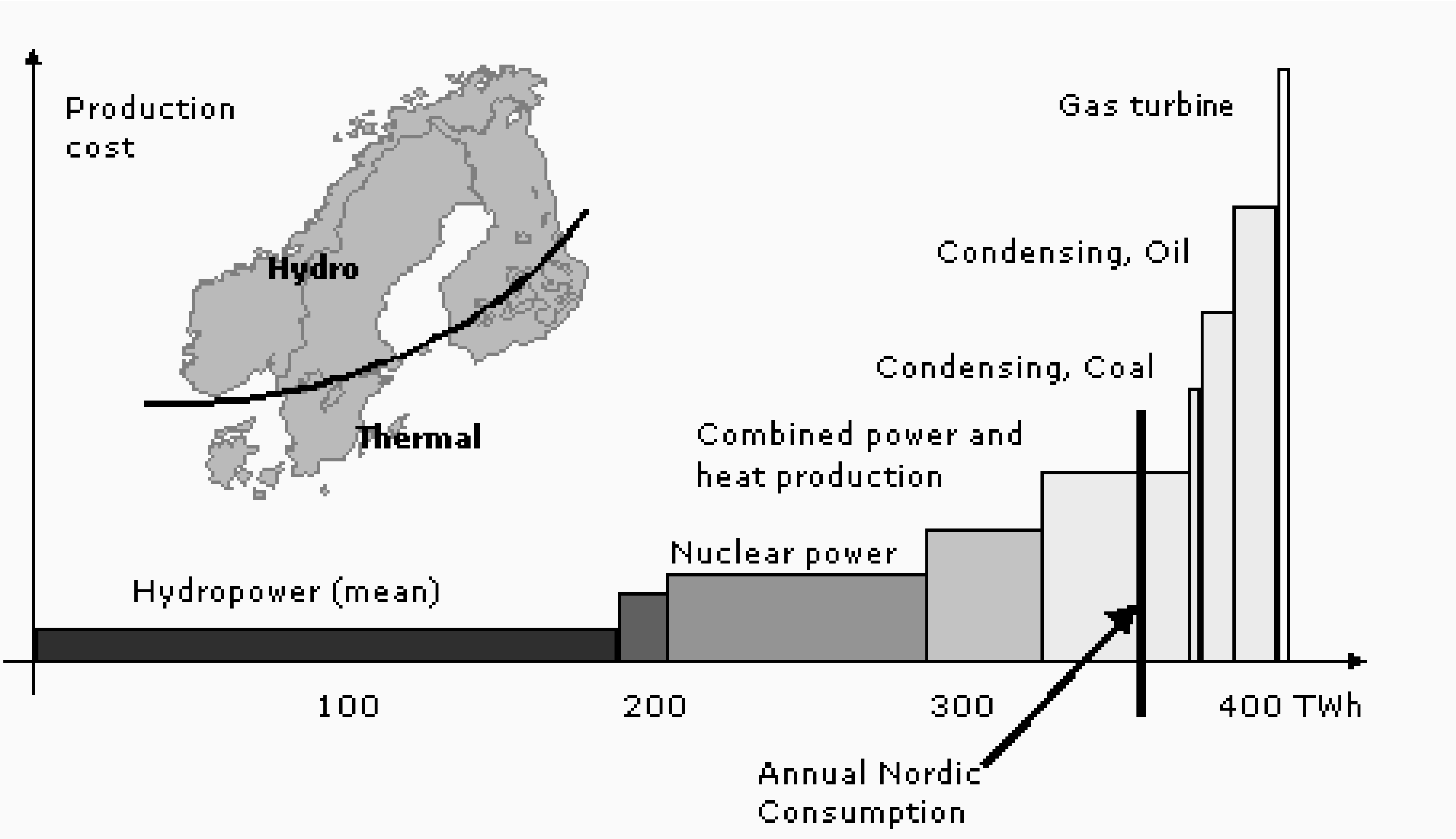
Fixed transactions must be agreed and reported before the specific hour

Common marketplace: Nord Pool

VOLUNTARY MARKET PLACE FOR ELECTRICITY

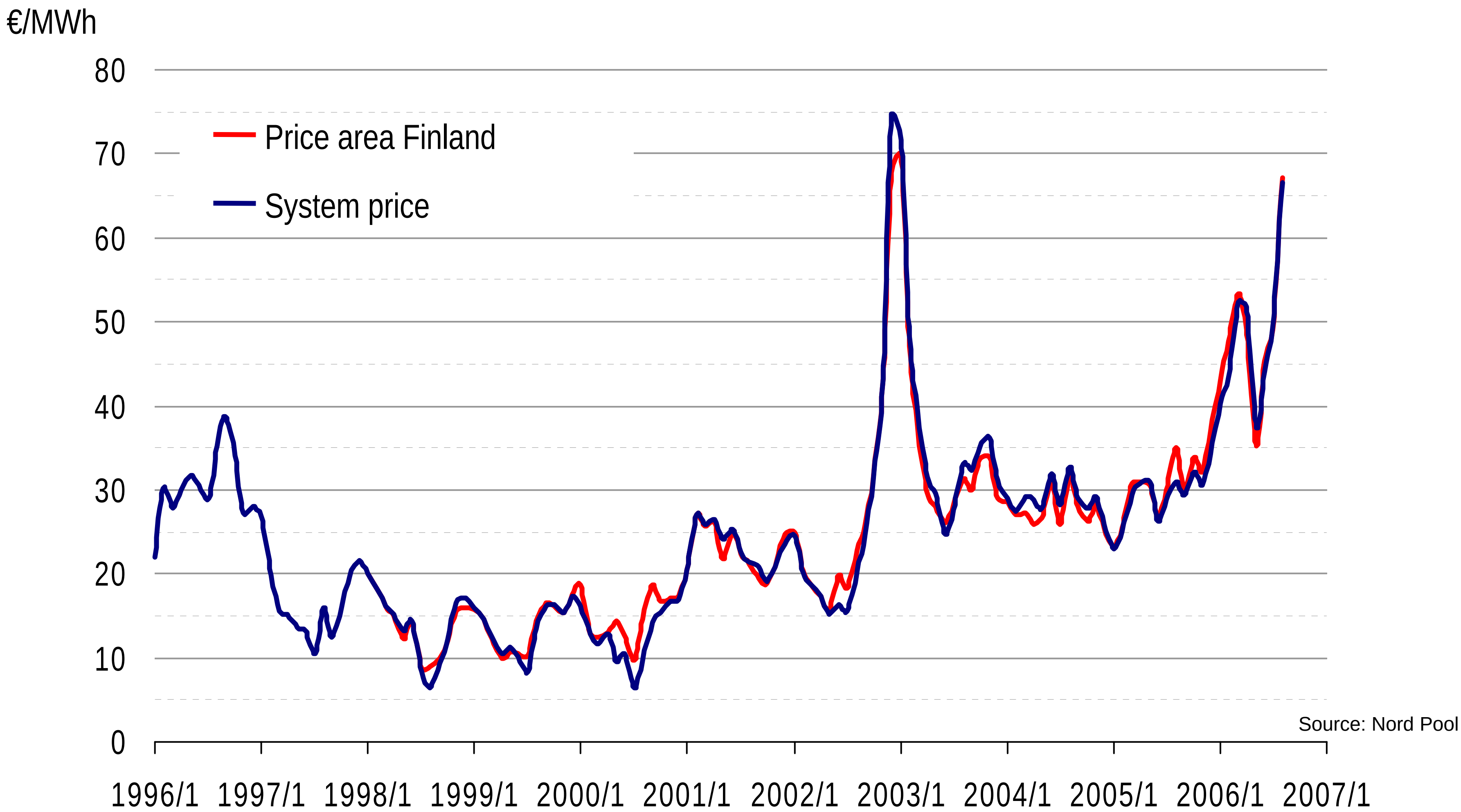
- Founded in 1993 in Norway
- Other countries joined later
- Owned mainly by system operators
- Not all electricity traded through NordPool, but it sets the marketprice
- Several types of products
    - Physical market (daily spot market on hourly bases (Elspot), Hourly market (Elbas)
    - Financial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

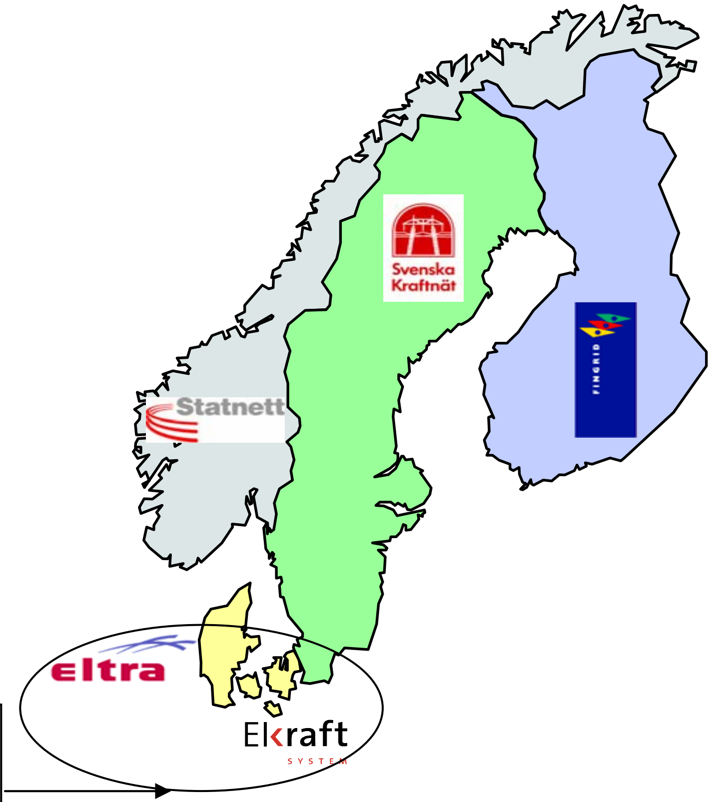


Nordic regulation power market

- ❑ TSOs specific balancing market
  => common nordic balancing management

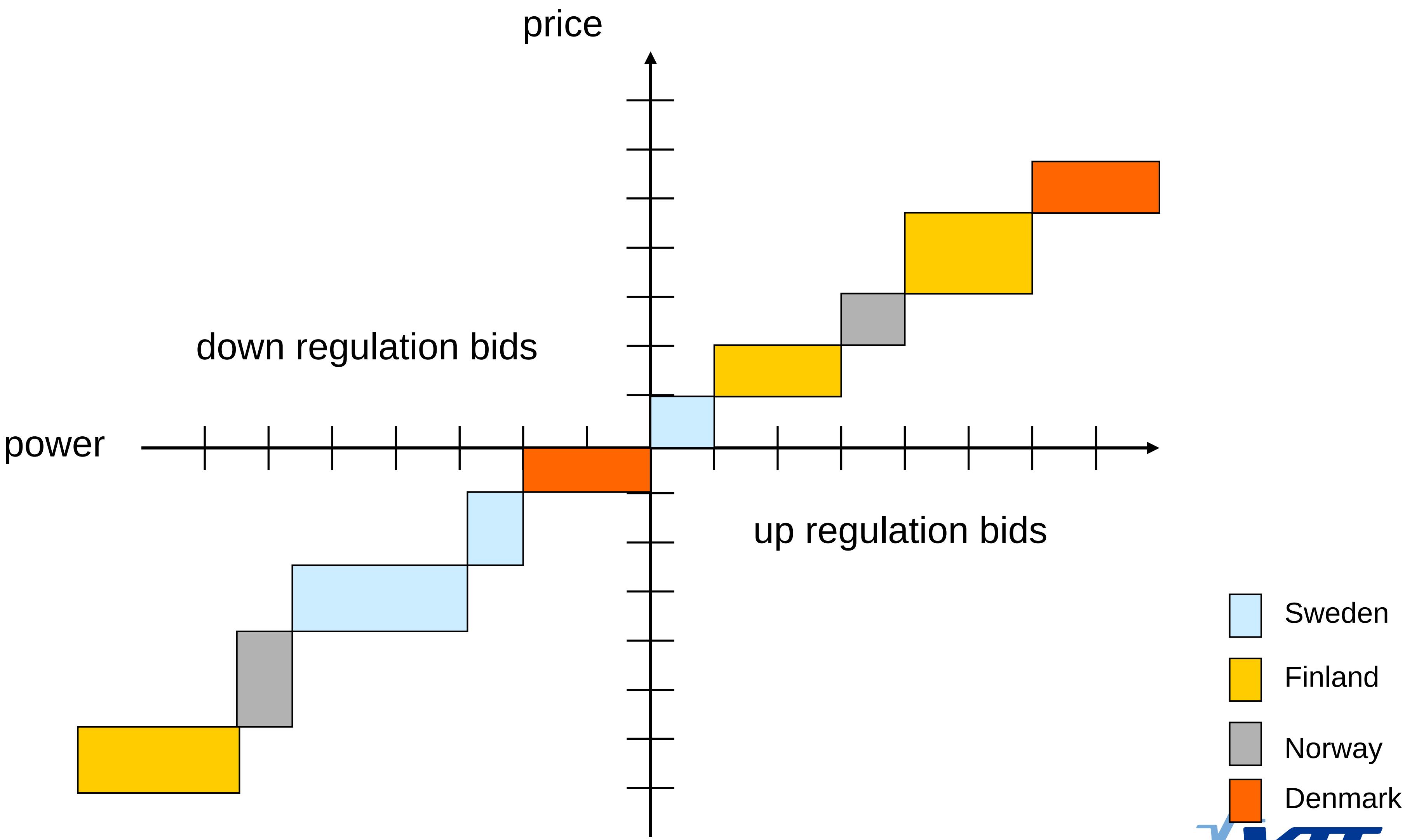
- ❑ The Finnish regulation power market
  is part of the Nordic regulation power
  market.

- ❑The synchronous area is regulated
  as a one system



Now one TSO in Denmark: Energinet.dk

Nordic regulation power market



DSM/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) (Norway)

❑ Successful participationfrom large industries:

- ➢ Predictable revenues
- ➢ Acceptable technical requirements
- ➢ Direct participants in Elspot
- ➢ Large demand units(> 25 MW)

❑ Evolution of demand side 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**

DSM potential in Nordic countries

Estimated DSM potential in Nordic countries

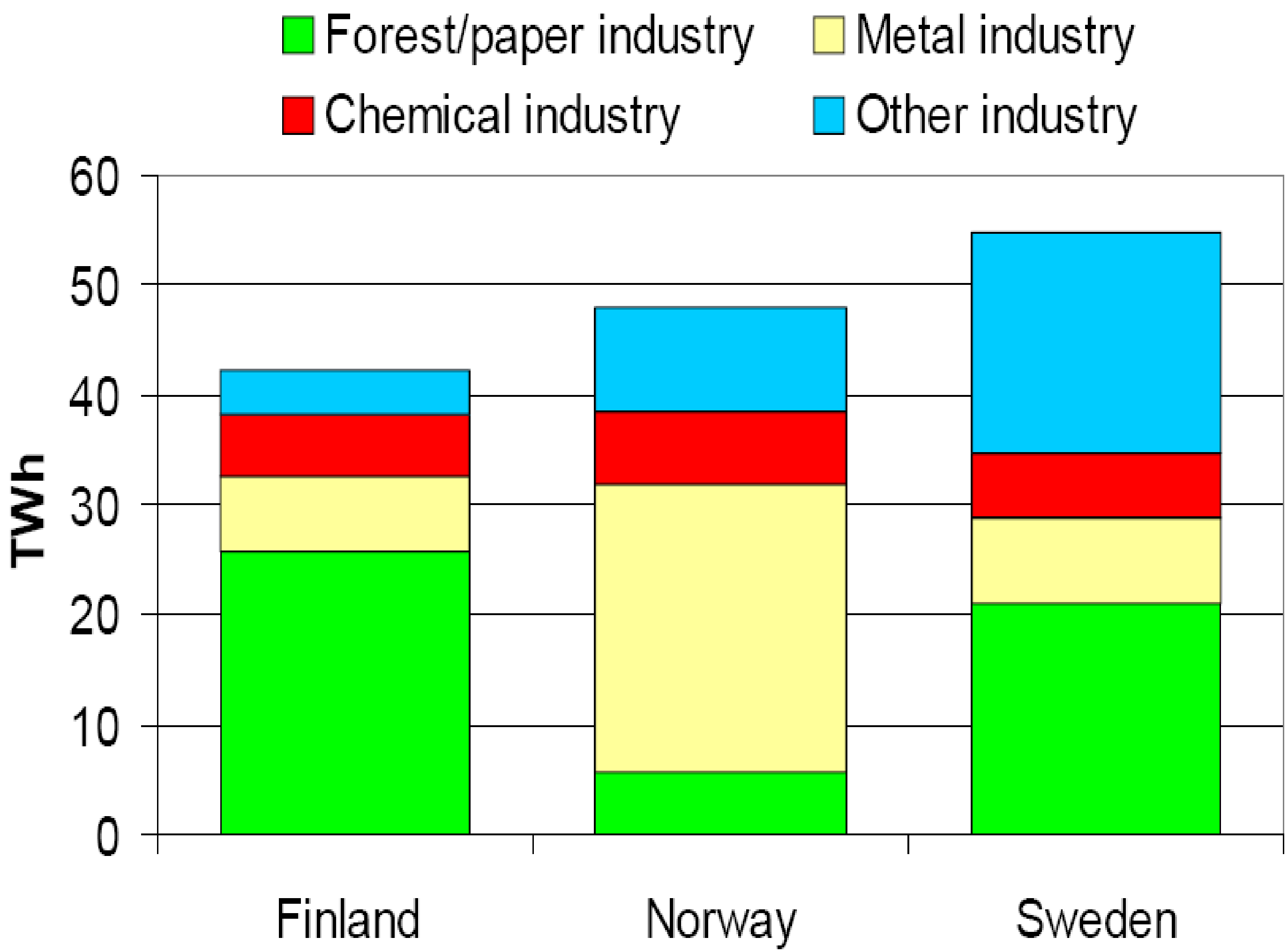
	Denmark	*Finland*	*Norway*	*Sweden*	*TOTAL*
Contracted by TSOs	25	365	1,300	385	2,075
Observed other response	20	140	800	700	1,660
Additional economic and technical potential in the short and medium term	800	2,400	4,600	3,000	10,800
A pessimistic estimate of the total potential	*At least 500*	*At least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

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

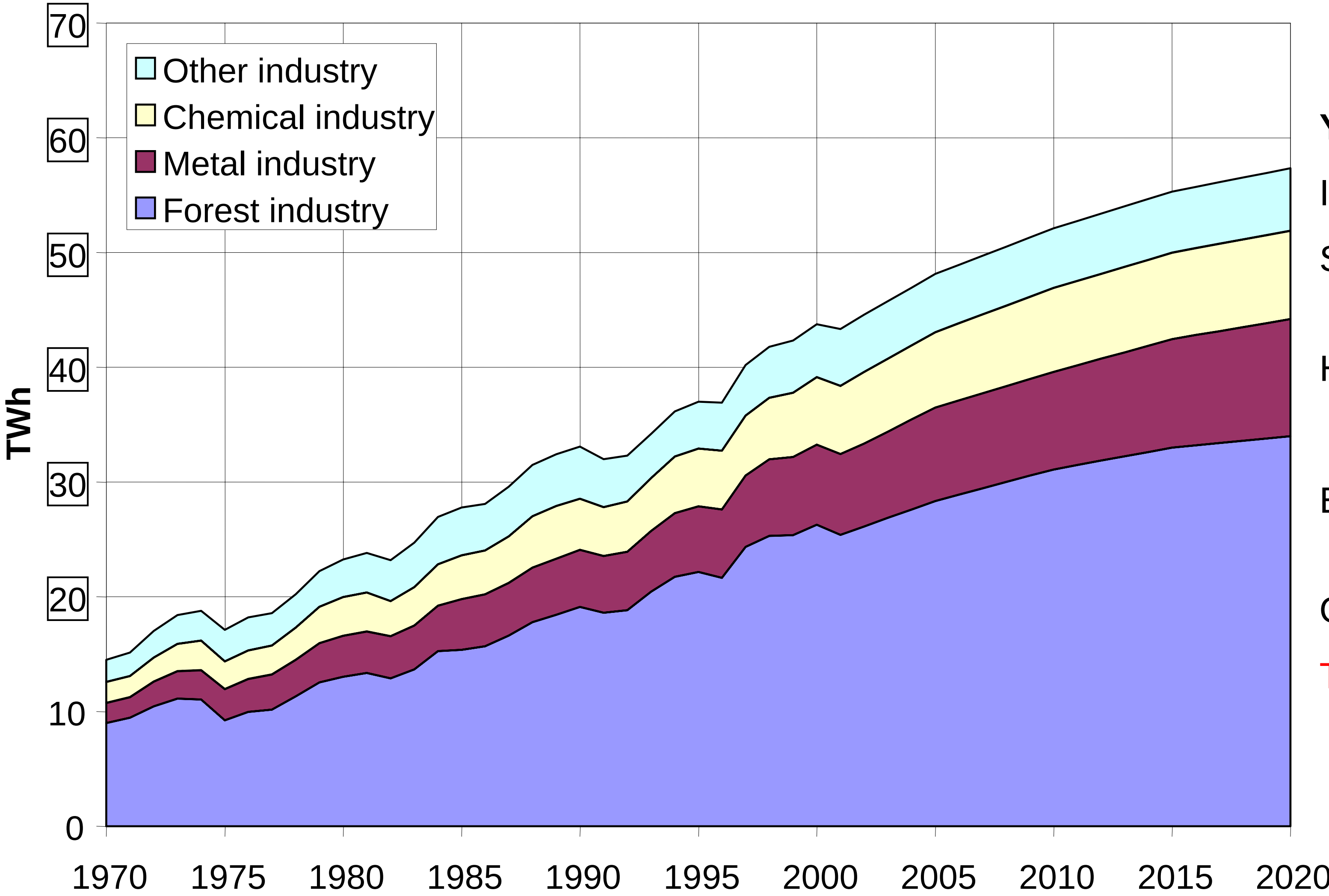
Main potential in large-scale industries and electric heating

DSM/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

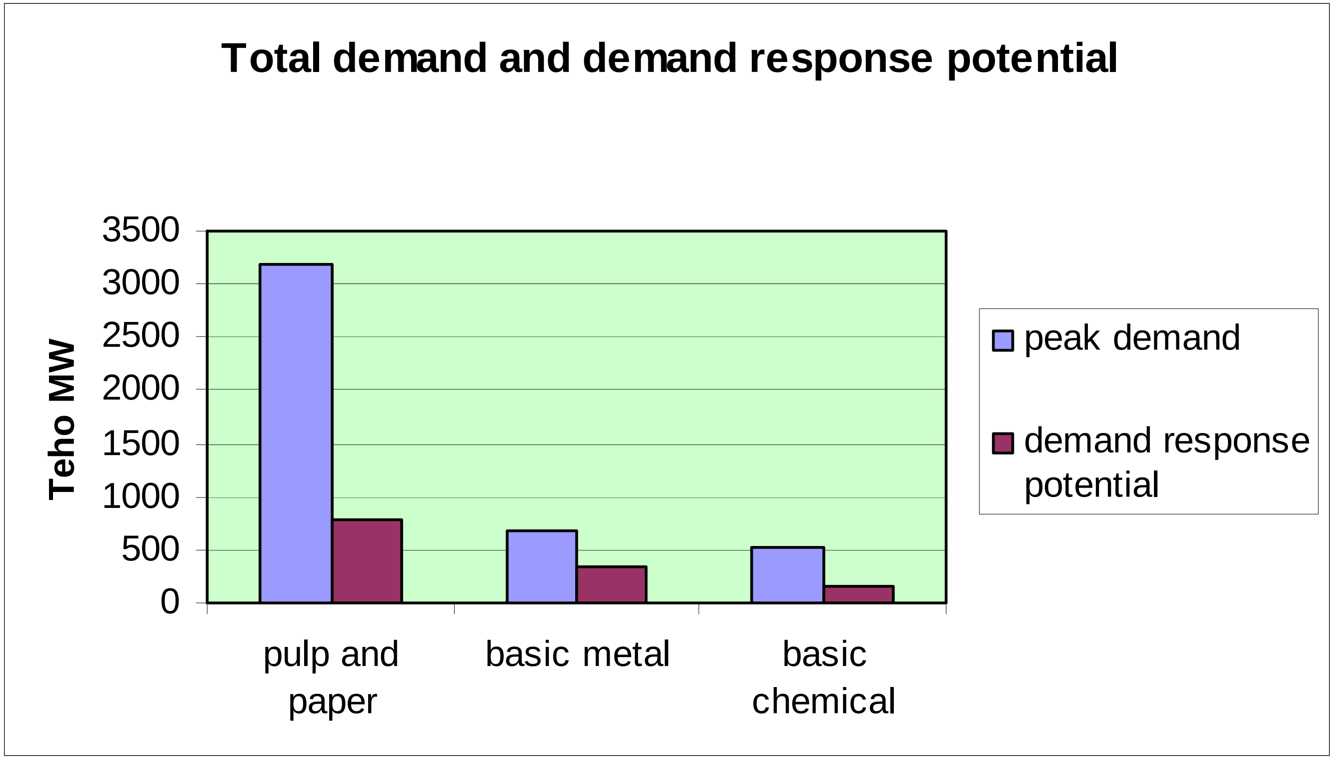
Electric heating 9 TWh

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)



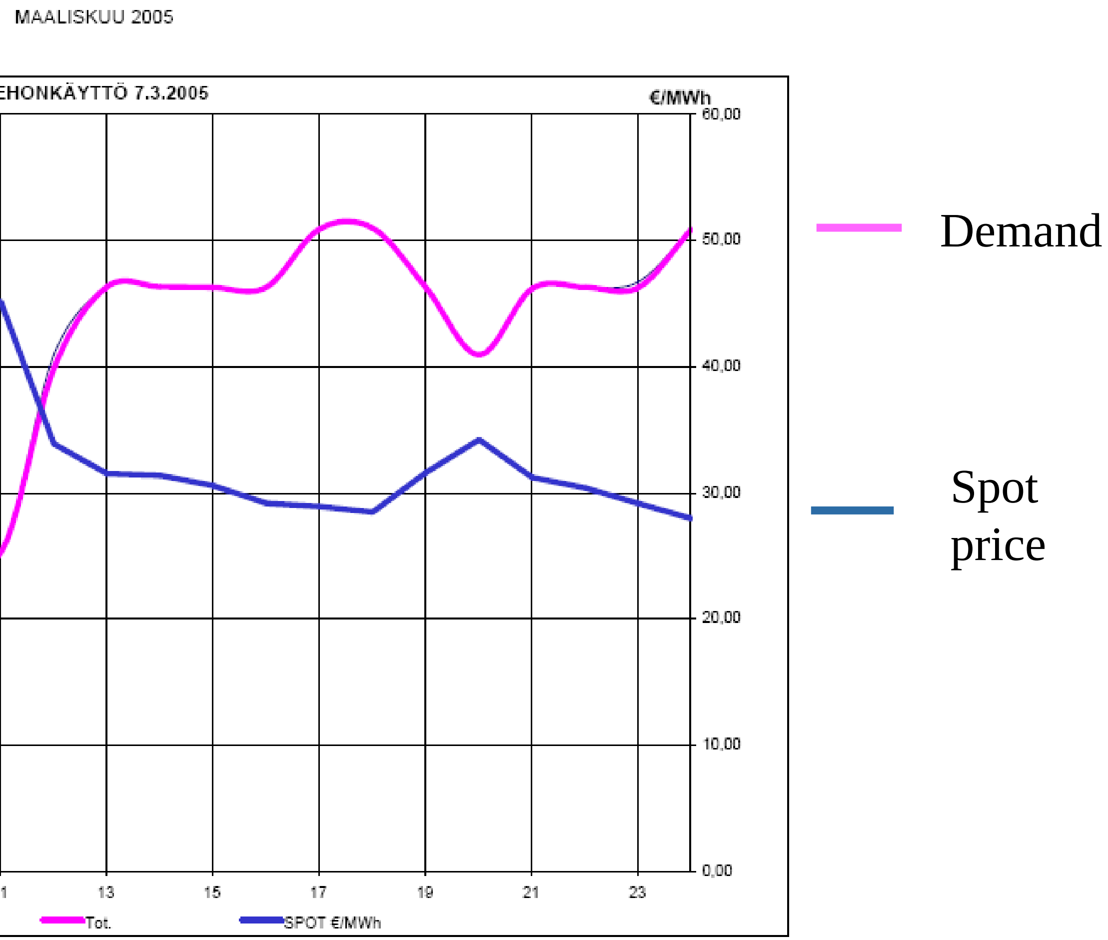
Effect of electricity price on activating Demand Response

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)



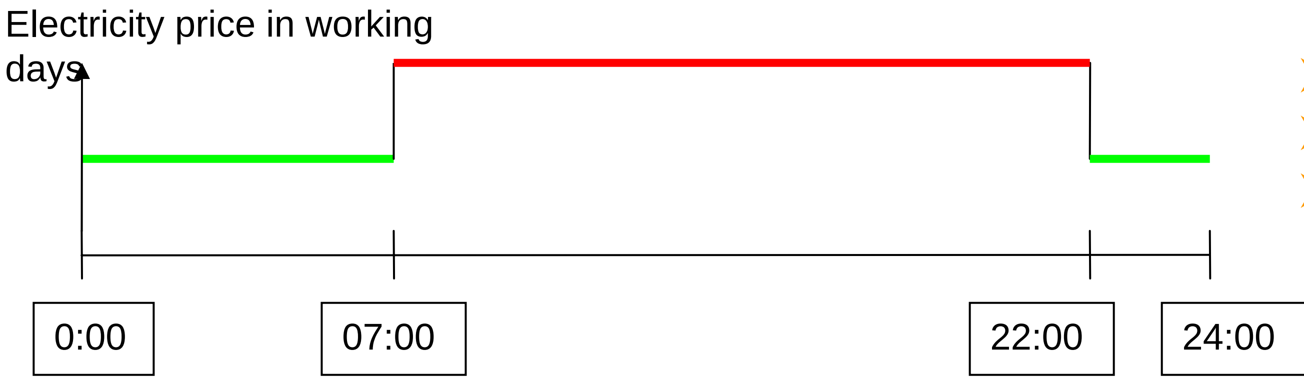
Conclusions

- 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 2010) 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

DSM at electrically heated customers in Finland

DSM 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)

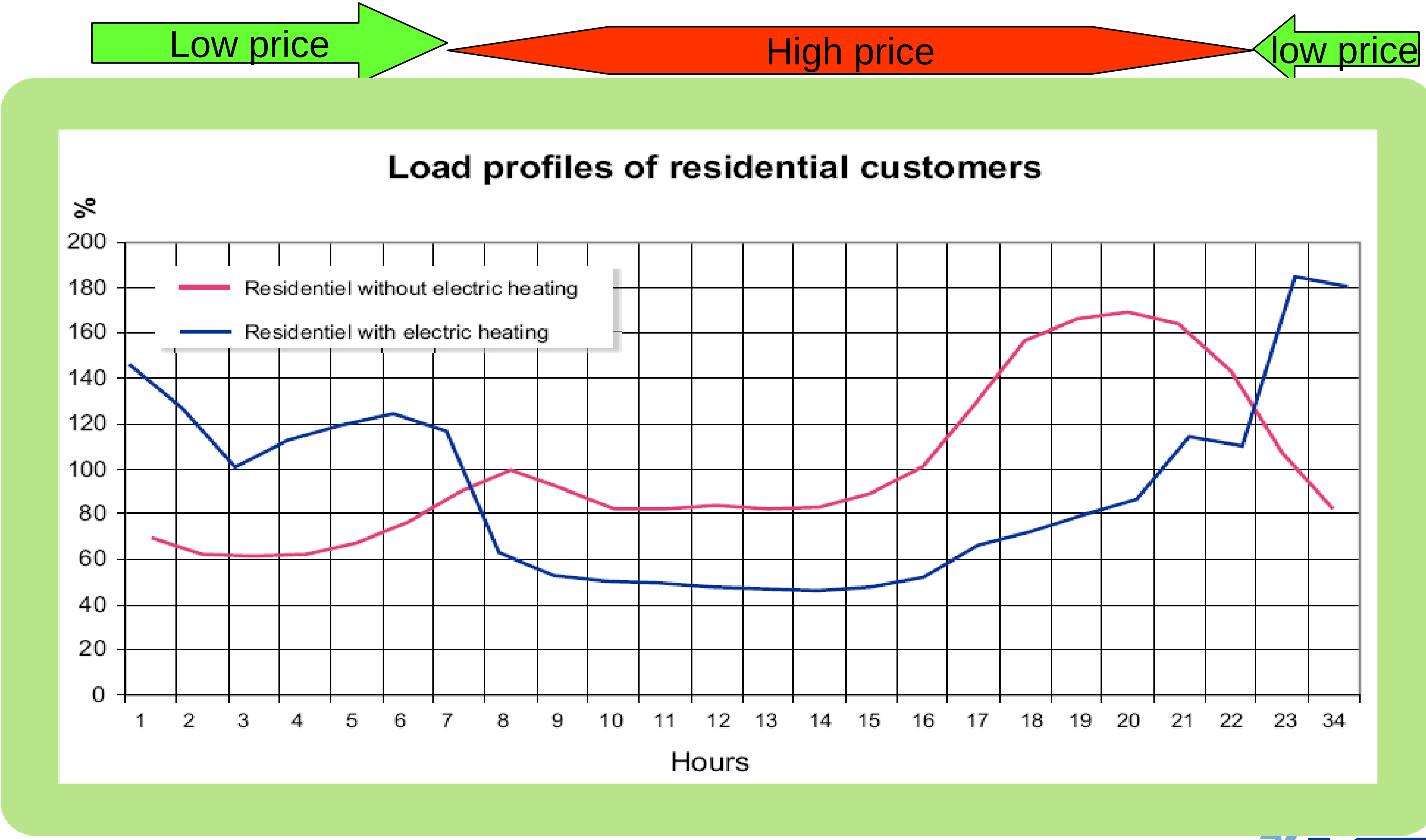


- Typical for working days
- Weekends often low-priced
- Also seasonal (winter – non-winter) variations possible

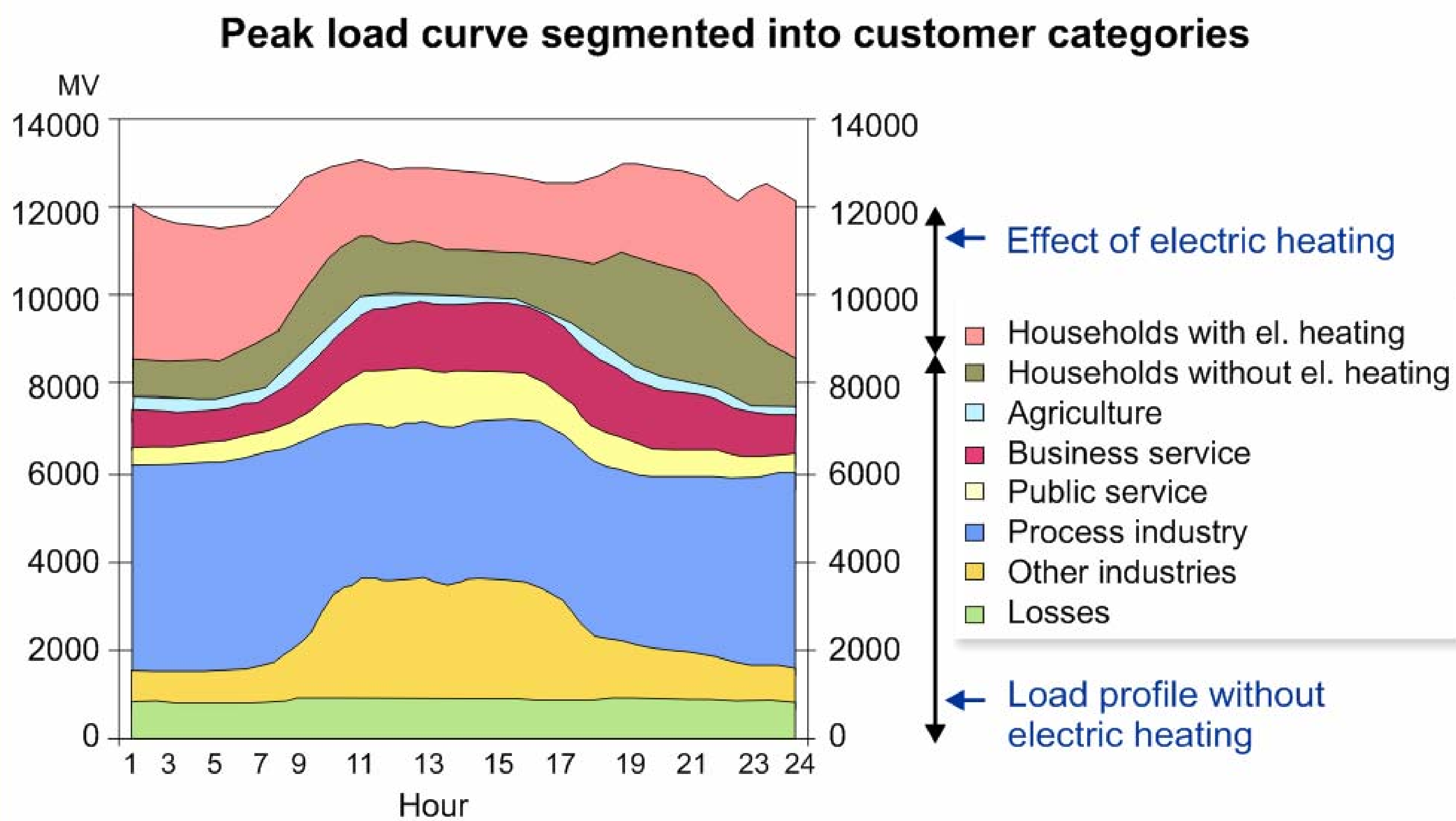
Development of new technologies:

- 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)

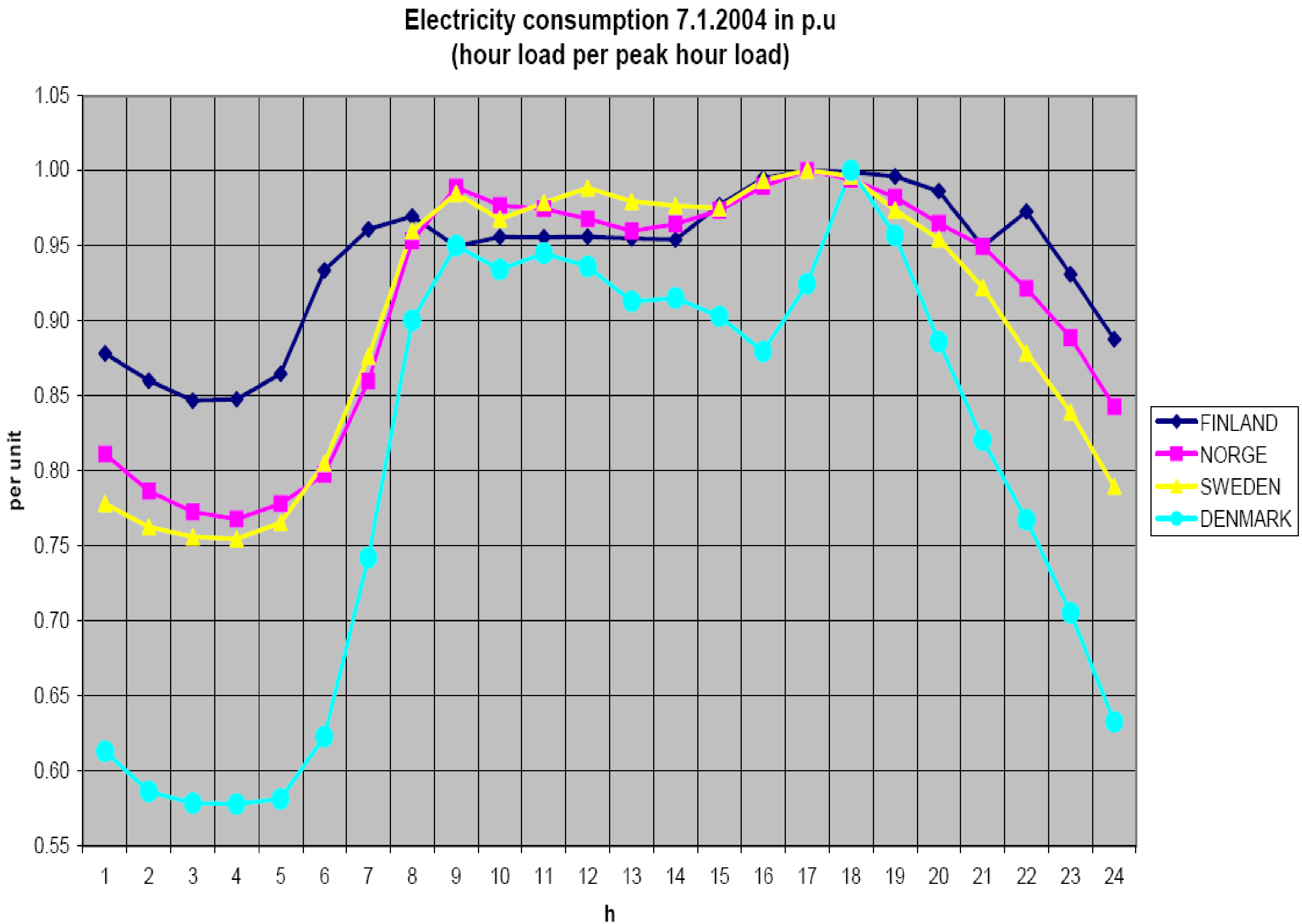
Effect of pricing: Average load profiles of small customers with electric heating
Large share of customers have TOU-pricing



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 usually 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 still has significant unused DSM potential. (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 electricity market legislation is a significant barrier.
- New innovative pricing structures are under discussion at retailes in all Nordic countries

Some examples of pilots/field test in other Nordic countries

Hourly metering with two-way communication and web-based interface for control and following consumption, Denmark (1)

The objectives of the Danish pilots are to increase the end-user flexibility in periods with scarcity of electrical energy and power by:

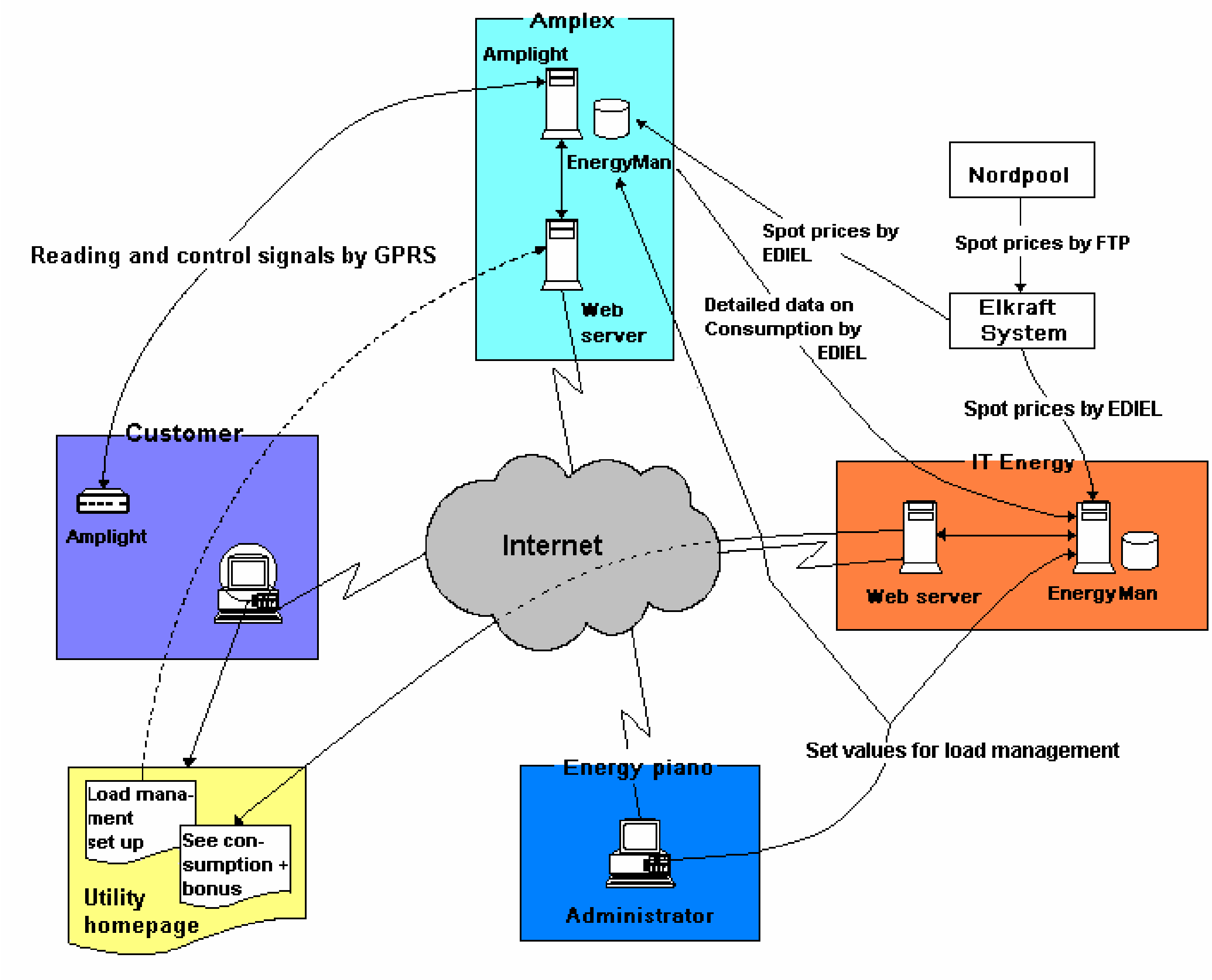
- Develop, test and evaluate incentives, which stimulates flexibility in consumption, with basis in an economical bonus (to be a part of a power price tariff) and implementation of IT in order to facilitate the customers acting and knowledge on their consumption.

Technology is based on

- Two-way communication (GPRS, internet)
- Remote meter reading and smart house
- Web

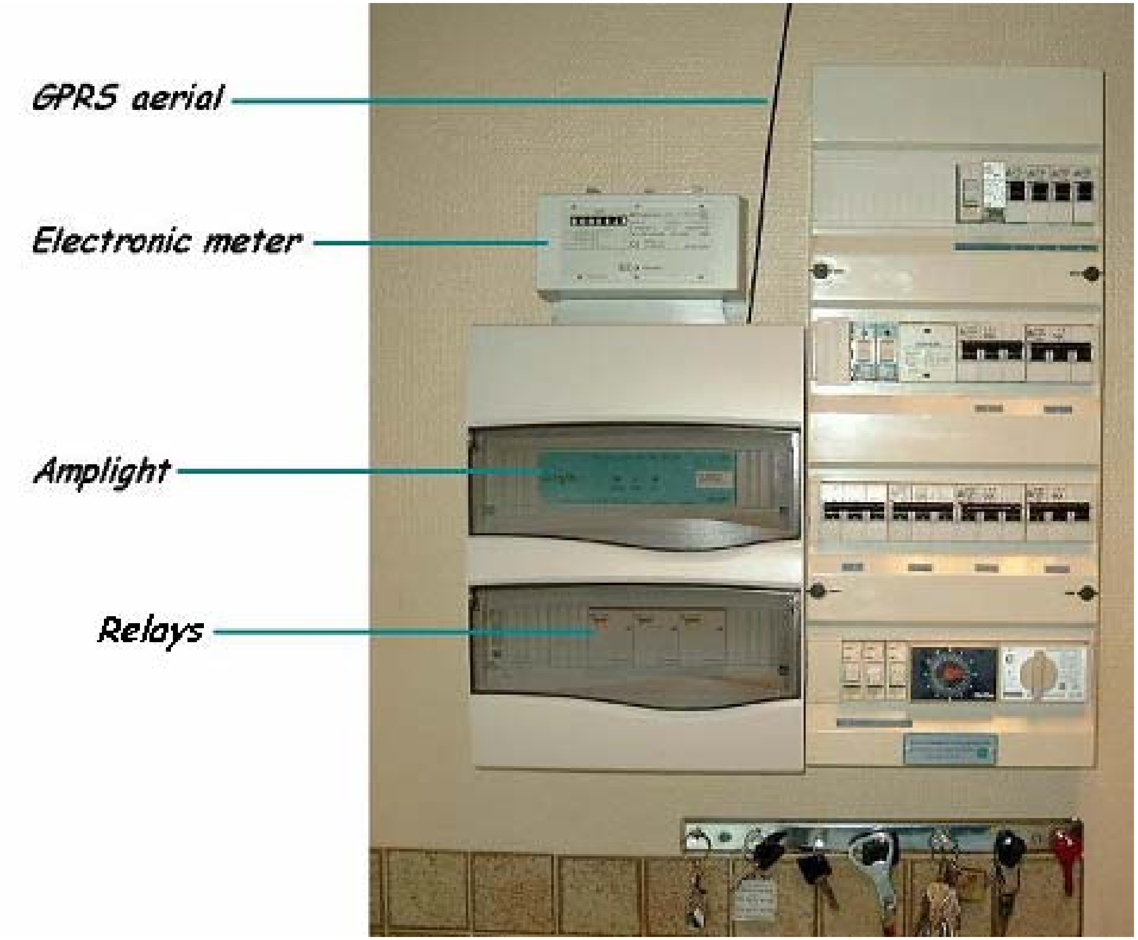
25 households in the pilot project

Hourly metering with two-way communication and web-based interface for control and following consumption, Denmark (2)



Hourly metering with two-way communication and web-based interface for control and following consumption, Denmark (3)

Household installation

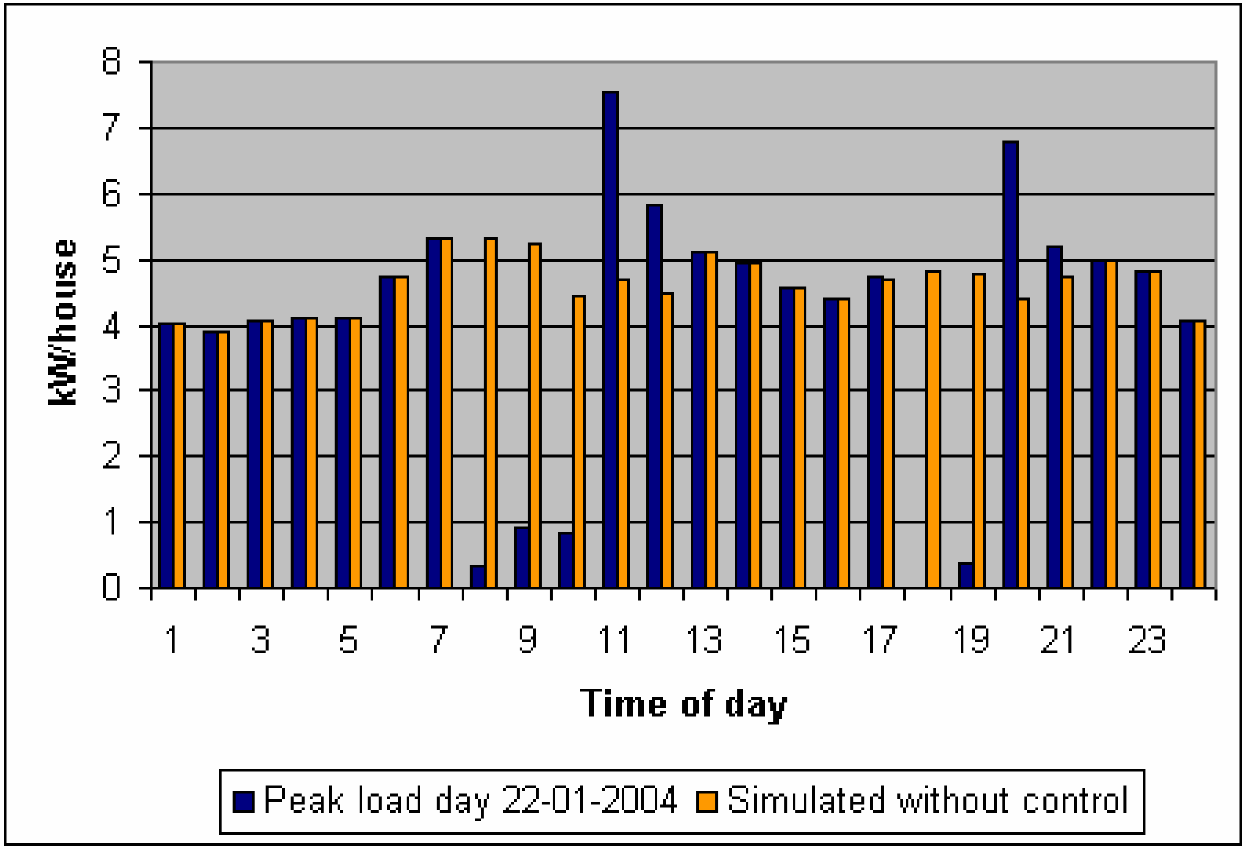


The customer communicate with the system by Internet. The Web site includes:

- Access to setting the limits for the maximum duration of interruption for up to five different control zones for different time periods of the day.
- Access to stop an actual interruption for some of or all the control zones.
- A report on the daily, weekly and monthly use of electricity and the saved bonus by demand response control.

Hourly metering with two-way communication and web-based interface for control and following consumption, Denmark (4)

Effect of demand response



- In the pilot project an extended potential for demand response including 100 hours per year is simulated.
- The highest spot prices appear typically on working days and in the two time periods: 06-11 and 16-19 hours.
- The bonus in the 100 hours of control varied between 0.13, 0.27 and 0.40 Euro/kWh for the electricity consumption interrupted in order to find the customer response depending on the size of the bonus.

Hourly metering with two-way communication and web-based interface for control and following consumption, Denmark (5)

Conclusions

- During winter 2003/04 (mild winter) customers obtained in average a bonus of 80 Euro per customer by offering flexible loads of electric heating
- In addition the value of extra saving in energy was 40 Euro per customer
- Estimated cost of equipment, installation and software is 800 Euro per customer in large scale (1000 households), 5 kW per household can be interrupted in cold days in typical electrically heated houses in Denmark with annual consumption over 16000 kWh
- Large scale pilot going on

Implementation of Demand Side management in Oslo (1)

Main objectives were

- to avoid/expose planned grid reinforcement with use of DSM (energy efficiency actions) and
- to increase knowledge about electricity end-users behaviour and compose a motivation model that can be used by the grid-owner and his coadjutant partner for energy economising.

Technology includes

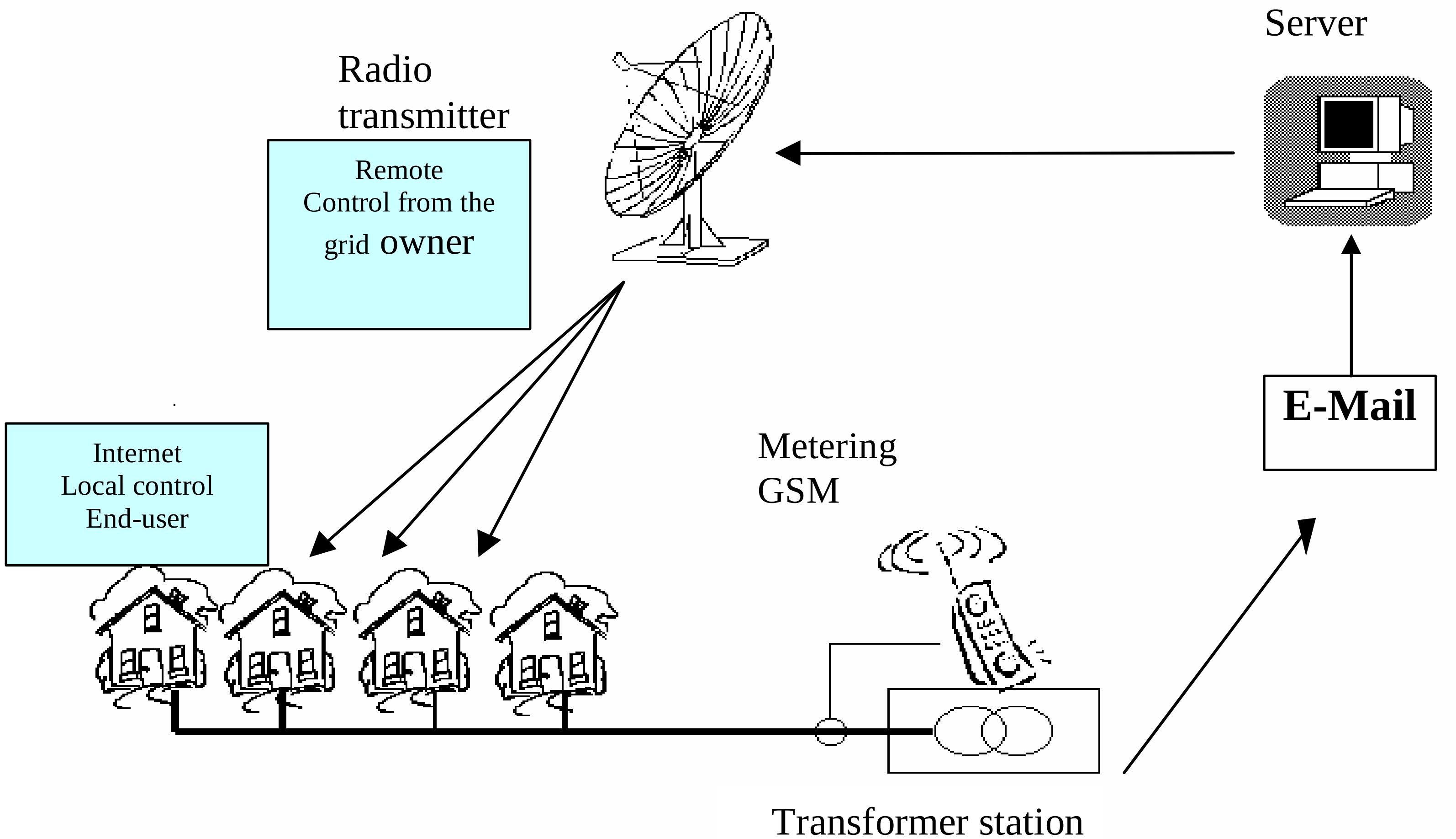
- the smart house solution based on Internet and wireless radio communication and
- the Ebox “plug and play” units implemented among residential end-users containing a switch, a radio receiver, a thermostat and a clock.

20 row house customers in this special part of DSM

- Other types of customers/technologies were also included but not discussed here

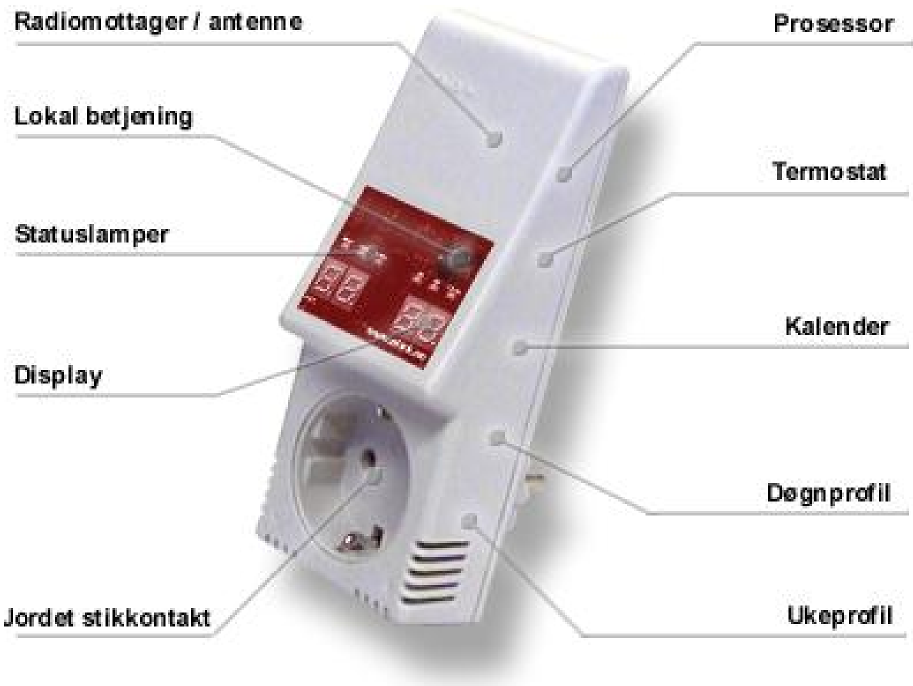
Implementation of Demand Side management in Oslo (2)

"Smart house – solution": Ebox based on Internet and wireless radio communication



Implementation of Demand Side management in Oslo (3)

The Ebox – design and contents

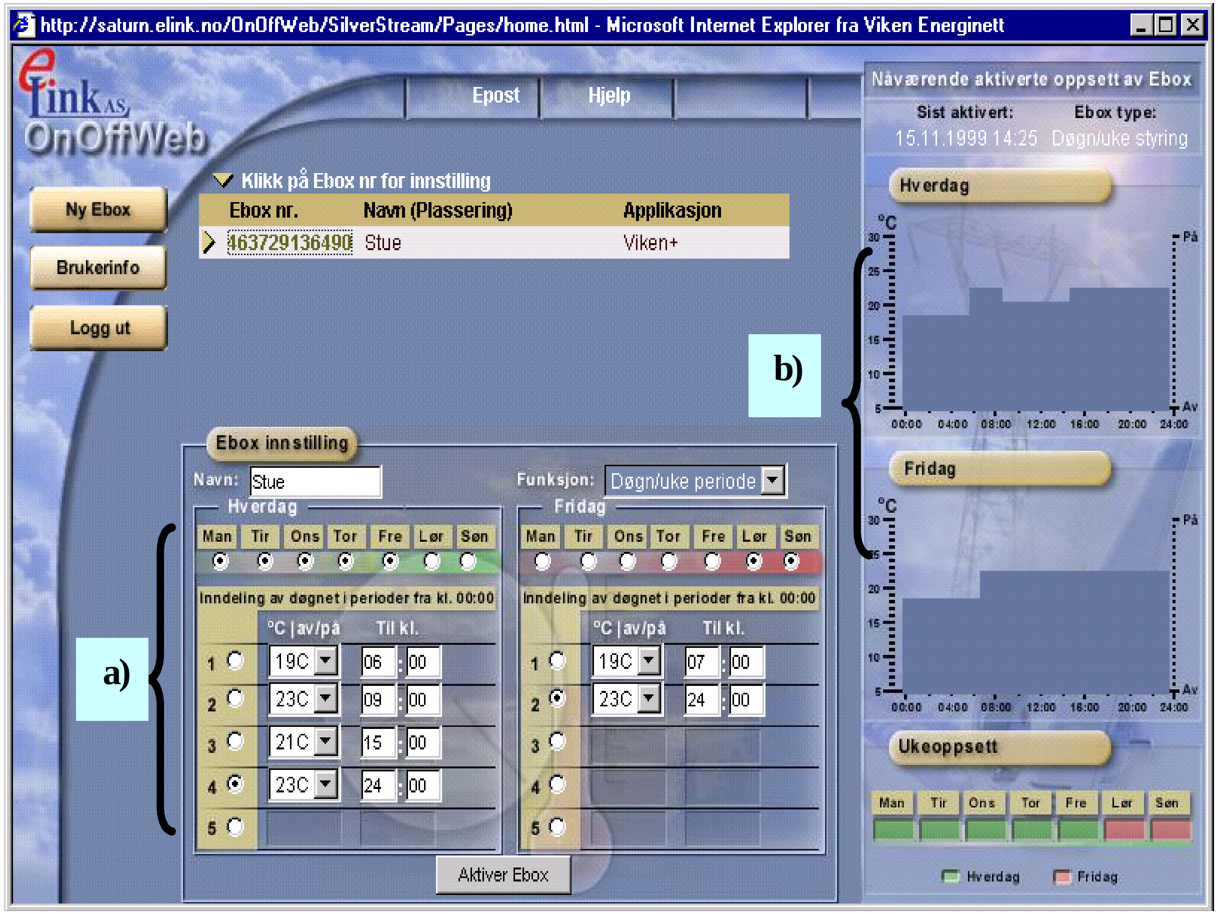


The Ebox contains a data processor, thermostat, radio receiver, on/off switcher, a clock and a display

- The load control (switching) can be based on room temperature level or time setting.
- Each Ebox has its own unique address and it can be configured from internet. When using the Ebox to control electrical heaters, the customer can make his/her own weekly temperature profile on hourly basis from a personal internet homepage.
- The desirable profile will be loaded from the operating server to the Ebox via radio signal.
- Using a button on the Ebox, the customer is also able to overrule the internet programmed profile

Implementation of Demand Side management in Oslo (4)

A private homepage of each customer



- While each customer was able to control their own room temperature using their homepage for controlling the Eboxes, the Network Company (grid owner) simultaneously was able to overrule the same Eboxes in limited time period.
- The Network Company remotely controls the Eboxes according to metered load in the transformer station. This transformer station represents the particular bottleneck in the distribution network

Implementation of Demand Side management in Oslo (5)

Experiences

The project experienced that 13 out of 20 row house customers decided to use the Eboxes throughout the test period of 2 years. Each customer was offered to keep the Ebox after the test period.

The different members of the test group claimed varying motivations in relation to the functions of Ebox as a device for private control of the cost of energy consumption, and a device that enables the network owner to control the peak load:

- One part of the group was ***highly motivated*** and found it interesting to participate in the project as such. They wanted to test the technology and followed the project closely. They also thought that the Ebox worked well.
- Another part of the test group was ***sceptical***. They considered it a duty to participate, and loyally used the device. To some of these the Ebox was a foreign body and not integrated into the household. Others used it actively even when they were not satisfied with its functions.
- A third group was mostly ***indifferent***. They were not particularly conscious about energy consumption, and were prepared to pay the costs of electricity whatever they might be. The Ebox was installed, but they did not pay much attention to it and had not tried to adjust it.

Consumer flexibility by efficient use of ICT (Norway) (1)

The objective of the project was to increase the end-user flexibility in periods with scarcity of electrical energy and power by

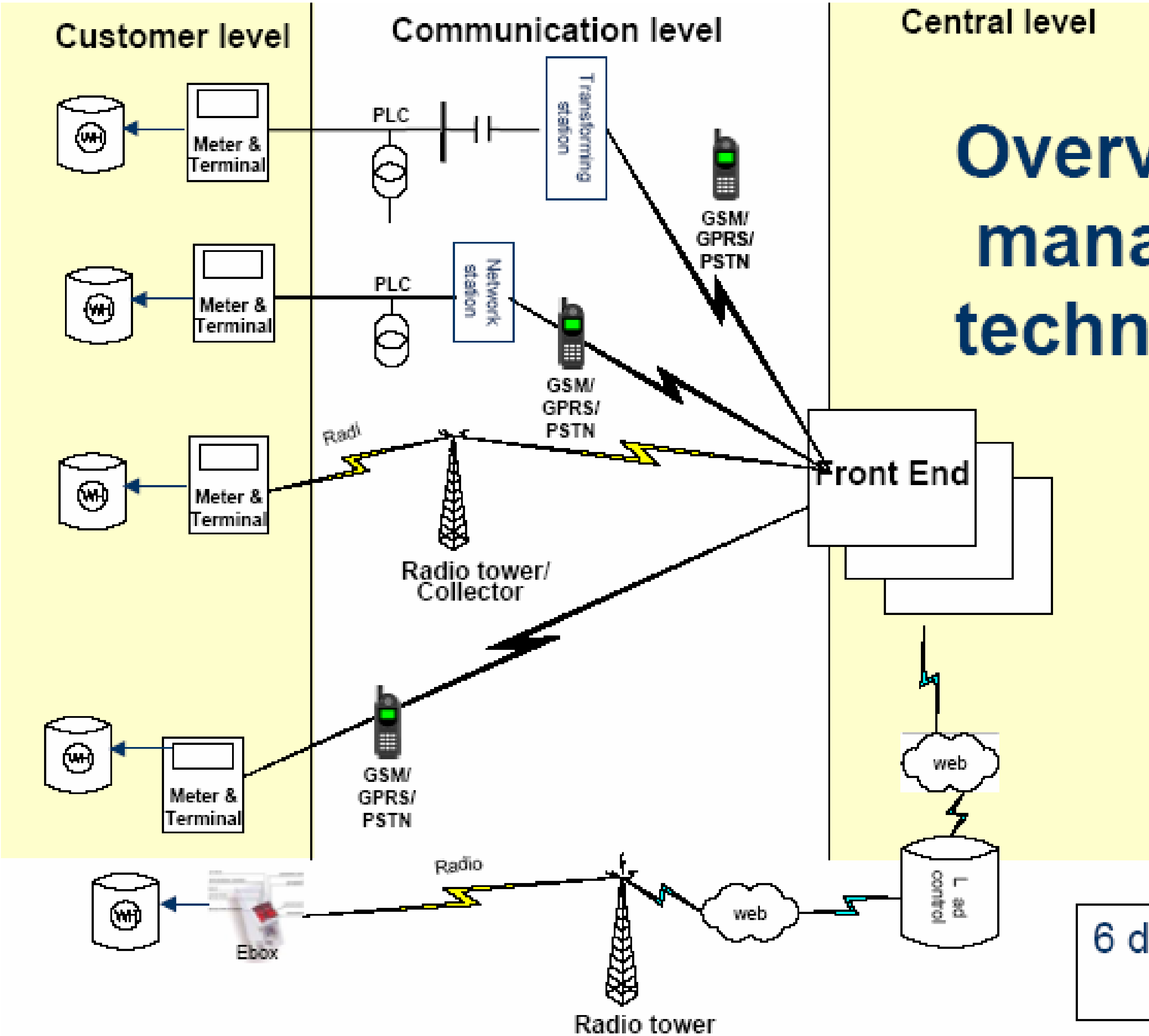
- Establishing a decision basis and propose framework for a prioritized development of infrastructure based on the futures` ICT solutions
- Developing, testing and evaluating different incentives, which stimulates to flexibility in consumption, with basis of network tariffs, power prices and other market solutions.

The technology of the project involves

- establishment of Direct Communication (two-way communication), including hourly metering and
- separate channel for remote control

10 000 customers in 2 different network areas

Consumer flexibility by efficient use of ICT (2)



Overview load management technology

6 different vendors are tested

Consumer flexibility by efficient use of ICT (3)

“Price signals” used in the project:

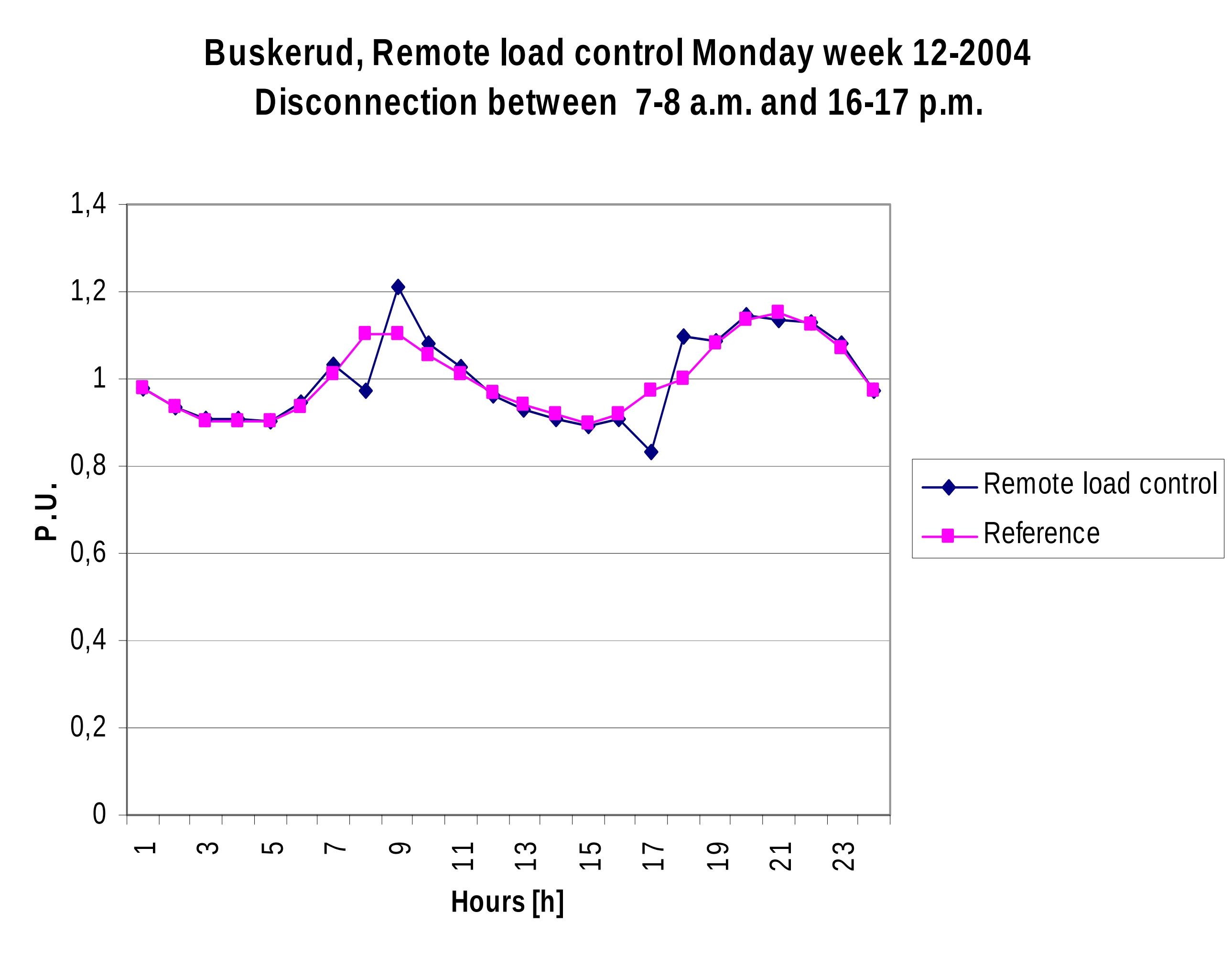
- Network tariff (NO)
  - Time of use tariff with high price in periods with shortage (Shortage defined by time: Mon-Fri, hour 7-11 and 16-19, November -March)

- Energy price (Supplier)
  - Spot price products
  - Spot price products with agreement of remote load control

- Remote load control based on spot price
  - Network owner 1 (Buskerud): Hour with highest spot price + hour before or after
  - Network owner 2 (Skagerak): Every hour with spot price above a predefined limit

Consumer flexibility by efficient use of ICT (4)

Example from the results



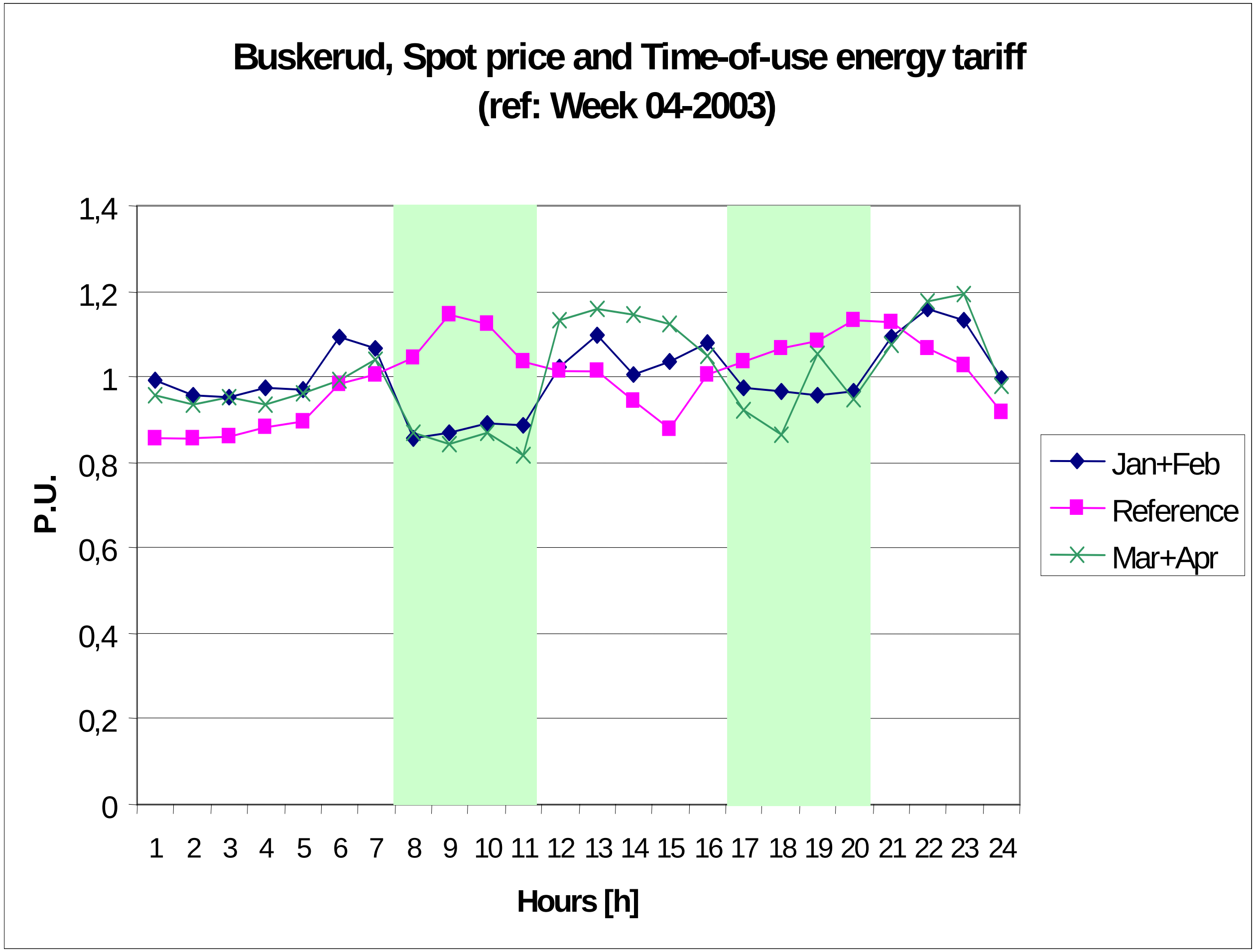
The figure shows the results from remote control of loads at household customers.

- The reference curve is based on consumption at similar customers in the same period and the same geographical area.
- The consumption is reduced as a result of the remote load control compared to the reference.
- The reduction is 12 % in the morning and 14 % in the afternoon.

Number of customers: 1230.

Consumer flexibility by efficient use of ICT (5)

Example from the results



The figure shows the results for household customers with both time-of-use energy tariff and spot price on an hourly basis.

- The figure shows considerable reduction in the consumption during the two peak load periods.
- The maximum reduction is 35% during the morning and 31% during the afternoon.

Number of customers: 6

Consumer flexibility by efficient use of ICT (6)

Test description	Network Operator I	Network Operator II
Remote control (Disconnection of water heaters)	~0,5 kWh/h	~0,57 kWh/h
Tou energy tariff (price difference high/low load: ~0,125 €/kWh)	~0,18 kWh/h	~0,18 kWh/h
Hourly spot price	~0,6 kWh/h	~0,4 kWh/h
ToU + Hourly spot price	~1 kWh/h	~0,3 kWh/h

On average, the 0,5 kWh/h/customer response for remote control of water heater

Heating vs. cooling

Heating vs. cooling: learning from each other

Comparison:	Heating	Cooling
➢ heat insulation optimisation	+	?
➢ direct load control	+	+
➢ TOU/Dynamic-pricing	+	?
➢ storing of heat/cool at residential level in building structures or storages	+	?
➢ efficient control of heating/cooling through automation	+	+ (?)
➢ application/response to real-time pricing	starting	?
➢ selling back of heating/cooling loads into market	under consideration	

Thank You