Real-time pricing project at small customers in Finland, MAHIS

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MAHIS, spot market price based demand response, a research project in Finland

- Field trials of demand response to spot market price based real-time tariffs, 2004-2005 (probably extended till 2006).
- The purpose is to study and develop solutions that enable the use of load control potential in the electricity market.
- Partners:

Electricity retail: Turku Energy (spot price tariff)
Remote building management, building automation and data communication: Estera
Research: VTT Processes
Advisory partners: Fingrid (TSO)
Association of Finnish Energy Industries
Adato
Public funding: Tekes

Background, the status of demand response 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.)
- Large energy intensive industry reacts to the energy market price variations etc. with their own energy management systems.
- 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.

On DR and metering related electricity market rules in Finland

- Power distribution and transmission are unbundled from trade and generation. Billing metering is a part of the power distribution monopoly of the local DSO.
- Need to improve legislation and authority regulation regarding metering.
- The DSOs together develop their recommended practices for billing metering via the Association of Finnish Energy Industries (www.energia.fi)
- Every customer can buy electric energy from whom she/he wants.
- Customer segment load curves are applied, even for many customers that have hourly metering. After 27.12.2004 using customer load curve based balance settlement is not allowed for over 3x63A customers, if the load is measured for each hour. After 27.12.2004 customer segment load curves must be used for customers 3x63 A or less for balance settlement (, if electricity is bought from other than the local supplier). => New barrier for demand response of small customers. What are the consequences on this DR-project?

MAHIS, Field trials of spot market price based real-time tariffs

Test sites

- 5 electrically heated detached houses
- 5 electrically heated apartments in a row house
- bigger buildings connected in the district heating network, apartment buildings, services (consisting apartments for elderly people, elementary school, health centre)

Status

- Meters and building automation systems are installed and working, data is being collected
- The 10 small customers have chosen the spot price based energy tariff.
- Tuning the systems and development of models and response methods continues

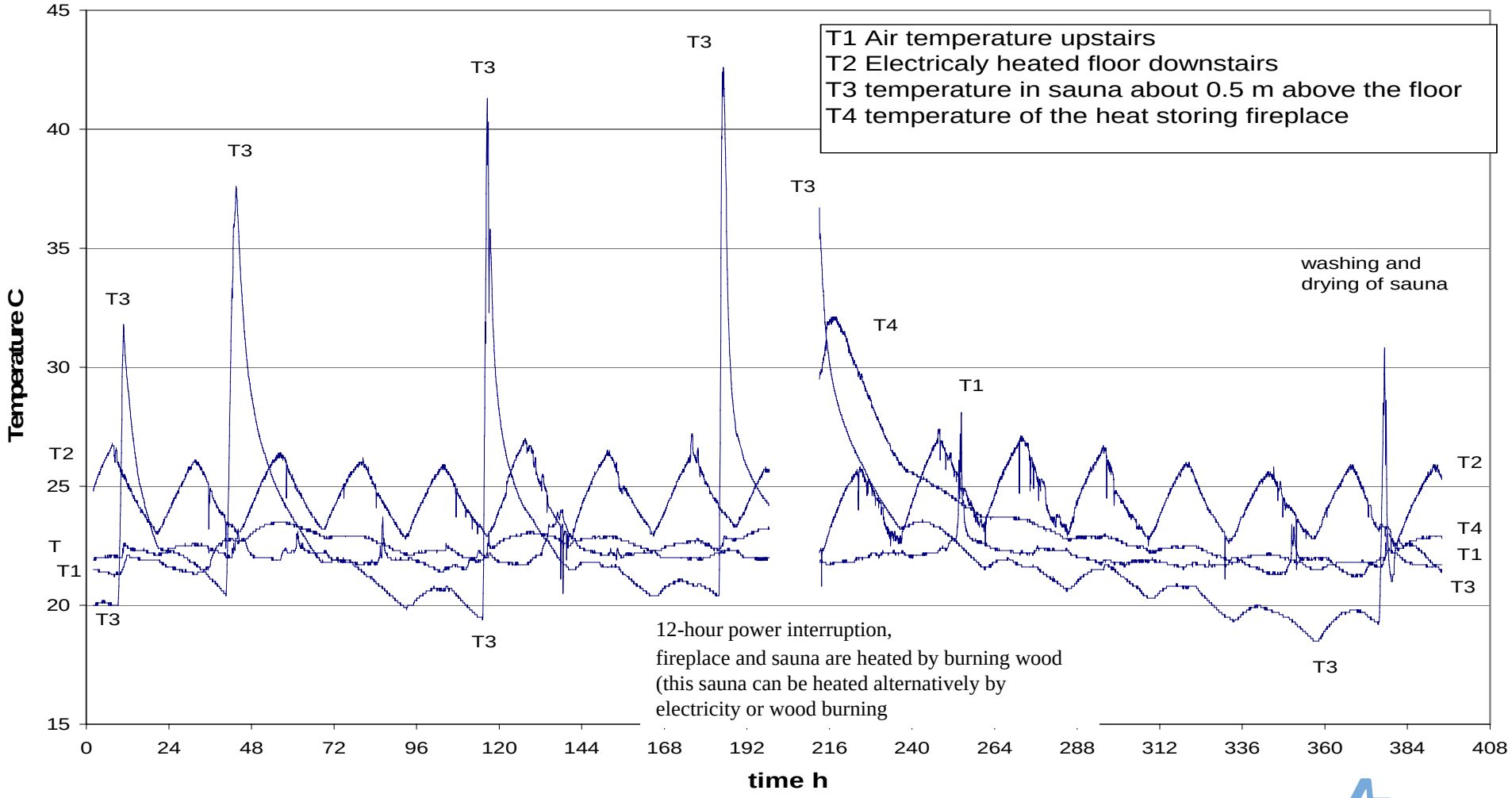
5 electrically heated detached houses

- Floor area 168 - 252 m2
- Both storing and direct electrical space heating
- Hot domestic water is heated by electricity
- Heat recovery from ventilation
- Heat storing fireplace (wood as fuel)
- Electrically heated sauna
- Cooking by electricity, dishwasher, washing machine, deep-freezer, fridge, PC with Internet access, TV….
- Distribution tariff is a two time tariff. It is much higher during working days than during nights, weekends etc.
- Building automation system in 4 houses. These houses were built in 2003.
- No automation, except clock controlled scheduling of heating in 1 house. In this house the project installed a remote monitoring system for recording temperatures and electricity consumption. In this house the sauna can also be heated by burning wood. This house was built in 1983.

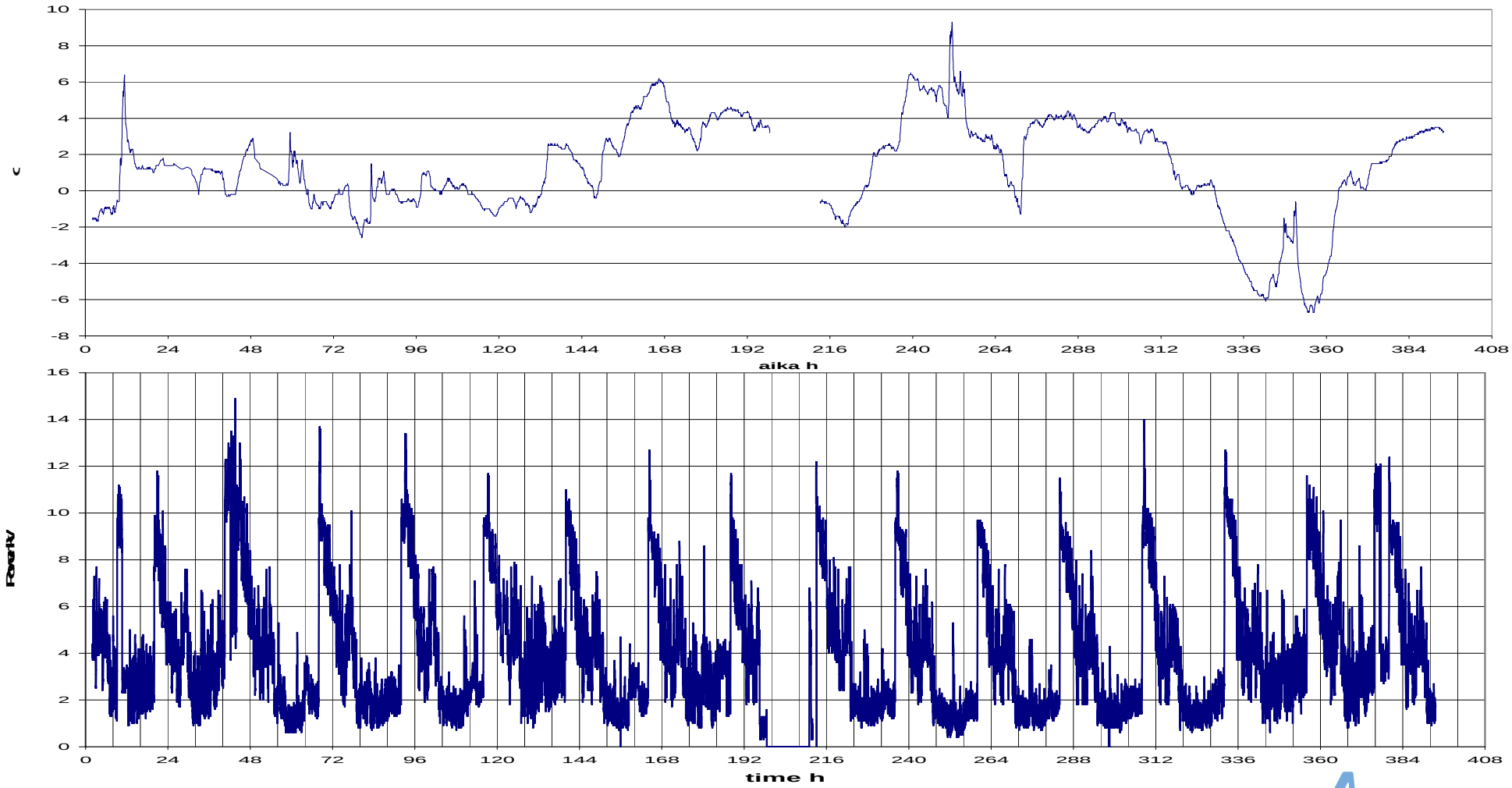
An electrically heated detached house test site

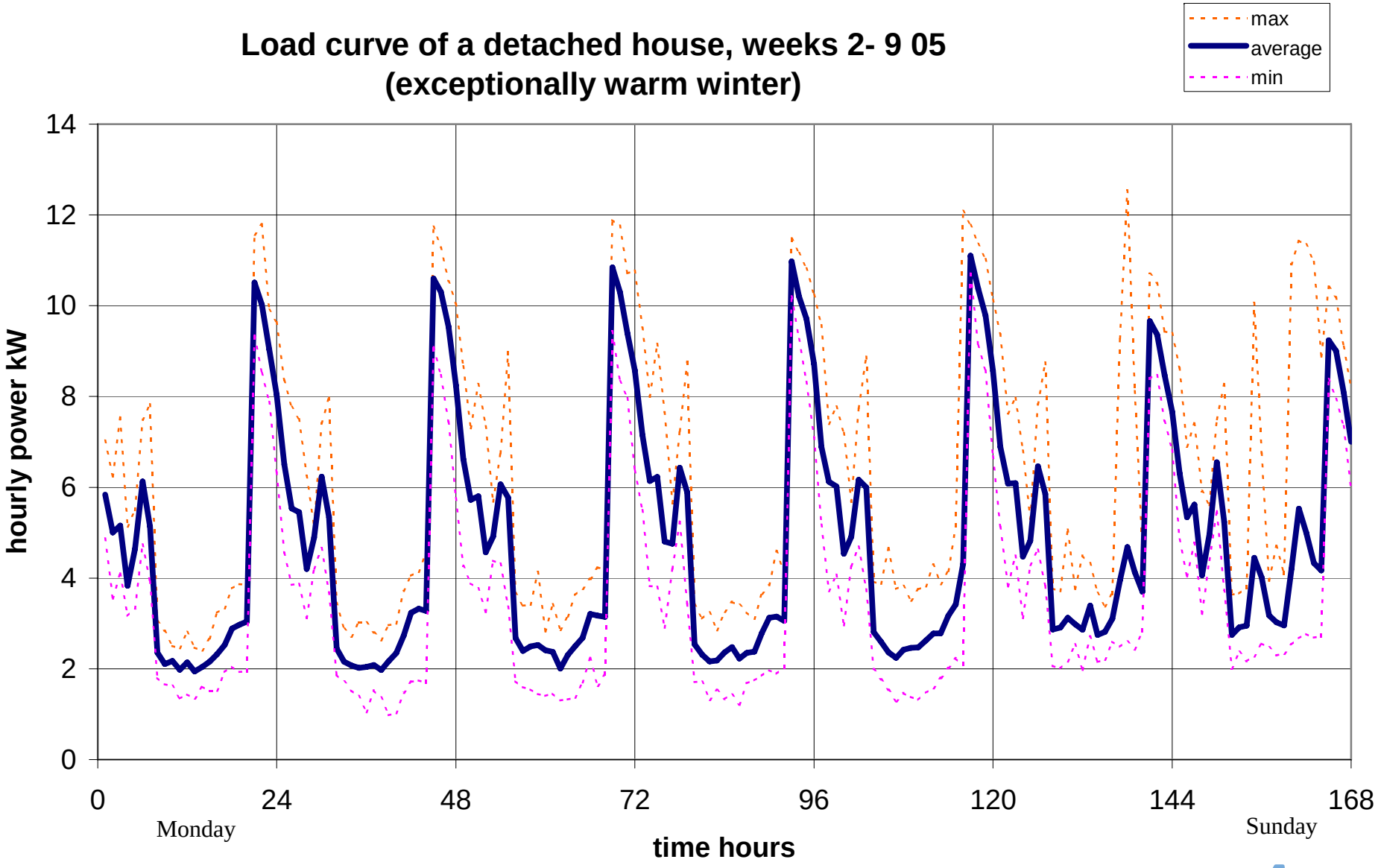
- 200 m^2 , about 500 m3
- 3x63 A (about max 40 kW) , total electricity bill in 2003 was about 1920 € (893 € energy and 1027 € for the distribution and transmission)
- built in 1983
- electrical heating (12.7 kW includes heating of massive downstairs floor (storage heating, 5.3 kW) and direct heating (7.4 kW)
- hot domestic water is electrically heated (300 l, 3.0 kW, temperature controllable 30 …. 90 ^{o}C.)
- both direct and storing heating, and domestic water heater are controlled by their own clocks
- backup heating is provided by a heat storing fireplace
- sauna has two heating methods: electrical stove and wood burning stove. Wood burning stove also gives heat to the building via the chimney structures.
- 2001 renewed ventilation system with heat exchanger between in and out air

Indoor temperatures are permanently measured in MAHIS test sites. Example: an electrically heated detached house



MAHIS, Outdoor temperature and electricity consumption (with interval 1-10 min) are also measured permanently on-line for each test site




Load curve of a detached house, weeks 2- 9 05
(exceptionally warm winter)
max
average
min
hourly power kW
0
2
4
6
8
10
12
14
0
24
48
72
96
120
144
168
Monday
Sunday
time hours

DR possibilities with the detached house without automation

- Work day versus night and weekend rhythm in heating is controlled by clocks.
- High price tomorrow => 1) Burn wood in the fireplace in the previous evening 2) use the wood burning sauna stove in the previous evening and/or during the high price hours 3) Do not use electrical sauna stove during peak price 4) Increase the temperature of the hot domestic water tank during the night 5) Set the clock to use reduced direct heating at the end of the peak price period (this may have the wrong effect, if temperature drops so low that storing heating turns on) 6) Switch completely off the storing heating during the high price peaks. 7) Avoid cooking, washing, dishwashing etc. during peak price.
- Temporary low price in the daytime => 1) Turn on storing heating and water heating for the low price periods.

The row house of 5 apartments

- Floor area120-155m^2, volume 300 - 400 m^3
- Each apartment buys electricity separately. Thus all are in the small customer category (3x63A or less)
- Each apartments has both storing and direct electrical space heating, own electrically heated hot water tank and a heat storing fireplace as a backup.
- Price response possibilities are similar to the detached houses
- Temperature and consumption measurements are being collected but they have not yet been properly analysed.

Bigger buildings

- Connected to the district heating network
- The buildings were selected based on analysis of electricity consumption measurements
- Some buildings were selected because the load depended on outdoor temperature (winter peak and summer peak). The reason for the winter peak is electrical floor heating in the washing rooms of the apartments and in the common saunas. This heating can be switched off from the building automation system.
- The cool storage operating cycles are long and there is potential to move the running periods even some hours.
- Ventilation power can be controlled from the automation system

Although these block houses are in district heating there is also electrical floor heating in the washing rooms,

(the floor heating can be turned off from the building automation system)

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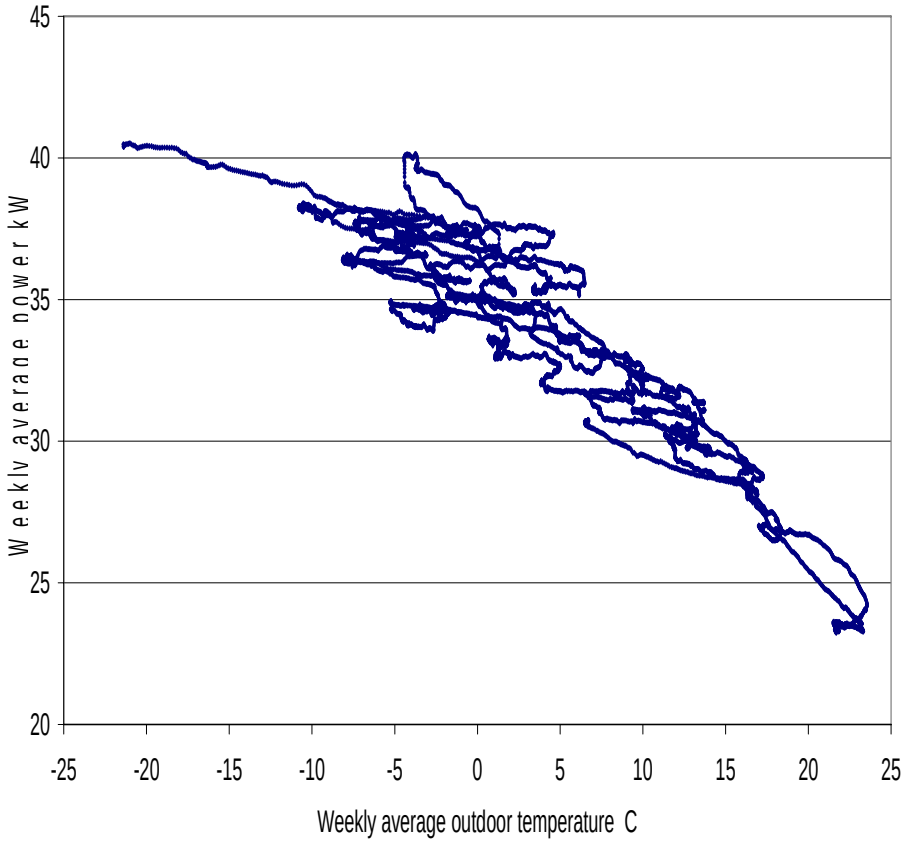

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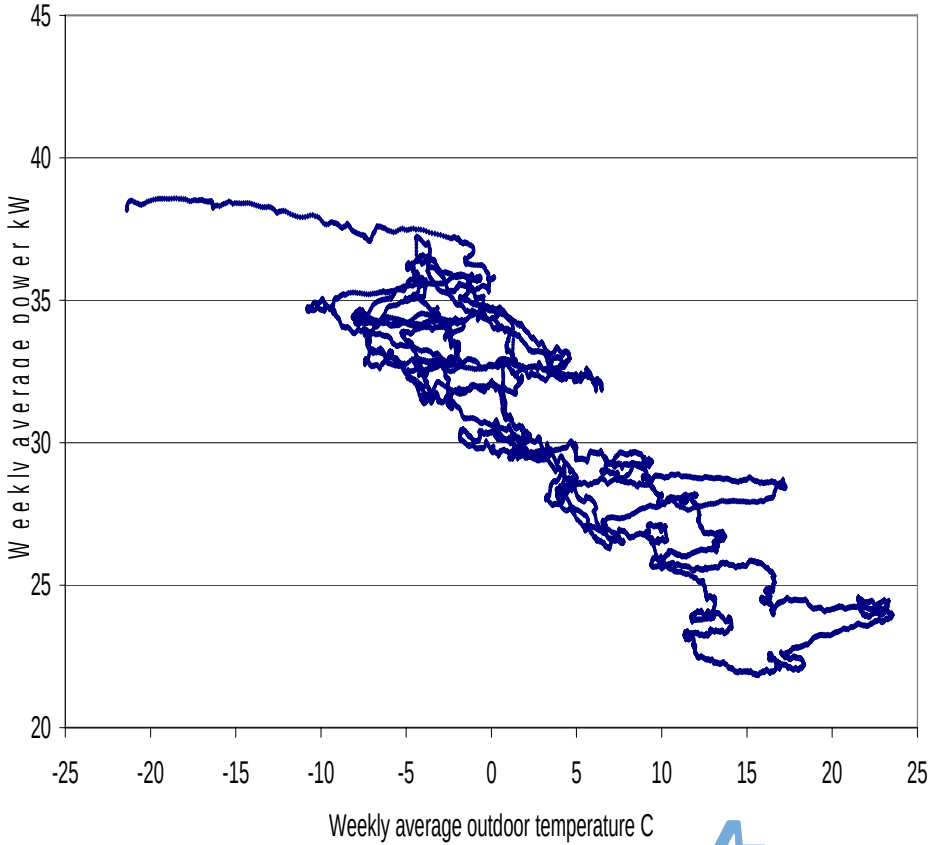
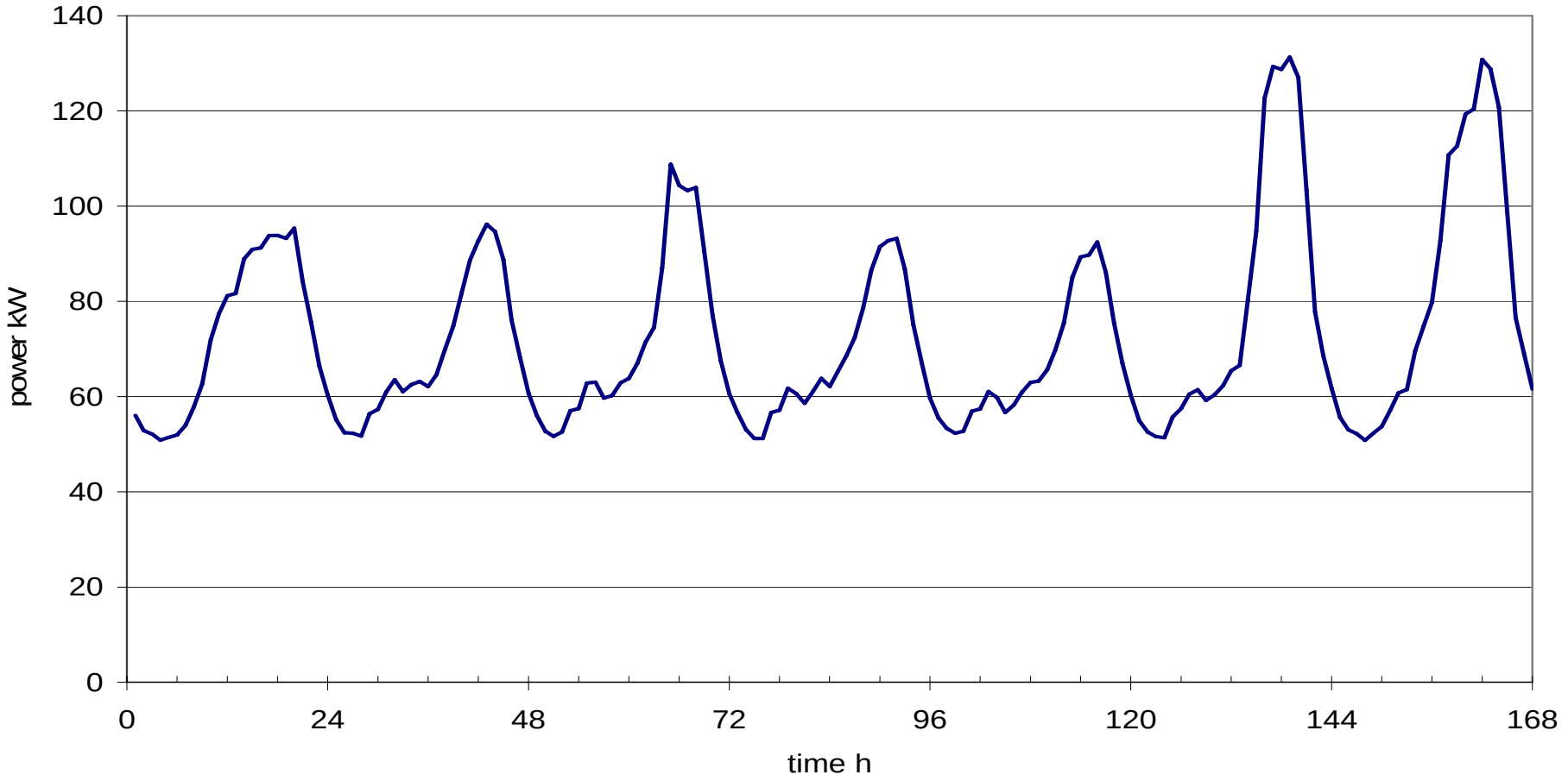
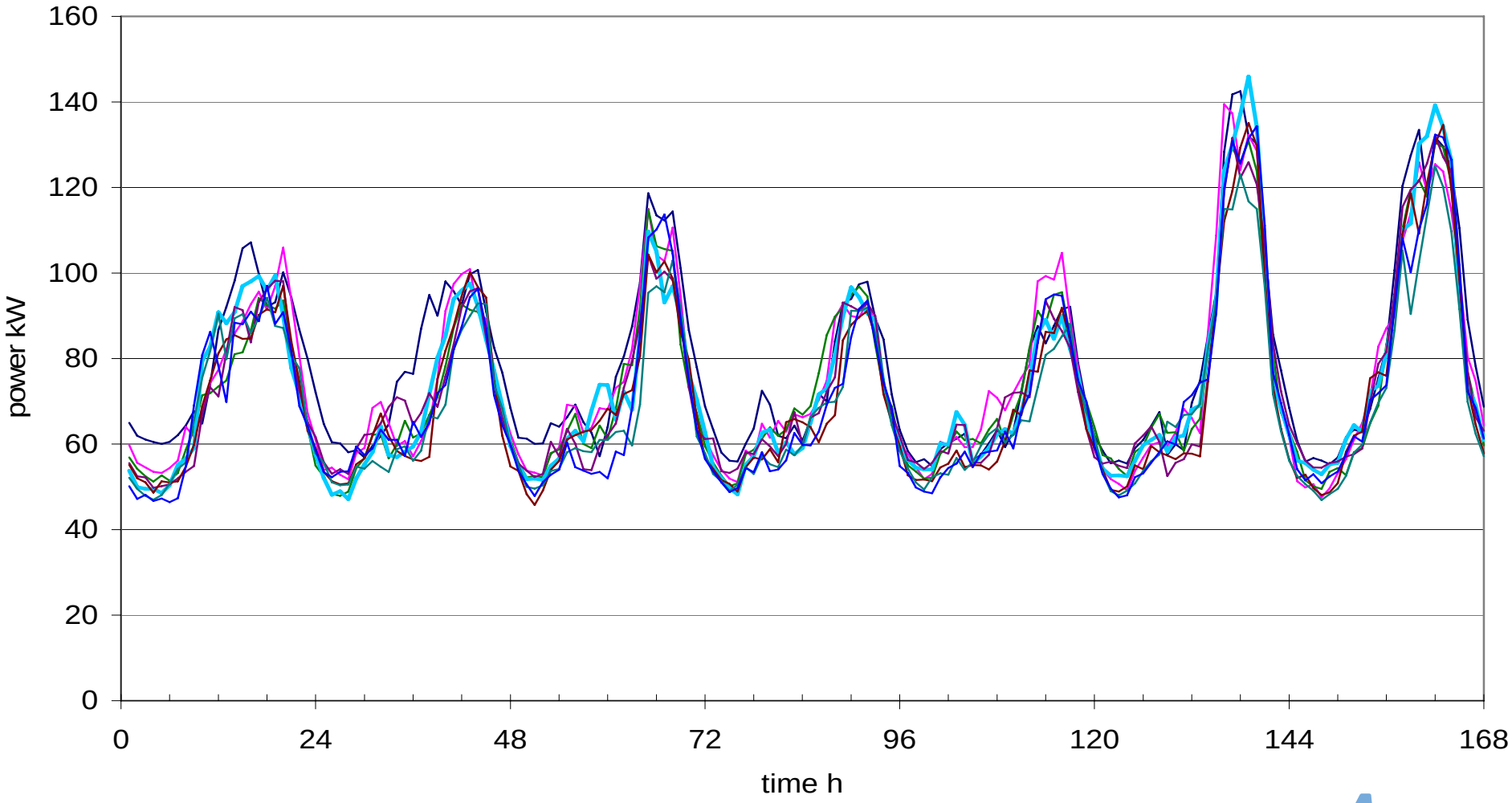


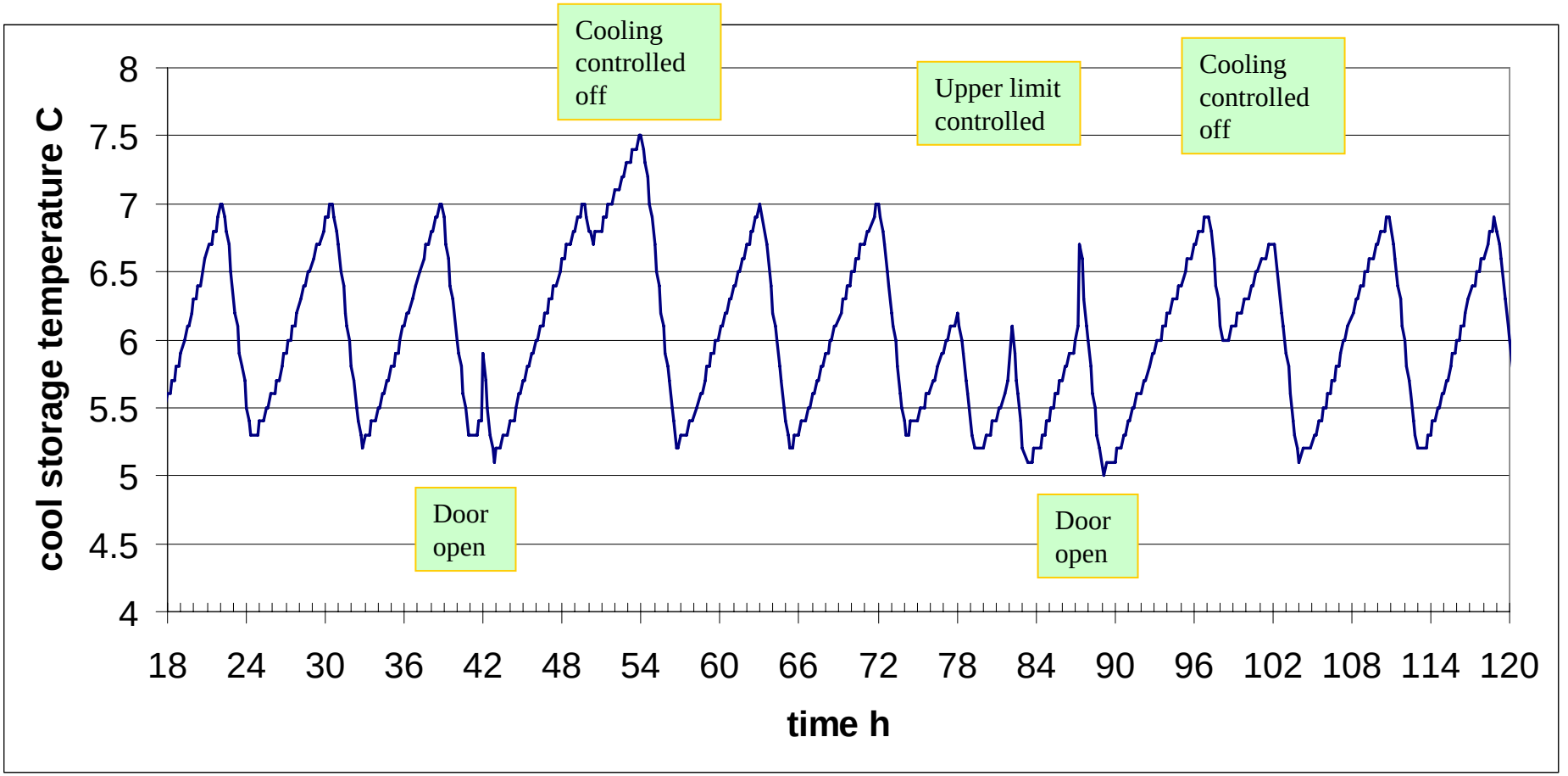
Load curve of the sum of the two block house sites, average of weeks 2-9, 2003



Variation in the load curve of the previous slide is small, weeks 2-9, 2003 are shown here



The control system can affect the timing of the running cycles of 3 cool storage rooms, here storage 2.



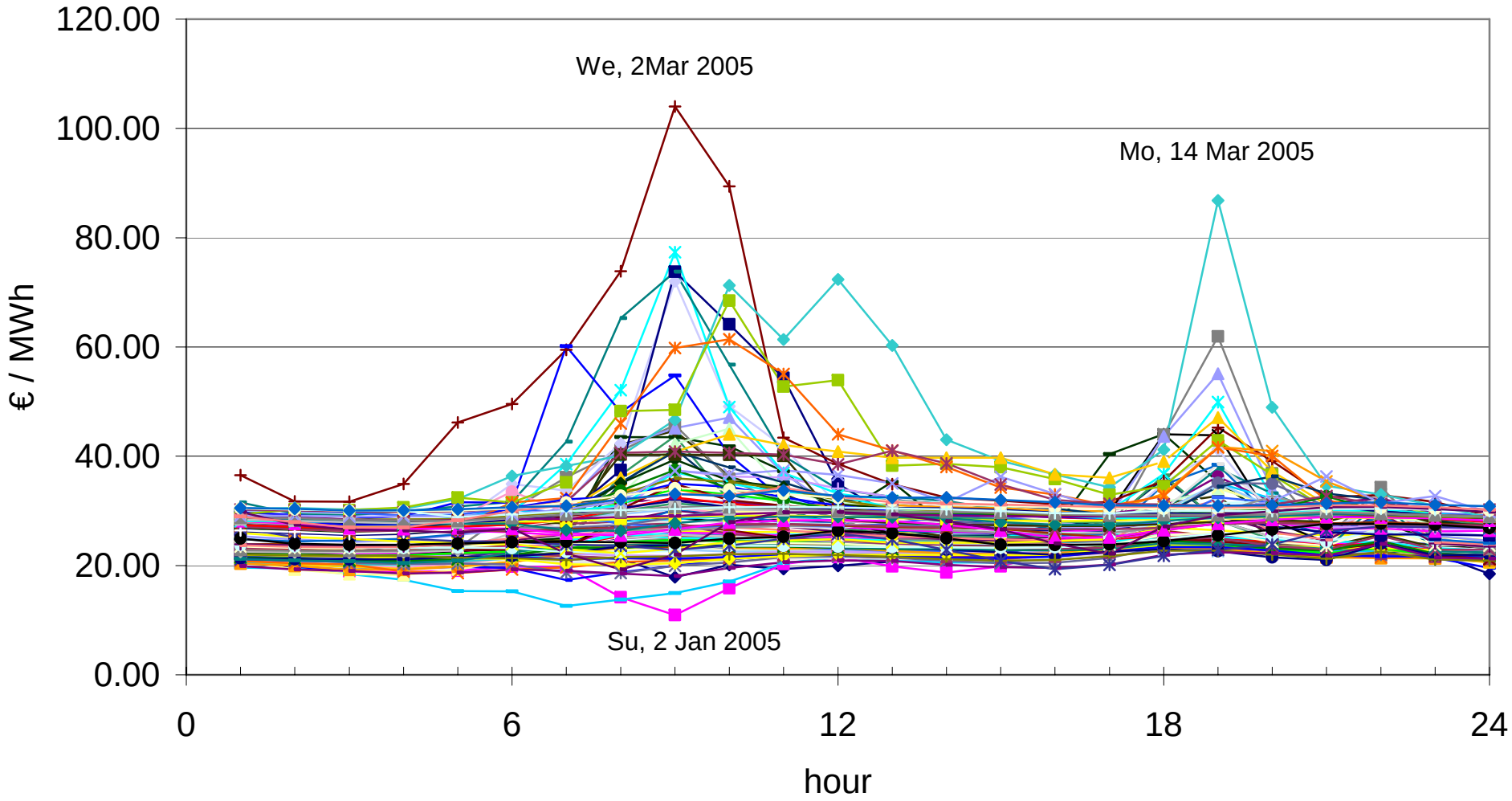
Readily available but unused load control possibilities were found in the block house sites

- These sites were chosen,because there is a suitable building automation system.
- It is possible to use existing control functions of floor heating, cool storage and ventilation for demand response purposes
- Some new measurements and control functionality is needed to exploit the full control potential of floor heating. Now the improvement would be too small to justify the costs.

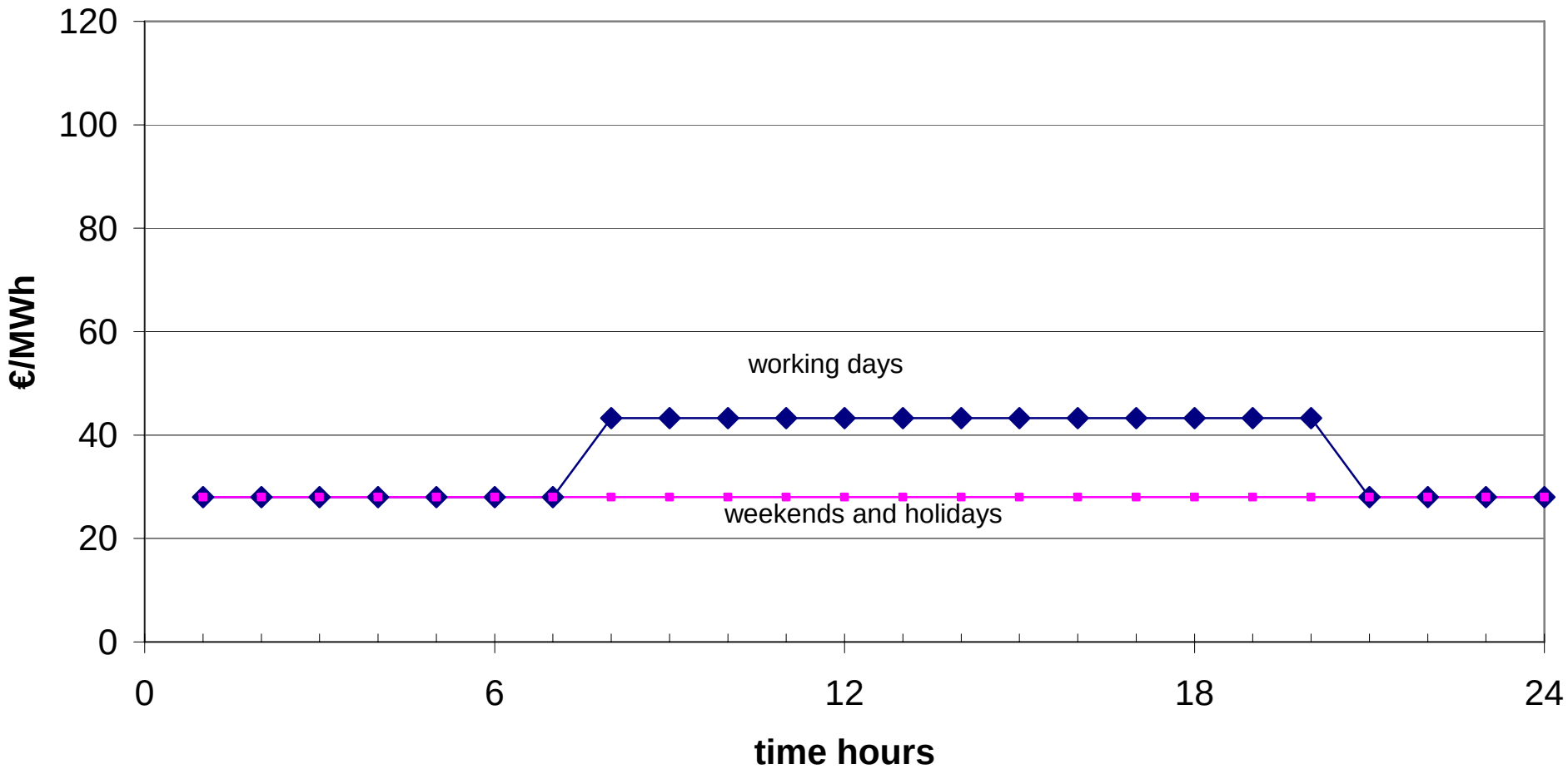
Discussion about small house and row house sites

- 3x63 A electrical heating customers are interesting targets for DR response actions, but the new Electricity Market Degree is a barrier
- under < 3x63A customers have less potential for DR because the needed investment is the same but the benefit potential significantly smaller
- the number of electrically heating customers with over 3x63A fuse is small.
- Adequate temperature measurements and their monitoring is inexpensive compared to the costs of hourly electricity billing measurements in Finland.

Spot price (Helsinki) 1.1.2005 - 19.4.2005



All small house sites have time dependent distribution tariff (why?), most of the time it varies more than the spot price



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Metering related problems and barriers identified so far

- Large differences between DSOs in terms of metering tariffs and technology in the practices of arranging hourly metering and local on-line metering for electricity consumption. DSO has the electricity billing metering monopoly in Finland, so there is no alternative. (=> Large scale DR business is impossible now)
- Since 27 December 2004 new electricity market legislation has required that customer segment load curves are used for billing small customers that are hourly measured. (=> No benefit any more for retailers from DR measures. The exception is the retailer who has most load in the area. Thus this retailer now has absolute monopoly for DR in Finland)
- Many billing & metering systems are too unreliable, inaccurate and inflexible to be applied for small customers. (=> implementing hourly price response to small customers is too expensive for small customers or any small DER, because of high electricity metering costs and other costs.)

MAHIS, Field trials of spot market price based real-time tariffs
Other problems and barriers identified so far

- Slow response of many floor temperature measurements due to lousy instrument installation practices in building automation. (=> response modelling needed)
- Low and stable energy prices especially this winter in the Nordic electricity market (=> 1) too small incentive to DR 2) spot-price tariff customers win)
- Two time distribution tariffs encourage to shift loads from work days, but may sometimes counteract with the spot-market price signal. The distribution tariff does not reflect the true distribution costs.

Real time monitoring helps energy management
The following problems we detected in the project and lead to corrective actions:

- Poor instrumentation and tuning caused energy losses and sifted some heating to high price hours.
- The storage heating was used in a way that sometimes turned the storing heating on during the most expensive evening hours, because the minimum floor temperature was reached then.
- In a cool storage of larger building the cooling was stopped during some night hours, which caused some load shift to daytime hours. Also potential to improve the timing of the cooling cycles was detected.
- Open doors and windows can be seen in the temperatures immediately

Conclusion

- Spot price based tariffs are available to all customers and customers have now got benefit from them even without demand response actions.
- There are significant barriers to the demand response of 3x63A customers in Finland: legislation requires the use of load curves instead of real load, poor metering and billing systems, system costs, low and stable prices.
- 3x63A customers have significant demand response potential that is not utilised
- Some unused demand response potential exists also in the apartment blocks. Much of this potential can easily be taken to use at those sites that have a good building automation system.