Start Point to Savings

- Better Load Demand Analysis in Commercial Buildings

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Focus on load demand

Energy demand [kWh] and load demand [kW]

Factors defining load demand:

- Customer type
- Building type
- Customer's end-use equipment
- Climate and season
- Behaviour

Knowledge on load demand:

- Low – both at the customer side and utility side
- Tradition - Big vs small users in focus
- Changing communication between utility and customer

Potential problems caused:

- Expensive peak power production
- Insufficient capacities
- Network "bottlenecks"
- Blackouts

Solutions:

- Supply side (Increased capacities)
- Demand side activities (Demand response, energy efficiency)

Case – IKEA buildings in Sweden

- 50 buildings/units, around 1.000.000 m^2 floor area.
- 13 department stores in operation (2004 -2006).

- Energy efficiency target (2006-2009) - use reduction by 15 % in all IKEA units in Sweden

- The first stage - in-depth energy surveys in all IKEA buildings carried out by E.ON.

- Load demand and demand response (DR) issues are interesting both for IKEA and E.ON but so far not reseached in detail.

Objective of this study

- To develop a detailed load demand analysis of selected IKEA department stores and to compare it to total load demand of IKEA stores in Sweden.

- To discuss DR possibilities and constraints at the stores (considering techno-economic and behavioural aspects).

Methods

Two IKEA stores - Stockholm and Malmö

- **Data collection and analysis**
- Hourly electricity use data from years 2004, 2005 and 2006 Jan-Aug.
- Outdoor temperature data.

- **Interviews**
- Facility managers at the selected stores
- Technical manager of buildings' owner IKEA Fastigheter (IKEA Properties)
- E.ON energy advice – consultants

Energy use in IKEA stores

	Stockholm	Malmö
Year of construction (extension)	1965 (1998-2001)	1970 (1998)
Area, m^2	55000	24515
Electricity use (2005), MWh	6944 (126,3 kWh/m^2)	3792 (154,7 kWh/m^2)
Subscribed electric load, kW	-	1150
District heating use (2005), MWh	3937	1445
District cooling use (2005), MWh	1364	-

Analysing load demand

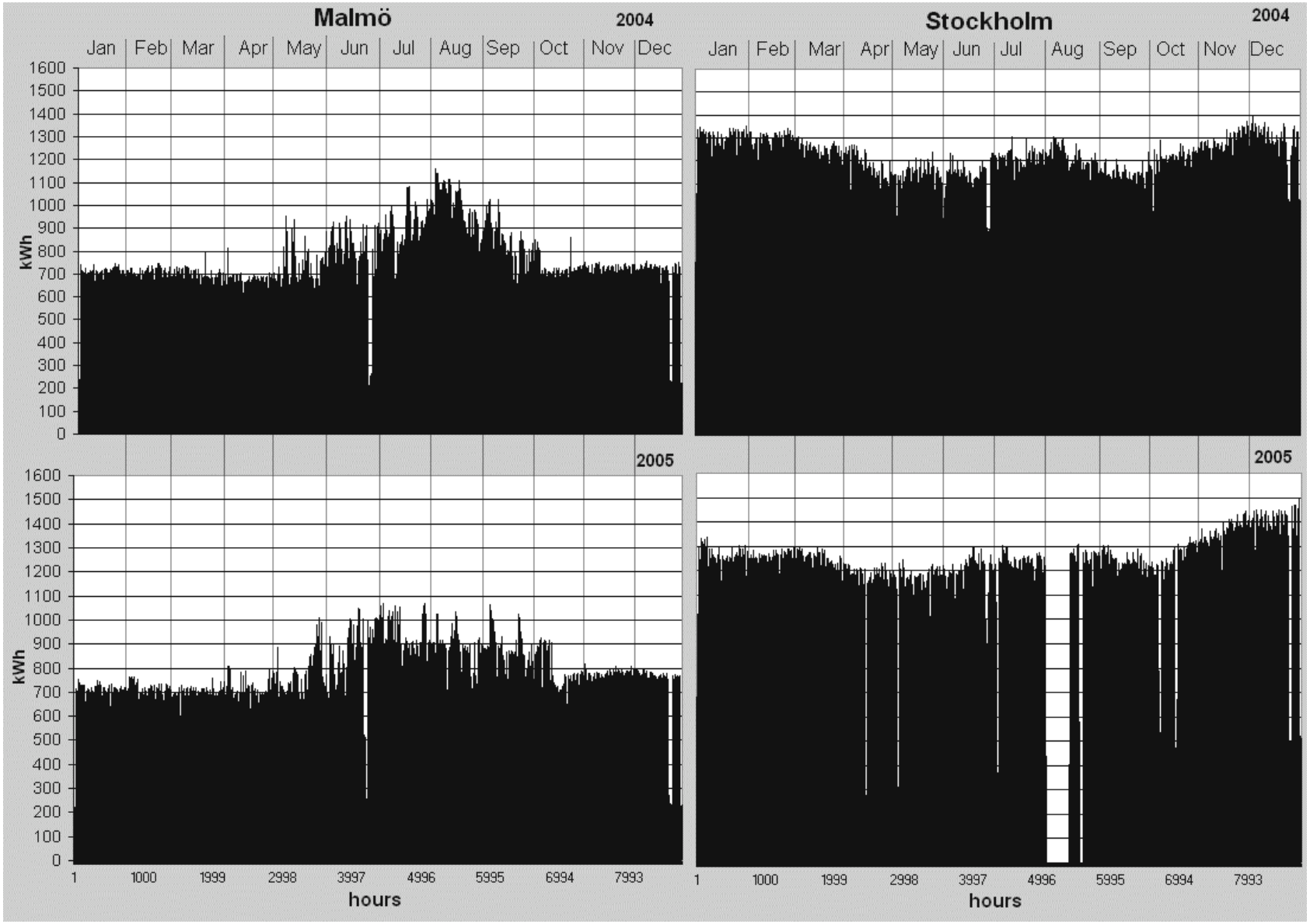
Characteristics

- Magnitude of energy use and load demand
- Variation of the demand in time
- Minimum and maximum demand values
- Duration of minimum and maximum load
- Contribution to total pattern/total load

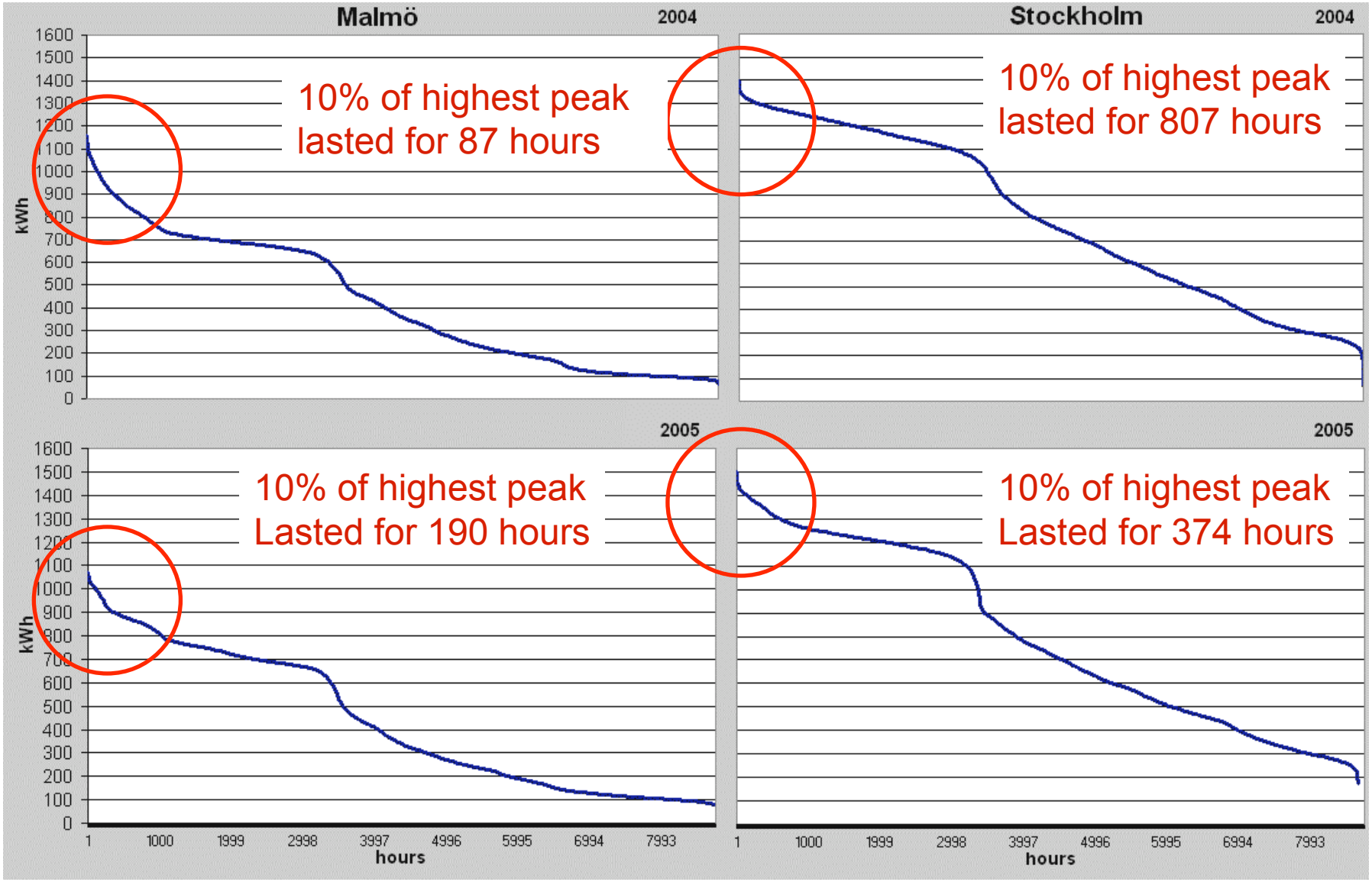
Tools and examples

- Load curve
- Duration curve
- Typical load curve
- Load factor
- Exploitation time
- Superposition factor

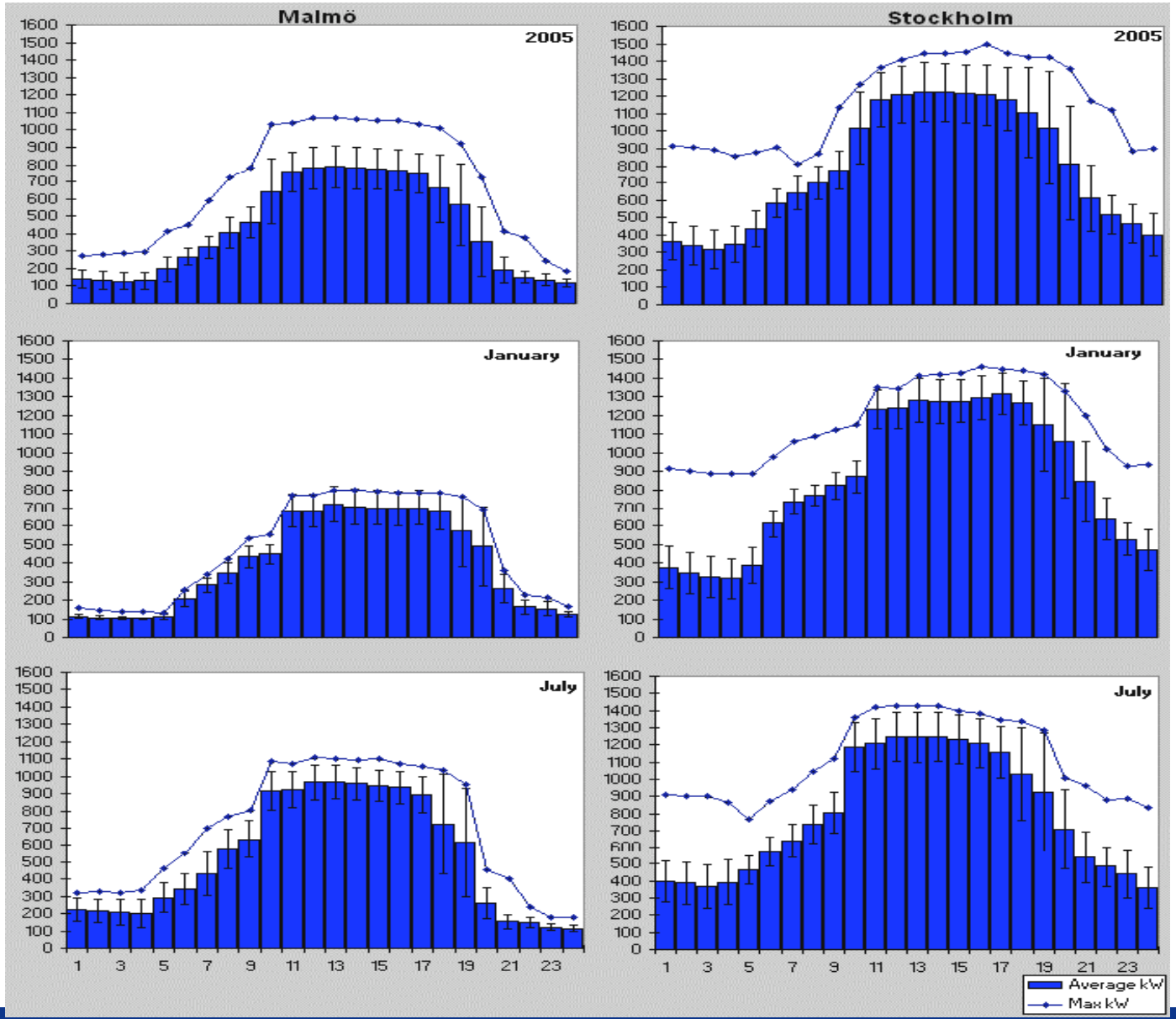
Load curve – illustrates variation of load demand during a specific period



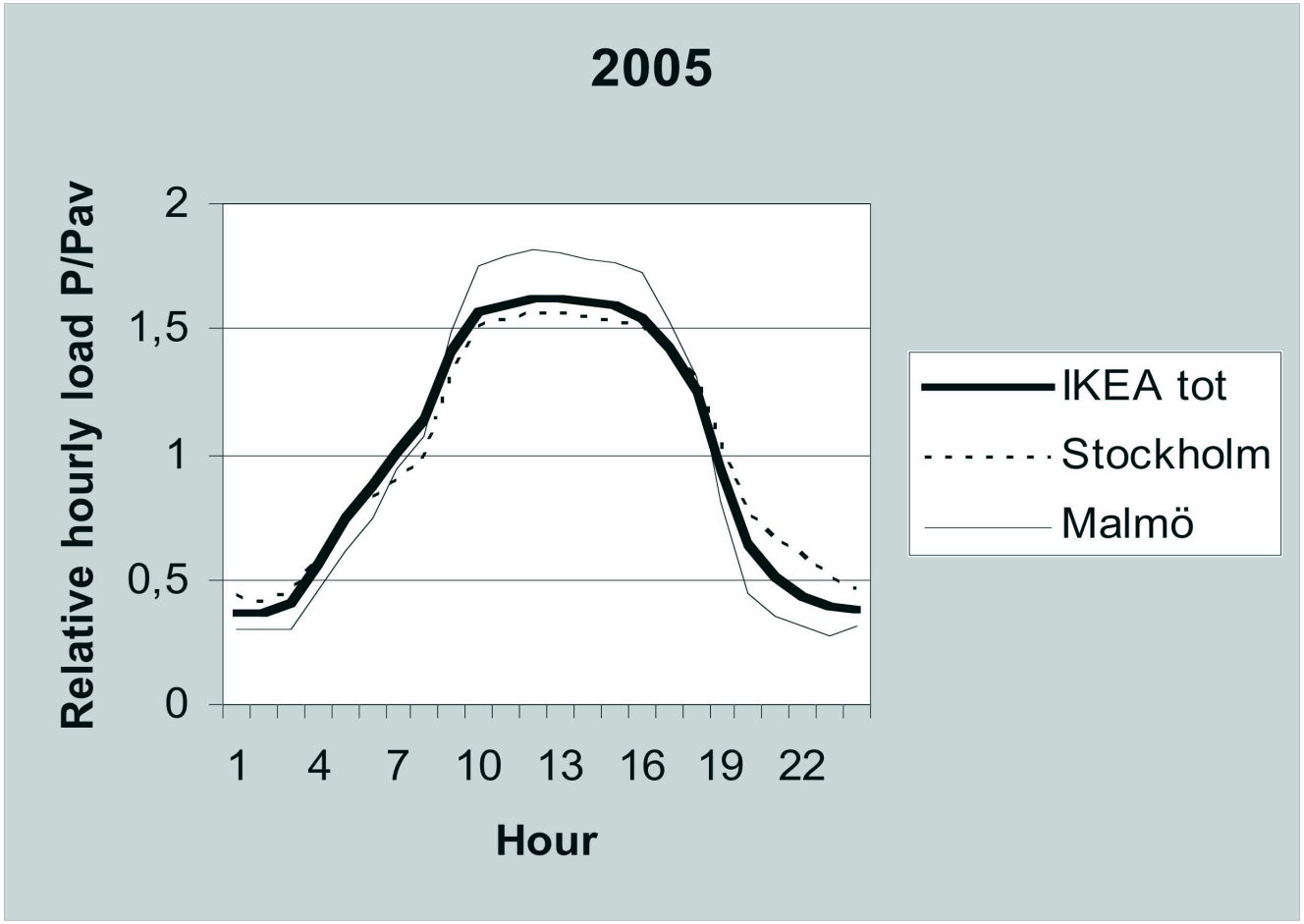
Duration curve - shows duration of a particular load demand



Typical daily load curve - defines daily load pattern within specified period



Dimensionless typical load curves



Relative hourly load curves (ratio of load demand and average annual load demand) for IKEA Sweden totally and the two investigated stores.

Load factor and exploitation time

- Load factor

$$\text{Load Factor} = \frac{Load_{average}}{Load_{\max}}$$

- Exploitation time

$$\text{Exploitation Time (h)} = \frac{\text{Electricity Consumption}}{Load_{\max}}$$

Load factor and exploitation time

Load demand characteristics at IKEA store in Malmö and Stockholm

	Malmö		Stockholm		All stores in Sweden	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**
Total use, kWh	3 733 894	3 792 064	6 993 538	6 944 000	42 858 443	46 045 769
Max load, kW	1159	1070	1392	1498	9836	10547
Min load, kW	68	75	134	176	1310	1251
Aver load, kW	425	433	796	787	4879	5256
Load factor	0,37	0,40	0,57	0,53	0,50	0,50
Exploitation time, h	3222	3544	5024	4636	4357	4366

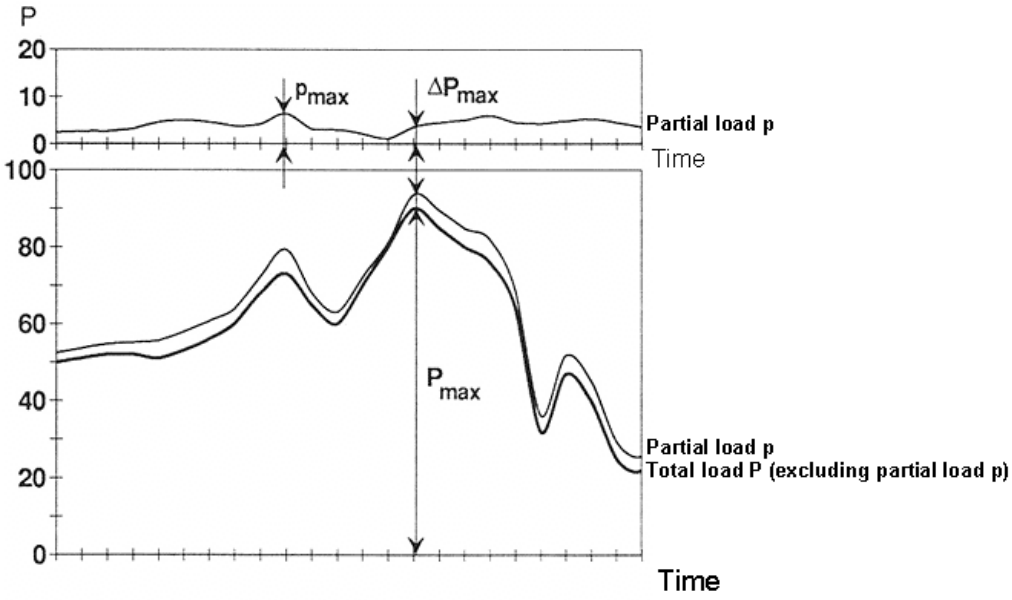
Superposition factor

$$SF = \Delta P_{max} / p_{max}$$

where:

ΔP_{max} = increase of total load peak value due to partial load p,

p_{max} = partial load maximum value

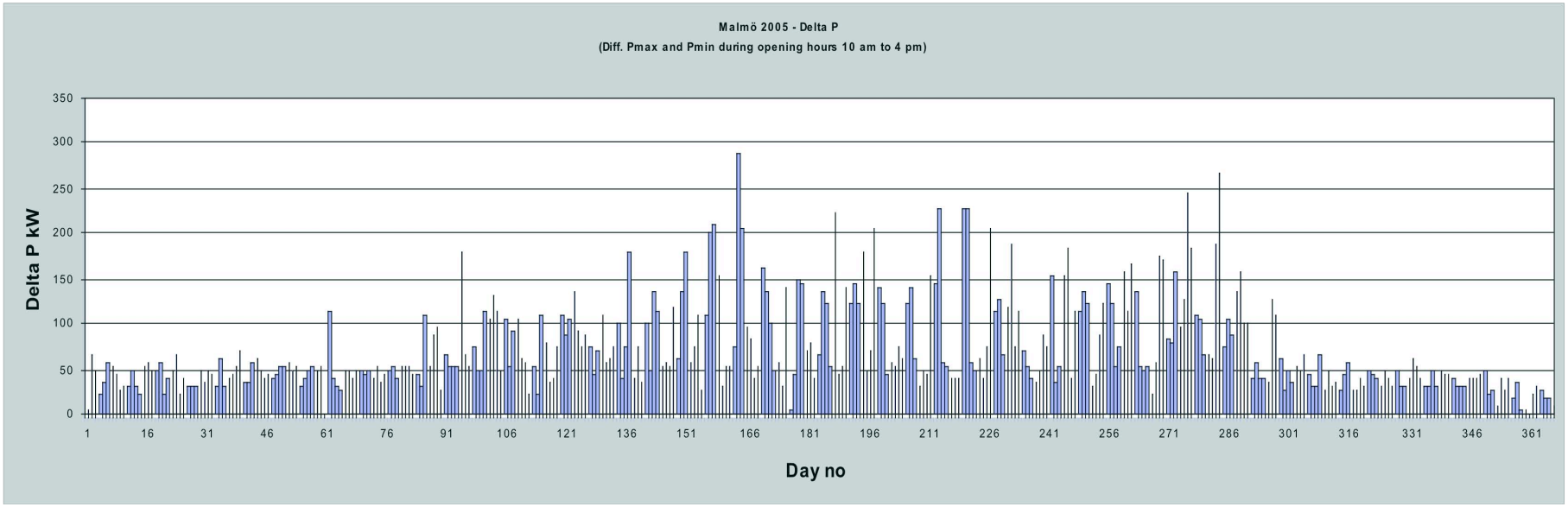


Superposition factor

Superposition factor during 3 highest peaks of all IKEA stores in Sweden 2006

	All stores	Stockholm					Malmö				
	P_{max}	ΔP_{max}	T_{out}	p_{max}	T_{out}	SF	ΔP_{max}	T_{out}	p_{max}	T_{out}	SF
	kWh/h	kWh/h	ºC	kWh/h	ºC		kWh/h	ºC	kWh/h	ºC	
2006-07-07 11:00	12444	1350	30,5	1350	30,5	1,00	1079	26,3	1079	26,3	1,00
2006-07-06 11:00	12281	1346	28,9	1346	28,9	1,00	1071	28,3	1071	28,3	1,00
2006-07-27 12:00	12272	1410	26,9	1410	26,9	1,00	1070	28,1	1070	28,1	1,00

Load pattern deviations



Difference between maximum and minimum hourly load demand during opening hours 10 am - 4 pm, Malmö 2005.

Energy savings and Demand Response possibilities in IKEA stores

Energy related decision making

- Store “steering committee” consisting of 6 members. The facility (technical) manager is not included (advices only).

- IKEA Properties (in Swedish “IKEA Fastigheter”) as an owner of the building. Energy control and automation systems belong to the IKEA properties.

Obstacles in decision making

- Interest "conflict" between the steering committee and the building owner IKEA Properties.
  - The store management staff is not motivated to make signifficant investments
  - IKEA Properties is not aimed at getting profit from IKEA sales; however, all the investments in buildings done by the owner have to be compensated by IKEA sales.
- Lengthy decision making process.
- "Conflict" between the interior staff (personnel responsible for exhibiting and sales) and facility manager.
- The facility managers' knowledge of load management and demand response measures is rather general and insufficient.

Proposed energy savings measures in the stores and possibilities for Demand Response

After energy auditing performed by E.ON, several technical electricity savings or efficiency measures were proposed for both stores (IKEA,2006):

- *Ventilation system:* installation of frequency converters and pressure controllers for ventilation fan motors; operation time control of ventilation fans
- *Heating system:* pressure controller and frequency converter for radiator pump; operation time control of circulation pump
- *Cooling system (Malmö case)*: cooling media pump exchange; pressure control and flow regulation.
- *Lighting system*: time control of lighting and occupancy sensors

All these efficiency measures have a potential to decrease load demand as well.

Constraints for participation in Demand Response programmes

- Interference with the main functions of the store,
- Attitude and behaviour of the employees (low motivation in savings, complaints, “cheating”)
- “Negative” experiences (load guards in Stockholm case)
- Slow decision making process
- Required investments in equipment
- Lack of time and resources

  The DR related work would probably be carried out by technical managers, sometimes even with the help of other employees.

Conclusions

Conclusions

- Load demand analysis gives detailed information about load patterns in department stores, can indicate possible technical problems, creates grounds for DR strategies' design
- Both stores are normally contributing to the total demand peaks of all IKEA stores in Sweden. In the Malmö case it is slightly more significant.
- Low economic motivation, "interest conflicts" lack of information from energy supplier are identified as the major constraints for Demand Response.
- Already planned energy efficiency improvements have the potential to increase demand responsiveness as well.
- Potentials for National (Swedish) system level.

Thank You!

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Electricity costs

- **Energy price:**
- The electricity price is fixed for all IKEA stores (no Time of Use or other type of rates). Electricity is purchased from the utility E.ON.
- **Grid tariffs:**

IKEA Stockholm is located in Vattenfall's grid area and the fees are following (Vattenfall, 2006):

Fixed fee	Variable fee
Monthly fee – 16 000 SEK/month [1680 EUR/month]	Monthly load fee – 10 SEK/kW, month [1,06 EUR/kW, month] (Highest recorded hourly load demand value during the charged month)
	Monthly load fee (High load demand period) – 27 SEK/kW, month [2,85 EUR/kW, month]
	Transmission fee – 2 öre/kWh [0,21 EUR cent/kWh]
	Transmission fee (high load demand period) – 5 öre/kWh [0,53 EUR cent/kWh]

IKEA Malmö is located in E.On's grid area with following grid fees (E.On, 2006):

Fixed fee	Variable fee
Yearly fee: 7000 SEK/year [739 EUR/year]	Transmission fee: 3,9 öre/kWh [0,41 EUR cent/kWh]
Subscription fee: 467 SEK/kW, year [49 EUR/kW, year]	Transmission fee (high load demand period): 6,5 öre/kWh [0,69 EUR cent/kWh]

High load demand period: November - March weekdays 06-22 h. Normal time: April – October all time and November - March weekdays 22-06h and weekends (holidays)

Example – potential savings of load reduction

Malmö case – reduction of **subscribed load level**

e.g. by 100 kW would save 428 EUR/month.

Stockholm case – **highest monthly load demand value (hourly)** reduction,

e.g. by 100kW would save 297EUR/month.

In both cases the savings from transmission costs could be achieved by decreasing the overall energy use or shifting part of the use to low load demand period (22-06 hour).