ADVANCED HVAC & NATURAL GAS TECHNOLOGIES

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

BUILDING MANAGEMENT SYSTEM IMPACT ON ENERGY EFFICIENCY

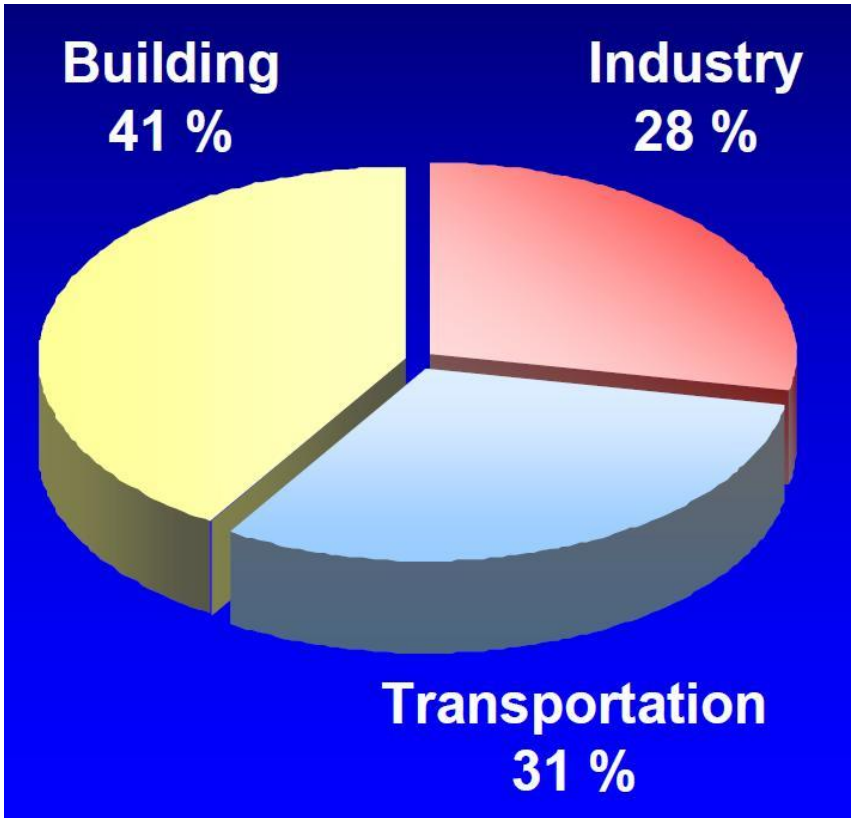
Andris Krūmiņš
Riga Technical University
Leader of BMS department in company Lafivents

MAIN TOPICS

- Main goals of building management system
- European standard EN 15232
- International standard DIN EN ISO 16484
- System integration / BACnet
- Case study

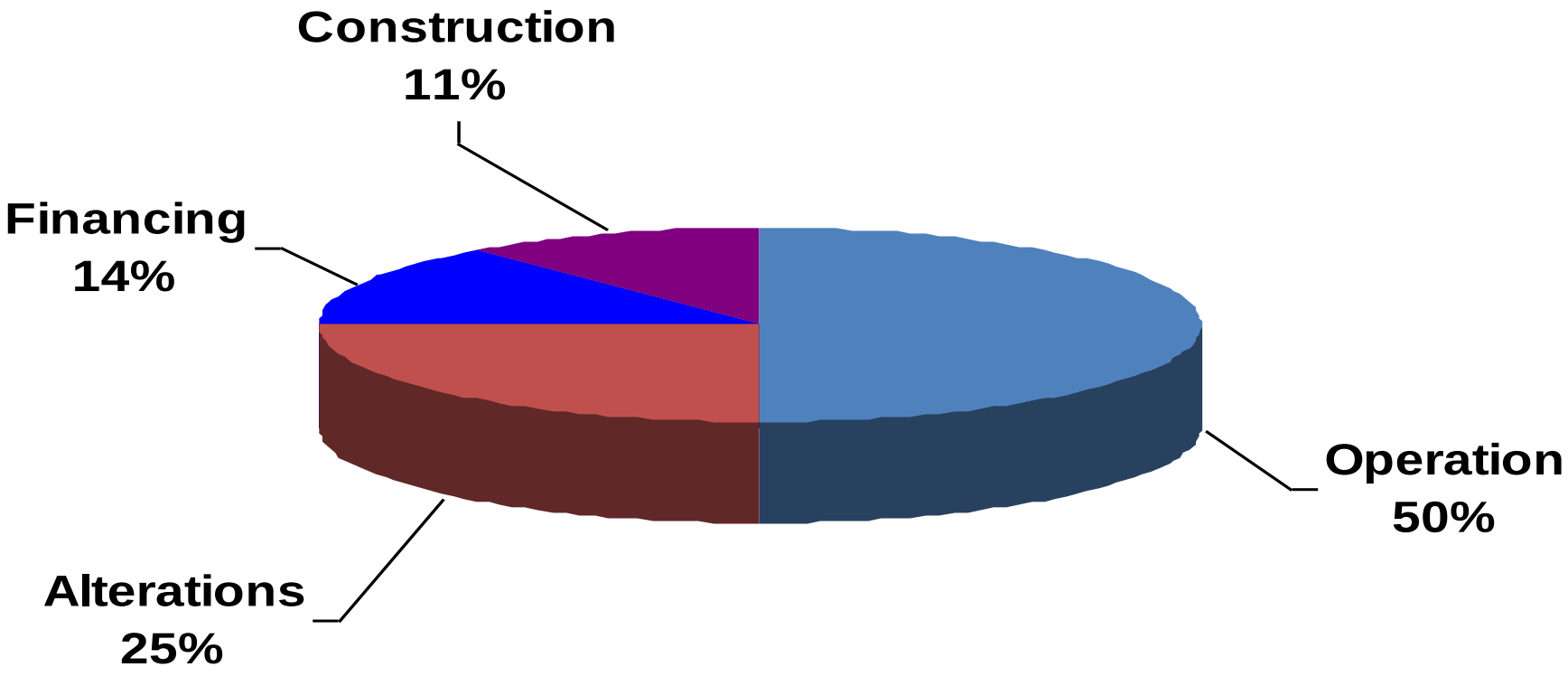
More than **40%** percent of primary energy are consumed **in buildings**.

Significant part of that are consumed by **HVAC** systems.



Olli Seppanen Riga 15.10.2009.

TYPICAL BUILDING COST OVER A 40 YEAR LIFE CYCLE



SUSTAINABLE DESIGN AND OPERATION OF BUILDINGS

building envelope
building physics, facade systems

building systems
heating, cooling, ventilation, lighting

optimized operation of buildings
considering the user comfort, user interface and energy efficiency by advanced building automation and management systems

WITHOUT BUILDING AUTOMATION

1. it is too warm/cold
2. there is no air from the outlet
3. no one can operate the systems
4. no one knows why something does not work
5. unnecessarily wasted energy
6. money automatically flies out the window ...
7. complicated service of HVAC systems

without building automation is like driving a car without a speedometer!

- Not knowing is not an excuse .....

BUILDING AUTOMATION SYSTEM GOALS

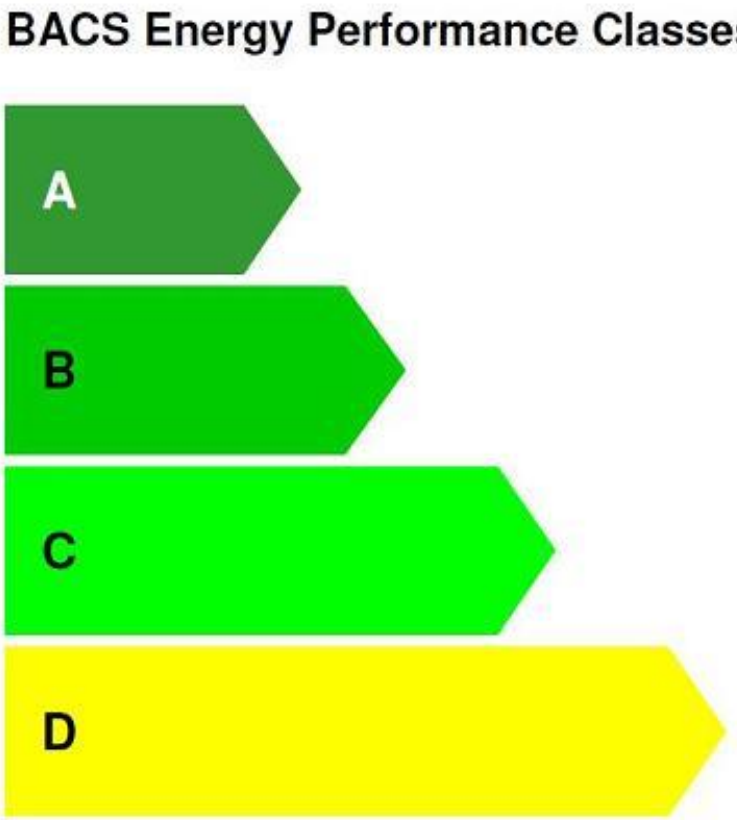
- Realistic
- Durable
- Efficient
- User – friendly
- Flexible
- Affordable
- Reliable
- Secure
- Open
- Powerful

EUROPEAN STANDART EN15232

Establishes the conventions and methods used to **estimate the effect** of control automation systems and BMS on a building's energy needs and performance

- a structured listing of the control automation and BMS **functions** which impact a building's energy performance;
- a method for **defining the minimum specifications** applicable to buildings of varying complexity with regard to automation control and BMS functions;
- a way of **estimating energy-saving factors** which can be used in conjunction with a building's energy evaluation

EUROPEAN STANDART EN15232



BACS – Building Automation and Controls System
TBM – Technical Building Management System

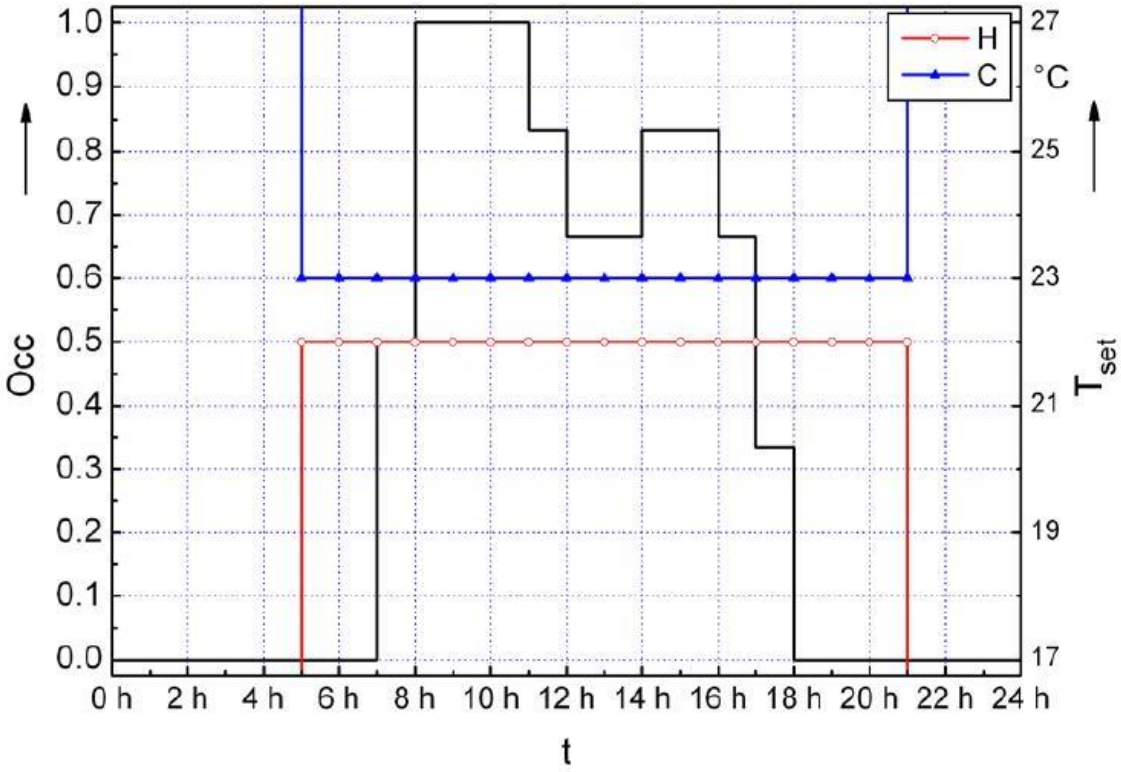
Class A:
High energy performance BACS and TBM

Class B:
Advanced BACS and TBM

Class C:
Standart BACS (is normally the reference)

Class D:
Non energy efficient BACS

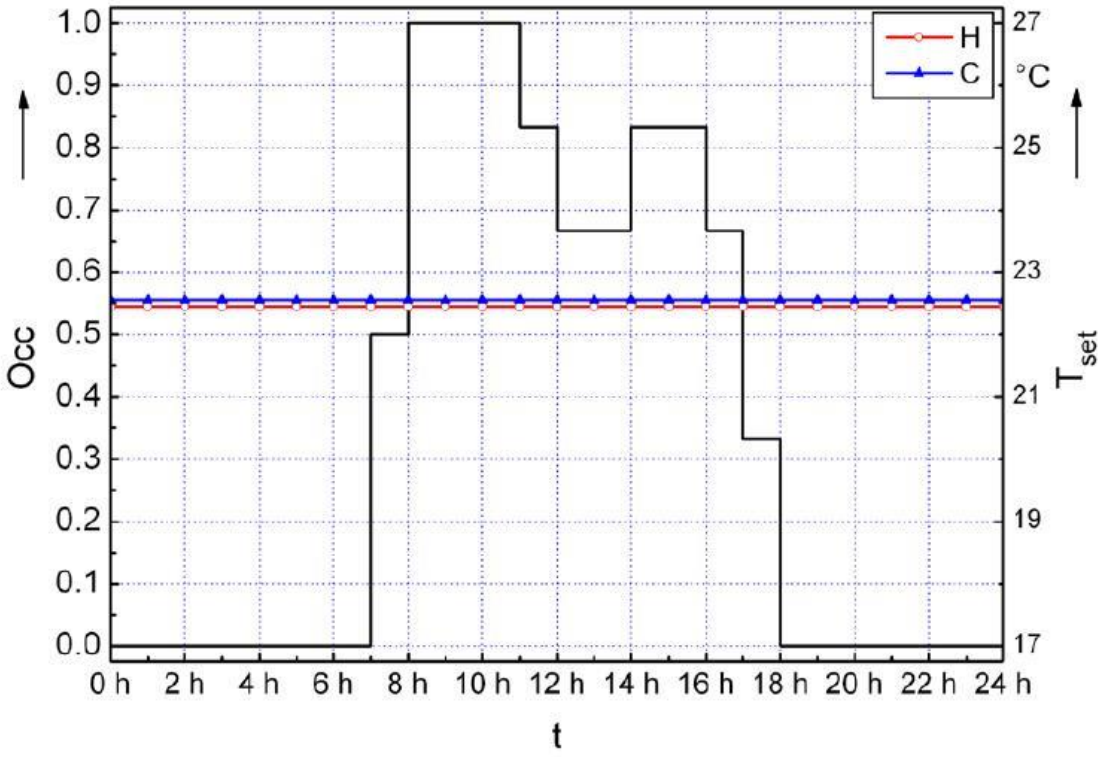
EFFICIENCY CLASS C (reference)



Key

Occ = standardised level of occupancy t = time T_{set} = temperature set point

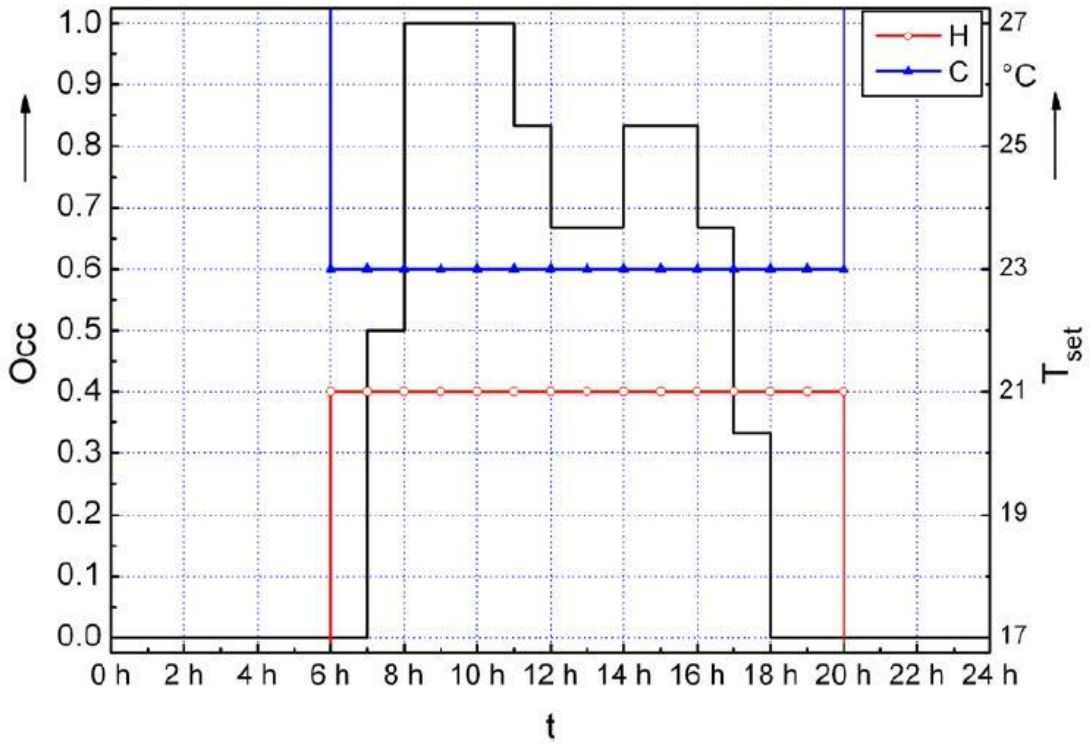
EFFICIENCY CLASS D



Key

Occ = level of occupancy t = time T_{set} = temperature set point

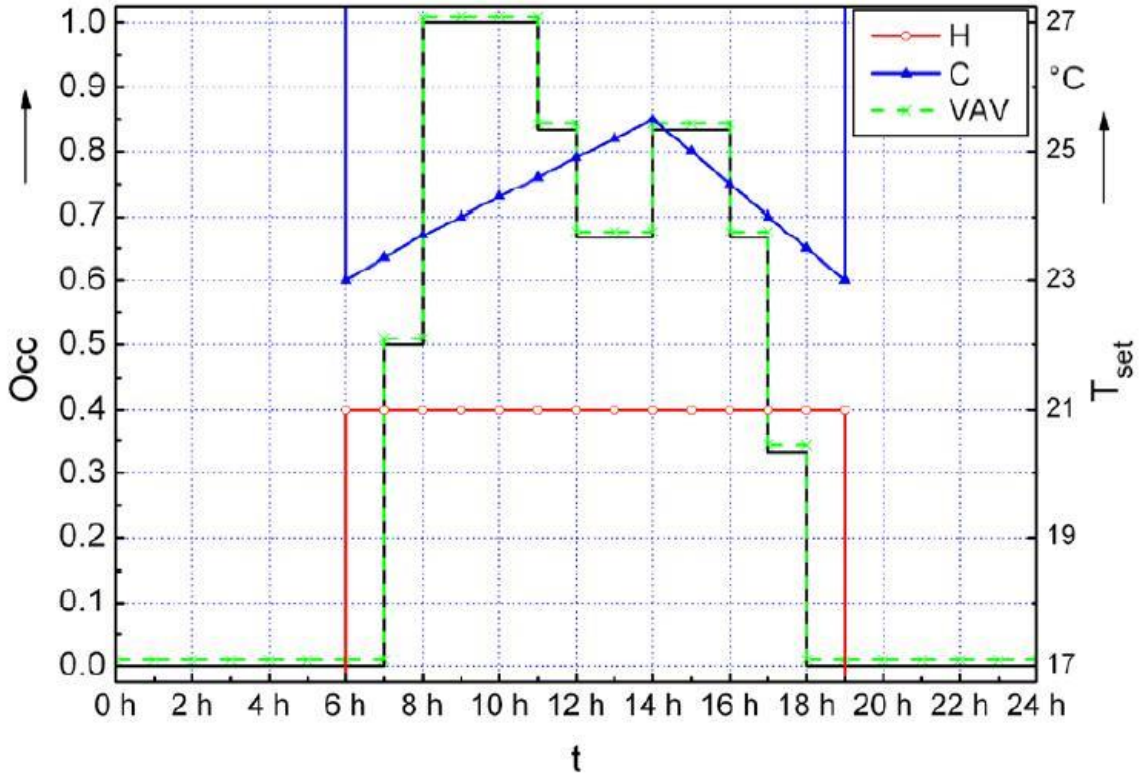
EFFICIENCY CLASS B



Key

Occ = level of occupancy t = time T_{set} = temperature set point

EFFICIENCY CLASS A

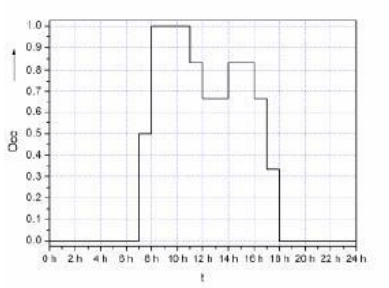


Key

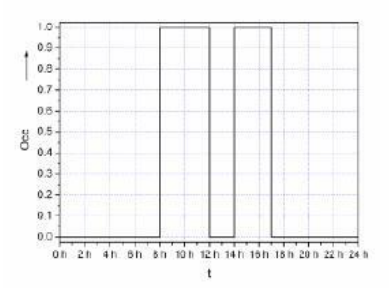
Occ = level of occupancy t = time T_{set} = temperature set point

USER PROFILE

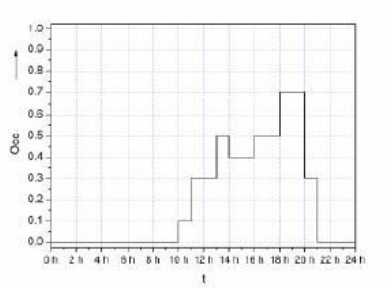
Office



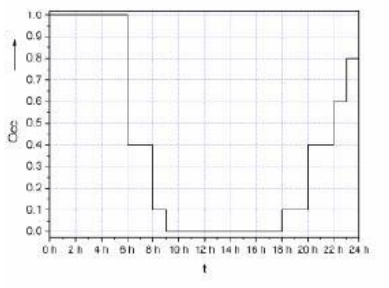
School



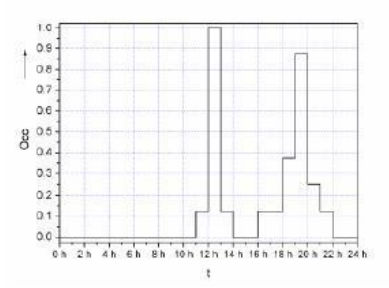
Wholesale centre



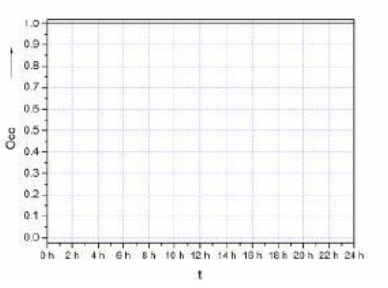
Hotel



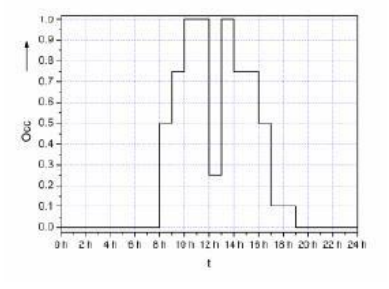
Restaurant



Hospital



Lecture hall



User profiles as defined by EN 15217

FUNCTION LIST AND ASSIGNMENT TO BACS EFFICIENCY CLASSES

- Heating control, Domestic hot water supply control;
- Cooling control;
- Ventilation and air conditioning control;
- Lighting control;
- Blind control;
- Technical home and building management.

EXAMPLE

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
4	VENTILATION AND AIR CONDITIONING CONTROL									
4.1	Air flow control at the room level									
	0	No automatic control	■				■			
	1	Time control	■	■	■		■	■		
	2	Presence control	■	■	■	■	■	■	■	
	3	Demand control	■	■	■	■	■	■	■	■
4.2	Air flow or pressure control at the air handler level									
	0	No automatic control	■				■			
	1	On off time control	■	■			■	■		
	2	Multi-stage control	■	■	■		■	■	■	
	3	Automatic flow or pressure control	■	■	■	■	■	■	■	■

EN 15232 / DIN V 18599-11 ENERGY CONSUMPTION SAVINGS

Non-residential building types	Overall BACS efficiency factors $f_{BACS,th}$			
	D	C (Reference)	B	A
	Non energy efficient	Standard	Advanced	High energy performance
Offices	1,51	1	0,80	0,70
Lecture hall	1,24	1	0,75	0,5 [a]
Education buildings (schools)	1,20	1	0,88	0,80
Hospitals	1,31	1	0,91	0,86
Hotels	1,31	1	0,85	0,68
Restaurants	1,23	1	0,77	0,68
Wholesale and retail trade service buildings	1,56	1	0,73	0,6 [a]
Other types: - sport facilities - storage - industrial buildings - etc.		1		

[a] These values highly depend on heating / cooling demand for ventilation.

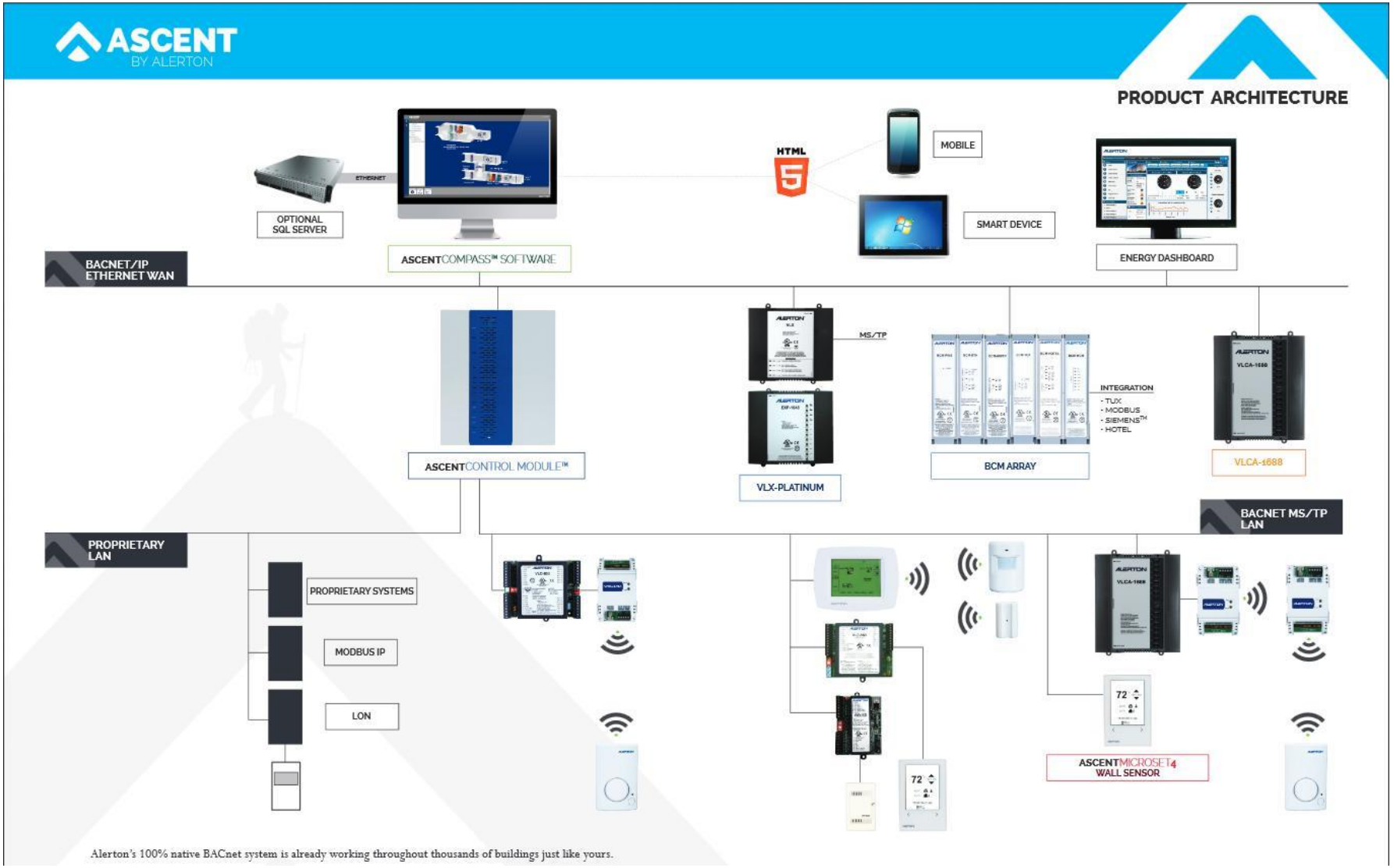
"STANDARDIZED" SAVINGS WITH HVAC BUILDING AUTOMATION

Values of DIN EN 15232 - demonstrated by building simulation.

The savings using light control is not included in DIN EN 15232.

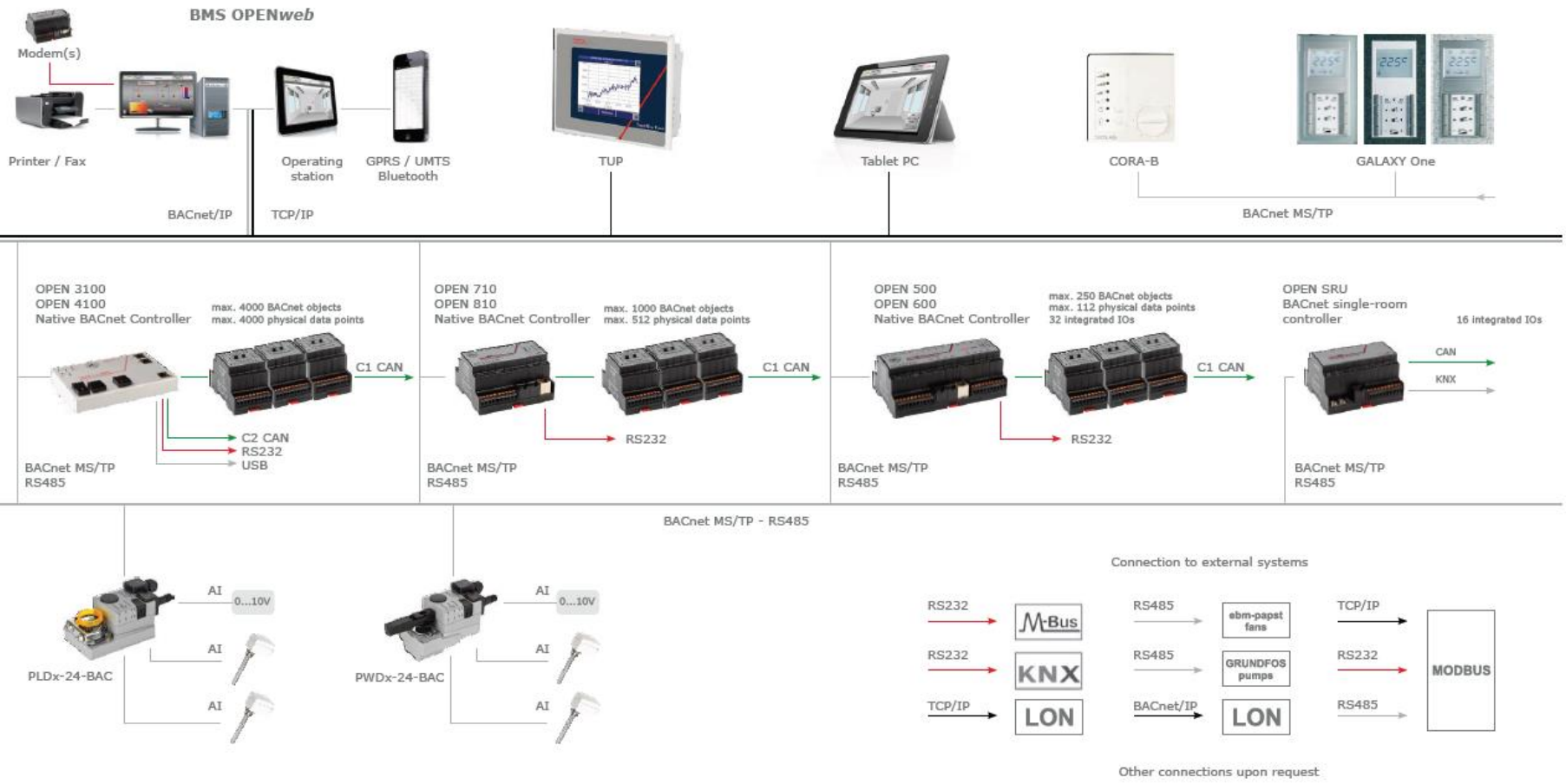
VDMA / EN 15232

BUILDING AUTOMATION TOPOLOGY / ALERTON

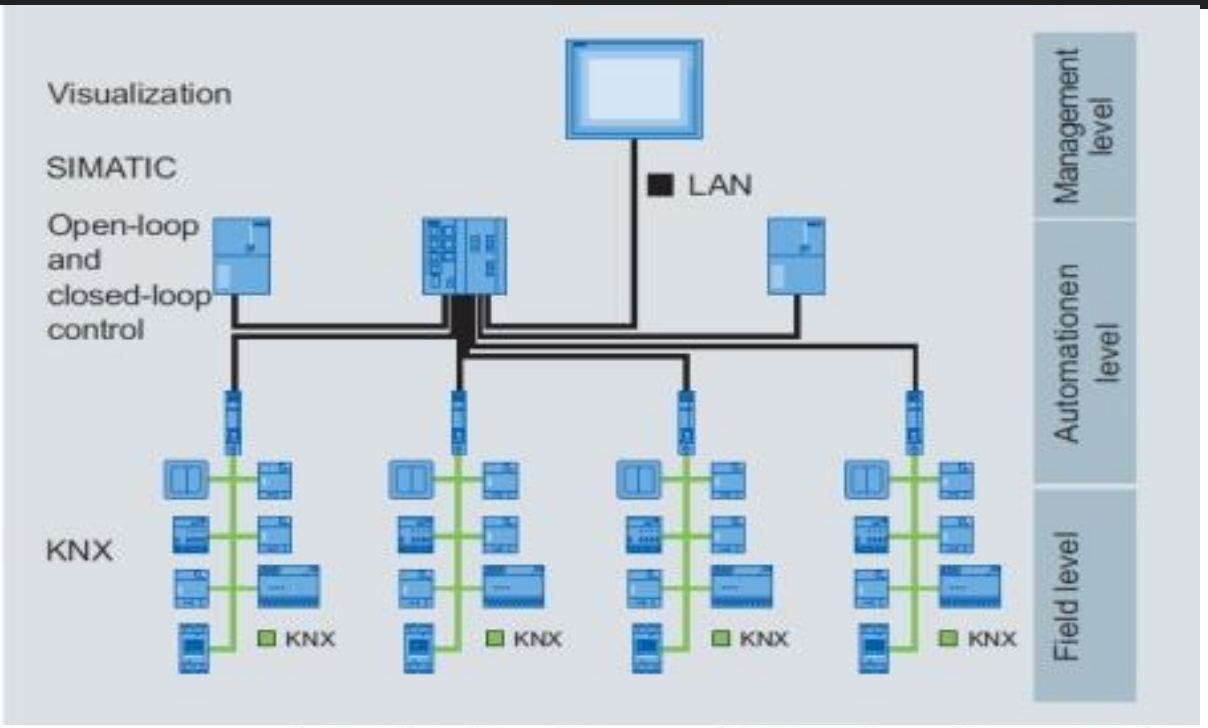


BUILDING AUTOMATION TOPOLOGY / DEOS

SYSTEM TOPOLOGY



BUILDING AUTOMATION TOPOLOGY
KNX

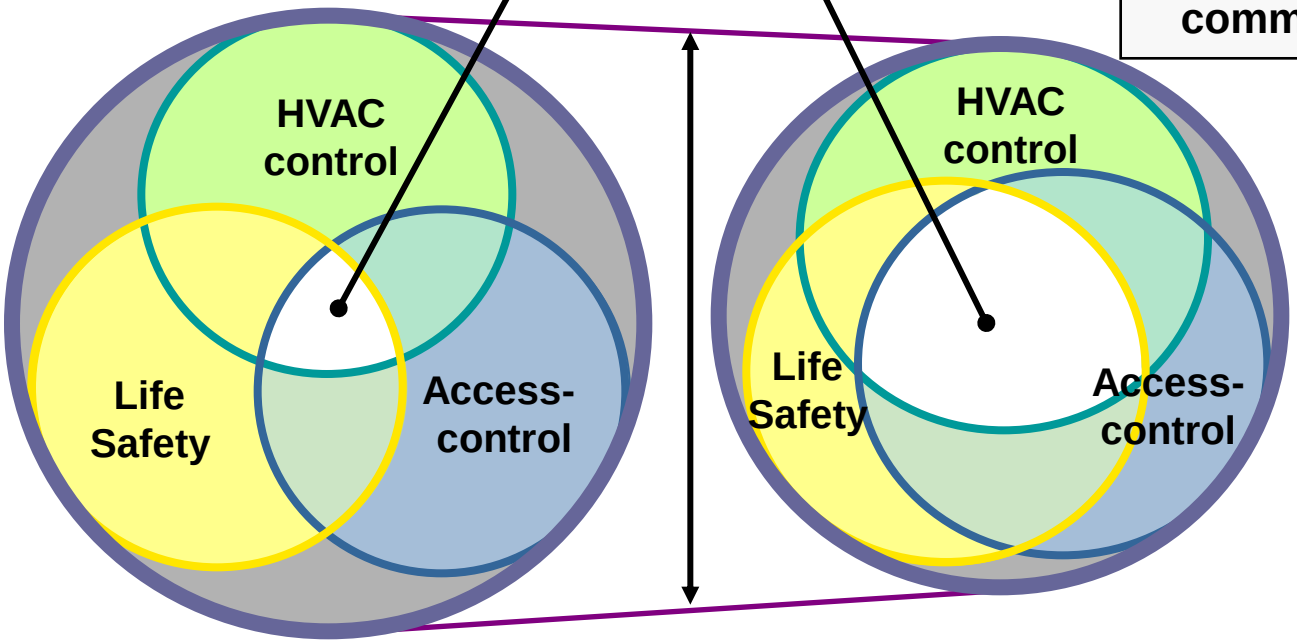


THE BENEFITS OF STANDARDIZATION

A wider functionality and reduced cost of integration

Common functionality due to common standards

- Alarm processing
- Time schedules
- Trending
- History evaluation
- Functional peer-to-peer communication



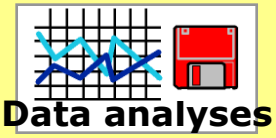
Costs of integration

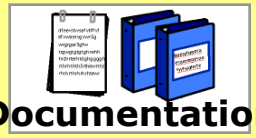
THE STANDARDIZED BACS FUNCTIONS

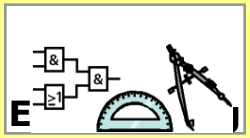
Structure given in EN ISO 16484-3

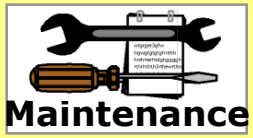
Operator functions

Management functions

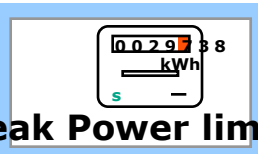


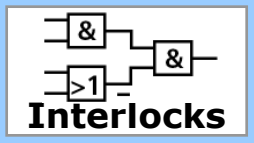


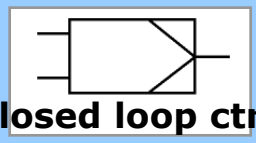


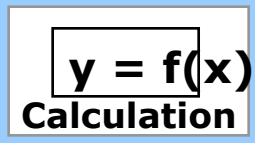


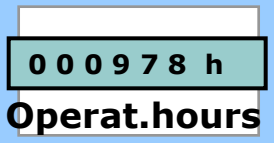
Processing functions

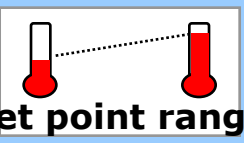


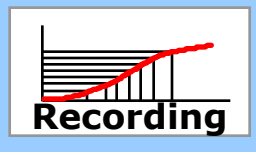


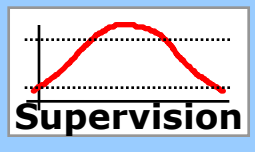




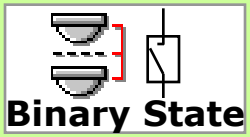








I/O functions (field devices)



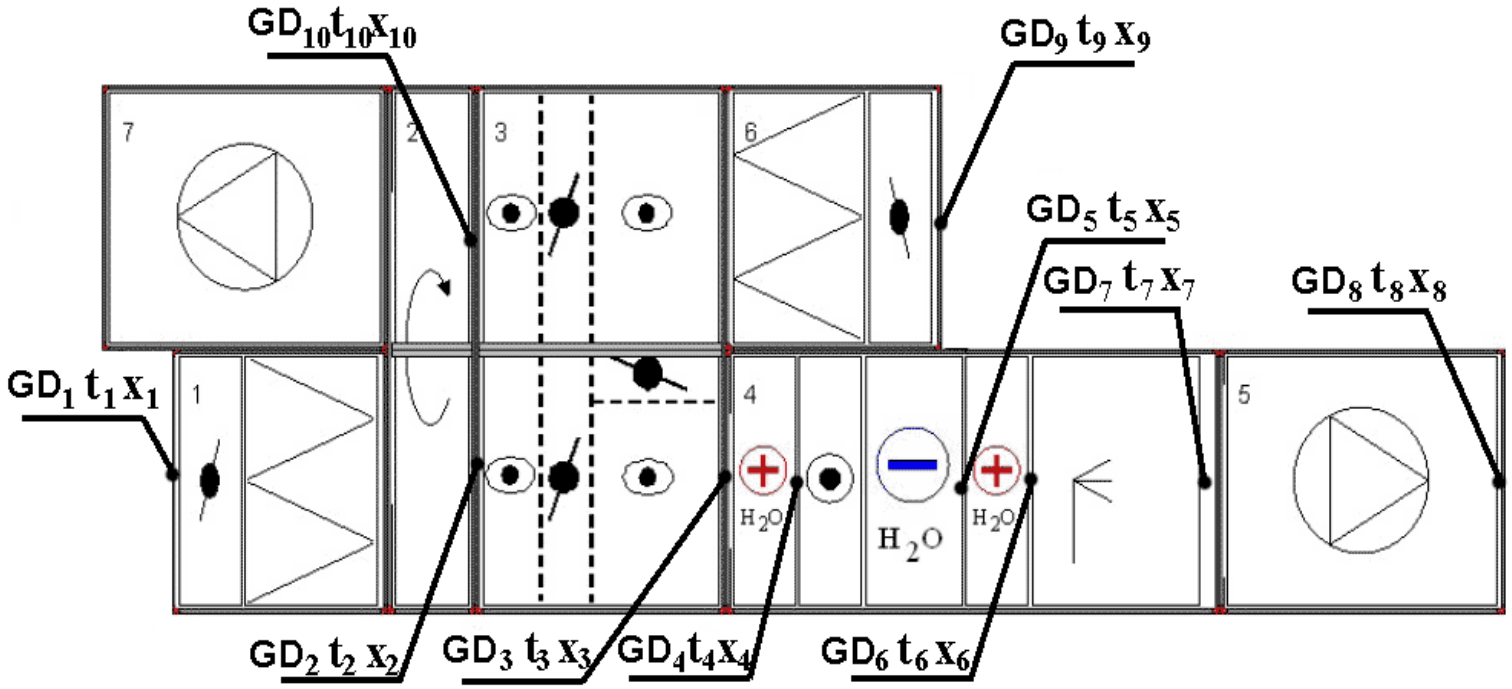
Case study
K-RAUTA stores

2 K-Rauta strores in **Latvia:** *Riga, Madona*
4 K-Rauta strores in **Estonia:** *Parnu,Tartu,Tallin*
1 K-Rauta strore in **Sweden:** *Umea*

Buildings where already constructed and we were invited to to give ideas about energy consumption decrease.

THEORETICAL ENERGY CONSUMPTION CALCULATION OF AIR HANDLING UNITS

We have developed Theoretical energy consumption calculation of air handling units in Matlab/Simulink



Energy consumption of air handling units depends from:
air handling unit configurations, outside air parameters, heating and humidity loads in premises and supply air parameters. Change of air parameters shall be calculated after each section.

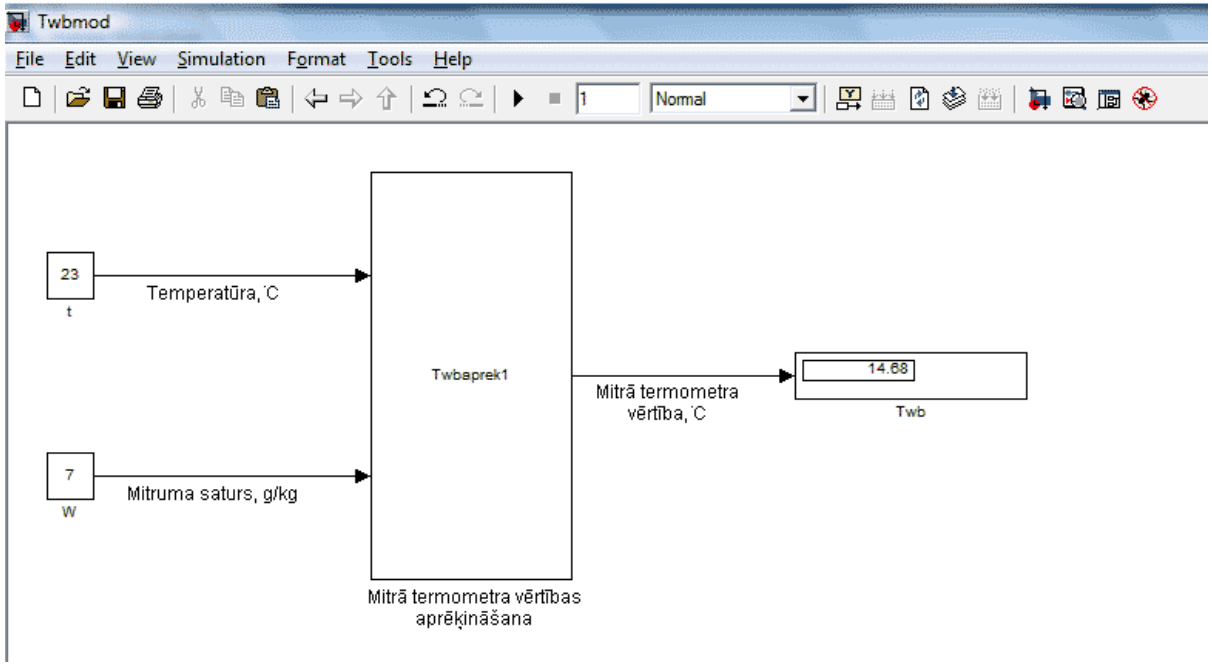
MATLAB / SIMULINK SOFTWARE

Mathematical model for **theoretical energy consumption** of air handling units is developed in Matlab and Simulink. Each air handling unit section has Simulink block with mathematical functions, written in Matlab.

Database of Simulink consists of:

- Outside air parameters;
- Air handling unit sections data;
- Work conditions of air handling unit (working time, sections).

EXAMPLE OF CALCULATION



Calculations allows to understand more easier:

- Possible **energy savings** with different control logics / parameters;
- **Payback time** of different investment solutions connected with configuration of air handling units and control methods.

CONTROL SYSTEM ANALYSE OFF K-RAUTA STORES IN PARNU, TALLIN, TARTU, UMEA

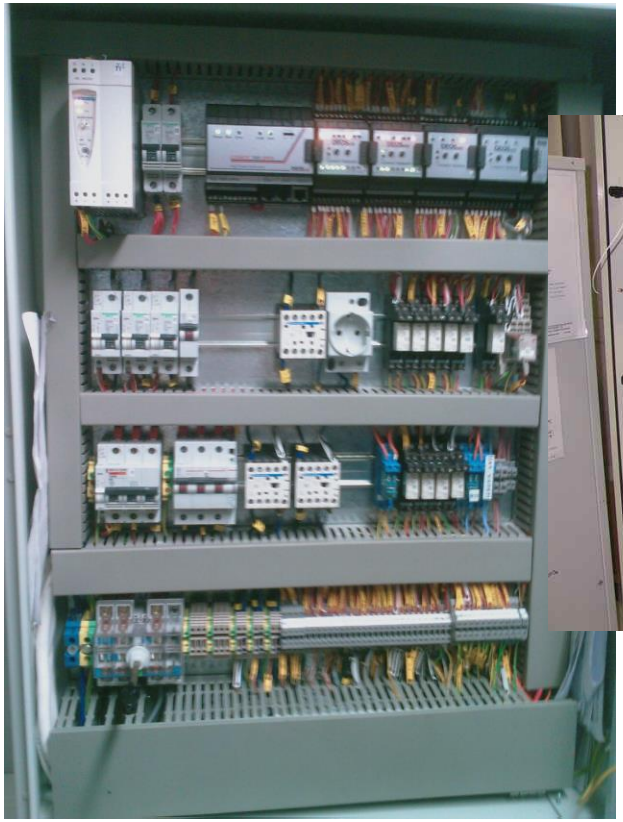
Stores were investigated and existing situation and necessary improvements in HVAC and lighting control was given in written Report. Main improvements:

- **CO2 detector** installation in trading halls;
- **water boiler pump** connection to BMS;
- correct **control of cooling system**;
- **indoor lighting control** according to time schedule, synchronized with store working time. Time of BMS is synchronized with internet time;
- **outdoor lighting control** according to outside light detector measurements. Each group is turned on by individual set point of light level. Each group has time schedule, which gives opportunity to turn on light just in store working time or during a night.
- connection of main **air curtains / air heaters** to BMS.;
- cascade temperature regulation of **air handling units**. Air handling units supply air temperature was calculated according to room temperature. Minimum supply air temperature was determined as 15 degrees C;

Our recommendation was to **change control system**.

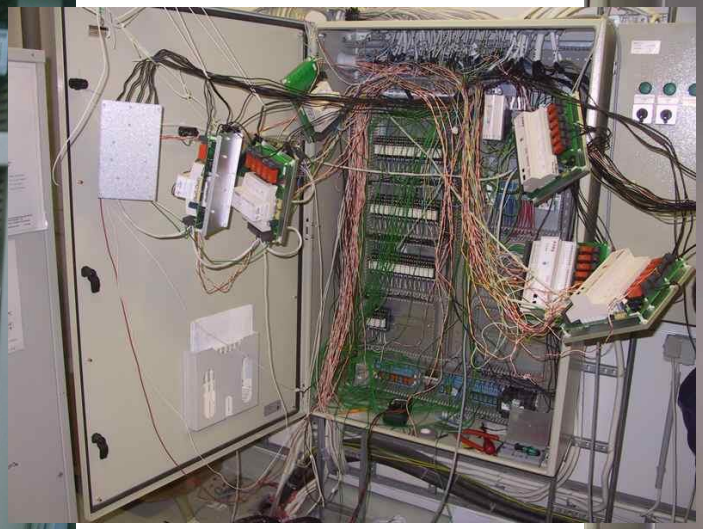
On average investement off 30 000 EUR/store, and payback time **2 years**.

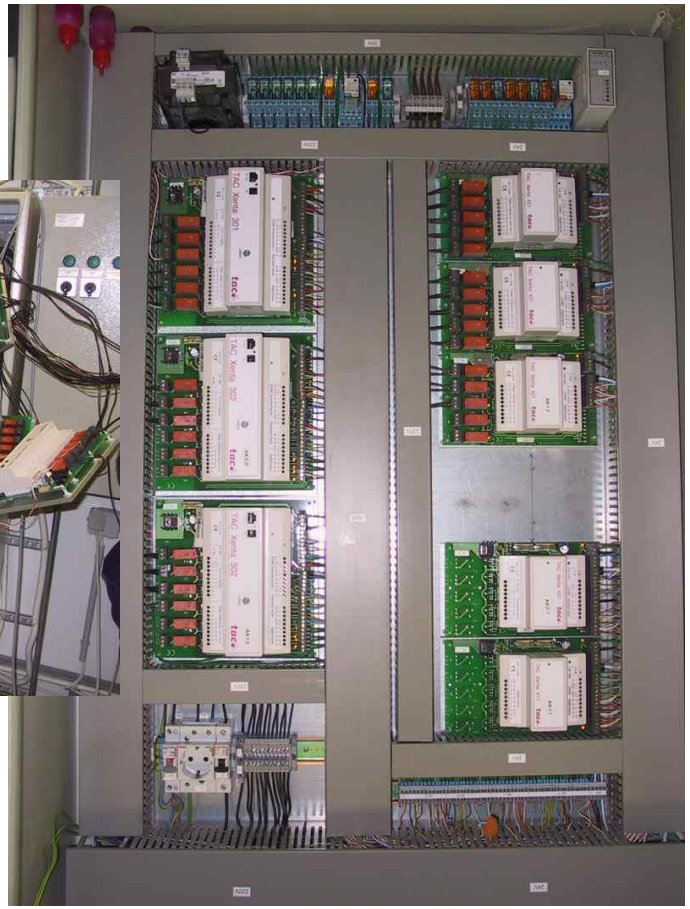
REPLACEMENT OF BMS, CONTROL STRATEGY



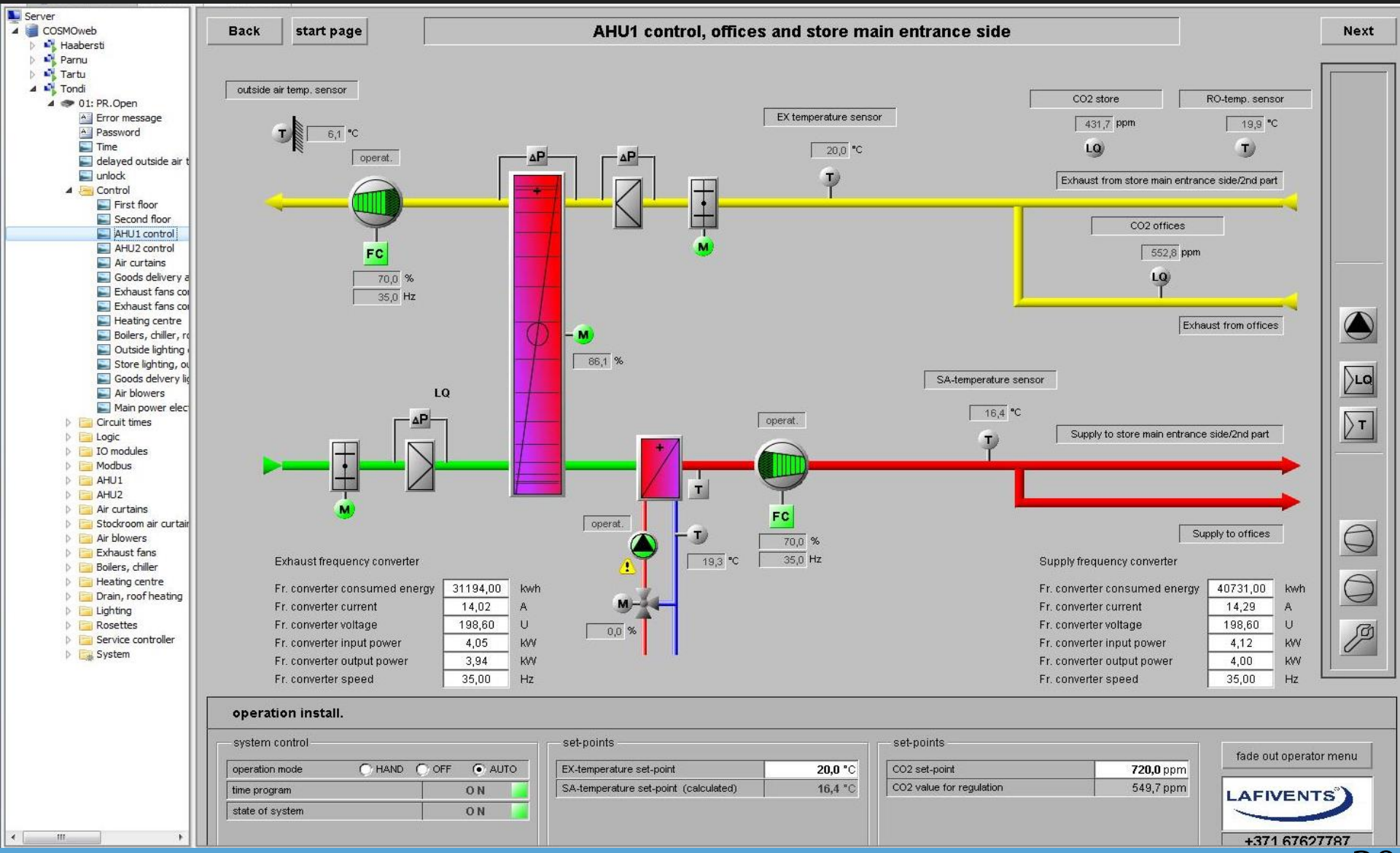
New DEOS controllers

Old controllers

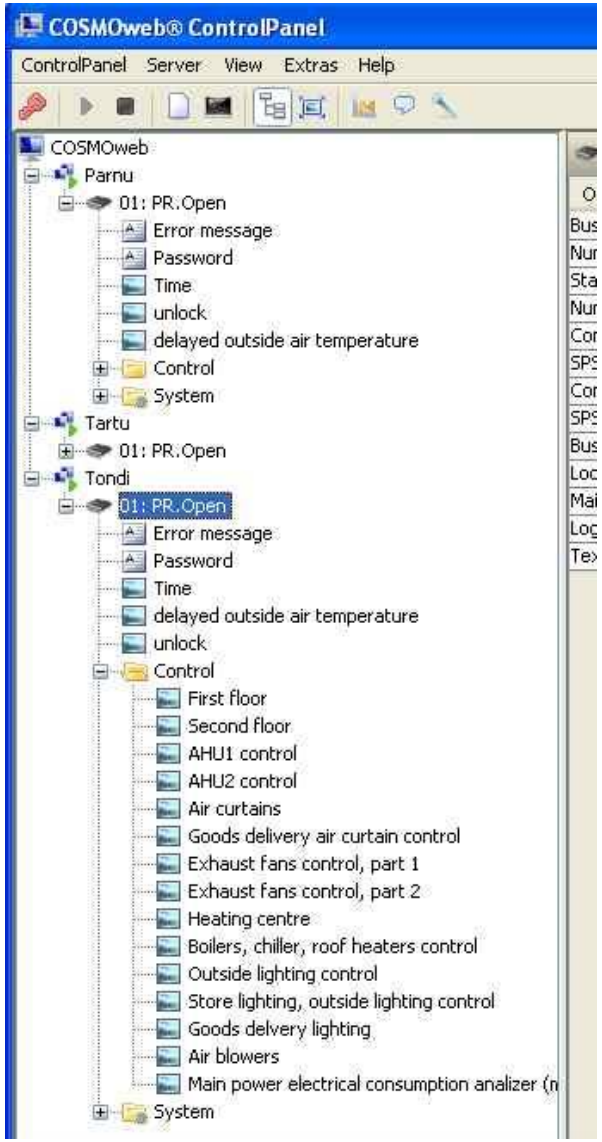




K-RAUTA stores



BMS SERVER

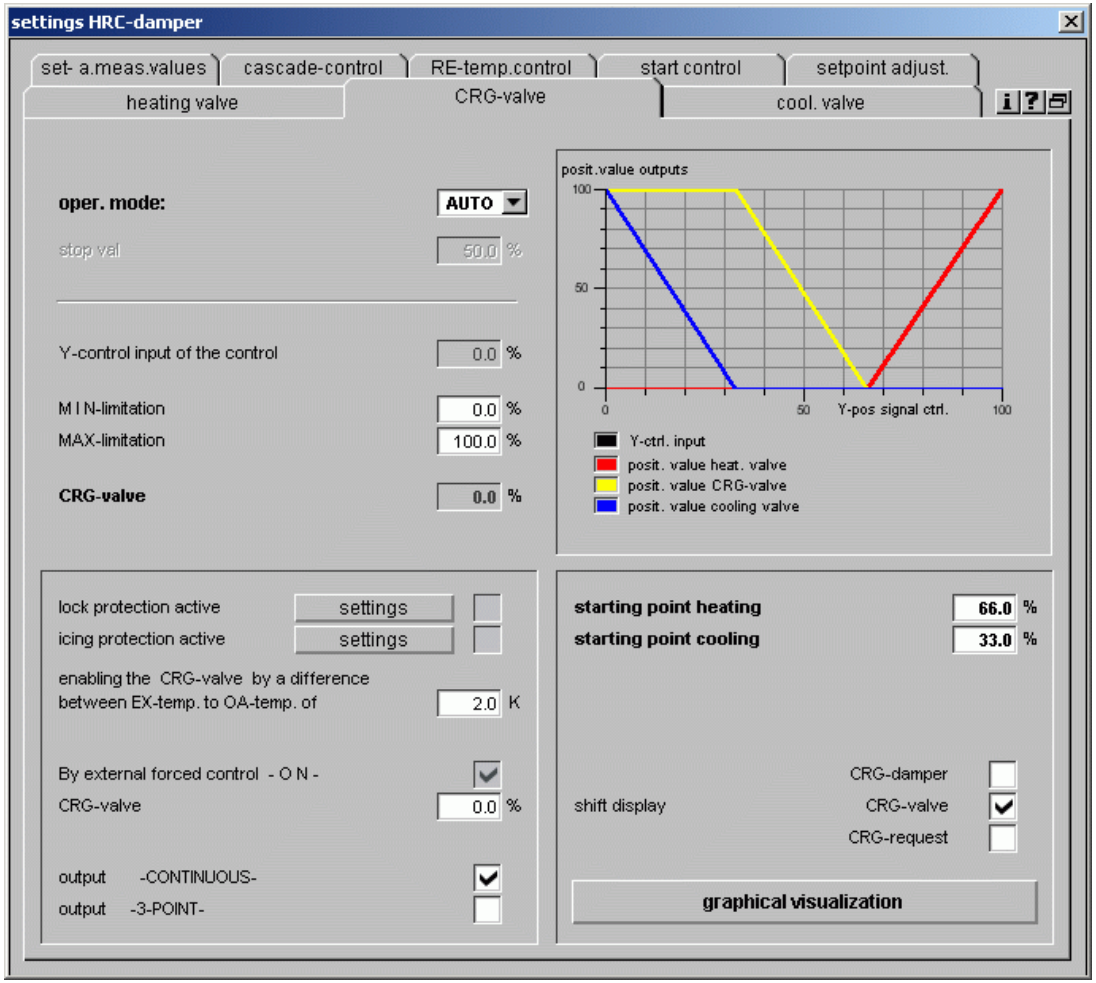


- BMS server for Estonian stores is located in Tallin main K-Rauta office. BMS server has **online Internet connection to K-Rauta stores** (Tondi, Tartu, Parnu, Haabersti).

- **Unlimited users** with access level can connect to BMS server with Internet Explorer or Control Panel (free software).

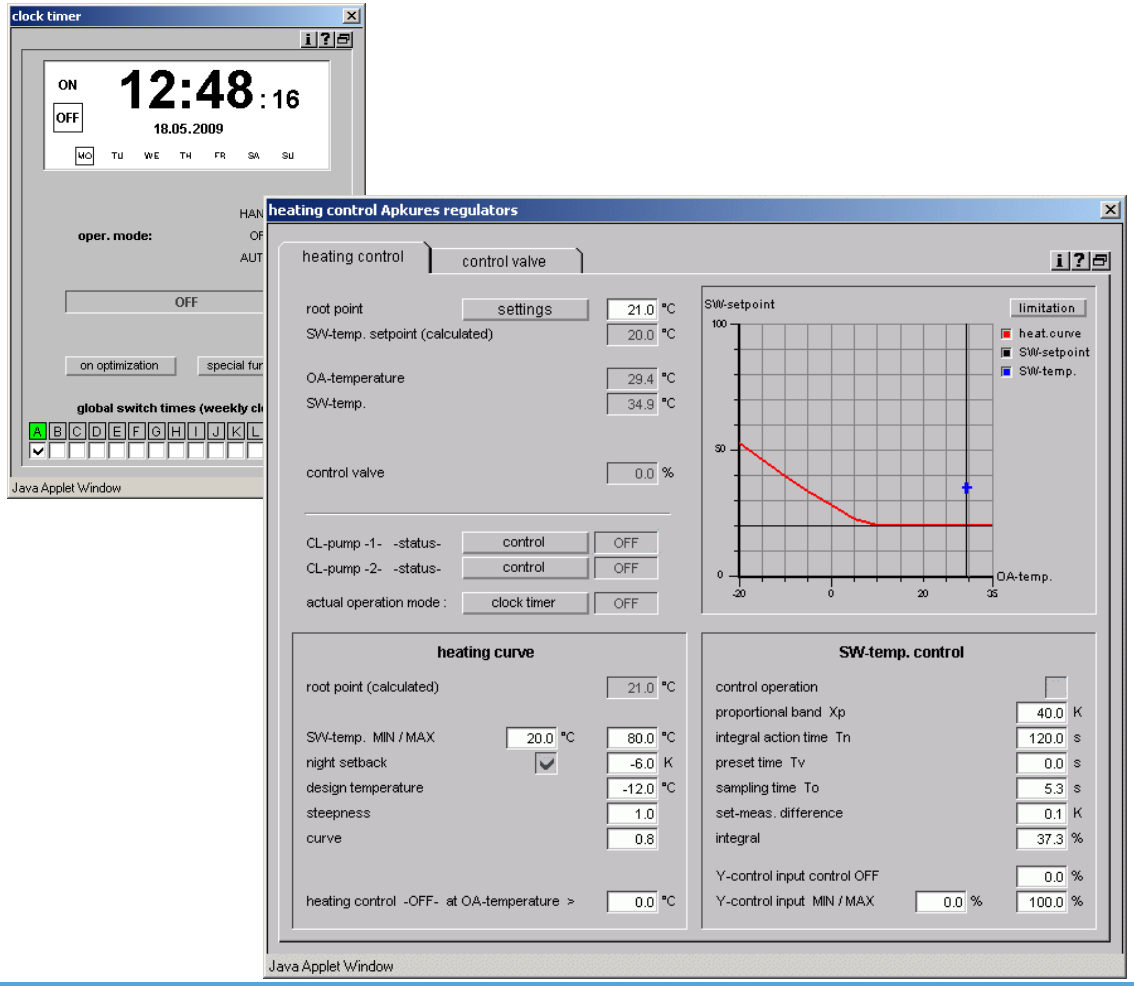
- BMS server **stores Trendlogs, events** (sends SMS, e-mails during alarm), synchronise controllers time with Internet time and gives all acceess to control parameter.

MACRO LIBRARY FOR ENERGY EFFICIENT CONTROL OF HVAC



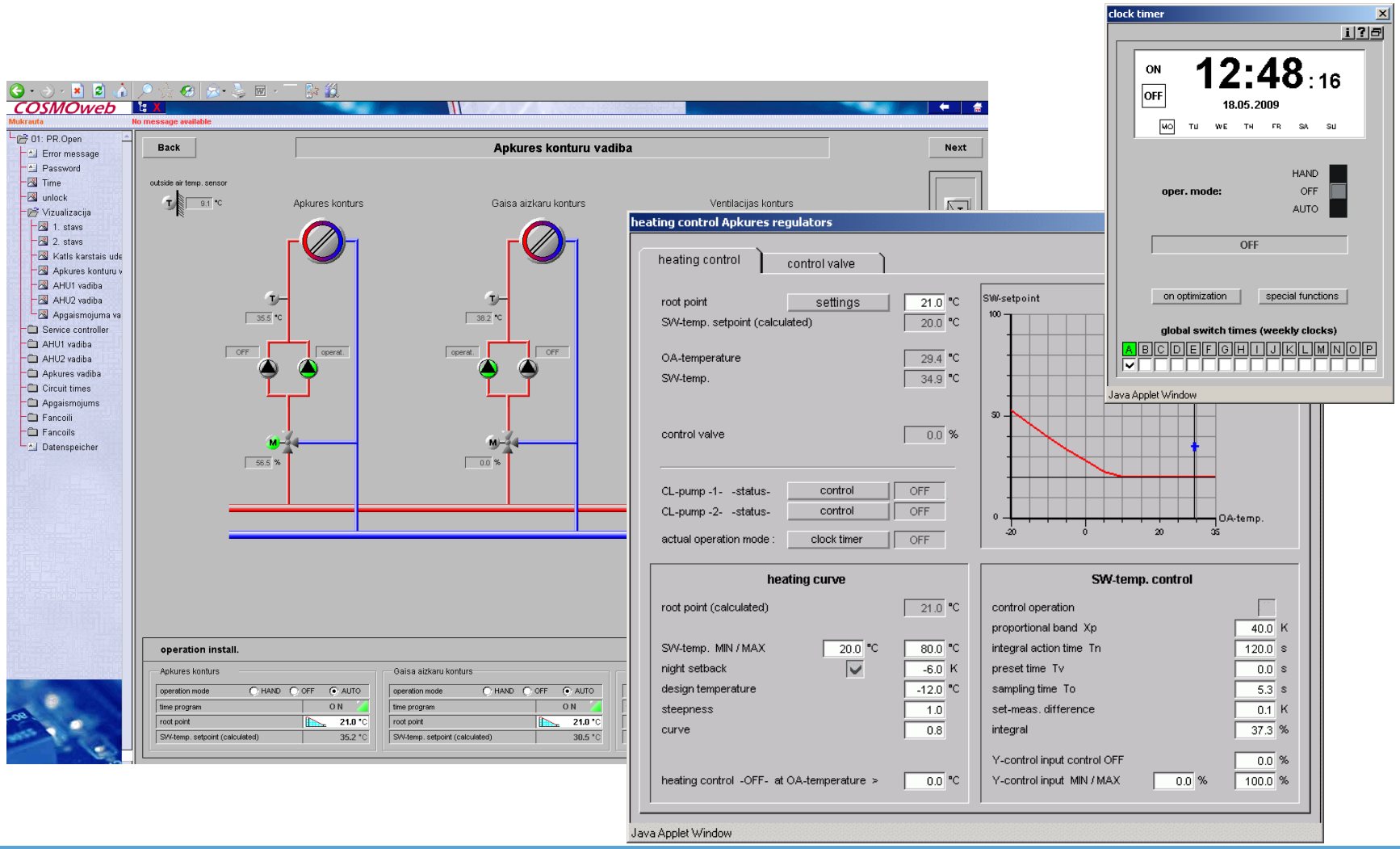
- FUP XL Software is used for programming of controllers. FUP XL software has **Macro library** *(algoritms for HVAC control, written by DEOS Germany)*
- Macro library is tested in many projects across Europe, it allows to **minimise programming mistakes**
- Used algorithms has energy saving functions

ENERGY SAVING FUNCTIONS

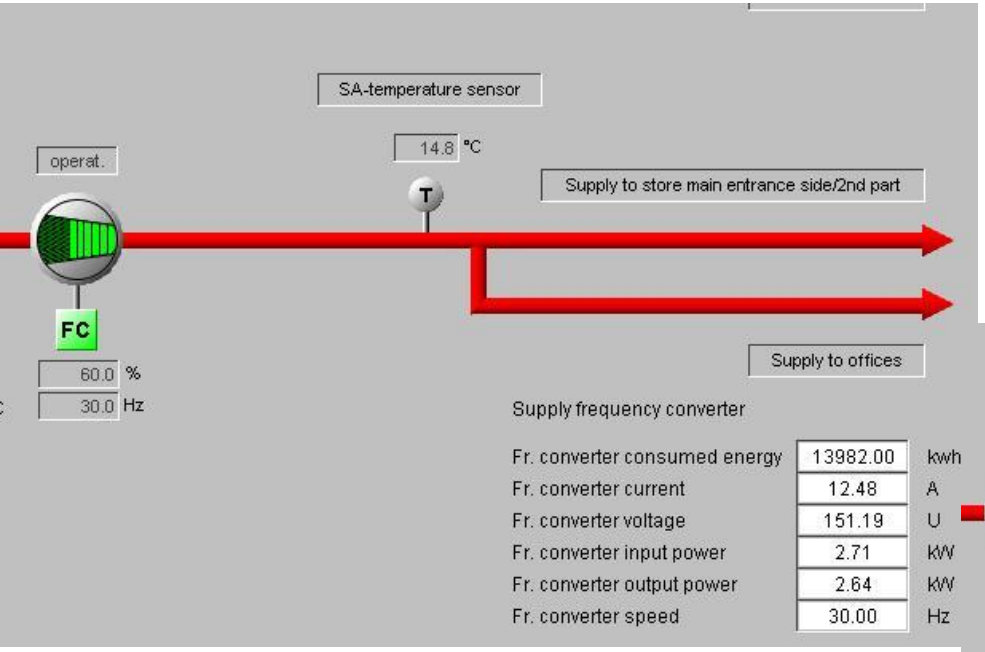


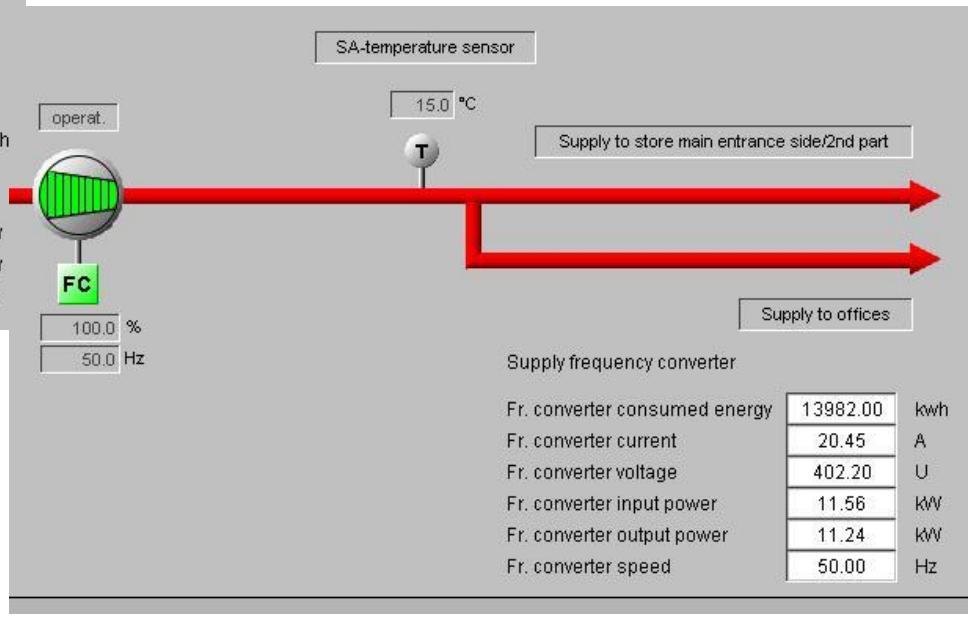
- Very important is store working time. Each HVAC unit has it owns **working time schedule**. Each time schedules can be activated from global time schedule
- Function for heating centres – **temperature decrease per night** is used
- Air handling units in Summer are cooling store **during a night** with **cold outside air**

MACRO LIBRARY FOR HEATING CENTER CONTROL



FAN SPEED

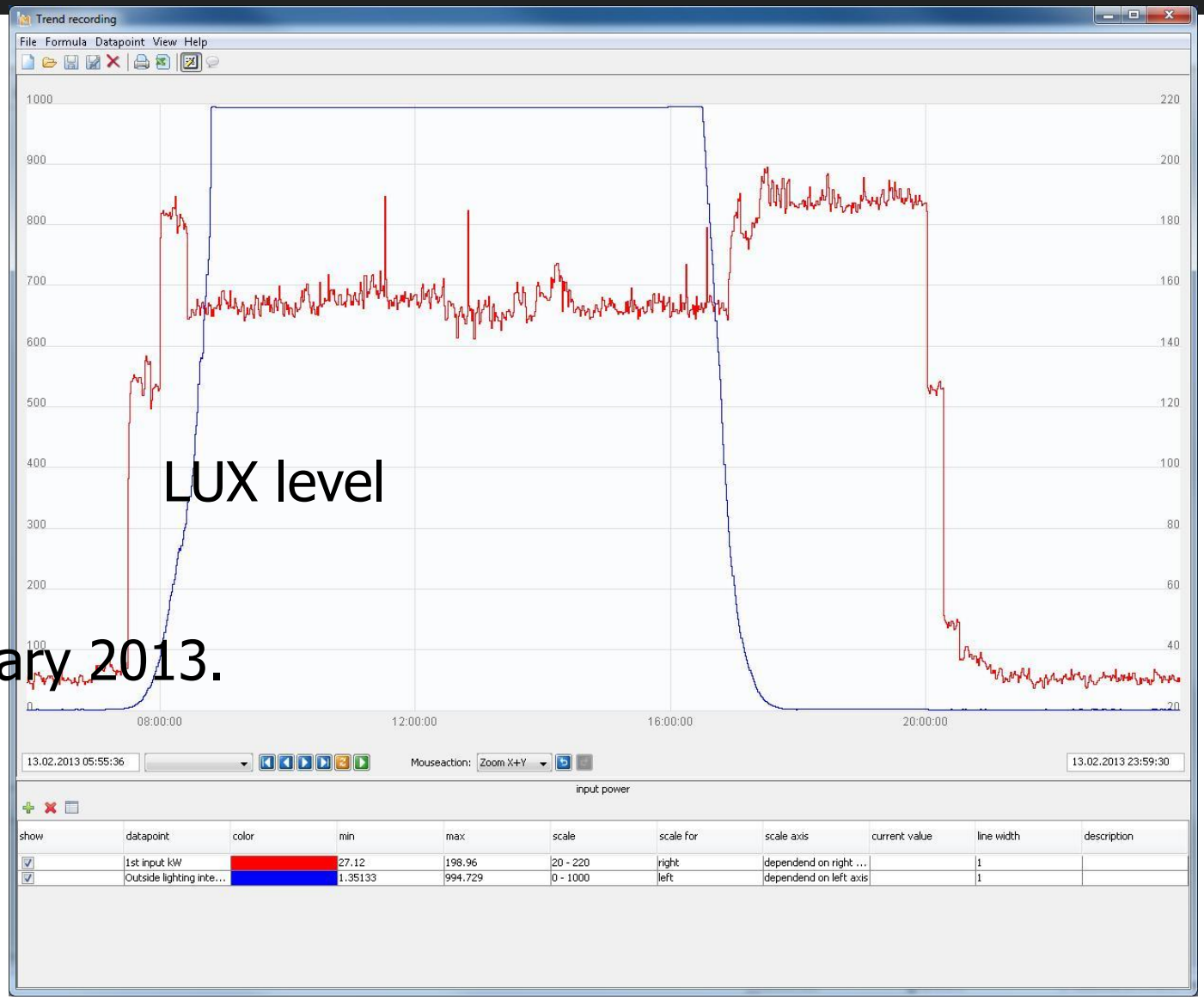

SA-temperature sensor
14.8 °C
operat.
T
Supply to store main entrance side/2nd part
FC
60.0 %
30.0 Hz
Supply to offices
Supply frequency converter
Fr. converter consumed energy 13982.00 kwh
Fr. converter current 12.48 A
Fr. converter voltage 151.19 U
Fr. converter input power 2.71 kW
Fr. converter output power 2.64 kW
Fr. converter speed 30.00 Hz


SA-temperature sensor
15.0 °C
operat.
T
Supply to store main entrance side/2nd part
FC
100.0 %
50.0 Hz
Supply to offices
Supply frequency converter
Fr. converter consumed energy 13982.00 kwh
Fr. converter current 20.45 A
Fr. converter voltage 402.20 U
Fr. converter input power 11.56 kW
Fr. converter output power 11.24 kW
Fr. converter speed 50.00 Hz

CO2 DEPENDENCE FROM FAN SPEED

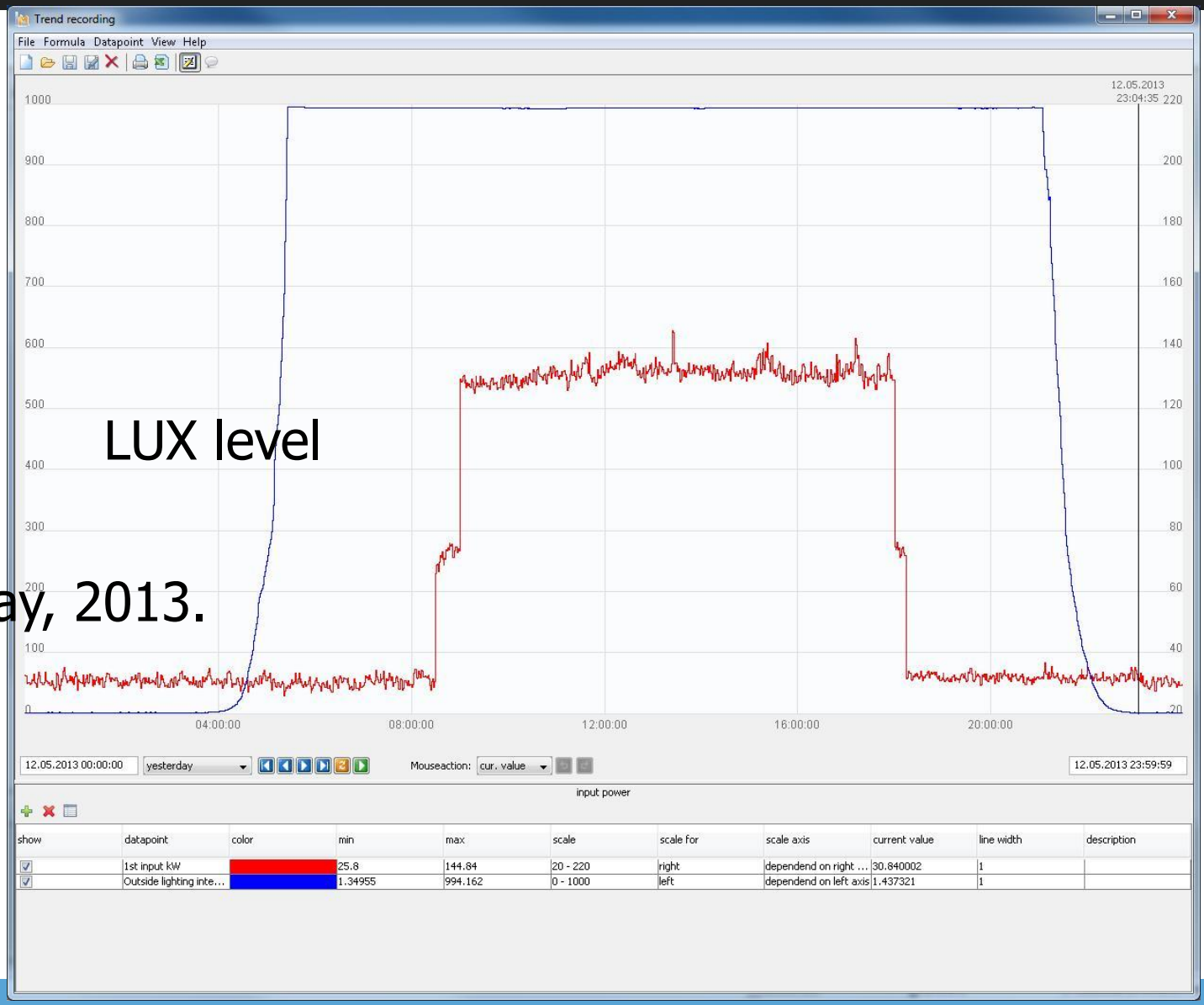
show	datapoint	color	min	max	scale	scale for	scale axis	current value	line width	description
☑	CO2 sensor offi...		537.053	705.880432	520 - 720	left	dependend on l...		1	
☐	CO2 sensor		479.307	560.689148	0 - 5000		dependend on r...		1	CO2 sensor for ...
☑	Fr1 Output spe...		0.0	5000.0	0 - 5000	right	dependend on r...		1	

TRADING CENTRE ELECTRICAL ENERGY CONSUMPTION (TONDI)



13. February 2013.

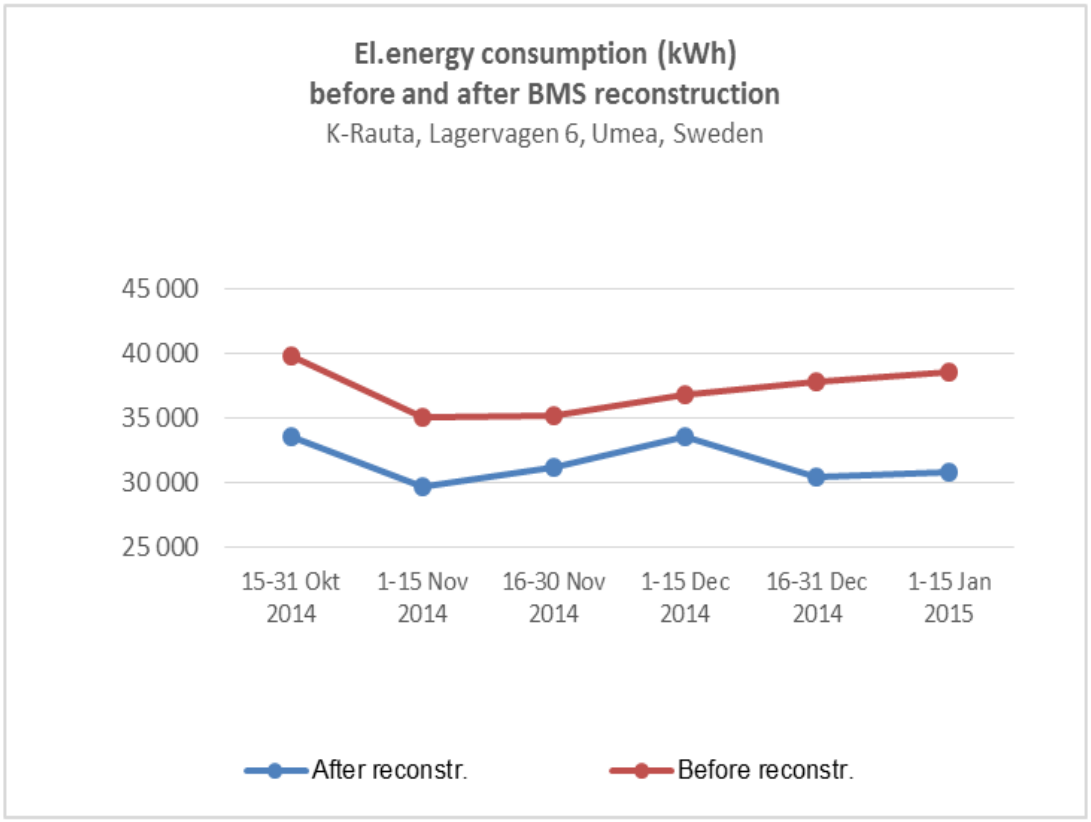
TRADING CENTRE ELECTRICAL ENERGY CONSUMPTION (TONDI)



LUX level

12. of May, 2013.

ELECTRICAL ENERGY CONSUMPTION ANALYSE IN YEARS 2015, UMEA



Savings calculated based on first 3 month performance:

135 500 kWh/year - el.energy
30 000 kWh/year – heat energy

Payback time: 1.8 years

QUESTIONS

Andris Krūmiņš

Docent, Riga Technical University

Leader of Lafivents control department

E-mail: andrisk@lafivents.lv