SAVE ENERGY

Grant agreement no.: 238882

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Helsinki Pilot Implementation

Document ID	D6.2.31.08.10
Authors:	Hilden Sari, City of Helsinki Kippo Asko, Metropolia UAS Kuusinen Katri, City of Helsinki
Contributors:	
Workpackage:	WP6
Version:	1.0
Date:	31.08.2010
Project Coordinator:	ALFAMICRO
Contract Start Date:	01.03.2009
Duration:	30 months
Dissemination Level:	Public

Project co-funded by the European Commission within the ICT Policy Support Programme

Revision History

Date	Version	Author/Contributor	Comments
17/08/2010	0.1	Helsinki	Pilot description first draft
23/08/2010	0.5	Metropolia	Pilot technical implementation
31/08/2010	1	Metropolia/Alfamicro	Final Version

Statement of originality:

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1 Save Energy Helsinki Pilot Implementation D6.3

The activities at the City of Helsinki

The city of Helsinki owns about 1.200 public buildings including 200 schools, 350 kindergartens and 7 hospitals, office buildings, libraries, etc. For several decades the city of Helsinki has done a lot of work to save energy and to achieve better energy efficiency. The city of Helsinki has in 1974 established an Energy Saving Board for energy saving coordination between various actors in the city administration and has commited to several voluntary agreements on energy saving, such as, The Covenant of Mayors and the Agreement between the City of Helsinki and Ministry of Employment and the Economy, etc.

2 Helsinki Pilot Overview

The Save Energy Helsinki Pilot has been implemented by the co-operating partners in Helsinki, namely, the City of Helsinki, Metropolia University of Applied Sciences, Aalto University/Helsinki School of Economics/CKIR Research Unit, Nokia Oyj and Green Net Finland ry. Helsinki pilots for Save Energy project are the two comprehensive schools at Helsinki;

- Ala-Malmi comprehensive school, built on 1965, volume of 25.160 m^3, area of 7.019 m^2, 6 buildings, 300 pupils, 50 teachers, grades 5 – 9, located in Ala-Malmi, Latokartanontie 16, 00700 Helsinki. The school has been reconstructed widely on 2005 – 2009.
- Pihkapuisto comprehensive school, built on 1989, volume of 25.312 m^3, area of 5.132 m^2, 1 building, 220 pupils, 25 teachers, grades 1 – 6, located in Malminkartano, Tuohipolku 10, 00410 Helsinki. The school has been reconstructed and enlargened on 1999 and includes also the kindergarten in the same building.

Both schools have been rewarded on environmental efficiency, paper recirculation and on the green thinking and operations at school. So it was natural that these schools were chosen and interested also in energy saving, energy efficiency and in the change of the user thinking and behavior on energy saving.

3 Key Objectives

The key objective is to improve energy efficiency and to reduce the carbon emissions through the behavioral transformation of the pupils, teachers and staff people with the support of the leading edge ICT systems including real time information displays and serious games. Based on the results achieved at these schools, it is planned to roll out

technologies, methodologies and best practices to other schools and public buildings in Helsinki.

Technologically, the key objective of the Helsinki pilot is to measure in real time all the relevant energy information on the consumed electricity, heat and water by

- using the intelligent wireless sensor network system and
- transferring the data from the existing building management & automation system (BMS) and from the separate transferable measurement units.

4 Research Hypothesis

The Helsinki pilot is a living lab experiment. A hypothesis has been developed for the experiment; a hypothesis being a proposed explanation for observable phenomenon. The hypothesis of the Helsinki pilot is:

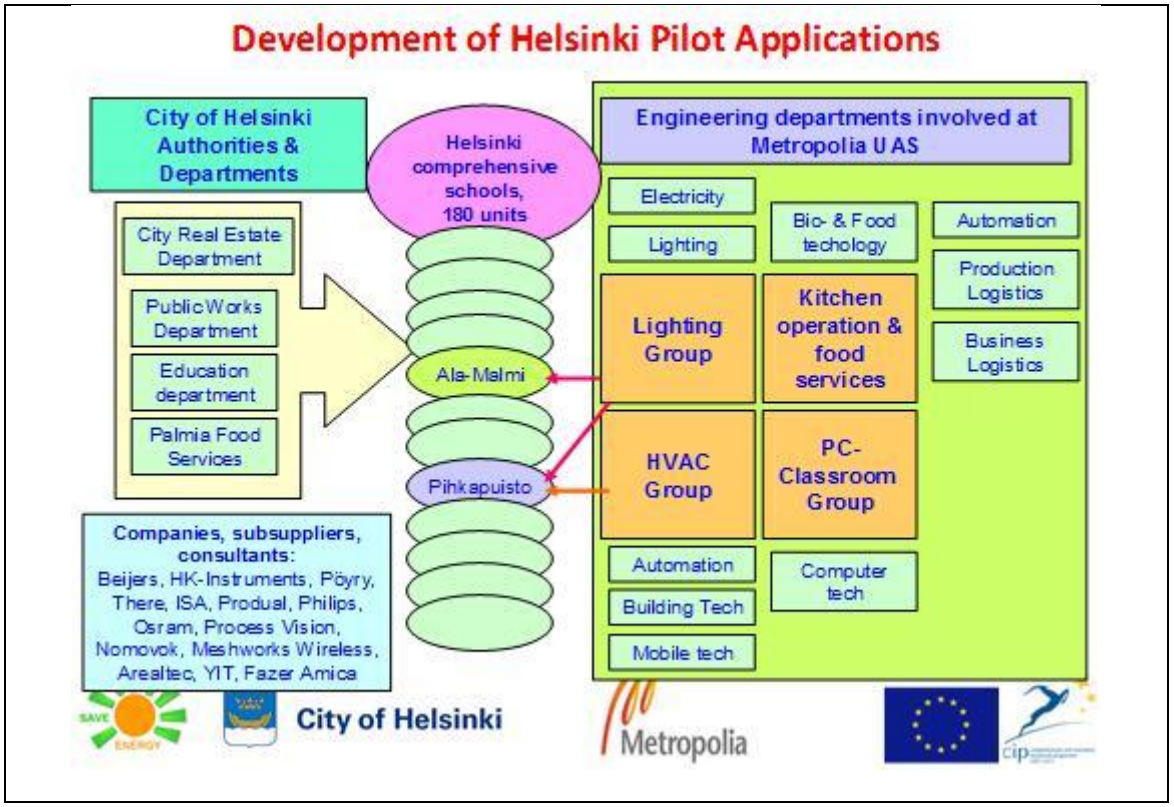
- The presentation of real time energy consumption measurements to the user groups will change the user behavior so that energy consumption and CO_2 emissions decrease.
- Presentation is the independent variable which allows indicating quantitative measures to the user.
- The real time energy consumption and other measurements are transfered from the building management & automation system or from the wireless sensor network system installed into the pilot school applications at the kitchen, classrooms, entrance hall or gym hall. These measurements will be translated from raw data to a presentation format.
- Users are the participants who will both use the energy and be recipients of the formatted information on consumption. The technical users (janitor, technical experts) have been focused as a special user group, who are responsible on the HVAC set points of the BMS and on the rules and standards available and to be obeyed.
- Energy consumption is the individual use of energy. The consumption of electricity, heat and water are the main focus areas of the pilot.

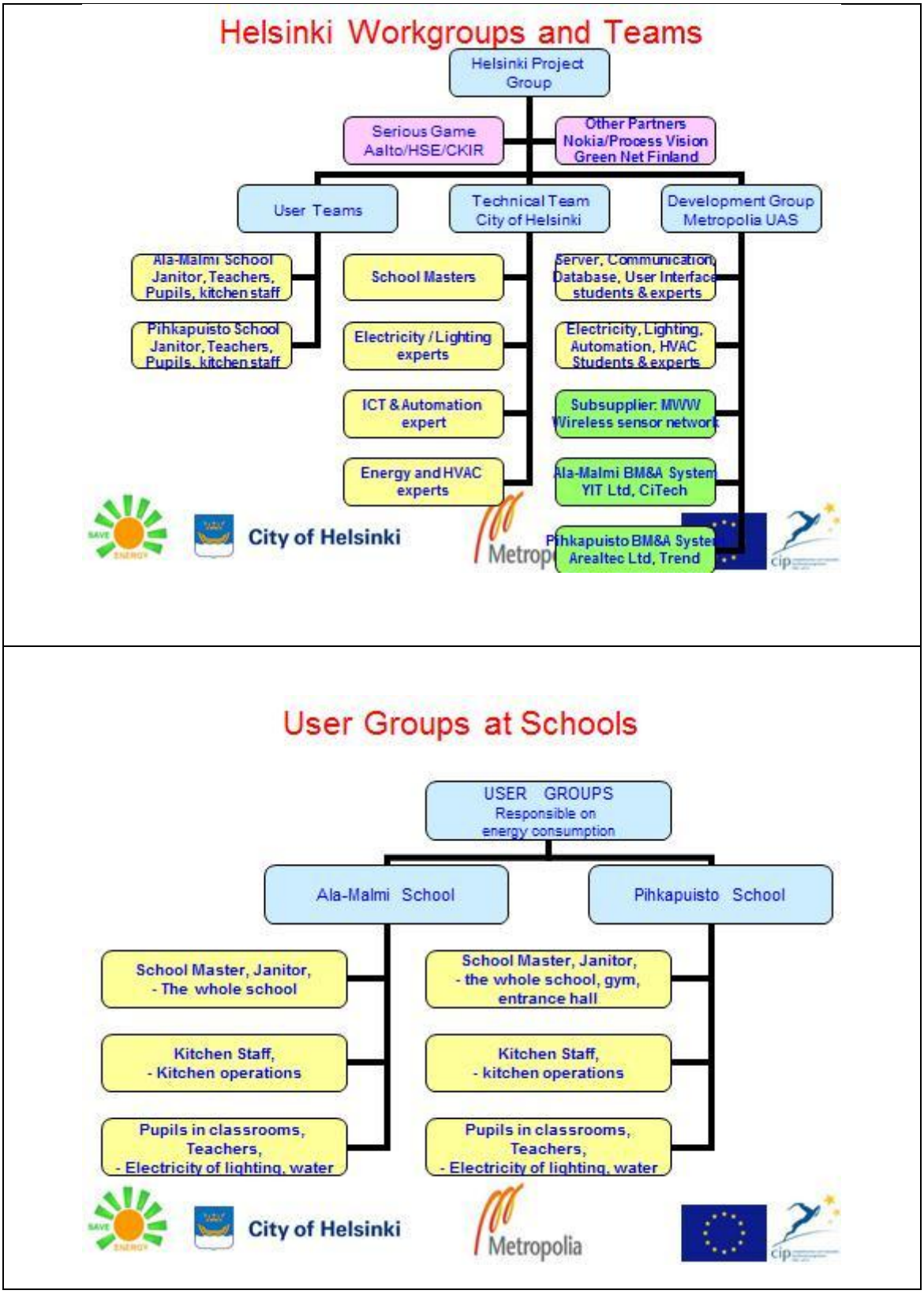
5 Living Lab Methodology

Helsinki Pilot has been developed using the Living Lab Methodology based on the user-driven open innovation methodology bringing together from the beginning all the responsible stakeholders such as teachers, pupils, janitor, kitchen personnel, technical designers and experts, technology suppliers and service providers for problem

definition, evaluation and discussion to define the functionality and user interface of the new energy efficient services and systems by providing the discussion platform and an engaging co-creative environment for users to improve their working surroundings and their ability to change their habits on energy consumption.

Discussions with pupils, teachers and technical experts revealed some energy consumption problems at schools that have been discussed and evaluated thoroughly within the project and technical groups. Based on these discussions the new test applications at Helsinki Pilot have been designed and implemented in the classrooms, entrance hall and gym hall. In addition there has been a special attention to the kitchen operations to reduce the consumption of the electricity and to improve the efficiency and throughput of the kitchen.




Helsinki Workgroups and Teams
Helsinki Project Group
Serious Game Aalto/HSE/CKIR
Other Partners Nokia/Process Vision Green Net Finland
User Teams
Technical Team City of Helsinki
Development Group Metropolia UAS
Ala-Malmi School Janitor, Teachers, Pupils, kitchen staff
Pihkapuisto School Janitor, Teachers, Pupils, kitchen staff
School Masters
Electricity / Lighting experts
ICT & Automation expert
Energy and HVAC experts
Server, Communication, Database, User Interface students & experts
Electricity, Lighting, Automation, HVAC Students & experts
Subsupplier: MWW Wireless sensor network
Ala-Malmi BM&A System YIT Ltd, CiTech
Pihkapuisto BM&A System Arealtec Ltd, Trend
City of Helsinki
Metropolia
User Groups at Schools
USER GROUPS
Responsible on energy consumption
Ala-Malmi School
Pihkapuisto School
School Master, Janitor, - The whole school
Kitchen Staff, - Kitchen operations
Pupils in classrooms, Teachers, - Electricity of lighting, water
School Master, Janitor, - the whole school, gym, entrance hall
Kitchen Staff, - kitchen operations
Pupils in classrooms, Teachers, - Electricity of lighting, water
City of Helsinki
Metropolia

6 Technology Platform at Helsinki Pilot

Based on the test applications at these schools, the target was set to find the functional model and best practices to be exploited in the other schools and public buildings. For example improving energy efficiency and controlling the air quality more flexibly by installing an intelligent EC-motor based HVAC systems in Pihkapuisto gym and the key role and the behavioral change of the operative personnel of the kitchens using the high power professional kitchen equipment were identified as the most important means to achieve significant energy savings.

The approach in the Helsinki pilot is to measure in real time all the relevant energy information on the electricity, heat and water consumption by using the intelligent wireless sensor network system and by transferring the collected measurement data from the existing building management & automation system. All the measurements are collected to the virtual server at Metropolia UAS for generating the real time information, trends, calculated indicators and other information. TV displays show the energy consumption and the CO_2 emissions simply and user-friendly to the user groups of the schools (kitchen personnel, janitor, teachers, pupils, technical experts, etc.) in order to inform about consumptions, to point out the potential ways of saving energy and to try to influence on the user thinking and operations to achieve a permanent awareness of behavioral change in saving the energy on these users.

Pilot applications at schools

Based on the profound technical energy evaluations, energy audits and the continuous discussions with the users and technical experts, the following application areas of energy efficiency at Helsinki pilot schools were found:

- New lighting technology and the users' energy consumption in the normal classrooms, PC classrooms and the entrance hall.
- Energy consumption of the whole HVAC system based on the energy audits of the schools.
- Energy efficiency improvement and more flexible air quality control by the intelligent EC-motor based HVAC system in the gym.
- The behavioral change on energy efficiency of the operative personnel of the kitchen using the high power professional kitchen equipment.

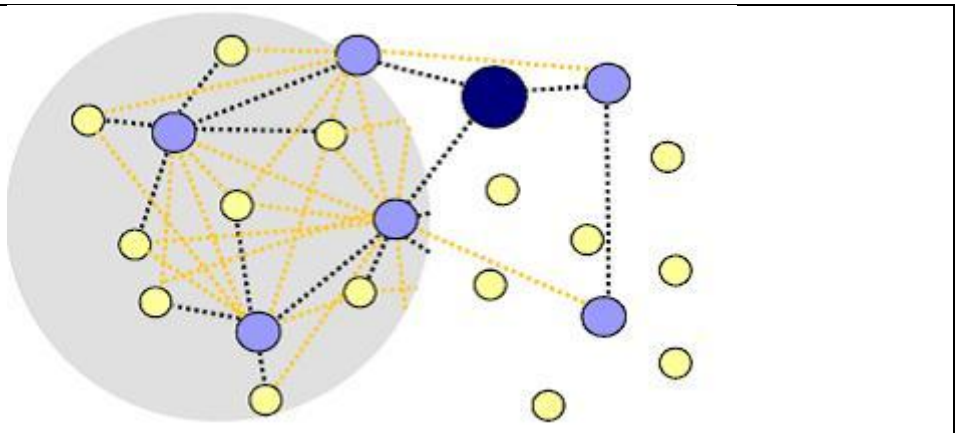
Virtual server at Metropolia UAS

The Helsinki pilot measurement data is stored into the MySQL database on a virtual server running with Linux. The way to retrieve data depends on the measurement

system. All data is transferred through the Internet. For the BMS of YIT Building Tech (at Ala-Malmi school) managed by YIT Building Technologies, the FTP protocol is used to get single text files once per hour. The data from both schools by Meshworks Wireless System is also retrieved as text files in XML format every five minutes (from a third party server). The Trend BMS system (at Pihkapuisto school) stores data every five minutes into the database, from which data is retrieved with an SQL query.

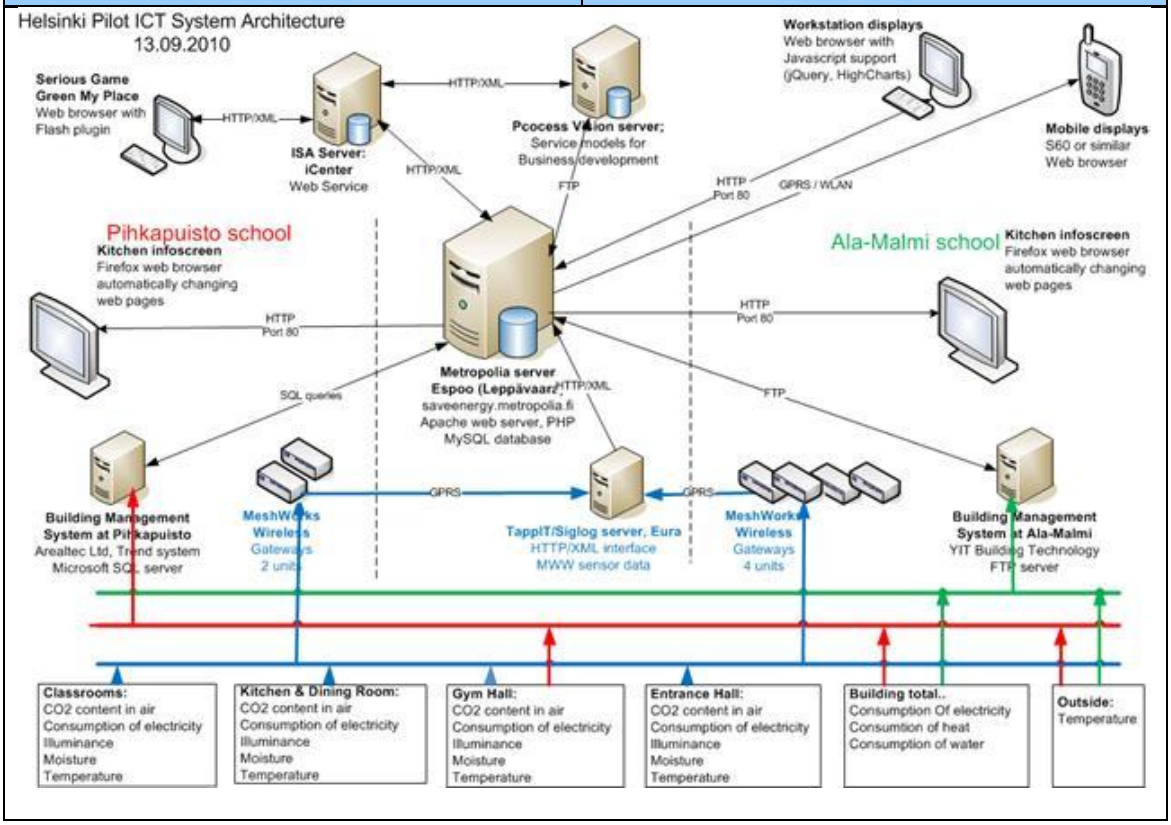
The virtual server at Metropolia UAS collects and stores the real time measurements from both the schools into the database, i.e.:

- the energy (heat, electricity, water) consumption and some HVAC-measurements (temperatures, moisture, CO_2, flow rate of water/district heating/heating network) from the existing building management & automation systems,
- the intelligent wireless sensor network system at schools including 47 (Pihkapuisto) and 52 (Ala-Malmi) sensors measuring temperature, moisture, illuminance and CO_2 collecting measurements once per 5 minutes. In addition to the main electricity consumption, the kitchen and the gym electricity consumptions are measured (6 in Pihkapuisto and 4 in Ala-Malmi). The number of the wireless real time measurements is totally 99. The following pictures are showing the wireless sensor network and the measuring sensor modules:



The Helsinki Pilot system architecture is shown below:

Helsinki Pilot ICT System Architecture 1.9.2010	

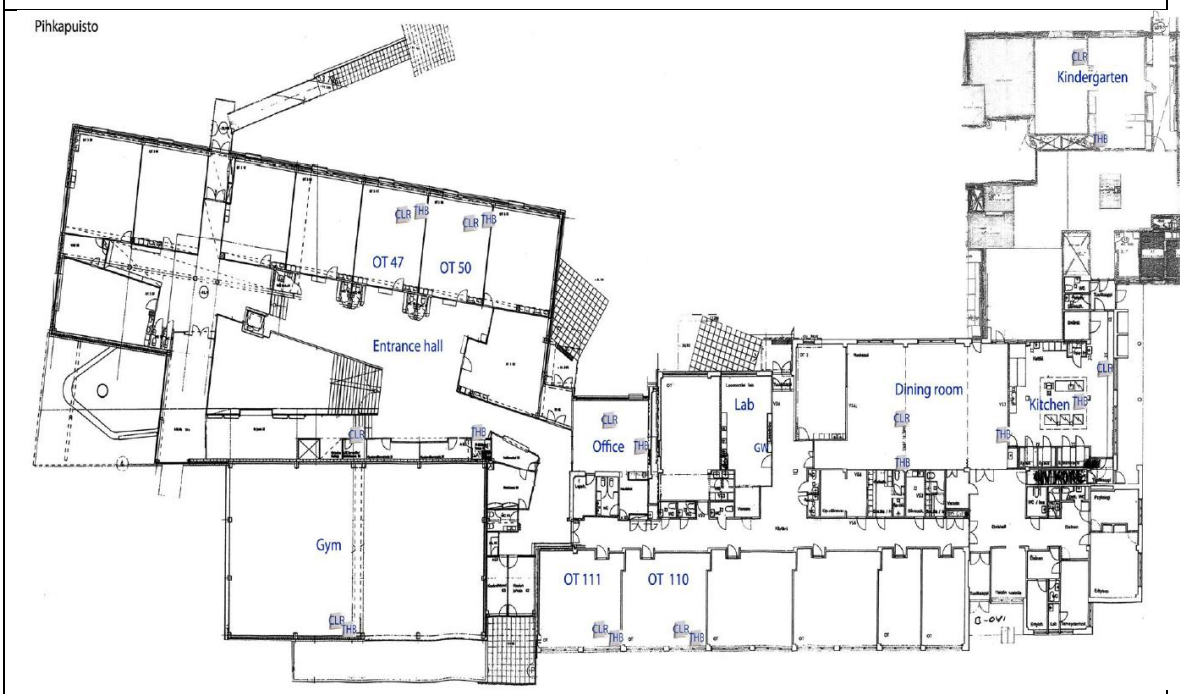


From the measurements collected the Metropolia virtual server system is generating sophisticated displays for different user groups almost in real time. The electricity consumption data gathered into Metropolia server is then forwarded once per day to ISA server in Portugal using their iCenter Web Service.

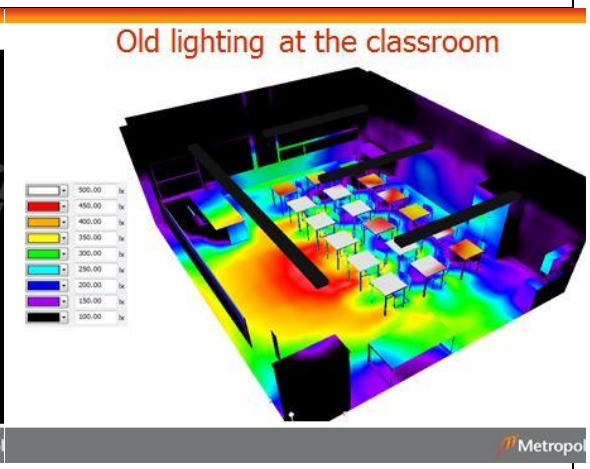
Pilot applications at Pihkapuisto school

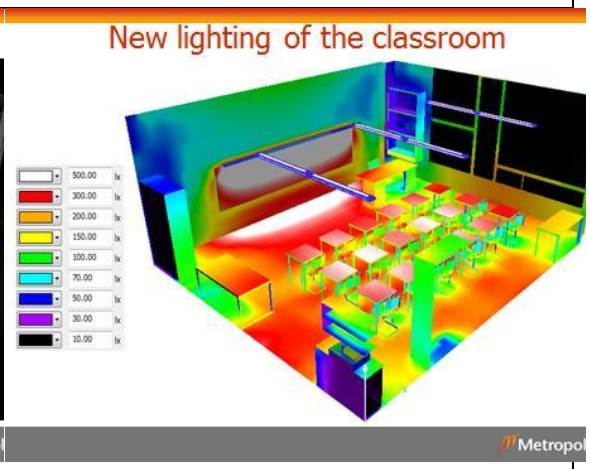
Multisensor controlled lights at the classroom (old part)

The location of the sensors at Pihkapuisto school:



The lighting at the schools have been designed by the Dialux system available at Metropolia. Below it is shown some examples of this design:





The lights in the classrooms are controlled by using multisensors (a multisensor unit includes a light sensor and a movement detector). Depending on the availability of daylight the light sensor (photocell sensor) automatically reduces/increases the amount of electrical lighting and keeps the illuminance level constant. The movement detector switches the lights off when the classroom is vacated (set to switch the lights off after 10 min. of absence). Two multisensor units are mounted into the luminaires. These master luminaires controls the illuminance level of the slave luminaires that are on the same row / luminaire group. The luminaires are equipped with T5 45 W and 25 W fluorescent tubes and electronic ballasts (DALI). The calculated energy consumption is about 439 kWh/a (assessment made by using standard EN 15193, typical values for a classroom).

Measurements at the classrooms: temperature, moisture, CO_2, illumination, consumption of electricity.

Movement detector controlled lights in the classroom (new part)

The lights in the classrooms are controlled by using two movement detectors (master and slave sensor, covers larger area) that switches the lights off when the classroom is vacated (set to switch the lights off after 10 min. of absence) The users still has to switch the lights on manually (manual on/automatic off). The luminaires are equipped with eco T8 51 W long life fluorescent tubes and electronic ballasts. The calculated energy consumption is about 587 kWh/a (assessment made by using standard EN 15193, typical values for a classroom)

Measurements at the classroom: temperature, moisture, CO_2, illumination, consumption of electricity.

Reference classrooms

The reference classroom 1 at Pihkapuisto's old part includes T8 36 W fluorescent tubes with magnetic ballasts. The calculated energy consumption is about 994 kWh/a (assessment made by using standard EN 15193, typical values for a classroom).

The reference classroom 2 at Pihkapuisto's new part includes T8 58 W fluorescent tubes with electronic ballasts. The calculated energy consumption is about 823 kWh/a (assessment made by using standard EN 15193, typical values for a classroom).

The lights have been on about 1400 h/a

Measurements at these classrooms: temperature, moisture, CO_2, illumination, consumption of electricity.

Lighting arrangements of the entrance hall in Pihkapuisto

The lights in the entrance hall are regrouped to a smaller luminaire groups. Regrouping of the lights allows user to use just the amount of an electrical light that is needed at that moment. To help the user to make the decision to switch the lights on and off, we provide measurement data where he/she can see the current illuminance level at that moment. In addition to manual controlling of the lights a clockswitch (a timer) is added to improve the control system. The 21 pcs of luminaires are equipped each with 168 W high intensity discharge light bulbs and magnetic ballasts. The calculated energy consumption is about 9173 kWh/a, 1086 kWh/ (9) months, lights on totally 2600 h/a.

Measurements at the entrance hall: CO_2, luminance, consumption of electricity. The new Janitza MDVH 3106 measurement unit for electricity with KUW200-27 Current

Transformers were installed for measuring the consumption of electricity at the Entrance hall.

Gym hall in Pihkapuisto

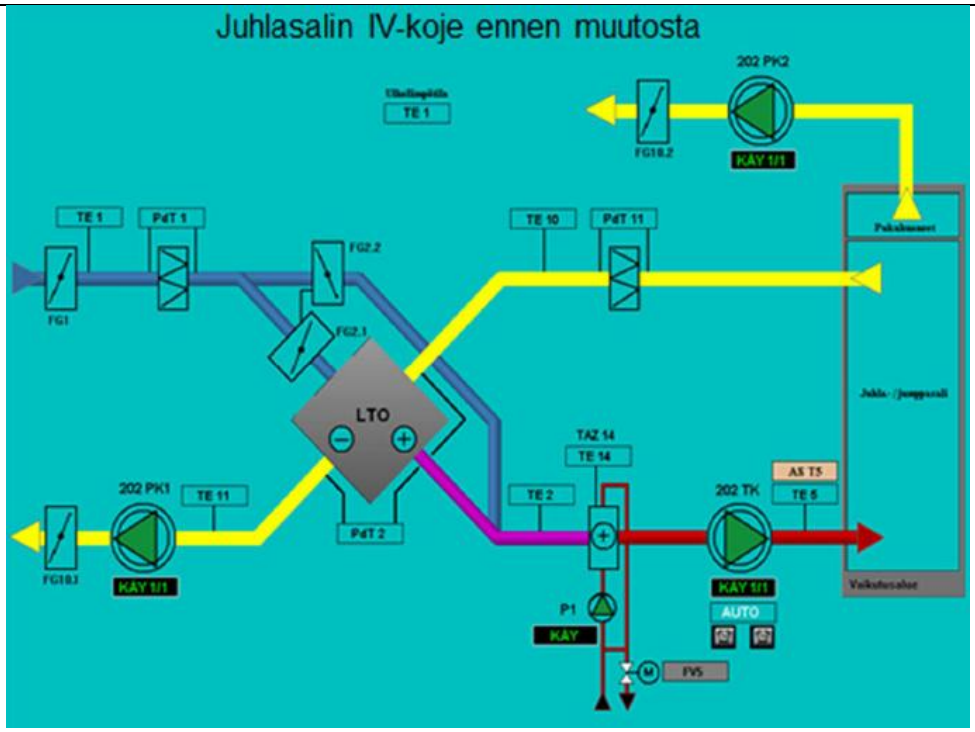
The new flexible, more beneficial and low powered CO_2 controlled EC motors were installed into the gym to control the HVAC with the building management & automation system. At the same the control system Trend was updated with a new software version.

The HVAC machine was earlier running with full power for 14 h/day (i.e. 70 h/week, 2590 h/a). The modernized new system is running all the time with minimum power and will increase the power according to the CO_2 measurements.

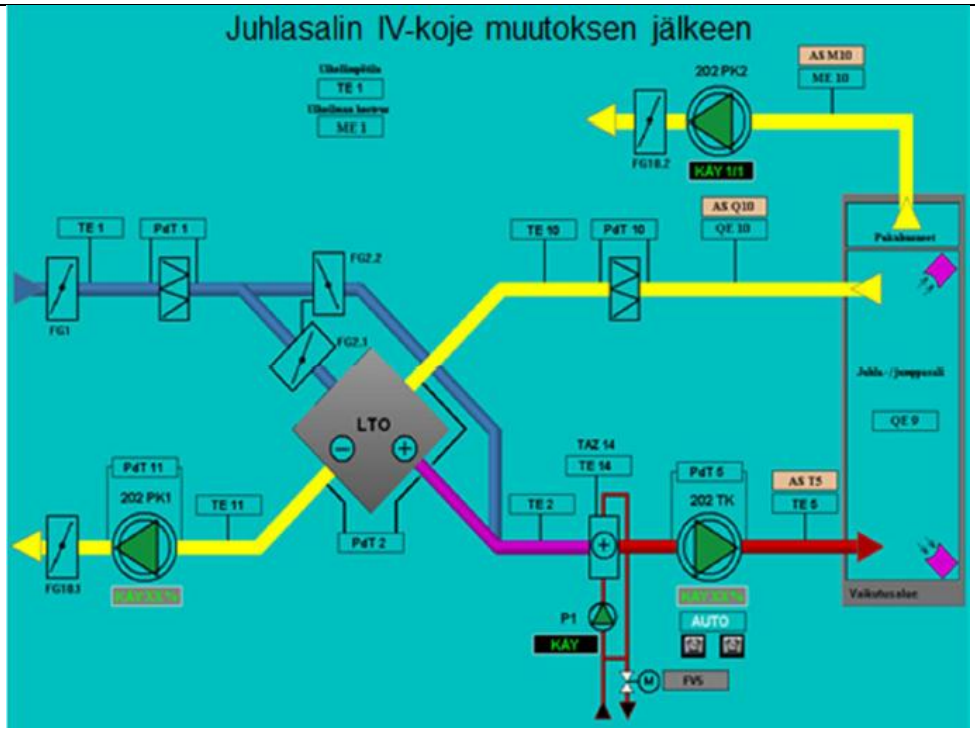
Measurements at the gym hall: temperatures, moisture, CO_2, illuminance, consumption of the electricity.

Pihkapuisto HVAC machine at Gym			Input machine		Output machine		Input machine		
			Power	Energy	Power	Energy	Amount of air	kWh	
Old HVAC machine:			kW	kWh	kW	kWh	l/sec		
Measured power			4		3		2 300		
Running time		07:00 - 21 .00							
	hours per day	14							
	hours per week	70							
Consumption per week		70 h * 3,53 kW		280		210		1 690	with 50 % he
New HVAC machine installed:		14. - 15.10.2009							
Measured energy consumtion during 25 weeks				2 667		2 663		727	
Old HVAC machine consumed during 25 weeks				7 000		5 250		0	
Electricity energy saved, kWh/25 weeks				4 333		2 587		963	Total:
Electricity energy saved, kWh/week									
Electricity energy saved, kWh/month									
Saving in %				**62**	**%**	**49**	**%**	**57**	**%**
Unit price for city of Helsinki			9	cnt/kWh			5	cnt/kW	
Saving in euros				368	€	220	€	52	
Total saving in euros during 25 weeks					588	€		1 305	€
Annual saving (during 41 weeks)					965	€		2 140	€
Total annual saving of heat and electricity					**3 105**	**€**			

HVAC machine before the change



HVAC machine after the change



Kitchen, dining room and kindergarten

The kitchen of Pihkapuisto is equipped with high power equipment and therefore it is natural to measure and supervise carefully the operational work and the usage of the kitchen machines.

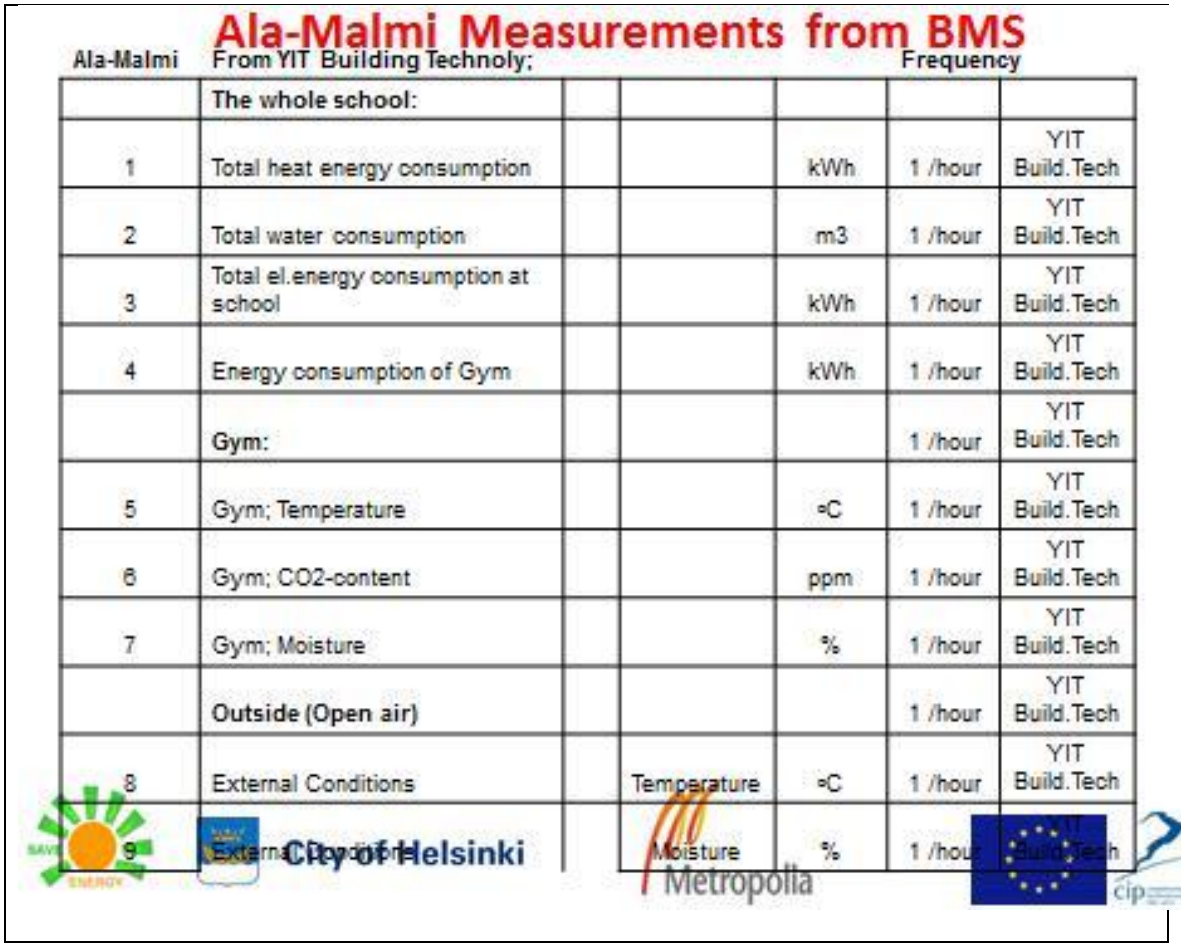
Measurements in the kitchen, dining room and kindergarten: temperatures, moistures, CO_2, illuminances and consumption of the electricity. The new Janitza MDVH 3106 measurement unit for electricity with KUW200-27 Current Transformers were installed for measuring the consumption of electricity at the Kitchen.

Measurements from the building management & automation system

Helsinki Pilot is based on the measurement information from the local building management & automation system. Pihkapuisto school has the Trend BMS system delivered by Arealtec Ltd, and Ala-Malmi school has the BMS system delivered by YIT Building Technologies.

Pihkapuisto measurements from BMS

Pihkapuisto:						
	From Trend/Arealtec:		Frequency			
	The whole school:				PointID	
1	Total heat energy consumption	kWh	1 /min	Trend	n/a	Arealtec
2	Total water consumption	m3	1 /min	Trend	n/a	Arealtec
3	Total el.energy consumption at school	kWh	1 /min	Trend	n/a	Arealtec
4	Energy consumption of Gym	kWh	5 /min	Trend	202EC1:1294 202EC2:1296	Arealtec
5	Energy consumption of kitchen equipment	kWh	1 /min	Trend	n/a	Arealtec
	Gym:		1 /min			
6	Gym, Temperature (recovery)	°C	1 /min	Trend	202TE10.1:1269	Arealtec
7	Gym; CO2-content	ppm	5 /min	Trend	202QE1:1265 202QE2:1266 202QE3:1267	Arealtec
8	Gym; Moisture, Shower Room	%	5 /min	Trend	202ME10.1(rel):1268 202Tv10.1(abs):1283	Arealtec
	Outside (Open air)		5 /min			
9	External Conditions (temperature)	°C	5 /min	Trend	101TE1: 1043	Arealtec
10	External Conditions (moisture)	%	5 /min	Trend	202ME01(rel): 714 202Tv01(abs):1285	Arealtec



Ala-Malmi Measurements from BMS

Ala-Malmi	From YIT Building Technoly;				Frequency	
	The whole school:					
1	Total heat energy consumption			kWh	1 /hour	YIT Build.Tech
2	Total water consumption			m3	1 /hour	YIT Build.Tech
3	Total el.energy consumption at school			kWh	1 /hour	YIT Build.Tech
4	Energy consumption of Gym			kWh	1 /hour	YIT Build.Tech
	Gym:				1 /hour	YIT Build.Tech
5	Gym; Temperature			°C	1 /hour	YIT Build.Tech
6	Gym; CO2-content			ppm	1 /hour	YIT Build.Tech
7	Gym; Moisture			%	1 /hour	YIT Build.Tech
	Outside (Open air)				1 /hour	YIT Build.Tech
8	External Conditions		Temperature	°C	1 /hour	YIT Build.Tech
9	External Conditions		Moisture	%	1 /hour	YIT Build.Tech

City of Helsinki
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Pilot applications at Ala-Malmi school

Multisensor controlled lights at the classroom (Pavilion 3)

The lights in the 3 classrooms of Pavilion 3 are controlled by using multisensors (a multisensor unit includes a light sensor and a movement detector). Depending on the availability of daylight the light sensor (photocell sensor) automatically reduces/increases the amount of electrical lighting and keeps the illuminance level constant. The movement detector switches the lights off when the classroom is vacated (set to switch the lights off after 10 min. of absence). Two multisensor units are mounted into the luminaires. These master luminaires controls the illuminance level of the slave luminaires that are on the same row / luminaire group. The luminaires are equipped with T5 45 W and 25 W fluorescent tubes and electronic ballasts (DALI). The calculated energy consumption is about 439 kWh/a (assessment made by using standard EN 15193, typical values for a classroom).

Measurements at the classrooms: temperature, moisture, CO_2, illumination, consumption of electricity.

Movement detector controlled lights in the classroom (Pavilion 2)

The lights in the 3 classrooms of Pavilion 2 are controlled by using two movement detectors (master and slave sensor, covers larger area) that switches the lights off when the classroom is vacated (set to switch the lights off after 10 min. of absence) The users still has to switch the lights on manually (manual on/automatic off). The luminaires are equipped with eco T8 51 W long life fluorescent tubes and electronic ballasts. The calculated energy consumption is about 587 kWh/a (assessment made by using standard EN 15193, typical values for a classroom)

Measurements at the classroom: temperature, moisture, CO_2, illumination, consumption of electricity.

Reference classrooms in the Pavilion 1

The reference classrooms in Pavilion 1 are including T8 36 W fluorescent tubes with magnetic ballasts. The calculated energy consumption is about 994 kWh/a (assessment made by using standard EN 15193, typical values for a classroom).

The reference classrooms in Pavillion 1 include T8 58 W fluorescent tubes with electronic ballasts. The calculated energy consumption is about 823 kWh/a (assessment made by using standard EN 15193, typical values for a classroom).

The lights have been on about 1400 h/a

Measurements at these classrooms: temperature, moisture, CO_2, illumination, consumption of electricity.

Kitchen, dining room

The kitchen of Ala-Malmi is equipped with high power equipment and therefore it is natural to measure and supervise carefully the operational work and the usage of the kitchen machines.

Measurements in the kitchen and dining room: temperatures, moistures, CO_2, illuminances and consumption of the electricity. The new Janitza MDVH 3106 measurement unit for electricity with KUW200-27 Current Transformers were installed for measuring the consumption of electricity at the Kitchen.

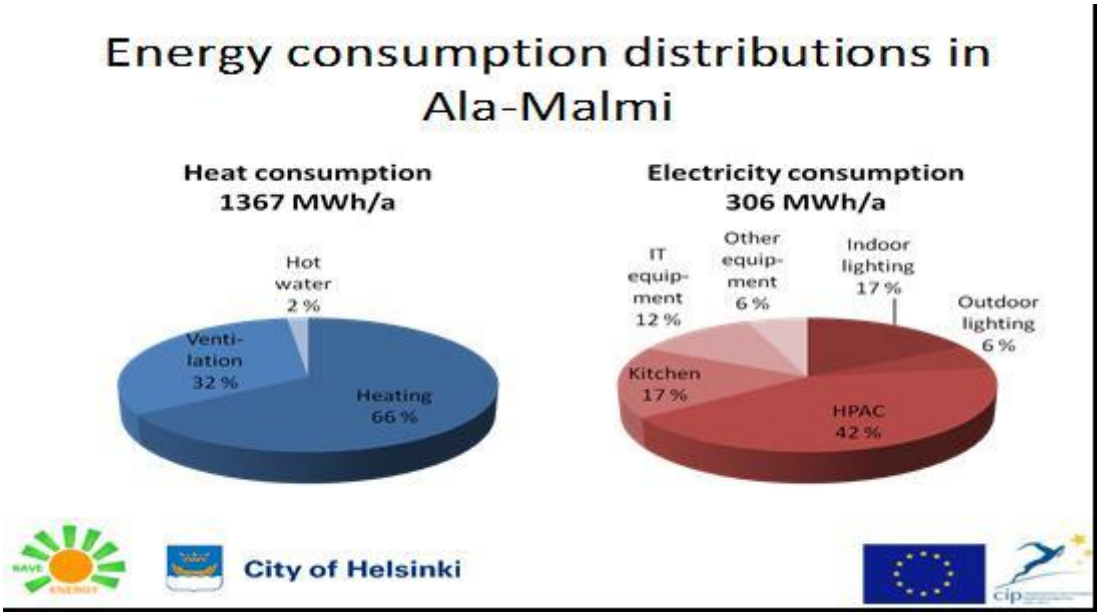
7 Energy Audit

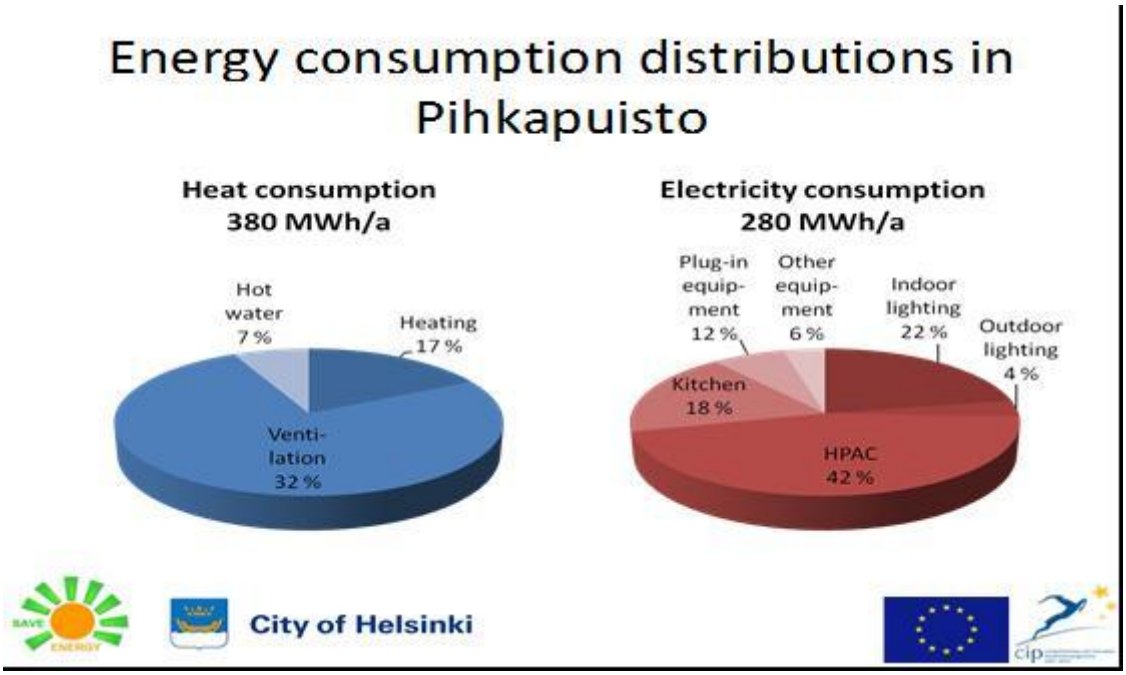
The Energy audits at Ala-Malmi and Pihkapuisto schools were made by the certified energy auditors of a private consulting company during February to May 2009. The consumption of the electricity at the kitchens were made during 6 weeks in April – May 2009.

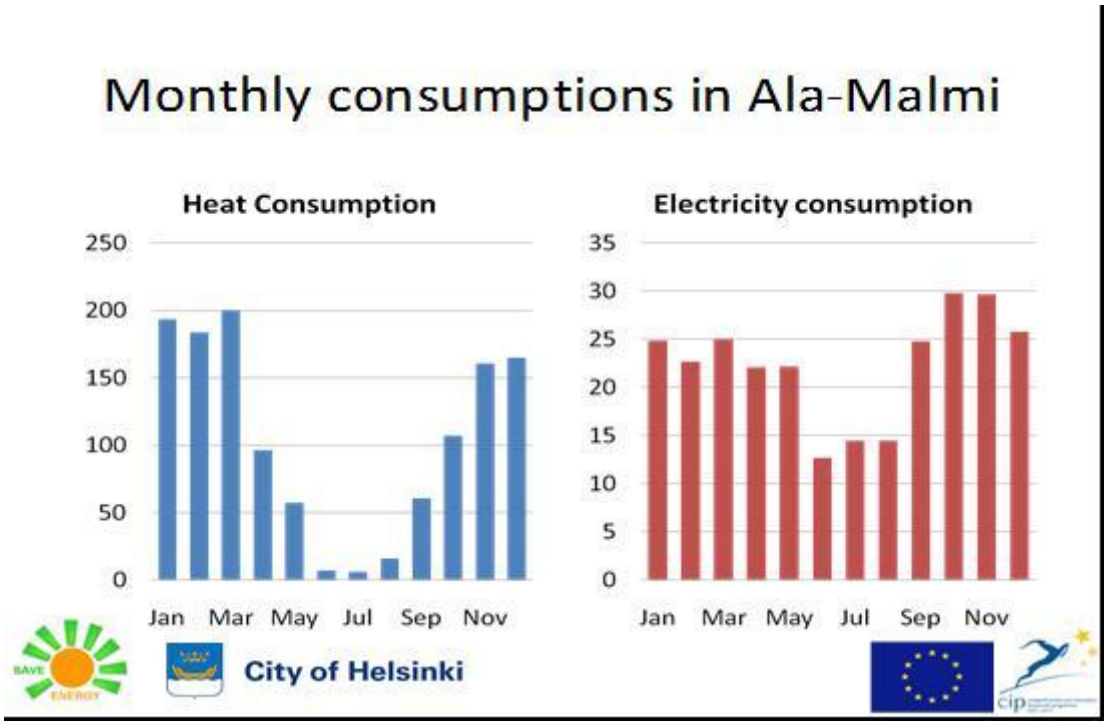
Final reports (after commenting & handover meetings) were received in October 2009 including the evaluation of the total electricity, heat and water consumptions of the whole school building, not just the pilot application areas. Calculation of energy consumption distributions were based on installed power and operational times of equipment.

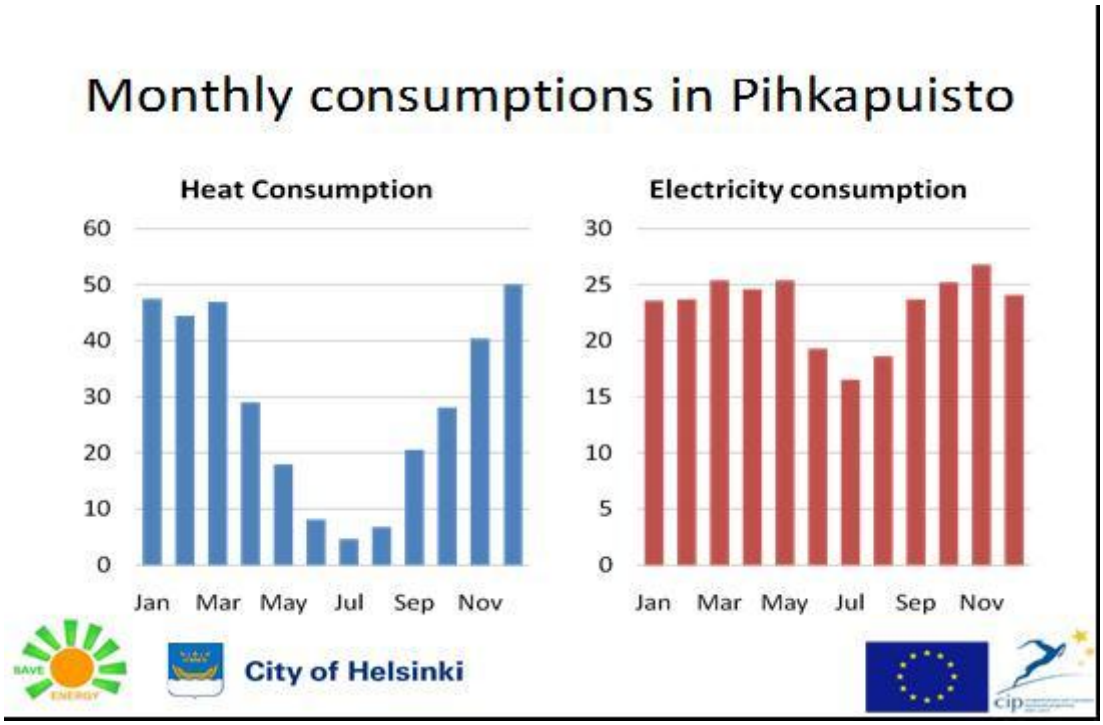
As the result of Ala-Malmi energy audit the following energy saving potentials were focused: 5 % in heat, 15 % in electricity and 4 % in water consumption. There were proposed 15 saving actions with profitability calculations, and 6 actions in check-list.

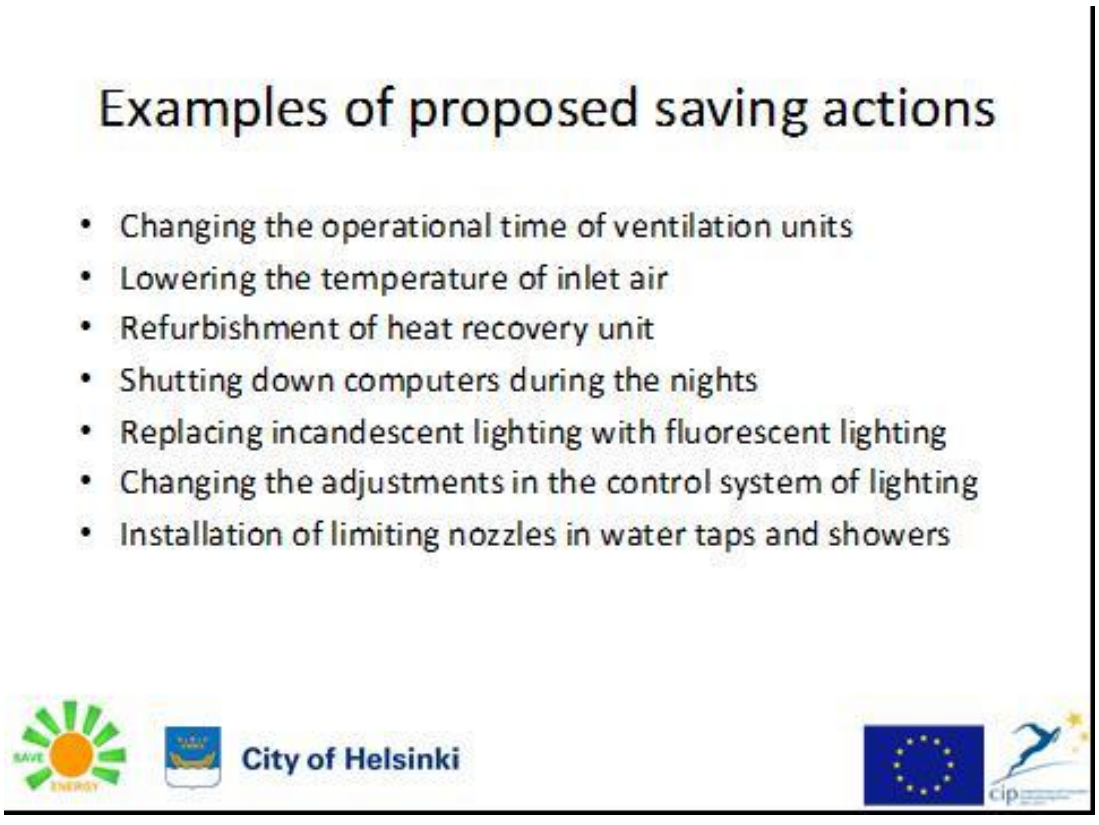
As the result of Pihkapuisto energy audit the following energy saving potentials were focused: 16 % in heat, 20 % in electricity and 4 % in water consumption. There were proposed 10 saving actions with profitability calculations, and 5 actions in check-list.




Energy consumption distributions in Pihkapuisto
Heat consumption
380 MWh/a
Hot water 7 %
Heating 17 %
Venti-lation 32 %
Electricity consumption
280 MWh/a
Plug-in equip-ment 12 %
Other equip-ment 6 %
Indoor lighting 22 %
Outdoor lighting 4 %
Kitchen 18 %
HPAC 42 %
City of Helsinki


Monthly consumptions in Ala-Malmi
Heat Consumption
250
200
150
100
50
0
Jan Mar May Jul Sep Nov
Electricity consumption
35
30
25
20
15
10
5
0
Jan Mar May Jul Sep Nov
City of Helsinki


Monthly consumptions in Pihkapuisto
Heat Consumption
60
50
40
30
20
10
0
Jan Mar May Jul Sep Nov
Electricity consumption
30
25
20
15
10
5
0
Jan Mar May Jul Sep Nov
City of Helsinki


Examples of proposed saving actions
• Changing the operational time of ventilation units
• Lowering the temperature of inlet air
• Refurbishment of heat recovery unit
• Shutting down computers during the nights
• Replacing incandescent lighting with fluorescent lighting
• Changing the adjustments in the control system of lighting
• Installation of limiting nozzles in water taps and showers
City of Helsinki

Results in Ala-Malmi

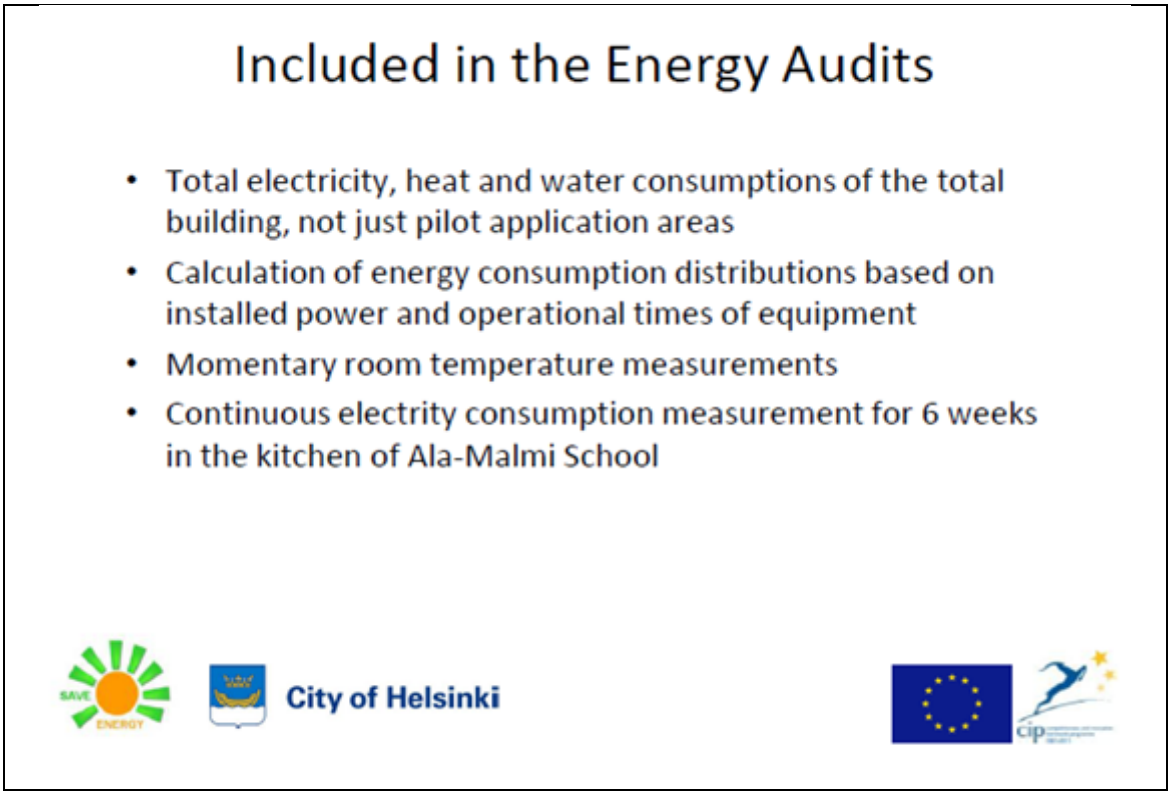
- Saving potential
  - Heat 5 %
  - Electricity 15 %
  - Water 4 %
- 15 proposed saving actions with profitability calculations
- 6 proposed actions in check-list
- Payback period of proposed actions on average 0.4 years (varying from 0 to 4.3 years)
- Required investments 1,960 €

City of Helsinki

Results in Pihkapuisto

- Saving potential
  - Heat 16 %
  - Electricity 20 %
  - Water 4 %
- 10 proposed saving actions with profitability calculations
- 5 proposed actions in check-list
- Payback period of proposed actions on average 2.1 years (varying from 0 to 7.5 years)
- Required investments 22,600 €

City of Helsinki


Included in the Energy Audits
Total electricity, heat and water consumptions of the total building, not just pilot application areas
Calculation of energy consumption distributions based on installed power and operational times of equipment
Momentary room temperature measurements
Continuous electrity consumption measurement for 6 weeks in the kitchen of Ala-Malmi School
City of Helsinki

8 Future Actions with the Users

The ICT system has now been developed and it is the time to advise the user to find it and to use in order to get the users to change their behavior. Thatswy we have proposed to users (teachers), how to get acquainted with the ICT system, and how to learn to save energy. As follows, there are some ideas we proposed:

- the way of implementation (teacher based activity at the classroom, max 1 h time reservation per two weeks, team working, small individual tasks at home for pupils together their parents, etc)
- supporting groups (Save Energy project and technical groups in Helsinki, Metropolia teachers & students, Motiva in Helsinki, energy companies, different teachers at schools

The objectives

- a list of topics to be discussed or taught at the classroom (with the aid of an expert (if needed), like, energy education, terminology, how we are using the energy, where we get the energy, the greatest energy consuming devices at schools, at homes, comparison of the energy consumption of the devices, the distribution of the energy consumption at home, at school, calculate with the energy calculator your own consumption at home, how could I save energy, find your own energy saving tips
- establish the energy user groups at school, like, water group, heat group, electricity group, energy game group, energy audit group, low energy house –group, energy car –group, energy consumption group (lighting, home & office devices), energy tips & quiz –group
- some tips for teachers on, what to do with pupils (f. ex. homework); info table (energy marks) of energy consumption on electrical devices (a comparison), stand by electric equipment at my home, unit consumption of devices (how to calculate kWh ?), one day without electricity, how to reduce water consumption, check the lights (wise lighting), what is energy house, I am energy detective, saving energy at school, at kitchen, at home, make your own Top10 list of energy saving tips, make your own promise to save energy
- some other operations, like, company visits, usage and benefits of web 2.0, interviews, net questionnaires, quizzes, monthly saving results (and rewards), energy saving week or theme days a day without electricity, supervision of the usage of the devices at home, networking internationally, etc.