Energy Management in Public Buildings

Notranje usposabljanje podjetja EUTRIP, d. o. o.

Celje, 21. januar 2014

Module RUE / Rational use of Energy

Module RES / Renewable Energy Sources

Module ICT / Implementing smart ICT concepts

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Key energy challenges for Europe

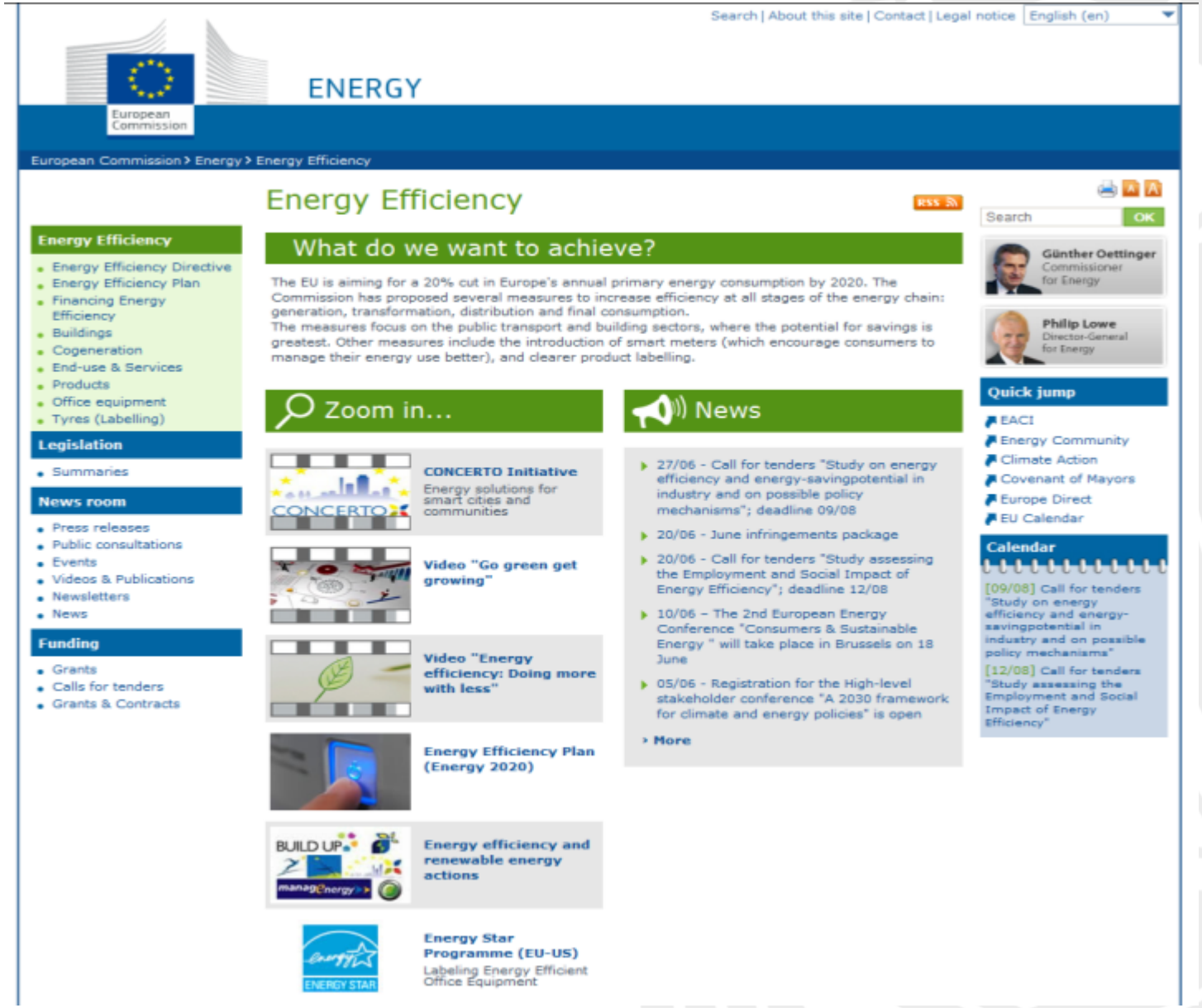
- Europe is increasingly dependent on importing energy from third countries
- Europe is in a global race for energy sources
- Some of the EU's price increases come from national policy choices - Energy bills for consumers are rising
- Investments in the energy sector at historically low levels
- The right policies are in place but implementation is too slow
- Energy efficiency: investing in a cheaper and cleaner source of energy
- Meeting the EU's 20% energy efficiency target by 2020 means saving the equivalent of 1.000 coal power plants or 500.000 wind turbines
- Open and competitive energy markets – meeting EU needs

- **Technology and innovation …**

More information of energy efficiency: http://ec.europa.eu/energy/efficiency/

Introduction

http://ec.europa.eu/energy/efficiency/index_en.htm



Energy efficiency

The Energy Efficiency Directive was adopted in October 2012 and is expected to allow the EU to approximately reach up to 17 % of the 20 % energy efficiency for 2020.

Also in 2012 the EU-US Energy Star agreement on labeling of energy efficiency office equipment was concluded and the Energy Efficiency Fund was set up with a EUR **265 million budget**. expected to integrate programmes promoting energy efficiency.

The Smart Cities and Communities European Innovation Partnership was launched in July 2012 to boost innovative energy-transport-and-ICT technologies' solutions enhancing sustainability in cities and communities.

Energy efficiency: transposition of the energy performance of buildings directive

Directive (2010/31/EU of 19 May 2010)
Transposition date: 9 July 2012

Member State	Energy performance of buildings directive*		
	Transposition	NZEB** report	Cost-optimal calculations
Austria			
Belgium			
Bulgaria			
Cyprus			
Czech Republic			
Denmark			
Estonia			
Finland			
France			
Germany			
Greece			
Hungary			
Ireland			
Italy			
Latvia			
Lithuania			
Luxembourg			
Malta			
Netherlands			
Poland			
Portugal			
Romania			
Slovakia			
Slovenia			
Spain			
Sweden			
United Kingdom			

- Transposition status is based on declared transposition by Member States (Green: Full; Orange: Partial; Red: No).

- The Commission is undertaking prima facie and conformity checks for those Member States having notified transposition measures.

- For the NZEB reports and the cost optimal calculations, the status is based on whether or not reports have been received and not on the completeness of the reports. The Commission is undertaking analysis of the reports received.

** Nearly-zero energy buildings.

The classification of objects into classes of energy efficiency

Class EE	Annual energy needed to heat the building per unit of useful floor area **(kWh/m²a)** - Eop
A1	0 - 10
A2	10 - 15
B1	15 - 25
B2	25 - 35
C	35 - 60
D	60 - 105
E	105 - 150
F	150 - 210
G	210 - 300 and more

Etn – energy number for electricity yearly consumption (kWh/m²a)

Eop – energy number for heating yearly consumption (kWh/m²a)

Energy parameters of building

TYPICAL PARAMETERS OF BUILDING CONSTRUCTION, E numbers

On the basis of annual energy consumption and the ground plan of school usable are calculated the annual number (index) of energy for heating and electrical installations.

Typical energy parameters of buildings

The classification of buildings

Energy indicators of buildings

Ee – energy number for electricity yearly consumption (kWh/m^{2}a)

Eh – energy number for heating yearly consumption (kWh/m^{2}a)

Energy parameters of building

Structural parameters of the building

Usable area of the building	Au = xxx m2
Heated building volume	Ve = xxx m3
The entire outer surface of the building	A = xxx m2
Form factor buildings	fo = A / Ve

Classification of buildings (building physics data)

Subject to an annual heat required	xxx kWh/m3a
Calculated annual heat required	xxx kWh/m3a
The actual heat consumption in	xxx kWh/m3a

Number of energy - energy efficiency indicators

Eh: heating	(kWh/m2, kWh/m3a)
Ehw: hot water	(kWh/m2 m3/a)
Ee: Electricity	(kWh/m2a)

E: the total number of buildings (kWh/m2) **E = Eh + Ehw + Ee**

Annual consumption of cold water (m3)

Annual CO2 emissions (t or. Kg)

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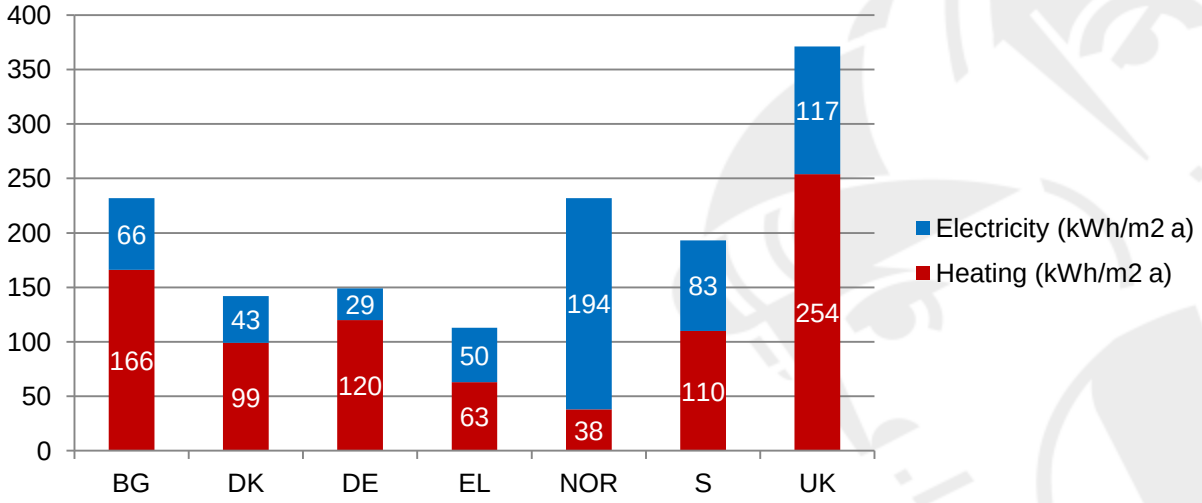
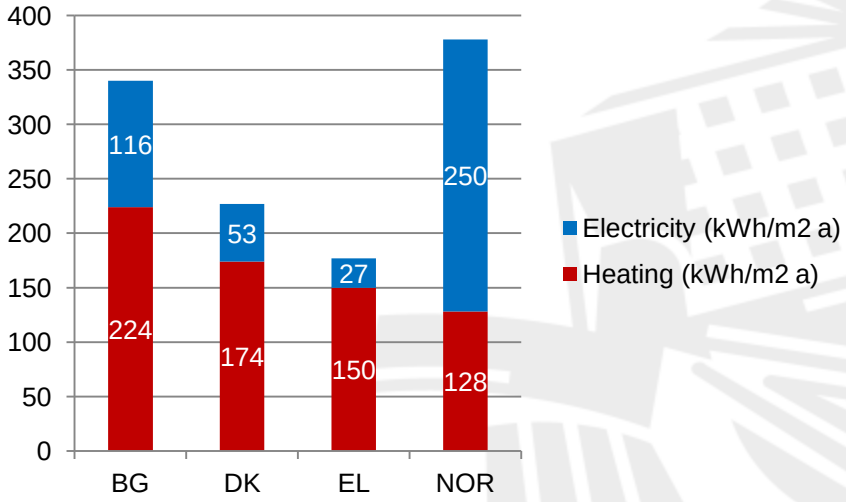
The average energy parameters of offices in some EU members (2005)



The average energy parameters of hospitals in some EU members (2005)



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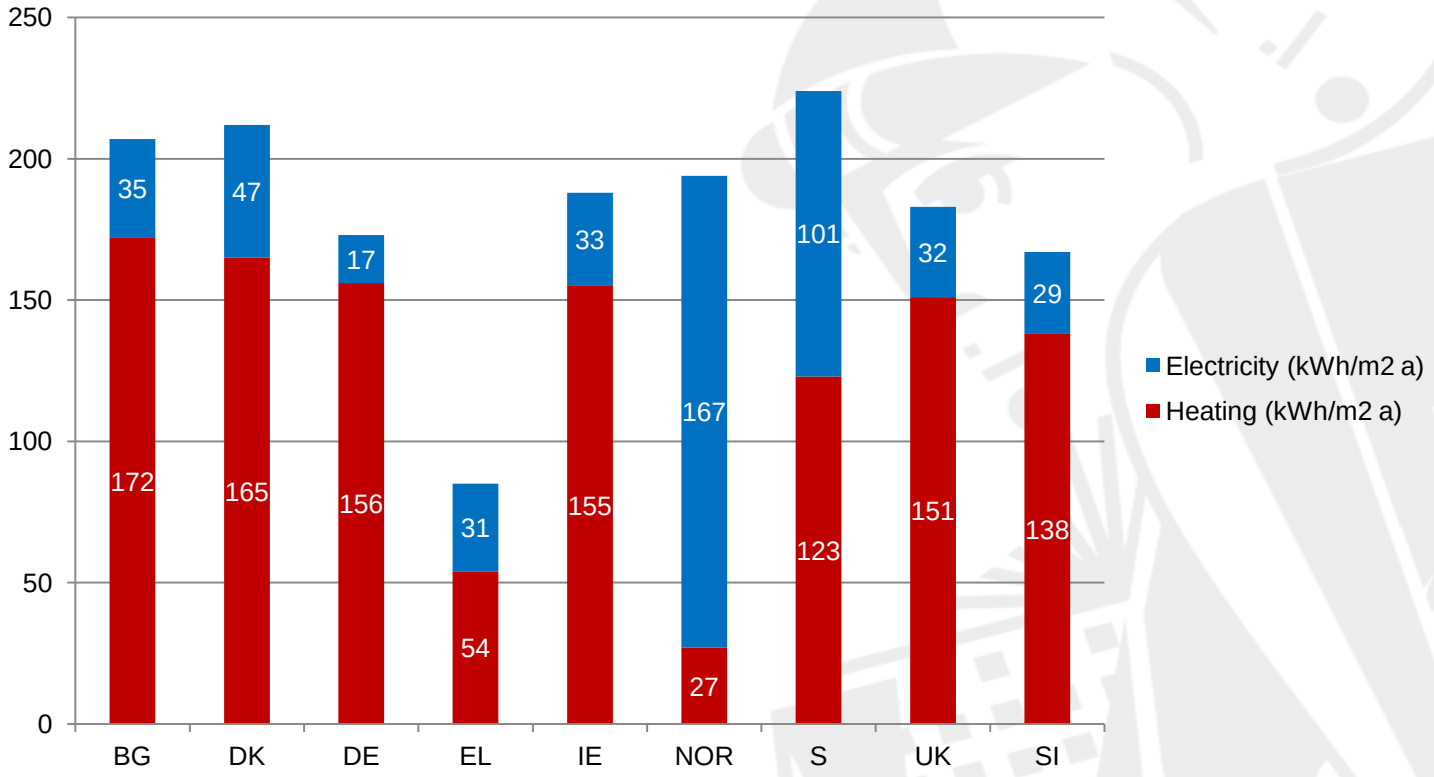
The average energy parameters of schools in some EU members (2005)



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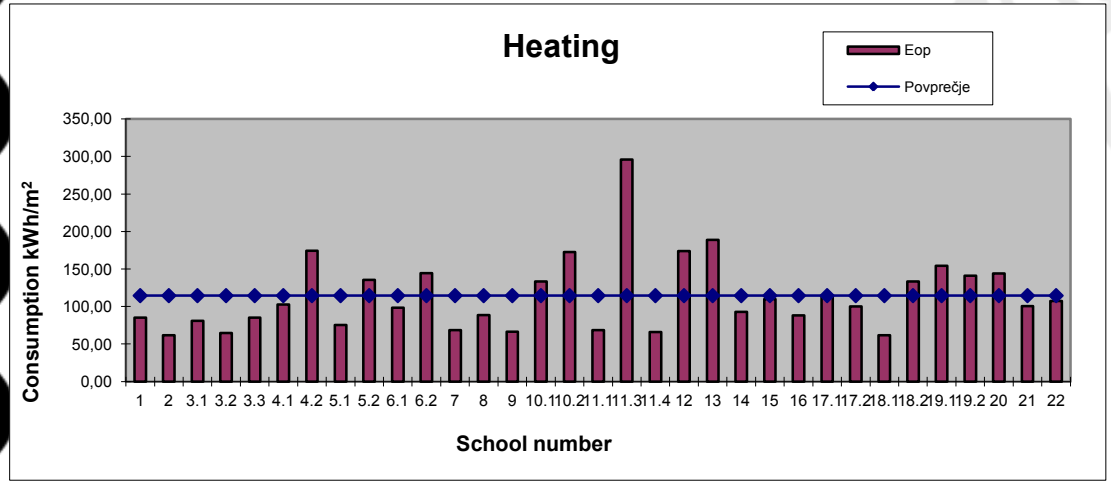
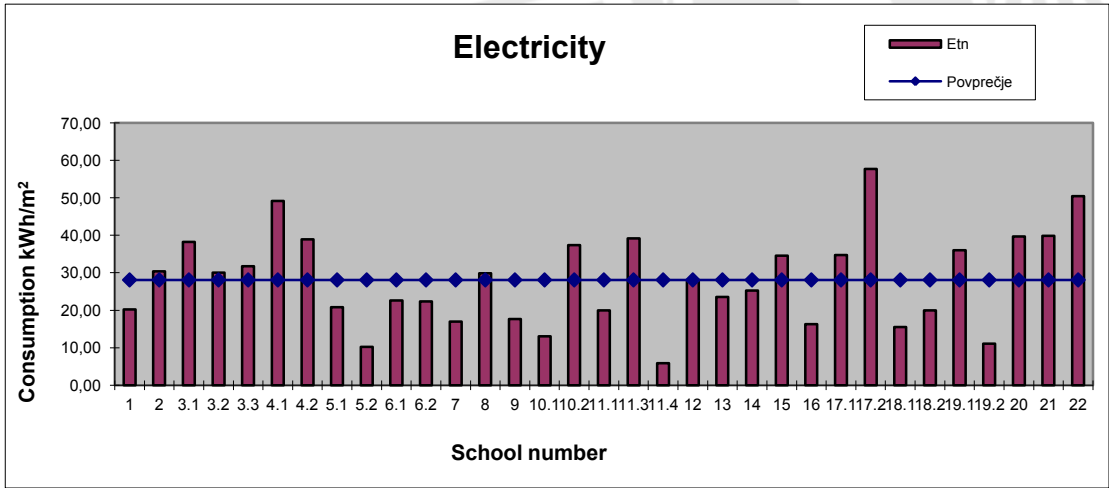
CASE SLOVENIA

The average energy parameters of secondary schools: Eop = 115, Etn = 28

The average energy parameters of primary schools: Eop = 160, Etn = 30



Data from the extended energy audits 22 secondary schools – Slovenia, February 2010

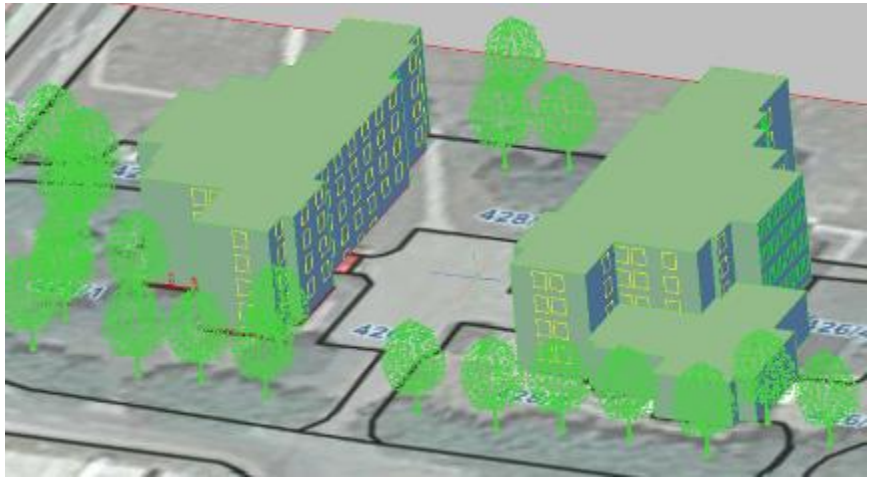


Energy status of some public buildings in Slovenia

LJUDSKA UNIVERZA VELENJE 2004 - adult education

Eop: 193
Etv: 0
Etn: 35
E: 228
Reu: **F**
Emisije CO_2 (t): 50

DIJAŠKI DOM NOVO MESTO 2007 – student hostel



Energy parameters	Year 2006	2007
Eop: heating	114	95
Etn: electricity	48	45
E	**162**	**140**
Reu:	**E**	**D**
Emisije CO_2 (t)	**412**	**365**

OSNOVNA ŠOLA GUSTAVA ŠILIHA VELENJE
Primary School

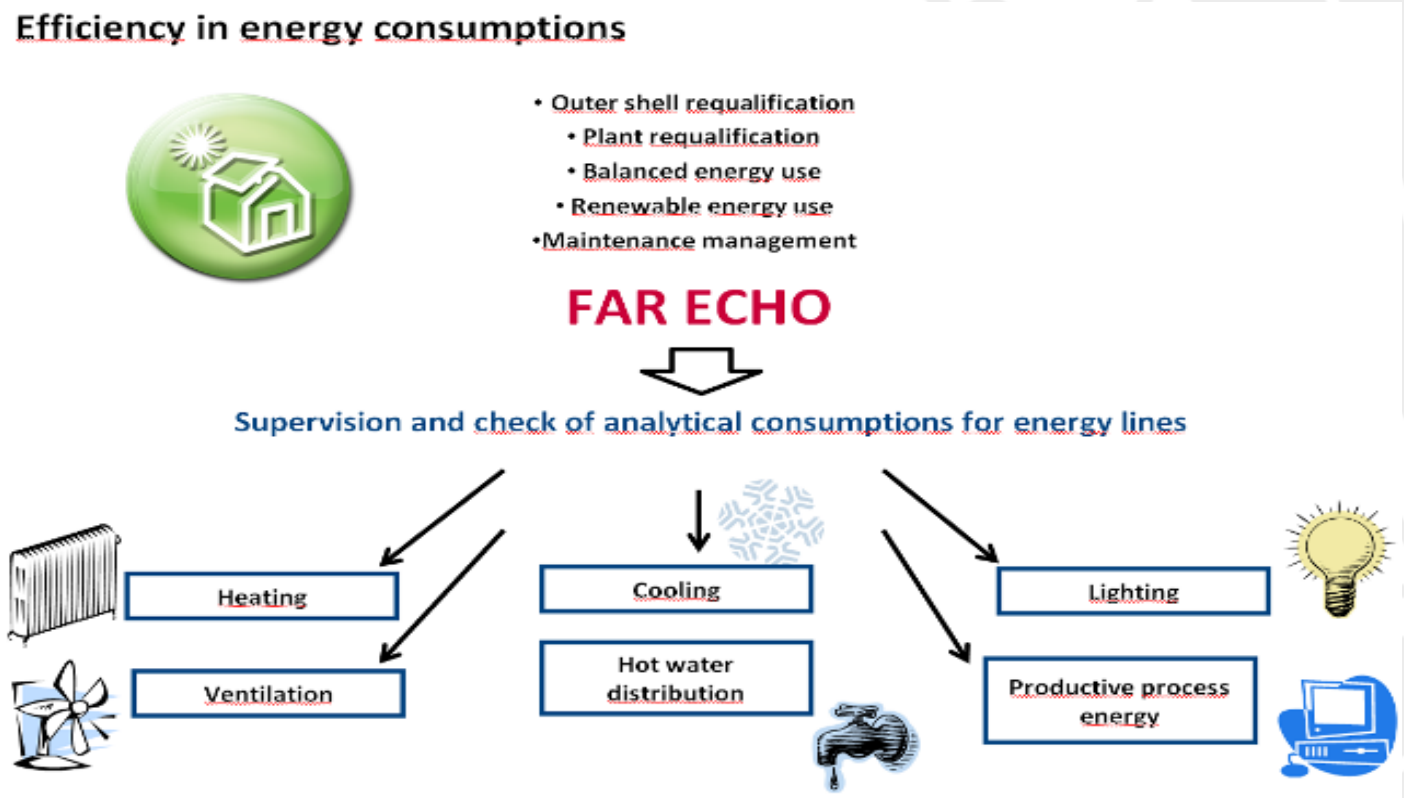
Year	2004	2005	2006
Eop: heating	214	179	157
Etn: electricity	24	18	15
E:	**238**	**197**	**172**
Reu	**G**	**F**	**F**
Emissions CO_2 (t)	**312**	**256**	**223**

OŠ Koroški jeklarji Ravne na Koroškem 2007
Primary school

Eop: 120
Etn: 32
E: 152
Reu: **E**
Emissions **CO_2 (t): 325**

Energy management in public buildings

- Energy management may be defined as the control of energy flows through a system, so as to maximize the net benefits to the system
- It involves the collection, analysis and monitoring of information on energy use, and the identification, evaluation and implementation of energy saving measures
- **Aim:** Reduce both Energy Demand/Costs and Environmental Damage!



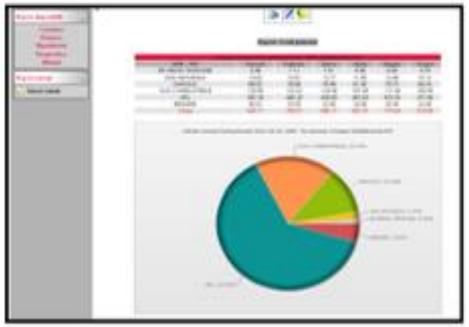
System of Energy Management

Multi-user system and authorization configuration management

Energy Manager

Maintainer

Money Administrator



Energy management primary tasks

- **building energy view and audits - construction building envelope, mechanical and electrical instalation and equipments**
- **implementation of energy bookkeeping**
- **continuous monitoring of energy use and energy costs**
- analysis and design of the building's energy needs
- implementation and control measures to save energy
- **surveillance and control of users living comfort in building**
- participation in internal and external projects
- cooperation with other governmental and non-governmental institutions
- dealing with issues of energy efficiency and renewable sources of energy and ecology
- **reporting on the state building energy efficiency, implementing awareness raising activities**
- planning of other organizational, technical and investment activities …

....

Primary topics of building energy audit

Functional view of buildings

Take periodic inspections and give some review (facade, sealing of the windows, insulation, the status of radiators and thermal substations, lighting, other electrical equipments ...). Define (measure) the basic parameters of the building construction (usable area, the volume ...).

Analysis of energy use in the building

Take the individual energy system audits with focus on measuring counting-off points:

- Implementation of heating and cooling
- The system for hot and cold water supply
- Electrical power system and consumers

Analyses, microclimate measurements

Analyses of energy with costs

- Audit the energy accounts for every month and with the help of EXC tables and charts make an month analysis of energy consumption, and specify the annual energy consumption.
- **Inventory of electrical and heat consumers in the building,** measure usage of each major energy consumers: heating, cooling, electrical
- **Measurements of electricity consumption and peak power**
  List daily and weekly consumption of electricity and analyze it.
- **Measurements of microclimate in the classroom**
  Make internal measurements of temperature, humidity, CO2 concentration and illumination of selected classrooms, ancillary rooms, offices …Take the external measure climatic parameters into account.

Some instruments for the measurement of living comfort and energy consumption

The internal temperature

Winter time:

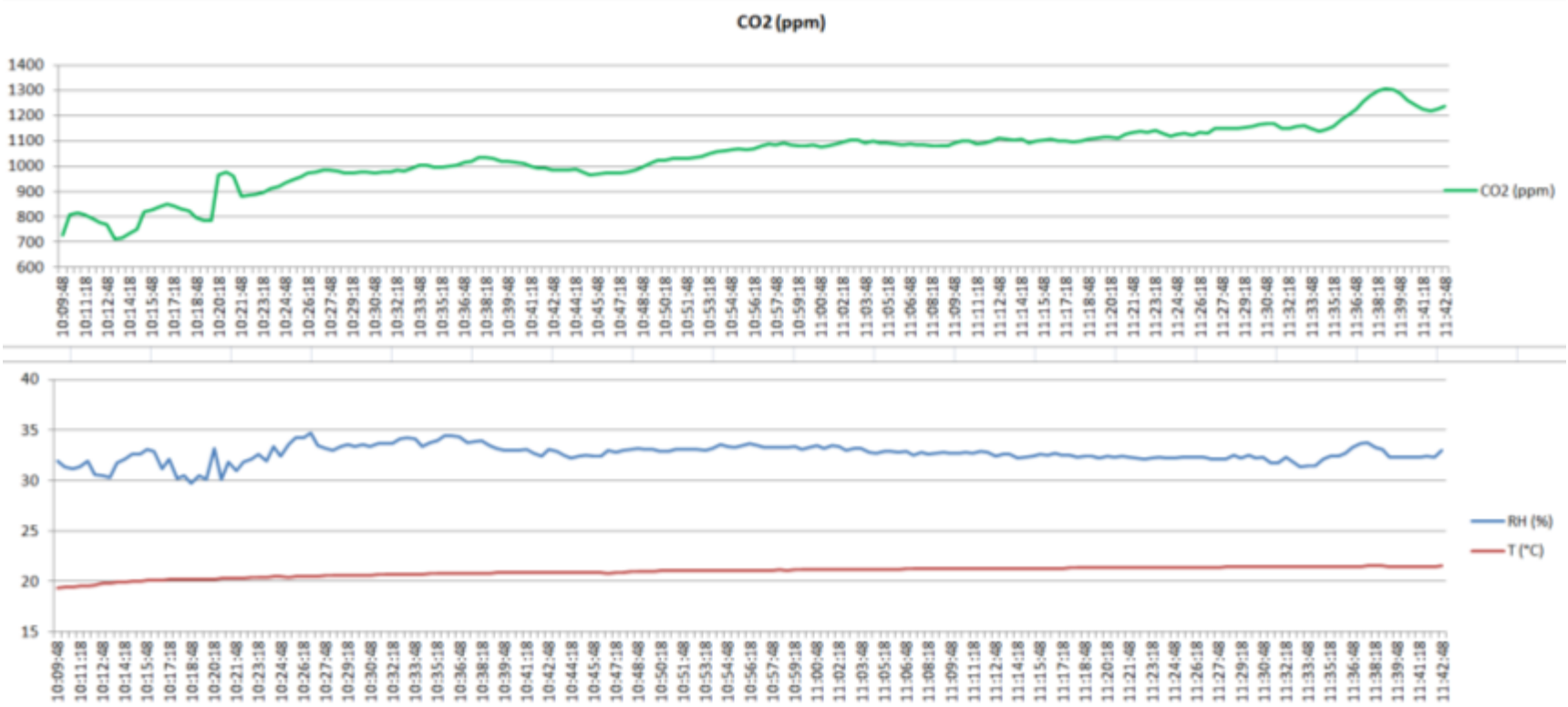
- air temperature ..... 22 ºC ± 2 ºC
- temperature difference of 0,1 meter and 1 meter above the ground .....less than 3 ºC
- soil temperature ..... 19 ºC - 26 ºC
- mean velocity of air movement ..... less than 0.15 m/s

Summer time:

- The air temperature in the room ..... 23 ºC - 26 ºC
- temperature difference of 0.1 and 1.1 meters above the ground ..... less than 3 ºC
- mean velocity of the air ..... less than 0.25 m/s

Other reference values of the living comfort parameters

- The relative humidity RH: from 35% to 85%
- Noise in the room: up to 35 dB / 40 dB contingent in shorter time interval
- Minimum average luminosity general classrooms Emin = 300 lux, table Emin = 500 lux
- The recommended concentration of CO2 in the room: up to 1000 ppm / conditional to 1500 ppm with occasional short-term ventilation



Example

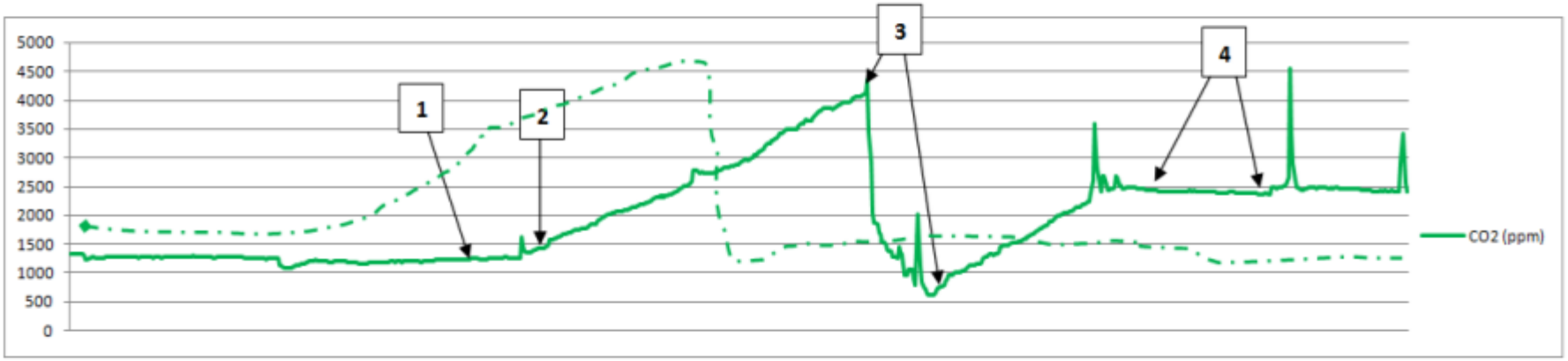
Example 1: Daily/Weekly/Monthly measurement of microclimate in the classroom A13/A14, ... /Date: _____

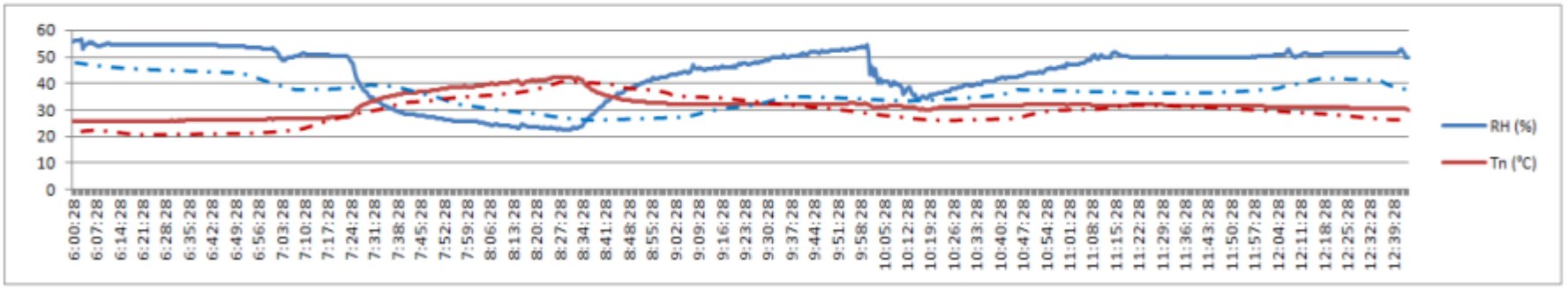
- **Outdor** hour 8.00: Tz = 17,0 °C; hour 12.30: Tz = 27,7 °C/ RHz = 47,8 %
- **Indor**

Event 1	Ura 8.00:	Tn = 38,7 °C;	RHn = 25,6 %;	CO2n = 1237 ppm	/ comming in clasroom
Event 2	Ura 8.20:	Tn = 41 °C;	RHn = 23,4 %;	CO2n = 1405 ppm	/ start of lesson
Event 3	Ura 10.00:	Tn = 32,1 °C;	RHn = 50,8 %;	CO2n = 4364 ppm	/ airing 20 minut
Event 4	Ura 11.15:	Tn = 31,7 °C;	RHn = 51,5 %;	CO2n = 2686 ppm	/ non-aerated empty classroom
Avg:		Tn = 31,8 °C;	RHn = 44,3 %;	CO2n = 1944 ppm	
Min:		Tn = 25,7 °C;	RHn = 22,5 %;	CO2n = 619 ppm	
Max:		Tn = 42,5 °C;	RHn = 56,9 %;	CO2n = 4555 ppm	
Num. of occup. : 20 students + teacher					

A13 ——

A14 - · - · -





Energy reconstruction facility - the introduction of energy management

1. Organisational measures

- **energy management** and the formation of an **Energy Fund**
- Implementation of quality expanded building **energy audit**
- implementation of **energy bookkeeping** and control
- **energy monitoring**
- time employees, scheduling adjustments, etc ...

2. Awareness for Schools

- introduction of optional subjects in the field of RUE, RES and ecology
- implementation of educational campaigns for students, staff, external
- Research works, participation in competitions, symposiums …

3. Technical and investment measures

4. The introduction and use of alternative energy sources - RES

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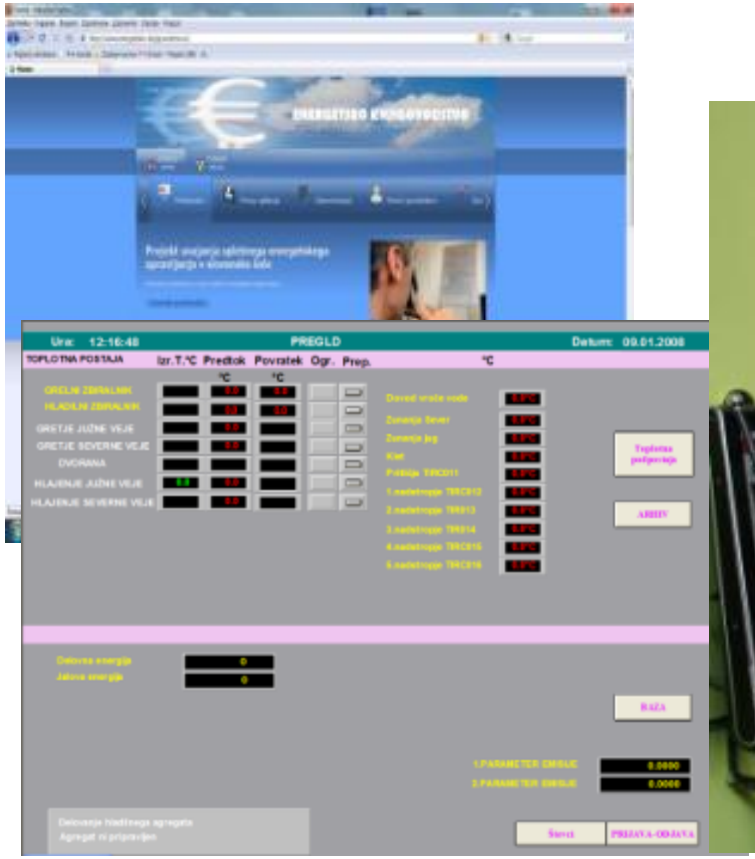
ENERGY MANAGEMENT

Web energy management in public buildings

1. Phase: a) web portal
   b) online energy bookkeeping

2. Phase: Installation info-energy points

3. Phase: installation of energy control system



Building Energy Monitoring

The basic tasks of the *building energy monitoring* are:

- energy capture, processing and analyzing of energy consumption and its costs **at the real current level** (e.g., minute, hourly and daily consumption from installed sensors)
- and **at monthly basis**, realized through invoices received from the energy suppliers.

We get a **real time database** and an **invoicing database of energy consumption** data which can be compared. So we can plan and analyze energy in daily and monthly consumption.

For **the successful building energy management** is necessary to monitor:

- **the rational use of energy,**
- **rational water supply and**
- **indoor environmental quality**.

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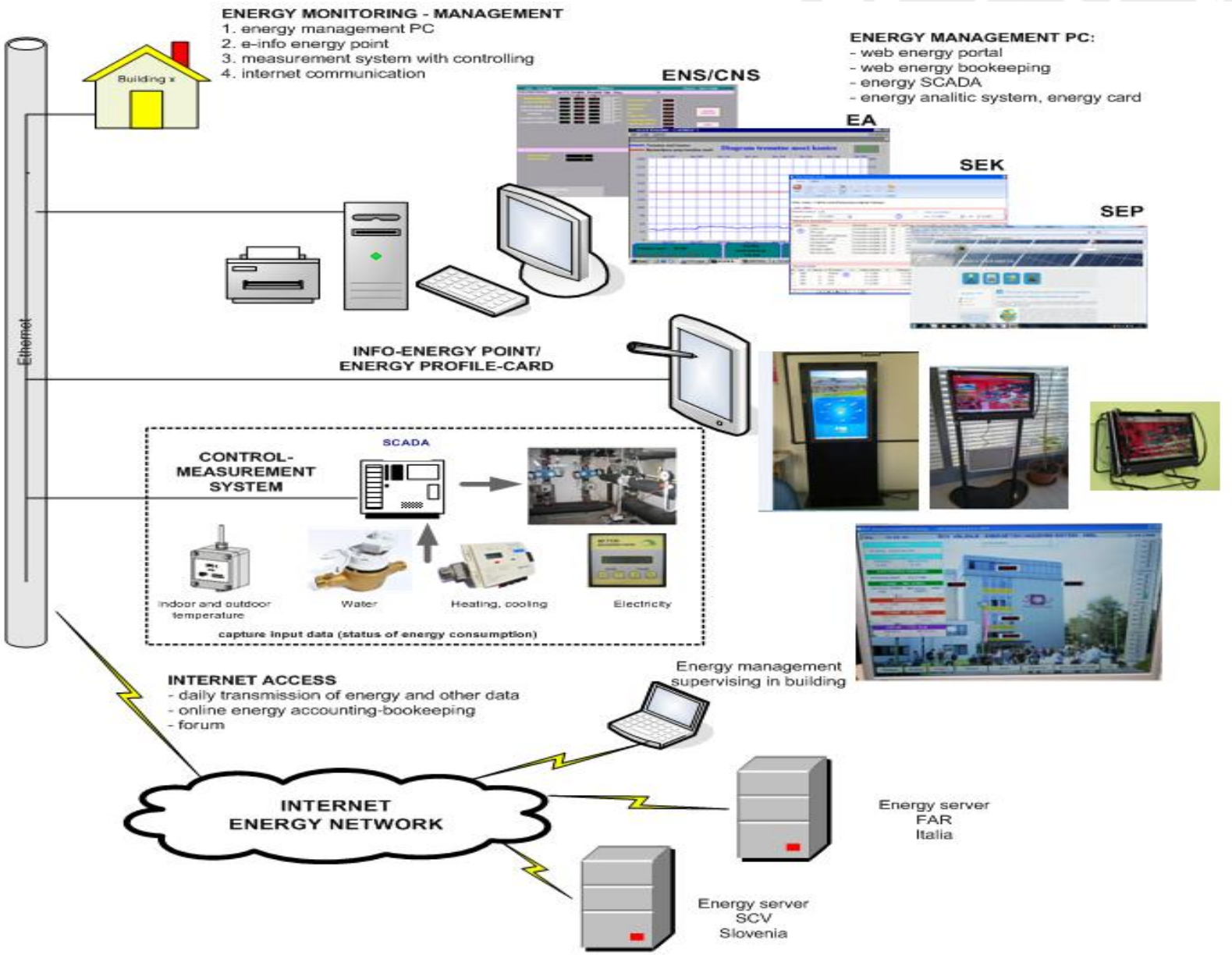
Online building energy management – WEB energy monitoring



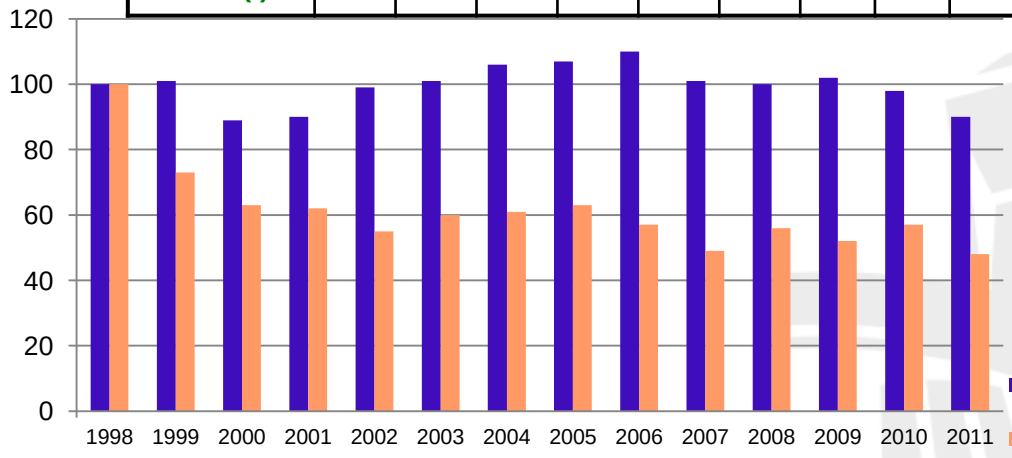
Example of good practice

Energy Efficiency at Velenje School Centre,
Location: Trg mladosti 3, Velenje

	energy saving
Organizational actions	*10 %*
Education and training activity	*5 %*
Technical and investment measures	*30 %*

Energy consumption SCV in the period 1998–2012

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Energy (GJ)	14256	11100	9624	9522	8567	9303	9453	9839	8906	7841	8734	8262	8900	7568	7165
Electricity (MWh)	**252**	255	224	227	250	255	266	270	276	254	251	256	246	227	233
El.peak power (kW)	1848	1999	1760	1628	1655	1712	1660	1703	1665	1559	1483	1477	1310	1137	1251
Heat (MWh)	**3890**	2828	2449	2418	2129	2329	2359	2463	2198	1924	2181	2039	2226	1875	1768
Etn (kWh/m²)	**14,6**	14,9	12,9	13,1	14,5	14,8	15,5	15,7	16	14,7	14,5	14,8	14,3	13,2	12,68
Epk (W/m²)	**107**	116	102	94	96	99	96	99	96	90,3	85,9	85,6	75,9	65,8	72,49
Eop (kWh/m²)	**225 G**	164 **F**	141 **E**	140 **E**	123 **E**	135 **E**	137 **E**	143 **E**	127 **E**	111,5 **E**	126,4 **E**	118,1 **E**	**128,9 E**	**108,6 E-D**	**102,4 D**
Emission CO2 (t)	1488	1118	969	960	870	943	959	997	907	803	897	841	910	774	733



Etn – energy number for electricity
Epk – energy number for el. peak power
Eop – energy number for heating

The cost of energy
Share in total yearly expenses in 1998: 3,3 %
Share in total yearly expenses in 2009: 1,9 %

Energy Efficient Appliances 1998-2013

➢ Organizational actions and education activities

- **Conducted energy audit of SCV buildings** – year 1999
- **Implementation of energy management into SCV organization scheme** – year 2000
- **Forming the project group for RUE in SCV** (2000), which basically deals with
  - **energy bookkeeping** and energy management
  - exterior and interior lighting
  - optimization of electricity consumption
  - education and providing information of RUE and RES
- **Establishment of ecological council in SC Velenje**,
  - the initiation of implementation of activities for acquiring the title »eco school» (2004)
  - acquisition of the title »ecology school« (April 2005)

Participation in Major EU projects

- European project INTERREG: **Future Public Energy**, in cooperation with Local energy agency KSSENA-o and Municipality Velenje (2007/08);
- Partnership in international project COMENIUS **House of the Future** (2007-2009);
- Implementation of educational activities in the framework of the European project **Active Learning** and **Kids for Future** in cooperation with Energy Restructuring Agency, Ljubljana-ApE (2007);
- European project IEE: **European Young Energy Manager Championship, 9 EU countrys;** Acronym of the project: **EYE Manager Championship;** (2008-2010)
- European project IEE: **Training courses for installers of small-scale renewable energy systems in buildings**; Acronym of the project: **InstalL+RES** (2010-12)
- European project IEE: **U4energy;** purpose is to promote awareness of the need to save energy across Europe (2010-11-12)
- European project CIP: **Smart Build;** Implementing smart ICT concepts for energy efficiency in public buildings (2012-14)

Energy Efficient Appliances 1998-2014

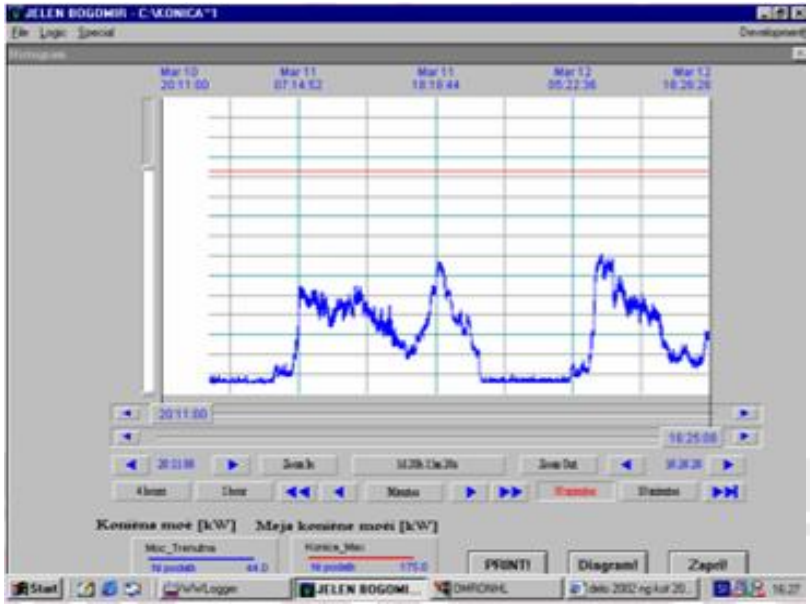
➢ Technical and investment measures

Implementation of RUE projects in SC Velenje mainly with own resources:

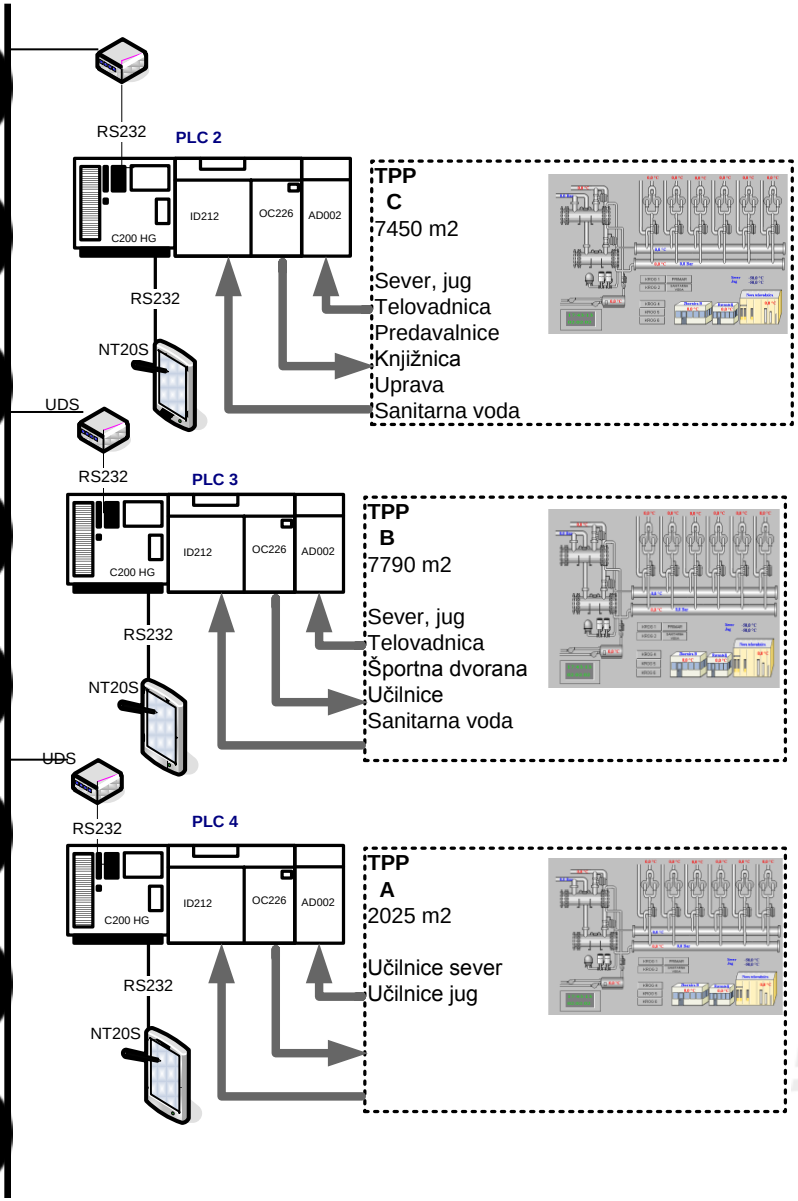
- Development of system for supervising electricity consumption (2000),
- Reconstruction of two thermal sub-stations in SCV in the context of RUE (2001),
- Modernization of interior lighting in the context of RUE (2002) …
- Comprehensive buildings energy refurbishment 2012

Automation of Energy Management in SCV

- Energetic automation of heating system for complex buildings in the school centre
- Supervising system for controlling of electric peak power demand
- First automation components based on PLCs, touch screens and PCs



SCV Energy information system for heating



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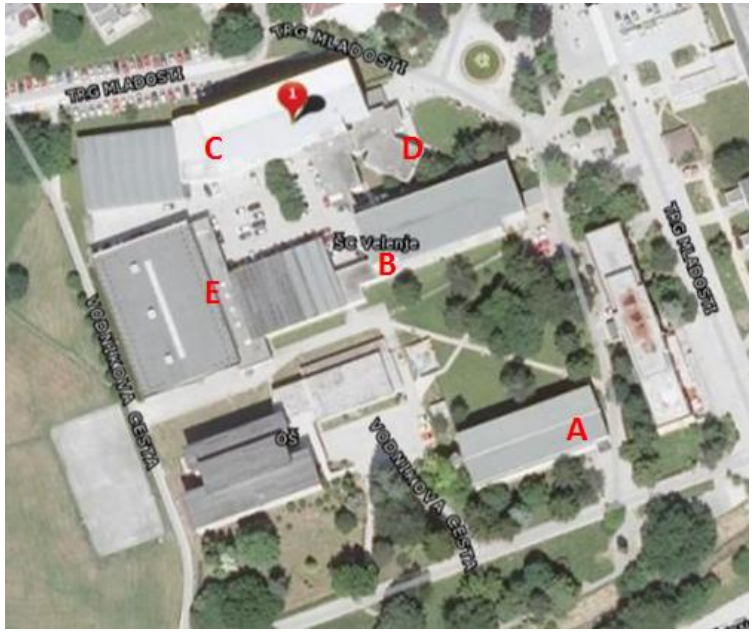
Interior lighting modernization …

Reconstruction of indoor lighting, which based on electronic ballasts and fluorescent lamps controlled with light-sensors

(DALI system - Digital Addressable Lighting Interface)

Energy Reconstruction of SCV- Building C



This is an educational institution with a long tradition in the field of electrotechnical and computer science education and higher professional education in the field of electronics, mechatronics and information technology.

Institute attend approximately 600 students and 40 teaching staff workers. Before the energy refurbishment was the **building energy number** of heating around **110 kWh/m2a,** calculations shows that the number of heating energy will be **65 kWh/m2a**.

Energy renovation project has been partially financed by the **European Union and the state**. The total investment amounted to approximately 750.000 €. **85% of the total investment value** was acquired by the Cohesion Fund and the Slovenian participation, 15% is provided by the Ministry of Education.

Comprehensive energy refurbishment
SCV – Building C

Thermal insulation of the building's envelope

The external walls of the building are concrete implementation of 20 cm thickness of and **16 cm** repaired with thermal insulation.

The outer wall of the gym is 35 cm implementation thickness and were insulated with **16 cm of thermal insulation;** as basic insulation material used **classic glass wool and foamed polystyrene** with a final rendering.

The roof of the building is made of sheet metal with 25 cm insulation and has a gentle slope for water drainage.

Building C - Heating System

Building is heating via heat substation, powered by the district heating system

Thermal instalation power is **1 MW** and average annual heat energy consumption is **700 MWh**. After the energy reconstruction buildings provided approximately **40 %** reduction in thermal energy.

Secondary heat system is conducted through 6 lines, which are controlled by high-efficiency pumps.

Controling system is implemented with the PLC and provides comprehensive energy monitoring system.

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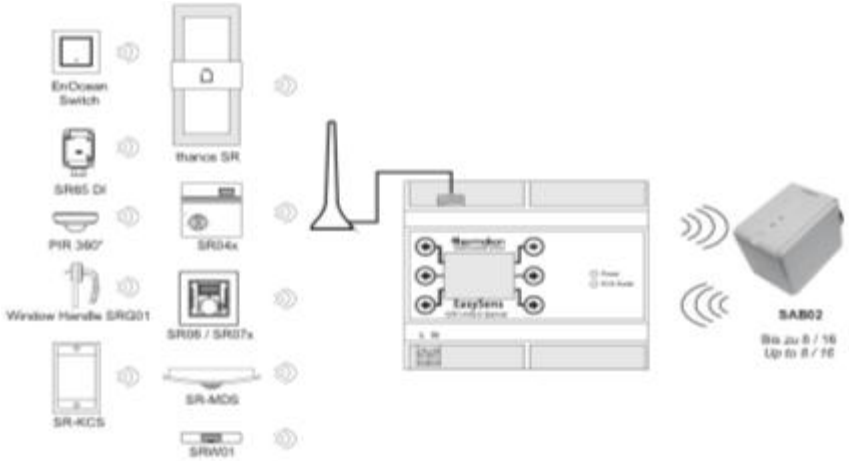
Smart Build

Energy monitoring system is designed for operation, management and supervision of the entire energy system. System allows displaying and monitoring the current, hourly, daily, monthly or annual energy data analysis and statistical processing of various data on energy production and consumption.

Energy Infopoint allows access to certain websites, in particular, provides an indication of the annual, monthly, daily and current consumption of all energy and energy savings and **CO2 emissions**. It is located in the lobby of the building where the transition of students, staff and other very large

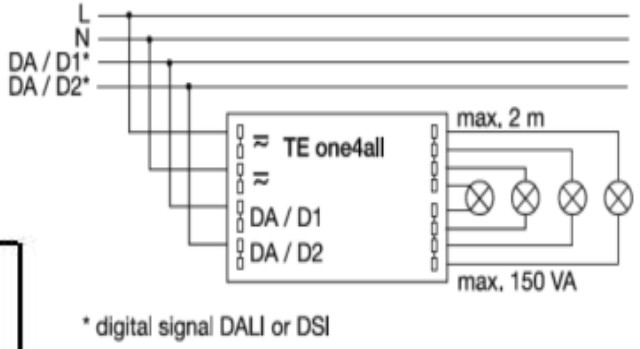
Radiator Heating system

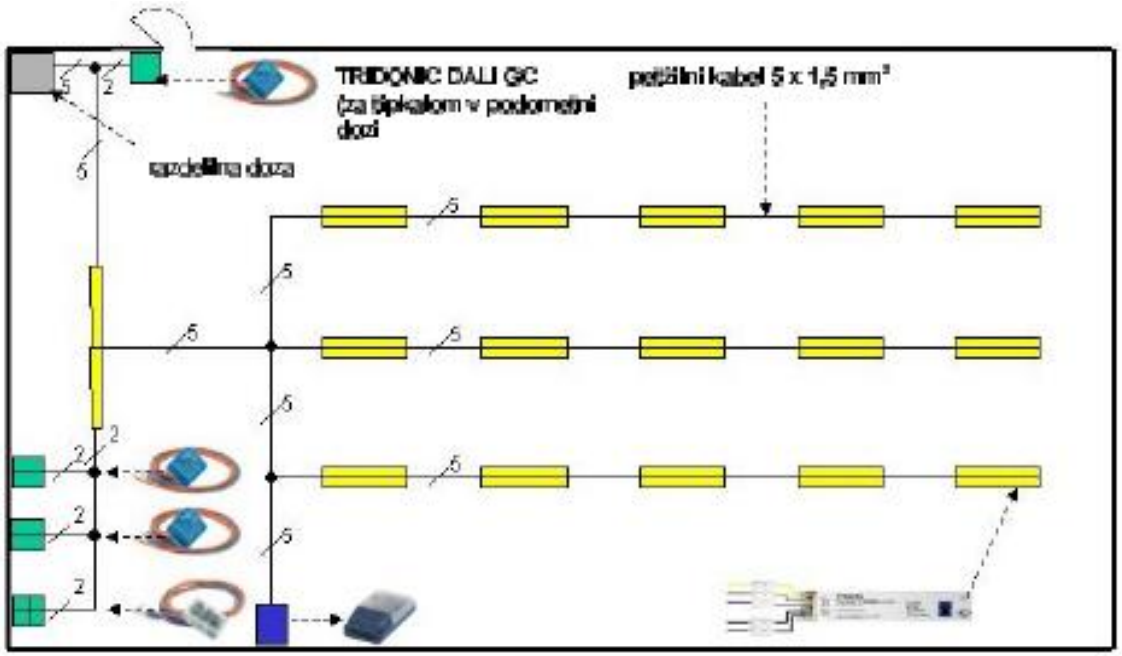


Interior lightning

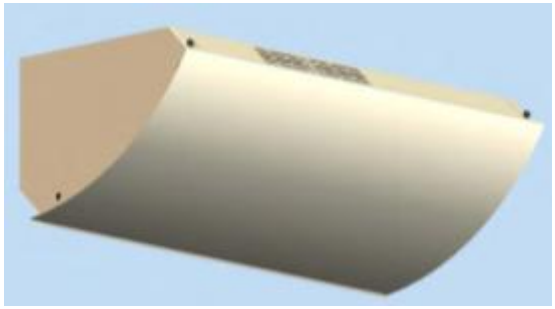
Light control is realised through a DALI system, basic requirements for DALI system are:

- 5 lines system electrical installations
- Luminaires with built-DALI ballasts
- Installation with one or two-pole push-buttons and controls: Touch screen panel, PC, software ...

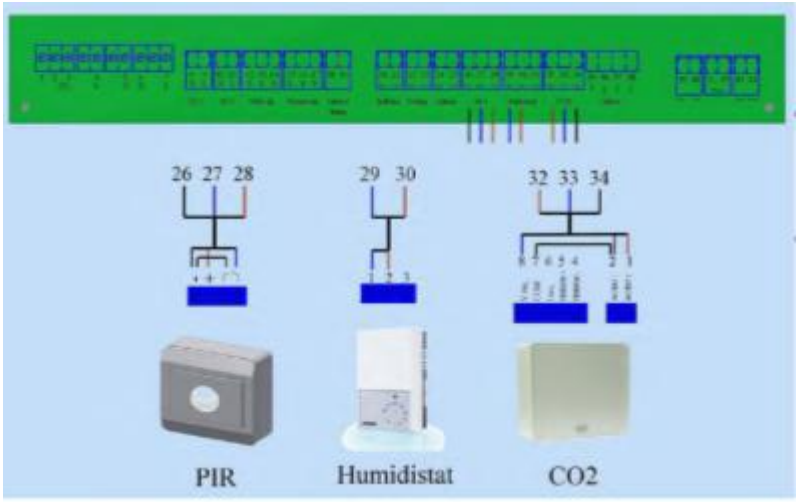




Fresh air supply via heat recovery system



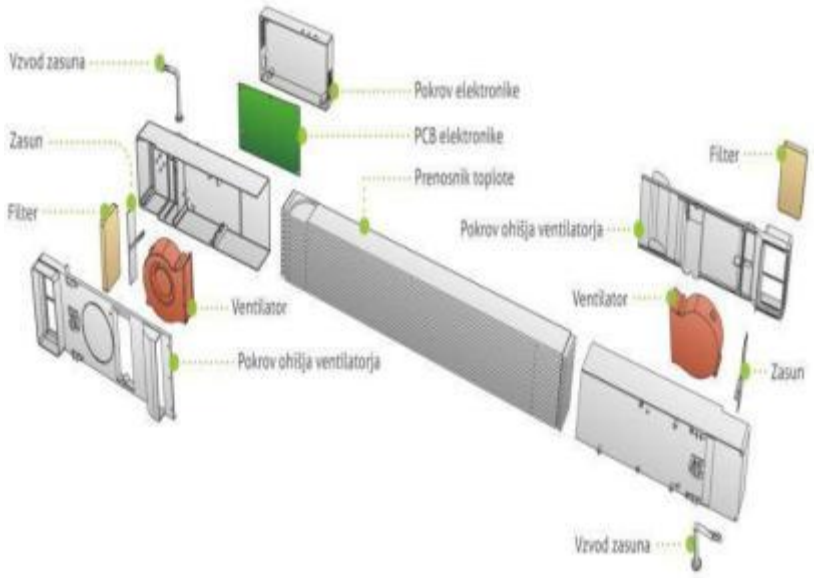
An electric air supply system with heat/cold energy recovery isinstalled



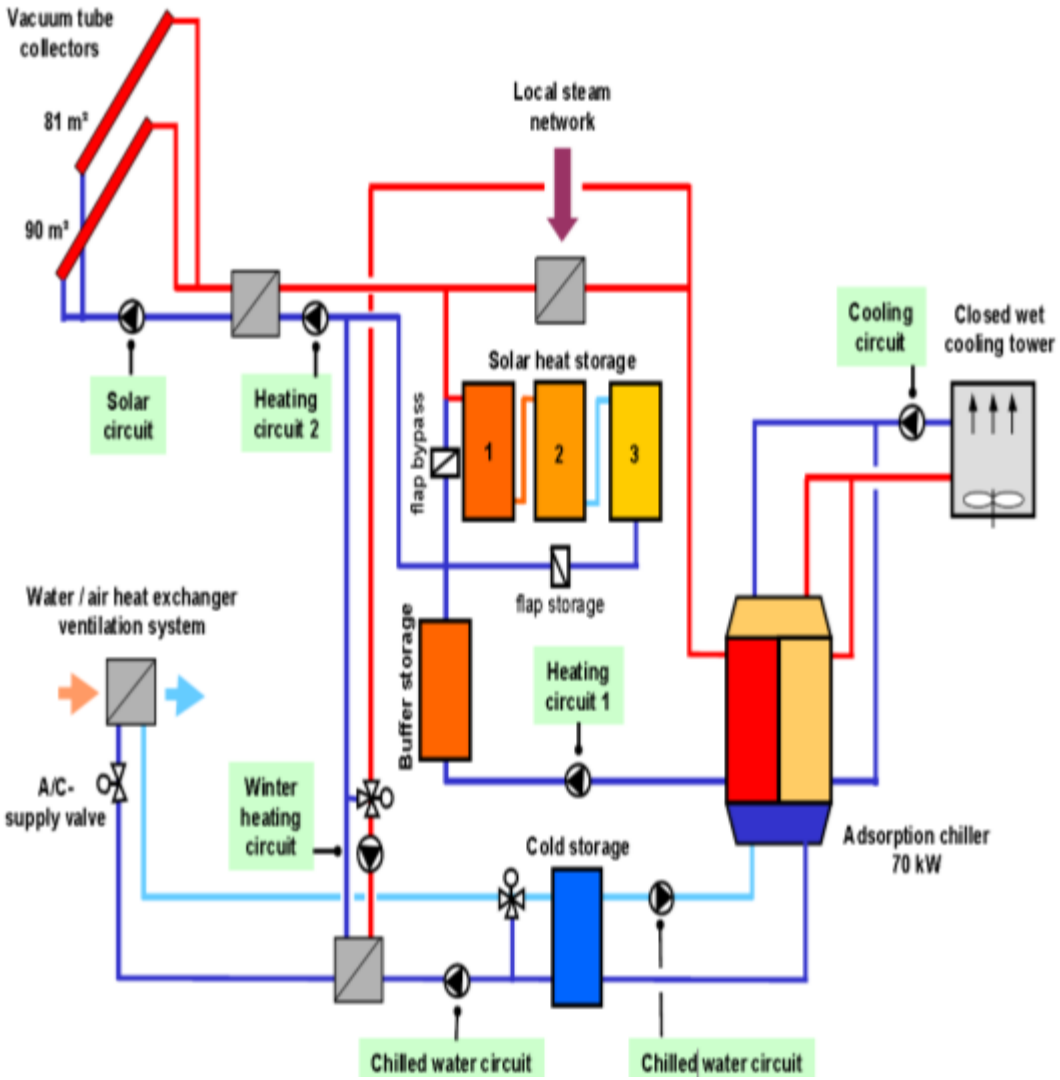
Control of local ventilation devices in the pilot areas of the project CIP Smart Build:

- large user friendly control panel
- can be connected to LON or MODBUS
- many opportunities for adjustments
- The controller can set multiple TX comfort systems. It is easy to move the display between systems.
- developed in cooperation with major danish compagny

Mikrovent system



Scheme of the SCV solar heating-cooling system



Central air-conditioning unit

Technology	closed cycle
Nominal capacity	70 kW_{cold}
Type of closed system	Adsorption
Brand of chiller unit	Nishiyodo NAK 20/70
Chilled water application	supply air cooling
Dehumidification	occasionally
Heat rejection system	closed wet cooling tower

Solar thermal

Collector type	vacuum tubes
Brand of collector	Seido 2-16
Collector area	167 m^2 aperture
Tilt angle, orientation	30° and 45°, south
Collector fluid	water-glycol
Typical operation temperature	75 °C driving temperature for chiller operation

Configuration

Heat storage	6 m^3 water
Cold storage	2 m^2 water
Auxiliary heating support	condensating steam heat exchanger, driven by the Hospital steam network
Use of auxiliary heating system	Auxiliary driving source for chiller, auxiliary driving source for supply air heating in winter
Auxiliary chiller	no