CE51 TOGETHER

D.T1.3.2 Master train the trainers - technical material

Version 1

03 2017

Master Train-the-Trainer Workshop, Cracow, 20-23.02.2017

Introduction to the TOGETHER training path

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CAPACITY BUILDING WITHIN TOGETHER (TWP1)

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
TOGETHER

Objective: Increasing interdisciplinary **knowlede and capacity** of relevant target groups in the area of comprehensive **energy efficiency measures** that may be implemented in public buildings and the most efficient ways of implementing them. The TOGETHER training path focuses on 4 main types of solutions that may be used to otimise energy consumption in buildings: **technical**, financial, **DSM** (behavioural and analytical) ones.

Target groups: Project partners (→ Master Train-the-Trainers Scheme)
Pilot buidlings owners, managers and decision makers(→ local trainings scheme)

Planned outputs:
1. Interdisciplinary transnational training model and toolbox on integrated EE solutions
2. Set of trainings implemented on the project (Master Train-the-Trainer) and on the local level (trainings for pilot buildings)

TOGETHER library → 1st concept of training material → Master train -the-trainer workshop → Finalization of training materia; → Series of local trainings

TOGETHER training path

TOGETHER LIBRARY

93 useful resources gathered, including

- guidebooks
- articles
- presentations
- on-line tools
- web materials
- case studies

Library will be available next week on the project website: http://www.interreg-central.eu/Content.Node/TOGETHER.html

Full version is already available for the consortium on the TOGETHER google drive

REPORT FROM INTERVIEWS WITH TRAINING EXPERTS

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
TOGETHER


SUMMARY REPORT

SUMMARY REPORT ON INTERVIEWED EXPERTS OPINIONS & GUIDELINES CONCERNING THE TOGETHER TRAINING PATH (Deliverable D.T.1.1.2)

01.2017

Report from interviews conducted with **11 training experts** who provided their suggestions and tips concerning:

- knowledge and skills that should be tranferred to the participants of trainings focused on the topic of energy efficiency in buildings
- development of good quality training material
- organisation of efficient and interactive trainings
- getting useful feedback from the trainees and assessment of their new knowledge and skills
- keeping the trainees interested and focused over longer period of time (series of trainings)

MASTER TRAIN-THE-TRAINER WORKSHOP IN CRACOW, POLAND

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
TOGETHER

Trainees: TOGETHER project partners and cooperating institutions

Trainers:
Technical expert: Cvetko Fendre, Slovenia
Financial expert: Aleksandra Novikova, Germany
Behavioural expert: Manuel Nina, Portugal
Analytical expert: Miguel Carvalho, Portugal

Objectives:

- Increasing PPs' **knowledge** and **skills** in the area of technical, financial, behavioural and analytical aspects related to the overall topic of energy efficiency in public buildings (including ability to address integration of different approaches);
- Increasing PPs‘ **skills** in using different training methods;
- Increasing PPs’ **capacity** to develop qood quality and efficient local trainings addressed to building owners, managers and decision makers;
- Discussing and improving **training material** develop by the consortium for the series of local trainings

Agenda:

Monday (20.02.17)	Tuesday (21.02.17)	Wednesday (22.02.17)	Thursday (23.02.17)
Technical aspects related to EE in public buildings	Financial aspects related to EE in public buildings	Behavioural aspects related to EE in public buildings (Behavioural DSM)	Analytical aspects related to EE in public buildings (Analytical DSM)

3 thematic parts: Technical aspects related to the overall topic of EE in public buildings (deliverable D.T1.2.1) → **University of Maribor**

Financial aspects related to the overall topic of EE in public buildings (deliverable D.T1.2.2) → **Province of Treviso**

DSM aspects related to the overall topic of EE in public buildings (deliverable D.T1.2.3) → **City of Zagreb**

Objectives:

- Structuring, organising and facilitating training activities targeted at public building owners, managers and decision makers
- Increasing trainees' knowledge and practical skills to choose, implement, optimise and integrated different types of EE measures by:
  - ✓ providing both theoretical introduction and practical exercises
  - ✓ focusing on the aspects that are especially relevant for public authorities and public buildings, includng horizontal topics like: **(1)** how to overcome most typical barriers with energy efficiency implementation, **(2)** how do develop optimisation scenarios, **(3)** how to involve building users in different types of actions or **(4)** how to analyse & use data from energy monitoring systems

Objectives: Increasing trainees' knowledge, skills and capacities regarding **technical aspects** related to EE in public buildings, with the specific focus on integration of different solutions, choosing most optimal scenarios, ensuring efficient monitoring and involving building users in the processes.

Modules:

Module 1: Energy audit & energy performance certificate
Module 2: Energy retrofit of the building
Module 3: Change of the heating source
Module 4: Installation of RES
Module 5: Modernisation of internal building installations, incl. lighting
Module 6: Purchase of energy efficient equipment
Module 7: Small technical interventions
Module 8: Choosing most optimal EE improvement scenario for a specific building
Module 9: Integration of technical measures with each other and with other types of EE solutions
Module 10: Things to remember and overcoming most typical barriers at the planning, implementation and monitoring phase of the EE intervention
Module 11: Involvement of building users in the technical EE intervention
Module 12: Selection and monitoring of key technical performance indicators

Objectives: Increasing trainees' knowledge, skills and capacities regarding **financial aspects** related to EE in public buildings, with the specific focus on the selection of most proper financing schemes, development of good quality project documentation, selection and monitoring of economic/financial indicators, involvement of building users in financing schemes (e.g. EPC contract).

Modules:

Module 1: EU, national & regional financing schemes
Module 2: Alternative financing methods
Module 3: Economic & financial assessment of the investment/action
Module 4: Development of financial documentation of the project (budget, business plan, applications for funding, market analysis...)
Module 5: Ensuring project's bankability, viability and profitability
Module 6: Tendering procedures and green public procurement
Module 7: Purchasing groups
Module 8: Choosing most optimal funding for the specific project
Module 9: Attracting & cooperation with potential investors
Module 10: Involvement of building users in financing schemes and/or in sharing financial benefits
Module 11: Reinvesting financial savings from implemented EE measures
Module 12: Overcoming most typical barriers related to financing investments and ensuring their financial viability & profitability

Objectives: Increasing trainees' knowledge, skills and capacities regarding **behavioural and analytical aspects** related to EE in public buildings, with the specific focus on:

- ✓ understanding rationale behind people's behaviours & consumption patterns, finding most effective ways to approach building users and motivating them to change their behaviours and engage in energy-related initiatives…
- ✓ most efficient methods & tools for monitoring energy consumption, standard and smart energy management systems, ICT technologies that may be implemented in buildings to optimise energy use…

Modules: Behavioural DSM

Module 1: Behavioural & psychological science related to consumers habits & practices
Module 2: Methods & tools for communicating and cooperating with building users
Module 3: Development of successful educational & information campaigns addressed at building users
Module 4: Methods & tools for changing habits and behaviours of building users
Module 5: Different incentive schemes for energy saving
Module 6: Monitoring of building users' behaviours
Module 7: No-cost and low-cost energy saving measures
Module 8: Integration of behavioural measures with other EE solutions

Modules:

Analytical DSM

Module 1: Collection, analysis, verification and presentation of the consumption data
Module 2: Development of energy-related data bases
Module 3: Standard energy monitoring/management systems
Module 4: Smart energy monitoring/management systems
Module 5: Advanced energy management systems (e.g. BEMS)
Module 6: Using ICT to analyse and reduce energy consumption in buildings
Module 7: Practical use of monitoring data - development of energy optimisation and adaptation scenarios
Module 8: Practical use of monitoring data - educating and involving building users

STRUCTURE OF THE TRAINING MATERIAL

OVERALL STRUCTURE

7. Introduction (→ PNEC)
8. Technical EE measures (→ UM)
   a) Introduction
   b) Module 1 → MODULE 1: ENERGY AUDIT
   c) Module 2
   d) ...
9. Financial EE measures (→ TREVISO)
   a) Introduction
   b) Module 1
   c) Module 2
   d) ...
10. DSM EE measures (→ ZAGREB)
    a) Introduction
    b) Module 1
    c) Module 2
    d) ...
11. Other relevant measures (→ PNEC)
12. Summary (→ PNEC)
    a) Summary on the EE measures that may be implemented in public buildings, as well as on their integration potential

MODULE 1: ENERGY AUDIT

1. Reference material in Word
2. PPT presentation
3. Exercise description/instruction
4. Case study
5. Checklist/questionnaire
6. Further suggestions for trainers:
   a) suggestions on further reference material
   b) suggestions on further relevant topics
   c) suggestions on further exercises/practical application

TOGETHER TRAINING MATERIAL

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theoretical part (reference material in Word and ppt slides)

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practical part (exercises, case studies, suggestions for practical application).

THANK YOU FOR YOUR ATTENTION!

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Catalogue of possible technical EE solutions that may be implemented in public buildings

1 The Energy

Energy is all around us and without it we could not live. We use it every day, in many different ways. The food we consume contains energy; the paper that is written on took energy to be produced; the light you are reading it by is also energy. But where does all this energy come from? And what are we doing with it? Are we using it wisely or are we wasting it needlessly? What are we going to do when all the coal and oil runs out? We also need to think about what the conversion and usage of this energy causes? Ever heard of climate change? Greenhouse gas emissions? These are serious problems for the whole world now and energy production is one of their main causes.

Video 1: EE-The world in 2030: https://www.youtube.com/watch?v=QG3HNQiEaTM

2 The Energy – Environmental problem

The environment and energy are in close connection. Destroying human environment from which we supply energy consequently affects the existence of our planet. Our generations do not have the right to prevent our descendants from enjoying the basic living conditions just because of our greed and excessive destructive behaviour towards nature. Our way of thinking and conduct has to be changed. The intensive use of energy needs to be passed to the sustainable use of energy. Renewable sources of energy have to be used to a great extent and the efficient use of energy included in our way of life. Or … we shall first live and only then make philosophy??

3 Building's energy use

160 million buildings in the EU use almost 40 % of Europe’s energy and create over 40 % of its CO_2 emissions, and that proportion is increasing. Moreover, this is higher than the share of industry and transport. Households consume the two-thirds of the energy used in the buildings.

Space heating is the most important component (57% of domestic and 52% of the non-residential buildings consumption). It is important to mention that, the use of fuel for heating buildings amounts to 25% of the total CO_2 emissions in the EU. Water heating accounts for 25% of the domestic consumption and 9% of non-residential use.

Lighting consumes around 4% of total energy in the residential sector (about 9 Mtoe), while in the tertiary sector, where the large majority of lighting is provided by fluorescent lamps, lighting consumes around 18 Mtoe, or 14% of the sector's energy. Another important aspect is that lighting accounts for up to 25% of the emissions due to commercial buildings.

Air-conditioning is a rapidly growing consumption activity in the residential and public sectors. The total energy consumption for air-conditioning is about 3 Mtoe (0.7% of total final energy consumption in the two sectors combined), and this is expected to double by 2020.

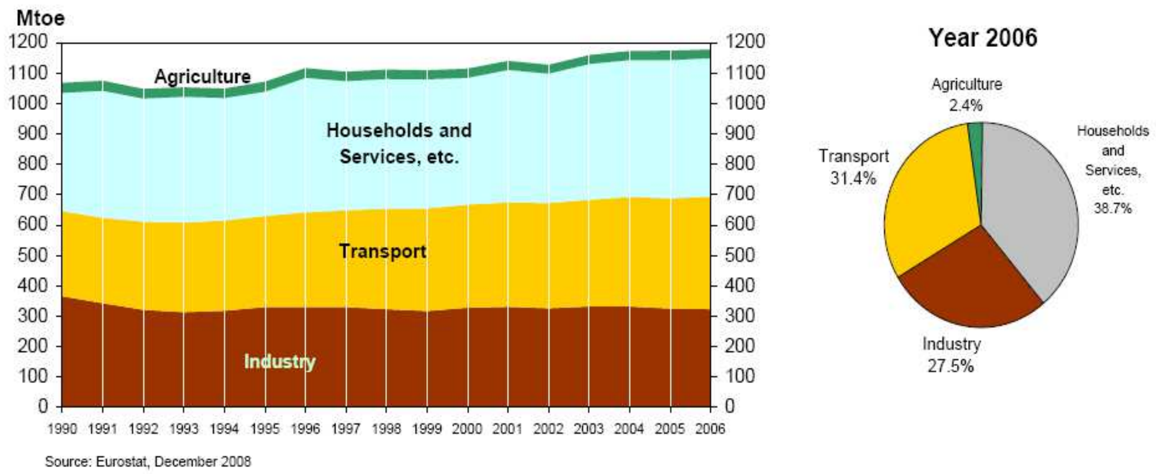


Figure 0: Final Energy Consumption in EU27 by sector (Mtoe[1])

Currently, most of the energy used in the built environment is derived from non-renewable fossil fuels. Oil, natural gas and solid fuels count form more than 70% of the final energy consumed in the EU, while RES are still contributing in very low percentages.

Video 2: The importance of making commercial buildings energy efficient

https://www.youtube.com/watch?v=Je99t9Z-G6M

Reducing the amount of energy consumed every day is Europe's biggest energy resource. We need to incorporate energy efficiency in our daily life to consume less and better -- It is cheaper, protects our environment and favours competitiveness. We are all involved!

[1] 1 **Mtoe** stands for 1 million **tonnes of oil equivalent** (**toe**), and is a unit of energy: the amount of energy released by burning 1 tonne of crude oil, approximately 42 GJ.

Video 3: EE – Doing more with less: https://www.youtube.com/watch?v=dtyzdofD18U

Given the fact that buildings account for about a third of total energy use worldwide and of energy related CO_2 emissions, the research suggests that business leaders are ready to go deep and are waiting for the right policy signals that can scale up energy efficiency in the sector.

Video 4: EE - Energy efficiency and energy savings - a view from the building sector:

https://www.youtube.com/watch?v=CpHHIS_hx3s&t=8s

4 Smart Build

What is a Smart Building? What are the benefits? Why do we need them? A smart building uses connectivity and data analytics to automatically take actions to solve real business problems. From optimizing the flow of people through a facility, to automatically adjusting lighting based on occupancy.

Video 5: What is Smart Building? https://www.youtube.com/user/HoneywellBuild

Video 6: Energy efficiency in buildings – Veolia:

https://www.youtube.com/watch?v=71q41-9gwmQ

5 Recommended Available Sources

Advanced Energy Retrofit Guide Office Buildings

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20814.pdf

https://www.researchgate.net/publication/241971982_Advanced_Energy_Retrofit_Guide_Office_Buildings

ESMAP_Energy_Efficient_MayoralNote_2014

https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/ESMAP_Energy_Efficient_MayoralNote_2014.pdf

Executive-Summary-Effectiveness-of-Energy-Retrofit-Methods-in-China

http://www.buildingefficiencyinitiative.org/sites/default/files/legacy/InstituteBE/media/Library/Resources/Existing-Building-Retrofits/Executive-Summary-Effectiveness-of-Energy-Retrofit-Methods-in-China.pdf

Energy Efficiency and Renewable Energy Handbook, Second Edition_2016
D. Yogi Goswami,Frank Kreith

https://books.google.cz/books?id=GtaYCgAAQBAJ&pg=PA873&lpg=PA873&dq=appropriately+selected+ECMs&source=bl&ots=YDx2eJgqsD&sig=-TCplCXABXFwgGvea6jkZ7jWbzQ&hl=sl&sa=X&ved=0ahUKEwj6vciWx5rSAhUQsBQKHYyoA6MQ6AEIHTAB#v=onepage&q=appropriately%20selected%20ECMs&f=false

Technical Training module

Module 1 - Public Building Energy Audit

Cveto Fendre

cfendre@gmail.com

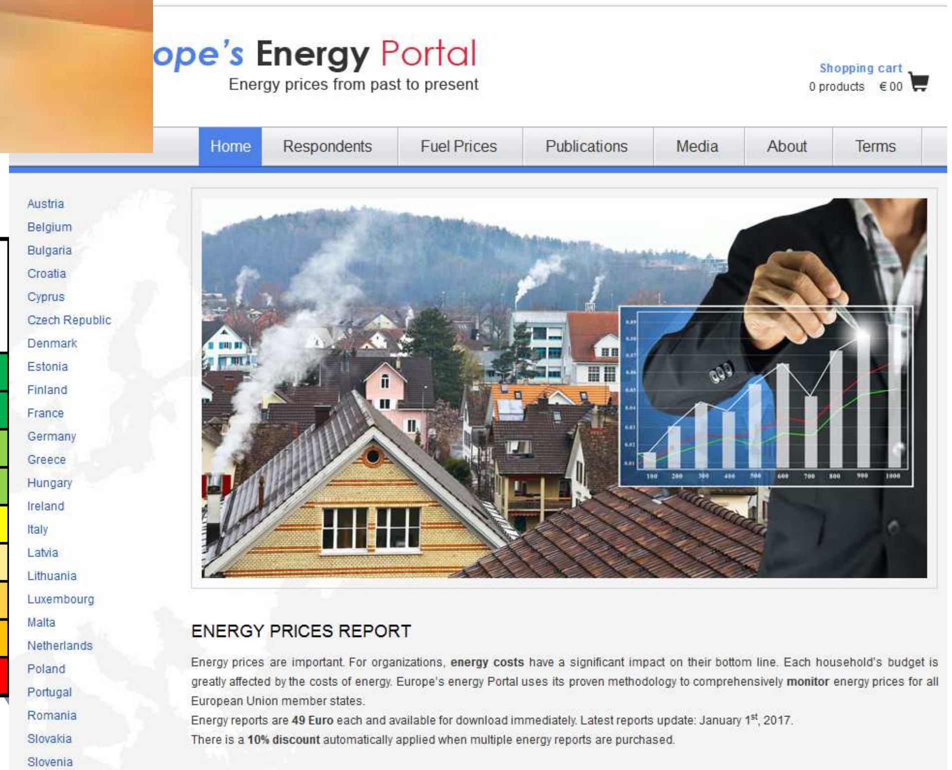
The classification of objects into classes of energy efficiency

https://www.youtube.com/watch?v=dnetql2-f4k

Source: www.tehno-razvoj.com

Class EE	Annual energy needed to heat the building per unit of useful floor area **(kWh/m²a)**
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

http://www.energy.eu



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)

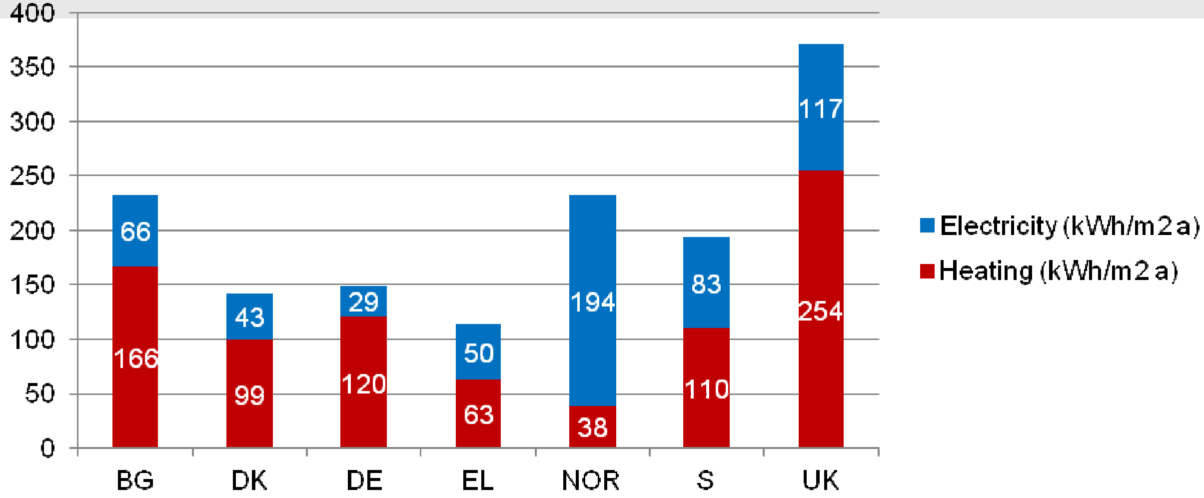
Annual CO2 emissions (t or. Kg)

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

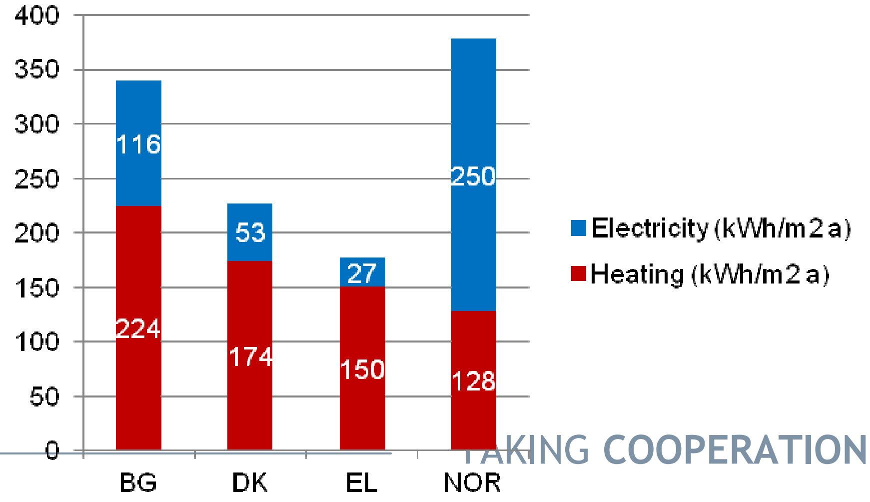
Cultural center Prevalje, Slovenia

- Useful surface: cca 2.919 m^2
- Year of construction : 1978
- Number of employees: 10 do 15
- Number of users at special events: to 250
- The total building energy number (2011-2013): E = **113,84** kWh/m2

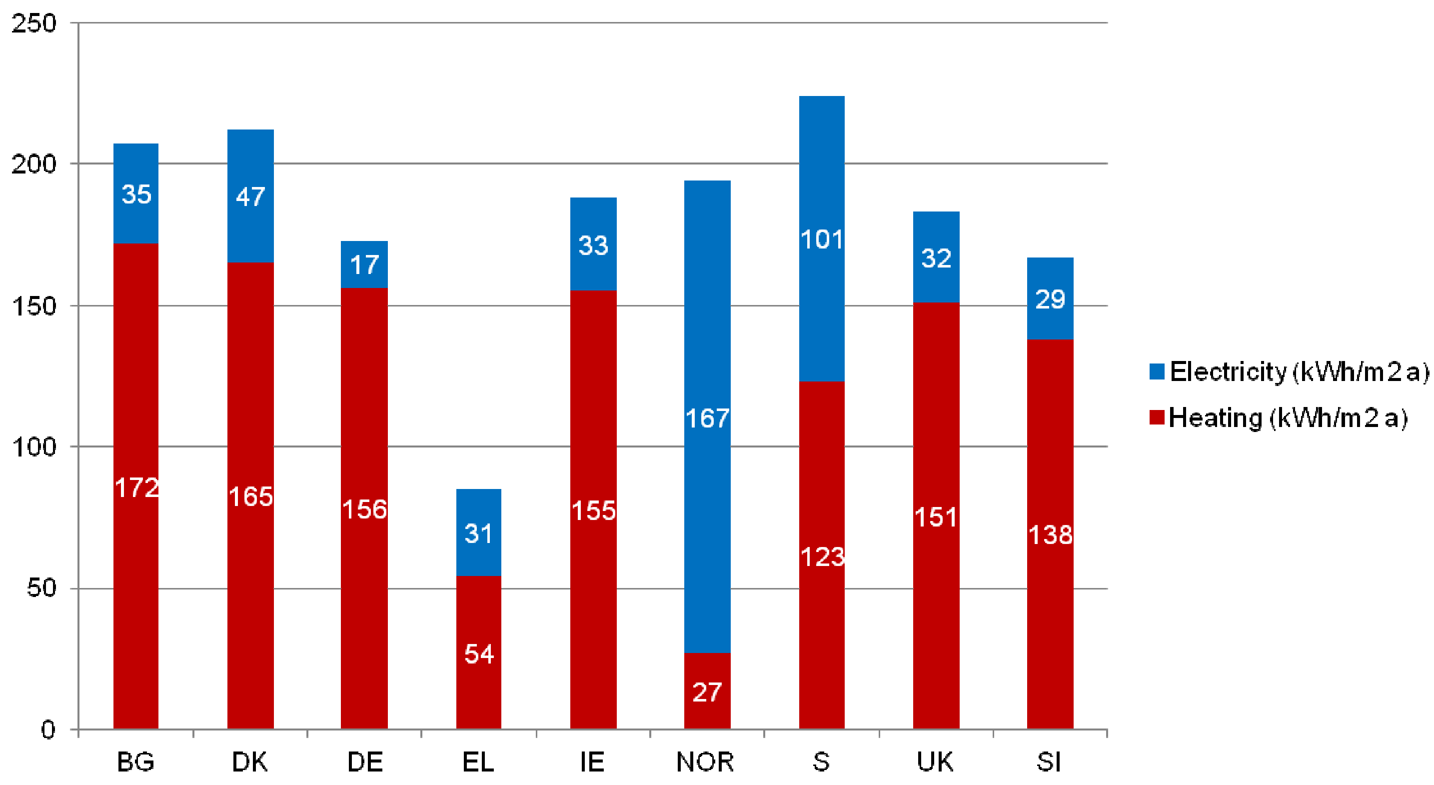
The average energy parameters of offices in some EU members (2005)



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



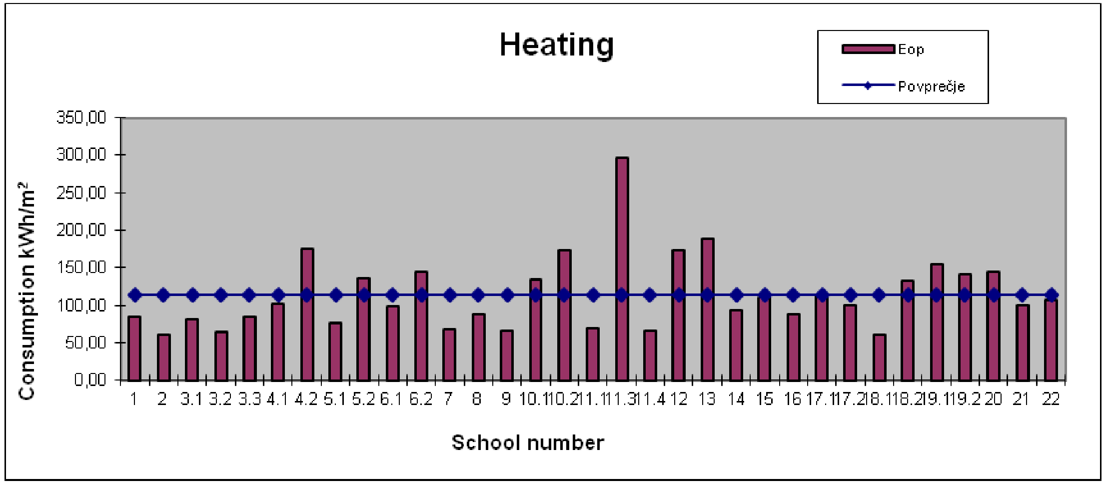
The average energy parameters of schools in some EU members (2005)



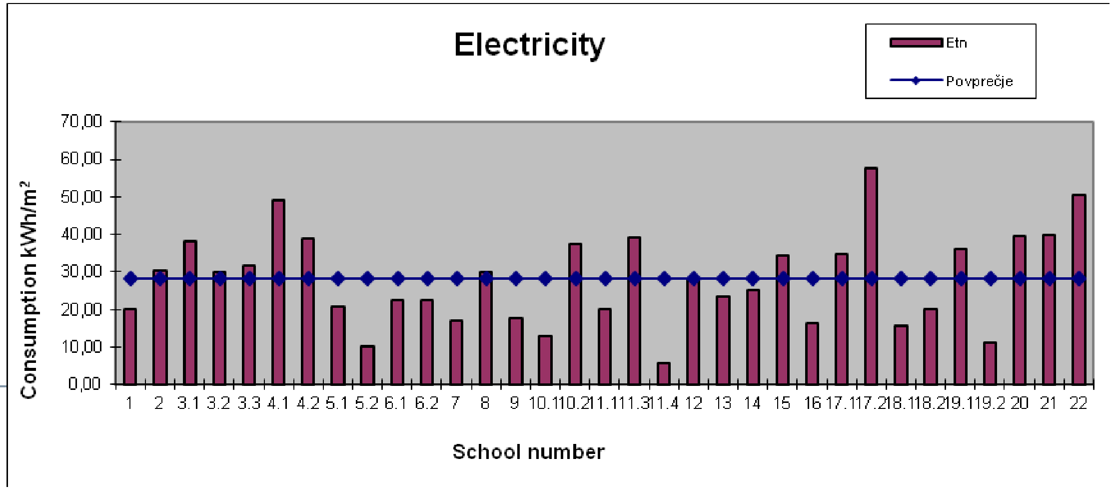
CASE SLOVENIA

The average energy parameters of secondary schools: Eh = 115, Ee = 28

The average energy parameters of primary schools: Eh = 160, Ee = 30



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

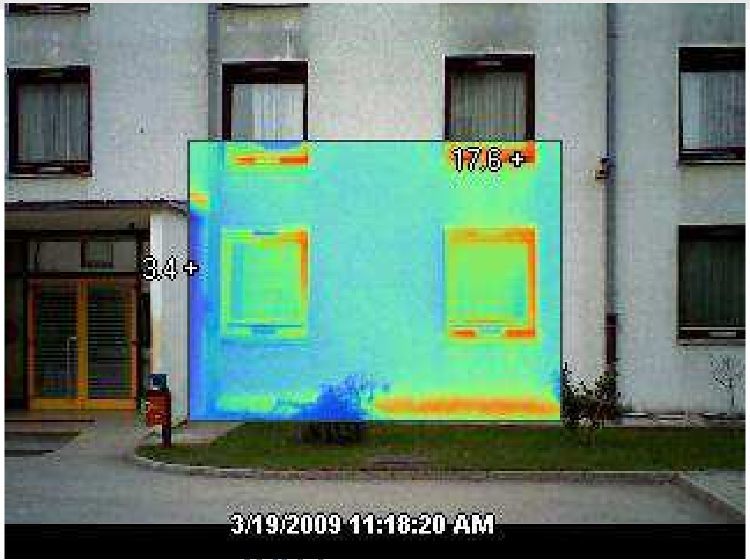


Energy status of some public buildings in Slovenia

LJUDSKA UNIVERZA VELENJE 2004 - adult education

Eh:	193
Ehw:	0
Ee:	35
E:	**228**
Class.:	**F**

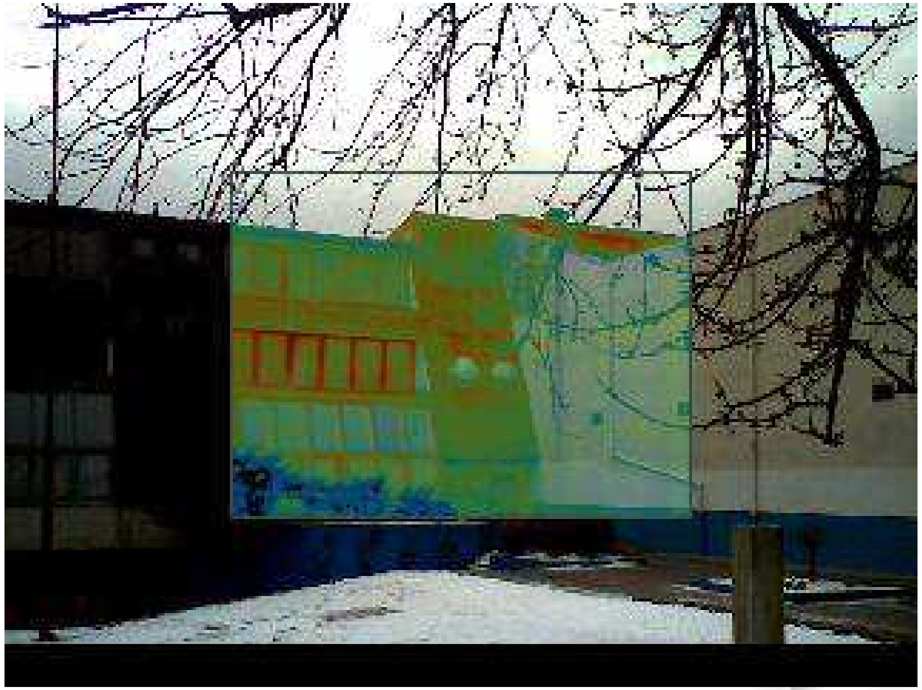
Emiss. CO_2 (t): 50



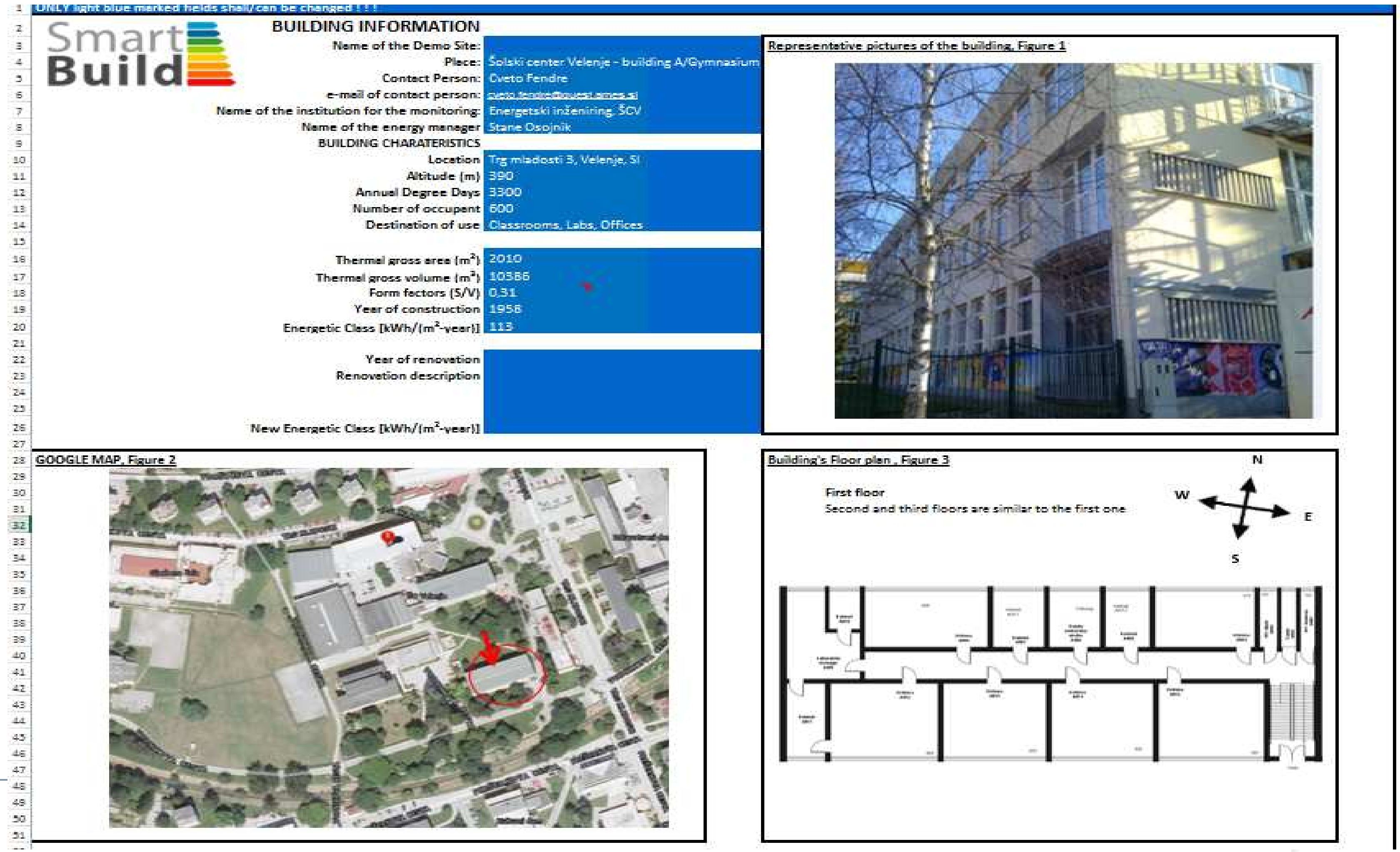
Energy parameters	Year 2006	2007
Eh: heating	114	95
Ee: electricity	48	45
E	162	140
Class.:	E	D
Emiss CO_2 (t)	412	365

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

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



Some of the tasks may have to be repeated, reduced in scope, or even eliminated based on the findings of other tasks. Therefore, the execution of an energy audit is not a linear process and is rather iterative.



Energy audit and primary tasks

1. the main goal is to achieve energy savings,
2. there may be other aspects to consider (technical condition, environment) but the main interest is on energy consumption and saving possibilities,
3. reports on energy saving measures are produced, the work may cover all energy using aspects of a site or certain limited parts (systems, equipment) of several sites (horizontal audit).

Analyses of energy with costs

- **Checking of energy invoices** for every month and charts make an month analysis of energy consumption, 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 indor areas, classrooms, ancillary rooms, offices …
- **Thermovision of building envelop, thermal bridges, doors, windows …**

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

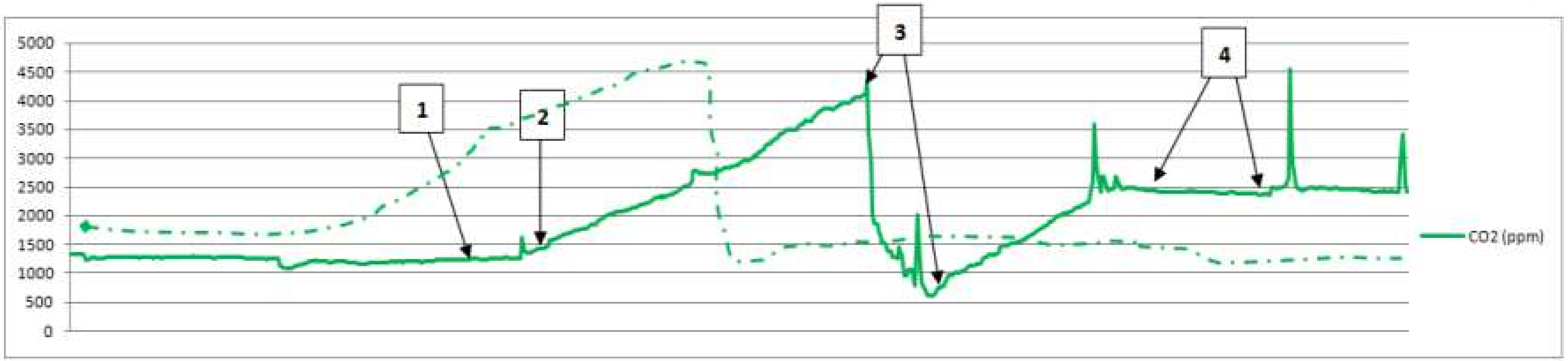
Example

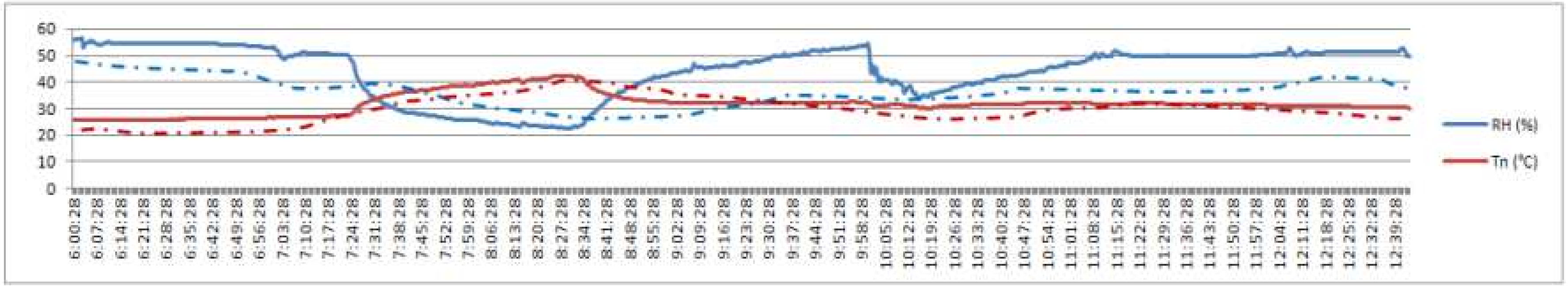
Measurements of microclimate

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 %;	CO_2n = 1237 ppm	/ comming in clasroom
Event 2	Ura 8.20:	Tn = 41 °C;	RHn = 23,4 %;	CO_2n = 1405 ppm	/ start of lesson
Event 3	Ura 10.00:	Tn = 32,1 °C;	RHn = 50,8 %;	CO_2n = 4364 ppm	/ airing 20 minut
Event 4	Ura 11.15:	Tn = 31,7 °C;	RHn = 51,5 %;	CO_2n = 2686 ppm	/ non-aerated empty classroom
○ Avg:		Tn = 31,8 °C;	RHn = 44,3 %;	CO_2n = 1944 ppm	
○ Min:		Tn = 25,7 °C;	RHn = 22,5 %;	CO_2n = 619 ppm	A13 ———
○ Max:		Tn = 42,5 °C;	RHn = 56,9 %;	CO_2n = 4555 ppm	
○ Num. of occup. : 20 students + teacher					A14 – · – ·





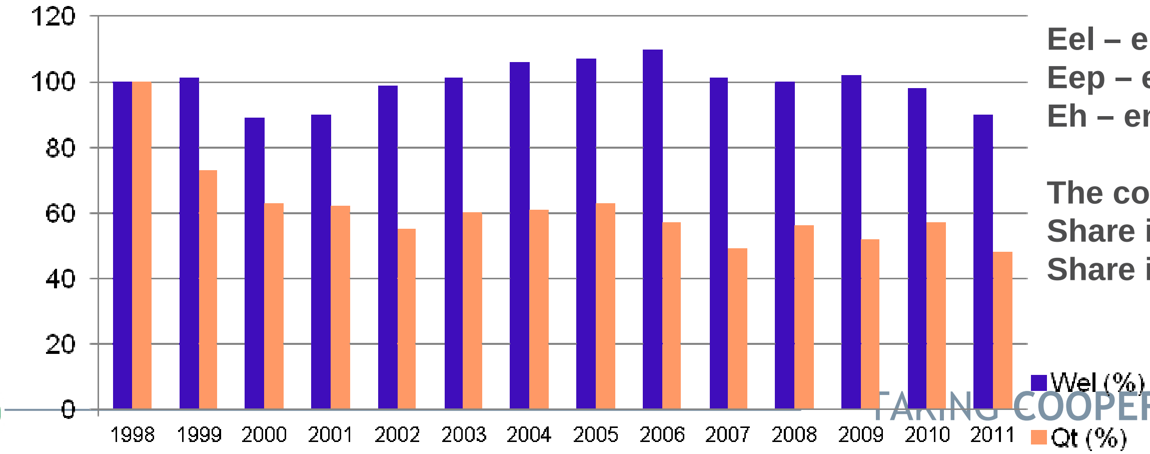
Step 1: Building and Utility Data Analysis

- Collect at least three years of utility data (to identify a historical energy use pattern)
- Identify the fuel types used (to determine the fuel type accounting for the largest energy use)
- Determine the patterns of fuel use by fuel type (to identify the peak demand for energy by fuel type).
- Understand utility rate structure (energy and demand rates) [to evaluate if the building is penalized for peak demand and if cheaper fuel can be purchased].
- Analyze the effect of weather on fuel consumption.

Perform utility energy use analysis by building type and size (building signature can be determined including energy use per unit area [to compare against typical indices].

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



Eel – energy number for electricity
Eep – energy number for el. peak power
Eh – 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 %

Step 2: Walk-through Survey

- Identify the customer concerns and needs.
- Check the current operating and maintenance procedures.
- Determine the existing operating conditions of major energy use equipment (lighting, HVAC systems, motors, etc.).
- Estimate the occupancy, equipment, and lighting (energy use density and hours of operation).

Type 1

Brand	IBM, Fujitsu
Model	
Type	PC station
Power [W]	110
Installation Year	
Control	Manual ON/OFF

Type 2

Brand	HP
Model	
Type	Printer
Power [W]	80
mption [kWh/year]	
Installation Year	
Control	Always

Type 3

Brand	
Model	
Type	Copier
Power [W]	400
Installation Year	
Control	Manual ON/OFF
Utilization	sometimes

Type 4

Brand	
Model	
Type	Projector
Power [W]	200
Installation Year	
Control	Manual ON/OFF
Utilization	2 times a week

Type 5

Brand	
Model	
Type	Refrigator
Power [W]	70
Installation Year	
Control	Manual ON/OFF
Utilization	always

Type 6

Brand	
Model	
Type	Circulator motor
Power [W]	1100
Installation Year	
Control	Manual ON/OFF

Type 7

Brand	
Model	
Type	Climate
Power [W]	2700
Installation Year	
Control	Manual ON/OFF

Type 8

Brand	
Model	
Type	TV
Power [W]	150
Consumption [kWh/day]	
Installation Year	
Control	Manual ON/OFF

Type 9

Brand	Elektromedicina
Model	
Type	Fenomat
Power [W]	2300
Installation Year	
Control	Automatic ON/OFF

Type 10

Brand	Bianchi
Model	
Type	Maker of smoothies
Power [W]	1600
Installation Year	
Control	

Type 11

Brand	
Model	
Type	
Power [W]	
Installation Year	
Control	

Type 12

Brand	
Model	
Type	
Power [W]	
Installation Year	
Control	

Step 3: Baseline for Energy Use

The main purpose is to develop a base-case model that represents the existing energy use and operating conditions for the building. This model will be used as a reference to estimate the energy savings due to appropriately selected ECMs (Energy Conservation Measures).

•Obtain and review architectural, mechanical, electrical, and control drawings.

•Inspect, test, and evaluate building equipment for efficiency, performance, and reliability.

•Obtain all occupancy and operating schedules for equipment (including lighting and HVAC systems).

•Develop a baseline model for building energy use.

•Calibrate the baseline model using the utility and/or metered data.

Step 4: Evaluation of the Energy Savings Measures

List of cost-effective ECMs is determined using both energy savings and economic analysis:

•Prepare a comprehensive list of energy conservation measures (using the information collected in the walk-through survey).

•Determine energy savings due to the various ECMs pertinent to the building using the baseline energy use model developed in step 3.

•Estimate the initial costs required to implement the energy conservation measures.

•Evaluate the cost-effectiveness of each energy conservation measure and maintenance actions using an economical analysis method.

Measures	U W/m²K	Investment (€)	Annual savings (kWh)	Payback period
The Ceiling insulation	0,11	33.300,00	15.990,00	24,1
The Roof refurbisement	0,13	15.750,00	7.430,00	24,5
Details refurbishem., the cornerstone	0,20	28.000,00	15.770,00	20,5
The basement wall rehabilitation	0,24	29.960,00	5.410,00	64,1
The Facade reconstruction	0,10	96.256,00	35.810,00	31,1
The Mansard reconstruction	0,14	49.920,00	11.490,00	50,2
The Windows reconstruction	0,9	39.900,80	21.170,00	21,8
The Doors reconstruction	1,1	3.200,00	680,00	54,7
		296.286,80	**113.750,00**	**30,1**

PHASE	THERMAL SYSTEM	ELECTRIC SYSTEM
1 UTILITY DATA ANALYSIS	▪ Thermal energy use profile (building signature) ▪ Thermal energy use per unit area (or per student for schools) ▪ Thermal energy use distribution (heating, DHW, process, etc.) ▪ Fuel types used ▪ Weather effect on thermal energy use ▪ Utility rate structure	▪ Electrical energy use profile (building signature) ▪ Electrical energy use per unit area (or per student for schools or per bed for hotels) ▪ Electrical energy use distribution (cooling, lighting, equipment, fans, etc.) ▪ Weather effect on electrical energy use ▪ Utility rate structure (energy charges, demand charges, power factor penalty, etc.)
2 ON-SITE SURVEY	▪ Construction materials (thermal resistance type and thickness) ▪ HVAC system type ▪ DHW system ▪ Hot water/steam use for heating, cooling, DHW and specific applications (hospitals, swimming pools, etc.)	▪ HVAC system type ▪ Lighting type and density ▪ Equipment type and density ▪ Energy use for heating, cooling, lighting, equipment, air handling, water distribution
3 ENERGY USE BASELINE	▪ Review architectural, mechanical, and control drawings ▪ Develop a base-case model (using any base lining method ranging from very simple to more detailed tools) ▪ Calibrate the base-case model (using utility or metered data)	▪ Review architectural, mechanical, electrical, and control drawings ▪ Develop a base-case model (using any base lining method ranging from very simple to more detailed tools) ▪ Calibrate the base-case model (using utility or metered data)
4 ENERGY CONSERVATION MEASURES	▪ Heat recovery system (heat exchangers) ▪ Efficient heating system (boilers) ▪ Temperature Setback ▪ Energy Monitoring and Control Systems (EMCS) ▪ HVAC system retrofit ▪ DHW use reduction ▪ Cogeneration	▪ Energy efficient lighting, equipment, motors ▪ HVAC system retrofit ▪ EMCS ▪ Temperature Setup ▪ Energy efficient cooling system (chiller) ▪ Peak demand shaving ▪ Thermal Energy Storage System ▪ Cogeneration ▪ Power factor improvement, Reduction of harmonics

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
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ENERGETSKA IZKAZNICA STAVBE

Podatki o stavbi

Št. izkaznice: 2014-20-39-3 Velja do: 09.02.2024

Vrsta izkaznice: računska

Vrsta stavbe: nestanovanjska

Identifikacijska oznaka stavbe,
posameznega dela ali delov stavbe: katastrska občina 964
številka stavbe 3538
Klasifikacija stavbe: 1263001
Leto izgradnje: 1973
Naslov stavbe: Trg mladosti 3, Velenje

Katastrska občina: VELENJE
Parcelna št.: 2571/20, 2602/9, 2571/7, 2602/10
Koordinati stavbe (X,Y): 135309,509118

Potrebna toplota za ogrevanje

Razred C 59 kWh/m²a

A1|A2 B1|B2 C D E F G
0 10 15 25 35 60 105 150 210 300+

57 kWh/m²a
REFERENČNA KLIMA

Dovedena energija za delovanje stavbe

69 kWh/m²a

0 100 200 300 400 500 600+

Primarna energija in Emisije CO_2

90 kWh/m²a

0 100 200 300 400 500 600+

0 25 50 75 100 125 150 175+

24 kg/m²a

Izdajatelj

DBSS d. o. o. (20)
Ime in podpis odgovorne osebe: Robert Špegel
Opcija: elektronski podpis.
Datum izdaje: 09.02.2014

Izdelovalec

Robert Špegel (39)
Ime in podpis: Robert Špegel
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ENERGETSKA IZKAZNICA STAVBE

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Št. izkaznice: 2014-20-39-3 Velja do: 09.02.2024

Vrsta izkaznice: računska

Vrsta stavbe: nestanovanjska

Podatki o velikosti stavbe

Kondicionirana površina stavbe A_k (m²)	7.206
Kondicionirana prostornina stavbe V_e (m³)	22.973
Celotna zunanja površina stavbe A (m²)	9.672
Oblikovni faktor $f_0=A/V_e$ (m⁻¹)	0,29

Klimatski podatki

Temperaturni primanjkljaj TP	3.500
Projektna zunanja temperatura (gretje) T_{eph}	-13

Dovedena energija za delovanje stavbe

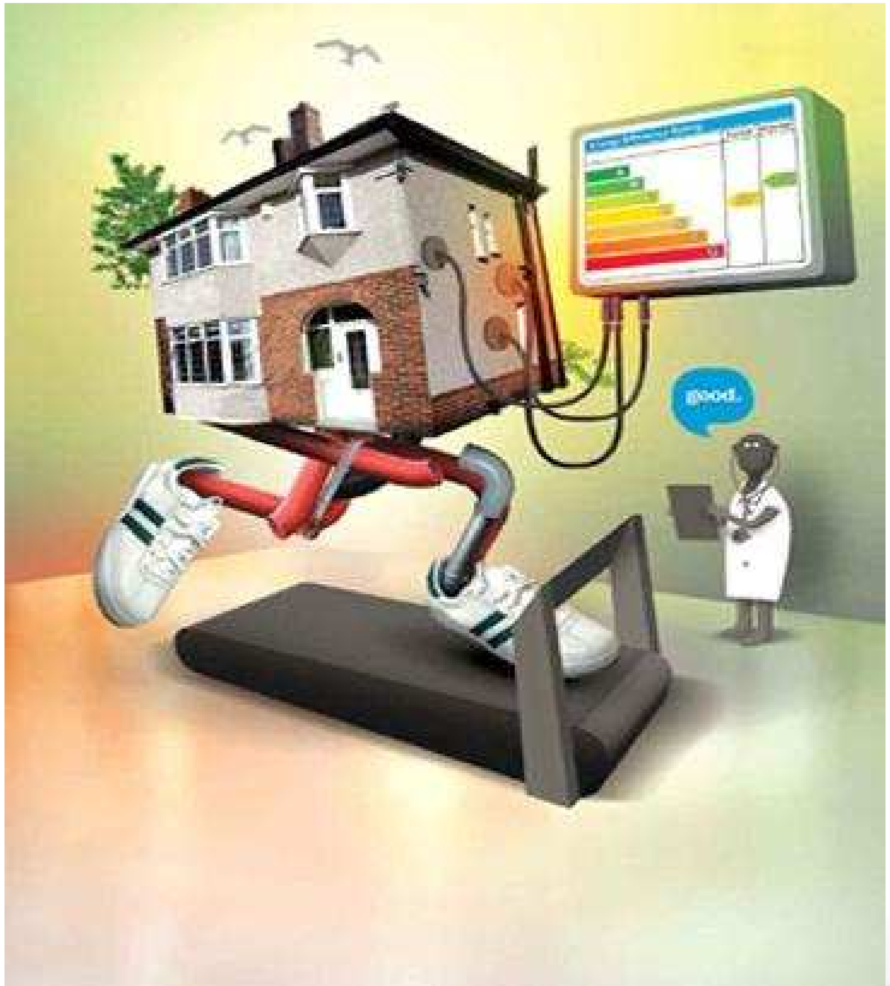
Dovedena energija za delovanje stavbe	Dovedena energija kWh/a	kWh/m²a
Gretje $Q_{f,h}$	456.231	63
Hlajenje $Q_{f,c}$	0	0
Prezračevanje $Q_{f,V}$	0	0
Ovlaževanje $Q_{f,st}$	0	0
Priprava tople vode $Q_{f,W}$	9.031	1
Razsvetljava $Q_{f,l}$	27.024	4
Električna energija $Q_{f,aux}$	4.965	1
Skupaj dovedena energija za delovanje stavbe	497.251	69

Struktura rabe celotne energije za delovanje stavbe po virih energije in energentih (kWh/a)

Obnovljiva energija porabljena na stavbi (kWh/a)	497.251
Primarna energija za delovanje stavbe (kWh/a)	649.522
Emisije CO_2 (kg/a)	173.580

CONCLUSION

- Energy audit is the starting point of investment in the energy field!
- Energy audit is usually a prerequisite for applying of tenders
- Energy audit is reasonable to be repeated every 3 to 5 years with establish a permanent energy monitoring system establishment!



Source: www.tehno-razvoj.com

3_STEP -Training module

Monitoring & evaluation of the results of energy renovation in a building

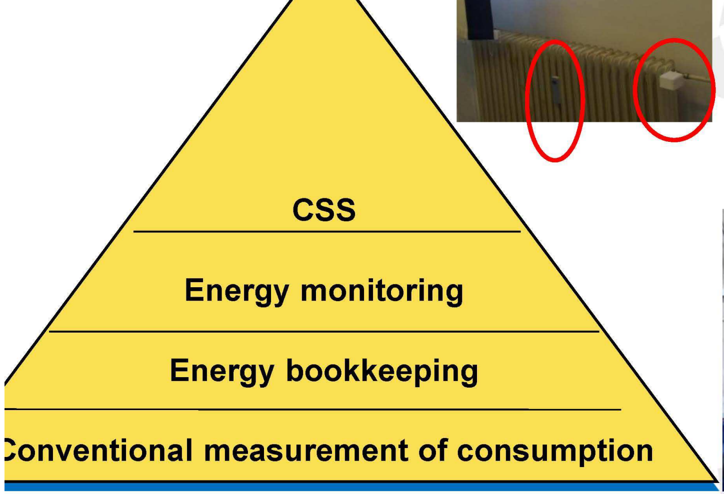
Case SC Velenje

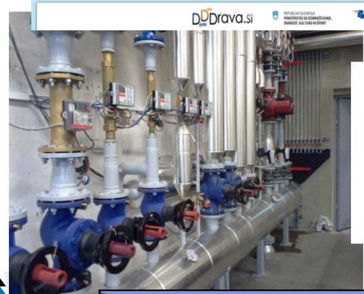
TAKING COOPERATION FORWARD

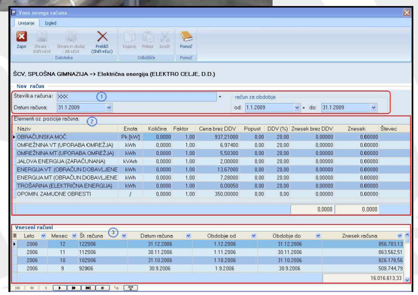
Cveto Fendre

cveto.fendre@guest.arnes.si

Energy management levels







Energy certificate of building

ENERGETSKA IZKAZNICA STAVBE

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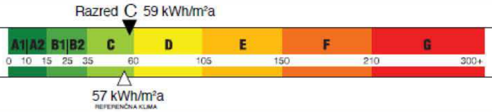
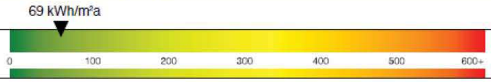
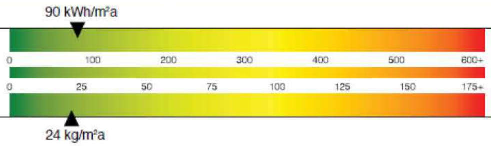


Dovedena energija za delovanje stavbe



Primarna energija in Emisije CO_2



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Datum izdaje: 09.02.2014

Izdelovalec

Robert Špegel (39)
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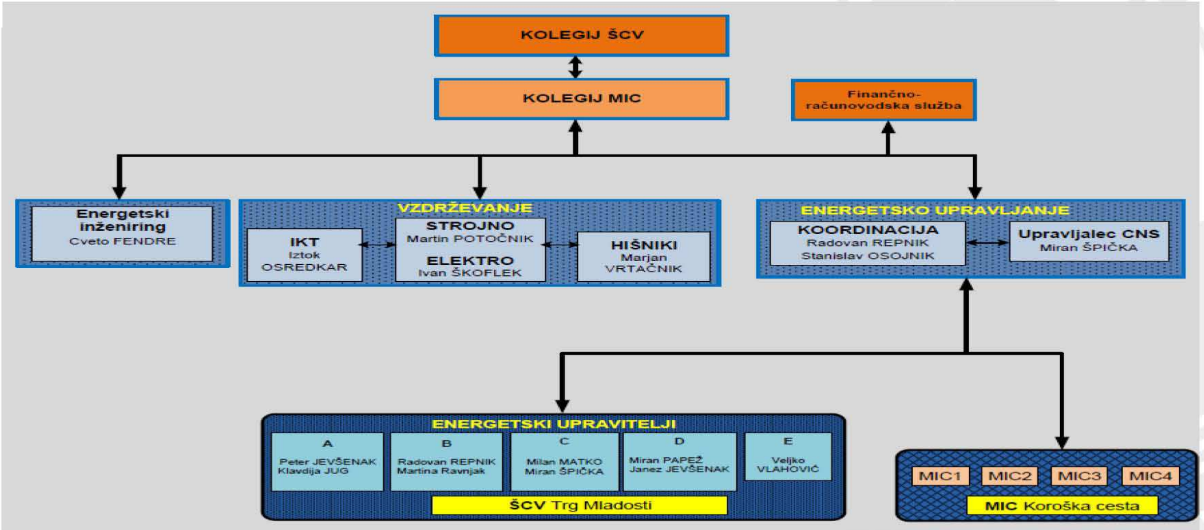
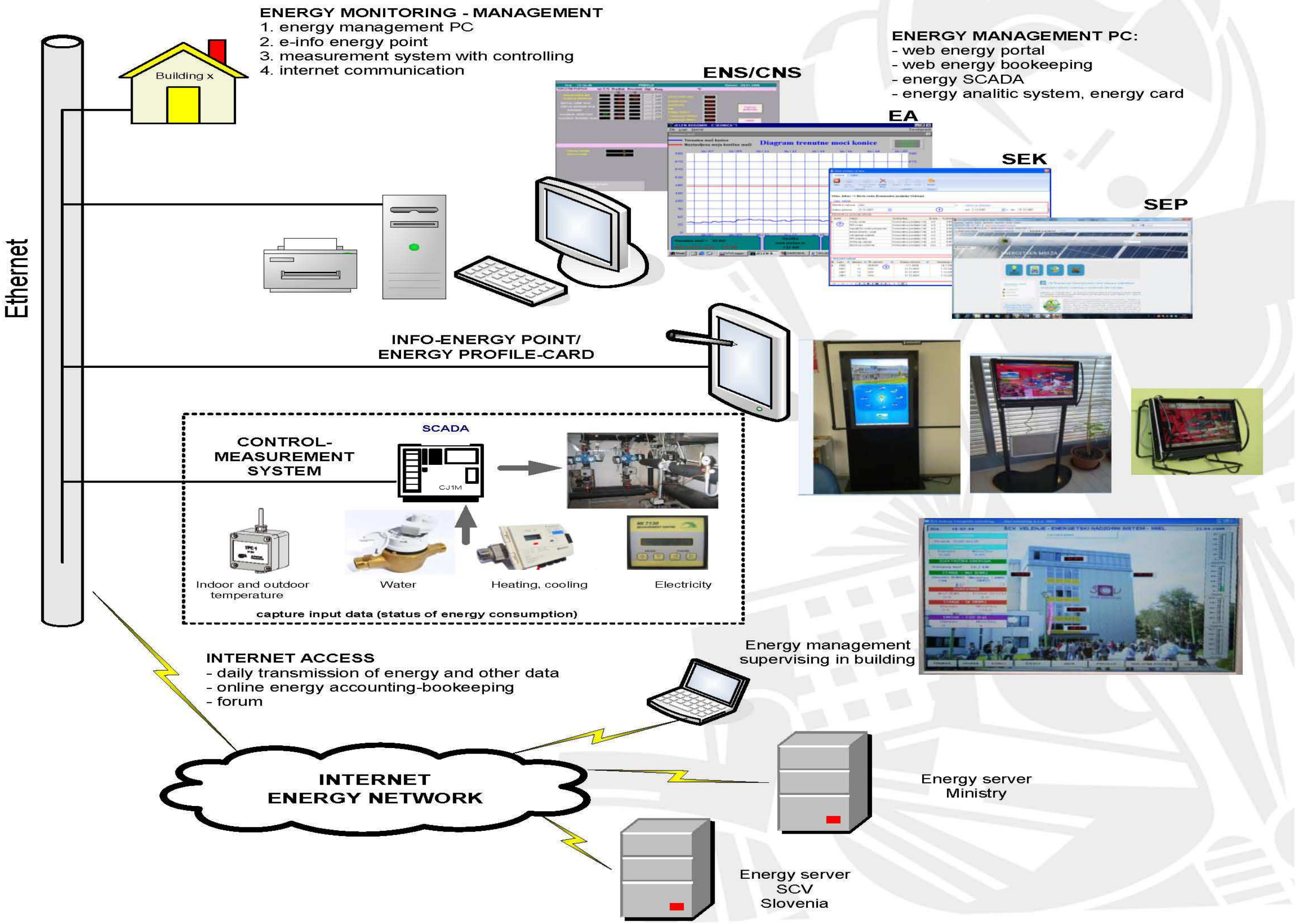
Organizational scheme of Energy management in SCV

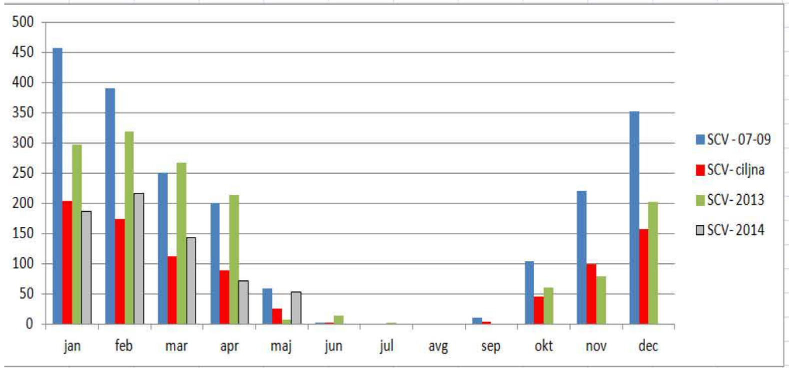


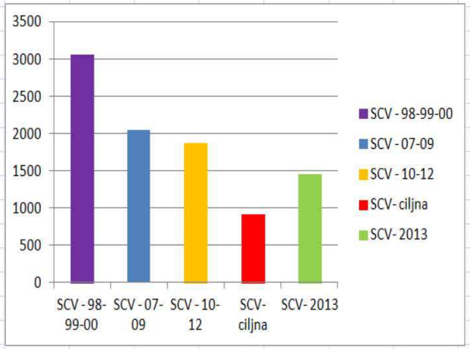
Energy Monitoring system – Case SCV



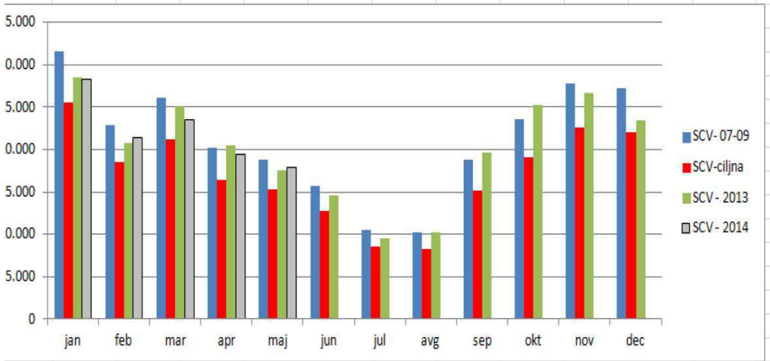
A comparative annual energy report of SC Velenje

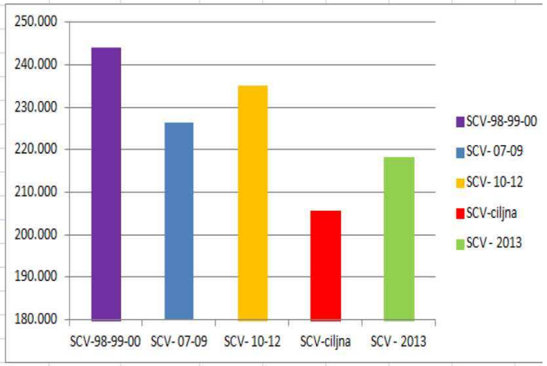
Heating (MWh)



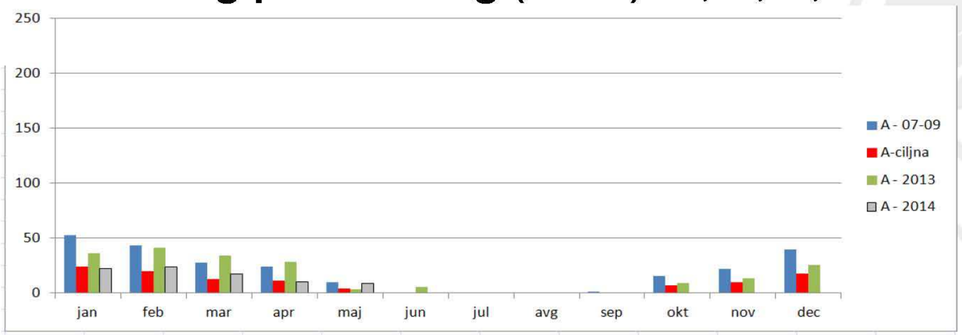


Electricity (kWh)

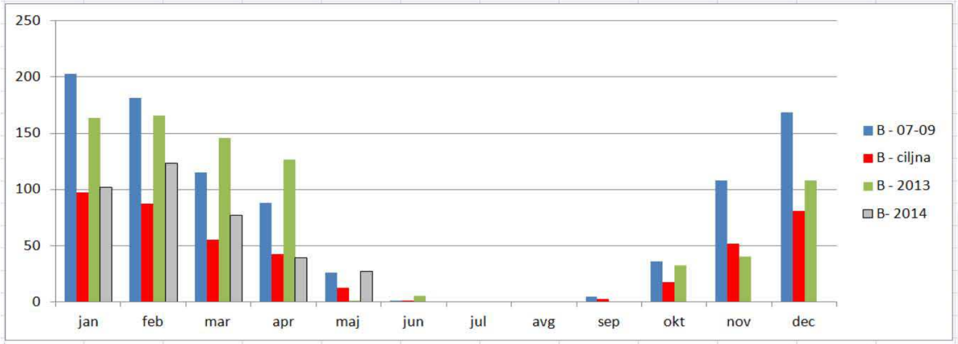




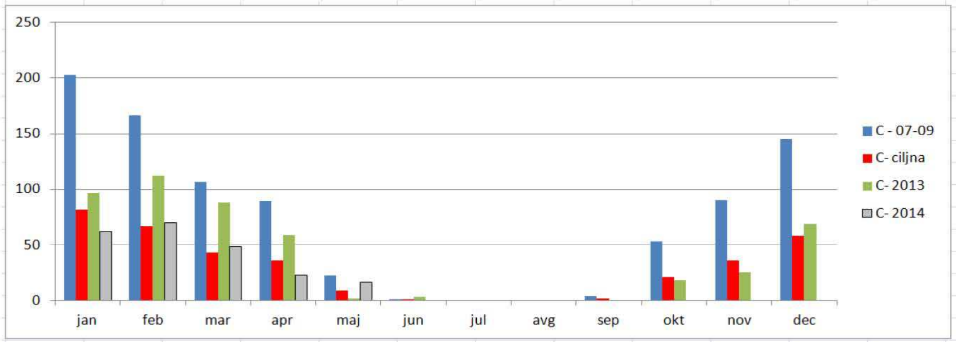
Heating per building (MWh): A, B, C,



A



B, E

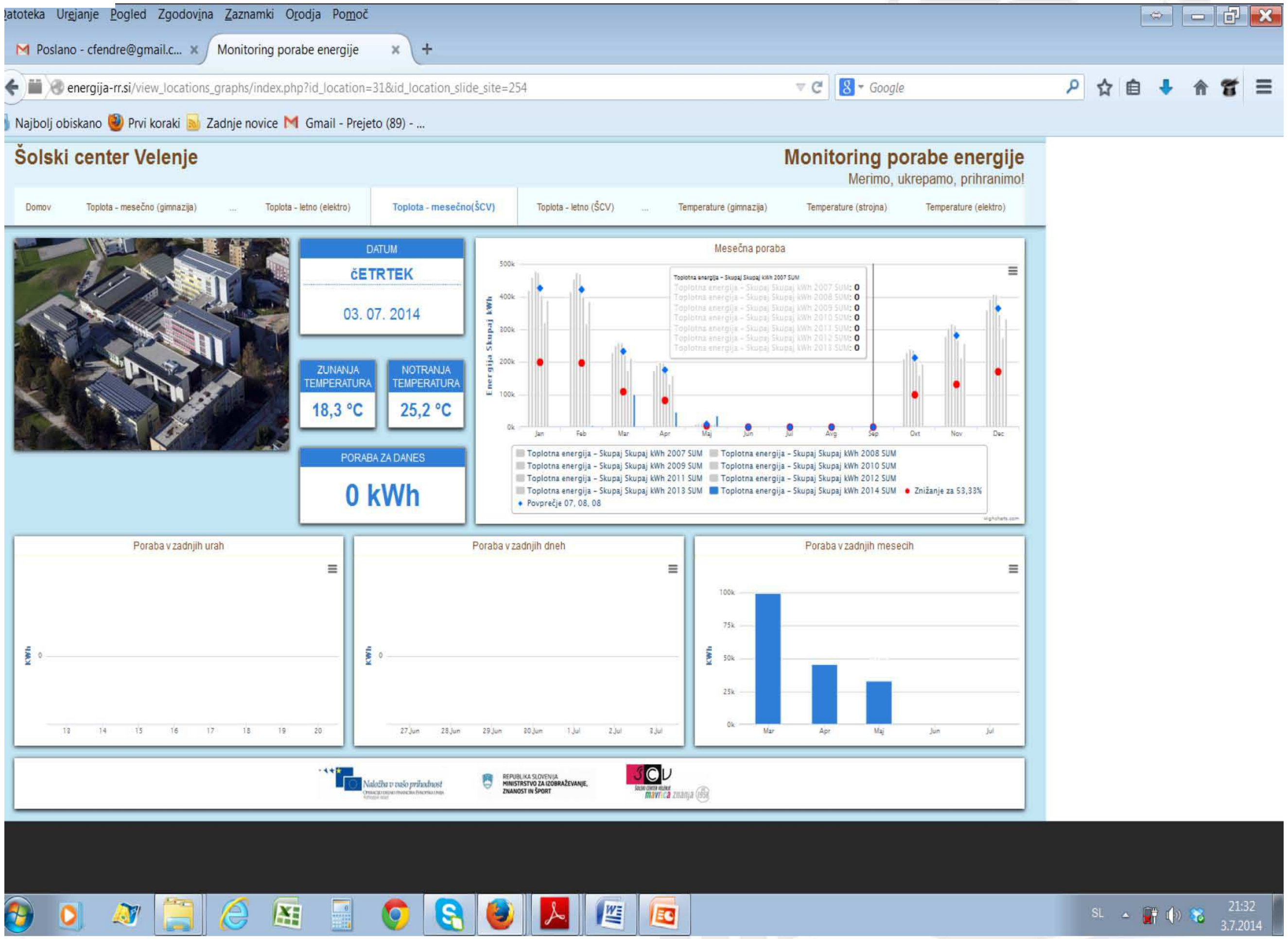


C, D, VSS

Energy e-Infopoint

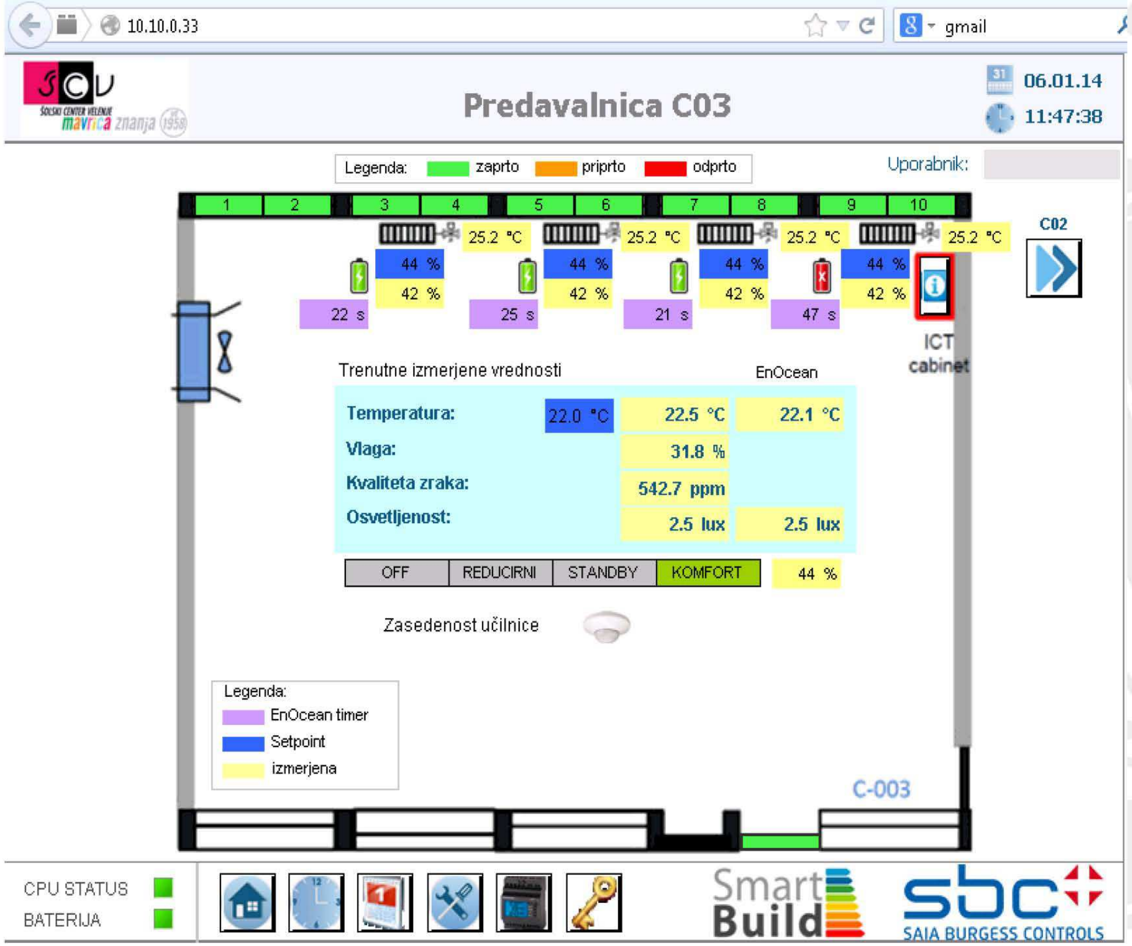
Dynamic building energy certificate

Energy monitoring DOM - heating

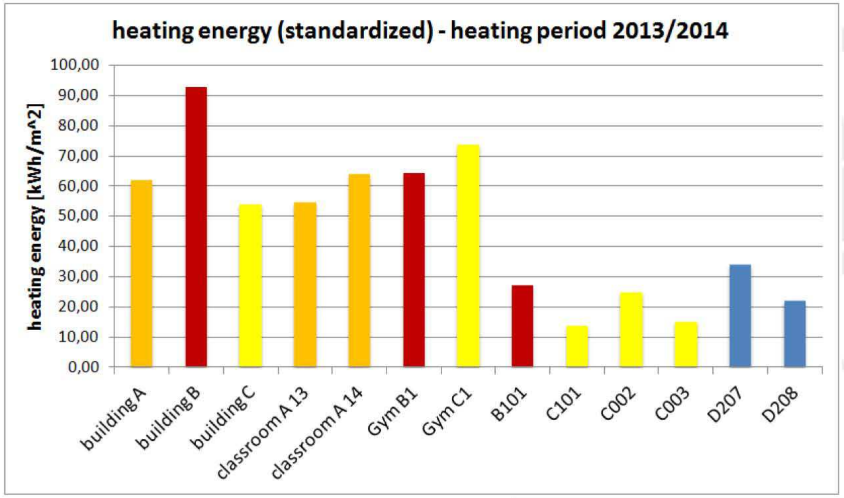


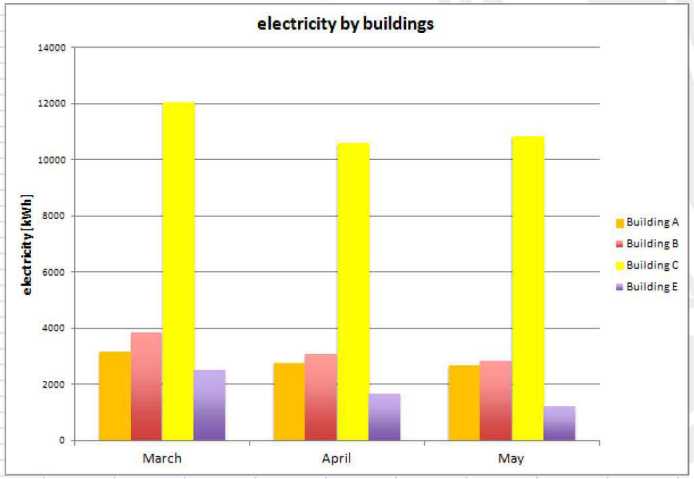
Energy monitoring DOM – electricity …

Central Supervising System CSS of room



Smart Build - analitics





Interreg CENTRAL EUROPE
European Union
European Regional Development Fund
TOGETHER

Technical Training module

Module 2

CaseSC Velenje, Trg mladosti 3

TAKING COOPERATION FORWARD

Cveto Fendre

Comprehensive Energy Retrofit of the Building

cveto.fendre@guest.arnes.si www.energetski-inzeniring.si

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:

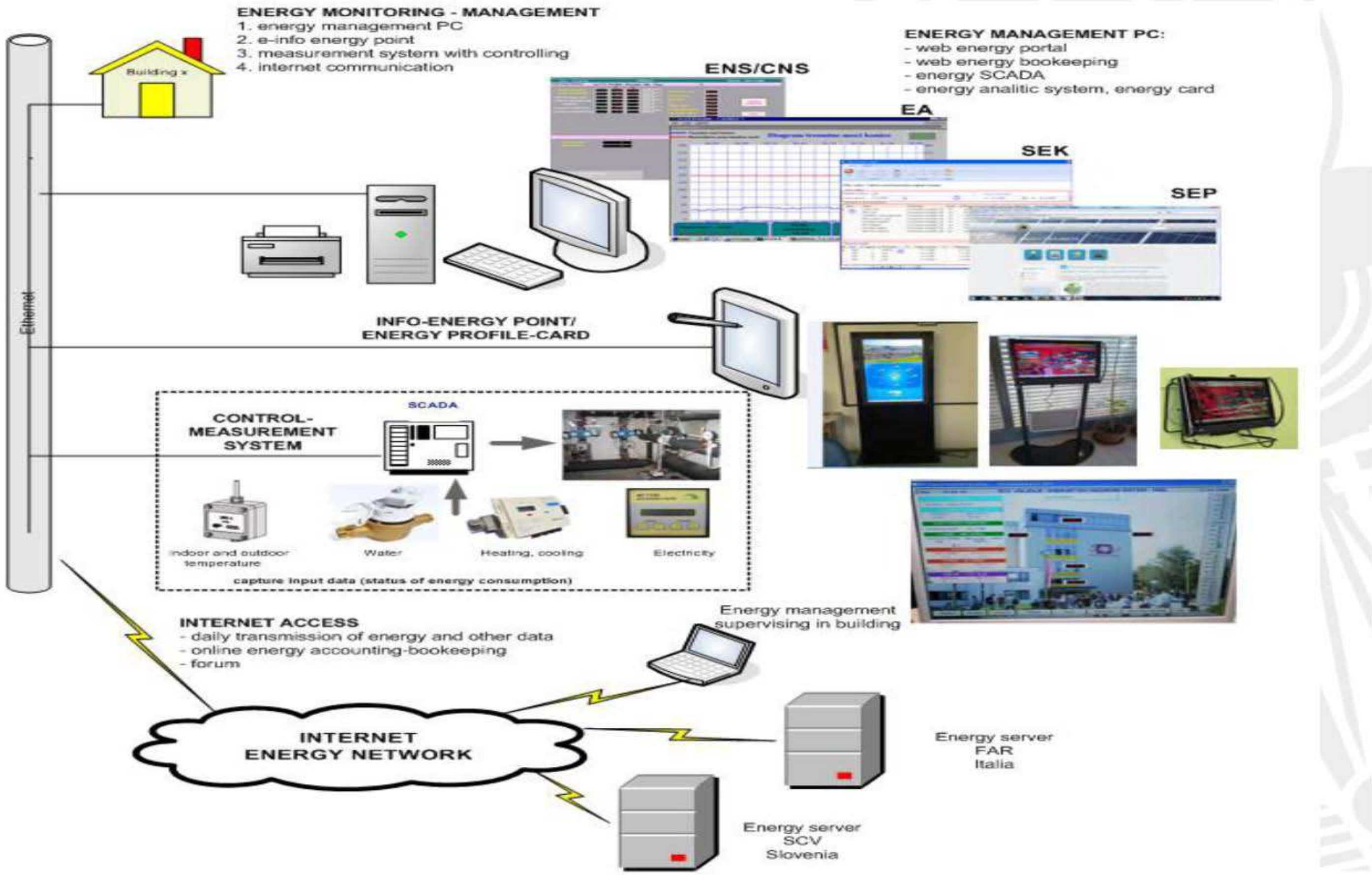
- energy capture, processing and analyzing of energy consumption and its costs **at the real current level** (e.g., minute, hourly and daily consumption from installed sensors)
- and **at monthly basis**, realized through invoices received from the energy suppliers.

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**.

Online building energy management – WEB energy monitoring



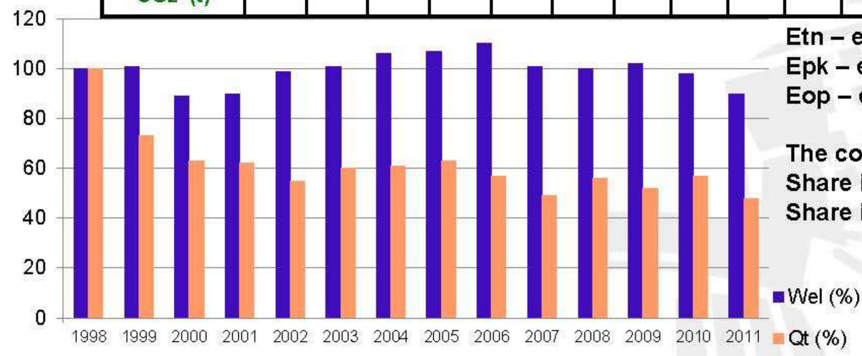
Example of good practice

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 - 50 %*

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/m^2)	**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/m^2)	**107**	116	102	94	96	99	96	99	96	90,3	85,9	85,6	75,9	65,8	72,49
Eop (kWh/m^2)	**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 CO_2 (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

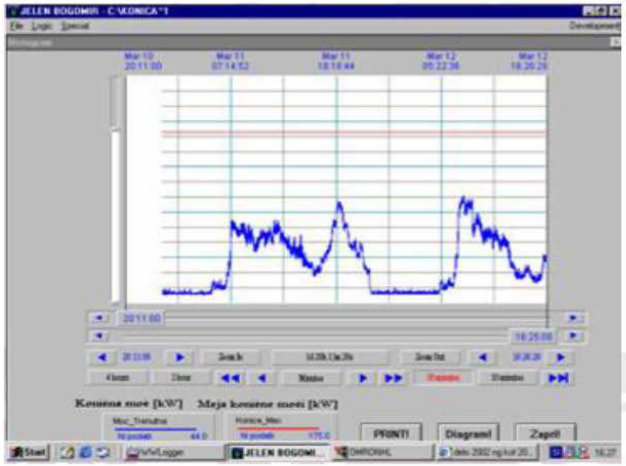
- **Technical and investment measures**

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

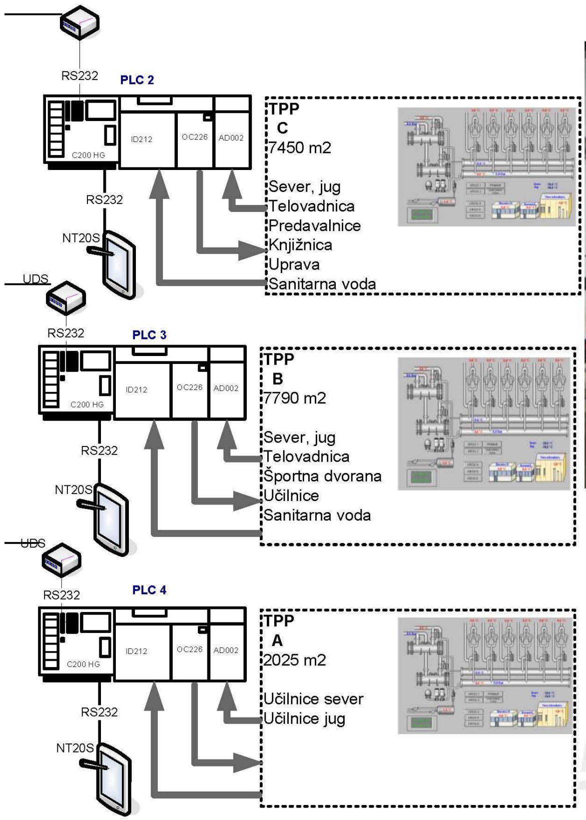
- Development of system for supervising electricity consumption (2000),
- Reconstruction of two thermal sub-stations in SCV in the context of RUE (2001),
- Modernization of interior lighting in the context of RUE (2002) …
- Comprehensive buildings energy refurbishment 2012

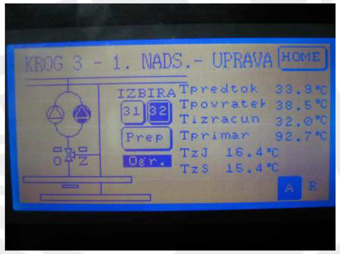
Automation of Energy Management in SCV

- 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





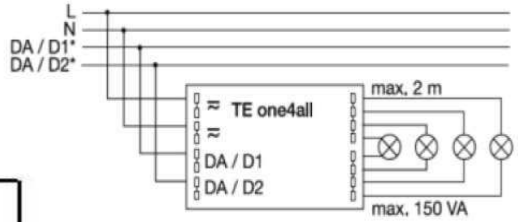
Interior lighting modernization ...

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

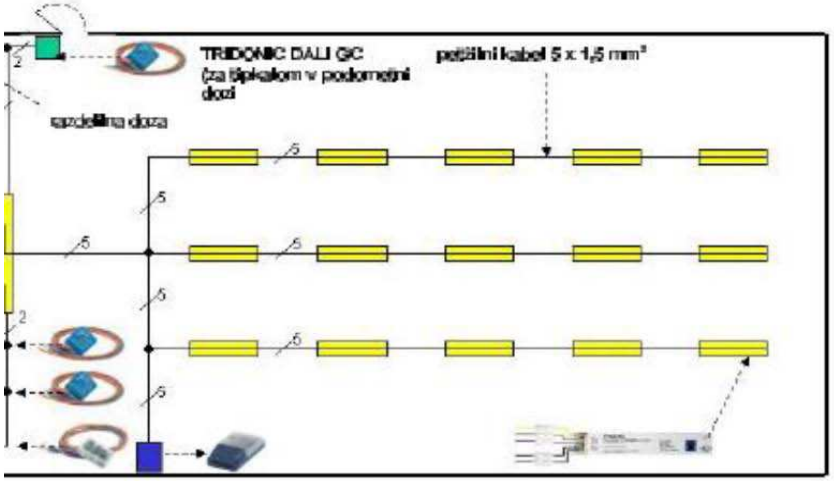
(DALI system - Digital Addressable Lighting Interface)

Interior lightning

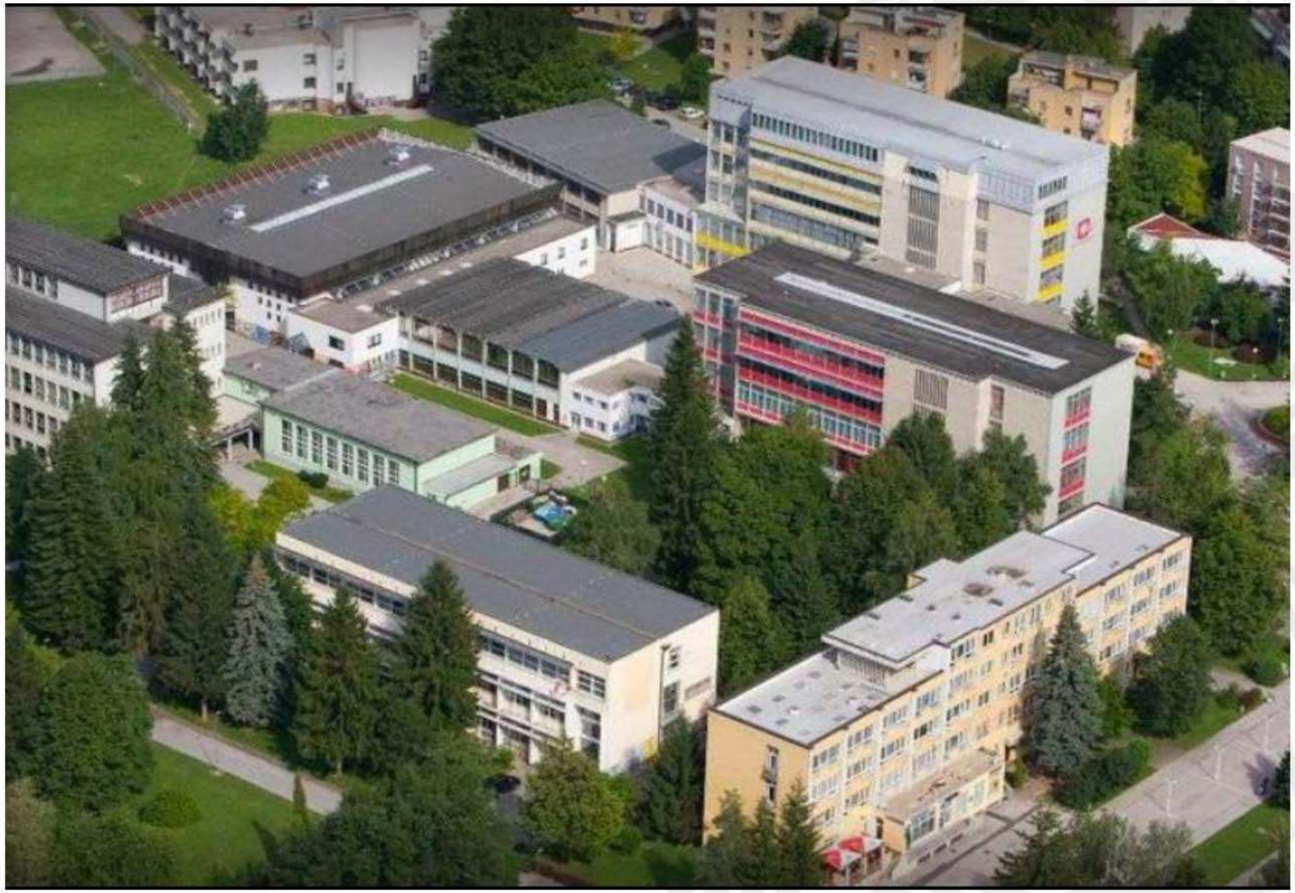
t control is realised through a DALI system, basic requirements for DALI system are:
- 5 lines system electrical installations
- Luminaires with built-DALI ballasts
- Installation with one or two-pole push-buttons and controls: Touch screen panel, PC, software ...



* digital signal DALI or DSI

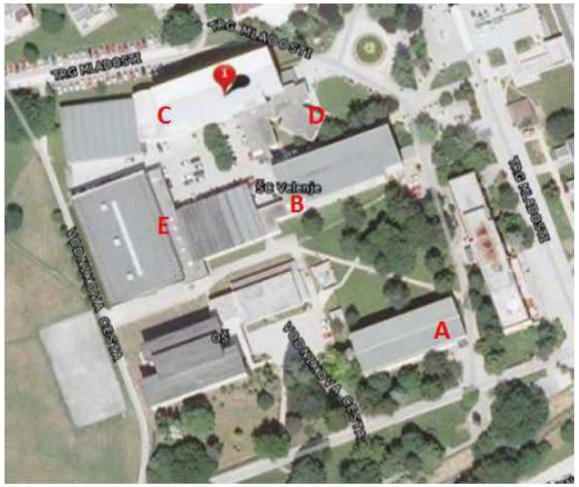


Complex SCV before refurbishment



Complex SCV after refurbishment

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 in building C 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.

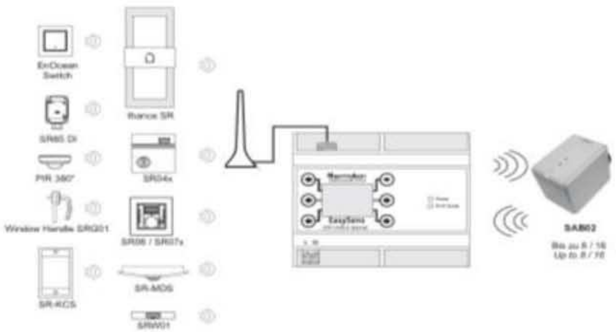
Controling system is implemented with the PLC and provides comprehensive energy monitoring system.

Energy Monitoring system

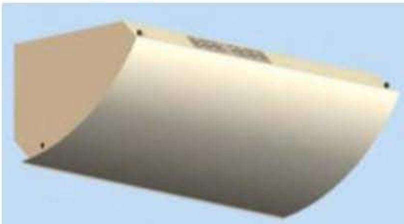
Energy monitoring system is designed for operation, management and supervision of the entire energy system. System allows displaying and monitoring the current, hourly, daily, monthly or annual energy data analysis and statistical processing of various data on energy production and consumption.

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

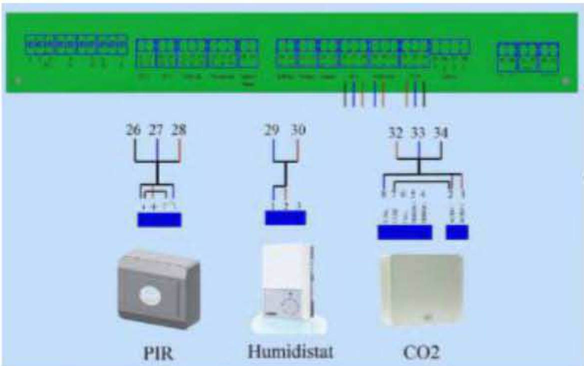
Radiator Heating system



Fresh air supply via heat recovery system



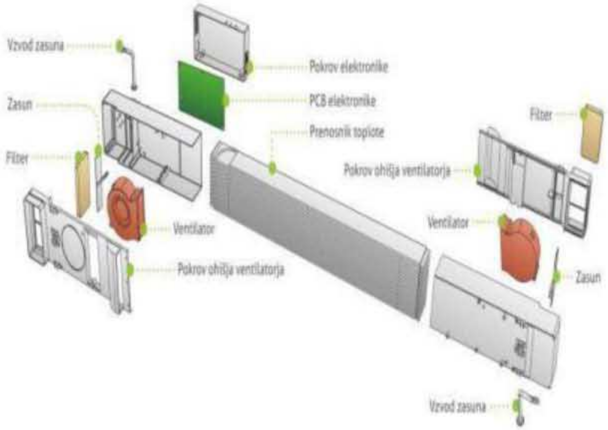
An electric air supply system with heat/cold energy recovery isinstalled



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

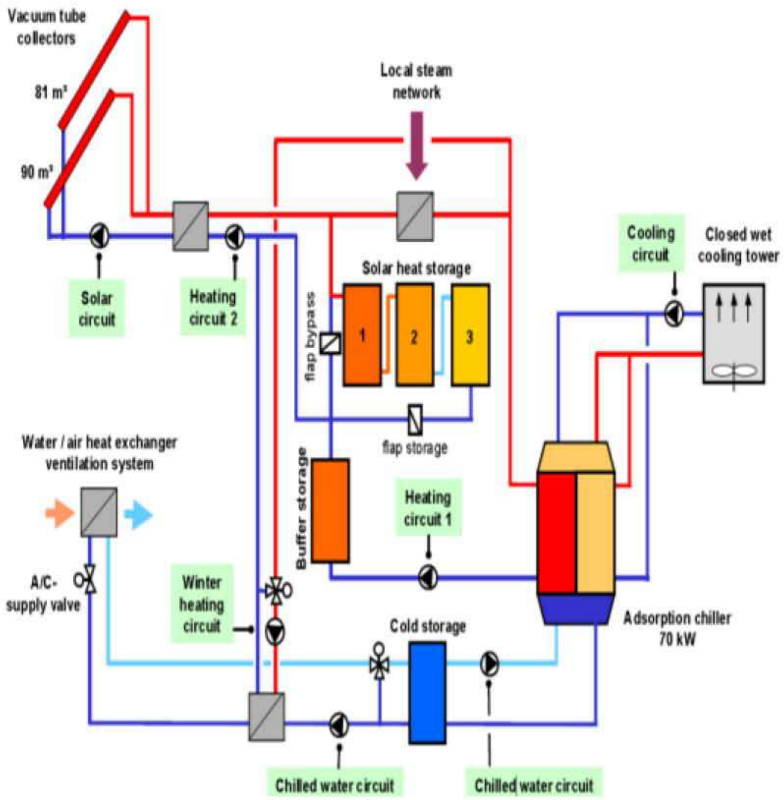
- large user friendly control panel
- can be connected to LON or MODBUS
- many opportunities for adjustments
- The controller can set multiple TX comfort systems. It is easy to move the display between systems.
- developed in cooperation with major danish compagny

Mikrovent system



RES - Scheme of the SCV solar heating-cooling system

SmartBuild



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

ZagEE

ZAGREB ENERGY EFFICIENT CITY

Refurbishment of public buildings and modernization of public lighting

MASTER TRAIN-THE-TRAINER WORKSHOP – 20 February 2017

Co-funded by the Intelligent Energy Europe
Programme of the European Union

FOND ZA ZAŠTITU OKOLIŠA I ENERGETSKU UČINKOVITOST

PROJECT ZAGEE

The project is implemented as part of the IEE program for technical assistance 2012. – MLEI Mobilization of local energy investments (call 2012) and includes financing of technical assistance as well as the production of the documentation necessary for energy refurbishment of objects, through the allocation of grants.

- the ZagEE project amounts **EUR 1.813.438**,
- total proposed energy investment cost (works for which the technical documentation will be produced amounts EUR **29.379.114**
- Leverage factor is **16,2**
- Duration is **36 month** (1 April 2013 – 31 March 2016)
- The works must be finished in three years after the end of the project

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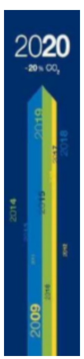
FOND ZA ZAŠTITU OKOLIŠA I ENERGETSKU UČINKOVITOST

WHY ZagEE ?

The building sector has the largest input of approximately 58% total consumption of the City of Zagreb. It has been estimated that the greatest potential for saving lies in exactly this sector.

The proactive energy policy of the City of Zagreb has set high targets in order to meet the obligations set out in the Covenant of Mayors and the Sustainable energy action plan of the City of Zagreb to reduce CO2 emissions min. by 21% through the application of energy efficiency measures and the use renewable energy sources by the year 2020.



Directive 2012/27/EU on energy efficiency obliges the public sector to acquire energy efficient buildings, products and services. The public sector is also obliged to reduce energy consumption in buildings it uses and owns by annually refurbishing 3% of total useful surface of heated or cooled parts of buildings belonging to the public sector in the aim of saving energy, starting with January 1, 2014.

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WHY ZagEE ?

Building sector in the City of Zagreb:

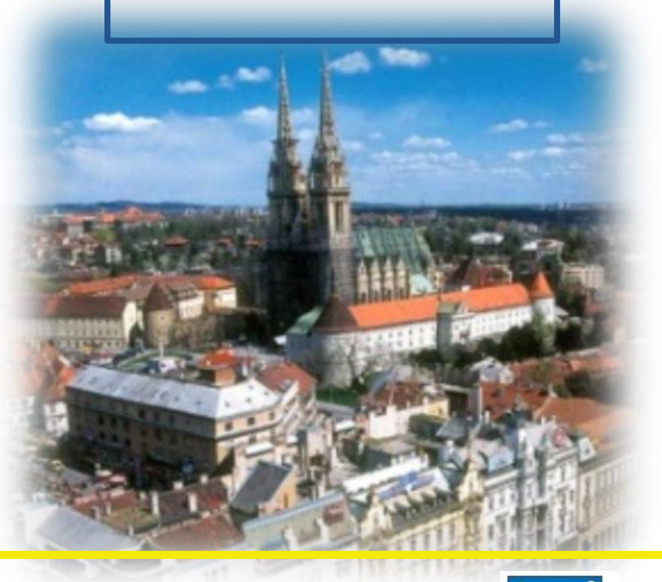
• Buildings of the City Administration and Local Self-Government	236 objects
• School and preschool buildings	387 objects
• The health service facilities	123 objects
• Homes for retired and elder people	12 objects
• Buildings for cultural activities	84 objects
• Offices and apartments (+ 51%)	792 objects
• Zagreb holding (17 branches, 4 trade associations and 1 institution) -	210 objects
• Sector for commercial and service activities	19.893 objects
• Housing sector - total number of apartments	280.354

Total annual energy consumption:

Buildings: 8.310 GWh
Transport: 3.532 GWh
Industry: 2.506 GWh
Public lighting: 90 GWh

In order to encourage the application of energy efficiency measures, the City of Zagreb shall provide an example of the usefulness of such measures for individuals and the society.

The project ZagEE supports the realization of energy savings through the implementation of economically justified EE measures on objects owned by the City of Zagreb.



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WHY ZagEE ?

GENERAL CONDITIONS

- SEAP of the City (planned EE measure)
- Data of energy consumption
- Energy audits (current state of buildings)
- Technical and human resources
- Good cooperation with stakeholders

PARTNERS CONTRIBUTED

- The City Office for Energy, Environment and Sustainable development (coordinator)
- City offices who are competent for objects (buildings and public lighting)
- REGEA (project partner)

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OBJECTIVES

ZagEE

Primary objectives

- Renovation of 87 public buildings – deep retrofitting measures
- Modernization of park lighting (3000 lamps)
- Reduced Energy consumption by 33.526 MWh , CO_2 emission by 8.390 t/year and 290 MWh green energy,
- More new jobs

Project background

- Largest retrofitting project in Croatia
- 90% of buildings below F energy class
- Ambitious energy saving targets (49-72%)
- Short time for implementation (clear division of responsibilities and strict deadlines)

Secondary objectives

- Capacity building (technical, financial, managerial) of city office employees and building managers
- Awareness raising among citizens and other stakeholders
- Find and use financing models for energy efficiency applicable to the city administration;
- Acquire knowledge and experience necessary for all participants of the energy refurbishment process through examples of energy efficiency implementation on a large number of objects of various purposes;
- To influence positive changes in the economy;
- to share the acquired skills and experiences and influence energy efficient development in other cities of the region and beyond;

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SUBJECT TO INVESTMENT

Type of investment	Energy investment costs (€)	Avoided GHG emissions (tCO2e/year)	Primary energy savings (MWh/year)	Renewable energy produced (MWh/year)
Refurbishment of public buildings	26.579.114	8.043	32.056	290
Public lighting	2.800.000	347	1.470	-
	29.379.114	8.390	33.526	290

Objects owned by the City of Zagreb

- 3 city administration buildings;
- 15 elementary schools;
- 7 secondary schools;
- 36 kindergartens;
- 6 retirement homes;
- 3 health centers;
- 17 buildings of local self-government

TOTAL 87 buildings, gross surface 226.654 m2

- modernization **of 3000** outdated luminaries in the public lighting system by LED luminaries with time based lighting control system.

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MAIN STEPS

- Establish Project Core team named by the Mayor: experts from different city offices responsible for implementation of action;
- Buildings register and database (validated and updated data from all energy audits, selection of buildings, the list of RUE and RES measures;
- Production of the City of Zagreb Lighting Masterplan;
- Production of quality technical documentation for the energy refurbishment of objects with a feasibility study;
- Find various financing sources, i.e. the city budget, EU and national funds, favorable bank loans and other sources acceptable for the city administration;
- Performing public tenders for works on the energy refurbishment of objects;
- Procedure of public procurement for documentation, works and supervisory activities.

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CHALLENGESS

- Define financial sources and set up in the city budget according the regulations
- Public procurement (long and complicated process)
- Preparations a lot of tender documentation and procedure of public procurement in a short time
- Catch the summer holidays for refurbishment of buildings (in kindergartens and schools) in 2015, 2016 and 2017
- Estimated costs for works (there is no experience)

Project ZagEE has political and public acceptance:
- Project Core team cooperate efficiently
- Politicians, experts, financial institutions and media support Project ZagEE

Program ZagEE 2013 – 2017 (in detail investment plan) is essential for estimate investment in the city budget and it is the base document for application on founds, banks, etc.
(Program ZagEE 2013 – 2017 has been approved by the City Assembly)

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FUNDING SOURCES

Type of investment	Size of the investment (€)	Sources and share of funding		
		Own budget	Loans	EU funding
Refurbishment of buildings	26.579.114	30%	35%	35%
Public lighting	2.800.000	30%	35%	35%

ESTIMATED IN PROJECT

- **Environmental Protection and Energy Efficiency Fund (EPEEF)**
  grants of 40% of total investment for works
- **Croatian Bank for Reconstruction and Development (HBOR)**
  loans + EIB grant
- **Calls for proposals of Ministry of Construction and Physical Planning**
  Pilot program *Energy renovation of public schools and other educational buildings*
  grants 50%
- **ESCo model** - Agency for Transactions and Mediation in Immovable Properties - coordinator of the program on national level

AVAILABLE SOURCES

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CURRENT SITUATION

Technical documentation for buildings

- 89 buildings (completed)

Technical documentation for public lighting

- 3.000 led lamps (completed)

Refurbishment of buildings (60)

- 26 buildings (finished)
- 4 buildings (work is going on)
- 7 buildings (in the process of contracting)
- 14 (in the process of public procurement)
- 9 buildings (preparation phase for public procurement in 2017)

Refurbishment of public lighting

- 1.153 led lamps (finished)
- 950 led lamps (preparation phase for public procurement)

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Current situation

Measures in buildings

- Thermal insulation of envelopes (walls and roof) with rock wool
- Replacement of old joinery with energy efficient joinery
- Replacement of inefficient fuel oil boilers with gas boilers
- Balancing the heating system and the installation of thermostatic valves
- Replacement of inefficient indoor light bulbs
- Installation of solar panels and solar collectors
- Smart metering

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REFURBISHMENT OF BUILDINGS

Kindergarten *Pčelica*

Surface: 2.368 m2
Year of built: 1972

Before refurbishment

- Energy consumption (2013): 466,99 MWh/year
- Energy class: E

After refurbishment

- Energy class: B
- Energy savings: 370 MWh/year
- CO2 reduction: 85 t/year
- Investment: 414.000 EUR
- Financial savings: approx. 26.790 EUR per year

The refurbishment involves

- the reparation of the building's external envelope - thermal insolation: rock wool - 16cm walls, 20 cm roof
- replacement of existing windows with more energy efficient (1,10 W/m2K)
- replacement of inefficient indoor light bulbs
- balancing the heating system and the installation of thermostatic valves
- smart metering

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REFURBISHMENT OF BUILDINGS

How it looks

KINDERGARTEN PČELICA

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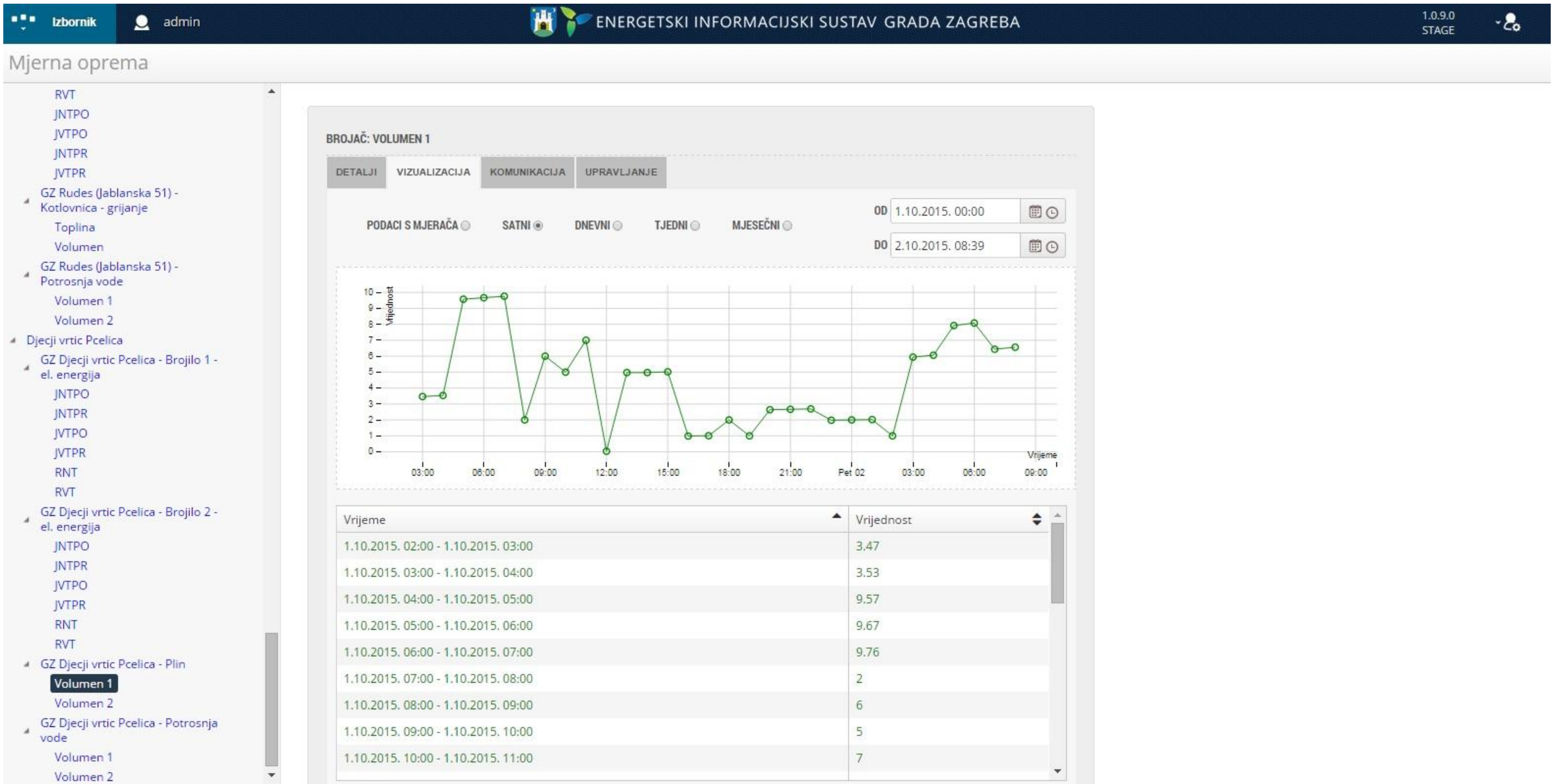
Smart metering



REFURBISHMENT OF BUILDINGS

ZagEE

- BEFORE RECONSTRUCTION:

- Object: Primary school *Lovro pl Matačića*
- Location: street Joze Laurenčića 1
- Year built: 1963.
- Area (Ak): 2.921,00 m2 (three floors, gym not included)
- Energy class, according to the physics of a building: F
- The annual demand of a thermal energy to the physics of a building: 625,56 MWh / a

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REFURBISHMENT OF BUILDINGS

- BEFORE RECONSTRUCTION:

- Designer: PRIMA PARS doo, Zagreb, D & Z doo, Zadar, INEL doo, Đakovo, BESTPROJEKT doo, Zagreb
- Contractor: TA-GRAD doo, Zagreb
- Supervision: MG PLAN doo, Sesvete
- Investment: 580,000 EUR
- Co-financing by National Fund: 40%
- Start of works: October 2015.
- Completed: May 2016.

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REFURBISHMENT OF BUILDINGS

- BEFORE RECONSTRUCTION:

- UNDER RECONSTRUCTION:

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REFURBISHMENT OF BUILDINGS

1. Thermal insulation of the external walls with the ETICS system made of a panels (expanded polystyrene) 18cm;

2. Thermal insulation of the walls above the foundation as a part of the ETICS system (boards of a extruded polystyrene) 10 cm;

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REFURBISHMENT OF BUILDINGS

3. Thermal insulation of the ceilings under the flat roof with panels of a rock wool - 32 cm;

4. Replace the salonit sheet with a painted metal sheet;

5. Replacement of the existing windows and doors with a energy-efficient aluminium doors and PVC windows, glazed with double layer insulated glass (heat transfer coefficient of 1.3 W / m2K);

BEFORE

AFTER

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REFURBISHMENT OF BUILDINGS

6. Replacement of the existing glazing with the three-layer insulated glass (heat transfer coefficient of 1.3 W / m2K);

7. Remote system readings of energy consumption and water.

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REFURBISHMENT OF BUILDINGS

After refurbishment

- Reducing the energy consumption for 487,63 MWh /a (78%);
- Reduction of CO_2 emissions by 146,29 tons / year;
- Total financial savings with energy consumption 50.300,00 EUR / year;
- Energy class B;
- Increase the services quality

- **Education** of the users about how to use the building after the reconstruction.
  Guidelines for managers have been produced.

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IS IT WORTH IT TO APPLY FOR MLEI - PDA?

This allows the beneficiaries to produce project documentation and feasibility studies and obtain the necessary documentation needed for financing the energy refurbishment of objects from sources other than the city budget, such as banks and EU funds.

With more effort, capacities of city administrations are directed to implementation of works (refurbishments of buildings and modernization of public lighting) due to certain deadlines for works.

Benefits of such investment have

- City administration (reduced bills, satisfied citizens, meeting performance target by SEAP, experience in implementation of such projects, economic growth)
- Manager of buildings (easier maintenance)
- Users of the buildings (better and healthier working environment)

As renovation of buildings and public lighting will be done in any case, MLEI - PDA funding allows this to be done in energy efficient way

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Thank you for your attention

Contact:
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melita.boric@zagreb.hr

www.zagee.hr

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Technical Training material

Module 1: ENERGY AUDIT

Case study: Sample of SC Velenje/Building A Energy audit

Energy Audit

An energy audit is the general term used for a systematic procedure that aims at obtaining an adequate knowledge of the energy consumption profile of a building or an industrial plant. It also aims at identifying and scaling the cost-effective energy saving opportunities for the unit. Energy audits are crucial in the implementation of energy saving measures and in the assurance of the targets of Energy Management.

In an energy audit:

- the main goal is to achieve energy savings,
- there may be other aspects to consider (technical condition, environment) but the main interest is on energy consumption and saving possibilities,
- reports on energy saving measures are produced,
- the work may cover all energy using aspects of a site or certain limited parts (systems, equipment) of several sites (horizontal audit).

Figure 1: Some instruments for the measurement of living comfort and energy consumption at energy audit in building

The term “energy audit” may have different meaning depending on the country and the service provider. There may be another name for the whole process (such as energy survey, assessment, etc.), but the activity meets the same criteria that stand for an energy audit. It is also important to notice that energy audit is not a continuous activity but should be repeated periodically. Energy auditing of buildings can range from a short walk-through of the facility to a very detailed analysis with hourly computer simulation.

Step-by-step procedure for a Standard Energy Audit

To perform an energy audit, several tasks are typically carried out depending on the type of the audit and the size and function of the building. Some of the tasks may have to be repeated, reduced in scope, or even eliminated based on the findings of other tasks. Therefore, the execution of an energy audit is often not a linear process and is rather iterative. A general procedure can be however outlined for most buildings, and is described in the following paragraphs. This is the procedure recommended to be followed too in the frame of the Smart Build approach.

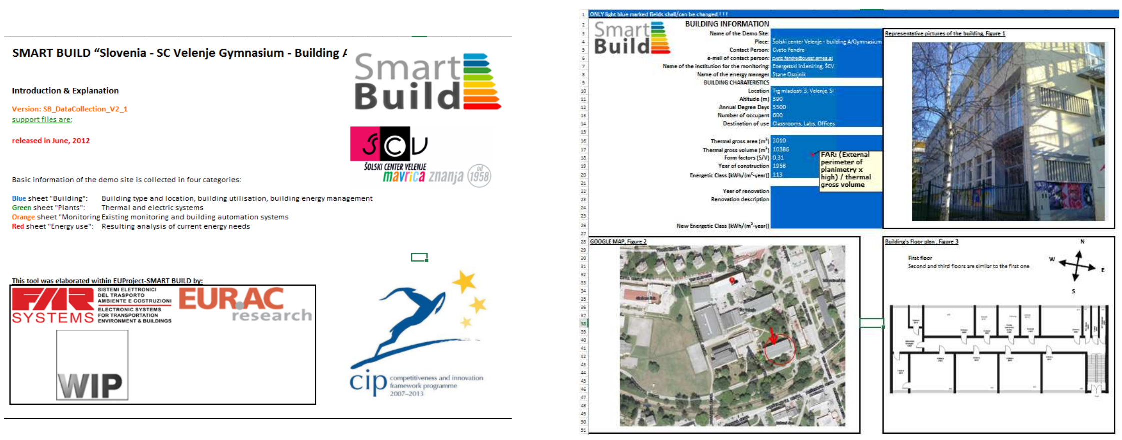


Figure 2: Main data of the reviewed building

Step 1: Building and Utility Data Analysis

The main purpose of this step is to evaluate the characteristics of the energy systems and the patterns of energy use for the building. The building characteristics can be collected from the architectural/mechanical/electrical drawings or from discussions with building operators. The energy use patterns can be obtained from a compilation of utility bills over several years. Analysis of the historical variation of the utility bills allows the energy auditor to determine if there any seasonal and weather effects on the building energy use. This data can be retrieved with the aid of a structured and concise questionnaire (the Energy Audit "Data Collection Form").

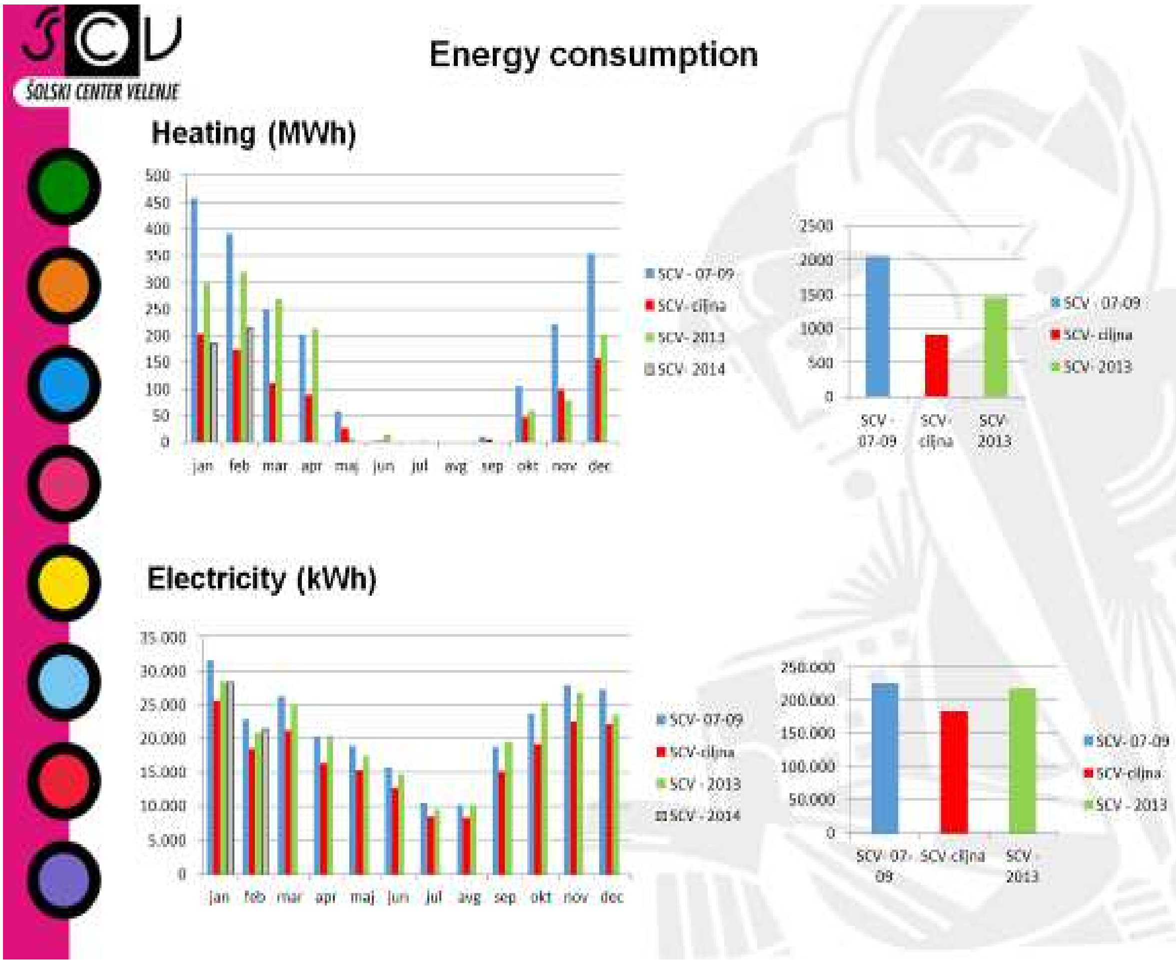


Figure **Errore. Nel documento non esiste testo dello stile specificato.**: SCV Energy consumption analysis of heat and electricity

Some of the tasks to be performed in this step [together with the key results expected from each task] are:

- Collect at least three years of utility data (to identify a historical energy use pattern).

- Identify the fuel types used (to determine the fuel type accounting for the largest energy use).
- Determine the patterns of fuel use by fuel type (to identify the peak demand for energy by fuel type).
- Understand utility rate structure (energy and demand rates) [to evaluate if the building is penalized for peak demand and if cheaper fuel can be purchased].
- Analyze the effect of weather on fuel consumption.
- Perform utility energy use analysis by building type and size (building signature can be determined including energy use per unit area [to compare against typical indices].

Step 2: Walk-through Survey

From this step, potential energy savings measures should be identified. The results of this step are important since they determine if the building warrants any further energy auditing work. The findings should be tabulated in another specific form. Some of the tasks involved in this step are:

- Identify the customer concerns and needs.
- Check the current operating and maintenance procedures.
- Determine the existing operating conditions of major energy use equipment (lighting, HVAC systems, motors, etc.).
- Estimate the occupancy, equipment, and lighting (energy use density and hours of operation).

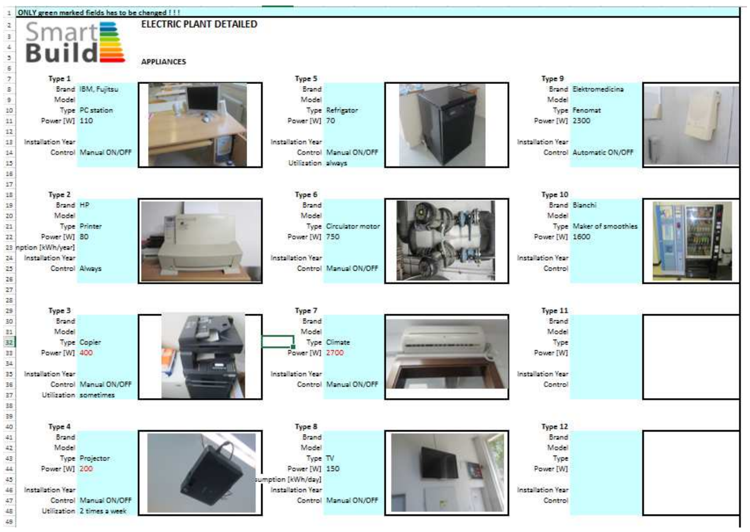


Figure **Errore. Nel documento non esiste testo dello stile specificato.**.1: Inventory and review of energy consumer

Step 3: Baseline for Energy Use

The main purpose of this step is to develop a base-case model that represents the existing energy use and operating conditions for the building. This model will be used as a reference to estimate the energy savings due to appropriately selected ECMs. The major tasks to be performed during this step are:

- Obtain and review architectural, mechanical, electrical, and control drawings.
- Inspect, test, and evaluate building equipment for efficiency, performance, and reliability.
- Obtain all occupancy and operating schedules for equipment (including lighting and HVAC systems).
- Develop a baseline model for building energy use.
- Calibrate the baseline model using the utility and/or metered data.

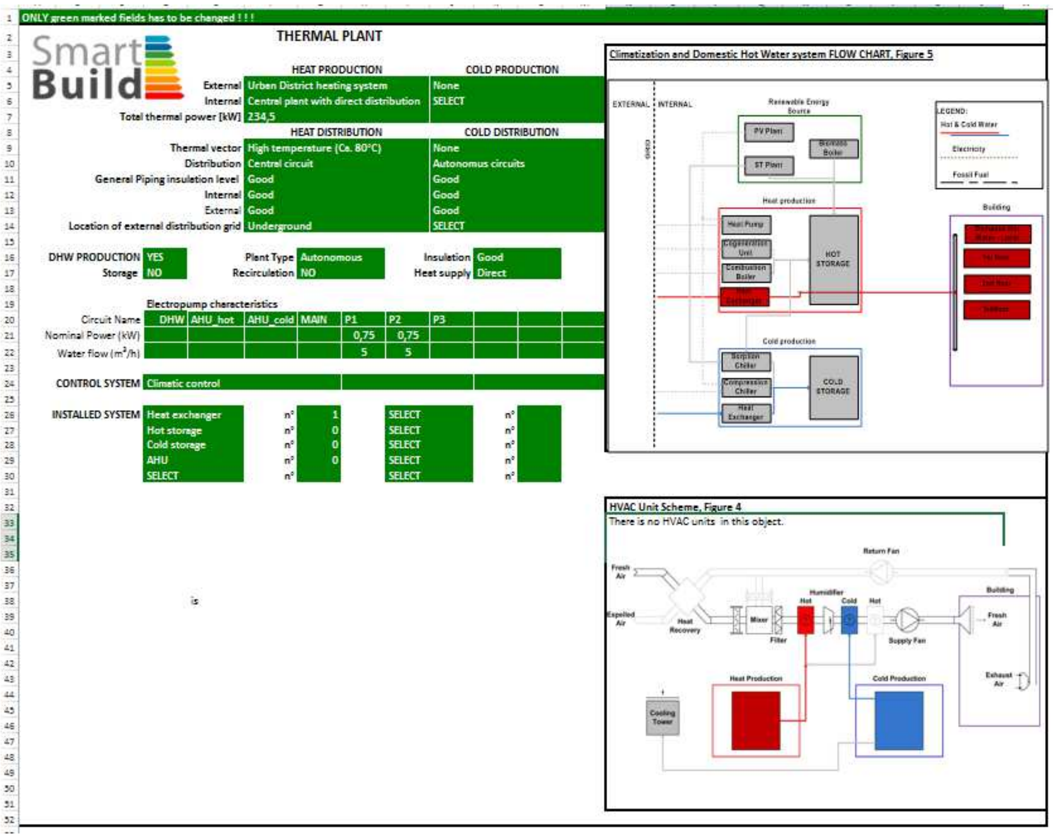
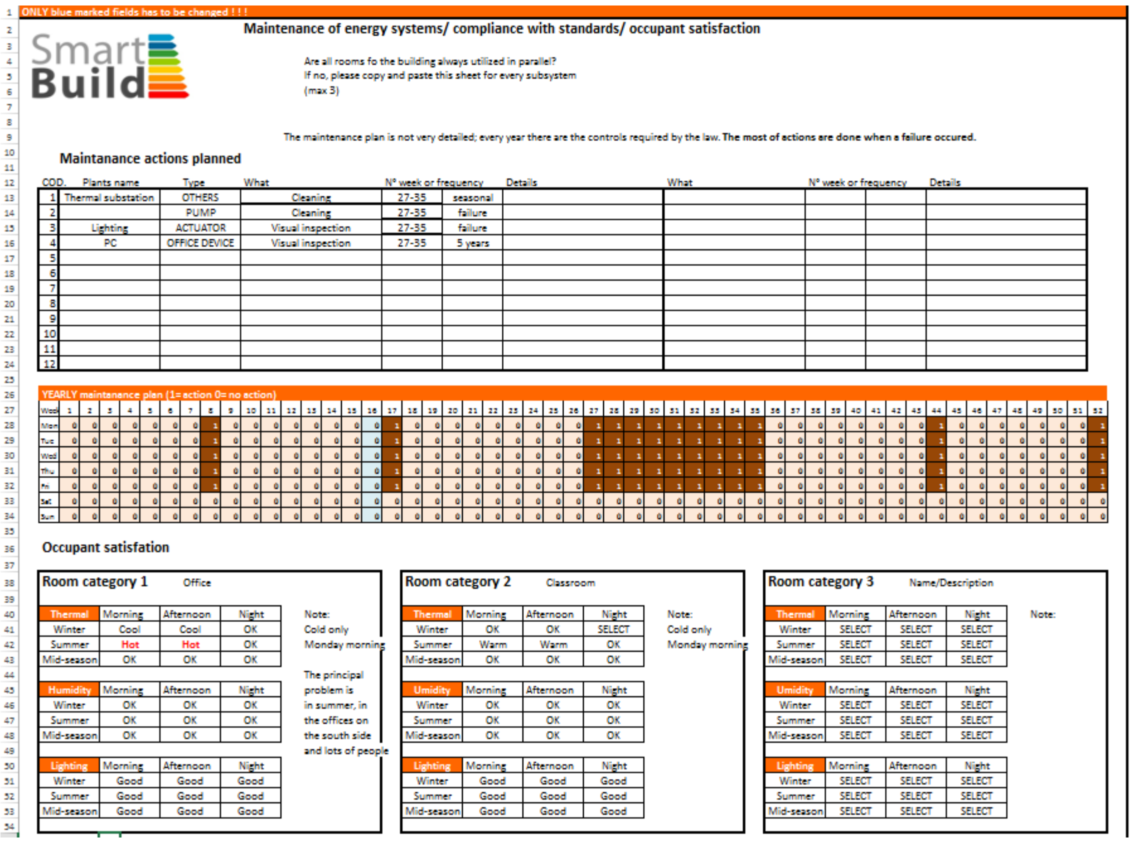


Figure **Errore. Nel documento non esiste testo dello stile specificato.**.2: Example of Building Audit Tool Template „TH-Plants

Step 4: Evaluation of the Energy Savings Measures

In this step, a list of cost-effective ECMs is determined using both energy savings and economic analysis. The following tasks are recommended:

- Prepare a comprehensive list of energy conservation measures (using the information collected in the walk-through survey).
- Determine energy savings due to the various ECMs pertinent to the building using the baseline energy use model developed in step 3.
- Estimate the initial costs required to implement the energy conservation measures.
- Evaluate the cost-effectiveness of each energy conservation measure and maintenance actions using an economical analysis method.


ONLY blue marked fields has to be changed ! ! !

Maintenance of energy systems/ compliance with standards/ occupant satisfaction

Smart Build

Are all rooms fo the building always utilized in parallel?
If no, please copy and paste this sheet for every subsystem
(max 3)

The maintenance plan is not very detailed; every year there are the controls required by the law. The most of actions are done when a failure occured.

Maintanance actions planned

COD.	Plants name	Type	What	N° week or frequency		Details	What	N° week or frequency		Details
1	Thermal substation	OTHERS	Cleaning	27-35	seasonal					
2		PUMP	Cleaning	27-35	failure					
3	Lighting	ACTUATOR	Visual inspection	27-35	failure					
4	PC	OFFICE DEVICE	Visual inspection	27-35	5 years					
5										
6										
7										
8										
9										
10										
11										
12										

YEARLY maintenance plan (1= action 0= no action)

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Mon	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Tue	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Wed	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Thu	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Fri	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Sat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Week	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Mon	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Tue	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Wed	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Thu	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Fri	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Sat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Occupant satisfation

Room category 1 — Office

Thermal	Morning	Afternoon	Night
Winter	Cool	Cool	OK
Summer	Hot	Hot	OK
Mid-season	OK	OK	OK

Humidity	Morning	Afternoon	Night
Winter	OK	OK	OK
Summer	OK	OK	OK
Mid-season	OK	OK	OK

Lighting	Morning	Afternoon	Night
Winter	Good	Good	Good
Summer	Good	Good	Good
Mid-season	Good	Good	Good

Note:
Cold only
Monday morning

The principal problem is in summer, in the offices on the south side and lots of people

Room category 2 — Classroom

Thermal	Morning	Afternoon	Night
Winter	OK	OK	SELECT
Summer	Warm	Warm	OK
Mid-season	OK	OK	OK

Umidity	Morning	Afternoon	Night
Winter	OK	OK	OK
Summer	OK	OK	OK
Mid-season	OK	OK	OK

Lighting	Morning	Afternoon	Night
Winter	Good	Good	Good
Summer	Good	Good	Good
Mid-season	Good	Good	Good

Note:
Cold only
Monday morning

Room category 3 — Name/Description

Thermal	Morning	Afternoon	Night
Winter	SELECT	SELECT	SELECT
Summer	SELECT	SELECT	SELECT
Mid-season	SELECT	SELECT	SELECT

Umidity	Morning	Afternoon	Night
Winter	SELECT	SELECT	SELECT
Summer	SELECT	SELECT	SELECT
Mid-season	SELECT	SELECT	SELECT

Lighting	Morning	Afternoon	Night
Winter	SELECT	SELECT	SELECT
Summer	SELECT	SELECT	SELECT
Mid-season	SELECT	SELECT	SELECT

Note:

Figure **Errore. Nel documento non esiste testo dello stile specificato.**.3: Audit Tool Template „Monitoring 0“ of Building

The Energy Audit procedure is completed with the presentation of all the energy saving proposals having the form of a summarized techno-economical report, which is composed by the Energy Auditor and presented to the building/unit manager. The table below provides a summary of the energy audit procedure recommended for commercial and residential buildings. Energy audits for thermal and electrical systems are separated since they are typically subject to different utility rates.

Table 1: Energy Audit Summary for Residential and Commercial Building

PHASE	THERMAL SYSTEM	ELECTRIC SYSTEM
1 UTILITY DATA ANALYSIS	▪ Thermal energy use profile (building signature) ▪ Thermal energy use per unit area (or per student for schools) ▪ Thermal energy use distribution (heating, DHW, process, etc.) ▪ Fuel types used ▪ Weather effect on thermal energy use ▪ Utility rate structure	▪ Electrical energy use profile (building signature) ▪ Electrical energy use per unit area (or per student for schools or per bed for hotels) ▪ Electrical energy use distribution (cooling, lighting, equipment, fans, etc.) ▪ Weather effect on electrical energy use ▪ Utility rate structure (energy charges, demand charges, power factor penalty, etc.)
2 ON-SITE SURVEY	▪ Construction materials (thermal resistance type and thickness) ▪ HVAC system type ▪ DHW system ▪ Hot water/steam use for heating, cooling, DHW and specific applications (hospitals, swimming pools, etc.)	▪ HVAC system type ▪ Lighting type and density ▪ Equipment type and density ▪ Energy use for heating, cooling, lighting, equipment, air handling, water distribution
3 ENERGY USE BASELINE	▪ Review architectural, mechanical, and control drawings ▪ Develop a base-case model (using any base lining method ranging from very simple to more detailed tools) ▪ Calibrate the base-case model (using utility or metered data)	▪ Review architectural, mechanical, electrical, and control drawings ▪ Develop a base-case model (using any base lining method ranging from very simple to more detailed tools) ▪ Calibrate the base-case model (using utility or metered data)
4 ENERGY CONSERVATION MEASURES	▪ Heat recovery system (heat exchangers) ▪ Efficient heating system (boilers) ▪ Temperature Setback ▪ Energy Monitoring and Control Systems (EMCS) ▪ HVAC system retrofit ▪ DHW use reduction ▪ Cogeneration	▪ Energy efficient lighting, equipment, motors ▪ HVAC system retrofit ▪ EMCS ▪ Temperature Setup ▪ Energy efficient cooling system (chiller) ▪ Peak demand shaving ▪ Thermal Energy Storage System ▪ Cogeneration ▪ Power factor improvement, Reduction of harmonics

Simply calculation of building physics

Usable area of the building	Au = xxx m^2
Heated building volume	Ve = xxx m^3
The entire outer surface of the building	A = xxx m^2
Form factor buildings	fo = A / Ve (m^{-1})

Au = 0,32 Ve

V = 0,8 Ve … usable building volume

The maximum allowed heat after building complex reconstruction:

Residential building/normally heated:	**Qh/Au = 45 + 40 x fo (kWh/m^2a)**
Public building/periodically heated on min 18 °C:	**Qh/Ve = 14,4 + 12,8 x fo (kWh/m^3a)**
Public building/mostly heated on min 18 °C:	**Qh/Ve = 28,8 + 25,6 x fo (kWh/m^3a)**

Data from EA

Building A / Energy indicators	
Au = 2.010 m^2 (2025 m^2 EA); A = 3.205 m^2; Ve = 10.386 m^3 ; **fo = 0,31**	
Qh before / after	Qh = 201.038 kWh / 107.810 kWh
Calculated Qh/Au before / after:	Qh/Au = 100 kWh/m^2a / 54 kWh/m^2a
Heating saving potential	**Q = 93.228 kWh**
Eh Building A in 2010:	Eh = 122 kWh/m^2 a (121 EA)

Building A / Heat required before refurbishment

	$Q_{H,tr}$ kWh	$Q_{H,ve}$ kWh	$Q_{H,ht}$ kWh	$Q_{H,int}$ kWh	$Q_{H,sol}$ kWh	$Q_{H,gn}$ kWh	γ_H	$\eta_{H,gn}$	Q_{NH} kWh
Januar	39881	22644	62525	5982	5202	11184	0,18	1,00	51341
Februar	32591	18504	51095	5403	7325	12728	0,25	1,00	38368
Marec	28487	16174	44661	5982	10109	16091	0,36	1,00	28570
April	20216	11478	31695	5789	12794	18583	0,59	1,00	13112
Maj	11395	6470	17864	5982	12500	18482	1,03	0,95	275
Junij	5514	3130	8644	5789	11519	17308	2,00	0,50	0
Julij	1899	1078	2977	5982	12411	18393	6,18	0,16	0
Avgust	3798	2157	5955	5982	11236	17217	2,89	0,35	0
Septemb	9189	5217	14407	5789	8975	14763	1,02	0,96	268
Oktober	18991	10783	29774	5982	7798	13780	0,46	1,00	15994
Novembe	29405	16696	46101	5789	4838	10627	0,23	1,00	35474
Decembe	37982	21565	59547	5982	4258	10240	0,17	1,00	49307
Skupaj	239348	135896	375245	70430	108965	179396			232709

	Dovoljeno	Izračunano
Koeficient specifičnih transmisijskih toplotnih izgub H_T (W/ m²K)	0,51	0,99
Letna potrebna toplota na enoto prostornine Q_{NH}/V_e (kWh / m³a)	9,74	22,41
Letna energija za hlajenje na enoto hlajene površine Q_{NC}/A_u (kWh / m²a)		0,02
Letna primarna energija, preračunana na uporabno površino Q_p/A_u (kWh/m²a)		9,38

Building A / Heat required after refurbishment

	$Q_{H,tr}$ kWh	$Q_{H,ve}$ kWh	$Q_{H,ht}$ kWh	$Q_{H,int}$ kWh	$Q_{H,sol}$ kWh	$Q_{H,gn}$ kWh	γ_H	$\eta_{H,gn}$	Q_{NH} kWh
Januar	22036	22644	44680	5982	4404	10386	0,23	1,00	34294
Februar	18008	18504	36513	5403	6219	11622	0,32	1,00	24891
Marec	15740	16174	31914	5982	8612	14594	0,46	1,00	17320
April	11171	11478	22649	5789	10954	16743	0,74	1,00	5906
Maj	6296	6470	12766	5982	10726	16707	1,31	0,76	1
Junij	3047	3130	6177	5789	9930	15719	2,54	0,39	0
Julij	1049	1078	2128	5982	10679	16661	7,83	0,13	0
Avgust	2099	2157	4255	5982	9630	15612	3,67	0,27	0
Septemb	5078	5217	10295	5789	7657	13445	1,31	0,77	1
Oktober	10494	10783	21276	5982	6632	12614	0,59	1,00	8662
Novembe	16248	16696	32944	5789	4103	9892	0,30	1,00	23052
Decembe	20987	21565	42552	5982	3602	9584	0,23	1,00	32969
Skupaj	132252	135896	268149	70430	93149	163579			147096

	Dovoljeno	Izračunano
Koeficient specifičnih transmisijskih toplotnih izgub H_T (W/ m²K)	0,51	0,55
Letna potrebna toplota na enoto prostornine Q_{NH}/V_e (kWh / m³a)	9,74	14,16
Letna energija za hlajenje na enoto hlajene površine Q_{NC}/A_u (kWh / m²a)		0,95
Letna primarna energija, preračunana na uporabno površino Q_p/A_u (kWh/m²a)		9,38

Building B / Heat required before refurbishment

✔ Primarna energija | Zagotavljanje OVE | Grafi | Napake pri izračunu

Potrebna toplota za ogrevanje cone | Potreben hlad za hlajenje cone

Toplotne izgube | Potrebna toplota za ogrevanje | ✔ Potreben hlad za hlajenje

	$Q_{H,tr}$ kWh	$Q_{H,ve}$ kWh	$Q_{H,ht}$ kWh	$Q_{H,int}$ kWh	$Q_{H,sol}$ kWh	$Q_{H,gn}$ kWh	γ_H	$\eta_{H,gn}$	Q_{NH} kWh
Januar	144790	78136	222926	8184	21251	29436	0,13	1,00	193491
Februar	118323	63853	182176	7392	25347	32739	0,18	1,00	149437
Marec	96527	52091	148618	8184	32204	40388	0,27	1,00	108229
April	66723	36008	102731	7920	35469	43390	0,42	1,00	59341
Maj	34474	18604	53078	8184	40323	48508	0,91	0,99	5093
Junij	13345	7202	20546	7920	36636	44556	2,17	0,46	0
Julij	0	0	0	8184	38260	46444	0,00	0,00	0
Avgust	6895	3721	10616	8184	37071	45256	4,26	0,23	0
Septemb	33362	18004	51366	7920	31756	39676	0,77	1,00	11706
Oktober	68948	37208	106155	8184	25427	33611	0,32	1,00	72544
Novembe	106758	57612	164370	7920	18492	26412	0,16	1,00	137958
Decembe	131000	70695	201695	8184	17813	25998	0,13	1,00	175698
Skupaj	821143	443133	1264277	96364	360050	456413			913497

	Dovoljeno	Izračunano
Koeficient specifičnih transmisijskih toplotnih izgub H_T (W/ m²K)	0,48	0,77
Letna potrebna toplota na enoto prostornine Q_{NH}/V_e (kWh / m³a)	9,07	22,05
Letna energija za hlajenje na enoto hlajene površine Q_{NC}/A_u (kWh / m²a)		0,00
Letna primarna energija, preračunana na uporabno površino Q_p/A_u (kWh/m²a)		2,68

Building B / Heat required after refurbishment

✔ Primarna energija | Zagotavljanje OVE | Grafi | Napake pri izračunu

Potrebna toplota za ogrevanje cone | Potreben hlad za hlajenje cone

✔ Toplotne izgube | Potrebna toplota za ogrevanje | ✔ Potreben hlad za hlajenje

	$Q_{H,tr}$ kWh	$Q_{H,ve}$ kWh	$Q_{H,ht}$ kWh	$Q_{H,int}$ kWh	$Q_{H,sol}$ kWh	$Q_{H,gn}$ kWh	γ_H	$\eta_{H,gn}$	Q_{NH} kWh
Januar	70440	78136	148576	8184	17655	25840	0,17	1,00	122736
Februar	57564	63853	121417	7392	21168	28560	0,24	1,00	92857
Marec	46960	52091	99051	8184	27076	35261	0,36	1,00	63790
April	32461	36008	68468	7920	30119	38039	0,56	1,00	30429
Maj	16771	18604	35375	8184	34470	42655	1,21	0,83	28
Junij	6492	7202	13694	7920	31498	39418	2,88	0,35	0
Julij	0	0	0	8184	32812	40997	0,00	0,00	0
Avgust	3354	3721	7075	8184	31520	39704	5,61	0,18	0
Septemb	16230	18004	34234	7920	26768	34688	1,01	0,96	943
Oktober	33543	37208	70751	8184	21319	29503	0,42	1,00	41248
Novembe	51937	57612	109549	7920	15449	23370	0,21	1,00	86179
Decembe	63731	70695	134426	8184	14808	22993	0,17	1,00	111433
Skupaj	399482	443133	842616	96364	304663	401026			549644

	Dovoljeno	Izračunano
Koeficient specifičnih transmisijskih toplotnih izgub H_T (W/ m²K)	0,47	0,35
Letna potrebna toplota na enoto prostornine Q_{NH}/V_e (kWh / m³a)	9,47	13,27
Letna energija za hlajenje na enoto hlajene površine Q_{NC}/A_u (kWh / m²a)		0,12
Letna primarna energija, preračunana na uporabno površino Q_p/A_u (kWh/m²a)		2,68

Building C / Heat required before refurbishment

✓ Primarna energija | ! Zagotavljanje OVE | Grafi | Napake pri izračunu

Potrebna toplota za ogrevanje cone | Potreben hlad za hlajenje cone

! Toplotne izgube | ! Potrebna toplota za ogrevanje | ✓ Potreben hlad za hlajenje

	$Q_{H,tr}$ kWh	$Q_{H,ve}$ kWh	$Q_{H,ht}$ kWh	$Q_{H,int}$ kWh	$Q_{H,sol}$ kWh	$Q_{H,gn}$ kWh	γ_H	$\eta_{H,gn}$	Q_{NH} kWh
Januar	151167	70140	221308	21446	16690	38136	0,17	1,00	183172
Februar	123535	57319	180854	19371	19437	38808	0,21	1,00	142046
Marec	107977	50100	158077	21446	23603	45049	0,28	1,00	113028
April	76629	35555	112184	20754	25682	46436	0,41	1,00	65747
Maj	43191	20040	63231	21446	28914	50360	0,80	1,00	12909
Junij	20899	9697	30596	20754	27427	48181	1,57	0,64	0
Julij	7198	3340	10538	21446	27301	48747	4,63	0,22	0
Avgust	14397	6680	21077	21446	26264	47710	2,26	0,44	0
Septemb	34831	16161	50993	20754	23574	44328	0,87	1,00	6855
Oktober	71985	33400	105385	21446	19822	41268	0,39	1,00	64117
Novembe	111460	51716	163176	20754	14595	35349	0,22	1,00	127827
Decembe	143969	66800	210769	21446	13996	35442	0,17	1,00	175327
Skupaj	907237	420949	1328186	252508	267305	519813			891028

	Dovoljeno	Izračunano
Koeficient specifičnih transmisijskih toplotnih izgub H_T (W/ m^{2}K)	0,48	0,95
Letna potrebna toplota na enoto prostornine Q_{NH}/V_e (kWh / m^{3}a)	10,73	26,36
Letna energija za hlajenje na enoto hlajene površine Q_{NC}/A_u (kWh / m^{2}a)		0,00
Letna primarna energija, preračunana na uporabno površino Q_p/A_u (kWh/m^{2}a)		1,25

Building C / Heat required after refurbishment

✓ Primarna energija | ! Zagotavljanje OVE | Grafi | Napake pri izračunu

Potrebna toplota za ogrevanje cone | Potreben hlad za hlajenje cone

✓ Toplotne izgube | ! Potrebna toplota za ogrevanje | ✓ Potreben hlad za hlajenje

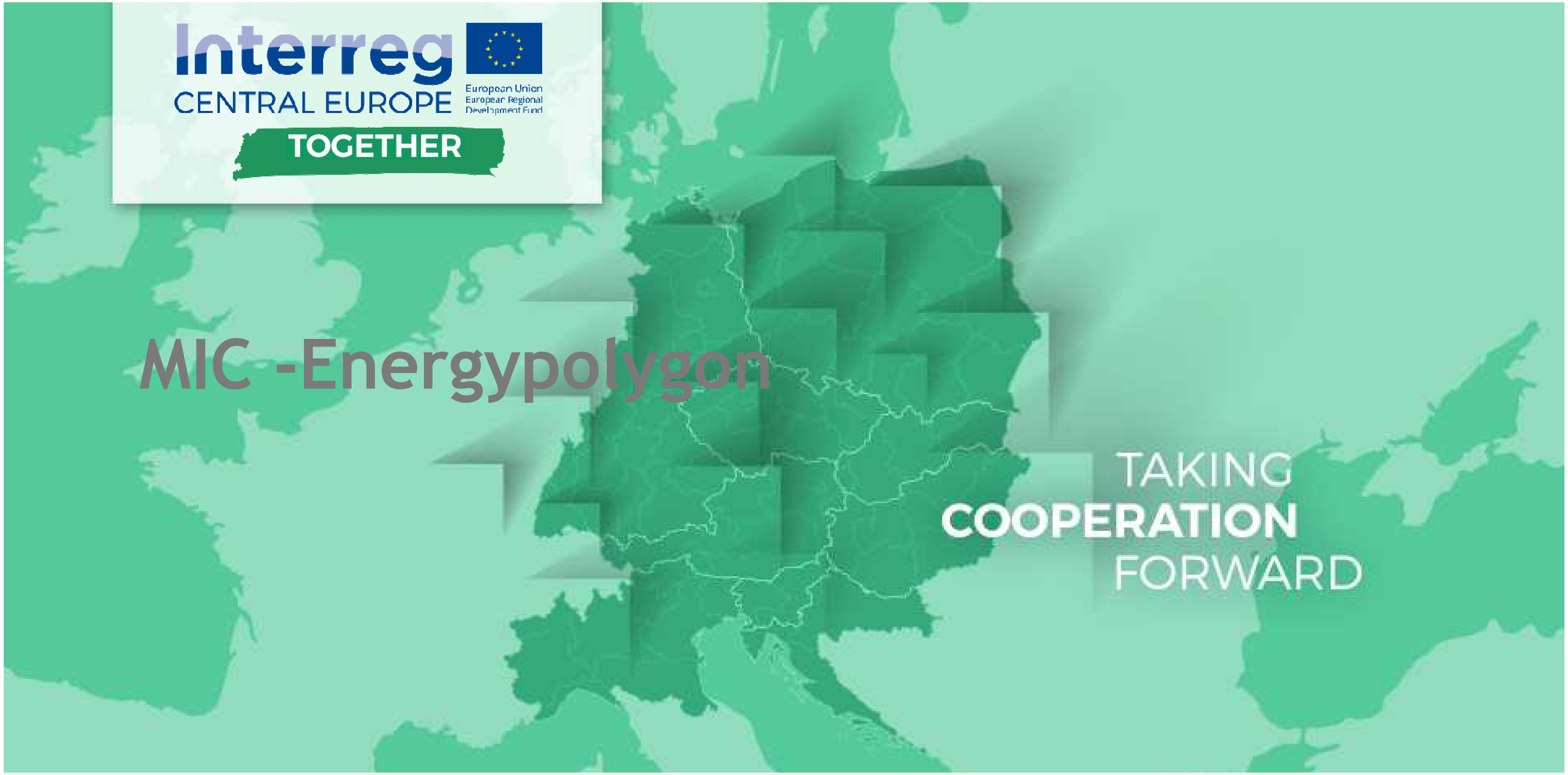
	$Q_{H,tr}$ kWh	$Q_{H,ve}$ kWh	$Q_{H,ht}$ kWh	$Q_{H,int}$ kWh	$Q_{H,sol}$ kWh	$Q_{H,gn}$ kWh	γ_H	$\eta_{H,gn}$	Q_{NH} kWh
Januar	60291	70140	130431	21446	15181	36627	0,28	1,00	93804
Februar	49270	57319	106589	19371	17659	37029	0,35	1,00	69560
Marec	43065	50100	93165	21446	21498	42944	0,46	1,00	50221
April	30562	35555	66117	20754	23532	44286	0,67	1,00	21832
Maj	17226	20040	37266	21446	26544	47990	1,29	0,78	9
Junij	8335	9697	18032	20754	25223	45977	2,55	0,39	0
Julij	2871	3340	6211	21446	25018	46464	7,48	0,13	0
Avgust	5742	6680	12422	21446	23973	45419	3,66	0,27	0
Septemb	13892	16161	30053	20754	21520	42274	1,41	0,71	1
Oktober	28710	33400	62110	21446	18124	39570	0,64	1,00	22540
Novembe	44454	51716	96171	20754	13358	34112	0,35	1,00	62058
Decembe	57420	66800	124220	21446	12774	34220	0,28	1,00	90000
Skupaj	361839	420949	782788	252508	244404	496912			410026

	Dovoljeno	Izračunano
Koeficient specifičnih transmisijskih toplotnih izgub H_T (W/ m^{2}K)	0,48	0,38
Letna potrebna toplota na enoto prostornine Q_{NH}/V_e (kWh / m^{3}a)	10,73	12,13
Letna energija za hlajenje na enoto hlajene površine Q_{NC}/A_u (kWh / m^{2}a)		0,56
Letna primarna energija, preračunana na uporabno površino Q_p/A_u (kWh/m^{2}a)		1,25

Cumulative savings (kWh) after investment

	HEATING REFURBISHEMENT
Building A	85.613
Building B	363.853
Building C	481.002
	930.468 kWh

MIC -Energypolygon



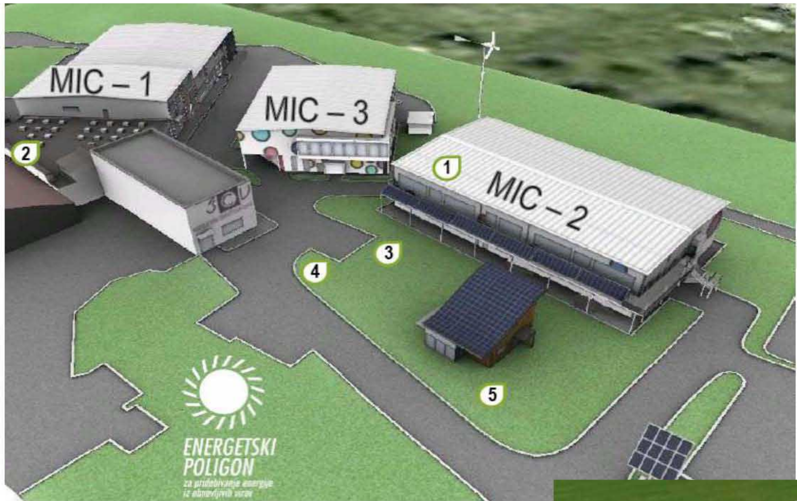
www.energetski-poligon.si

MIC - Energy polygon

www.energetski-poligon.si

Location: Inter-Company Training center, SCV, Velenje, SI
Was built to promote alternative energy sources for education and research purposes
It was partly financed by the EU – foundation for regional development

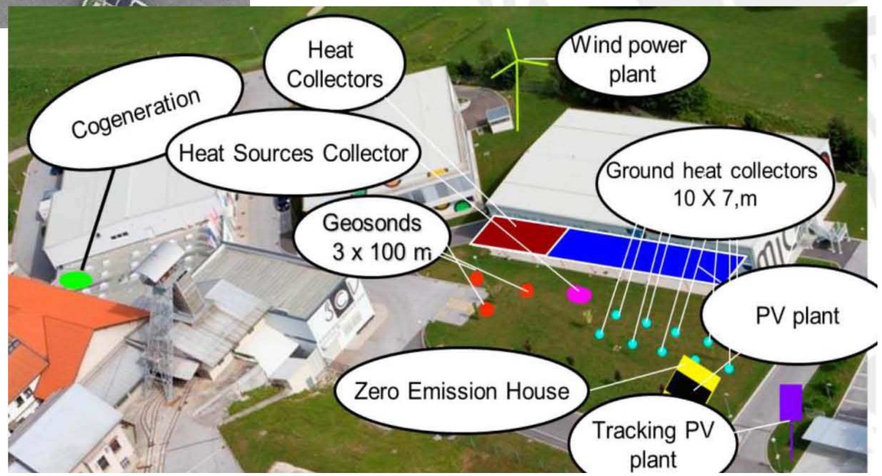
Energy polygon segments



Logo

ENERGETSKI POLIGON
za pridobivanje energije iz obnovljivih virov

Symbol



Thermosolar devices

Solar water heaters:

- Traditionally designed collectors (2 x 2.6 m^2) for DHW,
- Vacuum collectors (2 x 4m^2)
- All these collectors are connected to the heat pump in the laboratory

PV system

- Tracking PV system: 5kW
- Static PV system: 4kW
- Both are connected to the power distribution centre for power supply

Geothermal boreholes

- 3 heat exchangers in vertical bore holes with depths of 100 m
- Sandy clay soil,
- old mining corridors are below the boreholes

Loops - Borehole heat exchangers

- 10 loops - borehole heat excangers to a depth of 7 m
- Separately connected to the heat pump in the laboratory

Low energy house

- Sustainable design (compact volume, natural construction materials, glashouse, low energy consumption)
- Dimensions: ~ 8 m x 8 m
- Floor (net) area: 110 m^2
- Energy storage (water tank) in the basement with a volume of 105 m^3
- 10 kW PV electricity power station with an autonomy of 1.5 days
- Waste air recuperator

Building envelope

- Wooden building structure
- 35 cm of thermal insulation (sheep wool, celullose flakes)
- Ventilated facade claded with wooden panels and composite facade panels
- Windows with triple glazing (U_W = 0,80 W/m^{2}K, g_g = 0,47)
- Shading devices: motorized outdoor venetian blinds

Energy storage below the low energy house

- Water temperature 35°C is predicted in the summer time.
- Energy from renewable sources accumulates in the water tank in summer time.
- Foundations are insulated except for the bottom of the water tank (foamed glass), which permits heat flow between the soil and the concrete floor of the tank.
- The idea is to enlarge the storage capacity of the tank.

Inside the low energy house

Meeting room

PV Energy centre

Laboratory for renewable energy and energy efficiency

Learning sites for:

- Efficient heating/cooling and solar technology
- Electricity production with PV panels
- Use of other types of renewable energy sources

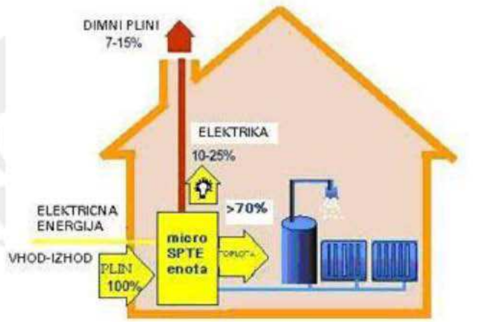
Different test devices for energy storage, distribution and production

Alternative heating station of building MIC2 in lab

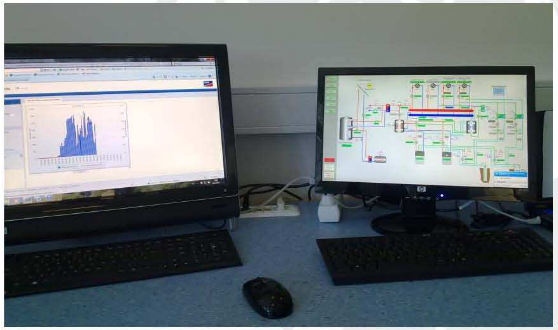
- View of the heat pumps 2 x 10 kW
- Hot and cold water storage tank 1000 l
- Domestic hot water tank 500 l

External energy-efficient co-generation

- Micro-cogeneration unit 12 kWt /5,5 kWe installed in the heating station
- A 750 l hot water tank complements the heating's remote control system.
- District heating from the Šoštanj thermo power plant



Energy monitoring system with E-Info point



- Acess to all information about energy consumption
- Informing people about the importance of energy saving and CO_2 emissions

Display of power consumption and meteorological data on e-Info Point

http://energija-rr.si/view_locations_graphs/index.php?id_location=31&id_location_slide_site=252.

Example Dijaški dom Drava Maribor: http://eikl-dddrava.energetski-inzeniring.si/

School Center Velenje
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METHODOLOGY OF PUBLIC BUILDING

ENERGY AUDIT

Prepared by:

Cveto Fendre

Velenje, May 2013

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3.2. Possible measures of effective energy consumption
- 3.2.1. Possible measures of effective energy consumption in buildings
- 3.2.2. Feasibility study of each RUE measures

3.3. Selection of measures on effective energy consumption
- 3.3.1. Savings calculation and investment cost
- 3.3.2. Determination of environmental effects of proposed measures
- 3.3.3. Order of measures on effective energy consumption

3.4. Energy audit report

3.5. Energy audit presentation

4. APPENDICES

Appendix 1: Schematic energy audit performance in building
Appendix 2: Index example on energy audit for building
Appendix 3: Table on emissions of CO_2 at fossil fuels burning
Appendix 4: Basic data on the building
Appendix 5: Energy savings at a primary school, research work

1. INTRODUCTION

A number of examples in practice on preparation and realization of effective energy consumption measures show that companies and institutions approach the task partially, coincidentally without any connection with other possible measures, without complex analysis of the problem. Such approach can lead to technically and economically inadequate solutions.

Energy audit, whose main part has a proposal of possible measures with certain priorities to advise reorganization and quality investment decision making to institutions, should be prepared before starting effective energy consumption programe.

The above stated arguments required a methodology on energy audit which should offer a correct methodology and study. The form of energy audit stated in the methodology determines the manner after which the energy analysis in institutions and blocks of flats is defined and is prepared on the grounds of the *Methodology of energy audit implementation* made by the *Ministry of the Environment and Spatial Planning of Slovenia* in 2003.

Implementation of energy audit should include some advise for energy audit elaboration given in the *Energy Audit Manual*.

2. ENERGY AUDIT TERMINOLOGY

Regarding the purpose and quantity of energy audits, they can be classified as follows:

Preliminary audit –which represents the easiest form of energy audit. The analysis is made on the basis of one-day examination of the building

Simplified energy audit – recommended for simple and easy cases.

Extended energy audit is a audit which requires a detailed building analysis. It includes energy consumption calculations and a detailed analysis of selected measures for effective energy consumption.

If buildings are smaller, a simplified energy audit is good enough if the measures to be carried out are clear. This type is used within larger buildings, higher ones and have more complex energy consumers. When working on the simplified audit, the preset approaches are simplified in methodology. Further on, a detailed methodology of extended energy audit is given.

3. ELEMENTS OF ENERGY AUDIT

The principles of energy audit are similar, but some specific factors of the field have to be taken into consideration.

In most cases the approach to individual energy audit is a multiphase one:

1. energy audit of the whole building (macro-analysis)
2. energy audit of individual technology ways or energy sets
3. energy audit of individual building parts (micro-analysis).

The details of individual audits may be different among the buildings, but the basic elements are equal for all energy audits and involve the following activities or products:

1. energy audit analysis and energy management
2. possible measures of effective energy consumption
3. selected measures analysis
4. energy audit report
5. energy audit presentation.

Energy audit schematic is given in Apendix 1.

It is advisable to estimate the possibilities of introducing monitoring of energy consumption in a building in compliance with the modern approaches of measures of effective energy consumption in the energy audit.

3.1. Energy analysis and energy management

Analysis of the records on energy consumption in the past shows some data on the structure and monthly consumptions of individual energy sources, which may be a basis for future energy forecast. The purpose of the analysis is to identify the main energy consumers and to work out a price audit of individual energy resources per one year.

What we have to check are the invoices for fuel and electricity in the period of the last 12 months. The invoices have to be checked carefully to make sure that they are the correct ones for energy consumption. The costs of fuel and electricity are usually poor criteria for the quantity of energy used. For example: the invoice for electricity involves also items on power, work energy etc. In some cases, the invoices are loaded with costs of overcoming the power rented. All these extra costs do not have any direct connection with the number of used kWh of electricity.

When preparing the analysis of energy consumed, it is necessary to work out an analysis of energy used regarding the tariff systems for individual energy sources.

As energy consumption depends on the level of productivity and other variable conditions (seasonal weather conditions), it is the best then to analyze the specific energy consumption, that is, the consumption of energy per student or to determine annual energy numbers ($kWh/m^2 a$).

3.1.1. Building

At the beginning it is advisable to select some general data necessary for future work. Some basic data are as follows:

- who is responsible for energy and effective energy consumption
- age of the building
- number of employees or consumers – pupils, students
- consumption schedule or full/vacant building
- description of the field, type of technologies, procedures and services used
- specific requirements with regard to microclimate
- costs of energy in common outcomes
- system of financing energy and investments in effective energy consumption
- list of types of energy sources and their origin
- list of the greatest energy consumers
- list of the greatest heat consumers
- list of measurement instruments to determine energy consumption
- hot water and steam pressure and temperature
- available technical documentation (heating technology, building …)
- opinion of consumers on comfort in the building
- planned and finished projects in the field of effective energy consumption and environmental protection
- energy issues at present and in the past …

General data on the building can be collected by means of the table in Appendix 4. It is necessary to check the house plans and energy systems in the building to produce quality energy audit. Going around the houses, you should mark all measurement spots (temperature, pressure, flow) and their readout intervals.

3.1.2. Data acquisition

True and correct data are the key to successful energy audit, that is, the audit has to be based on actual data. You should be critical about data needed. Some data gained by the existent measurement equipment are usable directly, but often some extra measurements are required.

3.1.3. Measurements

The quality energy audit depends on accuracy and correct data. A lot of data required to calculate the energy currents can be gained by measurements. We should collect systematically quantities, measurement points and instruments.

As measurements are closely linked with costs, you should check what types of measurements are absolutely necessary and what accuracy is needed. Every measurement point has to have an estimation of how accuracy affects whole energy balance of accounts.

We perform the following measurements of the building:
- indoor microclimate in classrooms, sports halls, other rooms (temperature, moisture, concentracion of CO2 and Rn, medium lighting-luminosity),
- electricity and power consumption in a certain period (day, week, month …),
- heating consumption in a certain period (day, week, month …),
- hot water consumption in a certain period (day, week, month …),
- building thermal imaging.

3.1.4. Data needed for buildings

Check of the conditions in the building should include a description of the house, construction and technical features:

- insulation
- heating system of the house
- hot sanitary water preparation
- ventilation and climatic conditions
- electricity consumers.

It is advisable to determine energy consumption on type of consumption. Such an analysis, which has to be based on true and correct data, shows a relationship by energy type or costs per energy and it can be the grounds of comparison. In heating, it is good to determine the losses at transformation and distribution of heating.

Annual energy audit of the building

On the grounds of the invoices of the supplied energy or measurement (at least per three years) you should work out the energy consumption audit in the building for

- electricity consumption
- heating energy consumption
- energy used to prepare hot sanitary water
- other means.

Energy cost

On the basis of the invoices for individual energy sources it is necessary to work out a cost audit for

- heating

- electricity
- hot and cold sanitary water
- cooling
- air-ventilation
- other.

Organization of energy management

Public institutions should study the relationship among all the parts involved in the process of decision making on investment into the RUE (Rational use of energy) to get actual savings and costs of energy consumption.

When talking to consumers and house management you should study their role and successful cooperation what regards the efforts of effective energy management. Knowing the conditions and factors of decision making is an advantage later on when energy audit measures are carried out.

Your special concern is

- organization and interest of the parties involved in energy management
- motivation of all participants and awareness of the RUE
- information system on energy consumption and acquire level of energy efficiency (who and how energy consumption and costs are controlled)
- thematic promotion of investments into the RUE
- decision making process of investments into the RUE
- energy policy of the municipality in the field.

3.2. Possible measures on effective energy consumption

Possible measures included in the energy audit can range from organization, reconstruction of existent devices or buildings, use of modern equipment and techniques and introduction of new technologies.

3.2.1. Possible measures of effective energy consumption in buildings

There are some of the most often used measures of effective energy consumption in buildings which can be completed within your findings. The measures can be put into three groups:

Organizational measures:

- awareness rising and education on effective energy consumption of
    - building consumers and
    - energy manager

- introduction of correct natural air-ventilation
- introduction of correct lighting considering daily light
- energy book-keeping introduced
- monitoring of energy consumption and costs.

Measures on regular maintenance and minor investments:

- measures on the whole building
    - furniture maintenance
    - window and door sealing
    - window glass assembly with low-emission layer and gas filling when repaired
    - air-tightening improved in light constructions
    - attic insulation
    - shutters inbuilt or repaired
- measures on heating system
    - preparing a central and local regulation of the heating system
    - heater maintenance and service
    - boiler maintenance and cleaning
    - thermal insulation of distribution network
    - hydraulic system balance
    - air-ventilation of building thermal substations
- measures on electricity consumption
    - when replacing worn out lights and energy efficient lightning
    - optimal lighting system introduced
    - judgment on suitability of measurements and tariff group, main building fuses
- measures on heating and ventilation
    - management and air-conditioning improved
    - simple automatic control built-in

Investment measures

- measures on the insulation layers
    - replacement of furniture
    - low-emission glass assembly with gas filling
    - thermal insulation shutters assembly
    - thermal insulation of the building
    - improvement of air-tightening of light constructions

- measures on heating system

  - central regulation of the heating system built-in
  - change from the central to zone regulation
  - local regulation of the heating system
  - central system of hot water heating
  - heating divided into several branches (north, south, functionality of rooms, for example, heating branches for classrooms and sports halls)
  - replacement of heaters, boilers
  - replacement of energy source
  - calorimeters built-in

- measures on electricity consumption

  - public network market balance
  - energy efficient lighting built-in
  - optimal lighting system introduced
  - control and regulation system of peak consumption
  - change to other energy sources in water heating or other high consumers

- measures on cooling and air-ventilation

  - central control and monitoring system built-in
  - recuperation of heating and airing
  - preheating of input air

When working on the energy audit which involves several buildings (schools, institutions, other complex buildings, …) you should produce a comparative analysis for all buildings that are included in the energy audit and a complete audit of present conditions, energy consumption and possible energy savings which will help the investor in future decision making.

3.2.2. Feasibility study on individual measures of effective energy consumption

Possible measures of effective energy consumption need to be considered carefully if feasible regarding the needs and conditions. You should calculate and estimate energy savings. You should consider only the most interesting measures which will bring you to the best possible energy savings with economically sensible investment return (payback) period. You have to be careful about positive environmental impacts too.

3.3 Analysis of selected measures on effective energy consumption

3.3.1. Savings and investments

The selected measures have to be considered precisely and calculate the energy savings and investment costs. The savings should be given separately on the investment costs. A simple return (payback) period of the proposed measures should be determined, which enables priorities of their implementation.

3.3.2. Determination of environmental impact of the measures

As environmental impacts are more and more important, it is advisable to determine the impact of the proposed organizational and investment measures to reduce the emissions of greenhouse gases. The largest greenhouse emissions are carbon dioxide (CO_2) whose emissions are directly linked with the use of fossil fuels. To calculate the reduction of CO_2 being the consequence of proposed measures, we use the factors in the Appendix 3.

3.3.3. Priority list of measures on effective energy consumption

The list represents a recommendation to implement organizational and investment measures. The decision if certain investment is realized, is the competence of the building management. A sample of the priority list and investment measures on effective energy consumption with an abstract of measures with the return (payback) period shorter than three years is enlisted in the table below:

No.	Measures described	Possible annual savings		Investment	Return period	Priority
		MWh	€	€	years	-
	ORGANIZATIONAL MEASURES					
1						
2						
	INVESTMENT MEASURES					
1						
2						

ABSTRACT OF MEASURES WITH THE RETURN PERIOD TO 3 YEARS:		% total savings in consumption
Annual savings of electricity	MWh	%
Annual savings of natual gas	MWh	%
Annual savings of fuel oil; TNP, petroleum spirit	MWh	%
Annual savings of remote heating	MWh	%
Annual savings of …	MWh	%

ABSTRACT OF ALL PROPOSED MEASURES		% total savings in annual consumption
Annual savings of electricity	MWh	%
Annual savings on natural gas	MWh	%
Annual savings on fuel oil, petroleum spirit	MWh	%
Annual savings on thermal energy	MWh	%
Annual savings on …................................	MWh	%
Total reduction of CO_2 emissions	tons	%
Total reduction of savings annually	€	%
Total investments needed	€	
Average return (payback) period	years	

Reduction of CO_2 emissions total	tons	% total CO_2 emissions
Total cost reduction per year	€	
Investments needed total	€	
Average return period	Years	

3.4. Report on energy study and audit

It is very important to report on the results of energy audit. The quality of energy study at building does not depend on the precision of data and quantity of analyses done, but also on the quality of the final report. The purpose of the report is to give quality ideas for investments into measures of effective energy consumption, which are competitive regarding other investment possibilities at school.

After the introduction, a presentation and energy card follow with all energy indicators of the building. Then main measures are written down, joined in individual groups considering the selected criterium (for example, return period less and more than 6 months, energy supply/consumption, type of energy, cost centers). Only then a presentation and analysis of feasibility of measures in question follows. The report should be finished by a presentation of results of energy audit. The component of the report is a priority list of measures. Larger tables and diagrams which belong to individual report items, should be given separately in a special appendix.

3.5. Energy audit presentation

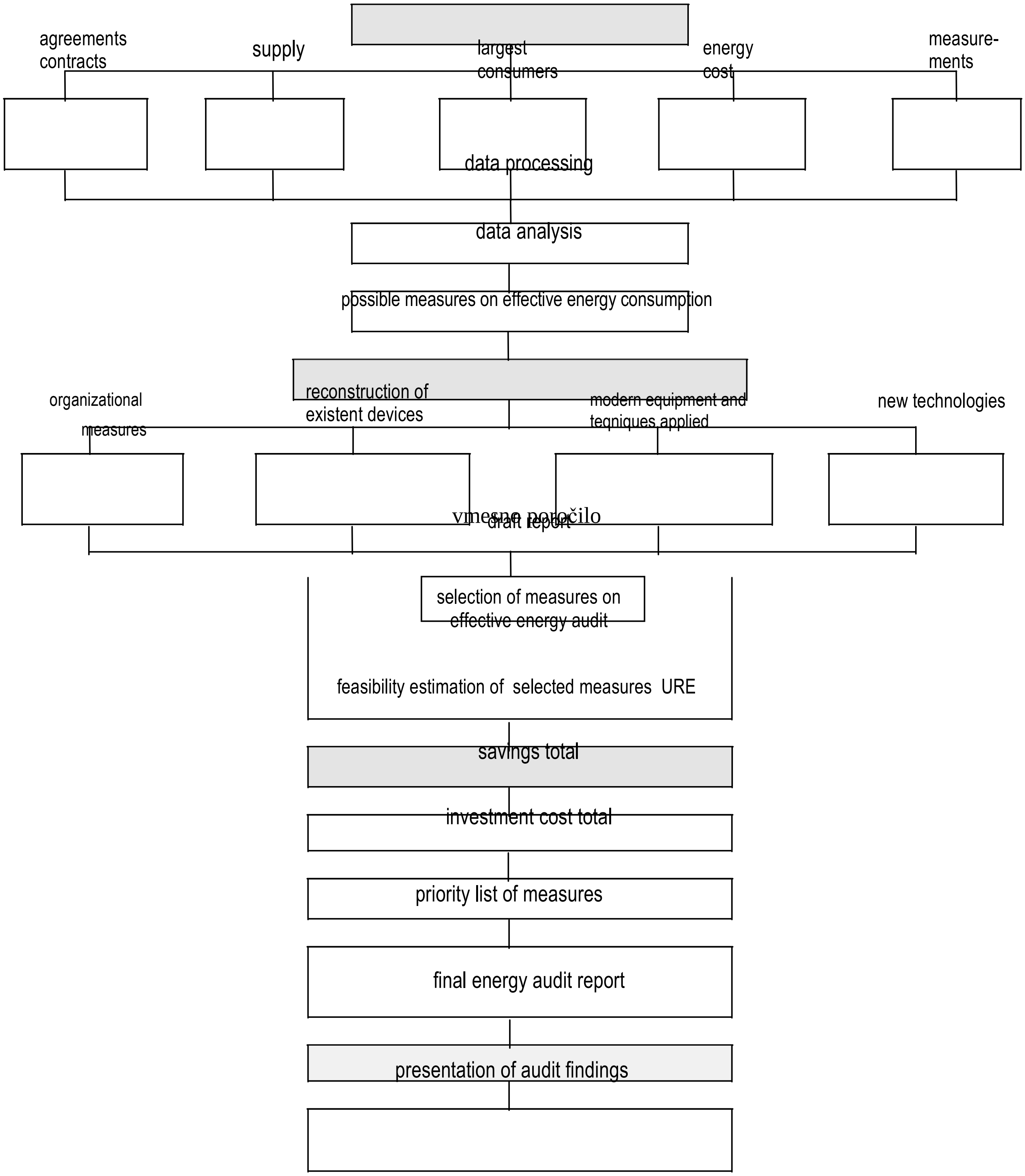
Besides the report, you should make a presentation of findings on energy audit to head of institute, institute managers and to other building users. The audit is an event with which we inform the consumers and all participants in the process of decision making on effective energy consumption. The audit is the first step to the implementation of organizational measures and creation of proper conditions for the implementation of investment proposals.

In the buildings with a similar parameters (i.e. a group of schools), the presentation of energy audit together with accompanying activities is even more important for higher awareness, information and motivation of consumers as the dispersion of energy saving potential and a large number of participants in the decision making on investments into measures of the URE are the key factors for successful RUE programmes.

APPENDICES

Appendix 1: Schematic energy audit elaboration of the building

Energy audit



Appendix 2: Index example of the public building energy audit report

Description of activity and places in the building

- Functional appearance of outside and inside of the building from power supply point of view
- Analysis of energy consumption and energy management in the building
- HVAC implementation
- Hot water system
- Cold water system
- Electricity supply and consumers

Energy consumption and cost analysis

- Electricity and heating consumers in the building – inventory with review
- Electricity installation report
- Heating installation report
- Public opinion research of building users on comfort at the building
- Electricity consumption measurements and supply
- Indoor microclimate measurement
- Building thermal imaging report

Characteristic construction parameters of the building

- Characteristic quantities of the building
- Building classification
- Energy indices

Estimation of savings

- Organizational measures
- Investments
- Audit of measures URE with the priority list

[3] ***Note: The index needs to be arranged regarding the quantity of tasks and specific energy audit.***

Appendix 3: Table of CO_2 emissions in fossil fuels combustion

N	**Fuel**	**tons CO_2 / MWh fuel**
	liquid fuels	
1	petrol	0,255
2	diesel	0,265
3	petroleum spirit	0,265
4	heavy KO (LS, L, LNS, S, SNS, T, TNS and ET)	0,280
5	liquified oil gas	0,225
	GASEOUS FUELS	
6	natural gas	0,200
7	furnace gas, oil gas, coke gas	0,215
8	REMOTE HEAT	given by the supplier
9	* ELECTRICITY	0,500

	Fuels or combustible organic matter	**tons CO_2 / ton of fuel**
	SOLID FUELS	
10	anthrac	2,9
11	coke	2,7
12	black coal	2,5
13	brown coal	1,2
14	lignit	1,0
	COMBUSTIBLE ORGANIC MATTER	
15	etha	2,9
16	waste oils	2,6
17	municipal waste	1,0

* The emissions of CO_2 at electricity generation in 0.5 t/MWh$_e$ is an average value of the emissions for the Slovenian power supply. The value is used in measures of reduction of electricity consumption. In case of cogeneration when CO_2 emissions are greater in a company and we reduce the emissions to the level of Slovenian power system supply, we should work out a net effect total as a difference.

Appendix 4: Basic data on the building

ENERGY AUDIT OF THE PUBLIC INSTITUTIONS BUILDINGS

Before doing anything, you will need some general data on the buildings. The data are divided into such groups:

a) General data on the institution____

Person in charge, position and phone number ____________________________________

- official title
- description of activities and services performed by the institution
- representative
- number of employees, number of consumers or visitors
- age of the whole building and individual parts

b) Organizational structure of the institution

Person in charge, position and phone number ____________________________________

- description of management, operation and stuff structure
- building management, management type of power supply and responsibility
- building full/vacant
- system and financial structure of energy cost ad electrical maintenance
- energy sources list and origin (copies of contracts)
- invoices copied for energy in the last year (electricity, municipal service, …)
- energy cost share in total outcome in the last three years
- criteria of decision making in new projects and investments
- opinion of the employees and consumers on comfort in the building

c) Technical field

Person in charge, position and phone number ____________________________________

- specific microclimate needs in the building
- available technical documentation of the building (constructional, mechanical and electro part)
- list of high consumers of electricity and heating
- connecting power, pressure and temperature of hot water and steam
- consumption of hot and cold sanitary water

- list of measurement instruments to determine energy consumption and numbers of measurement points
- problems in the field of energy in the past and present (reliability)
- finished and planned projects in the field of effective energy consumption and environmental protection

Energy Audit - Summary

Šolski center Velenje

Trg mladosti 3, Velenje

Velenje, marec 2011

Naslov študije:	**RAZŠIRJENI ENERGETSKI PREGLED OBJEKTA ŠC VELENJE**
Naročnik:	Šolski center Velenje, Trg mladosti 3, 3320 Velenje
Zastopnik naročnika:	**Ivan Kotnik**
Kontaktna oseba naročnika	
Številka naročilnice:	
Izvajalec:	Energetski inženiring, ŠC Velenje Trg mladosti 3, 3320 Velenje
Vodja naloge:	**Cveto Fendre**
Avtorji:	Martina Omladič, Radovan Repnik, Sašo Gnilšek, Ivan Škoflek, Stane Osojnik, Matjaž Žerak, Cveto Fendre
Zunanji sodelavci:	**Primož Praper, Iztok Topler**
Datum:	**marec, 2011**

Direktor ŠCV

Ivan Kotnik

POVZETEK ZA POSLOVNO ODLOČANJE

Pri energetskem pregledu so nakazane možnosti učinkovite rabe energije (URE) oz. zmanjšanje stroškov ogrevanja, porabe električne energije in vode. Analizirana je ekonomska upravičenost nekaterih posegov in ocenjena doba vračanja vloženih sredstev.

Predlagani ukrepi so ločeni na organizacijske in investicijske ukrepe. Vsi ukrepi vplivajo na URE in znižanje stroškov. Predlagani ukrepi se razlikujejo tako po dobi vračanja vloženih finančnih sredstev kot tudi po nujnosti izvajanja posameznega ukrepa.

Energetski pregled nakaže možnosti uporabe obnovljivih virov (OVE) energije za določen zavod oz. objekt, kar je pogojeno z lokacijo, orientiranostjo objekta. Kot splošne možnosti uporabe OVE smo se za šolske objekte posebej osredotočili na uporabo lesne biomase v kotlovnicah, izkoriščanje sončne energije, predvsem s stališča fotovoltaike in v določenih primerih še na uporabo deževnice kot sanitarne ali tehnološke vode.

Na osnovi opravljenega energetskega pregleda objektov Šolskega centra Velenje na lokaciji Trg mladosti 3, Velenje, ki ga je naročil zavod sam, predlagamo naslednje ukrepe učinkovite rabe energije:

A. Organizacijski ukrepi

Organizacijski ukrepi naj bodo naslednji:

1. izvajanje energetskega upravljanja objektov in energetskega knjigovodstva,
2. ciljno spremljanje rabe energije in stroškov, vpeljava spletnega energetskega knjigovodstva
3. osveščanje uporabnikov,
4. izobraževanje,
5. informiranje,
6. uvajanje pravilnega naravnega prezračevanja,
7. uvajanje pravilnega osvetljevanja ob upoštevanju dnevne svetlobe,

B. Ukrepi ob rednem vzdrževanju in manjše investicije

1. Ukrepi na ovoju zgradbe:
   - vzdrževanje stavbnega pohištva,
   - vgradnja zasteklitve s plinskim polnjenjem ob popravilih oken, vrat ali zasteklitve,
   - izboljšanje zrakotesnosti lahkih konstrukcij,

2. Ukrepi na ogrevalnem sistemu:
   - hidravlično uravnoteženje sistema,
   - vgradnja termostatskih ventilov na ogrevala.

3. Ukrepi na področju rabe električne energije:
   - vgradnja energetsko učinkovitih svetil ob zamenjavi dotrajanih svetil.

C. Investicijski ukrepi

Ukrepi na ovoju zgradbe:

- toplotna izolacija zunanje fasade šole,
- sanacija stropa strehe,
- menjava oken in vrat

Ukrepi na ogrevalnem sistemu:

- hidravlično uravnoteženje ogrevalnega sistema, delna posodobitev pogonske in krmilne opreme v toplotnih podpostajah, vgradnja termostatskih ventilov
- instalacija termosolarnega sistema za pripravo tople sanitarne vode

Ukrepi na področju rabe električne energije:

- dokončna posodobitev notranje razsvetljave,

Izvedba nadzornega sistema vodenja energetike

- vgradnja krmilnega sistema za zajemanje podatkov in centralnega nadzornega sistema,
- postavitev energetske upravljalne postaje,
- instalacija energetskih infotočk, kot močnega ozaveščevalnega orodja

Tabela 1: Pregled rabe energije v letu 2010

Izračunan potrebna toplotna energija za ogrevanje: 1.881.835 kWh

Šolski objekti /17.170 m^2

LETO 2010	Poraba (kWh)	Stroški (€)	*Emisije CO_2 (t)	Energijsko število (kWh/m^{2}a)
Toplotna energija – daljinsko	2.226.000	98.596	757	129
Električna energija	246.000	33.226	172	14
Skupaj	2.472.000	131.822	929	143
	Poraba m^3		Stroški (€)	
Mrzla voda	6.574		11.701	
Skupaj stroški 2009 (€)				**143.523**

Cena ogrevanja: 0,044 €/kWh; Cena električne energije: 0,135 €/kWh

Opomba: Ogrevanje - daljinsko. Za preračun emisij CO_2 je uporabljena metodologijo izračuna iz Uredbe o taksi za obremenjevanje zraka z emisijo ogljikovega dioksida: daljinsko ogrevanje : 0,340 kg CO_2/kWh. Za elektriko, dobavljeno iz javnega omrežja, smo uporabili faktor 0,7 kg CO_2/kWh$_e$.*

Tabela 2: Prednostna lista ukrepov učinkovite rabe energije

Št	Opis ukrepa	Možni letni prihranki MWh/a We	Wt	€	Investicija €	Vračilni rok (let)	Prioriteta -
	ORGANIZACIJSKI UKREPI						
1	- osveščanje uporabnikov	12		1.660	0		I
	- pravilno prezračevanje		110	4.900	0		
	- ciljno spremljanje rabe energije						
	- energetsko upravljanje						
	- nadzorni sistem vodenja energetike	12	110	6.560	70.000	11	I
	SKUPAJ	24	220	13.120	70.000	5	
	TEHNIČNO-INVESTICIJSKI UKREPI						
2	Sanacija ovoja zgradb		794	43.647	1.328.770	30	II
3	Hidravlično uravnoteženje ogrevalnega sistema, rekonstrukcija TPP		240	10.560	128.000	12	III
4	Rekonstrukcija notranje razsvetljave	60		7.970	145.000	18	III
5	*Rekonstrukcija NN razvoda				70.000		
6	*Vgradnja sistema za hlajenje prostorov				55.000		
7	*Vgradnja sistemov za centralno prezračevanje				55.000		
8	*Priprava sanitarne tople vode (STV) s solarnimi sistemi				115.000		
	SKUPAJ	**84**	**1.254**	**62.177**	**1.671.770**	**27**	

*ukrepi niso upoštevani v izračunu vračilnega roka

Tabela 3: Povzetek ukrepov in zmanjšanje energije, stroškov in emisij vseh predlaganih ukrepov

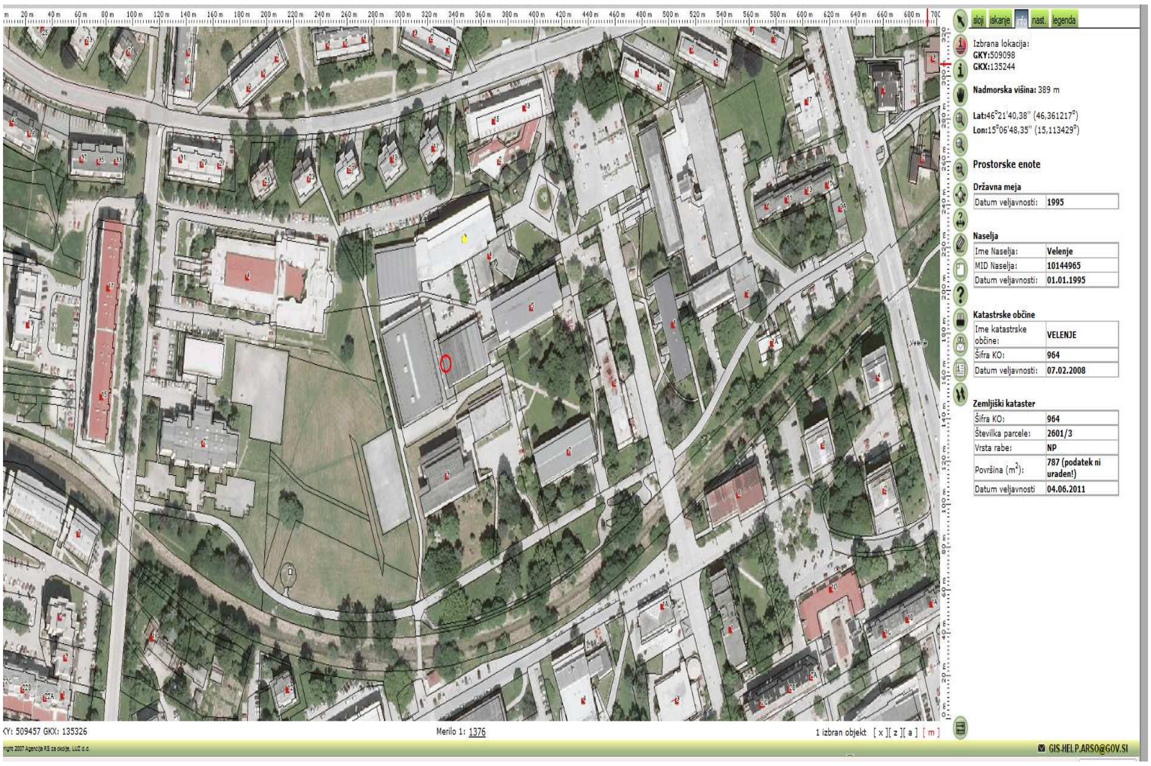
POVZETEK VSEH PREDLAGANIH UKREPOV:		% prihranka od skupne letne porabe
letni prihranek električne energije	84 MWh	34 %
letni prihranek toplote	1.254 MWh	54 %
skupno zmanjšanje emisij CO_2	446 ton	48 % celotnih emisij CO_2

skupno zmanjšanje stroškov na leto	62.177	€	% od letnega stroška za energijo	47	%
skupni znesek potrebnih investicij	1.671.770	€			
povprečni vračilni rok	27	let			

I SPLOŠNI DEL

2 Uvod

Naslov:	Šolski center Velenje
	Trg mladosti 3
	3320 Velenje
Katastrska občina:	
	Velenje
Parcelna številka:	
	2571/7, 2602/9, 2602/3, 2601/3, 2601/6, 2604,
Koordinate:	Y = 509098
	X = 135244
Temperaturni primanjkljaj:	3.300 K dni
Povprečna letna temperatura:	9,83 °C



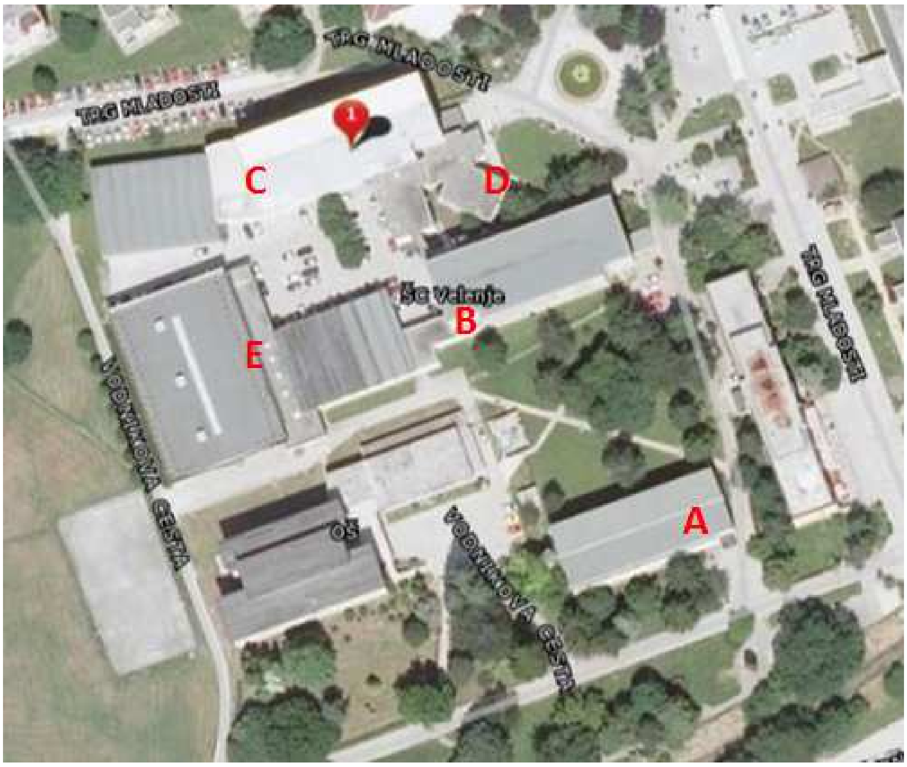
Vir: Atlas okolja Agencije RS za okolje: Trg mladosti 3, Velenje
(dostopno na http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@Arso, pridobljeno 08.06.2011)

Slika 1: Lokacija objekta

2.2 Prostorska razporeditev objekta z označeno namembnostjo

V zavodu so organizirane naslednje šole, ki so razmeščene na različnih lokacijah:

Kompleks ŠCV zajema:
- stavba A (splošna in strokovna gimnazija)
- stavba B (PTRŠ, PTSŠ, PTŠSD) s telovadnico
- stavba C (PTERŠ, VSŠ) s telovadnico
- stavba skupnih služb (PTŠSD, uprava) D
- športna dvorana E
- (predvidena je nova šola med gimnazijo in stavbo B)



Slika 2: Lokacije posameznih objektov ŠC Velenje

2. 3 *Skupna poraba energije in stroški*

Pri analizi porabe električne in toplotne energije je razvidno, da količinska poraba toplotne energije predstavlja skoraj 90 odstotkov porabljene celotne energije, izražene v kWh, dobrih 10 odstotkov pa poraba električne energije. Razvidno je, da več kot polovico stroškov predstavljajo stroški ogrevanja, električna energija predstavlja 30 odstotkov, preostanek so stroški vode, mešanih odpadkov in obratovalni stroški.

Tabela 4***:*** *Pregled porabe energentov, stroški in emisije CO_2 v letu 2010*

Šolski objekti skupaj / Au = 17.170 m^2;

LETO 2010	Poraba (kWh)	Stroški (€)	*Emisije CO_2	Energijsko število

			(t)	(kWh/m²a)
Toplotna energija – daljinsko	2.226.000	98.596	757	129
Električna energija	246.000	33.226	172	14
Skupaj	2.472.000	131.822	929	143
	Poraba m^3		Stroški (€)	
Mrzla voda	6.574		11.701	
Skupaj stroški 2009 (€)				**143.523**

Cena ogrevanja: 0,044 €/kWh; Cena električne energije: 0,135 €/kWh

Opomba: Ogrevanje - daljinsko. Za preračun emisij CO_2 je uporabljena metodologijo izračuna iz Uredbe o taksi za obremenjevanje zraka z emisijo ogljikovega dioksida: daljinsko ogrevanje : 0,340 kg CO_2/kWh. Za elektriko, dobavljeno iz javnega omrežja, smo uporabili faktor 0,7 kg CO_2/kWh$_e$.*

Tabela 5: Preglednica značilnih energijskih kazalcev za obdobje 2005 - 2010

LETO	2005	2006	2007	2008	2009	2010
Energija (GJ)	9839	8906	7841	8734	8262	8900
El. energija (MWh)	270	276	254	251	256	246
El. kon. moč (kW)	1703	1665	1559	1483	1477	1310
Topl. energija (MWh)	2463	2198	1924	2181	2039	2226
Etn (kWh/m2)	15,7	16	14,7	14,5	14,8	14,3
Epk (W/m2)	99	96	90,3	85,9	85,6	75,9
Eop (kWh/m2)	143	127	111,5	126,4	118,1	128,9
Emisije CO2 (t)	997	907	803	897	841	929

Pk letna obračunska (konična) moč (kW)
Pk' povprečna mesečna obračunska (konična) moč (kW)
P priključna mesečna moč po soglasju in pogodbi: 230 kW
VT letna porabljena električna energija po višji tarifi (kWh)
MT letna porabljena električna energija po nižji tarifi (kWh)
Epk energijsko število konične moči (W/m²)
Etn energijsko število porabe električne energije (kWh/m²)

Tabela 6: Pregled podatkov porabe toplotne energije 2007, 2008, 2009 (kWh)

Objekt	Ao (m2)	Qt(kWh) 2007	Qt(kWh) 2008	Qt(kWh) 2009	Qt (kWh) povprečna
A	2.025	211.200	252.000	244.000	235.733
B	5.637	625.746	683.955	714.580	674.760
C	7.176	734.628	852.435	699.658	762.240
D	1.273	114.072	132.364	108.641	118.359
E	2.149	238.554	260.745	272.420	257.240

Skupaj	18.260	1.924.200	2.181.499	2.039.299	2.048.333

Tabela 7: Pregled parametrov porabe toplotne energije 2009, 2010

Objekt ŠCV – Trg mladosti 3	Površina (m^2)	TPP (m^2)	P (kW)	Pop (kW)	Qop (MWh)	Qmv (m^3)	Eop (kWh/m^2)
A	2025	2025	234,5	234,5	245,50	765	**121,2**
B	5637	7786	986,3	986,3	1058,50	3619	**135,9**
Športna dvorana	2149						
C	6176	7449	1066,1	1066,1	922,40	2190	**123,8**
Uprava	959						
Predavalnice VSŠ	314						
SKUPAJ za leto 2010	**17260**	**17260**	**2286,9**	**2286,9**	**2226,40**	**6574**	**128,9**
2009			2286,9	2286,9	**2039,30**	**8041**	**118,1**

TPP neto ogrevalna površina po toplotnih predajnih postajah
P priključna ogrevna moč (kW)
Pop letna dovedena ogrevalna moč v TPP (kW)
Qop letna porabljena ogrevalna energija objekta (MWh)
Qmv letna poraba mrzle vode (m^3)
Eop energijsko število ogrevanja (kWh/m^2 leto)

4. 1 Cene energetskih virov

Tabela 8*: Tabela cen energetskih virov*

Energetski vir	Enota	Cena / poprečna cena

UPORABA OMREŽJA - ELEKTRO CELJE		
Obračunska moč	€/kW	3,39701; 4,30448
Omrežnina VT	€/kWh	0,02324; 0,03013
Omrežnina MT	€/kWh	0,01795; 0,02324
Prispevki po 64. čl. EZ	€/KW	0,53931
Prispevki po 15. čl. EZ	€/KW	0,11903; 0,15528
DOBAVLJENA ELE. ENERGIJA – ELEKTRO CELJE		
Elek. energija – VT	€/kWh	0,06668
Elek. energija – MT	€/kWh	0,03588
Trošarina	€/kWh	0,0005

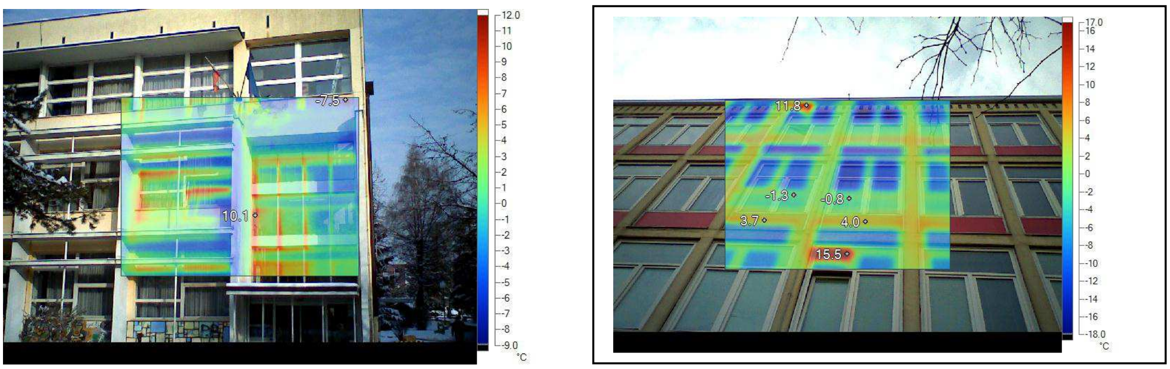
ENERGETIKA KP Velenje	**enota**	**cena**
Toplotna energija	MWh	20,8690
Obračun moči	kW	13,7292

6 *Pregled rabe končne energije*

6. 1 *Ovoj zgradbe*

Arhitektura zasnova zunanjega ovoja ima pomemben vpliv na toplotne karakteristike. Zasnova je glede na funkcijo objekta enostavna, objekt ima debele stare zidove, ki so razmeroma dobro ohranjeni. Večina izgub je na tleh in seveda na ravni strehi in pri starih oknih.

Pri energetskem pregledu je bil opravljen pregled celotnega ovoja zgradb. Na spodnjih slikah je prikazan del fasade in temperaturne razmere. Podrobnejša termografska analitika zgradb je predstavljena v prilogi 6.



Slika 3: posnetek dela južne fasade objekta A in severne objekta B s termovizijsko kamero

6. 2 Grelna telesa

Grelna telesa v učilnicah in prostorih so ploščati radiatorji VOGL&NOOT in drugi. Temperaturni režim ogrevanja je 90/70ºC. Razvod radiatorskega ogrevanja je izdelan iz črnih cevi. Podrobnejši opis porabnikov je podan v Prilogi 2.

Slika 4: Ploščati radiator v učilnici: V&N z navadnim ventilom

6. 3 Električni aparati

Fiksni električni porabniki so bojlerji, klimatske naprave in drugi močnostni porabniki v delavnicah vzdrževanja in učilnici za pripravo jedil.. V šoli so učilnice multimedijsko podprte, ostali porabniki (biroprema) pa se priključujejo na vtičnice. Razsvetljava notranjih prostorov je izvedena s klasično fluorescentno razsvetljavo delno z elektromagnetnimi dušilkami zastarelega tipa in elektronskimi predstikalnimi napravami ter fluorescentnimi ali varčnimi sijalkami po hodnikih in sanitarnih in pomožni prostorih

Slika 5 : Fiksno priključeni električni porabniki – klimatske split naprave in črpalka v TPP

Slika 6 : Fiksno priključeni električni porabniki – računalniška oprema, obdelovalni stroji

II ANALIZA MOŽNOSTI ZA ZNIŽANJE RABE ENERGIJE

7. 2 Raba energije in stroškovna specifikacija za leto 2010

Au = 17.170 m^2
Porabljena energija ogrevanja: Qop = 2.226 MWh
Strošek porabljene toplotne energije: 98.596 €
Strošek za ogrevanje sanitarne vode: 0 €
Strošek skupaj (brez DDV): 98.596 €

Porabljena električna energija: $W_{d\ VT+MT}$ = 246.000 kWh
Strošek električne energije (brez DDV): 33.226 €

Porabljena toplotna in električna energija skupaj: 2.472 MWh = 8.900 GJ
Strošek porabljene toplotne in električne energije skupaj: 131.822 €
Emisije CO_2: 929 t

8 Analiza energetskih tokov v zgradbah

Energetski pregled zajema skupino postopkov za izračun in oceno stanja rabe energije skozi ovoj stavbe, določa izračune in možne ukrepe za zmanjšanje rabe energije in jih ovrednoti s stališča učinkovitosti vlaganj. Pomembni so torej podatki o konstrukciji stavbe, predvsem sestav in debelina ter površina zunanjih sten, oken, stropa proti podstrešju ter tal. Pri energetskem pregledu smo uporabili metodo analize zgradbe. Podatke smo dobili iz literature, iz dosegljive tehnične dokumentacije in iz ogleda zgradbe ter s pogovorom z vzdrževalci objekta.

Analiza temelji na Elaboratih gradbene fizike objektov, ki so izdelani v skladu s Pravilnikom o toplotni zaščiti in učinkoviti rabi energije v stavbah, Ur. list RS št.: 42/2002, in zajema:

- Elaborat gradbene fizike - toplotne zaščite objekta,
- Izkaz toplotnih karakteristik stavbe.

Splošni podatki zgradb

- Nadmorska višina je 396 m
- Temperaturni primanjkljaj TP 20/12 je 3300 Kdni (stopinjski dnevi). Podatek poda klimatske pogoje kraja. Temperaturni primanjkljaj je definiran kot produkt časa ogrevanja z razliko temperatur med notranjostjo zgradbe (20 stopinj C) in zunanjim zrakom. Trajanje je po dogovoru omejeno na dni, ko je zunanja temperatura nižja od 12 ° C. Upošteva se povprečna temperatura v času kurilne sezone.
- Število kurilnih dni je 270/leto.
- Projektna zunanja temperatura je –13 °C.
- Razred zgradbe: 2

8.1 Potrebna toplota za ogrevanje zgradbe in toplotne izgube

Potrebna toplotna energija za ogrevanje posameznih zgradb je izračunana in podana v Prilogi 1: Poročilo gradbene fizike objektov A, B, C, D in E

8.2 Toplotne in difuzijske karakteristike kritičnih prerezov objekta

Izračun je izdelan v skladu z zahtevami Pravilnika o toplotni zaščiti in učinkoviti rabi energije v stavbah, Ur. list RS št. 42/2002 z dne 15. 5. 2002 in je v celoti podan v Prilogi 1: Elaborat gradbene fizike, Izkaz toplotnih karakteristik stavbe za objekt šole.

Zahteve o toplotni zaščiti objektov niso izpolnjene!

8.3 Karakteristične energetske veličine in energetski kazalci objekta

Zgradba A / Energijski kazalci

Au = 2.010 m^2 (2025 m^2 EA)

Izračun Qh pred / po sanaciji — Qh = 201.038 kWh / 107.810 kWh
Izračunana letna potrebna toplota pred / po: — Qh/Au = 100 kWh/m^2a / 54 kWh/m^2a
Toplotni sanacijski potencial — **Q = 93.228 kWh**

Eop za ogrevanje prostorov 2010: — Eop = 122 kWh/m^2 a (121 EA)

Zgradba B+B1+ E / Energijski kazalci

Au = 4.128 + 628 + 1963 m^2 = 6.719 m^2 (7.786 m^2 EA)

Izračun Qh pred sanacijo — Qh = 406.671 + 131.556 + 230.762 kWh = 768.989 kWh
Izračun Qh po sanaciji — Qh = 98.386 + 78.944 + 204.412kWh = 381.742 kWh
Toplotni sanacijski potencial — **Q = 387.247 kWh**

Izračunana letna potrebna toplota: — Qh/Au = 115 kWh/m^2a / 57 kWh/m^2a

Eop za ogrevanje prostorov 2010: — Eop = 158 kWh/m^2 a (136 EA)

Zgradba C + C1 + D + D0 +VSŠ / Energijski kazalci

Au = 4.991+ 953 + 958 + 160 + 304 = 7.366 m^2 (7.449 m^2 EA)

Izračun Qh pred sanacijo — Qh = 575.879+207.837+84.310+19.292+24.490 = 911.808 kWh
Izračun Qh po sanaciji — Qh = 233.782+ 75.462+63.889+ 8.950+17.104 = 399.187 kWh
Toplotni sanacijski potencial — **Q = 512.621 kWh**

Izračunana letna potrebna toplota pred/po: — Qh/Au = 124 kWh/m^2a / 54 kWh/m^2a

Eop za ogrevanje prostorov 2010: — Eop = 125kWh/m^2 a (124 EA)

Kompleks skupaj

Izračun Qh pred / po sanaciji — Qh = 1.881.835 kWh / 888.739 kWh

Izračunana letna potrebna toplota pred / po: Qh/Au = 110 kWh/m^{2}a / 52 kWh/m^{2}a
Toplotni sanacijski potencial Q = 993.096 kWh

9. Ocena energetsko varčevalnih potencialov zgradbe

Energetski varčevalni potenciali objektov so predvsem na:
- ovoju zgradbe,
- ogrevalnem sistemu in
- notranji razsvetljavi.

III PREDLOGI IN ANALIZA UKREPOV ZA UČINKOVITO RABO ENERGIJE

10 Organizacijski ukrepi

Najpomembnejši organizacijski ukrepi, ki jih predlagamo za analizirani objekt, so predvsem naslednji:

- **Sprotno spremljanje in merjenje porabe vseh energentov**.
- **Uvajanje energetskega knjigovodstva,**
- **Uvajanje energetskega upravljanja institucije,**
- **Časovno usklajevanje aktivnosti**
- **Uvajanje pravilnega in nadzorovanega naravnega prezračevanja**, ko večkrat za kratek čas (5 minut) intenzivno prezračimo prostor.

Na osnovi dognanj stroke ocenjujemo, da je možni prihranek iz organizacijskih brez investicijskih ukrepov cca. 5 %, kar pomeni:

a) prihranek toplotne energije Q_{pt} = 110 MWh/a; stroškovni prihranek = 4.900 €/a
b) prihranek električne energije Q_{pe} = 12 MWh/a; stroškovni prihranek = 1.660 €/a

skupaj prihranek energije Q_p = 122 MWh/a, cenovni prihranek = 6.560 € /a

11 Investicijski ukrepi

Najpomembnejši tehnično-investicijski ukrepi, ki jih predlagamo poleg organizacijskih ukrepov so predvsem:

- ukrepi na ovoju stavbe s poudarkom na izvedbi izolacije fasade, sanaciji stropa mansarde in menjavi oken
- vgradnja termostatskih ventilov na vsa grelna telesa, posodobitev krmiljenja v toplotni postajah
- priprava sanitarne tople vode (STV) s solarnimi sistemi
- vgradnja sistemov za centralno prezračevanje, toplozračno ogrevanje in klimatizacijo z vgradnjo prenosnikov toplote za vračanje toplote zavrženega ali odtočnega zraka pri gretju s temperaturnim izkoristkom nad 65 %
- ukrepi v sistemu notranje razsvetljave s poudarkom na posodobitvi fluorescentne razsvetljave in možnostih vpeljave nadzornega sistema porabe energije.

11. 1 Ovoj zgradbe

Tabela 9: *Pregled ukrepov na ovoju objektov, korekcijski faktor: 0,8*

Objekt A:

Ukrep	Debelina izolacije	Skupni U	Cena na enoto	Površina m2	Investicijska vrednost ukrepa	Prihranek na leto kWh
Menjava oken		1,0	350	145,63	50.970	
Izolacija fasade	16	0,19	60	833,76	50.025,6	
Izolacija stebrov	4	0,20	80	168,3	13.464	
1,24					114.459,6	92.491

Objekt B:

Menjava oken		1,0	350	406,56	142.296	
Izolacija fasade	16	0,19	60	1720,59	103.235,4	
Izolacija parapetov		1	150	295,82	44.373	
0,83					289.904,4	350.716

Objekt B1:

Menjava oken		1,0	350	293	102.550	
Izolacija fasade	10	0,16	50	243	12.150	
Izolacija stebrov	4	0,21	80	36	2880	
2,23					117.580,0	52.810

Objekt C:

Menjava oken		1,0	350	614,8	215.180	
Izolacija fasade	16	0,2	60	1.416	84.960	
Izolacija parapetov	4	1,0	150	357,24	53.586	
Izolacija stropa proti neogrevanemu podstrešju	20	0,11	30	923,50	27.705	
1,19					358.431	300.893

Objekt C1:

Ukrep	Debelina izolacije	Skupni U	Cena na enoto	Površina m2	Investicijska vrednost ukrepa	Prihranek na leto kWh
Menjava oken		1,0	350	297,36	104.076	
Izolacija fasade	16	0,2	60	481,31	28.878,6	
1,00					132.954,6	133.368

Objekt C - VSŠ:

Menjava oken		1,0	350	66,82	23.387	
Izolacija fasade	10	0,2	50	138,92	6.946	
4,23					30.333	7.172

Objekt D:

Menjava oken		1,0	350	232,04	81.214	
Izolacija fasade	10	0,2	50	641,59	32.079,5	
5,56					113.293	20.383

Objekt D0 - Knjižnica:

Menjava oken		1,0	350	59,52	20.832	
Izolacija fasade	16	0,2	60	95,34	5.720,4	
2,19					26.552,4	12.132

Objekt E - Športna dvorana:

Menjava oken		1,0	350	303,4	106.190	
Izolacija fasade	10	0,2	50	321,44	16.072	
5,56					122.262	22.003

					EUR	**kWh**
SKUPAJ					**1.328.770**	**991.968**
Faktor 0,8						**793.547,4**
EUR na kWh					**1.674,5**	

Letni prihranek iz aktivnosti na ovoju zgradb je: 43.647 €
Enostavna vračilna doba: 30 let

11. 2 Ogrevalni sistem

Hidravlično uravnoteženje sistema in rekonstrukcija TPP

Na osnovi tehničnih podatkov proizvajalcev ocenjujemo, da je prihranek toplotne energije pri vzpostavitvi hidravličnega uravnoteženja in optimizaciji ogrevalnega sistema vsaj 20 %.

Predvideni prihranki 20 % od (2.226 MWh – 244 MWh – 794 MWh):	240 MWh/a
Stroški so ocenjeni na:	128.000 €
Prihranki pri stroških ogrevanja:	10.560 €
Vračilni rok izvedbe ukrepa:	12 let

Drugi predvideni ukrepi:

Vgradnja sistema za hlajenje prostorov	55.000 €
Vgradnja sistemov za centralno prezračevanje:	55.000 €
Priprava sanitarne tople vode (STV) s solarnimi sistemi:	115.000 €

11. 3 Električna energija

Na šoli je v tretjini prostorov razsvetljava prenovljena. V prihodnje predlagamo zamenjavo preostalih zastarelih klasičnih fluorescentnih svetil s sodobno razsvetljavo s sijajnim rastrom, pri katerih je odstotek zmanjšane porabe električne energije v primerjavi z obstoječimi svetilkami (zaradi boljše svetilnosti in manjše porabe, ter že z vgrajenimi elektronskimi predstikalnimi napravami, ki so zakonsko predpisani), tudi 50% in več. Predvidi se tudi dodatna osvetlitev v prostorih, kjer je osvetljenost prostorov prenizka.

Rekonstrukcija razsvetljave

Delež razsvetljave v porabi električne energije je ocenjen: 60 %	148 MWh/a
Predvideni prihranki 50 % električne energije za razsvetljavo:	60 MWh/a
Stroški rekonstrukcije celotne razsvetljave so ocenjeni na:	145.000 EUR
Predvideni prihranki :	7.970EUR/a
Vračilni rok izvedbe ukrepa rekonstrukcije razsvetljave:	18 let
Stroški rekonstrukcije NN razvoda razsvetljave so ocenjeni na:	70.000 EUR

11. 4 Pregled ukrepov URE s prioritetno listo

Tabela 10: Prednostna lista ukrepov učinkovite rabe energije

Št	Opis ukrepa	Možni letni prihranki MWh/a			Investicija	Vračilni rok	Prioriteta
		We	Wt	€	€	(let)	-
	ORGANIZACIJSKI UKREPI						
1	- osveščanje uporabnikov - pravilno prezračevanje - ciljno spremljanje rabe energije - energetsko upravljanje - nadzorni sistem vodenja energetike	12 12	 110 110	1.660 4.900 6.560	0 0 70.000	 11	I I
	SKUPAJ	24	220	13.120	70.000	5	
	TEHNIČNO-INVESTICIJSKI UKREPI						
2	Sanacija ovoja zgradb		794	43.647	1.328.770	30	II
3	Hidravlično uravnoteženje ogrevalnega sistema, rekonstrukcija TPP		240	10.560	128.000	12	III
4	Rekonstrukcija notranje razsvetljave	60		7.970	145.000	18	III
5	*Rekonstrukcija NN razvoda				70.000		
6	*Vgradnja sistema za hlajenje prostorov				55.000		
7	*Vgradnja sistemov za centralno prezračevanje				55.000		
8	*Priprava sanitarne tople vode (STV) s solarnimi sistemi				115.000		

	SKUPAJ	84	1.254	62.177	1.671.770	27	

*ukrepi niso upoštevani v izračunu vračilnega roka

11. 5 Ekološka presoja ukrepov in njihov vpliv na bivalno ugodje

Manjša poraba električne energije in ogrevanja pomeni tudi zmanjšanje emisij toplogrednih plinov, predvsem CO_2. Za preračun emisij CO_2 je uporabljena metodologijo izračuna iz Uredbe o taksi za obremenjevanje zraka z emisijo ogljikovega dioksida: za daljinsko ogrevanje 0,340 kg CO_2/kWh. Za elektriko, dobavljeno iz javnega omrežja, smo uporabili faktor: 0,7 kg CO_2/kWh$_e$. Po tem izračunu je predvideno skupno zmanjšanje emisij CO_2 po izvedbi vseh ukrepov in ob ogrevanju vseh prostorov za 446 ton letno (za 48 %).

Tabela 11: Povzetek ukrepov in zmanjšanje energije, stroškov in emisij

POVZETEK VSEH PREDLAGANIH UKREPOV:			% prihranka od skupne letne porabe	
letni prihranek električne energije	84	MWh	34	%
letni prihranek toplote	1.254	MWh	54	%
skupno zmanjšanje emisij CO_2	446	ton	48	% celotnih emisij CO_2
skupno zmanjšanje stroškov na leto	62.177	€	% od letnega stroška za energijo 47	%
skupni znesek potrebnih investicij	1.671.770	€		
povprečni vračilni rok	27	let		

Pri izračunu zmanjšanja deleža stroškov energije proti letnemu strošku ni upoštevan strošek porabe mrzle vode.