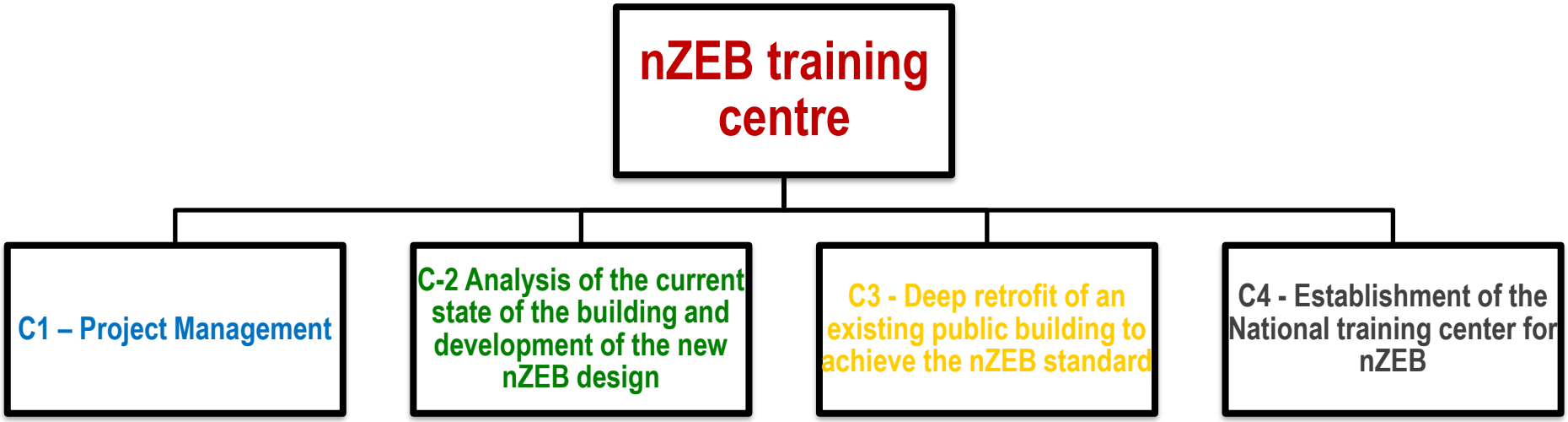
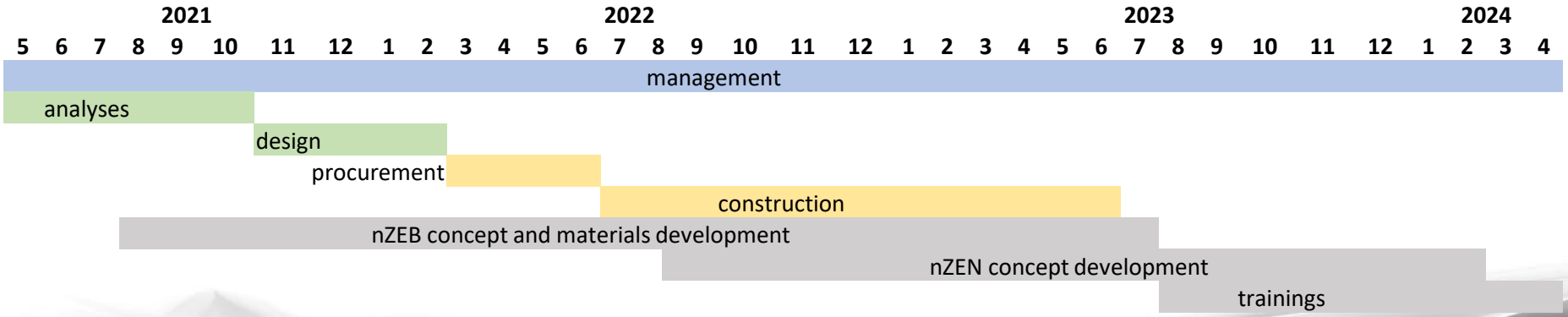
Establishment of the national training center for nearly Zero Energy Buildings (nZEB)

Energy Institute Hrvoje Požar

Structure and timeline of PDP-nZEB





Project components

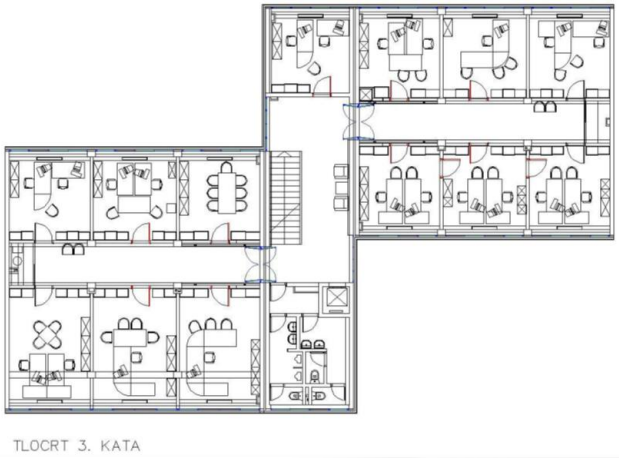
- Component 1 – Project management
- **Component 2 - Analysis of the current state of the building and development of the new nZEB design**
  - **Energy audit – in progress (pending cost optimal analysis for energy efficiency measures)**
  - **Feasibility studies (HVAC system – in development, building digitalization and energy storage system – in process of approval)**
  - **Detailed analysis of the structure - seismic analysis (Faculty of Civil Engineering)**
  - Building main design for deep retrofit
- Component 3 – Deep retrofit of an existing public building to achieve the nZEB standard
- Component 4 – Establishment of the National training center for nZEB

Energy audit

About the building

- Office building (5 floors + basement)
- 85 employees
- Usage time: 8-10 hours/day, 5 days/week

Useful heated area	A_k	m^2	2.061
The volume of the heated area	V	m^3	6.998,70
Heated air volume	V_e	m^3	5.670,25
Total area of building envelope	A_f	m^2	2.320,30
Building shape factor	f_0	m^{-1}	0,33



Energy audit

Thermal characteristics of the building envelope

Index	Surface area (m^2)	U (W/m^2K)	U_{max} (W/m^2K) According to legislation
VZ1 – exterior wall ventilated with glass paneling	400,70	0,37	0,30
VZ1 - external wall ventilated with sheet metal cladding	355,96	0,36	0,30
VZ2 - stone	99,70	0,36	0,30
ST – ceiling towards the unheated attic	395,9	0,29	0,25
SN – ceiling above unheated space	135,62	0,29	0,40
ZN – wall towards unheated space	25,63	0,32	0,40
ZT – wall to ground	130,76	4,08	0,40
PD - floor on the ground	256,15	0,59	0,40
PR1 – windows	461,60	1,43	1,60
PR2 - windows with fixed sunshades	15,20	1,43	1,60
VV – outer doors	29,30	1,43	2,00
VN - doors to unheated space	3,36	1,80	2,00

Energy audit

DISTRICT HEATING SYSTEM

- nominal heat power of the building district heating substation **250 kW** – plate heat exchanger Alfa Laval
- source of thermal energy for space heating and domestic hot water preparation (only for sanitary purposes)
- indirectly heated **hot water storage heater** of nominal capacity **120 L**
- **recirculation line with recirculation pump** (56 W) operating 24 hours/day
- expansion vessel

Indirect type of district heating substation in the basement of the nominal heat power 250 kW (manufacture date 2000.)

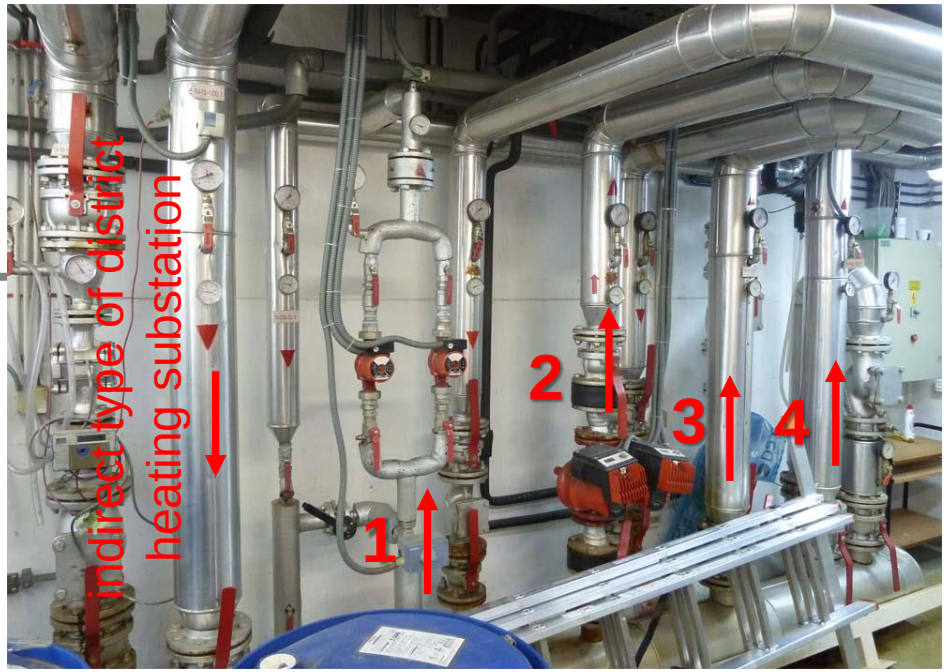
Indirectly heated hot water storage heater of nominal capacity 120 L

Expansion vessel

Energy audit

HEATING DISTRIBUTION SUBSYSTEM

- two pipe heating system with lower distribution piping
- **main distributor** in the building substation with **4 heating circuits**:
  - 11 – radiators
  - 22 – heaters of air handling units
  - 33 – fan coils - east
  - 44 – fan coils - west
- fixed speed pumps



Main hot water distributor in the building substation with 4 heating circuits

Vertical exposed and concealed two-pipe fan coil units

Panel radiators in sanitary facilities

HEATING EMISSION SUBSYSTEM

- **81 two-pipe fan coil units -** thermal output 255,99 kW (45/40°C)
- **14 panel radiators** without thermostatic valves – thermal output 11,20 kW (90/70°C)

Energy audit

COOLING GENERATION SUBSYSTEM

- **air-cooled chiller**, manufacturer CIAT model ILK 400A (build year 2000.) cooling capacity 99,6 kW, electrical power input 36,1 kW (*EER* = 2,76)

  R22 → R417A
- **4 individual air conditioners** (split air conditioners)

4 split air conditioners

Air-cooled chiller, manufacturer CIAT model ILK 400A (build year 2000.) cooling capacity 99,6 kW, electrical power input 36,1 kW (EER = 2,76) Refrigerant R22 → R417A

Ice bank system → 12 m³

Energy audit

COOLING DISTRIBUTION SUBSYSTEM

- **main distributor** with **3 cooling circuits**:

  11 – coolers of air handling unit

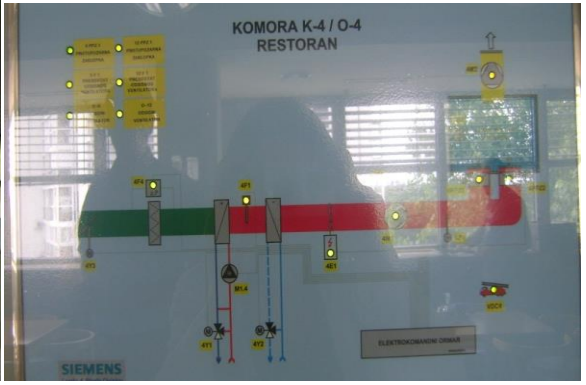
  22 – fan coils - east

  33 – fan coils - west

- steel pipes thermally insulated in bad condition → corrosion problems

Main COLD water distributor with 3 cooling circuits

Energy audit



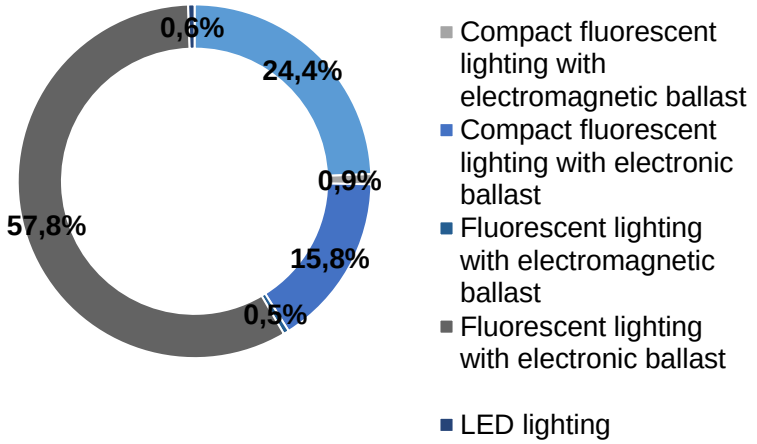
	AHU	Manufacturer	Design volume air flow rate – SUPPLY DUCT, [m³/h]	Design volume air flow rate – RETURN DUCT, [m³/h]	Heat recovery system YES=1, NO=0	Type of heat recovery system	Sensible heat recovery efficiency, [–]	Heating capacity of heating coil [kW]	Cooling capacity of cooling coil [kW]	El. power of supply air fan, [kW]	El. power of exhaust air fan, [kW]	Build year
1	KK Multimedijalna[1]	PROKLIMA	**3.500**	**3.500**	1	Cross-flow plate recuperator	0,63 – summer 0,703 winter	38,2	24	1,80	1,20	2000
2	KK Biblioteka	PROKLIMA	**1.500**	1.500	0	–	–	25	8	1,10	0,55	2000
3	KK Banka	PROKLIMA	**1.500**	1.500	0	–	–	25	8	1,10	0,55	2000
4	KK Restoran	PROKLIMA	**700**	700	0	–	–	8,8	5	0,25	–	2000
TOTAL			**7.200**	**7.200**	**1**			**97**	**45**	**4,25**	**2,30**	

Energy audit

Lighting system

Lighting system power [kW]	49,54
Lighting power density [W/m^2]	Target 7

Type	Number	Power [kW]
Halogen lighting	234	12,06
Compact fluorescent lighting with electromagnetic ballast	12	0,46
Compact fluorescent lighting with electronic ballast	318	7,83
Fluorescent lighting with electromagnetic ballast	5	0,25
Fluorescent lighting with electronic ballast	541	28,65
LED lighting	34	0,29
Ukupno	**1.144**	**49,54**



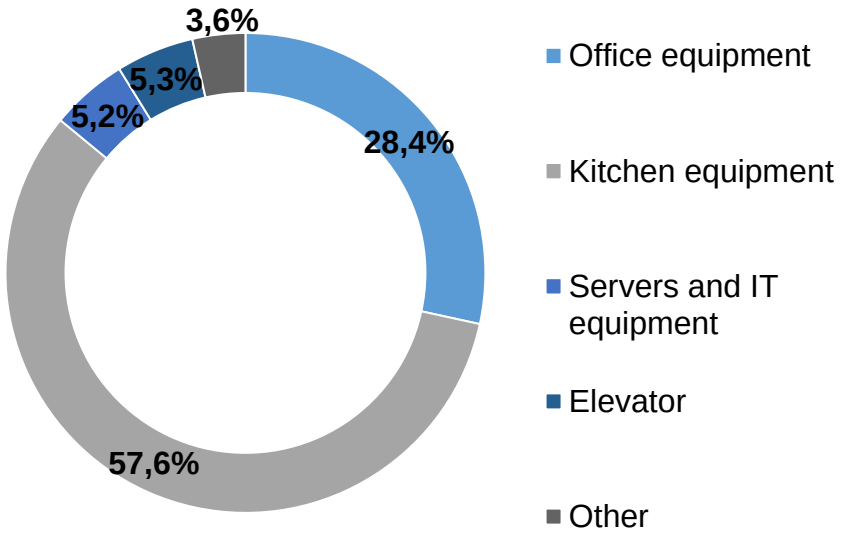
Energy audit

Other electrical equipment

Power of other electrical equipment [kW] 68,50

Power density of other electrical equipment [W/m^2] 33,24

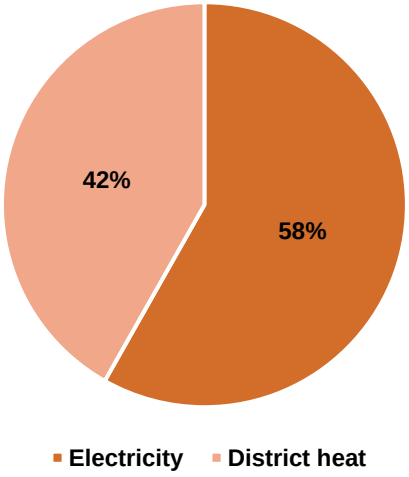
Type	Number	Power [kW]
Office equipment	213	19,47
Kitchen equipment	16	39,43
Servers and IT equipment	33	3,56
Elevator	1	3,60
Other	15	2,44
Ukupno	**278**	**68,50**

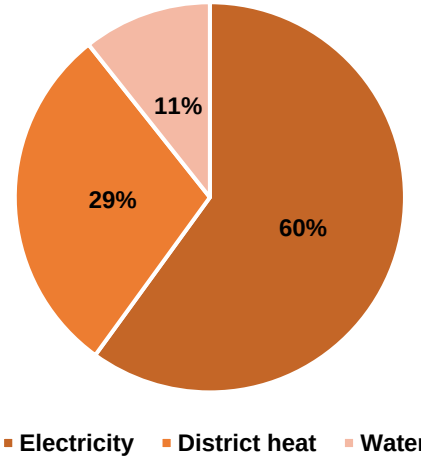


Energy audit

Energy consumption

Energy	Unit	Baseline values			
		Consumption	Consumption	Costs	CO_2
		[unit/a]	[kWh/a]	[kn/a]	[t/a]
Electricity	kWh	186.539,00	186.539,00	155.200,23	43,837
District heat	kWh	134.000,00	134.000,00	75.844,35	46,364
Water	m^3	1.051,50	-	27.628,81	0,236
Ukupno			**320.539,00**	**258.673,39**	**90,437**

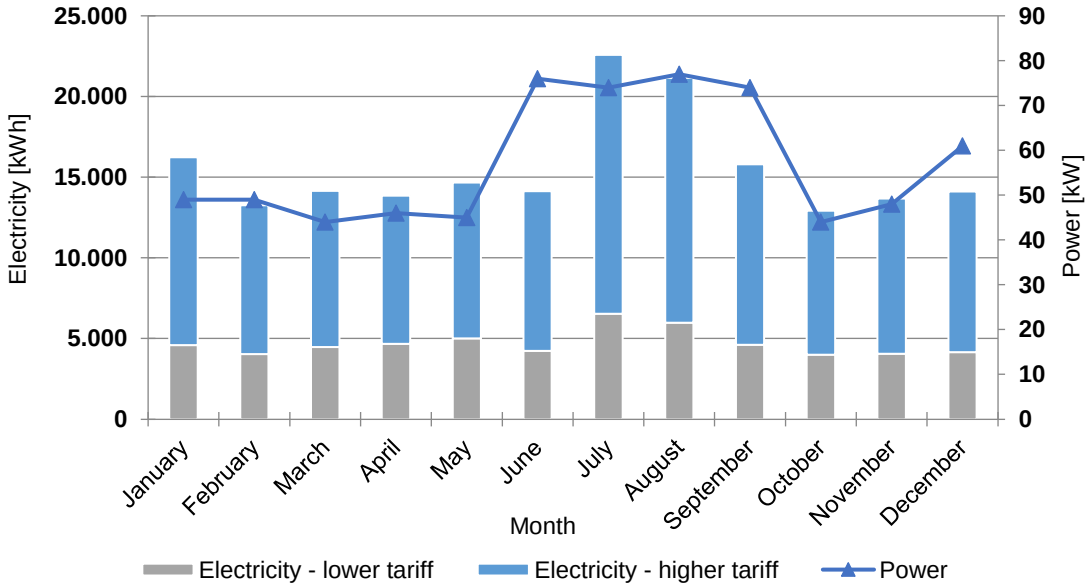


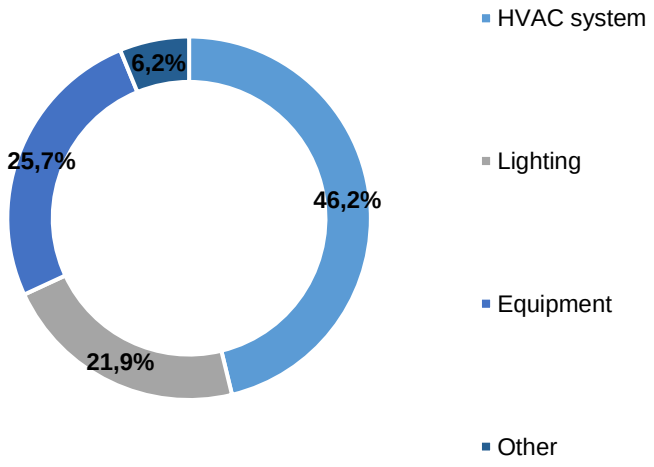


Energy audit

Electricity consumption

Total power [kW]	221,53
Total power density [W/m^2]	107,49
Electricity consumption per surface area [kWh/m^2]	90,51
Electricity consumption per employee [kWh/person]	2.194,58



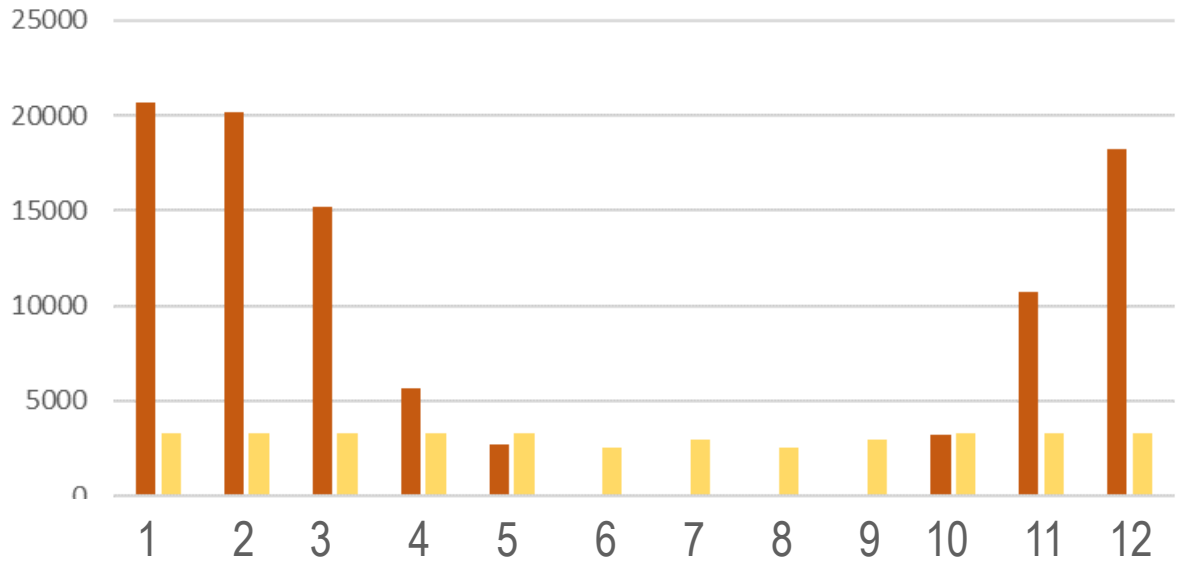


Energy audit

Annual thermal energy consumption: **134.000,00 kWh/a**

Annual water consumption: **1.051,50 m³/a**

87,63 m³/month



72,09 % **27,91 %**

Energy audit

Energy performance certificate

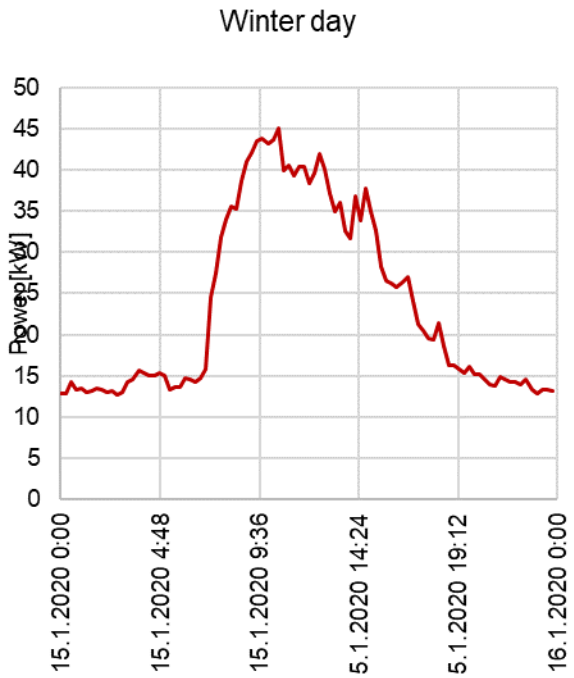
Needed energy for heating $Q''_{H,nd}$ [kWh/(m^{2}a)]	Needed primary energy E_{prim} [kWh/(m^{2}a)]	Energy performance rating – energy needed for heating $Q''_{H,nd}$	Energy performance rating – primary energy E_{prim}
38,66	***156,14***	**B**	**F**

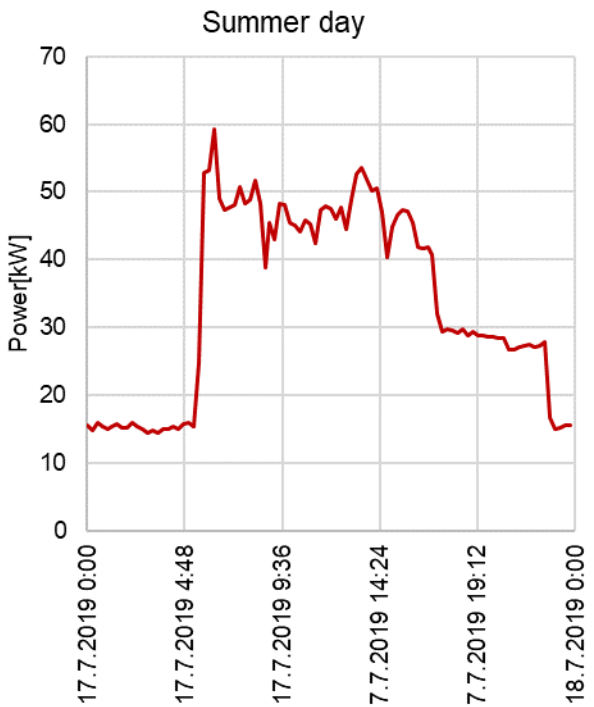
- Energy needed for heating: 76.540,66 kWh/a
- Energy needed for cooling: 52.338,59 kWh/a
- Energy needed for DHW: 3.717,95 kWh/a
- Energy needed for lighting: 74.890,31 kWh/a

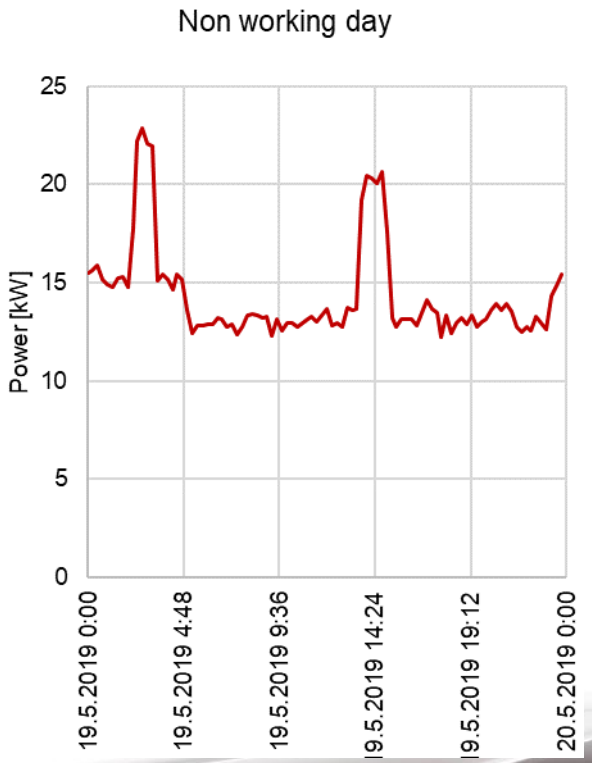
Energy audit

Consumption measurements

- Electricity for whole building



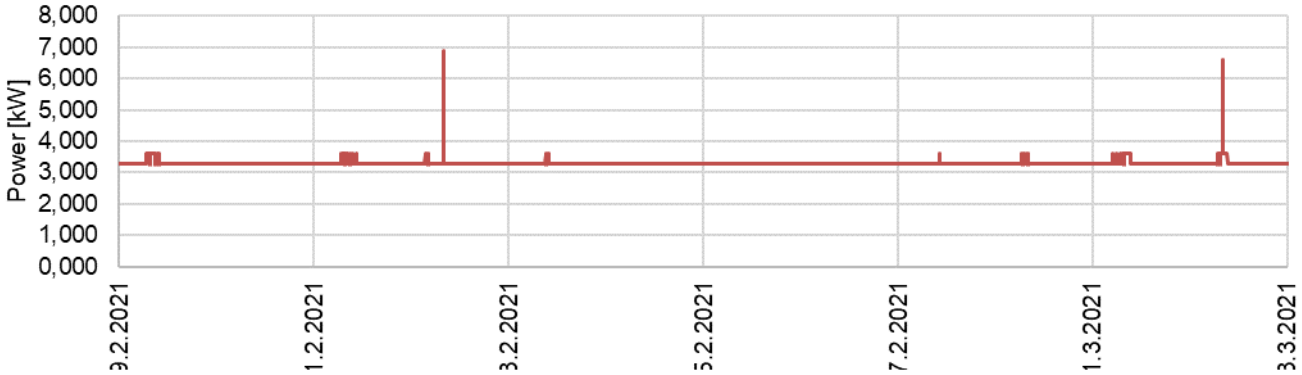




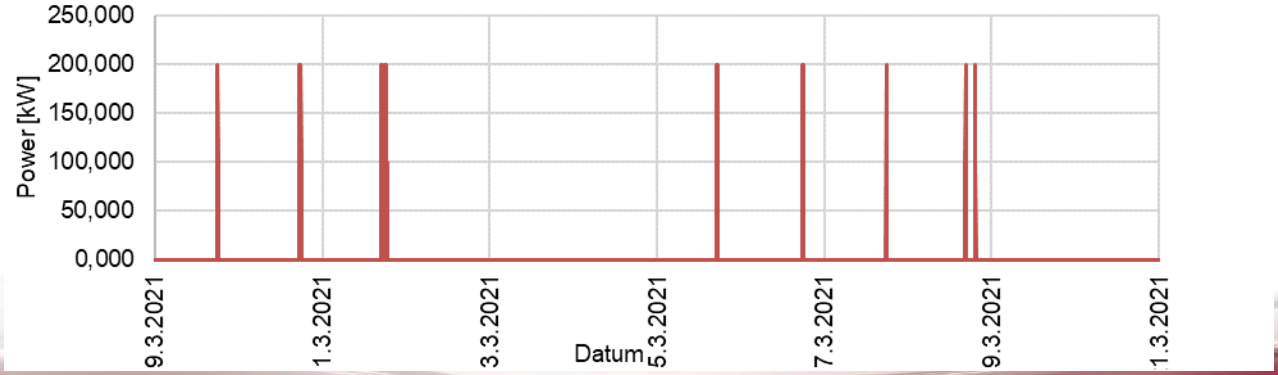
Energy audit

Consumption measurements

- Heating pumps



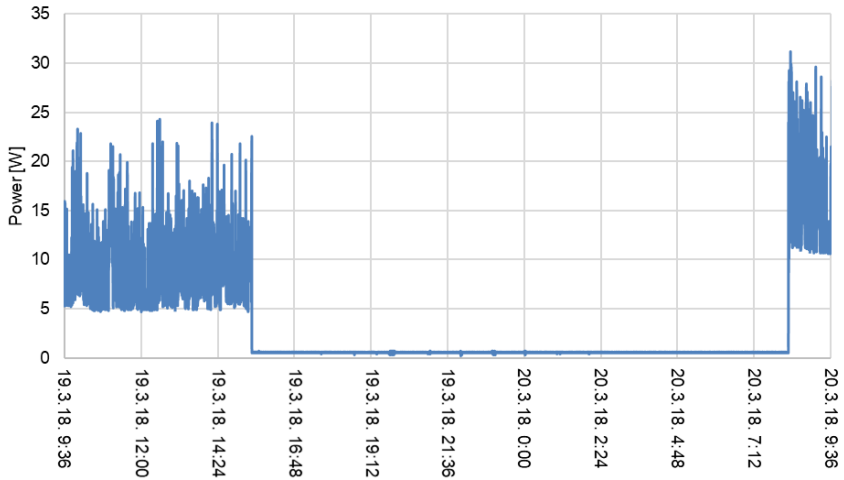
- Lighting system in hallway



Energy audit

Consumption measurements

- Lighting system for toilet
- Fan coil
- Printer and photocopier
- Display (monitor)
- Laptop
- Servers

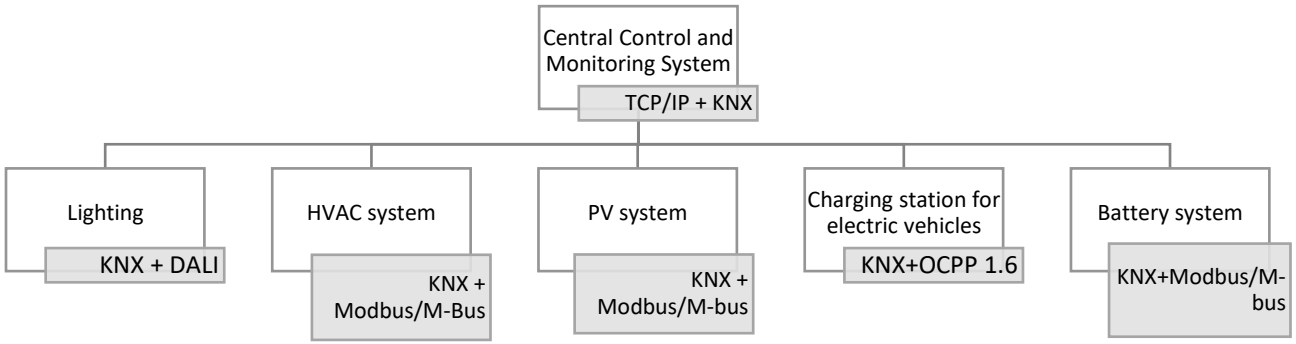


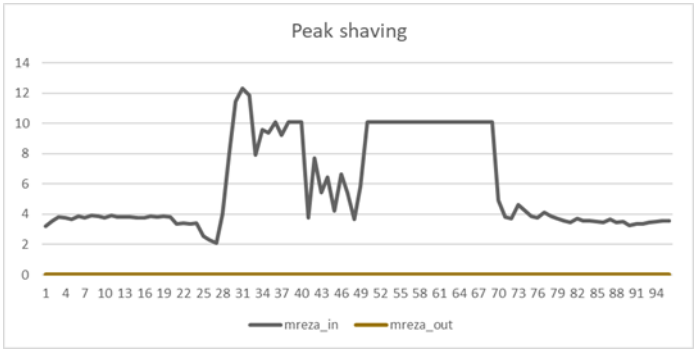
To align the building model with the actual usage

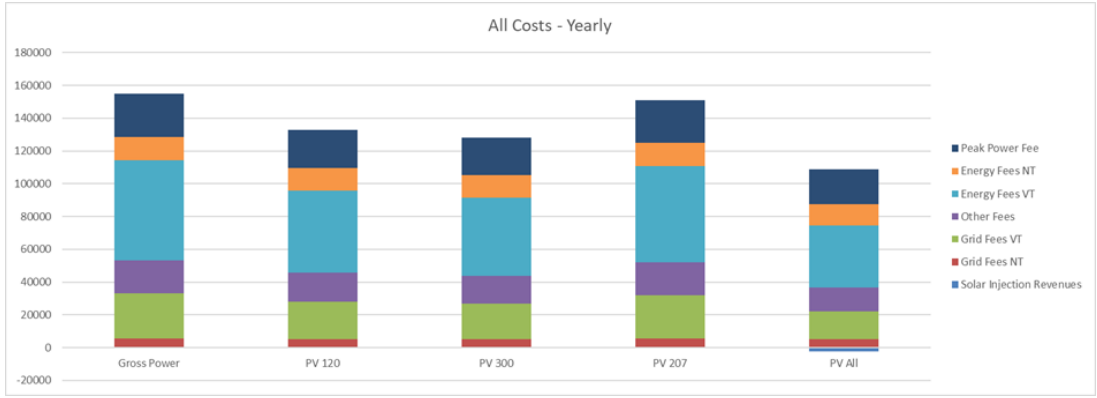
Feasibility studies

- Feasibility study of integration of photovoltaic system, battery system and charging stations for electric vehicles and digitalization of building systems – in process of approval
  - Determining the optimal technology and functionality of the integrated photovoltaic power plant system, stationary battery system and charging stations for electric vehicles
  - Determining the basic preconditions and proposing options for the introduction of a digital system for integrated monitoring and management of individual building systems
- Selection of the optimal software solution for lighting management – drafted
- Selection of the optimal technical solution of the HVAC system in a set of different variants of thermal protection of building envelope and lighting system solutions – drafted

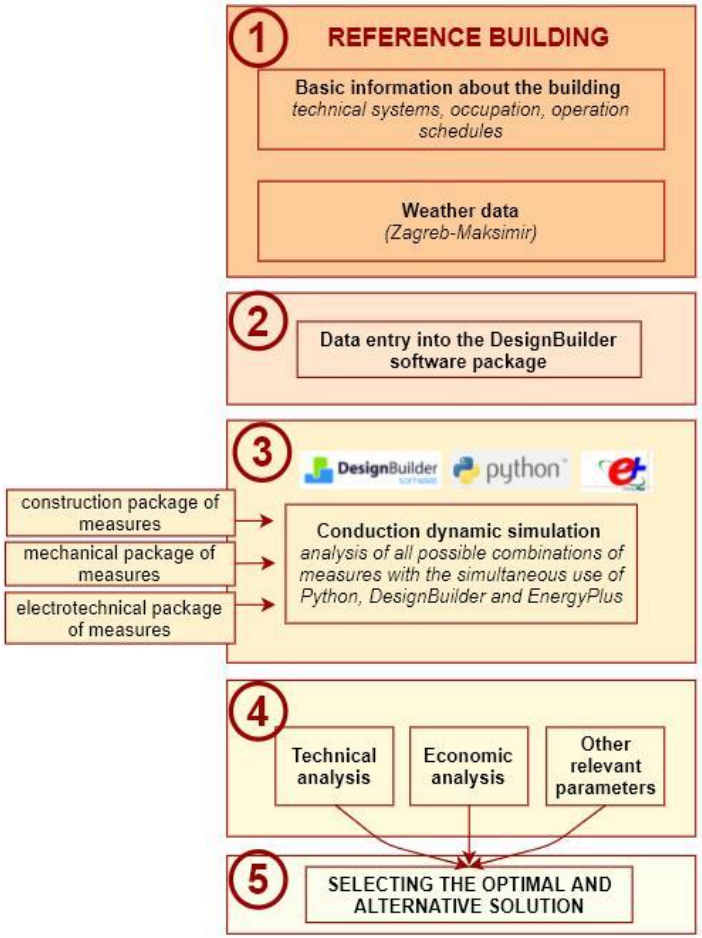
Feasibility studies – PV, battery and digitalization

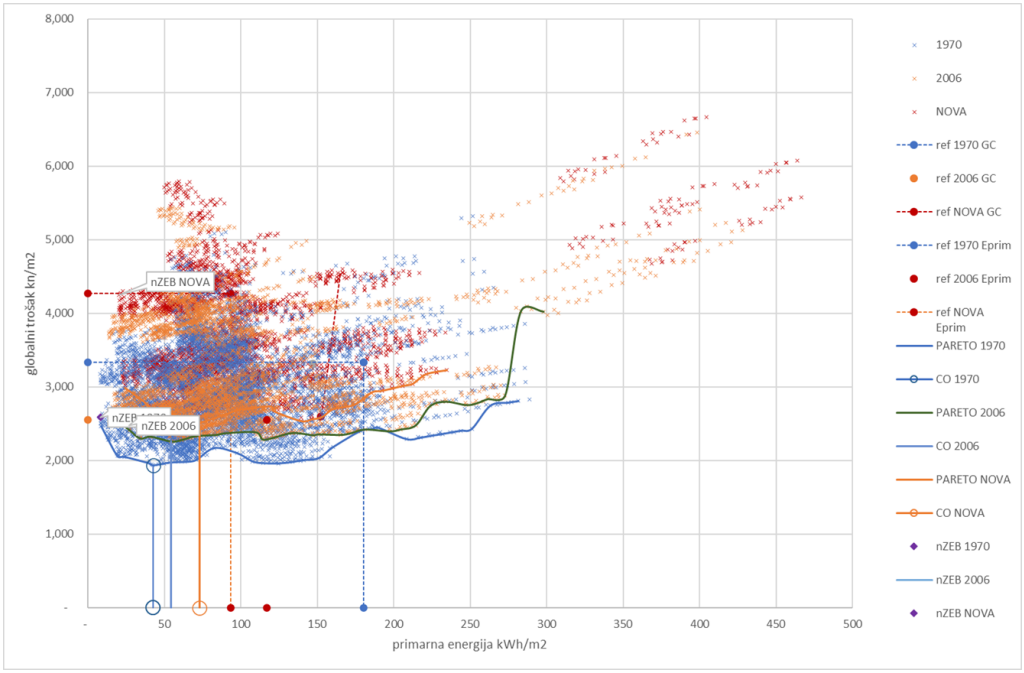






Feasibility studies – HVAC optimal solution





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