REGIONAL NZEB CASE STUDIES FOR REFERENCE PUBLIC BUILDINGS IN THE CENTRAL EUROPEAN REGION

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The eCentral project summary

Addressing poor energy performances of public buildings is at the core of EU's Energy Efficiency Directive and Energy Performance Building Directive but also one of growing financial issues in Central European countries. To address that eCentral project will support key stakeholders to realize benefits of newly implemented building standard – nearly zero energy building (nZEB). eCentral project will prove that nZEB approach, although innovative, is optimal and cost-effective solution for renovation and construction of public buildings. Project aims to capitalise on results of previous and ongoing EU initiatives. Austria has a proven track record with nZEB renovation projects and will be leading other implementing partners (CRO, SLO, HUN) by example. Transnational cooperation will be used to receive maximum international visibility of selected pilot actions. Main outputs of the project are:

- energy performance certificate (EPC) Tool for public authorities
- deployment and promotion of innovative financing schemes
- training programme and project development assistance for nZEB projects
- building renovation strategies for selected regions
- state of the art pilot nZEB public buildings in selected regions
- established cooperation with scientific institutions and other nZEB initiatives

Transnational Assessment and Support Group, formed from project experts and scientific institutions will act as a support team and provide quality checks of each output. EPC Tool will be developed and used by public sector decision makers and project developers beyond eCentral project lifetime. Trained energy efficiency teams within the regional government will serve as a backbone for conducting future nZEB projects. The European Academy of Bolzano (EURAC), one of the leading centres of expertise on energy efficiency in the Central Europe region, will focus on policy analysis and dissemination of eCentral project results.

About this document

This document aims to present twenty selected nZEB public buildings already built in five European Central regions, Italy, Slovenia, Austria, Hungary and Croatia. The buildings collected are schools and office buildings, new or renovated ones with the target of achieving nZEB standard. These buildings are the showcases to demonstrate and accelerate the progress towards the achieving of the nZEB target. They will be used as a good practices example to define energy renovation strategies, financing schemes and design-construction processes (D.T.2.3.2, D.T.14..3). Futhermore, they will be presented during the workshops, events (D.T3.1.1, D.T3.2.1, D.T3.3.1, D.3.4.3) and trainings (D.T2.2.1), in order to improve the knowledge on these types of buildings.

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1. Introduction and objectives

This document will collect the data information on nZEB already built in Central Europe region, for a total of twenty buildings, schools and offices, selected in five EU countries, four per country (Italy, Hungary, Slovenia, Croatia and Austria).

These buildings will be used within eCentral project like showcases to demonstrate and stimulate the public authorities to introduce and pursue the nZEB target in new buildings and renovated ones. At the end, “seeing is believing”, and the best strategy to persuade someone is to show that something works properly. For this the nZEBs collections is an important opportunity to stimulate and convince public owners to invest in this energy target.

Furthermore, the renovation process used in these “pilots’ case studies” already built, can be shared to several stakeholders in order to describe issues and opportunities found during the design, construction and operation process.

These case studies will be used as good practice examples in tools developed within the eCentral project, presented during the trainings or events.

Some objective and opportunities developed within this action are:

- To increase the decision makers and public owners to adopt the nZEB target;
- To increase the knowledge of public building owners and public policies to support design project with this energy target;
- To increase the visibility of these nZEB front-runners and disseminate the experiences and lessons learnt during the design, construction and operational phases;
- To mix final objects of decision makers, public owners, building professionals and financiers.

2. Selected nZEBs

The pilot case studies are nZEBs, or in case of absences of nZEB definition, high energy efficient buildings already built. As presented in the "*DT1.1.1 Report on nZEB initiatives in Central Europe*" the nZEB definition is similar for EU countries but with some differences. For this reason, the case study choice for each country, is given to each project partner in different countries.

2.1. Data Analisys

The selected nZEBs are prevalent schools with a share of 68%, followed by office and other typologies of buildings: one student home, one residential building and one Spa with swimming pool. 47% of the selected ones, are renovated buildings, 35% new ones, and enlargement buildings have a share of 18% (Figure 1).

Figure 1. Characteristics of nZEBs' selected, in relation to building use (a), and building typology (b).

2.1.1. Primary Energy Demand

The selected nZEBs are located in Italy, Austria, Hungary, Croatia and Slovenia, characterized by different legislations. That means, different energy performance requirements, different energy balance calculation methods, condition boundaries and primary energy factors were used. Nevertheless, Primary Energy (PE) calculated for heating, cooling and electricity demands, has been collected and reported in

Figure 2.

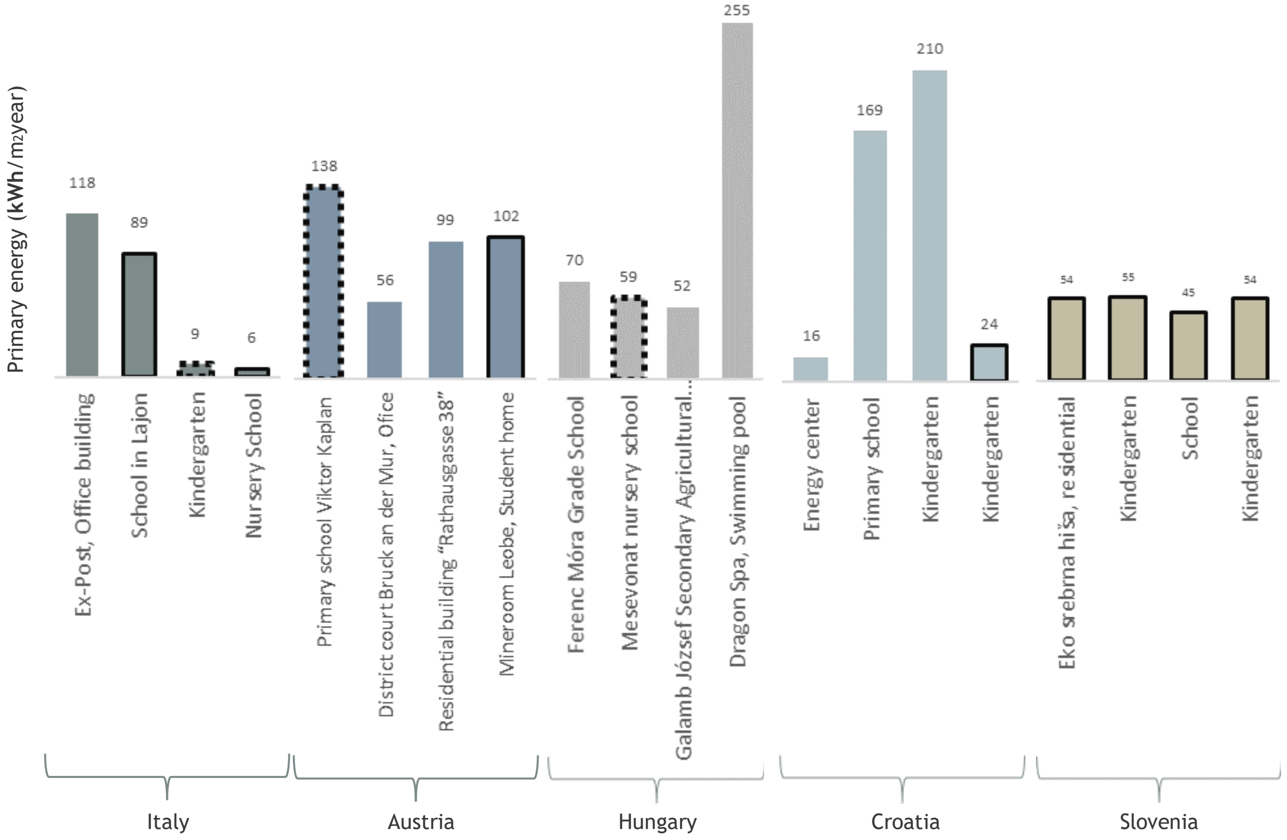
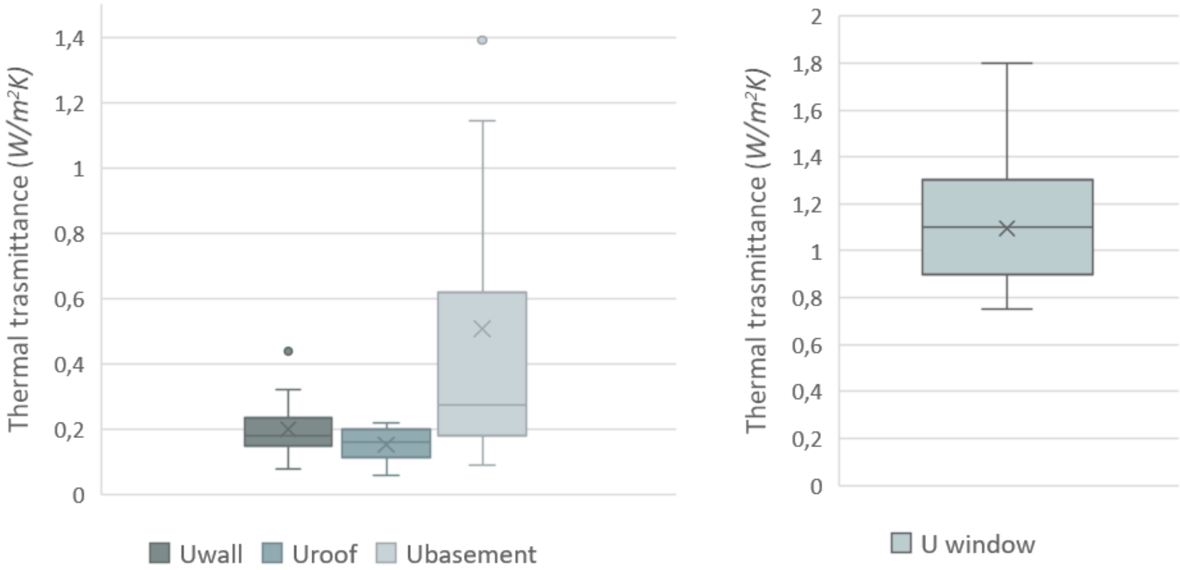


Figure 2. Primary energy (heating, cooling and electricity) (kWh/m2year). New buildings highlighted with a continuous black line, enlargement buildings with a dotted black line, and renovated ones without any line.

The PE are usually under 120kWh/m^{2}y, such as required by a Passive House standard building. Only in some cases, the PE results higher: in case of Dragon Spa building (resort providing therapeutic baths) located in Hungary, and in other three cases, the Primary school Viktor Kaplan (AU), the Primary school of Municipality of Hum Stubički and the Kindergarten of Pokupsko Municipality (both in Croatia). The reasons should be the building use for the Dragon Spa building, while in the other two cases due to the limit of the energy performance renovation of the buildings.



(a) (b)

Figure 3. Thermal transmittances of walls, roof, basement (a) and windows (b) of selected nZEBs.

The thermal transmittance of the single components of the nZEBs’ envelope was analysed.

The interquartile ranges (i.e., central rectangle that includes the 50% of the “heating demand” values) of thermal transmittance of walls and roofs, result in being more compact and lower than the thermal transmittance of the basements.

A possible reason can be due to the higher difficulty/costs and work typologies, of the energy improvement measures adopted in this kind of components.

- U_{wall} between 0.15 W/(m_2K) and 0.23 W/(m_2K) (median U_w-value at 0.20 W/(m_2K));
- U_{roof} between 0.115 W/(m_2K) and 0.20 W/(m_2K) (median U_r-value at 0.165 W/(m_2K));
- $U_{basement}$ between 0.18 W/(m_2K) and 0.23 W/(m_2K) (median U_b-value at 0.50 W/(m_2K));
- $U_{windows}$ between 0.90 W/(m_2K) and 1.30 W/(m_2K) (median U_{Win}-value at 1.10 W/(m_2K)).

These results confirm that the thermal transmittance of the nZEBs’ components is homogeneous in renovated nZEBs in different EU countries.

2.2. Building technical systems

2.2.1. Heating systems

The mostly used heating generation system in these renovated nZEBs is the heat pump technology with a share of 45%, followed by district heating (40%), and heating boiler systems (15%), see Figure 4 (a).

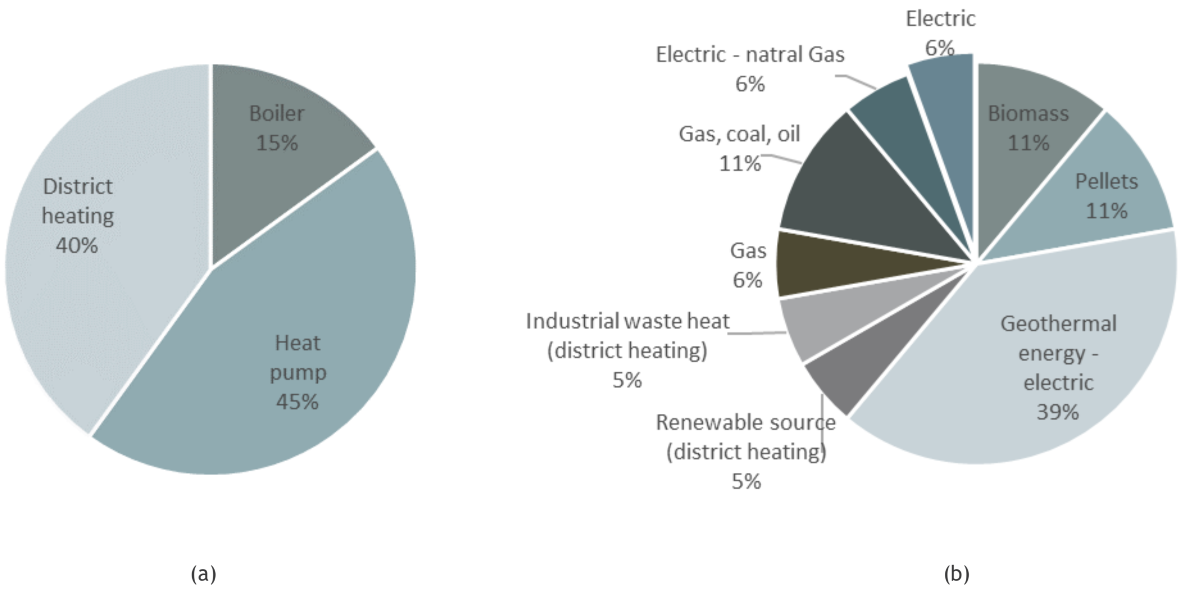


Figure 4. Share of heating generation systems used in the selected nZEBs (a) and the energy carriers used (b).

The mostly used energy carrier is geothermal energy used by heat pump systems.

The high share of gas, coal and oil, about 11%, usually used in district heating system, indicate that in some countries the utilization of these kind of energy carriers does not negatively affect energy balance calculation. The reason could be due to the national economic strategy, which change in relation to the country.

2.2.2. Cooling system

A cooling system is installed in the 45% of the selected nZEBs. The most common used system is the heat pump.

2.2.3. Ventilation system

The use of mechanical ventilation is very common in the selected nZEBs. It is installed in 75% of the cases. The ventilation system is a technology able to improve the indoor air quality and reduce the heating losses due to using natural ventilation.

2.2.4. Electricity generation – PV system

Generation of electricity is installed in 65% of the nZEBs selected. Only in one case, the PV technology combined with a cogeneration system.

2.3. Costs

The selected nZEBs are either new ones (40%), enlargements of existing buildings (15%) or renovated ones (45%).

The costs for the building construction or energy performance renovations are quite different, as showed in Figure 5.

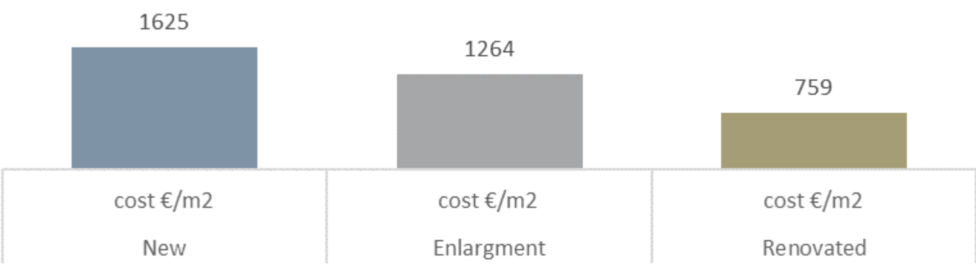


Figure 5. Unit costs (€/m2) of new, enlargement and renovated buildings.

3. Summary and conclusions

The data analysis of the selected nZEBs shows similar trends in the values of the thermal transmittance of buildings components, both opaque and transparent ones.

The heating generation systems used are heat pump technology (45%), district heating (40%), and heating boiler systems (15%). However, the used energy carriers are very varied, as showed by Figure 4.

The reason could be due to the national economic strategy, which changes in relation to the country.

Cooling systems are installed in 45% of the case studies, which are mainly based on heat pump technology. This means, that heat pumps are used throughout the whole year (heating and cooling.)

Ventilation systems are usually installed, with a share of 75%.

The photovoltaic technology is used in 65% of the cases for producing electricity.

The building construction costs of the selected nZEBs change in relation to the building typology, with a medium cost of:

- 760 €/m2 for energy renovations;
- 1270 €/m2 for building enlargement;
- 1625 €/m2 for new buildings.

1. nZEB Case Study - IT - Ex Post in Bozen

Refurbishment, Bolzano-Bozen, Italy

BEFORE RENOVATION	AFTER RENOVATION
	

GENERAL INFORMATION	
Use of the building	Office
Owner	Province of Bolzano
Built in (year)	1950
Renovated in (year)	2005
Design team	M. Tribus architects
Building is under protection as cultural heritage	no
GPS	Latitude = 46. 4971 Longitude = 11. 3591
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3131
CDD 26 (www.degreedays.net)	106
ENERGY PERFORMANCE	
Availability of energy performance certificate	CasaClima Certification
Energy Performance Classification	Standard CasaClima Gold
RENOVATION COSTS	
Costs of renovation (€)	4.820.000,00 €
Costs per m² GFA (€/m²)	976€ €/m2

Final use was Postal Service offices. In the original, the building was composed by three floors with a structure of bearing walls and reinforced concrete. In 2004, the building was dismissed and bought by Department of Planning and Environment of the local government, the Province of Bolzano.

In 2004, the Province of Bolzano decided to renovate it. The building was enlarged to five floors and the façade was modified with the aim to having both good illumination and shading, even though the architectural concept was not modified a very simple shape broken by the diagonally windows reveals. On the underground floor, there are the archives, the server room, and technical rooms for heating and cooling system. On the ground floor, there are three offices, two meeting rooms and the exhibition hall. On the other four floors, there are offices for two or three people and two lounge halls.

From the early design phases the Province of Bolzano, together with the design team, decided to achieve the Passive House standard. In the façade was installed a continuous layer of 35cm of EPS with a λ=0.035W/mK, in order to achieve a very low thermal transmittance (U=0.08 W/m2K). The cuts of the insulation layer produce the façade theme and rule the sun access in relation with the seasons. To reduce the artificial lighting, and the internal comfort, each desk is placed under the windows. Thermal bridges were analyzed and corrected. In order to reduce the energy impact, Polycrystalline PV panels were installed in the south façade of the building.

The energy performance of the building was calculated with PHPP, a tool used to design passive Houses. The energy performance achieved, in Primary Energy, was 118 kWh/m2year. The building achieved also the CasaClima Gold standard, the higher level of regional energy performance classification.

The building was monitored in order to assess the energy performance of the building and to optimize the energy consumptions.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	4940	*m2*
Heated net floor area (NFA)		*m2*
Heated gross volume	23208	*m3*
Heated net volume		*m3*
S/V		
Heating demand	7 (calculated with CasaClima)	*kWh/m2year*
Cooling demand		*kWh/m2year*
Final energy (heating, cooling and electricity)		*kWh/m2year*
Primary energy (heating, cooling and electricity)	118 (calculated with PHPP)	*kWh/m2year*
RES	PV panels integrated in the façade (26,73 kWp)	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	93.000	*kWh*
Cost related to previous query		€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)		*kWh*
Cost related to previous query		€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0.08	*W/m2K*
	Roof (Ur)	0.10	*W/m2K*
	Basement (Ub)	0.70	*W/m2K*
	Windows (Uw)	0.79	*W/m2K*
		Uf 0.87	*W/m2K*
		Ug 0.78 – g 0,80	

TECHNICAL SYSTEM	
Heating generation system	Gas condensing boiler (60 kW)
Energy carrier for heating	Natural gas
Heating distribution system	Floor heating
Domestic hot water DHW preparation	Together with the heating system
Energy carrier for DHW	Natural gas
Cooling generation system	Chilled water- (85 kW) battery of gas-driven absorption chiller
Energy carrier for cooling	Natural gas
Electric generation	PV - polycrystalline silicon (26.73 kWp)
Mechanical Ventilation System	Central ventilation system (heat recovery nominal efficiency 90%) Menerga (capacity of 10.000 m3/h)
Energy Carrier for Mechanical Ventilation System	Electricity

CONSTRUCTION TESTS		
Blower door test	0.60	*h-1*
Thermography	yes	

2. nZEB Case Study - IT - Primary School in Laion

New building, Laion-Lajen, Bolzano-Bozen, Italy

AFTER RENOVATION

GENERAL INFORMATION	
Use of the building	Educational
Owner	Municipality of Laion
Built in (year)	2006
Renovated in (year)	2005
Design team	Arch. Johann Vonmetz, Arch. Stefan Trojer
Building is under protection as cultural heritage	no
GPS	N 46°36.32" E 11°33.50"
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3131
CDD 26 (www.degreedays.net)	106
ENERGY PERFORMANCE	
Availability of energy performance certificate	CasaClima Certification
Energy Performance Classification	Standard CasaClima Gold
RENOVATION COSTS	
Costs of renovation (€)	1.207.000,00 €
Costs per m² GFA (€/m²)	1598 €/m2

In 1938 the elementary school building was built in Lajon. The building was enlarged in 1980.

In 2002 the Municipality of Laion completed a feasibility study, highlighting the positive results to build a new school instead to renovate the exited one.

In April 2003, the design project was assigned to Arch. Vonmetz. The energy target fixed by the Municipality of Laion was:

- CasaClima A +
- Architectural concept for maximizing the energy savings
- Passive House standard

In July 2004 started the construction phase, with the demolition of the existing school and beginning of construction works. In 2006 the school was built, in September the inauguration.

The building is compact (S/V=0.53) and composed by two heating floors.

The thermal transmittance of the building envelope is very low, thanks to thickness of the insulation layer, 20 cm of mineral foam on the walls, and 24cm of wood fibers in the roof. The south façade is characterized by large glazed surface with venetian blinds (128 m² out of 150m²), in order to maximize the solar gains and natural daylighting. Argon triple coated panes with oak frames compose the windows.

The technical system is composed by a mechanical ventilation system with heat recovery, electric heat pumps (1,8kW electric and 8.3 kW thermal).

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	755.37	*m^2*
Heated net floor area (NFA)	625	*m^2*
Heated gross volume	3115	*m^3*
Heated net volume	1562	*m^3*
S/V	0.53	
Heating demand	9 (calculated with CasaClima) 7 (PHPP tool)	*kWh/m^2year*
Cooling demand	0	*kWh/m^2year*
Final energy (heating, cooling and electricity)	33.80	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	89 (CasaClima tool)	*kWh/m^2year*
RES	PV panels integrated in the façade (26,73 kWp)	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)		*kWh*
Cost related to previous query		*€*
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	109824	*kWh*
Cost related to previous query	2250	*€*

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0.23	*W/m^2K*
	Roof (Ur)	0.13	*W/m^2K*
	Basement (Ub)	0.21	*W/m^2K*
	Windows (Uw)	0.798	*W/m^2K*
		Uf 0.80	*W/m^2K*
		Ug 0.50 W/m^2K - g 0.52	

TECHNICAL SYSTEM	
Heating generation system	Heat pump
Energy carrier for heating	Electric – Geothermal plant
Heating distribution system	Floor heating
Domestic hot water DHW preparation	Together with the heating system
Energy carrier for DHW	Electric – Geothermal plant
Cooling generation system	Heat pump
Energy carrier for cooling	Electric – Geothermal plant
Electric generation	PV - 140 m^2 Polycrystalline photovoltaic panels (17.7 kWp)
Mechanical Ventilation System	Central ventilation system with heat recovery
Energy Carrier for Mechanical Ventilation System	Electricity

CONSTRUCTION TESTS		
Blower door test	0.49	*h^{-1}*
Thermography	yes	

3. nZEB Case Study – IT - Kindergarten “Chico mendez”

Enlargement, Cologno Monzese, Milano, Italy

GENERAL INFORMATION	
Use of the building	Educational
Owner	Municipality of Cologno Monzese
Built in (year)	2007
Renovated in (year)	
Design team	Arch. Lorenzo Iachellini
Building is under protection as cultural heritage	no
GPS	45.542, 9.270
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	2752 (Milan)
CDD 26 (www.degreedays.net)	113 (Milan)
ENERGY PERFORMANCE	
Availability of energy performance certificate	*A+*
Energy Performance Classification	*CENED*
RENOVATION COSTS	
Costs of renovation (€)	1.050.000,00€ (690.000;00€ Cologno Monzese + 360.000€ Province of Milan)
Costs per m² NFA (€/m²)	1535 €/m2

In 2007 the Municipality of Cologno Monzese decided to enlarge the kindergarten. The energy performance target that the Municipality wanted to achieve was the passive house target. In 2008 the public tender for the assignment of the construction work was published.

The construction work began in 2008. June 2010, the public administration revoked the contract with the winner building company. The building realization was achieved the ¾ of total work. For the missing works the municipality contacted directly the craftsmen and the companies, in order to finish the works. The work finished in August 2011.

Some problems found were for the economic computation, because some of these works were innovative, so at national level there were a standard economic value.

This lack of economic costs were for the innovative technologies often used in passive buildings (air ventilation system with heating recovery, geothermal plant, heat pump) and on the building envelope solutions. In 2011 there was the inauguration of the school.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)		*m2*
Heated net floor area (NFA)	684 (412 m2 new building, 272 m2 refurbishment)	*m2*
Heated gross volume		*m3*
Heated net volume		*m3*
S/V	0.53	
Heating demand	39.3	*kWh/m2year*
Cooling demand	0.70	*kWh/m2year*
Final energy (heating, cooling and electricity)		*kWh/m2year*
Primary energy (heating, cooling and electricity)	10	*kWh/m2year*
RES	PV	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)		*kWh*
Cost related to previous query		*€*
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)		*kWh*
Cost related to previous query		*€*

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0.157	*W/m2K*
	Roof (Ur)	0.147	*W/m2K*
	Basement (Ub)	0.18	*W/m2K*
	Windows (Uw)	1.30	*W/m2K*
		Ug 0.70	*W/m2K*
		g 0.45	

TECHNICAL SYSTEM		
Heating generation system	Heat pump	
Energy carrier for heating	Electric	
Heating distribution system	Floor heating	
Domestic hot water DHW preparation	Heat pump	
Energy carrier for DHW	Electric	
Cooling generation system	Heat pump	
Energy carrier for cooling	Electric	
Electric generation	PV panels - 110 m² of silicon polycrystalline photovoltaic panels (80panels) Efficiency 13,4% - electric peak power of 14,8 kWp	
Mechanical Ventilation System	Heating recovery with efficiency of 90,50%. External air/new air: 3000m3/h	
Energy Carrier for Mechanical Ventilation System	Electric consumption 200Pa: 2*1000W.	
CONSTRUCTION TESTS		
Blower door test	-	*h-1*
Thermography	no	

4. nZEB Case Study - IT - Nursery school

New building, Bareggio, Milano, Italy

GENERAL INFORMATION	
Use of the building	Educational
Owner	Bareggio Municipality
Built in (year)	2007-2009
Renovated in (year)	
Design team	Arch. Gianluca Guzzon of Bareggio Municipality, with BEST Department - Politecnico di Milano
Building is under protection as cultural heritage	
GPS	N 45°29'19.4" E 9°00'32.8"
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	2752 (Milan)
CDD 26 (www.degreedays.net)	113 (Milan)
ENERGY PERFORMANCE	
Availability of energy performance certificate	A
Energy Performance Classification	ACE
RENOVATION COSTS	
Costs of renovation (€)	€
Costs per m² GFA (€/m²)	€/m2

The nursery school is the result of the collaboration between residents of Bareggio and a group of researchers, who supported the Municipality in making the most appropriate choices for the project in the light of current technological, energy and environmental issues.

The nursery school consists of a single-storey, C-shaped main building, around a central open courtyard. The shape of the building is extremely compact and ensures that heat loss is minimized, compatibly with current school regulations and modern principles in education. The area includes two gardens: a collective one located within the courtyard defined by the building itself, and an outer one, with sections that can be associated with each individual classroom, functioning as buffer that separates the "learning area" from the "play area". The building has a laminated wood frame, and brick walls with high-density, very thick, stone wool insulation. Moreover, the shape of the building envelope was designed so as to eliminate thermal bridges. The frames of windows and sliding glass doors are made of solid wood. The windows facing the garden are shielded with a double-blind system, while the South-facing façade is protected from excessive sun by a pergola.

A reversible geothermal heat pump provides heating during the winter and chilled water during the summer. Radiant floor panels were selected as heating terminals, as they are particularly suitable for the type of user. Some of the power required by the heat pump is supplied by a solar photovoltaic system, installed on the roof of refectory's building.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)		*m^2*
Heated net floor area (NFA)	2086	*m^2*
Heated gross volume	10377	*m^3*
Heated net volume		*m^3*
S/V	0.57	
Heating demand		*kWh/m^2year*
Cooling demand		*kWh/m^2year*
Final energy (heating, cooling and electricity)		*kWh/m^2year*
Primary energy (heating, cooling and electricity)	5.85	*kWh/m^2year*
RES		
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)		*kWh*
Cost related to previous query		*€*
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)		*kWh*
Cost related to previous query		*€*

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0.16-0.20	*W/m^2K*
	Roof (Ur)	0.20	*W/m^2K*
	Basement (Ub)	0.23	*W/m^2K*
	Windows (Uw)	1.3	*W/m^2K*
		Uf	*W/m^2K*
		g	

TECHNICAL SYSTEM		
Heating generation system	Reversible ground source heat pump (GSHP) - 105,90 kW	
Energy carrier for heating	Ground source	
Heating distribution system	Floor heating	
Domestic hot water DHW preparation	n.a.	
Energy carrier for DHW	n.a.	
Cooling generation system	Chiller power - Reversible ground source heat pump (GSHP) - 50,70 kW	
Energy carrier for cooling	Ground source	
Electric generation	Polycrystalline silicon panels - Peak power 19.80 kW – Collecting area 115.3 m^2	
Mechanical Ventilation System	Controlled mechanical ventilation	
Energy Carrier for Mechanical Ventilation System	n.a.	
CONSTRUCTION TESTS		
Blower door test	no	*h^{-1}*
Thermography	no	

5. nZEB Case Study – AT - Primary school “Viktor Kaplan”

Enlargement, Graz, Austria

AFTER RENOVATION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GENERAL INFORMATION	
Use of the building	Educational
Owner	GBG – Gebäude und Baumanagement Graz GmbH
Built in (year)	2016
Renovated in (year)	/
Design team	Hohensinn Architektur ZT GmbH
Building is under protection as cultural heritage	no
GPS	47°06'10.0"N 15°25'20.1"E
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3514
CDD 26 (www.degreedays.net)	n/a
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes
Energy Performance Classification	B
RENOVATION COSTS	
Costs of renovation (€)	€ 2 Mio (net) incl. furniture
Costs per m² GFA (€/m²)	€ 1.440

The case study describes an enlargement of an existing primary school in Graz, Austria. The goal was to create a “wooden school”. It’s just constructed in wood from regional production. The bearing structure is an optimized mixture of BBS walls and slabs, ribbed slabs and a wooden frame façade. The classrooms can be enlarged by opening the sliding doors. These learning landscapes allows pupils to use the available areas fully. Additionally, the all-day school offers several leisure opportunities. The terrace on the ground floor is directly connected with sport grounds. The lightning in the building is based on energy efficient LEDs.

The school enlargement was built in 13 months from fall 2015 to September 2016.

The nZEB requirement of Austria in 2016 (primary energy demand <210 kWh) is fulfilled.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	1.391	*m2*
Heated net floor area (NFA)	1.196	*m2*
Heated gross volume	5.003,3	*m3*
Heated net volume	4.182,5	*m3*
S/V	0,46	
Heating demand	28,55	*kWh/m2year*
Cooling demand	35,73	*kWh/m2year*
Final energy (heating, cooling and electricity)	94,83	*kWh/m2year*
Primary energy (heating, cooling and electricity)	138,3	*kWh/m2year*
RES	-	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on one-year analysis)	43.710	*kWh*
Cost related to previous query	3.507,58	€
Average consumption of electrical energy- lightning - ventilation (based on one-year analysis)	21.837,68	*kWh*
Cost related to previous query	3.432,89	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,15	*W/m2K*
	Roof (Ur)	0,131	*W/m2K*
	Basement (Ub)	0,187	*W/m2K*
	Windows (Uw)	0,91 / SSG 0,84	*W/m2K*
		Uf 1,1	*W/m2K*
		Ug 0,6	*W/m2K*

TECHNICAL SYSTEM		
Heating generation system	Central district heating	
Energy carrier for heating	District heating city of Graz (6% renewable (2013)	
Heating distribution system	Floor heating	
Domestic hot water DHW preparation	Central district heating	
Energy carrier for DHW	District heating city of Graz (6% renewable (2013)	
Cooling generation system	-	
Energy carrier for cooling	-	
Electric generation	-	
Mechanical Ventilation System	yes - sanitary only	
Energy Carrier for Mechanical Ventilation System	n.a.	
CONSTRUCTION TESTS		
Blower door test	no	*h-1*
Thermography	no	

6. nZEB Case Study - AT - District court Bruck an der Mur

Refurbishment, Bruck an der Mur, Austria

AFTER RENOVATION

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GENERAL INFORMATION	
Use of the building	Office
Owner	Bundesimmobiliengesellschaft mbH, 1031 Wien
Built in (year)	1963-1965
Renovated in (year)	2012
Design team	pittino & ortner architekturbüro ZT Gesellschaft mbH
Building is under protection as cultural heritage	no
GPS	47°24'28.9"N 15°16'18.9"E
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3.710
CDD 26 (www.degreedays.net)	n/a
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes
Energy Performance Classification	A
RENOVATION COSTS	
Costs of renovation (€)	approx. € 4 Mio
Costs per m² GFA (€/m²)	1.540,6 €/m²

Integral planning approach with integration of high energy efficiency criteria in the planning process.

The metal façade elements contain so called solar combs made of cellulose as absorber for the solar radiation. The solar comb in combination with the glazing in front of it absorbs the sunlight (both direct solar radiation and diffuse radiation) and is integrated in a surrounding frame construction. The system can be integrated into all aluminum systems such as mullion-transom or element cladding systems of well-known manufacturers. Tipple-glazed-windows with glazing integrated blinds that are daylight controlled were used.

An insulated intermediate layer was applied directly to the existing façade (compensation for protrusions and recesses as well as unevenness of the existing façade). Then the prefabricated façade element with absorber and the window elements were mounted.

Ventilation system with high efficient heat recovery (85%).

Replacement of the old gas boiler by district heating with 100% biomass.

Bivalent brine-water heat pump with energy piles for pre-warming the ventilation air and for the cooling system.

Energy efficient lighting with presence detection and daylight-dependent regulation.

Promoted by BMvit programme „Haus der Zukunft plus“.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	2.614,06	*m^2*
Heated net floor area (NFA)	n/a	*m^2*
Heated gross volume	n/a	*m^3*
Heated net volume	8.655,54	*m^3*
S/V	0,33	
Heating demand	6,9	*kWh/m^2year*
Cooling demand	0,3	*kWh/m^2year*
Final energy (heating, cooling and electricity)	56,03	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	n/a	*kWh/m^2year*
RES	PV, District heating from 100% Biomass / geothermal energy	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	n/a	*kWh*
Cost related to previous query	n/a	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	n/a	*kWh*
Cost related to previous query	n/a	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,15	*W/m^2K*
	Roof (Ur)	0,2	*W/m^2K*
	Basement (Ub)	0,275	*W/m^2K*
	Windows (Uw)	1,16	*W/m^2K*
		Ug 0,7	*W/m^2K*
		Uf 1,6 / g 0,52	

TECHNICAL SYSTEM	
Heating generation system	District heating / bivalent brine-water heat pump
Energy carrier for heating	District heating (100% Biomass) /electricity /geothermal. energy
Heating distribution system	Ventilation system / radiators
Domestic hot water DHW preparation	Decentral - undercounter boiler
Energy carrier for DHW	Electricity
Cooling generation system	Bivalent brine-water heat pump
Energy carrier for cooling	Electricity /geothermal energy
Electric generation	PV (24,24 kWp, 26.800 kWh - measured first year)
Mechanical ventilation system	yes /centralized with high efficient heat recovery, pre-warming of air with bivalent brine-water heat pump
Energy Carrier for Mechanical Ventilation System	Electricity /geothermal energy

CONSTRUCTION TESTS		
Blower door test	n/a	*h^{-1}*
Thermography	n/a	

7. nZEB Case Study – AT – Residential building “Rathausgasse 38”

Refurbishment, Gleisdorf, Austria

BEFORE RENOVATION	AFTER RENOVATION
	

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GENERAL INFORMATION	
Use of the building	Residential
Owner	LIM Projektentwicklungs GmbH
Built in (year)	1883
Renovated in (year)	2015
Design team	Baumeister Leitner Planung & Bauaufsicht GmbH
Building is under protection as cultural heritage	no
GPS	47°06'10.1"N 15°42'54.1"E
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3852
CDD 26 (www.degreedays.net)	n/a
ENERGY PERFORMANCE	
Availability of energy performance certificate	*Energieausweis, klimaativ*
Energy Performance Classification	*A++, Klimaaktiv Gold*
RENOVATION COSTS	
Costs of renovation (€)	€ 7 Mio (net) incl. underground parking
Costs per m² GFA (€/m²)	€ 1.258

Renovation in passive house standard. Insulation of outer shell with multi-layer insulation system. Almost no thermal bridges in the truss. Three layers of insulation glass for windows and doors. Inside insulation partly open for diffusion. Usage of VIP vacuum insulation, foam glass ballast, low-temperature heat distribution system. Renewable insulation materials (cellulose

Reduction of motorized private transport with reduced parking space prescription (1:1 instead of 2:1). Carsharing with e-mobility is tested for one year to reduce the need of a second car per flat. High performance charging infrastructure for 2 e-cars.

Heating operation influenced by weather forecasting for optimization. “Energy eye” collects all the consumption and conditions in flats. LED in public areas. DHW with decentral long-distance boilers. Controlled domestic ventilation system with heat recovery for best air quality.

Tablet in each flat that inform about improvements regarding the energy consumption and quality. Can also be used to communicate with the property management and book carsharing.

Usage of 100% renewable energy by using bio district heating. PV contracting with 90kWp on roof area.

Promotion of the federal state 4.750.000 € (divided into 15 years). Promotion of state 70.000€ (smart city demonstration project)

The nZEB requirement in Austria (2014) with primary energy demand <230 kWh for deep renovation of residential buildings was fulfilled.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	5.564	*m^2*
Heated net floor area (NFA)	3.620	*m^2*
Heated gross volume	19162,73	*m^3*
Heated net volume	n/a	*m^3*
S/V	0,39	
Heating demand	9,71	*kWh/m^2year*
Cooling demand	-	*kWh/m^2year*
Final energy (heating, cooling and electricity)	46,81	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	99,3	*kWh/m^2year*
RES	PV, 100% renewable district heating	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on two-year analysis) (5% of tenants set higher room temperature)	266,5	*kWh*
Cost related to previous query	n/a	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	n/a	*kWh*
Cost related to previous query	n/a	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,12	*W/m^2K*
	Roof (Ur)	0,11	*W/m^2K*
	Basement (Ub)	0,1	*W/m^2K*
	Windows (Uw)	0,8	*W/m^2K*
		Uf 1,045	*W/m^2K*
		G 0,51	

TECHNICAL SYSTEM		
Heating generation system	District heating	
Energy carrier for heating	District heating 100% renewable	
Heating distribution system	Floor heating	
Domestic hot water DHW preparation	District heating	
Energy carrier for DHW	District heating 100% renewable	
Cooling generation system	no	
Energy carrier for cooling	-	
Electric generation	yes, PV	
Mechanical ventilation system	yes, 3 centralized units	
Energy Carrier for Mechanical Ventilation System		
CONSTRUCTION TESTS		
Blower door test	0,4	*h^{-1}*
Thermography	yes	

8. nZEB Case Study – AT – "Mineroom Leoben" student home

New building, Leoben, Austria

AFTER COMPLETION

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GENERAL INFORMATION	
Use of the building	Residential
Owner	Gem. Wohn- u. Siedlungsgenossenschaft ennstal
Built in (year)	2016
Renovated in (year)	/
Design team	aap.architekten
Building is under protection as cultural heritage	no
GPS	47°22'09.7"N 15°05'31.4"E
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	4.092
CDD 26 (www.degreedays.net)	n/a
ENERGY PERFORMANCE	
Availability of energy performance certificate	Passive house certification (PHI,) Klimaaktiv
Energy Performance Classification	Passive house plus Klimaaktiv Gold
RENOVATION COSTS	
Costs of renovation (€)	€ 14.000.000 (building costs)
Costs per m² GFA (€/m²)	€ 1.936

A student home for 201 people. 103 single apartments, 12 double and 86 single in shared apartments. Wooden construction except 2 staircases, basement and entrance area in concrete. 1900 m^3 of wood used on 5 floors. Prefabricated external wall elements in wooden frame construction with mineral wool insulation – basically non-load-bearing façade. Horizontal reinforcement by KLH solid wood board wands in combination with KLH ceilings. Just 11-month construction period. Passive house plus standard (PHI Darmstadt).

Green walls on south façade. 620 m^2 PV (388 modules) with 116,7 kW_p deliver 110.000 kWh electrical energy. No battery storage but ducts to be prepared to add one day. LED lightning in the whole building.

Built without housing subsidy. PV system was promoted. Operator of the student home OeAD-WV invested € 1 Mio.

The nZEB requirement in Austria (2016) with primary energy demand <180 kWh for residential buildings was fulfilled.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	7.231,43	*m2*
Heated net floor area (NFA)	5.785,14	*m2*
Heated gross volume	25.303,26	*m3*
Heated net volume	n/a	*m3*
S/V	0,3	
Heating demand	17,6 (PHPP)	*kWh/m2year*
Cooling demand	-	*kWh/m2year*
Final energy (heating, cooling and electricity)	51,57	*kWh/m2year*
Primary energy (heating, cooling and electricity)	102,1	*kWh/m2year*
RES	PV	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	n/a	*kWh*
Cost related to previous query	n/a	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	n/a	*kWh*
Cost related to previous query	n/a	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,13	*W/m2K*
	Roof (Ur)	0,06	*W/m2K*
	Basement (Ub)	0,11	*W/m2K*
	Windows (Uw)	0,75	*W/m2K*
		Uf 0,9	*W/m2K*
		g 0,51	

TECHNICAL SYSTEM		
Heating generation system	District heating transmission station (100% industrial waste heat)	
Energy carrier for heating	District heating (100% industrial waste heat)	
Heating distribution system	Floor heating	
Domestic hot water DHW preparation	District heating transmission station (100% industrial waste heat)	
Energy carrier for DHW	District heating	
Cooling generation system	-	
Energy carrier for cooling	-	
Electric generation	PV	
Mechanical Ventilation System	yes, with heat recovery	
Energy Carrier for Mechanical Ventilation System	n.a.	
CONSTRUCTION TESTS		
Blower door test	0,27	*h-1*
Thermography	n/a	

9. nZEB Case Study - HU - Ferenc Móra Grade School

Refurbishment, Budapest, Hungary

BEFORE RENOVATION	AFTER RENOVATION

Source: Municipality of Capital City of Budapest District XIV / Zugló

GENERAL INFORMATION	
Use of the building	Educational
Owner	Municipality of Zugló, Budapest, Hungary
Built in (year)	1972
Renovated in (year)	2017
Design team	na
Building is under protection as cultural heritage	no
GPS	N 47.512417 E 19.1424169
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3438
CDD 26 (www.degreedays.net)	78
ENERGY PERFORMANCE	
Availability of energy performance certificate	
Energy Performance Classification	BB
RENOVATION COSTS	
Costs of renovation (€)	1 056 725,7EUR
Costs per m² NFA (€/m²)	98 €/m2

The Municipality of Zugló (Hungary), has applied funding at the Norwegian/ EEA Grants, which they won in 2016. They prepared a feasibility study to support their proposal.

The school is located in Budapest (Hungary) in the 14th district. It is made of prefabricated reinforced concrete panels, flat roofs. The main energy consumption of central heating, DHW production and the ventilation is based on district heating. The system was originally equipped with a central regulator, regulating heat dissipation was only with manual shutdowns. The kitchen and the dining room had a balanced ventilation system in the building. The high energy demand of the ventilation system was mainly due to the fact that, the supply air was produced without heat recovery. Lighting and the building's electrical network were upgraded in 2006. The luminaires are fluorescent systems controlled in groups with a light switch. The heat supply took place according to the heating schedule set by the service provider (adapted to the needs of the school).

The building facade and flat roof had been insulated. The doors and windows of the institution were outdated and could not serve their function. Their full replacement had been implemented. During the modernization, the central controllability of the heating system circuits, and the control of the heat dissipater were solved so that the system can follow the reduced heating needs due to lower heat demand.

A compact heat recovery air handling unit was also installed. A 32.34 kW solar power system connected to a network was installed on the building's flat roof. In addition, a complex energy management system had been developed, which provides adequate control and controls the defined intervention points while storing the measured energy operating parameters.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	na	*m^2*
Heated net floor area (NFA)	10 802	*m^2*
Heated gross volume	na	*m^3*
Heated net volume	20102	*m^3*
S/V	0,537	
Heating demand	30,16	*kWh/m^2year*
Cooling demand	none	*kWh/m^2year*
Final energy (heating, cooling and electricity)	43,16	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	63,25	*kWh/m^2year*
RES	PV	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	na/ 1 081,872 GJ/y estimated data	*kWh*
Cost related to previous query/ savings	na/34 334 EUR/y estimated data	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	na/ 25 929,46 kWh/y estimated data	*kWh*
Cost related to previous query	na/3 725 EUR/y estimated data	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,26;0,23;0,20	*W/m^2K*
	Roof (Ur)	0,18	*W/m^2K*
	Basement (Ub)/ Floor slab	1,39	*W/m^2K*
	Windows (Uw)	1,1;1,8	*W/m^2K*
		Uf na	*W/m^2K*
		G na	

TECHNICAL SYSTEM	
Heating generation system	District heating
Energy carrier for heating	Gas, coal, oil
Heating distribution system	
Domestic hot water DHW preparation	District heating
Energy carrier for DHW	
Cooling generation system	na
Energy carrier for cooling	
Electric generation	yes - 32,34 kWp PV
Mechanical Ventilation System	no
Energy Carrier for Mechanical Ventilation System	n.a.

CONSTRUCTION TESTS		
Blower door test	none	*h^{-1}*
Thermography	no	

10. nZEB Case Study – HU – Mesevonat nursery school

Refurbishment - expansion, Budapest, Hungary

BEFORE RENOVATION	AFTER RENOVATION
	

Source: Municipality of Capital City of Budapest District XIII

GENERAL INFORMATION	
Use of the building	Educational
Owner	Municipality of Capital City of Budapest District XIII.
Built in (year)	1980
Renovated in (year)	2015-2016
Design team	Archikon Kft. Pólus Károly, Nagy Csaba
Building is under protection as cultural heritage	no
GPS	N 47°31.189' E 19°03.819'
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	2781
CDD 26 (www.degreedays.net)	137
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes; Darmstadt Passivhaus Institut
Energy Performance Classification	A+
RENOVATION COSTS	
Renovation Costs	3 082 543€
Costs per m² GFA (€/m²)	820 €/m2

During the renovation the designers planned keep low the building volume and the cooling surface ratio as low as possible. The proportion of facade glass surfaces does not exceed 40%. The windows are triple glazed and made of heat-soundproofed, hermetically sealed security glass. There is 25 cm insulation on the façade and 35-40 cm on the roof and on the floor.

The essence of the optimum building orientation is that, the group rooms, should be oriented to the south. The central lockers, the walkers, also receive direct natural light through the skylights.

The building was provided with heat-retardant ventilation. With constant air exchange, recovering 70-90 % of the heat energy of the extracted air can provide the energetic parameters needed to obtain the "passive house" rating. Air supply is provided in rooms where clean air is needed (group rooms, gym stalls, offices, etc.), air extraction takes place only in rooms with contaminated air (kitchen, washbasins). The incoming air enters the building through a fine filter, which by filtering the bulk of the dust and the pollens allows for a cleaner air than if the ventilation was done through the window. The system also saves nearly 20 times as much energy as it needs to operate.

The requirements for usable electricity are met by energy-saving machines and energy-saving LED lamps with light and motion sensors.

The electric sunshade helps keep the constant temperature in the building during the summer.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	3757,43	*m^2*
Heated net floor area (NFA)	3005,94	*m^2*
Heated gross volume	11272,29	*m^3*
Heated net volume	9017,83	*m^3*
S/V	na	
Heating demand	2,11	*kWh/m^2year*
Cooling demand	1,97	*kWh/m^2year*
Final energy (heating, cooling and electricity)	58,53	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	58,53	*kWh/m^2year*
RES		
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	115 278	*kWh*
Cost related to previous query/savings	15 752	
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	87 401	*kWh*
Cost related to previous query	7 466	

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,12	*W/m^2K*
	Roof (Ur)	0,13	*W/m^2K*
	Basement (Ub)/ Floor slab	0,1	*W/m^2K*
	Windows (Uw)		*W/m^2K*
		Uf 0,79	*W/m^2K*
		g 0,47	

TECHNICAL SYSTEM	
Heating generation system	District heating
Energy carrier for heating	Gas, coal, oil
Heating distribution system	
Domestic hot water DHW preparation	District heating
Energy carrier for DHW	Gas, coal, oil
Cooling generation system	no
Energy carrier for cooling	no
Electric generation	yes
Mechanical Ventilation System	Heat pump
Energy Carrier for Mechanical Ventilation System	Electricity
CONSTRUCTION TESTS	
Blower door test	0,4 *h^{-1}*
Thermography	no

11. nZEB Case Study – HU – Galamb József Secondary School

Refurbishment, Makó, Hungary

BEFORE RENOVATION	AFTER RENOVATION
	

GENERAL INFORMATION	
Use of the building	Educational
Owner	Municipality of Makó, Hungary
Built in (year)	1928
Renovated in (year)	2016
Design team	na
Building is under protection as cultural heritage	yes
GPS	N 46°13.002' E 20°28.273'
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3286
CDD 26 (www.degreedays.net)	105
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes/na
Energy Performance Classification	AA++
RENOVATION COSTS	
Costs of renovation (€)	798 626 € (supported by EEA Funds)
Costs per m² NFA (€/m²)	120 €/m2

The Municipality of Makó (Hungary), has applied funding at the Norwegian/ EEA Grants, which they won in 2016.

They prepared a feasibility study to support their proposal.

The technical details of the development:

The main building of the school was built in 1928. It is under protection. The building had a complex refurbishment including wall insulation, attic insulation, and window change. The building is connected to the geothermal system of the nearby swimming pool a heat provision is set up based on a renewable energy sources which leads to a reduction of the CO2 emission.

With the measurements a total of 2858GJ is saving can be achieved a year.

A 52 kWp solar power system connected to a network was installed on the building's roof.

The finished works had been handed over in 2017. They have reached AA++ efficiency category, which meets the nZEB requirement with the RES built in.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	na	*m^2*
Heated net floor area (NFA)	6658	*m^2*
Heated gross volume	na	*m^3*
Heated net volume	14 173	*m^3*
S/V	0,47	
Heating demand	54,02	*kWh/m^2year*
Cooling demand	0	*kWh/m^2year*
Final energy (heating, cooling and electricity)	67,02	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	4,28	*kWh/m^2year*
RES	52 kWp PV	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	na/ 268 580kWh/y estimated data	*kWh*
Cost related to previous query	na	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	na/ 7 610 kWh/y estimated data	*kWh*
Cost related to previous query	*na*	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,294; 0,279; 0,269	*W/m^2K*
	Roof (Ur)/ Ceiling (Uc)	0,203/ 0,15	*W/m^2K*
	Floor (Uf)	1,19; 1,10	*W/m^2K*
	Windows (Uw)	1,1; 1,0	*W/m^2K*
		Uf na	*W/m^2K*
		g 0,6	

TECHNICAL SYSTEM	
Heating generation system	Heat Pump - geothermal DH
Energy carrier for heating	Geothermal heat
Heating distribution system	
Domestic hot water DHW preparation	Electric heating cartridge
Energy carrier for DHW	Electricity
Cooling generation system	no
Energy carrier for cooling	-
Electric generation	PV
Mechanical Ventilation System	no
Energy Carrier for Mechanical Ventilation System	na

CONSTRUCTION TESTS		
Blower door test	na	*h^{-1}*
Thermography	no	

12. nZEB Case Study – HU – “Dragon Spa”

Refurbishment, Nyírbátor, Hungary

GENERAL INFORMATION	
Use of the building	Swimming pool, spa
Owner	Municipality of Nyírbátor, Hungary
Built in (year)	2009
Renovated in (year)	2016
Design team	na
Building is under protection as cultural heritage	no
GPS	N 47°50.937' E 22°06.715'
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	3497
CDD 26 (www.degreedays.net)	72
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes/na
Energy Performance Classification	BB
RENOVATION COSTS	
Costs of renovation (€)	442 000 €
Costs per m^2 NFA (€/m^2)	84 €/m2

The Municipality of Nyírlugos (Hungary), has applied funding, which they won in 2014. They prepared a feasibility study to support their proposal.

The swimming pool is located in Nyírbátor (Hungary). It was built in 2009. It is made of block walls, flat roofs. The main energy consumption of central heating, DHW production was partly based on gas boiler and geothermal waste heat recovery. The ventilation was based on gas boiler and was equipped with heat recovery devices. The building structures were in good condition, there was no need to refurbish them.

The project includes local renewable energy utilization. The project aims at utilizing heat generated from indirect geothermal energy to provide environmentally friendly and energy-efficient heat energy supplies. The aim of the investment is to enable the project developer to fully exploit the local geothermal potential, coupled with the ventilation system of the spa, to fully cover the heat demand that was based on natural gas energy. Throughout the project, the utilization of waste heat from 2280 GJ/year of thermal water, primarily by saving the amount of natural gas used, reduces greenhouse gas emissions, which significantly reduces the environmental load.

During the renovation, water-water heat pumps were installed to cover the existing air handling system heating system over the entire heating period, with the introduction of renewable energy. The units are capable of delivering 85kW and 98kW power at a temperature of ~15°C. Air handling units are connected to the new heat pump system. A 39 kWp solar power system connected to a network was installed on the building's flat roof. The finished works had been handed over in 2016. They have reached BB efficiency category, which meets the nZEB requirement with the RES built in.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	na	*m^2*
Heated net floor area (NFA)	5234,7	*m^2*
Heated gross volume	na	*m^3*
Heated net volume	10521,7	*m^3*
S/V	0,498	
Heating demand	315,48	*kWh/m^2year*
Cooling demand	0	*kWh/m^2year*
Final energy (heating, cooling and electricity)	352,48	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	255,71	*kWh/m^2year*
RES	49 kWp PV	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	na/154 410kWh/y estimated data	*kWh*
Cost related to previous query	na	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	na/236 900 kWh/y estimated data	*kWh*
Cost related to previous query	na	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	$U_{wall\ average}$ 0,32 (0,22; 0,32; 0,39; 0,35; 0,33; 0,34; 0,30)	*W/m^2K*
	Roof (Ur)	$U_{roof\ average}$ 0.20 (0,24; 0,25; 0,23; 0,1; 0,18)	*W/m^2K*
	Basement (Ub)/ Floor (Uf)	$U_{basement\ average}$ 0.40 (0,33; 0,44 / 1,01; 0,42; 0,48; 0,40; 0,31)	*W/m^2K*
	Windows (Uw)	$U_{w\ average}$ 1.25 (1,1; 1,4)	*W/m^2K*
		Uf na	*W/m^2K*
		g 0,6	

TECHNICAL SYSTEM	
Heating generation system	Geothermal waste heat recovery by heat pump, condensing boiler
Energy carrier for heating	Geothermal waste heat, gas
Heating distribution system	
Domestic hot water DHW preparation	Condensing boiler
Energy carrier for DHW	Gas
Cooling generation system	na
Energy carrier for cooling	
Electric generation	PV
Mechanical Ventilation System	yes
Energy Carrier for Mechanical Ventilation System	na

CONSTRUCTION TESTS		
Blower door test	na	*h^{-1}*
Thermography	no	

13. nZEB Case Study – HR - Energy Center Bračak

Refurbishment, City of Zabok, Croatia

BEFORE RENOVATION	AFTER RENOVATION
	

GENERAL INFORMATION	
Use of the building	Office
Owner	Krapina-Zagorje County
Built in (year)	1889
Renovated in (year)	2017
Design team	architects, engineers, building enterprise, energy agency
Building is under protection as cultural heritage	yes
GPS	46.017068, 15.937554
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	2939,5
CDD 26 (www.degreedays.net)	-
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes - HEDOM d.o.o.
Energy Performance Classification	B – educational centre, basement (Z1) C - hotel & restaurant, ground floor (Z2) B – office, floor/ attic/staircase (Z3)
RENOVATION COSTS	
Costs of renovation (€)	3,19 m EUR
Costs per m² GFA (€/m²)	2000 €/m2

The reconstruction and revitalization of Bračak Manor is a unique example of energy renovation of a historic building under cultural heritage protection focusing on two aspects – application of advanced technical solutions and retrofitting of a public building.

During history the Manor has changed its purpose twice, starting off as an aristocratic summer house in late 1800s and turning into a hospital after WWII. When in 2007 the hospital relocated the old Manor was emptied and in need of a revitalization.

A collaboration between the estate owner, Krapina-Zagorje County, and North-west Croatia Regional Energy Agency – REGEA led to the conceptualization of Bračak Energy Centre, a regional hub of excellence and knowledge in energy efficiency and renewable energy sources hosting a business incubator for promising start-up companies in the field of energy, a multi-purpose education and demonstration centre and offices of the regional development agency ZARA and the regional energy agency REGEA.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	208,00 (Z1) + 305,86 (Z2) + 1006,00 (Z3)	*m2*
Heated net floor area (NFA)	131,10 (Z1) + 226,97 (Z2) + 725,81 (Z3)	*m2*
Heated gross volume	753,00 (Z1) + 1006,00 (Z2) + 3715,00 (Z3)	*m3*
Heated net volume	572,28 (Z1) + 764,56 (Z2) + 2972,00 (Z3)	*m3*
S/V	0,65 (Z1) / 0,38 (Z2) / 0,38 (Z3)	
Heating demand	60,62 (Z1) / 79,49 (Z2) / 47,80 (Z3)	*kWh/m2year*
Cooling demand	12,67 (Z1) / 21,43 (Z2) / 21,87 (Z3)	*kWh/m2year*
Final energy (heating, cooling and electricity)	59,73 (Z1) / 77,16 (Z2) / 51,87 (Z3)	*kWh/m2year*
Primary energy (heating, cooling and electricity)	14,92 (Z1) / 18,65 (Z2) / 15,58 (Z3)	*kWh/m2year*
RES	Biomass	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,24 (0,26)	*W/m2K*
	Roof (Ur)	0,11	*W/m2K*
	Basement (Ub)	0,22	*W/m2K*
	Windows (Uw)	1,40	*W/m2K*
		Uf	*W/m2K*
		g	
TECHNICAL SYSTEM			
Heating generation system		Central heating boiler, VRV heat pump	
Energy carrier for heating		Pellets, electrical energy	
Heating distribution system			
Domestic hot water DHW preparation		Central heating boiler, micro cogeneration on natural gas	
Energy carrier for DHW		Pellets, natural gas	
Cooling generation system		VRV heat pump	
Energy carrier for cooling		Electrical energy	
Electric generation		Micro cogeneration on natural gas (6 kW of electrical power)	
Mechanical Ventilation System		Centralised with recuperation	
Energy Carrier for Mechanical Ventilation System		Electricity	
CONSTRUCTION TESTS			
Blower door test		2,35 (Z3)	*h-1*
Thermography		yes	

14. nZEB Case Study – HR - Primary school Hum Stubički

Refurbishment, Hum Stubički, Croatia

BEFORE RENOVATION	AFTER RENOVATION
	

GENERAL INFORMATION	
Use of the building	Educational
Owner	Krapina-Zagorje County
Built in (year)	1950
Renovated in (year)	2011
Design team	architects, engineers, building enterprise, energy agency
Building is under protection as cultural heritage	no
GPS	45.9762, 16.0421
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	2939,5
CDD 26 (www.degreedays.net)	-
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes - REGEA
Energy Performance Classification	B
RENOVATION COSTS	
Costs of renovation (€)	115.357 EUR
Costs per m² GFA (€/m²)	382 €/m2

Hum Stubički primary school is a public building owned by Krapina-Zagorje County. Refitted under the project Reconstruction of Krapina-Zagorje County schools, financed by the European Community and the European Investment Bank.

The main goal of reconstruction was decreasing the energy consumption for minimum amount of 30%. In addition an increased energy performance of the school contributes to lower the energy bills, the operation costs and the thermal comfort and the well-being of the building occupants as well.

The reconstruction of the building has been performed in 2012 whilst North-West Croatia Regional Energy Agency was very active during the whole process by preparing the documentation, communicating the process between the County and builders, monitoring energy/financial savings before and after reconstruction.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	302,44	*m_2*
Heated net floor area (NFA)	271,08	*m_2*
Heated gross volume	1329,15	*m_3*
Heated net volume	1100,00	*m_3*
S/V	0,73	
Heating demand	48,59	*kWh/$m_2$year*
Cooling demand	8,63	*kWh/$m_2$year*
Final energy (heating, cooling and electricity)	105,77	*kWh/$m_2$year*
Primary energy (heating, cooling and electricity)	169,71	*kWh/$m_2$year*
RES	geothermal energy	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	6127	*kWh*
Cost related to previous query	69,00	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	1272	*kWh*
Cost related to previous query	968,00	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,29	*W/m_2K*
	Roof (Ur)	0,18	*W/m_2K*
	Basement (Ub)	2,67	*W/m_2K*
	Windows (Uw)	1,34	*W/m_2K*
		Uf	*W/m_2K*
		g	

TECHNICAL SYSTEM		
Heating generation system	Central system (heat pump)	
Energy carrier for heating	Geothermal energy, electricity	
Heating distribution system	-	
Domestic hot water DHW preparation	Central	
Energy carrier for DHW	Geothermal energy, electricity	
Cooling generation system	n.a.	
Energy carrier for cooling	n.a.	
Electric generation	no	
Mechanical Ventilation System	n.a.	
Energy Carrier for Mechanical Ventilation System	n.a.	
CONSTRUCTION TESTS		
Blower door test	-	*h_{-1}*
Thermography	no	

15. nZEB Case Study – HR - Kindergarten Pokupsko

Refurbishing, Pokupsko, Croatia

BEFORE RENOVATION	AFTER RENOVATION
	

GENERAL INFORMATION	
Use of the building	Educational
Owner	Municipality of Pokupsko
Built in (year)	1965
Renovated in (year)	2008
Design team	architects, engineers, building enterprise, energy agency
Building is under protection as cultural heritage	no
GPS	45.4847403, 15.991792
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	2939,5
CDD 26 (www.degreedays.net)	-
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes - REGEA
Energy Performance Classification	C
RENOVATION COSTS	
Costs of renovation (€)	100.681 EUR
Costs per m² GFA (€/m²)	290 €/m2

Pokupsko Kindergarten is a public building owned by Municipality of Pokupsko, situated in Zagreb County (north-west Croatia). Building has been retrofitted under the Demonstrative geothermal heat pump applications for public buildings project, co-financed by Energy Efficiency and Environmental Protection Fund and Zagreb County.

The main goal was demonstrative usage of geothermal heat pump for heating, cooling and hot water preparation. In addition, an increased energy performance of the building contributes to lower energy bills and operational costs and raise of thermal comfort and well-being of children as building occupants.

The reconstruction of the original building has been performed in 2009 whilst North-West Croatia Regional Energy Agency participated as project partner in a process of preparation of project documentation, reconstruction works and monitoring energy/financial consumption before and after reconstruction.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	350,00	*m^2*
Heated net floor area (NFA)	265,00	*m^2*
Heated gross volume	929,14	*m^3*
Heated net volume	900,00	*m^3*
S/V	0,67	
Heating demand	47,86	*kWh/m^2year*
Cooling demand	13,06	*kWh/m^2year*
Final energy (heating, cooling and electricity)	70	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	210	*kWh/m^2year*
RES	geothermal heat pump	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	1923	*kWh*
Cost related to previous query	2.200,00	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,44	*W/m^2K*
	Roof (Ur)	0,22	*W/m^2K*
	Basement (Ub)	0,62	*W/m^2K*
	Windows (Uw)	1,80	*W/m^2K*
		Uf	*W/m^2K*
		g	

TECHNICAL SYSTEM		
Heating generation system	Central system (heat pump)	
Energy carrier for heating	Geothermal energy, electricity	
Heating distribution system		
Domestic hot water DHW preparation	Central system (heat pump)	
Energy carrier for DHW	Geothermal energy, electricity	
Cooling generation system	Central system (heat pump)	
Energy carrier for cooling	Geothermal energy, electricity	
Electric generation	no	
Mechanical Ventilation System	Heat pump	
Energy Carrier for Mechanical Ventilation System	Geothermal energy, electricity	
CONSTRUCTION TESTS		
Blower door test	-	*h^{-1}*
Thermography	no	

16. nZEB Case Study - HR - Kindergarten Radost

New building, Desinec, City of Jastrebarsko, Croatia

BEFORE RENOVATION	AFTER RENOVATION
	

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GENERAL INFORMATION	
Use of the building	Educational
Owner	City of Jastrebarsko
Built in (year)	2014
Renovated in (year)	-
Design team	architects, engineers, building enterprise, energy agency
Building is under protection as cultural heritage	no
GPS	45.6670667, 15.65048
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	2939,5
CDD 26 (www.degreedays.net)	-
ENERGY PERFORMANCE	
Availability of energy performance certificate	Project of rational use of energy
Energy Performance Classification	B
RENOVATION COSTS	
Costs of renovation (€)	1,61 m EUR
Costs per m² GFA (€/m²)	1836 €/m2

The new kindergarten building is located in Gornji Desinec, a small settlement (552 inhabitants) which administratively is a part of the City of Jastrebarsko (15 866 inhabitants). The settlement had no previous kindergarten or nursery school and the steady growth of population resulted in need for introduction of educational pre-school programme. This building was chosen for the pilot project as part of the Sustainco project.

The City of Jastrebarsko wanted to explore possibilities of implementing nZEB principles during the construction of the new kindergarten building and REGEA, as the lead consultant, had the task to propose technical solutions that would follow specific requirements and goals.

The passive design of the building is based on efficient building materials and building orientation that lets in light and passive solar gains, as well as reducing glare and overheating to the building interior. With the application of energy efficiency measures and installation of a biomass boiler the building is considered a nearly zero energy building since all consumed energy is roughly equal to the amount of renewable energy created on the site.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	877,00	*m^2*
Heated net floor area (NFA)	822,40	*m^2*
Heated gross volume	4269,30	*m^3*
Heated net volume	4000,00	*m^3*
S/V	0,62	
Heating demand	7,69	*kWh/m^2year*
Cooling demand	2,28	*kWh/m^2year*
Final energy (heating, cooling and electricity)	51.79 (only heating and cooling)	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	24.05 (only heating and cooling)	*kWh/m^2year*
RES	biomass	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	*€*
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	*€*

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,18	*W/m^2K*
	Roof (Ur)	0,13	*W/m^2K*
	Basement (Ub)	-	*W/m^2K*
	Windows (Uw)	1,33	*W/m^2K*
		Uf	*W/m^2K*
		g	

TECHNICAL SYSTEM	
Heating generation system	Central heating boiler
Energy carrier for heating	Pellets
Heating distribution system	
Domestic hot water DHW preparation	Central heating boiler
Energy carrier for DHW	Pellets
Cooling generation system	n.a.
Energy carrier for cooling	n.a.
Electric generation	no
Mechanical Ventilation System	Present, with split
Energy Carrier for Mechanical Ventilation System	Electricity

CONSTRUCTION TESTS		
Blower door test	-	*h^{-1}*
Thermography	no	

17. nZEB Case Study - SI - Eko srebrna hiša

New building, Ljubljana, Slovenia

GENERAL INFORMATION	
Use of the building	Residential
Owner	
Built in (year)	2014
Renovated in (year)	-
Design team	Akropola d.o.o.
Building is under protection as cultural heritage	no
GPS	104133, 462709
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	
CDD 26 (www.degreedays.net)	
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes
Energy Performance Classification	A1
RENOVATION COSTS	
Costs of renovation (€)	32 million EURO
Costs per m² GFA (€/m²)	2489 €/m2

The concept and design of the Eco Silver House are adapted to the new Dunajska City Avenue as foreseen in the Spatial Plan of Ljubljana. Due to this, a high built is now possible by the Dunajska Street.

The Eco Silver House has been designed in two rays forming a shape of inverted letter »L«. The interior of the quarter resembles a park in which the residents can spend their leisure time. Green terraces are located on the Eastern side of the building. Residents have at their disposal all the services offered in the business part of the Eco Silver House, which are located on the ground floor and the mezzanine by Dunajska Street. Eco Silver House presents new standards of the energy-efficient apartment building. By using the renewable energy sources from its own solar power plant. The rainwater taken from the roof is stored in the water storage tanks on the roof. Eco Silver House ranks within the passive class, with a yearly heating energy consumption of less than 15 kWh/m2a. CO2 emissions are likely to be about two-thirds lower than the already existing similar buildings in Ljubljana.

According to the statutory Energy Performance Certificate, the Eco Silver House is classified with the highest energy class A1 with 8 kWh/m2a (Source: EI ZRMK, 2014). The construction concept of installation and cost-independent apartment units, good insolation and the possibility of individual management of living conditions, ensures that each apartment will function much like an independent passive house.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	12.859	*m2*
Heated net floor area (NFA)	11.565	*m2*
Heated gross volume	44.408	*m3*
Heated net volume	35.526	*m3*
S/V	0,26	
Heating demand	8	*kWh/m2year*
Cooling demand	unavailable	*kWh/m2year*
Final energy (heating, cooling and electricity)	48	*kWh/m2year*
Primary energy (heating, cooling and electricity)	54	*kWh/m2year*
RES	solar energy	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	*€*
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	*€*

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	< 0,2	*W/m2K*
	Roof (Ur)	< 0,2	*W/m2K*
	Basement (Ub)	< 0,35	*W/m2K*
	Windows	Uw =0,9	*W/m2K*
		Ug =0,7	*W/m2K*
		g	

TECHNICAL SYSTEM		
Heating generation system	District heating system	
Energy carrier for heating	District heating	
Heating distribution system	Integrated systems for automatic mode to ensure the comfort and pleasantness in the apartments	
Domestic hot water DHW preparation	Central boiler	
Energy carrier for DHW	-	
Cooling generation system	District heating	
Energy carrier for cooling	Electricity	
Electric generation	PV power plant	
Mechanical Ventilation System	Central ventilation system with heat recovery, with split system	
Energy Carrier for Mechanical Ventilation System	Electricity	
CONSTRUCTION TESTS		
Blower door test	0,2	*h^{-1}*
Thermography	no	

18. nZEB Case Study - SI - Vrtec Lavrica

New building, Škofljica, Slovenia

GENERAL INFORMATION	
Use of the building	Educational
Owner	Škofljica Municipality
Built in (year)	2012
Renovated in (year)	-
Design team	Arhitektura Branko Hojnik
Building is under protection as cultural heritage	no
GPS	
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	
CDD 26 (www.degreedays.net)	
ENERGY PERFORMANCE	
Availability of energy performance certificate	no
Energy Performance Classification	-
RENOVATION COSTS	
Costs of renovation (€)	2,3 million EURO
Costs per m^2 GFA (€/m^2)	1323 €/m_2

The kindergarten was built in 2012. The main energy related targets were to achieve low energy standard, to use renewable energy sources and to focus on indoor air quality. The owner and investor is the Municipality of Škofljica, Slovenia.

Škofljica Municipality has successfully applied in the public tender of the Ministry of Infrastructure and Spatial Planning, Operational Programme for the energetic renovation of public buildings co-financed from the EU Cohesion Fund. The heating demand of the kindergarten is 22KWh/m2 a GFA. In Slovenia the average heating demand of old kindergartens is over 200 kWh/m2a GFA.

The heat pump for Lavrica kindergarten operates until the outside temperature is 0 ° C. Below this temperature the kindergarten is heated by a gas condensing boiler using natural gas. The share of the heat produced by the heat pump is 60 %. The rest is provided by the gas boiler. The heating is a combination of floor heating and wall heating. The wall heating is used in summertime for cooling. The shading is constructed with outside blind and is driven electrically. The new facility has a rectangular ground plan articulating a slightly condensed form, with a small atrium at the entrance. The facade of the building is part of the final treated with silicate plaster, partially in vertical larch panelling, with which the facility is structurally and dimensionally adapted to the surrounding housing estate. The garden pavilion is rectangular in shape; the facade of the pavilion is fully lined with vertical larch panelling. Three-layer wooden windows are installed in the facility.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	1.738	*m2*
Heated net floor area (NFA)	unavailable	*m2*
Heated gross volume	8.111	*m3*
Heated net volume	6.083	*m3*
S/V	unavailable	
Heating demand	22	*kWh/m2year*
Cooling demand	-	*kWh/m2year*
Final energy (heating, cooling and electricity)	unavailable	*kWh/m2year*
Primary energy (heating, cooling and electricity)	< 55	*kWh/m2year*
RES	the heat of the environment (heat pump)	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	< 0,15	*W/m2K*
	Roof (Ur)	< 0,2	*W/m2K*
	Basement (Ub)	< 0,35	*W/m2K*
	Windows	Uw =0,9	*W/m2K*
		Ug =0,7	*W/m2K*
		-	

TECHNICAL SYSTEM		
Heating generation system	Heat pump, gas boiler, combination of floor and wall heating	
Energy carrier for heating	Electricity, natural gas	
Heating distribution system		
Domestic hot water DHW preparation	Heat pump	
Energy carrier for DHW	Electricity	
Cooling generation system	-	
Energy carrier for cooling	-	
Electric generation	yes	
Mechanical Ventilation System	no	
Energy Carrier for Mechanical Ventilation System		
CONSTRUCTION TESTS		
Blower door test	no	*h-1*
Thermography	no	

19. nZEB Case Study – SI - MIC Nova Gorica

New building, Nova Gorica, Slovenia

GENERAL INFORMATION	
Use of the building	Educational
Owner	Public Administration
Built in (year)	2014
Renovated in (year)	-
Design team	Mašera Mahnič arhitekti and Dulc, d.o.o.
Building is under protection as cultural heritage	no
GPS	
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	
CDD 26 (www.degreedays.net)	
ENERGY PERFORMANCE	
Availability of energy performance certificate	no
Energy Performance Classification	-
RENOVATION COSTS	
Costs of renovation (€)	3.414.350,57 EUR
Costs per m² GFA (€/m²)	595 €/m2

There are 136 solar collectors on the roof for the use of solar energy. The acquired heat in the solar collectors will be stored in a warm earth storage in the bases building. For the cooling of the building, shade from the environment (groundwater, free cooling) is used and, if necessary, it is additionally cooled by means of a heat pump in case of peak load. The cooling of the groundwater from the boreholes is exploited (two original bore holes about 40 meters and one sink).

The quantity of groundwater meets the needs of the facility. The Solinterra system will reduce the estimated (in IDP) energy consumption for heating, cooling and cooling ventilation of the building for at least 50-70%. It is expected that there will be a warm earth storage next year more effective.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	5.736,46	*m^2*
Heated net floor area (NFA)	5.076,06	*m^2*
Heated gross volume	19.922,40	*m^3*
Heated net volume	16.501,62	*m^3*
S/V	0,255	
Heating demand	20,48	*kWh/m^2year*
Cooling demand	16,75	*kWh/m^2year*
Final energy (heating, cooling and electricity)	7,71	*kWh/m^2year*
Primary energy (heating, cooling and electricity)	44,94	*kWh/m^2year*
RES	the heat of the environment	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	*€*
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	*€*

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	0,184 – 0,193	*W/m^2K*
	Roof (Ur)	0,105 – 0,12	*W/m^2K*
	Basement (Ub)	0,099 – 0,14	*W/m^2K*
	Windows (Uw)	0,99	*W/m^2K*
		(Ug=0,7; Uf=1,2)	*W/m^2K*
		-	

TECHNICAL SYSTEM		
Heating generation system	Solar collectors with ground heat storage, heat pump	
Energy carrier for heating	Electricity	
Heating distribution system		
Domestic hot water DHW preparation	Solar collectors	
Energy carrier for DHW	Solar energy - groundwater energy, electricity	
Cooling generation system	Heat pump	
Energy carrier for cooling	Groundwater energy (ground coolness)	
Electric generation	yes	
Mechanical Ventilation System	Centralised	
Energy Carrier for Mechanical Ventilation System	-	
CONSTRUCTION TESTS		
Blower door test	no	*h^{-1}*
Thermography	no	

20. nZEB Case Study – SI - Vrtec Storžek

New building, Preddvor, Slovenia

GENERAL INFORMATION	
Use of the building	Educational
Owner	Preddvor Municipality
Built in (year)	2012
Renovated in (year)	-
Design team	Renato Repše, udia
Building is under protection as cultural heritage	no
GPS	
CLIMATE DESCRIPTION	
HDD 20 (www.degreedays.net)	
CDD 26 (www.degreedays.net)	
ENERGY PERFORMANCE	
Availability of energy performance certificate	yes
Energy Performance Classification	-
RENOVATION COSTS	
Costs of renovation (€)	2,5 million EURO
Costs per m² GFA (€/m²)	1598 €/m2

The main energy related targets were passive house/plus house standard, use of prefabricated timber facades, installation of a central ventilation system and achieving excellent air tightness. To build the facility public funds were provided, part of which was under the ECO subsidy in accordance with the tender obtained from the Eco Fund (Slovenian Environmental Public Fund). The heating demand is 18 kWh/m2a GFA. The heating consists of 100 % thermal energy generated in a central boiler plant in the town Preddvor using biomass. Hot water is supplied to the facility by pipeline from the central boiler room-the district heating system. Electricity produced from PV modules mounted on the roof is emitted into the electricity grid and the PV modules installed power is 96 kW. To ensure EE a structural system of external walls (Jelovica Thermo Plus) was selected. The insulation of external walls, facade, ceiling and roof structure below the base plate was increased. 3-play cross laminated larch boards were installed on site, prefabricated walls and ceilings were made in the factory. The primary load-bearing wooden framework of the outer wall is built of 14 cm thermal insulation (rock wool), on the inner side is made even installation plane, wherein the built-in 6 cm of insulation on the outside is carried out in the two cross-layers built yet 2x 10cm rock wool. A total of 40cm-built insulation. On mounting rails of ventilated planes 3-layer larch plywood were stationed at the site. The kindergarten was built in 6 months. A central ventilation system with 85% heat recovery was installed in the building. Shading with outside blind is installed. The building has excellent air tightness (0,2), which almost 3-times better than the requirements for airtightness from side of the Eco Fund for passive standard.

The result in the Slovenian scale represents a remarkable achievement for such a large wooden structure. Only with integral planning and management of the construction of the facility could the kindergarten be built energy, functional and cost effective. Most of the potential changes that occurred during the construction phase and completion of the building was much more expensive than if they had been taken into account at the design stage of the building.

ENERGY PERFORMANCE DATA		
Heated gross floor area (GFA)	1.564	*m2*
Heated net floor area (NFA)	unavailable	*m2*
Heated gross volume	7.299	*m3*
Heated net volume	5.474	*m3*
S/V	unavailable	
Heating demand	18	*kWh/m2year*
Cooling demand	-	*kWh/m2year*
Final energy (heating, cooling and electricity)	unavailable	*kWh/m2year*
Primary energy (heating, cooling and electricity)	54	*kWh/m2year*
RES	Biomass, solar energy	
CONSUMPTION COST AFTER THE RENOVATION		
Average consumption of energy for heating (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	€
Average consumption of electrical energy- lightning - ventilation (based on three-year analysis)	-	*kWh*
Cost related to previous query	-	€

BUILDING SPECIFICATIONS

BUILDING ENVELOPE			
Thermal transmittance of	*Wall (Uw)*	< 0,2	*W/m2K*
	Roof (Ur)	< 0,2	*W/m2K*
	Basement (Ub)	< 0,35	*W/m2K*
	Windows	Uw =0,9	*W/m2K*
		Ug =0,7	*W/m2K*
		-	

TECHNICAL SYSTEM		
Heating generation system	District heating system	
Energy carrier for heating	Biomass	
Heating distribution system	-	
Domestic hot water DHW preparation	Central boiler	
Energy carrier for DHW	Biomass	
Cooling generation system	-	
Energy carrier for cooling	PV power plant	
Electric generation	Central ventilation system with 85 % heat recovery	
Mechanical Ventilation System	no	
Energy Carrier for Mechanical Ventilation System	-	
CONSTRUCTION TESTS		
Blower door test	0,2	h^{-1}
Thermography	no	