TECHNICAL REPORT ON NZEB PILOT ACTIONS

Deliverable D.T3.4.5

Final

12 2020

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 is part of workpackage T3, named D.T3.4.6 Technical report on nZEB pilot actions. The report provides a recapitulation of technical aspects of pilot actions which were conducted in three pilot counties: Croatia, Slovenia and Hungary. The following partners were responsible for development of this report:

- Croatia – City of Sveta Nedelja, Municipalities of Marija Bistrica and Stupnik (supported by REGEA)
- Slovenia – Municipality of Velenje (supported by KSSENA)
- Hungary – 18th District of Budapest (supported by Energiaklub)

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1. Introduction

eCentral pilot actions serve to test applicability of three innovative financing models: energy performance contracting, public-private partnership and crowdfunding on projects which require (re)construction of public buildings in accordance with the nearly zero energy standard. nZEB standard can be reached with different types of technologies and equipment and leaders of pilot actions were required to find cost optimal solutions for reaching this standard and to demonstrate its long term cost-effectiveness.

Due to the different types and stages/results of pilot actions the report covers technical data retrieved from three phases of their development:

1. Conceptual phase – feasibility study
2. Main project design
3. Monitoring and verification of (re)constructed building

Technical differences between these three project stages were recorded, including reasons for changes of equipment and development approaches. Since not all pilot actions have reached the third (final) stage of development, projections for further expected development was given. In cases where building has not reached an nZEB standard a proposition on additional technical interventions which are needed for it to become one were made.

2. Hungary

Construction of public nearly zero energy buildings with ESCO model was the pilot action which was tested in Hungary on three different locations: Vackor Kindergarten, Vilmos Endre Swimming Pool and Park Swimming Pool.
According to Directive 2010/31/EU, in Hungary minimum energy efficiency requirements should be set cost-optimally and in the case of the construction of new public buildings after 31 December 2018, after 31 December 2020 for all new buildings zero energy requirements with the public should be met.
Law No 39/2015 (IX.14) according to the amendment to Regulation MVM 7/2006 TNM, the permitted value of the aggregate energy characteristics are:

Building type	Eprim [kWh/m2a]
Residential buildings	100
Office/commercial buildings	90
Educational buildings/ auditoriums exhibition halls	85

Share of renewable energy: min. 25%
In the case of buildings for other purposes, the aggregate energy characteristic requirement value may be determined according to the guideline of the Regulation. The Annexes to the TNM Regulation also specify the requirements for delimitation and windowing structures and for the specific heat loss factor.
With regards to the fore mentioned regulation a number of different technical solutions have been analysed in order for these buildings to reach the nZEB status.

2.1. Renovation of Vackor kindergarten in 18th District of Budapest

2.1.1. Initial condition of the building

Short technical summary from the energy certificate/energy audit.

Vackor Kindergarten was built in 1978 – 1982 as a lightweight (DVM 12/8 system) building. Its main features are encompassing walls: PREMISOL external panels, inside partition walls are made of ALBAFAL partition panels. Roof: bitumen waterproofing flat roof. Slabs: wireframe + load bearing corrugated plate. The original windows and doors have metal frame with air closing, double glazing.

There is a separate building for the heating system / boiler room that supplies the kindergarten and that is located 10 m from the building. There is 1pcs 52 kW gas boiler (HOTERM 52 ECB and 1 pcs 116 kW HOTERM 116 ES gas boilers as cascade system, with specific dispense, two-tubed, traditional radiators heating system. HMV is created by a 1000L FUTOBER MVT 1000 gas fired hot water system, without circulation and with the usage of the same sewer utilities.

2.1.2. Conceptual phase

The building overall is classified low rank in terms of energy efficiency (II).

Vackor Kindergarten's energy consumption, costs and CO2 emission is high, so in term of energy efficiency the building is poor. Therefore, multiple renovation scenarios were explored. The main goal was to increase the energy efficiency performance of the building according to nZEB principles and improve the quality of the energy system by technically and/or operationally improving energy production.

In accordance with the preliminary assessment the following renovations were explored:

		Current status	„A" version	„B" version	„C" version	„D" version	„E" version
Renovations		-	- Thermal insulation of non-insulated walls with 20 cm EPS insulation - Replacement of metal doors and windows with triple glazed PVC doors/windows - Thermal insulation of the flat roof with 30 cm XPS thermal insulation				
			-	10 cm EPS additional thermal insulation of the walls already insulated			
				-	efficient condensing gas furnaces		
					-	installation of solar panels	
						-	wood gasification
Heat loss factor (q_{max}=0,280)	W/m3K	0,889	0,299	0,28	0,28	0,28	0,28
Aggregate energy indicator (E_{pmax}=85)	kWh/m2, a	395,14	229,91	225,16	165,71	94,409	82,082
Energy class	-	I I	G G	G G	E E	CC	B B
Renewable share	%	4,4	6,1	6,3	8,5	45,2	111,7
Gas consumption	MWh/a	216,11	105,46	102,27	62,24	62,24	34,29
	net Ft/a	2 769 148	1 351 323	1 310 447	797 519	797 519	439 379
Electricity consumpti on	MWh/a	19,41	19,41	19,41	19,5	0,4	0,39
	net Ft/a	271 099	271 099	271 099	272 357	5 587	5 447
Firewood consumption	MWh/a	0	0	0	0	0	32,86
	net Ft/a	0	0	0	0	0	250000
Total primary energy consumption	MWh/a	264,6	154	150,8	111	63,2	55
	net Ft/a	3 040 248	1 622 422	1 581 547	1 069 875	803 106	694 826
Total CO2 emission	t/a	50,96	28,49	27,85	19,75	12,78	7,1

Upon recommendation from the Project partners, a 'Modified D' version was created as well with the following renovations:

- wall insulation 10 and 20 cm EPS

- PVC insulated metal window replacement
- flat roof insulation XPS 30 cm
- 30 cm above the false ceiling blown insulation heat pump heating system + heat recovery ventilation
- 37.125 kWp solar installation

2.1.3. Conclusions and next steps

Version "Modified D" deals with the renewal of the building's energy efficiency, in addition to the architectural and mechanical energy modernization of the previous "C" version, which includes the installation of a sun panel sytem on an across roof. It is reduced by the building's CO2 emissions and the Total Energy Indicator, which in this case meets the requirements of nearly zero Energy requirements for certification under the 7/2006 TNM Regulation, but not yet in the case of real consumption data in case of a certification.

Based on a cost-benefit analysis, the simple payback of each of the nZEB technical renovation variants is more than 40 years. When paying a gross own share of ~ 191MFt, the return on an ESCOtype investment of ~ gr.120MFt turns positive after 15 years. The required own part can be covered from own resources, subsidized / energy efficiency loans, EU support schemes and special funds, interest-free construction of a green investment fund, depending on the possibilities of the municipality.

2.2. Renovation of Park swimming pool in the 18th District of Budapest

2.2.1. Initial condition of the building

The building of the Park Swimming Pool was built in the 1980s and its current energy efficiency grading is EE (better than average).

The total heated floor area of the building is 1163.9 m2. Heated air volume 5326m3. The total cooling area is 3034m2, of which 148m2 is a door and window, 50m2 is a skylight and ~ 700m2 is a polycarbonate roof with a hollow chamber. Regarding the building services systems, the heat demand for all heating and DHW production is currently covered entirely by natural gas, from the boiler room. The heat generator is 2 pieces of open-fired gas boilers made by Fűtőber, with a total installed heat output of 700 kW (2 ERKA-Super 90 type RK300 boilers with a nominal output of 350 kW).

For the water blocks of the building, the domestic hot water is provided via 2pc 1000 litre indirectly heated DHW tanks. The swimming pool is a specially operated building due to, among other things, the amount of water evaporating from the large pool, which not only greatly affects the feeling of human comfort through the air condition but can also cause rapid damage to building structures. The need for fresh air and the required number of air changes in the changing rooms, showers and other service rooms of the flat-roofed building are also provided by an air handling unit with a heating coil with a back-mixing of 1850 m3 / h. Thus, the air handling units operate without heat recovery equipment, and due to the uncontrolled, continuous back-mixing (humidity independent), the dehumidification capacity of the moist ventilation air is lower), which results in continuous condensation in the Park pool even during uninterrupted operation of the air handling unit.

The electrical network of the building consists of extremely outdated equipment. The luminaires used in the lighting network are fluorescent fixtures with conventional ballasts, compact fluorescent luminaires, and incandescent luminaires. Each lighting circuit can be operated manually.

Conceptual phase

The current energy consumption, energy costs and CO2 emissions of the Park Swimming Pool are extremely high, so its energy efficiency rating is weak. Different scenarios were explored in order to achieve a cost-effective renovation of the nearly zero-energy building.

Objectives of the project:

- Reducing financial costs (lower energy bill)
- Increase users' sense of comfort and improve working conditions
- Reducing greenhouse gas and pollutant emissions by replacing them with more sustainable energy sources, such as renewables (solar energy, etc.)
- Meeting local / regional / national energy efficiency targets and commitments

The following versions were explored:

Renovation variants	Technical detail of the renovation	Regulatory compliance
A	- thermal insulation of facade walls with 12 cm closed-cell PIR thermal insulation with metal armament (Lindab sandwich panel, λ = 0.022W / mK) - subsequent thermal insulation of a brick wall supported by a retaining wall and earth filling with 12 cm closed-cell EPS thermal insulation (λ = 0.036W / mK) - thermal insulation of mounted wall with 16 cm metal-armored closed-cell PIR (Lindab sandwich panel, λ = 0.034W / mK) - after the demolition of the existing polycarbonate shell above the swimming pool, construction of a new, 22cm glass wool thermal insulation (λ = 0.034W / mK) curved bottom-top sheet metal roof - installation of U = 1.45W / m²K polycarbonate glass roof in curved sheet metal roof - thermal insulation of a flat roof with bituminous waterproofing, 14cm EPS step-resistant ROCWOOLMONROCK (λ = 0.038W / mK) with thermal insulation, new waterproofing - thermal insulation of a flat roof with a corrugated sheet metal (workshop) with 15cm PIR thermal insulation (λ = 0.022W / mK), with a new sheet roof - subsequent thermal insulation of the basement floor with 10 cm closed cell EPS thermal insulation (λ = 0.03W / mK) plastered - replacement of existing open-fired gas boilers with condensing boilers (2x100kW), chimney reconstruction - replacement of an existing air handling unit with a new air handling unit equipped with a heat recovery unit (80% efficiency) - installation of a heat pump system (for each A2 / W35 the nominal power is 26.5 kW each) with a 750 l buffer tank; With 3m³ DHW tank	corresponds to nZEB level
B	Version "A" supplemented: - replacement of old existing doors and windows with heat transfer Uw = 1.15 W / m²K (except for doors already replaced in the 2014 renovation) - demolition of existing roof skylights, installation of new ones U = 1.7W / m²K	corresponds to nZEB level
C	Version "A" supplemented: - replacement of all existing windows with windows with heat transfer Uw = 1.15 W / m²K - demolition of existing roof skylights, installation of new ones U = 1.7W / m²K	corresponds to nZEB level
D	Version "C" supplemented - 50kWp Installation of a small household power plant	corresponds to nZEB level
E	Version "B" supplemented: - 50kWp Installation of a small household power plant	corresponds to nZEB level
F	From the implementation of version "E" we omit the subsequent thermal insulation of the basement floor	corresponds to nZEB level

The recommended renovation for Park Swimming Pool meet the values of the nearly zero energy requirement (nZEB) requirement. According to the preliminary survey, Version F was recommended:

- replacement of existing boilers with condensing gas boilers with outdoor temperature control; air handling units with heat recovery units
- replacement of original doors and windows with doors and windows that meet nZEB requirements
- thermal insulation of external walls and roof structures in accordance with nZEB requirements
- thermal insulation of all external boundary structures (including basement slabs and structures in contact with the ground) in accordance with nZEB requirements
- installation of modern renewable energy production technology, 50% replacement of the energy demand of DHW production by installing an air-to-water heat pump, increasing the thermal efficiency of the heat recovery equipment of an air handling unit by using an air-to-air heat pump, installing a small photovoltaic power plant
- installation of intelligent measurements

2.2.2. Conclusions and next steps

Based on a cost-benefit analysis, the simple payback of each of the nZEB technical renovation variants is 25 years. At the same time, in addition to the gross own share of ~ 117MHUF, the return on the investment of an ESCO-type investment of ~ br.130MHUF turns positive after 15 years. The required own share was recommended to be covered from own resources, subsidized / energy efficiency loans, EU support schemes and special funds, interest-free construction of a green investment fund, depending on the possibilities of the municipality. The Municipality needs to look into the above-mentioned funds.

2.3. Renovation of Vilmos Endre sportcenter in the 18th District of Budapest

2.3.1. Initial condition of the building

Vilmos Endre Sportcentrum Swimming Pool was built in the 1980s and its current energy efficiency grading is EE (better than average). In the tract containing the pool area, there is a 60 cm reinforced concrete and brick parapet structure, the roof is placed on laminated, glued wooden beams with a cross section of 16x80 cm at 5.4 m. The curved roof structure is covered with bituminous shingles on the outside. End closure of the arched roof structure of the swimming pool with plastic-framed, heat-insulated glazed windows.

The part of the building that includes the service spaces has a flat roof. The design of the flat roof according to the data is a single-shell warm roof with conventional gravel bitumen sheet insulation. In the flat roof part of the building, 2 rows of skylights with a 45° inclination angle were also installed in order to ensure the natural lighting of the rooms and their gravity ventilation.

The total heated floor area of the building is 1421.7 m2. Heated air volume 7712m3. The total cooling area is 3999m2, of which 333m2 are windows and 109m2 skylights.

With regard to building services systems, the heat demand for all heating and DHW production is currently covered entirely by natural gas, from a container boiler building ~ 50 meters from the northern corner of the swimming pool building, via a transmission line. The heat generator is 2 Viessmann Vitoplex low-temperature gas boilers with a total installed heat output of 1410kW (one equipped with an 860 kW, the other with a 550kW gas burner).

Welded steel plate boilers with ionisation flame protection provide a priority control of DHW production as well as the control of heating circuits with mixing valves with their own. For the water blocks of the building, the domestic hot water is prepared through 1 2500 litre indirectly heated DHW tank.

The electrical network of the building consists of extremely outdated equipment. The luminaires used in the lighting network are fluorescent fixtures with conventional ballasts, compact fluorescent luminaires, and incandescent luminaires.

2.3.2. Conceptual phase

The current energy consumption, energy costs and CO2 emissions of the Vilmos Endre Sportcentrum Swimming Pool are extremely high, so its energy efficiency rating is weak. Therefore, several scenarios were examined.

Objectives of the project:

- Reducing financial costs (lower energy bill)
- Increase users' sense of comfort and improve working conditions
- Reducing greenhouse gas and pollutant emissions by replacing them with more sustainable energy sources, such as renewables (solar energy, etc.)
- Meeting local / regional / national energy efficiency targets and commitments

The following renovations were examined:

Renovation variants	Technical detail of the renovation	Regulatory compliance
A	- thermal insulation of facade walls with 15 cm Rockwool thermal insulation (λ = 0.037W / mK), using modern weatherproof covering - above the swimming pool space 22cm glass wool thermal insulation (λ = 0.034W / mK) with curved bottom-top sheet metal shell- warm roof - post-thermal insulation of a flat roof with bituminous waterproofing with 14cm step-resistant ROCWOOLMONROCK (λ = 0.038W / mK) thermal insulation, with new waterproofing - post-thermal insulation of the basement floor with 8 cm closed cell EPS thermal insulation (λ = 0.03W / mK) plastered - installation of condensing gas boilers (3x100kW) instead of existing low temperature gas boilers, reconstruction of chimney - replacement of existing air handling units with an air handling unit equipped with a heat recovery unit (80% efficiency) - installation of a heat pump system (for each A2 / W35 the nominal power is 26.5 kW each) with a 750 liter buffer tank and a 3m3 DHW tank	corresponds to nZEB level
B	Version "A" supplemented: - replacement of old existing doors and windows with heat transfer Uw = 1.15 W / m^2K (except for doors already replaced in the 2018 renovation) -we omit the subsequent thermal insulation of the basement floor	corresponds to nZEB level
C	Version "A" supplemented: - replacement of all existing windows with windows with heat transfer Uw = 1.15 W / m^2K - we omit the subsequent thermal insulation of the basement floor	corresponds to nZEB level
D	Version "C" supplemented - 50kWp Installation of a small household power plant	corresponds to nZEB level
E	Version "B" supplemented: - 50kWp Installation of a small household power plant	corresponds to nZEB level

The renovation aims to meet the values of the nearly zero energy requirement (nZEB). According to the preliminary survey, the following renovations were recommended:

- replacement of existing boilers with condensing gas boilers with outdoor temperature control; air handling units with heat recovery units
- replacement of original doors and windows with doors and windows that meet nZEB requirements
- thermal insulation of external walls and roof structures in accordance with nZEB requirements
- thermal insulation of all external boundary structures (including basement slabs and structures in contact with the ground) in accordance with nZEB requirements
- installation of modern renewable energy production technology, 50% replacement of the energy demand of DHW production by installing an air-to-water heat pump, increasing the thermal efficiency of the heat recovery equipment of an air handling unit by using an air-to-air heat pump, installing a small photovoltaic power plant
- installation of intelligent measurements

2.3.3. Conclusions and next steps

A nearly-zero level can only be achieved by renovating as many (almost all) structures as possible. In two versions (D, E) the structural and mechanical packages with a solar system were supplemented, as the electricity consumption is very high due to the swimming pool technology, among others. The final reccomendation was Version E.

Based on a cost-benefit analysis, the simple payback of each of the nZEB technical renovation variants is more than 40 years. When paying a gross own share of ~ 191MFt, the return on an ESCO type investment of ~ gr.120MFt turns positive after 15 years. The required own part can be covered from own resources, subsidized / energy efficiency loans, EU support schemes and special funds, interest-free construction of a green investment fund, depending on the possibilities of the municipality. The Municipality needs to look into the above-mentioned funds.