TECHNICAL REPORT ON NZEB PILOT ACTIONS

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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 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. Country overview

Construction of public nearly zero energy buildings with public-private partnership model was the pilot action which was tested in Croatia on three different locations: Sveta Nedelja, Marija Bistrica and Stupnik.

The transposed European Energy Performance of Buildings Directive Recast (EPBD) in Croatia requires all new public buildings to be constructed as nearly zero energy buildings from 31st of December 2018 and all privately owned buildings from 31st of December 2020. Croatian Technical Regulation on Energy Economy and Heat Retention in Buildings sets requirements on the consumption of thermal energy for heating in residential and non-residential buildings, requirements related to airtightness of buildings, the maximum allowed transmission heat loss coefficient of building elements, etc. Also, the maximum primary energy demand is established, depending on the climate zone, including energy for heating, cooling, ventilation and sanitary hot water preparation. All three Croatian cities and municipalities are situated in the continental climate zone.

According to the Regulation, the following table shows the maximum allowed values for the nearly Zero Energy Buildings. All three pilot buildings are classified as educational buildings.

Table 2.1 - nZEB requirements for new buildings

BUILDING CATEGORY	Q"hnd [kWh/m²a]			Eprim [kWh/m²a]
	continental climate zone			continental climate zone
	f0 ≤ 0,20	0,20 < f0 < 1,05	f0 ≥ 1,05	
multi-residential	40.5	32.39 + 40.58·f0	75	80
single-family	40.5	32.39 + 40.58·f0	75	45
office	16.94	8.82 + 40.58·f0	51.43	35
educational	11.98	3.86 + 40.58·f0	46.48	55
hospital	18.72	10.61 + 40.58·f0	53.21	250
hotel & restaurant	35.48	27.37 + 40.58·f0	69.98	90
sports hall	96.39	88.28 + 40.58·f0	130.89	210
commerce	48.91	40.79 + 40.58·f0	83.4	170
other non-residential	40.5	32.39 + 40.58·f0	75	/

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. Construction of kindergarten in the City of Sveta Nedelja

2.1.1. Initial condition of the building

Short technical summary from the energy certificate/energy audit.

2.1.2. Conceptual phase

The City of Sveta Nedelja planned to expand the capacity of existing kindergarten (DV Slavuj) by constructing an additional building adjacent to the old one. Education buildings, a category under which kindergartens are classified, allows maximum primary energy consumption of 55kWh/m²a.

However, both Sveta Nedelja and REGEA representatives agreed that the kindergarten should go beyond minimum nZEB energy efficiency standards. Only one technical solution for reaching required energy efficiency standards was proposed which foresaw modern, high-quality external thermal insulation composite system (ETICS) with thermal insulation made of stone wool or slab lamella, design of lighting system based on LED technology with option of intelligent control, installation of reactive energy compensation equipment and construction of an integrated solar power plant, mounted on the roof of the building. Both City of

Four technical solutions for heating and cooling purposes were proposed as nZEB standard can be reached with different combinations of energy efficiency and renewable energy production technologies.

Table 2.2 Overview of characteristics of proposed heating and cooling systems

Indicators / description	V1 - Condensing boiler + PV	V2 - Pellet boiler	V3 - Heat pump (air/water) + condensing boiler + PV	V4 - Heat pump (water/water) + PV
Technical description	- Condensing boiler - 2 x 25 kW - underfloor heating (40/35°C) - mechanical ventilation with heat recovery ŋ=0,75 (45/35°C) - outside temperature controlling - solar panels - 50 m^2 (10 kWp)	- wood pellet boiler - 50 kW - radiator heating 90/70°C - mechanical ventilation with heat recovery ŋ=0,75 (90/70°C) - outside temperature controlling	- condensing boiler - 2 x 25 kW (45/35°C) - heat pump (air source) – 2 x 16 kW - mechanical ventilation with heat recovery ŋ=0,85 - underfloor heating (45/35°C) - solar panels - 35 m^2 (7 kWp)	- heat pump (water source) – 2 x 26 kW - underfloor heating (40/35°C) - mechanical ventilation with heat recovery ŋ=0,85 (40/35°C) - solar panels - 25 m^2 (5 kWp)
Aggregate energy indicator (Epmax=55) (kWh/m2, a)	23,26	30,63	26,97	37,18
Energy class	A+A+	AA+	A+A+	AA+
Renewable share (%)	30,19	57,07	31,07	30,54
Gas consumption (kWh/a)	5.636,80	-	2.787,34	-
Electricity consumption (kWh/a)	12.971,57	2.254,16	18.790,06	29.753,80
Biomass consumption (t/a)	-	22,25	-	-
Total primary energy consumption (kWh/a)	18.608	24.507	21.577	29.754
Total CO_2 emission (t/a)	3,02	3,87	3,29	4,33

A cost-benefit analysis with financial and economic analysis was used for assessment of all four technical options over a time span of 10, 20 and 30 years. The analyses revealed that longer assessment of four options resulted in larger differences in total life-cycle costs of different technologies. Although REGEA suggested that version 4 which foresees a heat pump system (water-

water) combined with a PV system should be used in the main design of the building, the City of Sveta Nedelja ultimately chose version 1 due to lowest investment costs, familiarity of the technology and the small technical risk it brings.

2.1.3. Main project design

The addition to the existing kindergarten was required by the law to be constructed as an nZEB building. However, since it was not a stand-alone building and had to be incorporated within the existing complex, technical solutions in the main project design had to be adjusted accordingly. The new kindergarten in Rakitje had to follow modular design guidelines that foresaw adding new wings to the building. According to the main design the building will be connected to the existing kindergarten so that educators and children can commute between the two spaces. The existing kindergarten possesses a kitchen and a washing room and will therefore ensure cooking and cleaning services for the annexed building as well.

The demanding energy efficiency nZEB requirements will be met with high-quality external thermal insulation composite system (ETICS) with 20 cm thick thermal insulation made of stone wool (30 cm for the roof surface). Due to increased airtightness caused by the thermal insulation, a centrally managed recuperation (waste heat recovery) system was foreseen to be installed to allow enough flow of fresh air in all rooms.

Outer joinery is to be made of aluminium frames with LOW-E glasses which have to allow maximum amount of natural light. New LED internal lighting system needs to be done in accordance with the norm (EN 15193:2007) and provide durability, quality of light and energy efficiency.

Heating system consists of a 120 kW highly-efficient condensation gas boiler which will be located outside of the building and floor heating in combination with radiators will be used to distribute heat in rooms. VRV heat pump systems with both cooling and heating functions are also to be installed in all rooms. Six solar thermal collectors for preparation of hot water in bathrooms and kitchen will be installed on the roof of the building.

Solar PV plant will be installed on the roof of the kindergarten, primarily for its own needs while the surplus energy would be delivered into the grid. The estimated installed power would reach 10 kWp, which would produce about 10.420 kWh yearly (projected 1042 working hours at 100% nominal capacity) and would be contacted to the grid (net metering). The production from the PV power plant would significantly offset the current electrical energy demand.

With all forementioned energy efficiency and renewable energy technologies being implemented, an above nZEB standard can be reached for the kindergarten building as the primary energy per heated surface area is well below the nZEB targets (37,41 vs 55 kWh/m^2) as well as minimum energy produced from renewable energy sources (47,89% vs 30%) Exact technical requirements of the new kindergarten which were set by the main design are defined in the following table (Table 1.3).

Table 2.3 Basic technical data

Energy relevant data	
Total heated surface (m^2)	764,38
Total heated volume (m^3)	3.213,65
Building shape factor (m-1)	0,47
Average inside temperature (C°)	22,00
Heating energy demand Q H,nd [kWh/a]	17.257,61
Heating energy demand per heated surface Q" H,nd [kWh/(m^2 a)]	22,58
Cooling energy demand Q C,nd [kWh/a]	14.403,99
Cooling energy demand per heated surface Q" C,nd [kWh/(m^2 a)]	18,84
Energy demand for lighting system E L [kWh/a]	6.886,91
Energy produced from local RES [kWh/a] E EL, RES	10.307,68
Delivered energy for heating and hot water HW,del [kWh/a]	14.676,62
Share of energy delivered from renewable sources (%)	47,89
Delivered energy E del [kWh/a]	19.561,02
Primary energy E prim [kWh/a]	28.591,64
Primary energy per heated surface area E prim [kWh/(m^2 a)]	37,41

2.1.4. Monitoring and verification of reconstructed building

The building was not constructed and commissioned by the end of the project.

2.2. Construction of primary and music school in the Municipality of Marija Bistrica

2.2.1. Conceptual phase

To address this growing demand for public school and educational services the municipality planned to construct a new, modern nZEB building in accordance with national educational standards. This way, the municipality would be able to provide public educational services for 300-600 students.

The goal of eCentral's pilot action was to perform an assessment of whether a public-private partnership (PPP) model is likely to offer better value for the public than traditional public procurement (i.e., value for money analysis (VfM)). Therefore, a PPP screening report and Public Sector Comparator (PSC) analysis were made to determine if and which PPP model would be the most adequate and affordable for the municipality.

PSC analysis proved that Design-Build-Finance (DBF) model would be more suitable than the traditional model for construction of the new primary and music school with a gym in Marija Bistrica. Next steps in the process included development of DBF model terms of reference, project contract (with financial structuring, financial model, risk allocation, service standards, payment mechanism, guarantee drafts) and preliminary design of the school.

The DBF PPP model does not anticipate fully precise technical solutions for construction of the building but it does set standards (e.g., energy, comfort levels) and gives general technical and architectural guidelines to the private partner. In that regard, although the nZEB standard is mandatory and for educational buildings is set at 55 kWh/m^2, with a minimum of 30% of local renewable energy production, the municipality decided to go beyond that and required the building to be designed to produce 100% of energy from local renewable energy sources. Continental Croatia does not have one predominant source of renewable energy so different combinations can come into consideration (solar, biomass, geothermal). The task of the private partner is to decide which technology is cost-optimal in the long run.

PPP screening report initially estimated total costs for construction of primary and music school with a gym and outdoor sport facilities at approximately EUR 11 million (without VAT).

2.2.2. Conclusions and next steps

The project of construction of primary and music school in the Municipality of Marija Bistrica is entering a critical phase: securing of financial resources for payment of PPP fee and search for private partner. Financial resources needed for realization of this PPP project represent a huge burden for a small municipality like Marija Bistrica. Therefore, financial support from the regional government is needed and Krapina-Zagorje County has expressed its willingness to assist the municipality. Another potential resource for funding of the investment are ESIF and Renovation and Resilience Facility funds for the period of 2021-2027. The search for private partner consists of market consultations with large companies which would have to assess PPP documentation before launching of the public tender.

2.3. Construction of primary school in the Municipality of Stupnik

2.3.1. Conceptual phase

Due to the constant growth of municipal population and non-existence of primary schools in Stupnik, the local government is faced with public demands for construction of municipality's own school. Students from Stupnik have to attend schools in the City of Zagreb for which the municipality has an organized transportation. To address growing demands for construction of municipal public school and educational services local government plans to construct a new, modern nZEB building in accordance with national educational standards. This way, the municipality would be able to provide public educational services for up to 400 students.

Although the nZEB standard for educational buildings is set at 55 kWh/m^2 and 30% of renewable energy production, the municipality decided to go beyond that and required the building to be designed to produce 100% of energy from local renewable energy sources.

PPP screening report initially estimated total costs for construction of primary school with a sports hall and outdoor sport facilities at approximately EUR 8 million (without VAT).

PSC analysis once again proved that Design-Build-Finance (DBF) model would be more suitable than the traditional model for construction of the new primary school with a sports hall in Stupnik.

Next steps in the process included development of DBF model terms of reference, project contract (with financial structuring, financial model, risk allocation, service standards, payment mechanism, guarantee drafts) and preliminary design of the school.

2.3.2. Conclusions and next steps

Being a very similar, greenfield project as the one in Marija Bistrica, the next steps also include securing of financial resources for payment of PPP fee and search for private partner. Financial support from the regional government was formally agreed with Zagreb County which will cover a part of the PPP fee. ESIF and Renovation and Resilience Facility funds have also been mentioned as potential sources of co-funding. The search for private partner might be conducted in cooperation with the project in Marija-Bistrica, depending on the overall time-frame for implementation of both projects.