NEARLY ZERO-ENERGY & EMISSION BUILDINGS AND PLUS ENERGY HOUSES

- 23rd EECG Meeting

KFW ZRMK Fraunhofer IBP

AGENDA




Topic	Presenter
Introduction	Bodo Schmülling, KfW
What means Nearly Zero-Energy Building (NZEB) • Definition of NZEB in the EPBD • Overview of EU Member States NZEB definitions (CA EPBD) • Lessons learned and recommendations	Heike Erhorn-Kluttig, Fraunhofer IBP
Examples from EU Member States • Collection of NZEB example buildings (report of CA EPBD) • Plus energy school renovation project in Stuttgart/Germany • NZEB progress in Slovenia and multi-family house project in Brdo/Slovenia	Hans Erhorn, Fraunhofer IBP Marjana Šijanec-Zavrl, GI ZRMK
Summary/follow up	Bodo Schmülling, KfW

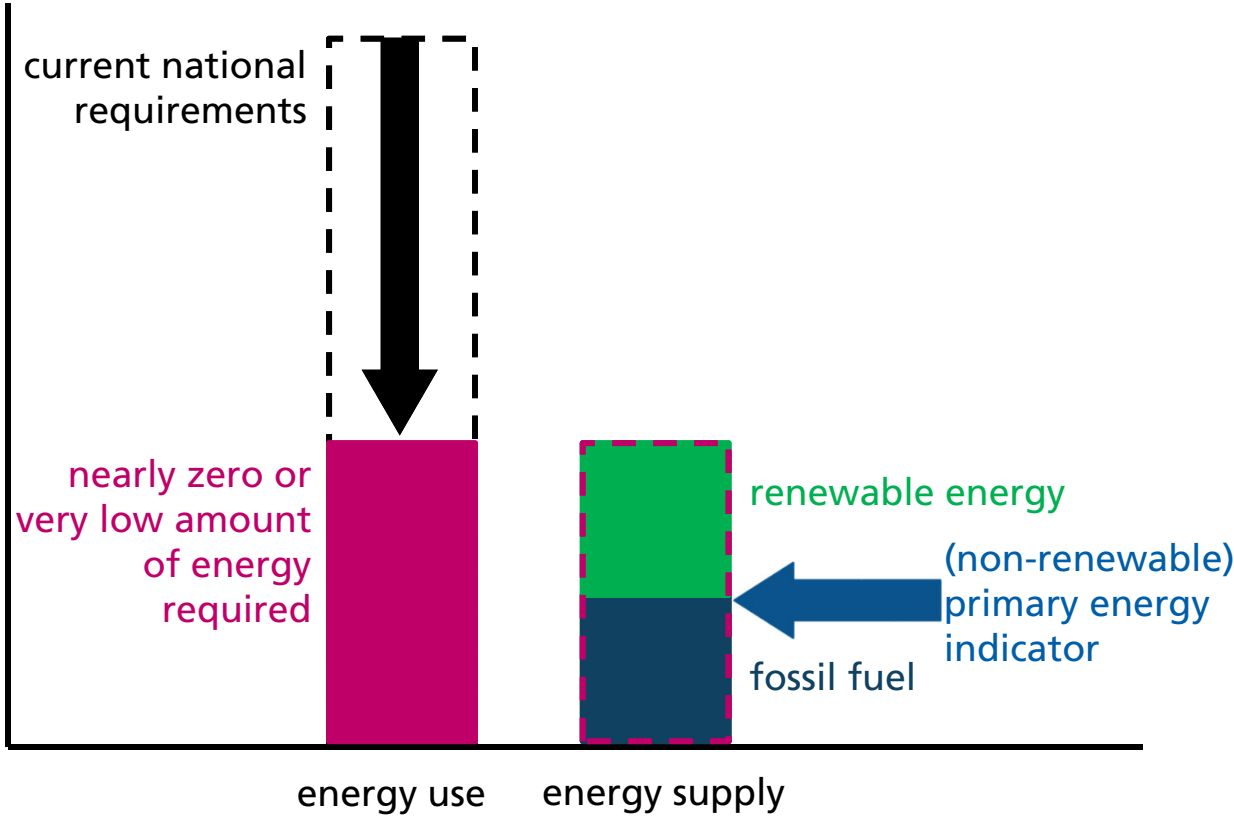
Definition of the Nearly Zero-Energy Building in the EPBD

NZEB Definition of EPBD recast Article 2:

- 'nearly zero-energy building' means a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby;

Article 9:

- Member States are responsible for the practical application of the definition.
- The national application of the definition of nearly zero-energy buildings shall reflect national, regional or local conditions…
- … shall include a numerical indicator of primary energy use expressed in kWh/m² per year.



Overview of the EU Member States Definitions

- A lot of work has been spent on supporting and mapping the EU MS national applications of the NZEB definition
  - CA EPBD presentations and discussions:
    - NZEB definitions of front runner states
    - Mapping of MS' NZEB definitions
    - Number and type of requirements for NZEBs
    - How to integrate RES in urban NZEBs
    - Pilot projects have been collected and documented
    - Study tours to NZEBs and beyond
    - ….
  - EU Commission: studies and recommendations
- Details per country are contained in the National Plans for increasing the Number of NZEBs

Overview of the EU Member States Definitions

Main points of the national NZEB definition (as reported by the CA EPBD delegates)			Country: Belgium			Austria	Brussels	Flanders	Walloon	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg *	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovak Republic	Slovenia	Spain	Sweden	United Kingdom
Detailed definition	Included in a legal document	Governmental decree/law					■	■	■	■		■				■				■		■	■		■	■			■			■	■		■	
		Technical regulation									■		■	■	■		■				■	■		■								■				
		National NZEB plan				■					■																					■		■		
	Not yet included in a legal document																	■	■						■	■	■			■				■		■
	Draft available																	X							X		X							X		
Very high energy performance	Tighter requirements compared to current values for	General														■													■						X	
		Mean U-value of building envelope											■																							
		Reference technologies											■																			■				
		Heating energy demand																															■			
		Final energy	■																																	
		Primary energy				■	■	■				■				■						■									■	■	■			
		(Primary) energy performance coefficient			■	■																					X									
	Top building class					■		■			■									■	■		■	■	■	X	■					■				X
	Specific new building class													■																						
	Passive house (building envelope) level		■																																	
	KfW efficiency house 55/70																	X																	
Nearly zero or very low amount of energy required. Limits on:	Component U-values			■	■			■												■	■	■					X		■			■	■	X		
	Thermal bridges																				■															
	Mean U-value of building envelope			■	■	■			■									X									X						■		■	
	Heat transfer coefficient/heat loss of building envelope																					■		■												
	Air permeability																				■															
	(Net) heat demand	■	■					■										X		■					■	X									
	Installed lighting power							■																												
	System efficiencies					■														■	■	■														
	Heating energy demand																					■	■										■	X		
	Cooling energy demand																					■												X		
	Total energy efficiency	■																																		
	Electrical input																																		■	
	Final energy (total or divided into energy uses)	■							■																				■			■				X
	Primary energy		■	■	■	■	■	■	■	■	■	■	■	X		■	■	■	■	■	■	■	X	■	X		■		■	■	■		X	■	
	CO_2 emissions	■																		■											■					X
	Summer overheating																			■		■														
Very significant extent of renewable energy	Direct	Minimum share in %	■		■		■	■	■									X		■	■	■	■	■		■					■	■	■			
		Minimum contribution in kWh/m².year			■											■					■															
		(Choice of) exemplary RES measures	■		■					■												■														
	Indirect **			■		■				■	■	■	■											■	X		X		■					X	■	X
Primary energy indicator in kWh/m².year	Included		■	■		■	■	■	■	■	■	■	■	X		■		■	■	■	■	■	X	■			■		■	■	■		X	■	
	Other main indicator, but PE as additional/interim result. Main indicator:	CO_2																																		
		Primary EP coefficient			■	■															■						X									X

* At the time of the factsheet Luxembourg had a national NZEB definition for residential buildings in place, but not yet a NZEB definition for non-residential buildings.
** Indirect: RES contribution required in order to achieve the minimum energy performance requirements.

Source:

CA EPBD report

National applications of the NZEB definition – The complete overview

Status February 2018

Authors: Heike Erhorn-Kluttig, Hans Erhorn, Fraunhofer Institute for Building Physics, Germany

countries with many different NZEB requirements

vs.

countries with only few NZEB requirements

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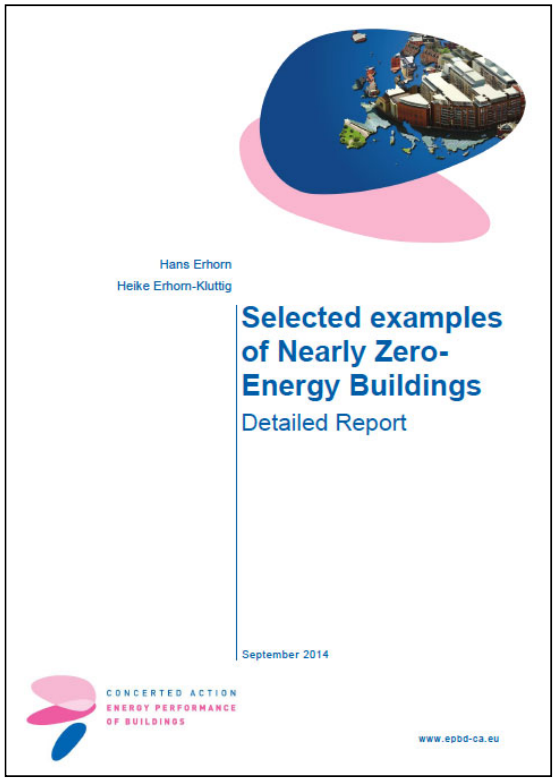
Lessons Learned and Recommendations based on EU Member States Definitions

- There is not one NZEB definition that fits all countries
- Requirements can't be adapted by simply looking at different climate regions
- NZEB definition are very much based on national boundary conditions such as existing national minimum energy performance requirements. Mainstream solutions are:
  - Tightenings of energy performance requirements
  - Introduction or increase of ratio of renewables
  - Primary energy indicator, that can be supported by other indicators: final energy, CO_2 emissions, …
- NZEB definitions should be defined or at least tested (as voluntary level) some years in advance
  -> experience as well as cost-optimum calculations with view to the future can lead to adjustments
- Pilot and demonstrations buildings are important to convince building owners and building industry
- Study tours to other/neighbour countries allow for information exchange (alternative: case study presentations by building owners and/or planners)

Selected NZEB Examples in Member States (CA EPBD Report 2014)



Selected NZEB Examples in Member States (CA EPBD Report 2014)

- 32 examples from 20 countries
- Cross-comparison of:
  - Project aims, building types
  - Building envelope quality
  - Used building service systems and renewable systems
  - Energy values
  - Experiences made
  - Costs:

	Additional costs of the selected examples of NZEBs compared to the energy level according to the current national requirements		
	Average	Lowest	Highest
% of total costs	11	0	25
€/m²	208	0	473

CONCERTED ACTION ENERGY PERFORMANCE OF BUILDINGS

NZEB-like Educational Buildings

Pilot projects from 13 countries

Authors: Hans Erhorn, Fraunhofer Institute for Building Physics, Germany
Heike Erhorn-Kluttig, Fraunhofer Institute for Building Physics, Germany

Introduction

Throughout the Energy Performance of Buildings Directive (EPBD) it is requested that "*the public sector in each Member State should lead the way in the field of energy performance of buildings*" and "*buildings occupied by public authorities and buildings frequently visited by the public should set an example*". New buildings occupied and owned by public authorities shall be Nearly Zero-Energy Buildings (NZEB) two years earlier than all other types of new buildings. Among the most promising public building types to act as lighthouse projects are educational buildings including school buildings. They are visited by different age groups like pupils, teachers and parents. Furthermore, educational buildings are often used for providing lectures on energy efficiency and environmental awareness, showcasing actual improvements of the buildings' envelope and the buildings' own technical services systems, as well as on how to support energy savings by responsible user behaviour.

A collection of pilot projects within CA EPBD

Database

Between November 2015 and May 2016, the Concerted Action EPBD has collected and discussed detailed information on good practice examples of NZEB(-like) educational buildings in the different Member States (MSs). In total, 17 examples of educational buildings have been collected and compared, three of which are kindergartens, eight are schools (mostly primary schools), two are combined kindergartens and schools, and four are university buildings. Figure 1 gives a graphical overview of the pilot projects.

IT-1: Childcare Centre Cologno Monzese | FI-1: Luhtaa Nursery | SL-1: Kindergarten in Preddvor © Jelovica HIŠE d.o.o. | AU-1: Elementary School and Kinder-garten Albrechtsberg | NL-1: Multifunctional School Houthaven © Marlies Rohmer | AU-2: Primary School Mariagrün © Markus Kaiser

FR-1: École François Mitterand ©Bruno Patel | DE-1: Plus Energy School Hohen Neuendorf | NO-1: Brynseng Skole | NO-2: Frydenhaug Skole | PL-1: Primary School in Bielawa | PL-2: Primary School in Budzów

UK-1: Bushbury Hill Primary School | BG-1: Technical University Sofia © Technical University Sofia | HR-1: Faculty of Agriculture, University of Osijek | DK-1: Green Lighthouse © The VELUX Group, credits Adam Mørk | HU-1: Sustainable Building Energy Information Centre Debrecen

Figure 1. Photos of the 17 different NZEB-like educational buildings collected within the CA EPBD.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 692447.

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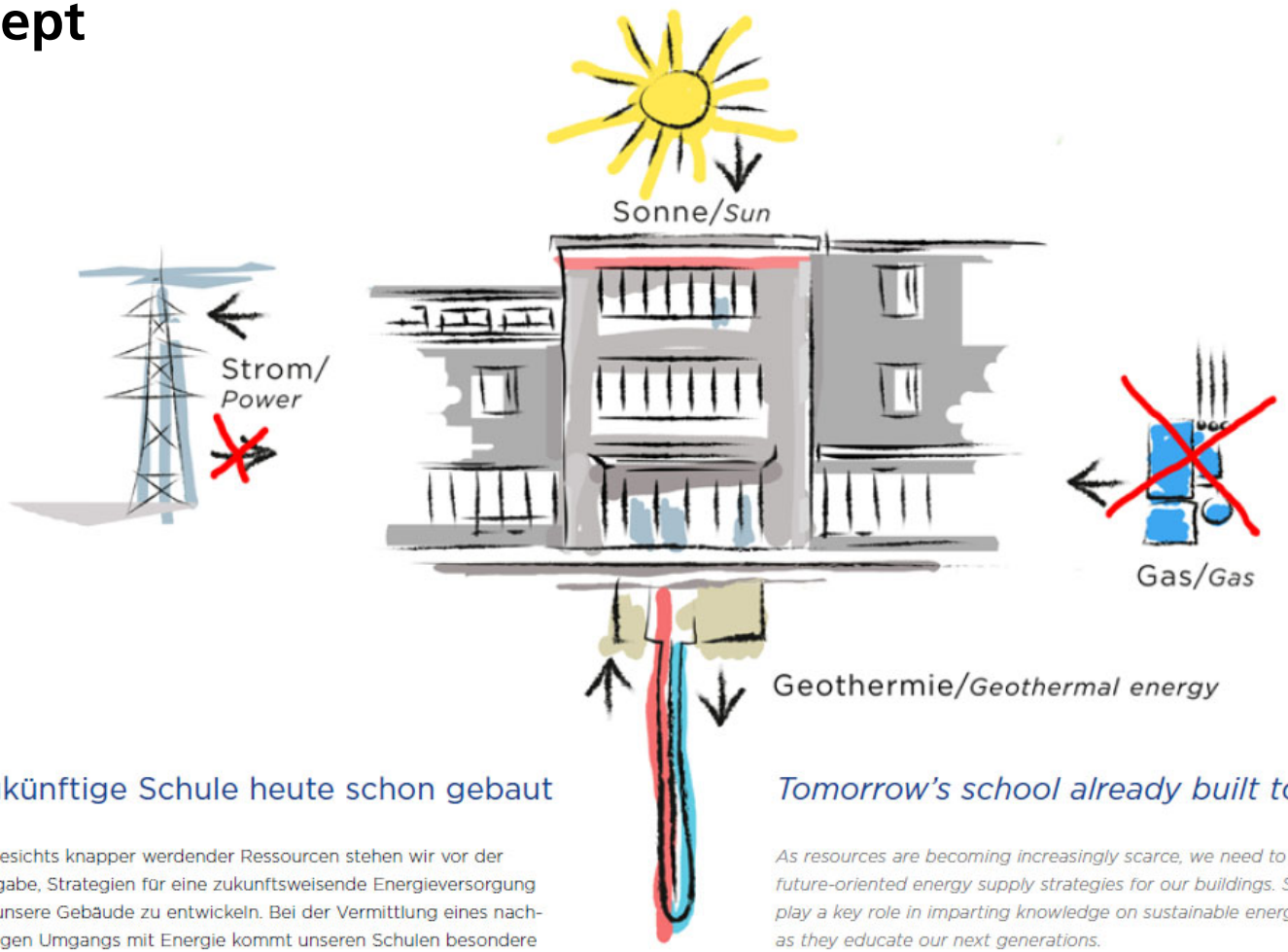
KOMFORT MACHT SCHULE /
COMFORT AT SCHOOL CATCHES ON

PLUSENERGIESCHULE STUTTGART

Vision & Concept



Zukünftige Schule heute schon gebaut

Angesichts knapper werdender Ressourcen stehen wir vor der Aufgabe, Strategien für eine zukunftsweisende Energieversorgung für unsere Gebäude zu entwickeln. Bei der Vermittlung eines nachhaltigen Umgangs mit Energie kommt unseren Schulen besondere Bedeutung zu: Hier werden die heute noch jungen Generationen ausgebildet.

Tomorrow's school already built today

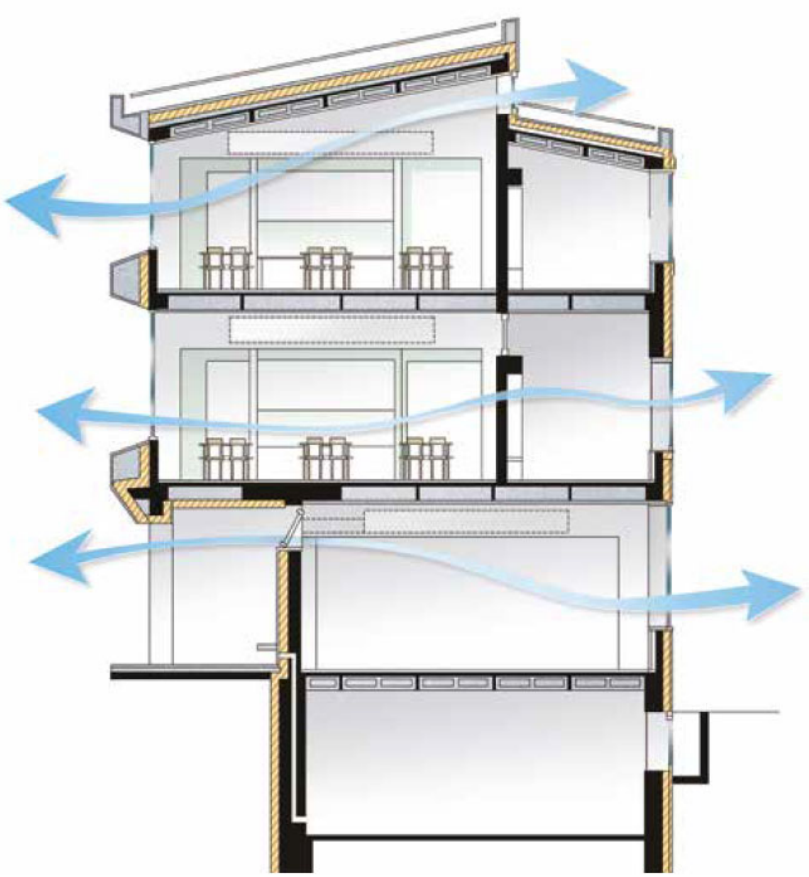
As resources are becoming increasingly scarce, we need to develop future-oriented energy supply strategies for our buildings. Schools play a key role in imparting knowledge on sustainable energy use as they educate our next generations.

Key Elements of the Energy Concept

- Insulation:
  - Roof 20 cm,
  - External wall 10 - 30 cm,
  - Floor / roof: vacuum insulation panels (VIP), expanded polystyrene (EPS)

- Heat generation: heat pump with 54 geothermal probes 90 m deep
- Heat transfer: low temperature surface heating system (temperatures of 45 °C / 35 °C)
- Power generation: photovoltaic system with 220 kWp (1,800 m²)
- Hybrid ventilation: mech. system with 90% heat recovery (winter), natural ventilation (summer)
- Efficient lighting system: daylight-dependent control + presence detector; sun shade redirection (slats)
- No cooling (exception: server room)

Hybrid Ventilation



Durchströmungskonzept der Nachtlüftung

Night ventilation airflow scheme

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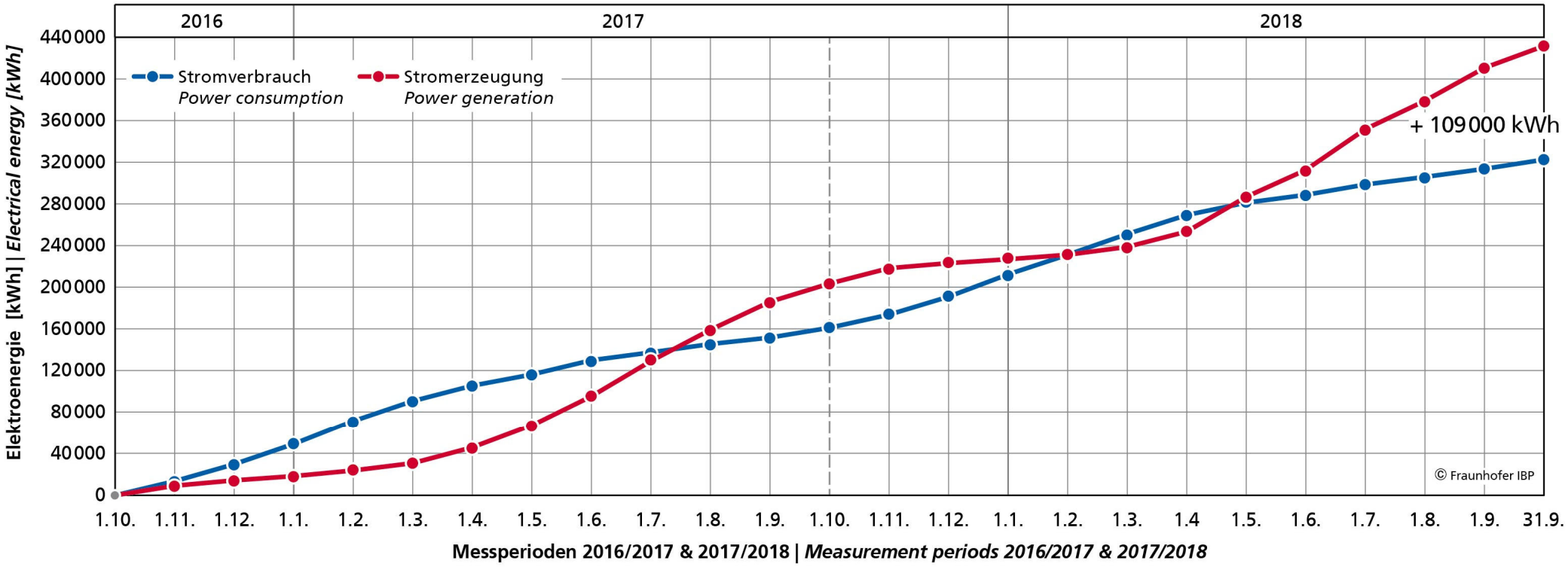
Old

New

Plus Energy Balance (Monitoring 10/2016 – 09/2018)



NZEB progress in Slovenia and multi-family building (MFB) project in Brdo/Slovenia

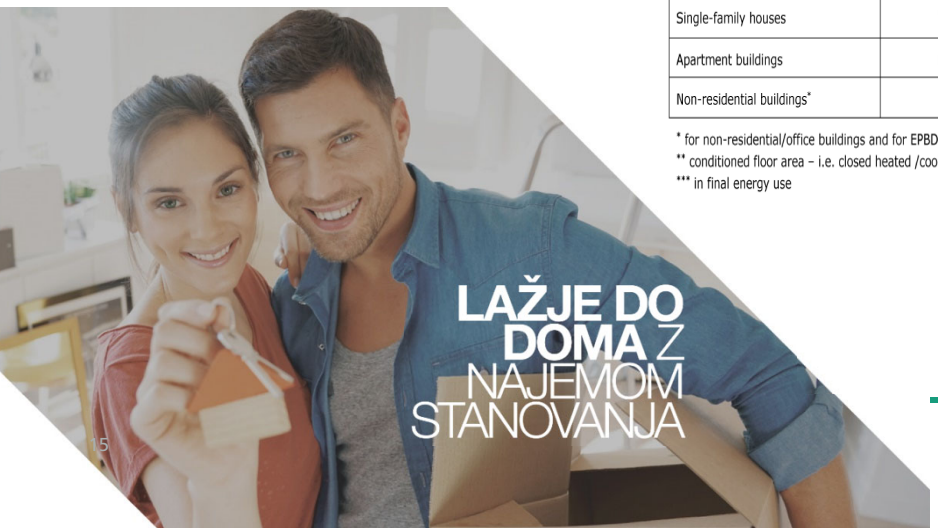
- NZEB requirement is transposed in Slovenian Energy Act (EZ-1, 2014; Art. 330 and 542.).
- NZEB technical definition **NZEB Action Plan (**AN_sNES, 2015)
- Integration in building code (PURES 2020)
- **MFB NZEB min. req.:** PE < 80 kWh/m²a; min. 50% RES, $Q_{h,nd}$ < 25 W/m²K

Building category	Maximum primary energy per conditioned floor area** per year (kWh/m².year)		Minimum share*** of RES (%)
	New buildings	Renovation	
Single-family houses	75	95	50
Apartment buildings	80	90	50
Non-residential buildings*	55	65	50

* for non-residential/office buildings and for EPBD related energy use
** conditioned floor area – i.e. closed heated /cooled net floor area
*** in final energy use

Table 2: National definition of NZEB as given in the national plan for NZEB (April 2015).

STANOVANJSKI SKLAD REPUBLIKE SLOVENIJE
JAVNI SKLAD




Source: SSRS

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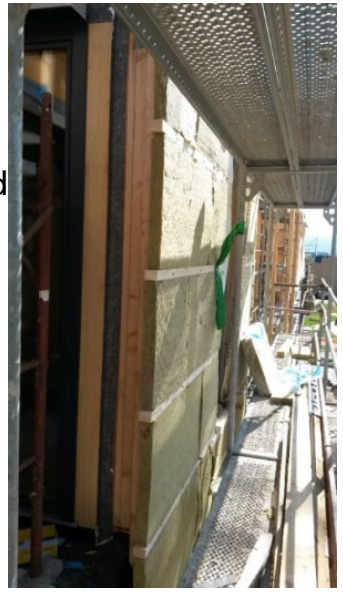
NZEB demonstration project Brdo/Ljubljana (investor: Slovenian Housing Fund – SSRS)

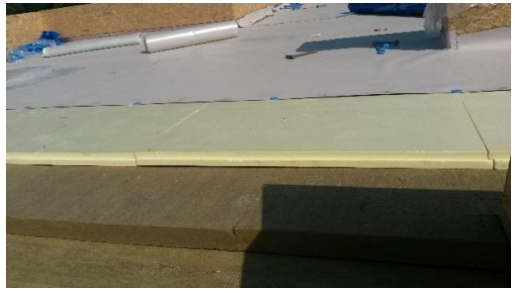
- Construction 2014-2016 / 7,3 mio EUR
- A_u 5.515 m², 52 flats in 4 lamellas, floors: G+3+T, underground garage
- Demonstration: architecture, construction technology,
- HVAC, NZEB and QA, EPC Class A2 (< 15 kWh/m²a), passive house

Building project:
Prof. Aleš Vodopivec, architect
Assoc. prof. Tadej Glažar, architect
Prof. Janez Koželj, architect
Assoc. prof. Jurij Kobe, architect
Outdoor areas: Dekleva Gregorič arhitekti d.o.o. Ljubljana
Investor: Housing fund of the Republic of Slovenia (SSRS)
Duration: Construction commenced in 2014, completion of construction and outdoor areas in 2016
Number of flats: 52 (in 4 building sections/lamellas)
Total net floor area: 5,515 m²
Other premises: 1 nursery school 207 m², 2 offices 15 m²
Parking spaces: 110 (68 in underground garage, 42 outside)

Structure and envelope

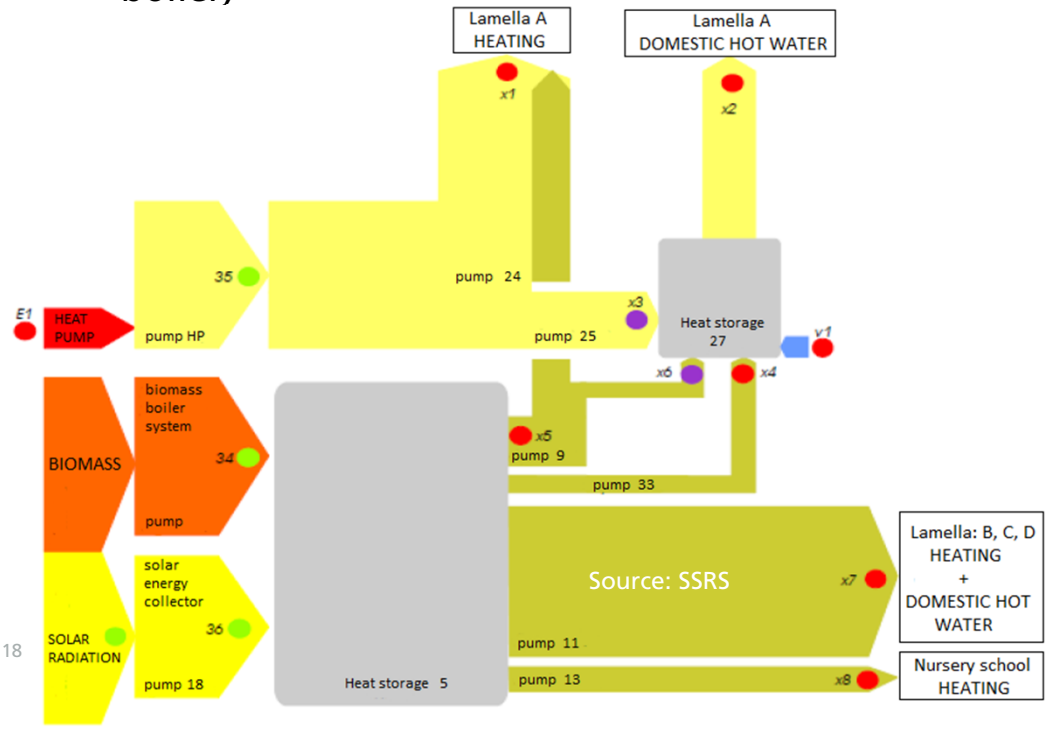
- **Structure:** one-level underground garage - reinforced concrete
- G+2 reinforced concrete structure
- 3+T wooden structure
- **Windows:** wooden + aluminium, 3-glazed, Argon, low-e
  - U_g = 0,50 W/(m²K)
  - U_w = 0,68 W/(m²K)
  - R_w 36 dB
  - g-value: 0,5
  - Passivhaus certified
  - RAL installation standard with three-level sealing
- **Wall:** 28 – 26 cm TI (X-LAM, concrete)
  - U = 0,15 W/(m²K)
- **Flat roof:** 36 cm rock wool + XPS 5 cm
- **Air tightness:** n_{50} = 0,6 /h





HVAC

- **Ventilation:** mechanical with heat recovery 0,84
  (central within 31 flats),
  partly natural ventilation with hygro-sensible fans
- **Heating and DHW:**
  - Biomass boilers (wood chips)
  - Heat pump A/W in „lamella A“ (supported by biomass boiler)



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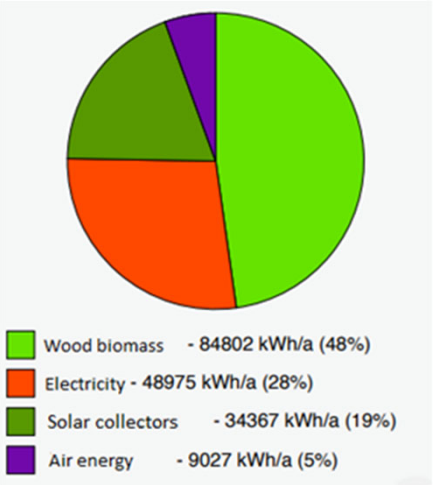
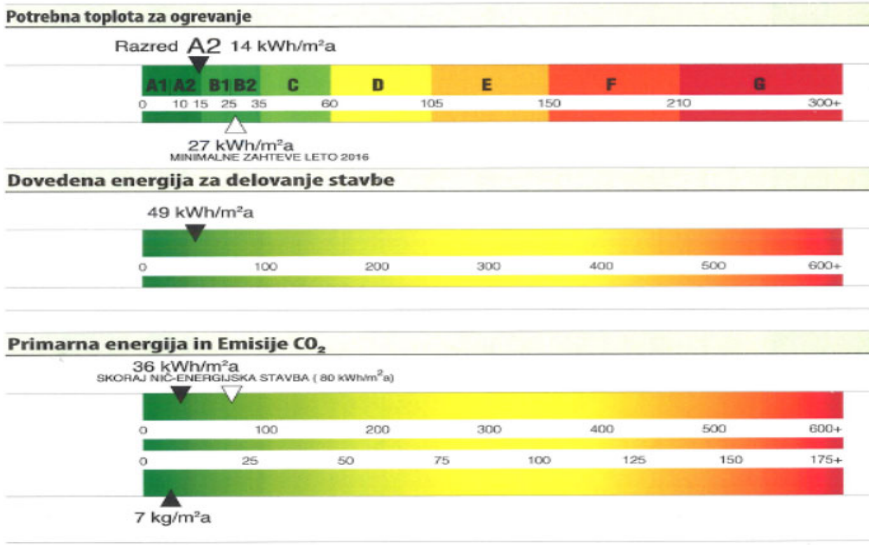
Energy indicators of Brdo/Ljubljana NZEB case study

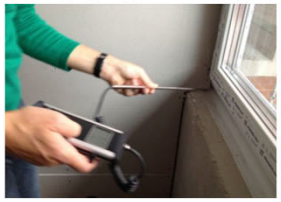
- building as a whole is NZEB — **MFB - as built**
- annual heat demand max. 25 kWh/m²a =>>> **14 kWh/m²a** (energy class A2)
- primary energy max. 80 kWh/m²a =>>> **36 kWh/m²a**
- renewable energy sources >50% =>>> **72 %** RES (biomass (woodchips), solar energy collectors, air/water heating pump)
- CO_2 emission in use (-) =>>> **7 kg/m²a**
- PHPP certificates for 31 passive dwellings

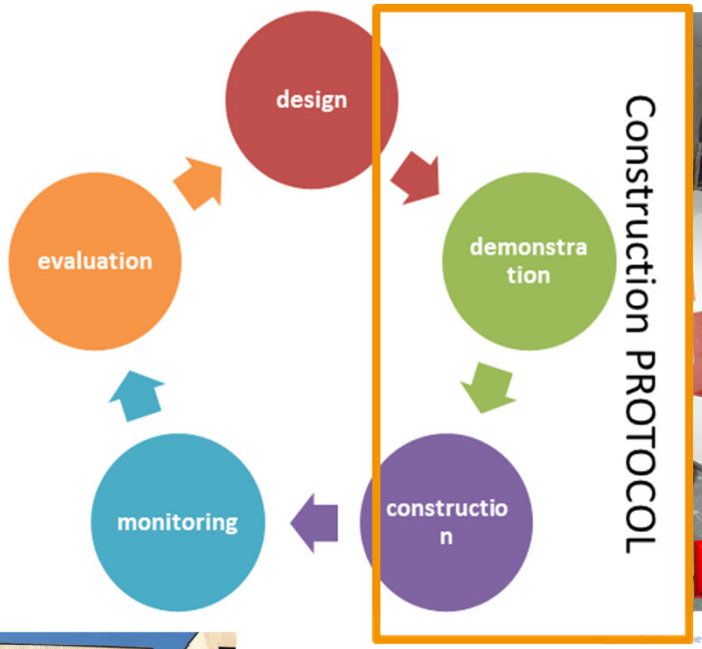


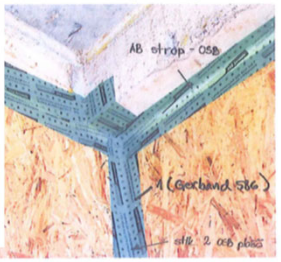


Lessons learnt - Brdo/Ljubljana NZEB case study

- **QA in design and construction - airtightness**
  - Traditionally QA is imposed in construction phase
  - Design & Technological study: project details, materials, certificates, work protocol, responsible persons
  - Construction protocol
  - Training of staff on-site
  - Demonstration
  - Internal control, liabilities
  - External control - intermediate and final Blower-door tests
- **QA in post occupational maintenance**
  - Numerous NZEB technologies need skilled building manager







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Conclusion – progress in early NZEBs in Slovenia

- Multi-family buildings - private developers, at least half with vent. with HR
  Eco fund: subsidy for individual buyers of flats in MFB NZEB
- Single family houses – over 1,200 NZEBs – incentives of Eco fund:
  NZEB, wooden frame windows, wooden facade, eco insulation



- New public NZEBs - **„CC-SI 126: buildings of general social interest“**,
  for culture and entertainment, museums, libraries, education and research work, health care, sport activities – Eco fund soft loan and subsidy
- SFH NZEBs are leading early NZEBs / public NZEB – progress close to the plan / other building types – slower
- Reduction of NZEB costs – not yet the case / quality assurance – fast progress
- Comprehensive design skills – needed / skilled designers & contractors – not sufficient in some sectors
- Green procurement rules – future development towards sustainability
- Literature: D. Varšek, G. Rak (SSRS), 2721 - Model House F3 in Ljubljana – Nearly Zero-Energy Building, IAQVEC 2019, H2020 CoNZEBs (GI ZRMK, SSRS)


Source: www.ee-highrise.eu (H2020 EE_HIGHRISE, 2016)


Source: Vendramin, Eko Sklad, LOČE kindergarten

Outlook – what comes next?

- KfW/Fraunhofer IBP offer country-specific NZEB/Energy Plus House workshops (new construction and refurbishment) as video conference or on-site (if travel restrictions allow)
- Study trip on NZEB / Energy Plus Houses planned for late 2020 / early 2021
- Proposal for NZEB / Energy Plus Houses (TA and INV) submitted to EU (-> REEP PLUS)

Thank you for your attention!

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