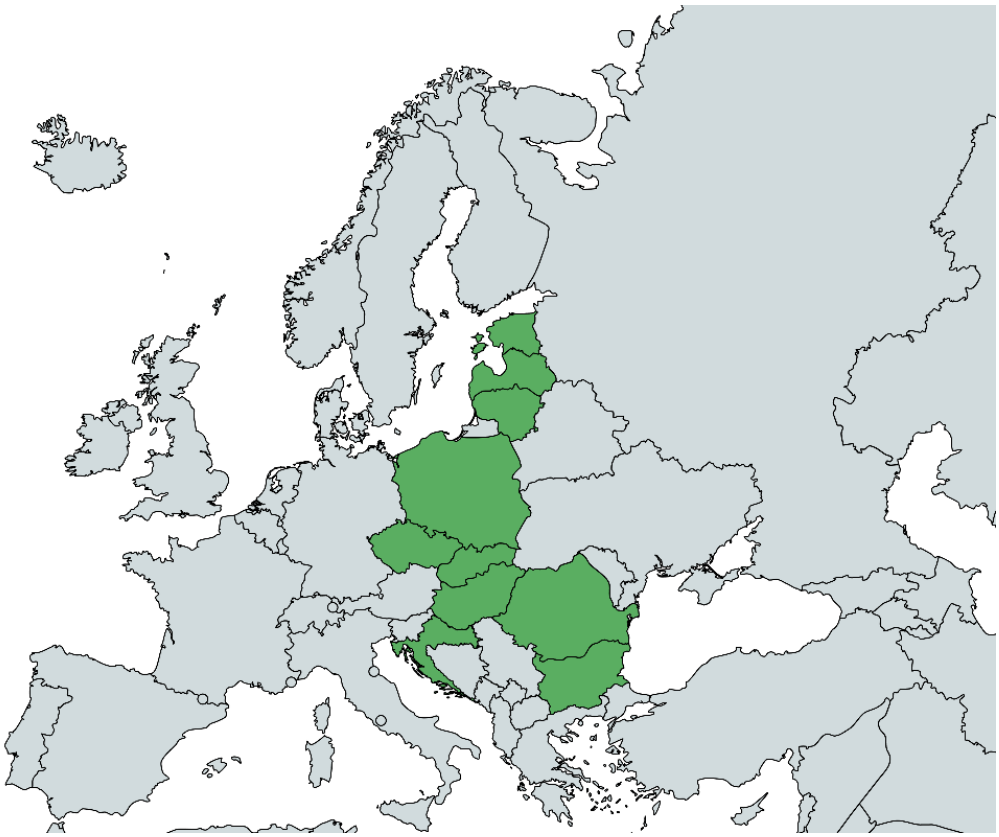
DATA ON RESIDENTIAL NEARLY ZERO ENERGY BUILDINGS (nZEB) DESIGN IN EASTERN EUROPE

Shady Attia, Piotr Kosiński, Oriane Laurent, Nicola Mihailov, Boris Evstatiev, Hrvoje Krstić, Karel Struhala, Roman Brzoň, Jarek Kurnitski, Zsofia Deme Belafi, Anatolijs Borodiņecs, Karolis Banionis, Ion Visa, Macedon Moldovan, Miroslav Čekon, Silvia Vilčeková



2022, April – Version 3.0

DATA ON RESIDENTIAL NEARLY ZERO ENERGY BUILDINGS (nZEB) DESIGN IN EASTERN EUROPE

Shady Attia[a], Piotr Kosiński[b], Oriane Laurent[ac], Nicola Mihailov[d], Boris Evstatiev[d], Hrvoje Krstić[e], Karel Struhala[f], Roman Brzoň[f], Jarek Kurnitski[g], Zsofia Deme Belafi[h], Kistelegdi István[i], Anatolijs Borodiņecs[j], Karolis Banionis[k], Ion Visa[l], Macedon Moldovan[l], Miroslav Čekon[m,n], Silvia Vilčeková[o]

Affiliations:

[a] Sustainable Building Design Lab, Department UEE, Faculty of Applied Sciences, Université de Liège, Belgium

[b] University of Warmia and Mazury, Olsztyn, Poland

[c] EPF Graduate School of Engineering, Montpellier, France

[d] University of Ruse Angel Kanchev, Ruse, Bulgaria

[e] Faculty of Civil Engineering and Architecture Osijek, Josip Juraj Strossmayer University of Osijek, Vladimira Preloga 3, 31000 Osijek, Croatia

[f] Brno University of Technology, Faculty of Civil Engineering, Veveří 331/95, 602 00 Brno, Czech Republic

[g] Department of Civil Engineering and Architecture, Tallinn University of Technology, Tallinn, Estonia

[h] Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Building Services and Process Engineering, Budapest, Hungary

[i] University of Pécs, János Szentágothai Research Centre - Faculty of Engineering and Information Technology, Institute of Architecture - Department of Building Structures and Energy Design, Pécs, Hungary

[j] Riga Technical University, Faculty of Civil Engineering, Riga, Latvia

[k] Laboratory of Building Physics, Institute of Architecture and Civil Engineering, Kaunas University of Technology, Kaunas, Lithuania

[l] Renewable Energy Systems and Recycling Research Centre, Transilvania University of Brasov, Romania

[m] Slovak Academy of Science, Institute of Construction and Architecture, Bratislava, Slovakia

[n] Slovak University of Technology, Faculty of Civil Engineering, Bratislava, Slovakia

[o] Technical University of Košice, Faculty of Civil Engineering. Vysokoškolská 4, 04200 Košice, Slovakia

*Corresponding author.
Mailing address and contact information:
Shady Attia,
Université de Liège, Sustainable Building Design Lab, Office +0/542, Quartier Polytech 1, Allée de la Découverte 9
4000 Liège, Belgium
Tel: +32 43.66.91.55 – Fax: +32 43.66.29.00 – Email: **shady.attia@uliege.be**

Summary

3. Overview of nearly Zero Energy Buildings status in EasterN Europe .....**Error! Bookmark not defined.**

3.1. Bulgaria **Error! Bookmark not defined.**

3.2. Croatia **Error! Bookmark not defined.**

3.3. Czech REPUBLIC **Error! Bookmark not defined.**

3.4. Estonia **Error! Bookmark not defined.**

3.5. Hungary **Error! Bookmark not defined.**

3.6. Latvia **Error! Bookmark not defined.**

3.7. Lithuania **Error! Bookmark not defined.**

3.8. Poland **Error! Bookmark not defined.**

3.9. Romania **Error! Bookmark not defined.**

3.10. Slovakia **Error! Bookmark not defined.**

APPENDIX 1: QUESTIONAIRE 165

3. OVERVIEW OF NEARLY ZERO ENERGY BUILDINGS STATUS IN EASTERN EUROPE

Following the legislative context of nZEB in Europe reviewed in Chapter 2, we present the results of interviewing national experts in countries for which we could have access to representative information and insights.

3.1. BULGARIA

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.1.1: nZEB status in Bulgaria

Legislation	
Definition nZEB available	Yes. The national definition for nZEB is given in the "NATIONAL NEARLY ZERO-ENERGY BUILDING PLAN 2015–2020", which was accepted by the Councils of Ministers at the end of 2015.
Min. threshold set	Yes.
Subsidy retrofitting towards nZEB	No, there are no financial instruments directly for nZEB. However, there are such improvements in the energy efficiency of existing residential buildings by the replacement of windows, insulation of walls, roofs, etc. For example, by the end of 2019, 1820 high-rise buildings were renovated and more than 3000 are in progress.
Min. Energy efficiency PE use intensity ($kWh/m^2.a$)	Residential – 48 kWh/m^2 Administrative – 70 kWh/m^2 Schools – 25 kWh/m2 Universities – 45 kWh/m^2 Etc.
Min. perf. Threshold heating demand ($kWh/m^2.a$)	No.

Min. perf. Threshold cooling demand ($kWh/m^2.a$)	No.
Life Cycle Assessment	No.
CO_2	No.
Airtightness	Yes. According to the "NATIONAL NEARLY ZERO-ENERGY BUILDING PLAN 2015–2020," the airtightness should be taken into account when calculating the "specific annual consumption of primary energy".
Heating Cooling Balance	
Natural ventilation possible	Yes.
Technical System Min. performance requirements	Not defined.
Thermal Comfort Limits	
Climate Zones	There are a total of 9 climate zones in Bulgaria to calculate the energy efficiency of buildings.
Overheating risk	Yes, the climate in Bulgaria is characterized by very hot summers.
Thermal comfort Standard	Yes. The thermal comfort standard is defined in "Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (ISO 7730:2007)".
Efficiency vs Renewable Threshold **RES (%)**	Not defined.
Construction Quality	
Available materials	Medium.

Available knowledge	Low.

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

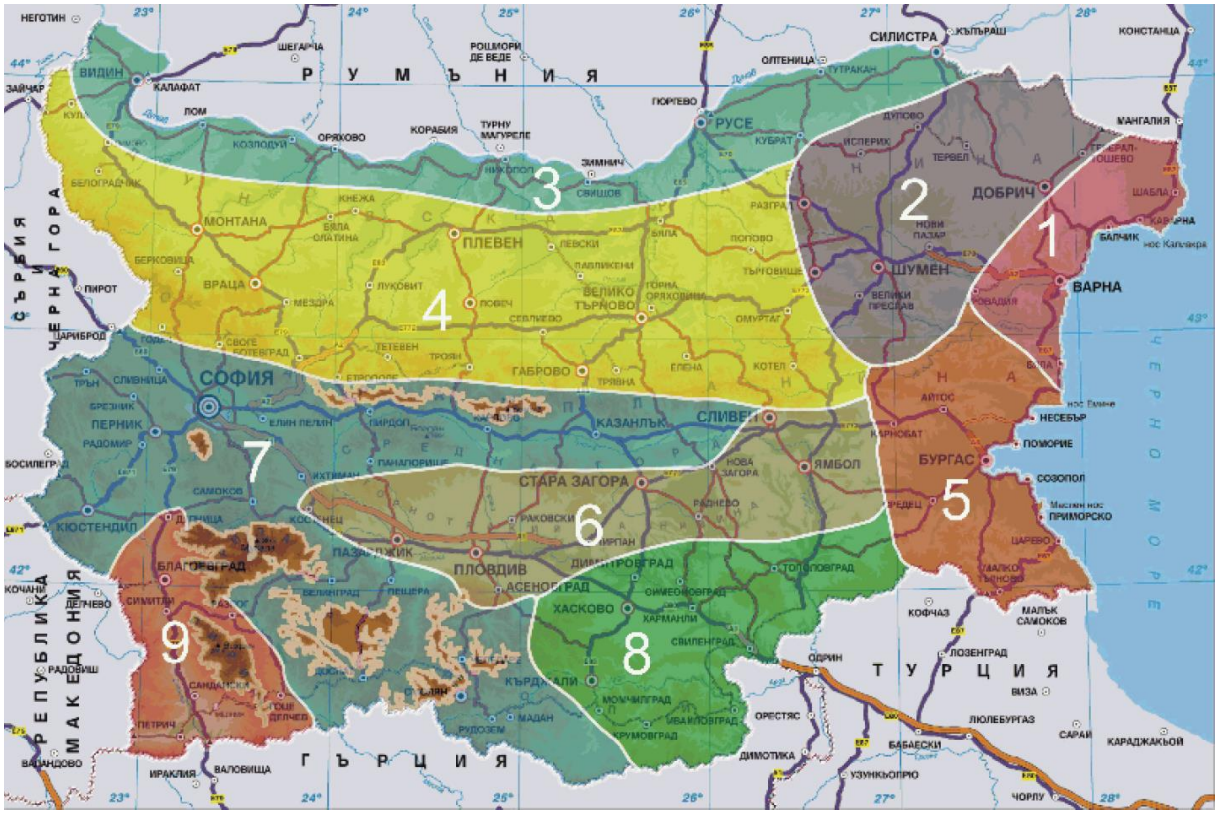


Figure 3.1.1: Climate zones of Bulgaria to calculate the energy efficiency of buildings

Source: Ordinance №7 of 2004 on the energy efficiency of buildings of the Ministry of Regional Development and Public Works, Bulgaria.

3. What is the minimum energy efficiency threshold for nZEBs in your country?

In Bulgaria, the minimum energy efficiency threshold for nZEB consists of:

1. Energy class A (total primary energy consumption)
2. At least 55 % of the energy consumption (for cooling, heating, ventilation, domestic hot water, and lighting) is from renewable energy sources (without appliances)

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

Currently, there are no such thresholds set.

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

The number of nZEB houses in Bulgaria is still low which limits the experience related to them. Furthermore, the definition of such thresholds is a complex task, which should be decided by different types of experts (architects, civil engineers, energy experts, economists, etc.).

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m2/a for heating demand. Could this become the case in your country? and why?

The climate conditions in Bulgaria are characterized by hot summers and relatively cold winters. The average temperature in January is (-2 … -3) °C and in July is (25 … 26) °C. The main energy expenses for climatization are during the winter season, therefore the threshold of 15kWh/m2.a, which is set in the PassivHaus Standard should be applicable in Bulgaria.

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity, and heating and cooling balance. If you have a climate contrast (for example heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

According to the Bulgarian standard БДС 14776:1987, the inside building temperature should be from 18 to 25 °C. Considering the average climate temperatures during the summer are (25 … 26) °C, the cooling demand is relatively low.

Furthermore, in all 9 climate zones in Bulgaria (to calculate the energy efficiency of buildings) the heating season is 6 months. Therefore, there is no significant climate contrast, and all cities are heating-dominated.

4.b. Can you reach nearly zero heating demand?

The nearly zero heating demand cannot be reached for already existing buildings because of limitations implemented during design time. The nearly zero heating demand could be reached for new buildings.

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

According to Savov et al [7] the recommended value of the airtightness is n_50<1 h^(-1) of the air exchange rate at 50 Pa difference. According to the same authors, for a passive house, it should be n_50<0.6 h^(-1).

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity regarding the electric or thermal demand?

Currently, the heating demand is met as follows: Electricity – 28.62%, Firewood - 34.07%, Coal - 19.81%, District heating 15.07%, and other - 2.43%. The cooling demand is met mostly with electricity.

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBS.*

The thermal comfort standard is defined in “Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria” (БДС EN ISO 7730: 2007) and in “Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics” (БДС EN 15251:2007). Furthermore, the standard “Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics - Module M1-6” (БДС EN 16798-1:2019) is also in force.

5.a.2. Cite the reference, and share the reference in pdf format if possible.

1. https://www.bds-bg.org/bg/standard/?natstandard_document_id=47977

2. https://www.bds-bg.org/standard/?national_standard_id=62584

3. https://www.bds-bg.org/bg/standard/?natstandard_document_id=94080

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

In Bulgaria, both standard EN 15251 and EN ISO 7730 are in force. However, the Bulgarian Ordinance №7 (last modified in 2017) for the energy efficiency of buildings does not recommend the application of a specific model.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.1.2: Overheating assessment in Bulgaria

Country	Bulgaria
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	In Bulgaria there are 9 climate zones (1,2,3,4,5,6,7,8,9). Civil engineers size the building thermal parameters according to Ordinance №7.
Do you have a specific comfort calculation approach for heatwaves?	No.
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No.
Occupant type and representation	
What is your comfort standard?	БДС EN 15251 БДС EN ISO 7730
For which building types?	Residential and commercial.
Does your method embrace the four occupant categories (I, II, III, IV)? *	Yes.
How do you represent occupancy presence in the simulation model?	
Comfort model	
What is your overheating indicator?	The building's inside temperature.
Is your comfort model based on an adaptive or static method?	Static.
What are your overheating thresholds? and according to which standard are those thresholds defined?	For commercial spaces: - maximal 28 °C in normal cases and 26 °C in case of heavy physical work

	- minimal from 12 °C to 18 °C, depending on the type of activity Standard: БДС 14776:1987
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	No.
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air-conditioned chairs, electric heating mattresses…)?	No.
<u>Simulation model</u>	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	In practice different simulation software, which adopts different models. There are no requirements to use a specific methodology or software.
Is your overheating calculation based on a single or multizone model?	Multizone model.
Does your calculation distinguish sleeping rooms from other living areas?	No.
<u>Mandatory envelope requirements</u>	
Does your method oblige the installation of external shading?	No.
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No.
Does your method recommend a g-value? If yes, what is the limit?	No.
* We are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

Bulgaria has fuel poverty problems, caused by: low income, low energy efficiency (inadequate insulation, old or inefficient heating systems), relatively high energy prices, under-occupancy (there is a tendency for a decrease in the population).

5.c.1. What are the overheating criteria for nZEBs in your country?

The room temperature is at least two consecutive days during the winter and summer seasons. There are no specifics for nZEB.

5.c.2. What is the overheating risk for nZEB (highly insulated) in your climate?

The overheating risk for nZEB depends on the climate zone. In some zones, there are extreme summer temperatures and therefore the overheating risk is high, while in other zones the risk is low.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

According to [8] (Ordinance № РД-07-3 from 18.07.2014 for the minimal requirements of microclimate at working places), the temperature is measured on equally spaced time intervals in at least two consecutive days during the winter and summer seasons. The temperature should be within the necessary range all the time.

5.d. Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?

In some of the climate zones, passive cooling for nZEB is applicable. To the best of our knowledge, there are no experimental results for Bulgaria to assure that passive cooling is applicable in all zones.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

The investment in RES is mainly related to the creation of PV plants. The investment in energy efficiency is mainly related to improving the insulation and windows. For both of them, there are appropriate national financial instruments. Both of them have problems with the implementation.

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?

PV energy has the highest potential from the RES in Bulgaria. Considering the energy production is mostly in the summer and the required energy consumption for heating is mostly in the winter, an appropriate threshold would be 30%. If the price of

energy-storing devices decreases significantly in the future, this percent could be easily increased.

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

Yes, the current legislation allows easy construction of small and medium-sized PV power plants (less than 30 kW) on roof and façade constructions. For the time being, such installations are joined to the grid without problems.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

Maybe medium and low-tech nZEB solutions are more appropriate for Bulgaria.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

The main barriers are the price, the lack of experience of the civil engineers, the lack of expertise and competencies of the workers.

8. What should be (your recommendation) the minimum energy efficiency and RET in your country? Fill in the table below (energy efficiency, RET Renewable Energy Threshold onsite):

Table 3.1.3: EE and RES recommended thresholds for Bulgaria

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
Residential buildings	20 – 40 kWh/m^2.a	10 kWh/m^2.a	30 %
	30 – 40 kWh/m^2.a	30 – 40 kWh/m^2.a	

9. REFERENCES / KEY PUBLICATIONS:

1. БДС EN ISO 7730:2007. Ергономия на заобикалящата топлинна среда. Аналитично определяне и интерпретация на топлинния комфорт чрез пресмятане на индексите PMV и PPD и критерия за локален топлинен комфорт (ISO 7730:2005).

2. БДС EN 15251:2007. Входящи параметри за качеството на вътрешния въздух, заобикалящата топлинна среда, осветлението и акустиката при проектиране и оценка на енергийната характеристика на сгради

3. БДС EN 16798-1:2019. Енергийни характеристики на сгради. Вентилация на сгради. Част 1: Входни параметри на вътрешната околна среда за проектиране и оценяване на енергийните характеристики на сгради, насочени към качеството на вътрешния въздух, топлинната среда, осветлението и акустиката. Модул М1-6.

4. БДС 14776:1987. Охрана на труда. Работни места в производствени помещения. Санитарно-хигиенни норми за температура, относителна влажност, скорост на въздуха и топлинно облъчване.

5. National nearly zero-energy building plan 2015–2020, Sofia, Bulgaria, November 2015.

6. Ministry of Regional Development and Public Works. Ordinance №7 of 2004 on the energy efficiency of buildings of the Ministry of Regional Development and Public Works, Bulgaria. Last modified on 21st of November, 2017.

7. R. Savov, V. Maneva, D. Jordanov, D. Ivanov. Handbook for construction professionals (In Bulgarian: Савов Р., В. Манева, Д. Йорданов, Д. Иванов. Наръчник за строителни специалисти. https://www.bcci.bg/resources/files/RAKOWODSTWO.pdf)

8. Minister of Labour and Social Policy and Minister of Health Care. Ordinance № РД-07-3 from 18.07.2014 for the minimal requirements of microclimate at working places (In Bulgarian: НАРЕДБА № РД-07-3 от 18.07.2014 г. за минималните изисквания за микроклимата на работните места).

3.2. CROATIA

The first official introduction of the term annual energy needs for heating, Q_h [kWh/a] in Croatia can be traced back to 2006 and a document titled Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings [1]. This Regulation first allowed energy needs for heating for residential and non-residential buildings heated to a temperature of 18 °C or higher. Allowed energy needs were defined concerning the building shape factor f_0 [m^{-1}].

Croatia's entry into the European Union on July 1, 2013, marked the beginning of energy certification of buildings with the first Ordinance on energy audits and energy certification of buildings [2]. The calculation of energy required for cooling was later introduced in 2008.

And finally, the primary energy consumption limitation and definition of nearly zero energy buildings (nZEB) in Croatia was brought in 2014 by Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings [3]. The regulation was written to align with the requirements of Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings. Even before 2014, there have been many educational and promotional activities- from European projects where Croatia had a representative (i.e. IEE project SUSTAINCO, 2011) to local and regional events (nZEB Regional Conference in Dubrovnik, 2014) [4].

Regulation [3] stipulated that from December 31, 2020, all new buildings must be nZEB, and after December 31, 2018, also all new buildings used by public authorities or owned by public authorities. Regulation [3] was revised in 2015 but the definition of nZEB building stayed the same - Nearly zero energy building is a building with very high energy properties. This almost zero or very low amount of energy should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on or near the building, for which the requirements are laid down in Regulation.

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.2.1: nZEB status in Croatia

Legislation	
Definition nZEB available	Yes.
Min. threshold set	Yes.
Subsidy retrofitting towards nZEB	Currently no, but there is the document titled Programme for encouraging the

	construction of new and retrofitting existing buildings to nZEB standard made by the Ministry of Physical Planning, Construction and State Assets in 2018 [13].
Min. Energy efficiency PE use intensity (kWh/m^2.a)	See Table 3.2.2.
Min. perf. Threshold heating demand (kWh/m^2.a)	See Table3.2.2.
Min. perf. Threshold cooling demand (kWh/m^2.a)	50 or 70 kWh/m^{2}a depending on the share of window surfaces in the total façade area.
Life Cycle Assessment	No.
CO_2	No, but there is an obligation to calculate emissions when issuing an Energy certificate for all buildings stated in kg/m^{2}a.
Airtightness	Yes, a maximum value of n_{50} is specified, 3.0 h^{-1} for buildings with natural ventilation or 1.50 h^{-1} for buildings with mechanical ventilation. The fulfillment of the airtightness requirements is supposed to test on the new buildings or reconstructed existing ones according to HRN EN ISO 9972: 2015, method of determination 1, before technical inspection.
Heating Cooling Balance	
Natural ventilation possible	Yes.
Technical System Min. performance requirements	In [5] there is only the following requirement: The designed and constructed heating system of a building must predict heat losses at least at the level of internal thermal comfort defined by this Regulation or listed in the project task, if stricter than prescribed.

Thermal Comfort Limits	
Climate Zones	Yes, 2 zones. See Figure 3.2.1.
Overheating risk	Yes, covered in [5], it is stated how overheating should be prevented by applying proper technical solutions. Building areas should not overheat more than 4 °C due to solar radiation compared to the internal design temperature of the area.
Thermal comfort Standard	Yes, but our Regulation [5] refers to EN 15251:2008. The comfort of the indoor area shall be ensured by fulfilling the conditions for heating, cooling, and ventilation, thermal stability and indoor surface temperatures, regulated humidity, proper lighting, and allowed noise level in the space. The recommended values are defined by EN 15251:2008 where microclimatic parameters of the buildings are related to the air quality, thermal comfort, lighting, and acoustics.
Efficiency vs Renewable Threshold **RES (%)**	At least 20% of the total energy delivered for the operating systems in a building covered by energy from renewable energy sources or - the share of renewable energy sources in the total energy delivered for the operation of thermomechanical systems at least: 25% from solar radiation or 30% from gaseous biomass or 50% from solid biomass or 70% from geothermal energy or 50% from ambient heat or 50% from a cogeneration plant with high efficiency or 50% of the energy needs of a building covered from remote heating.
Construction Quality	
Available materials	High.

Available knowledge	Medium. Perhaps it should be stated how there are problems on the market regarding well-skilled workers which often tend to work rather in western European countries than in Croatia. The lack of qualified workers is a huge problem in Croatia due to the migration of workers to the Western European countries as well as because of increased demand for workers for energy retrofitting projects caused by importing the foreign unqualified or under qualified workforce [10].

Residential building and non-residential building of nearly zero energy is a building where:

- The annual heating energy required per area unit of the useful area of the heated part of the building, $Q'_{H,nd}$ [kWh/(m^2a)], does not exceed the permitted values set out in Table 3.2.2. (Annex B of the Regulation [5]) and
- The annual primary energy per area unit of the useful area of the heated part of the building E_{prim} [kWh/(m^2a)], which includes energy specified in Table 2. (Annex B of the Regulation [5]) and does not exceed the other permitted values of Regulation [5] like the maximum allowed values of heat transfer coefficient U-value [W/(m^2K)] and a minimum class of airtightness of windows, balcony doors and roof windows.

Guidelines for nZEB for investors and design engineers are made by the Ministry of Physical Planning, Construction and State Assets, there are two sets of them:

- Guidelines for nearly zero energy buildings - Part ONE (intended for the general public concerned) [6] and
- Guidelines for nearly zero energy buildings - Part TWO (intended for the professional public concerned) [7].

Table 3.2.2: Maximum allowed values of $Q'_{H,nd,}$ and E_{prim} for new buildings (nZEBs) heated and/or chilled to a temperature of 18°C or higher

Requirements for new buildings	**$Q''_{H,nd}$ [kWh/(m^2a)]**		**E_{prim} [kWh/(m^2a)]**	
	nZEB		**nZEB**	
Type of building	**Continental part of**	**The coastal part of**	**con**	**coa**

	Croatia, $\theta_{mm} \leq 3°C$			Croatia, $\theta_{mm} > 3°C$			t. $\theta_{mm} \leq 3°C$	st $\theta_{mm} > 3°C$
	$f_0 \leq 0,20$	$0,20 < f_0 < 1,05$	$f_0 \geq 1,05$	$f_0 \leq 0,20$	$0,20 < f_0 < 1,05$	$f_0 \geq 1,05$		
Residential	40.50	$32.39 + 40.58 \cdot f_0$	75.00	24.84	$19.86 + 24.89 \cdot f_0$	45.99	80	50
Family houses	40.50	$32.39 + 40.58 \cdot f_0$	75.00	24.84	$17.16 + 38.42 \cdot f_0$	57.50	45	35
Offices	16.94	$8.82 + 40.58 \cdot f_0$	51.43	16.19	$11.21 + 24.89 \cdot f_0$	37.34	35	25
Education	11.98	$3.86 + 40.58 \cdot f_0$	46.48	9.95	$4.97 + 24.91 \cdot f_0$	31.13	55	55
Hospitals	18.72	$10.61 + 40.58 \cdot f_0$	53.21	46.44	$41.46 + 24.89 \cdot f_0$	67.60	250	250
Hotels and restaurants	35.48	$27.37 + 40.58 \cdot f_0$	69.98	11.50	$6.52 + 24.89 \cdot f_0$	32.65	90	70
Sports halls	96.39	$88.28 + 40.58 \cdot f_0$	130.89	37.64	$32.66 + 24.91 \cdot f_0$	58.82	210	150
Market	48.91	$40.79 + 40.58 \cdot f_0$	83.40	13.90	$8.92 + 24.91 \cdot f_0$	35.08	170	150
Other non-residential	40.50	$32.39 + 40.58 \cdot f_0$	75.00	24.84	$19.86 + 24.89\ f_0$	45.99	/	/
Θ_{mm} is the mean monthly temperature of the outdoor air of the coldest month of the year at the location of the building								

Table 3.2.3: Technical systems defined* for the calculation of delivered and primary energy

No	Type of building	Heating system	Cooling system	Preparation of hot water	Mechanical ventilation and air conditioning system	Lighting system
1	Residential	Yes	No	Yes	Consider if there is	No

2	Family houses	Yes	No	Yes	a system installed	No
3	Offices	Yes	Yes	No		Yes
4	Education	Yes	No	No		Yes
5	Hospitals	Yes	Yes	Yes		Yes
6	Hotels and restaurants	Yes	Yes	Yes		Yes
7	Sports halls	Yes	Yes	Yes		Yes
8	Markets	Yes	Yes	No		Yes
9	Other non-residential	Yes	No	No		Yes
* For the calculation of the share of renewable energy sources in the total energy delivered, all delivered energies of all technical systems installed in the building can be used.						

The annual heat demand for cooling, $Q_{C,nd}$ (kWh/a), is a calculated determined the amount of heat to be taken from the building by the cooling system during one year by maintaining the indoor design temperature in the building during the cooling period and it is calculated under HRN EN ISO 13790:2008.

Residential and non-residential buildings for office purposes, educational purposes, hospitals, hotels, and restaurants must be designed and constructed in a way that the QC,nd per area unit of the useful surface of the building does not exceed 50 kWh/(m^2a), but for the buildings with the share of window surfaces in the total façade higher than 30% restriction of $Q_{C,nd}$ is limited to 70 kWh/(m^2a) [5].

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

Table 3.2.2 shows how requirements for nZEB buildings are defined based on the type of building and building location, the continental part of Croatia, or the coastal part of Croatia. This division puts the whole of Croatia in two climate zones based on the mean monthly temperatures of the outdoor air of the coldest month of the year at the location of the building, graphically presented in Figure 1:

- Continental zone (when the mean monthly temperature of the coldest month at the location of the building is ≤ 3 °C according to meteorological data for the nearest meteorological station) and
- Coastal zone (when the mean monthly temperature of the coldest month at the location of the building is > 3 °C according to meteorological data for the nearest meteorological station).

The division of Croatia into two climate zones according to the network of climatological meteorological stations is presented in Figure 1 based on the data from the Croatian Meteorological and Hydrological Service [8]. Eastern from the blue line is the continental part of Croatia and western is the coastal part.

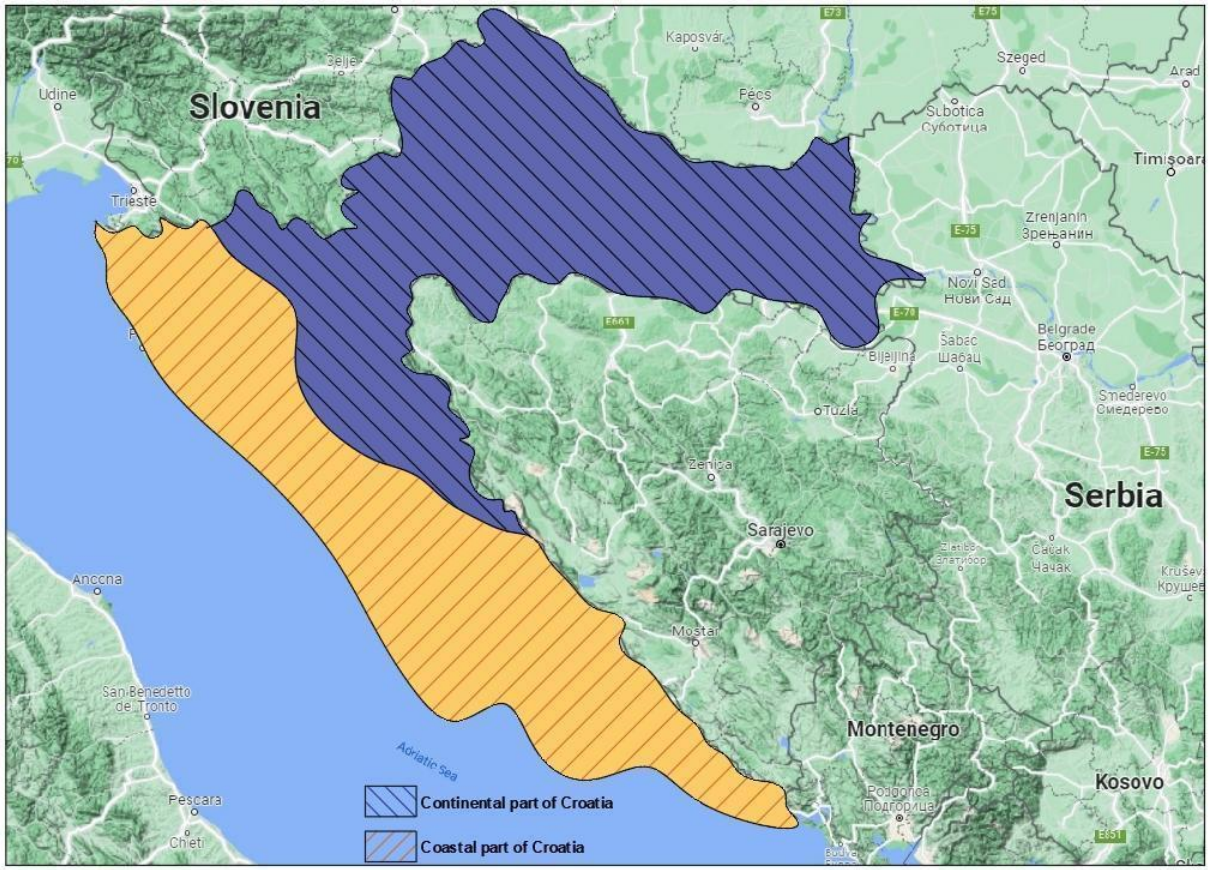


Figure 3.2.1: Two climate zones of Croatia

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency threshold regarding end-use and primary use intensity and CO_2 emissions?

Thresholds are defined based on the $Q'_{H,nd,}$ and E_{prim}. Our regulations define maximum allowed values according to Table 3.2.2 and Table 3.2.3. However, we don't have thresholds related to CO_2 emissions.

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

I would probably go for a principle of reciprocity concerning prescribed maximum values of $Q'_{H,nd}$ and/or E_{prim}. For nZEB it should not be higher than 15 kg/m^{2}a. But the type of building should be one of the criteria for determining thresholds.

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m2/a for heating demand. Could this become the case in your country? and why?

Probably not since EU directives were followed when determining the values of heating demand therefore I think there is no need for adaptation of PassivHaus Standard in Croatia. Climate zones vary across the EU to adopt one unique standard.

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity, and heating and cooling balance. If you have a climate contrast (for example heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

Table 3.2.2 shows how requirements for nZEB buildings are defined based on the type of building and building location, the continental part of Croatia, or the coastal part of Croatia. This division puts the whole of Croatia in two climate zones based on the mean monthly temperatures of the outdoor air of the coldest month of the year at the location of the building, graphically presented in Figure 3.2.1:

- Continental zone (when the mean monthly temperature of the coldest month at the location of the building is ≤ 3 °C according to meteorological data for the nearest meteorological station) and
- Coastal zone (when the mean monthly temperature of the coldest month at the location of the building is > 3 °C according to meteorological data for the nearest meteorological station).

The division of Croatia into two climate zones according to the network of climatological meteorological stations is presented in Figure 3.2.1 based on the data from the Croatian Meteorological and Hydrological Service [8]. Eastern from the blue line is the continental part of Croatia and western is the coastal part.

The annual heat demand for cooling, $Q_{C,nd}$ (kWh/a), is a calculated determined the amount of heat to be taken from the building by the cooling system during one year

by maintaining the indoor design temperature in the building during the cooling period and it is calculated under HRN EN ISO 13790:2008.

Residential and non-residential buildings for office purposes, educational purposes, hospitals, hotels, and restaurants must be designed and constructed in a way that the QC,nd per area unit of the useful surface of the building does not exceed 50 kWh/(m^2a), but for the buildings with the share of window surfaces in the total façade higher than 30% restriction of $Q_{C,nd}$ is limited to 70 kWh/(m^2a) [5].

4.b. Can you reach nearly zero heating demand?

As far as I know, yes but on the other hand, during this research, I was unable to find any data regarding the number of nZEB's in Croatia, private or public ones.

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

The maximum value of n_{50} is specified, 3.0 h^{-1} for buildings with natural ventilation or 1.50 h^{-1} for buildings with mechanical ventilation. The fulfillment of the airtightness requirements is supposed to test on the new buildings or reconstructed existing ones according to HRN EN ISO 9972:2015, method of determination 1, before technical inspection. The stricter requirement would not be recommended as far as I'm concerned because out of five nZEBs I have tested so far only 2 fulfilled the requirement. Problems are with windows, doors, sockets, and junctions of walls and ceilings in the attic. Also, private investors when building family houses are not willing to invest in controlled ventilation systems and windows that can't be opened.

I would suggest maintaining levels of airtightness set by current regulations and trying to research for a few years regarding levels of airtightness in buildings to see where the biggest problems are and how to avoid them.

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity concerning the electric or thermal demand?

As far as I know, there is no influence when it comes to pricing or problems with supply. I didn't find research or data to answer this question.

Perhaps this can help [14]:

In today's balance of primary energy supply in Croatia, oil and oil products are represented with 50% and natural gas with 25,6%. Consumption of these fuels shall grow in the future, while local oil and natural gas production is going to decrease due to exhaustion of deposits (beyond 2010). Croatia is therefore facing many challenges to the security of the energy supply:

- Oil deposits are concentrated in politically unstable regions of the world;

- Wars, terrorism, accidents, and natural disasters can disturb oil and natural gas supply, prevent new investments and increase the price of oil and natural gas;
- Share of locally produced oil and natural gas covering the demand shall decrease, while the dependence on imports shall increase. Share of imports in covering overall energy demand is going to increase as well!

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBs.*

Guidelines for nZEB buildings for investors and design engineers are made by the Ministry of Physical Planning, Construction and State Assets, two sets of them:

- Guidelines for nearly zero energy buildings - Part ONE (intended for the general public concerned) and
- Guidelines for nearly zero energy buildings - Part TWO (intended for the professional public concerned).

But there are no special recommendations regarding thermal comfort in them. Regulation [5] refers to EN 15251:2008 when it comes to thermal comfort regardless of whether it is an nZEB or not. The comfort of the indoor area shall be ensured by fulfilling the conditions for heating, cooling, and ventilation, thermal stability and indoor surface temperatures, regulated humidity, proper lighting, and allowed noise level in the space. The recommended values are defined by EN 15251:2008 where microclimatic parameters of the buildings are related to the air quality, thermal comfort, lighting, and acoustics.

5.a.2. Cite the reference, and share the reference in pdf format if possible.

They are at the end of the section.

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

Article 43, Regulation [5]: Recommended budget values are defined by HRN EN 15251:2008 containing input values of microclimatic parameters for the design and evaluation of the energy performance of buildings relating to air quality, thermal comfort, lighting, and acoustics.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.2.3: Overheating assessment in Croatia

Country	Croatia

Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	No.
Do you have a specific comfort calculation approach for heatwaves?	No.
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No.
Occupant type and representation	
What is your comfort standard?	Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting, and acoustics (EN 15251:2008).
For which building types?	All.
Does your method embrace the four occupant categories (I, II, III, IV)? *	No.
How do you represent occupancy presence in the simulation model?	No.
Comfort model	
What is your overheating indicator?	Yes, covered in [5], it is stated how overheating should be prevented by applying proper technical solutions. Building areas should not overheat more than 4°C due to solar radiation compared to the internal design temperature of the area.
Is your comfort model based on an adaptive or static method?	Static.

What are your overheating thresholds? and according to which standard are those thresholds defined?	We don't have them.
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	Yes.
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air-conditioned chairs, electric heating mattresses…)?	No.
<u>Simulation model</u>	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Quasi-dynamic calculation based on monthly values.
Is your overheating calculation based on a single or multizone model?	-
Does your calculation distinguish sleeping rooms from other living areas?	No.
<u>Mandatory envelope requirements</u>	
Does your method oblige the installation of external shading?	No.
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No.
Does your method recommend a g-value? If yes, what is the limit?	0.25 to 0.87 depending on the glazing and shading type.
* we are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

I would say when it comes to our position in GDP (PPP) per capita in Europe, we take position number 32 from 40 countries. We are the second last country in the EU when it comes to GDP per capita, consumption per capita, and price level indices: https://ec.europa.eu/eurostat/statistics-explained/index.php/GDP_per_capita,_consumption_per_capita_and_price_level_indices. So, poverty, low GDP are negatively influencing nZEB objective! But this year we also had a "Public call for financing energy renovation of family homes for vulnerable citizens at risk of energy poverty".

5.c.1. What are the overheating criteria for nZEBs in your country?

Except ones stated above in the text, we don't have any other.

5.c.2. What is the overheating risk for nZEB's (highly insulated) in your climate?

Glass facades. Large windows without shading mechanism. Or an inappropriate one.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

No. I did not find any in our regulations or guidelines for nZEBs.

5.d. Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?

Since a significant part of the country is at the Adriatic coast, there are definitely active cooling systems for nZEB's. This probably wouldn't be necessary for one part of the country with a mountain climate, but that part of the country is sparsely populated anyway.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

Until two years I would probably say in energy efficiency but this year we had two calls:

- Public call for co-financing the use of renewable energy sources for the production of heat or heat and cooling energy in households, for own consumption
- Public call for co-financing energy renovation of family houses (besides co-financing energy efficiency it also included co-financing by 60% of the investment in renewables.

Calls were under our Energy Efficiency and Environmental Protection Fund.

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?

We now have for new buildings at least 20% of the total energy delivered for the operating systems in a building covered by energy from renewable energy sources. I would not recommend higher demand for now (considering what I wrote about energy poverty, low GDP, problems with workers…). The type of renewable energy onsite depends on location, at the coastal part we have a lot of potential of using sun and wind. In the continental part sun and geothermal sources are at several locations.

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

Regulations and policies in Croatia are not ready for encouraging energy-producing buildings. Energy grid I would probably say yes in densely populated areas, but there are problems in areas with depopulation.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

For the wider population, I would say low-tech nZEB solutions and leave the high-tech nZEB solutions for funding through EU projects accompanied by the case studies.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

Lack of money, labor force, and dependence on imports of all these high-tech solutions! We will spend more money than benefit from it! People see those high-tech solutions as imposed by richer countries and don't see the benefit of embracing them!

8. What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold onsite):

Table 3.2.4: EE and RES recommended thresholds for Croatia

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
Residential buildings and single-family	40 kWh/(m^2a)	50 kWh/(m^2a)	20 %

houses			
Other types of buildings according to Table 1 (Office, Education, Hospitals, Hotels and restaurants, Sports halls, Market, Other non-residential	25 kWh/(m2a) except Hospitals - 50 kWh/(m2a)	From 60 kWh/(m2a) (Education, Hospitals) to 30 kWh/(m2a) (Office, Hotels and restaurants, Sports halls, Market	From 20% (Hospitals) to 40% (Office, Education, Hotels and restaurants, Sports halls, Market)

Additional information:

- Existing buildings

It is important, however, to emphasize the data given in Table 3.2.2. refer exclusively to nZEB. For existing buildings, other rules apply. Reconstruction is considered only if the parts of the envelope of the heated part of the building are restored, partially, or completely replaced, and if the works are covering more than 75% of the envelope of the heated part of the building. In this case, the allowed values from Table 3.2.2. are significantly higher. For example, for family houses in continental Croatia when renovating, the maximum Eprim is 135 kWh/(m^2a) as opposed to 45 kWh/(m^2a) for nZEB.

Since the general quality of existing buildings in Croatia varies according to different periods of construction as a result of different climatic, technical-technological, economic, legislative, and sociological impacts it is important to analyze buildings according to the construction period and corresponding building technology when conducting energy renovation to reach the nZEB level [9]. Furthermore, buildings constructed in periods of construction expansion i.e. until 1980 are already more than 38 years old which highlights the need to perform energy performance and cost analysis taking into consideration building age, service life, energy savings, and payback periods [9].

- Qualified workers

The lack of qualified workers is a huge problem in Croatia due to the migration of workers to the Western European countries as well as because of increased demand for workers for energy retrofitting projects caused by importing the foreign unqualified or underqualified workforce [10]. Besides the fact that the lack of quality is sometimes present when it comes to building construction and nZEB's, building professionals

are often faced in practice with new materials and products, the integration of renewable energy sources, new systems or processes, and the use of BIM tools [11].

- The long-term strategy

The Long-Term Strategy to Encourage Investment in the Renovation of the National Building Stock of the Republic of Croatia by 2050 is crucial for the use of renewable energy sources in building construction, which, through the nZEB request for new buildings and the renovation of existing buildings, includes the obligation to cover a substantial portion of primary energy for the building by using renewable energy sources at the location of the building or in its immediate vicinity [12]. Estimation of investments in the building sector (energy renovation & nZEB) in Croatia for the years 2021-2030 and 2031-2050 is presented in Table 3.2.5.

Table 3.2.5: Estimation of investments in the building sector (energy renovation & nZEB) in Croatia

EUR billions	2021-2030	2031-2050
Building sector- energy renovation of buildings	1.74	3.72
Building sector- nZEB new construction	5.10	13.92

9. References / key publications:

1. Tehnički propis o racionalnoj uporabi energije i toplinskoj zaštiti u zgradama (Translation: Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings). „Narodne novine“ broj 79/05.

2. Pravilnik o energetskom pregledu zgrade i energetskom certificiranju (Translation: Ordinance on energy audits and energy certification of buildings). „Narodne novine“ broj 81/12.

3. Tehnički propis o racionalnoj uporabi energije i toplinskoj zaštiti u zgradama (Translation: Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings). „Narodne novine“ broj 97/14

4. eCentral, Report on nZEB initiatives from the central Europe region. 2018.

5. Tehnički propis o racionalnoj uporabi energije i toplinskoj zaštiti u zgradama (Translation: Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings). „Narodne novine“ broj 128/15, 70/18, 73/18, 86/18, 102/20.

6. Ministry of Physical Planning, Construction and State Assets, Guidelines for nearly zero energy buildings - Part ONE. 2019, https://mgipu.gov.hr/UserDocsImages/dokumenti/EnergetskaUcinkovitost/Smjernice_1_dio_nZEB_mgipu.pdf.

7. Ministry of Physical Planning, Construction and State Assets, Guidelines for nearly zero energy buildings - Part TWO. 2019, https://mgipu.gov.hr/UserDocsImages/dokumenti/EnergetskaUcinkovitost/Smjernice_2_dio_nZEB_mgipu.pdf.

8. Croatian Meteorological and Hydrological Service. 2020; Available from: https://meteo.hr/infrastruktura.php?section=mreze_postaja&param=pmm&el=klimatoloske.

9. Teni, M., K. Čulo, and H. Krstić, Renovation of Public Buildings towards nZEB: A Case Study of a Nursing Home. Buildings 2019. 9(153).

10. Gumbarević, S., et al., Improving competencies of engineers and workers in the AEC industry for delivering NZEBs. Organization, Technology, and Management in Construction, 2020. 12: p. 19.

11. Milovanović, B., et al., Innovative training schemes for retrofitting to nZEB-levels. 2019.

12. Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030. 2019, Ministry of Environment and energy, Republic of Croatia.

13. Ministry of Physical Planning, Construction and State Assets - Programme for encouraging the construction of new and retrofitting existing buildings to nZEB standard 2018.

14. Update/upgrade of the energy strategy and of the implementation program of the Republic of Croatia. 2008: Ministry of economy, labor and entrepreneurship and United nations development program (UNDP).

3.3. CZECHIA

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.3.1: nZEBs status in Czechia

Legislation	
Definition nZEB available	Yes (Act no. 406/2000, § 2, w). “nZEB is a building with very low energy demand, whose energy consumption should be to a large extent covered by renewables.”
Min. threshold set	Yes,/No (Ordinance no. 264/2020 Coll., valid from 1st September 2020 and accompanying standards, such as ČSN 730540 series). The ordinance and standards set “limits” for the energy performance assessment based on a comparison of the designed building with a “reference building”. See 3.a) for details.
Subsidy retrofitting towards nZEB	No. However there are subsidy programs such as “Nová zelená úsporám” (New Green Savings), which favor nZEB solutions over others – Either during the assessment of requests or by the extent of the subsidy itself.
Min. Energy efficiency PE use intensity ($kWh/m^2.a$)	Yes/No (Ordinance no. 264/2020 Coll.). See 3.a) for details.
Min. perf. Threshold heating demand ($kWh/m^2.a$)	No. Ordinance no. 264/2020 Coll. sets only overall energy thresholds. However, particular subsidy programs or certifications have their own heating thresholds. In the case of New Green Savings, the achieved thresholds limit the amount of subsidy. The limits include: - Annual heat demand (max. 20 for

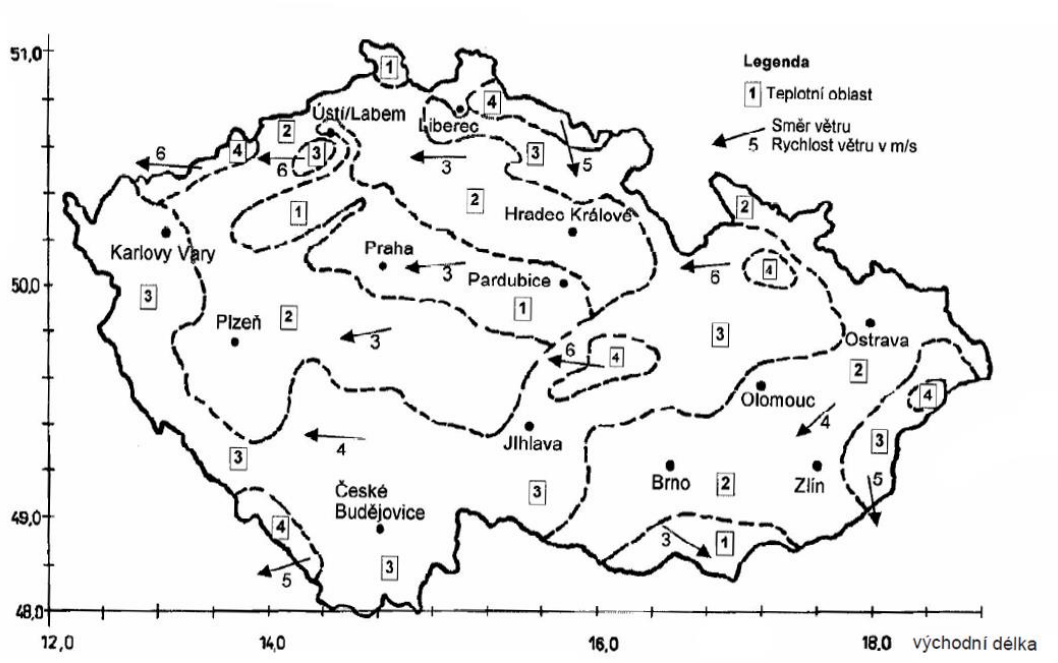
	"passivehaus" or for "passivehaus+" 15 kWh/m2a), Annual non-renewable primary energy demand (max. 0,8E_R for passivehaus or 0,6 E_R for passivehaus+ which corresponds with A-level energy performance certificate). E_R here represents is primary energy consumption of "reference building", Average U-value of building envelope (U ≤ 0.7 E_R). E_R here represents the average U-value of the envelope of reference building.
Min. perf. Threshold cooling demand (kWh/m^2.a)	No. See the previous comment.
Life Cycle Assessment	No. ISO and EN standards on LCA were adopted by the Czech standardization body: Office for Standards, Metrology, and Testing (e.g. ISO 14040 into ČSN EN ISO 14040). However, a particular act or ordinance introducing LCA in our legislation is missing so far. According to our "internal knowledge", CTU Prague is currently developing a national methodology for LCA in Czechia. LCA is also included in voluntary certification schemes, such as SBToolCZ (buildings) or EPD (materials and products). This is also the reason for increasing demand for LCA from material producers, developers, etc.
CO_2	No. However, subsidy programs are dealing e.g. with adding thermal insulation to building envelopes, where CO_2 emission reduction is one of the indicators.
Airtightness	No. However, subsidy programs may have airtightness thresholds. For

	example, New Green Savings requires a max of 0.6 – n50.
Heating Cooling Balance	
Natural ventilation possible	Yes. However, subsidy programs such as “Nová zelená úsporám” (New Green Savings) may require mechanical ventilation.
Technical System Min. performance requirements	No for the designed nZEB. However, parameters of the “reference building” (see 3.a)) have specific requirements on the efficiency of HVAC. The compared nZEB doesn’t have to comply with them, but in that case, it has to be much better in other parameters. E.g. inefficient heating source could be outweighed by the high thermal resistance of the envelope and an efficient ventilation system with heat recovery. Subsidy programs such as “Nová zelená úsporám” (New Green Savings) have their own requirements on the performance of technical systems.
Thermal Comfort Limits	
Climate Zones	1 zone for nZEB. Calculations (with monthly step) of the energy performance of buildings according to Ordinance no. 264/2020 Coll. use average climate data from standard ČSN 730331-1, Appendix C. 4 zones for calculations of thermal parameters of buildings/structures according to ČSN 730540-3 standard (see map below)
Overheating risk	Yes. The overheating thresholds are set in ČSN 730540-2 standard. However, these standardized thresholds are mandatory for all buildings, not just

	nZEBs. Some subsidy programs also set their own thresholds.
Thermal comfort Standard	Yes. ČSN 730540-2 standard sets thresholds for thermal stability, temperature factor (fRsi), or air permeability of structures for buildings (not only nZEBs). Some subsidy programs also set their own thresholds. For example, New Green Savings require max. daily indoor air temperature ≤ 27°C.
Efficiency vs Renewable Threshold **RES (%)**	No. Similar to the answer to "Technical system min performance" above, the reference building is set in such a way that it is easier to comply with its requirements by adding RES than highly efficient equipment or large quantities of thermal insulation.
<u>Construction Quality</u>	
Available materials	High.
Available knowledge	High, if we're speaking about available knowledge. however, in our opinion specialists in the field have state-of-the-art knowledge, "common" building designers and contractors have average or below-average knowledge, the general public has poor knowledge. The situation gets better slowly, but it is still common to hear someone mistaking nZEB and passive house.

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

Návrhové hodnoty parametrů venkovního prostředí



Obrázek H.1 – Teplotní oblasti v zimním období, směr a rychlost převládajících větrů

Figure 3.3.1: Climate zones of Czechia

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

The CO_2 thresholds for buildings are not defined in the current legislation (they may differ for particular subsidy programs such as “New Green Savings”). Particular energy and primary energy “thresholds” (specific numerical values valid for all buildings of specific class/type) are also not defined. They were disregarded in 2013 as they favored particular building geometries.

Currently, everything depends on comparison with a “reference building” defined in ordinance no. 264/2020 Coll. The reference building is a hypothetical copy (same geometry, use, climate, …) of the designed building, which performs exactly as the legislation (the ordinance) and standards (e.g. ČSN 730540-2 Thermal protection of buildings – Part 2: Requirements) says. The designed building has to perform better than the reference building to pass the assessment - it gets an energy certificate rating depending on how much better/worse it is compared to the reference building.

Table 3.3.2 provides an exemption of the rating matrix (our own translation) regarding primary energy. Note that new construction or major renovations have to pass with an A-C rating according to above mentioned ordinance and standards.

Table 3.3.2: Rating matrix for primary energy in Czechia

Rating	**Primary energy from non-renewable resources (E_R = reference building)**
A	0.8 x E_R
B	1.2 x E_R
C	1.6 x E_R
D	2.3 x E_R
E	3 x E_R
F	3.7 x E_R

Table 3.3.3 shows the exemption of a table (our own translation again) with the primary energy requirements on buildings (% value of how much better a building should be compared to reference case). This Table is valid since January 2022.

Table 3.3.3: Primary energy requirements on buildings in Czechia

Reference building heating energy demand $E_{A,R}$ [kWh/(m^2.a)]	**Reduction of the reference value of primary energy from non-renewable energy sources $\Delta e_{p,R}$ [%]**		
	Residential zone*		**Other than residential zones**
	Total energy-specific area of the building ≤ 120 m^2**	**Total energy-specific area of the building** ≥ 120 m^2**	
≥ 90	50	60	40
80	45	55	
70	40	50	
60	35	45	
50	30	40	
40	25	30	

≤ 30	20	20	
* residential part of the building (living room, kitchen, bathroom, etc.)			
** area of all floors calculated from external dimensions			

Definition of the reference building and the assessment procedure is not available in English. Czech version is available e.g. in this article: https://www.tzb-info.cz/energeticka-narocnost-budov/20685-novela-vyhlasky-c-78-2013-sb-cast-2-uprava-parametru-referencni-budovy.

It, for example, says that the efficiency of the heating source in the reference building is 92 % and the efficiency of the heat transfer inside the building is 90 %.

A recent report "Praxe nulových staveb podle nové legislativy" (nZEB practise according to new legislation; available in Czech only) by "Passive house center" agency shows that a building fulfilling nZEB according to ordinance no. 264/2020 Coll. could have overall non-renewable primary energy consumption ≤ 75 kWh/m^2.a as visible in Figure 3.3.2.

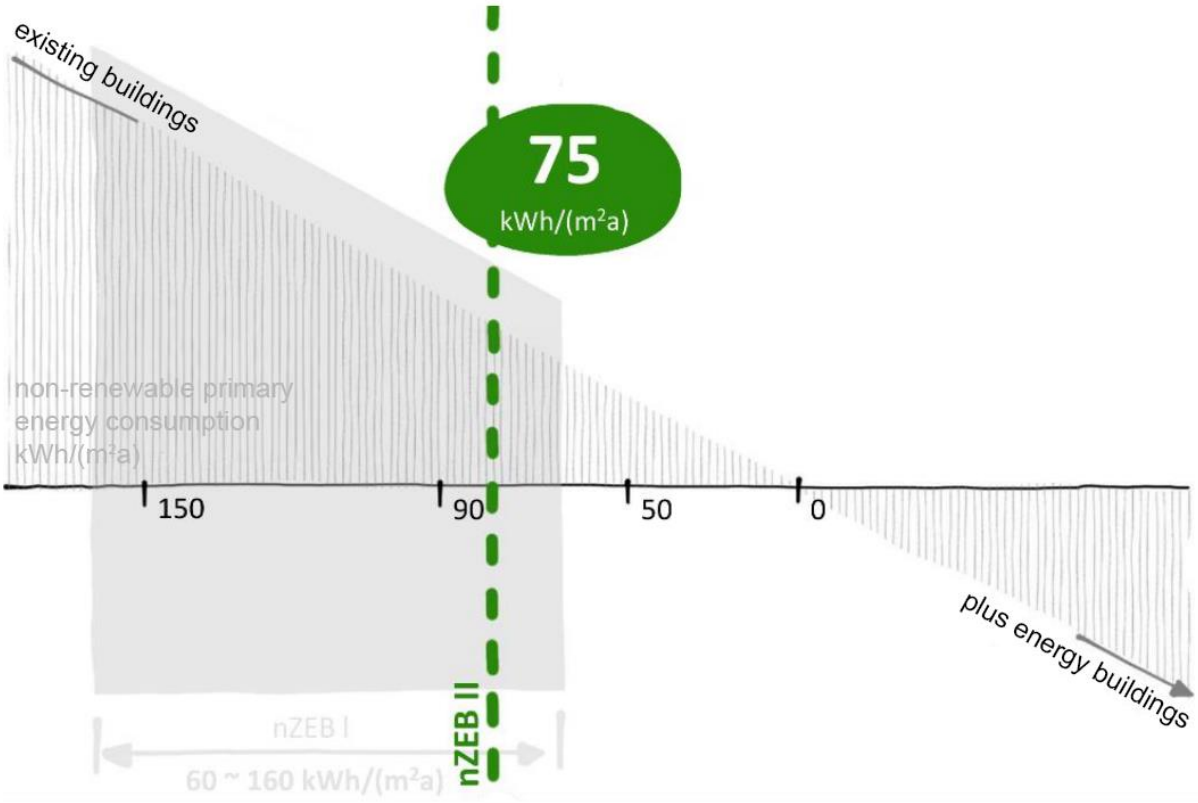


Figure 3.3.2: Primary energy of buildings according to previous and current Czech legislation (ordinance no. 264/2020 Coll.).

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

In our opinion, it is not good to have single-criteria thresholds such as GHG (or CO_2-equivalent) emissions representing anthropogenic environmental impacts. Favoring a single impact category (GHG) can lead to an undesirable increase of environmental impacts elsewhere (e.g. water pollution). Something like the Swiss UBP method would be better. This LCA-based method evaluates various environmental impacts and presents them as single-point values.

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m^2/a for heating demand. Could this become the case in your country? and why?

In our opinion, focusing only on very low heating energy demand without context is not a good option. People (at least here in Czechia) will want to achieve this as cheaply/simply as possible. This will lead only to the overuse of thermal insulation. Particular thresholds for primary energy or environmental impacts, in general, would be better for sustainable development.

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity, and heating and cooling balance. If you have a climate contrast (for example heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

Considering building design, Czechia is divided into four zones depending on outdoor winter "design temperature": I = -13 °C, II = -15 °C, III = -17 °C, IV = -19 °C (see Figure 3.3.1). Summer design temperatures are not set like this. Overall, overheating/cooling is not sufficiently addressed in Czech buildings.

We found news articles stating that the number of cooling degree days in Czechia almost doubled between 2010 and 2018. In 2018 it was 61.2 cooling degree days. However, there are 3500-4000 (the value varies depending on region and source) heating degree days in Czechia at the same time. This indicates that Czechia is mostly dominated by heating zones. The difference between regions is rather small. For example, the average air temperature in Hradec Králové region (including Krkonoše mountains) was 6.9 °C, while the average air temperature in the South Moravian region (mostly flatlands) was 8.3 °C and Central Bohemian region (vicinity of Prague) was 8.2 °C in 2019.

The exception of the above mentioned may be larger cities such as Prague, Brno, or Ostrava that suffer from summer overheating due to climate change and urban heat island effect. News and presentations we saw during the last few years state that

average air temperatures in cities are 3-5 °C above average there in summer (we weren't able to find the verified source of this information). Currently, there are various subsidy programs addressing this by promoting green infrastructure, green roofs, parks, etc. Also, if we talk about particular buildings or building typologies, heating is more likely related to housing, while cooling is an issue related to offices, warehouses, etc.

4.b. Can you reach nearly zero heating demand?

Hypothetically speaking, yes. However, there is still a lack of will to build high-quality nZEBs. It is partially caused by the denial of climate change by some of the top representatives and other influential people (e.g. former president Václav Klaus). Other issues (in the eyes of average investors and end-users) include complexity and costs. For example, solar energy gains in Czechia are lower compared to Southern countries. At the same time, grid energy costs are also relatively low (at least for those who could afford the construction of a new house – see energy poverty in 5.b.). Thus, a lot of building owners and users hesitate to install RES or air conditioning with heat recovery as they question the rate of return of such investment.

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

Considering the willingness of people described in 4.b) and the lack of knowledge and discipline of an average construction worker, it would be better to opt for medium airtight envelopes. Even subsidy programs such as New Green Savings require "only" 0.6 or 1.0 n50 air exchange rates. Average building stock has 2.3-2.7 n50 air exchange rates.

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity concerning the electric or thermal demand?

We weren't able to find any specific data on this matter. Only general plans and pledges regarding the increasing capacity of supply grids (e.g. "Státní energetická koncepce" or State Energy policy of Czechia from 2015). A lot of these plans are related to electricity in the context of increasing electromobility.

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBS.*

We do not have standards designated specifically for nZEBs in Czechia. Thermal comfort (surface temperature limits, overheating, and temperature decrease) of all buildings is evaluated according to general standards such as ČSN 730540-2 (see 5.c.3).

It should be also noted that government regulation no. 41/2020, Coll. (describing health protection conditions at work) defines working conditions (e.g. indoor air temperatures). It permits higher temperatures at workplaces than ČSN 730540-2 if specific conditions are met (e.g. freshwater supply).

5.a.2. Cite the reference, and share the reference in pdf format if possible.

Government regulation no. 41/2020, Coll. In Czech: https://www.zakonyprolidi.cz/cs/2007-361/zneni-20200301 (available in Czech only)

(2011). Standard ČSN 730540-2 Tepelná ochrana budov – Část 2: Požadavky (Thermal protection of buildings – Part 2: Requirements), Prague: Czech Office for Standardization, Metrology, and Testing, 56 p. (available only in Czech and for a fee).

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

ČSN EN 16798 standard series (localization of EN 16798) is valid in Czechia. Previously, the hourly calculations were performed according to other standards, such as ČSN EN ISO 52016-1 and ASHRAE 140-2017.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.3.4: Overheating assessment in Czechia

Country	Czechia
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	No. We have only one climate zone for the whole country in this regard.
Do you have a specific comfort calculation approach for heatwaves?	No.
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No
Occupant type and representation	

What is your comfort standard?	ČSN EN ISO 52016-1 for summer stability ČSN 730540-4 for winter stability
For which building types?	"non-production" and others.
Does your method embrace the four occupant categories (I, II, III, IV)? *	No.
How do you represent occupancy presence in the simulation model?	It is possible (not mandatory) to include indoor energy gains from people, equipment, etc. into the calculations.
Comfort model	
What is your overheating indicator?	Maximum daily indoor air temperature in an assessed “critical room”.
Is your comfort model based on an adaptive or static method?	Static.
What are your overheating thresholds? and according to which standard are those thresholds defined?	ČSN 735040-2 Natural ventilation: 27°C indoor air temperature in a critical room in summer for non-production buildings (housing, offices, etc.), 29.5 (buildings with indoor heat sources ≤ 25 W/m3) or 31.5°C (buildings with indoor heat sources > 25 W/m3) for the rest of buildings. Air conditioning: 32°C indoor air temperature in a critical room in summer.
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	In the calculation method no. In practice yes: it is possible to define air exchange rates to differentiate between natural and mechanical ventilation. It is also possible to define a cooling source (in hourly steps).
Does your model take into account	In general no, but it is possible to add

local personalized heating/cooling & ventilation systems (ceiling fans, air-conditioned chairs, electric heating mattresses…)?	heat energy gains from equipment or people, the air supply, and exchange rates to reflect the operation of such systems.
Simulation model	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Dynamic model & hourly calculations.
Is your overheating calculation based on a single or multizone model?	Single zone. The assessment is performed only for a "critical room", (see 5.c.3. for definition).
Does your calculation distinguish sleeping rooms from other living areas?	No.
Mandatory envelope requirements	
Does your method oblige the installation of external shading?	No. However, it is difficult to comply with the indoor air temperature threshold without it.
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No.
Does your method recommend a g-value? If yes, what is the limit?	No.
* we are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

According to a short report (https://www.tacr.cz/wp-content/uploads/2019/10/190531_TZ_energetickaChudoba.pdf), 4.7% of Czech households were endangered by energy poverty in 2019. Another report (https://bit.ly/3sqVhL2) from 2021 further elaborates this. It states that approx. 25 % of Czech households faced some sort of energy poverty in 2018.

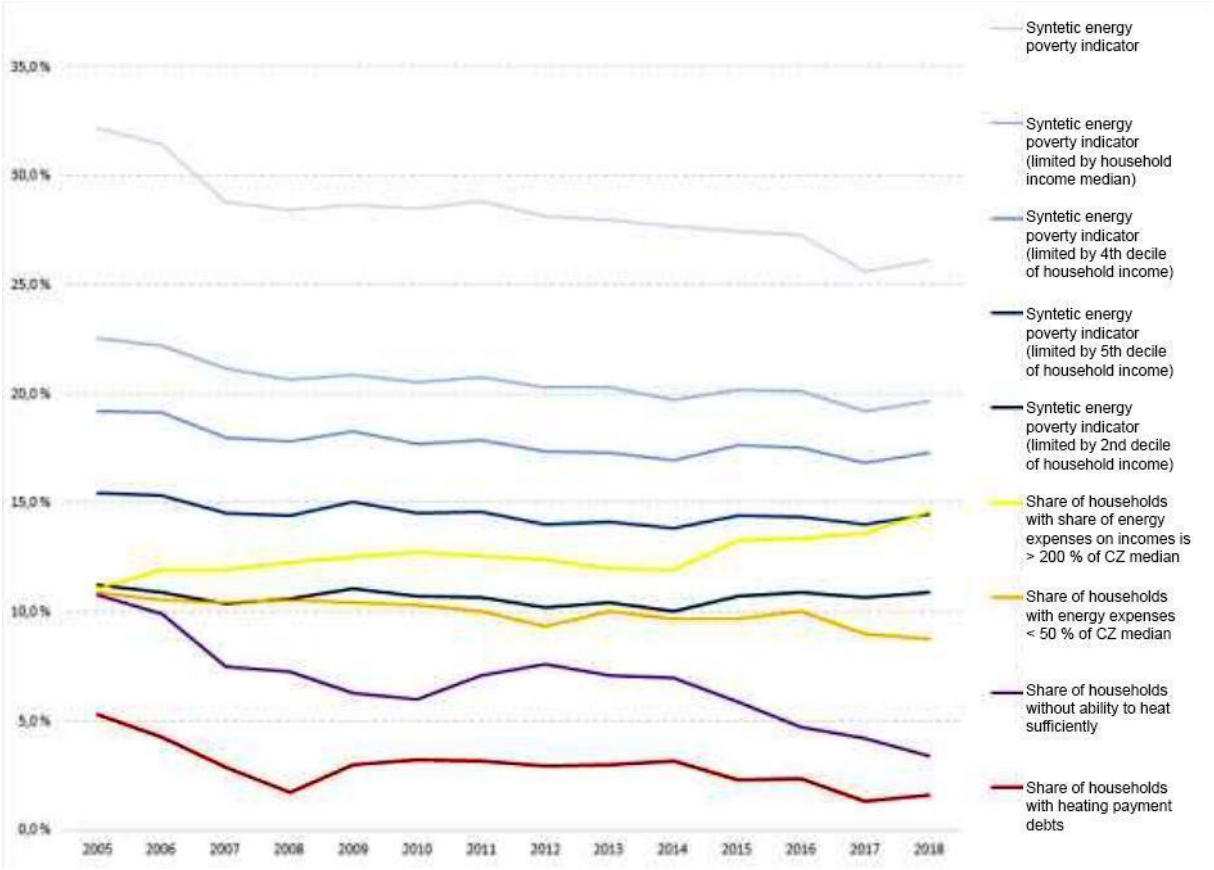


Figure 3.3.3: Percentage of households influenced by energy poverty in Czechia.

This could have a noticeable impact on the implementation of nZEB, especially if we consider the fact that housing in Czechia is the least affordable compared to most EU countries: Deloitte report states that own housing costs approx. 11.4 annual average gross income in Czechia (https://www2.deloitte.com/content/dam/Deloitte/cz/Documents/real-estate/Property_Index_2020.pdf).

5.c.1. What are the overheating criteria for nZEBs in your country?

There are no particular requirements on nZEBs in this regard. All buildings should comply with the "≤ 27°C indoor air temperature" requirement specified in ČSN 730540-2. It is not defined how this requirement should be met (air conditioning, shading, etc.).

5.c.2. What is the overheating risk for nZEB (highly insulated) in your climate?

We did not find any reliable (written) source on this matter; however, we think that the risk could be quite high if there is no change in approach towards building design and construction: A lot of Czech designers still focus on maximizing winter solar gains (to reduce heating demand), but neglect summer cooling (external shading, air conditioning). We found some old news articles stating that approx. 50% of existing Czech building stock is suffering from summer overheating and we presume that this

issue will be further stressed by ongoing climate change.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

Summer thermal stability (overheating) is evaluated according to ČSN EN ISO 52016-1. This standard utilizes hourly dynamic calculations to assess maximum temperature in a critical room (room with the worst ratio between floor area and area of openings exposed to direct sunlight in E-SE-S-SW-W directions). The thresholds are defined in ČSN 730540-2:2011: 27°C indoor air temperature in summer for naturally ventilated "non-production" buildings (housing, offices, etc.), 29.5 or 31.5°C for the rest of buildings "with internal heat source" (depending on the output of the source). The standard says that the threshold can be increased to 29°C "... for periods shorter than 2 hours … in a residential building... if the investor agrees." The threshold for mechanically ventilated buildings is 32°C.

Overheating in winter is not evaluated. Indoor air temperature decrease in case of heat source failure is evaluated instead (according to ČSN 730540-4).

It should be noted that overheating is often omitted not only by designers (as stated in5.c.2) but by building authorities as well (authors' own experience). The exceptions are mostly buildings where its fulfillment is questionable (such as offices with transparent facades).

5.d. Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?

So far, we can say that passive cooling is sufficient for buildings (especially residential) in the Czech climate. However, ongoing climate changes may change this in the following decades. We think (see 5.c.2)) that more attention should be paid to passive measures such as external shading instead of air conditioning systems that i. a. increase buildings' electricity consumption. The exception may be urbanized areas (urban heat islands), with above-average temperatures.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

In our opinion it is or it will be easier to invest in RES.

Large-scale (public energy supply): Major part of the Czech energy supply is made up of fossil fuel plants. An increase in their efficiency and service life is not feasible in our opinion. Replacement by renewables and nuclear power should be easier (and is planned between 2030 and 2050).

Small scale (buildings): The principle of the reference building that we use in energy certification suggests finding equilibrium between RES and efficiency. However, it could be said that it is easier (and sometimes more feasible) to fulfill the limits with RES.

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?

No, we would leave people the liberty in choosing measures that suit their needs/behavior/budget. It shouldn't matter if the reduction of building-related environmental impacts is achieved by "active" (RES, air conditioning, etc.) or "passive" (thermal insulation, solar energy gains, etc.) measures.

Comment on 6.a) mentions the environmental inefficiency of the Czech energy mix. For example, the conversion factor for primary electricity is 2.6 in Czechia (was 3.0 till last year). Thus, I think that (at least for now) responsibility for renewable energy production should be primarily delegated to large energy suppliers, not consumers.

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

There are general outlines, e.g. in the State energy policy from 2015 or plans.

Documents such as https://www.mpo.cz/assets/cz/energetika/strategicke-a-koncepcni-dokumenty/narodni-akcni-plan-pro-chytre-site/2020/10/Summary_Potrebnost-zdroju-jaloveho-vykonu-pro-rizeni-U-Q.pdf (in Czech) state that the energy grid is ready for contemporary RES production. However, an increase in RES (especially photovoltaics) expected till 2030 would needlessly stress its capacity. Therefore, modernization of the grid is planned/underway.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

Low-tech solutions would be better in our opinion. It would be better to work with passive energy gains/losses, natural ventilation, etc. because these solutions are cheaper (both investment and operation costs) compared to high-tech solutions and less demanding on contractors and users.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

The biggest barrier is a low understanding of the nZEBs among the general public and professionals that are not specialists in this field. In our personal opinion, the

nZEB principles were not properly communicated, instead, the media often came up with out-of-context information, e.g. that air conditioning will be mandatory after 2020. Other factors may include lack of time or willingness to study relevant information. This situation improved in the past 2-3 years, but they're still is:

- Lack of cooperation during the design process. Designers often focus on particular thresholds and requirements without consideration to other aspects of building design and operation.
- Fear (among investors and end-users) that nZEB or other efficient buildings would be significantly more expensive compared to "standard" buildings because they are used to assess investment costs instead of Life-Cycle Costs. This behavior is the result of recent history (communism) and public denial of climate change by several influential people. It is also influenced by valid legislation because for example, the Public Procurement Act describes (in context) investment costs as the most important evaluation criterion.
- Intentional non-compliance with designs (e.g. omitting air conditioning system in an airtight building) on the side of investors and contractors that try to cut the construction costs.

8. What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold onsite):

Table 3.3.5: EE and RES recommended thresholds for Czechia

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
Non-production (housing, offices, etc.)	20-40 kWh/m^{2}a	0-20 kWh/m^{2}a	(see comment in 6.b)

We apologize, but we weren't able to gather sufficient data for industrial buildings. As we mentioned earlier, we think that RES thresholds are currently not desirable for (non-production) buildings in Czechia. At least if the state energy mix does not improve. Also, as we mentioned earlier, the cooling of (residential) buildings could be solved by passive measures in areas with low urbanization. However, we admit that active cooling might become a necessity soon due to climate change. In that case, we think that its energy demand should not exceed ½ of the heating energy demand. Heating energy thresholds are already indirectly set in Czech nZEB definitions (between 30-90 kWh/m^{2}a, see Table 3.3.3). We think that it would be possible to further reduce this threshold. In this regard, we personally think that the values that EPBD recommends for primary energy could be used. We tried to confirm this idea by a short "research" on living expenses in Czechia. We found Czech statistics stating:

- Average flat size: 86.7 m^2 in 2019
- Average heating energy cost: 581 CZK/GJ on 1st January 2020
- Average monthly housing costs (per household): 5979 CZK in 2020. This means 14.6 % of average household income.
- Average monthly household income: approx. 41000 CZK in 2020

These data suggest that the average household pays for approx. 40 kWh of heat per m^2 annually… We think that further reduction is desirable (and achievable). However, we have to admit that such a simple calculation may not be accurate due to varying household incomes, omission of life-cycle costs, etc.

9. REFERENCES / KEY PUBLICATIONS:

- (2011). ČSN 730540-2 Tepelná ochrana budov – Část 2: Požadavky (Thermal protection of buildings – Part 2: Requirements). Prague: Czech Office for Standardization, Metrology and Testing. 56 p.
- (2005). ČSN 73 0540-4 Tepelná ochrana budovy - Část 4: Výpočtové metody (Thermal protection of buildings – Part 4: Calculation methods). Prague: Czech Office for Standardization, Metrology and Testing. 60 p.
- (2020). Vyhláška č. 264/2020 Sb. o energetické náročnosti budov (Ordinance no. 264/2020 Coll. on energy performance of buildings). Prague: Ministry of Industry and Trade. URL: https://www.zakonyprolidi.cz/cs/2020-264 (last visit 11th Feb. 2022)
- (2014). State energy policy of Czechia. Prague: Ministry of Industry and Trade. 159 p. URL: https://www.mpo.cz/assets/en/energy/state-energy-policy/2017/11/State-Energy-Policy-_2015__EN.pdf (last visit 11th Feb. 2022)
- Drábková, I. (2019) Energetická chudoba hrozí až pětině českých domácností (Energy poverty threatens up to a fifth of Czech households). Prague: Technology Agency of Czechia. URL:

https://www.tacr.cz/wp-content/uploads/2019/10/190531_TZ_energetickaChudoba.pdf (last visit 11th Feb.. 2022)

- (2021). Zranitelný zákazník a energetická chudoba v ČR, Mapovací a plánovací studie (Vulnerable user and energy poverty in CZ, Mapping and planning study). Prague: Prague University of Economics and Business. URL: https://bit.ly/3sqVhL2 (last visit 11th Feb. 2022)
- Čejka, M. (2020). Novela vyhlášky č. 78/2013 Sb. – Část 2: Úprava parametrů referenční budovy (Novelization of ordinance no. 78/2013 Coll. – Part 2: Changing parameters of reference buildings). Prague: tzb-info.cz. URL: https://www.tzb-info.cz/energeticka-narocnost-budov/20685-novela-vyhlasky-c-78-2013-sb-cast-2-uprava-parametru-referencni-budovy (last visit 11th Feb. 2022)

3.4. ESTONIA

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.4.1: nZEB status in Estonia

Legislation	
Definition nZEB available	Yes.
Min. threshold set	Yes.
Subsidy retrofitting towards nZEB	Yes (mainly for residential apartment buildings).
Min. Energy efficiency PE use intensity (kWh/m^2.a)	Yes (14 categories, see Table 3.4.2).
Min. perf. Threshold heating demand (kWh/m^2.a)	No.
Min. perf. Threshold cooling demand (kWh/m^2.a)	No.
Life Cycle Assessment	No.
CO_2	No.
Airtightness	Yes.
Heating Cooling Balance	
Natural ventilation possible	Yes in theory. No in practice.
Technical System Min. performance requirements	No.
Thermal Comfort Limits	
Climate Zones	No, one national TRY.
Overheating risk	Yes.
Thermal comfort Standard	Yes.
Efficiency vs Renewable Threshold	No, but it is included in primary energy requirements.

RES (%)	
Construction Quality	
Available materials	High.
Available knowledge	High (HVAC Master study program, Energy expert, energy auditor, and energy modeler qualifications in use).

Primary energy requirements

The energy efficiency requirements for buildings in Estonia are defined through the maximum allowed non-renewable primary energy (PE) consumption and are set in the national regulation [1]. The building energy performance is presented as Energy Performance Indicator (EPI) value in kWh/(m2 a) and the allowed EPI value limit depends on the building type. The EPI value incorporates the energy used for space heating, space cooling, domestic hot water (DHW) production, lighting, appliances, and auxiliary devices, i.e. fans and pumps. The EPI value calculation follows the system boundaries of REHVA's definition [2], but only on-site produced and consumed by the building systems are taken into the account and are subtracted from the delivered energy [3]. Exported energy is not taken into account when calculating the EPI value. The system boundaries are shown in Figure 3.4.1.

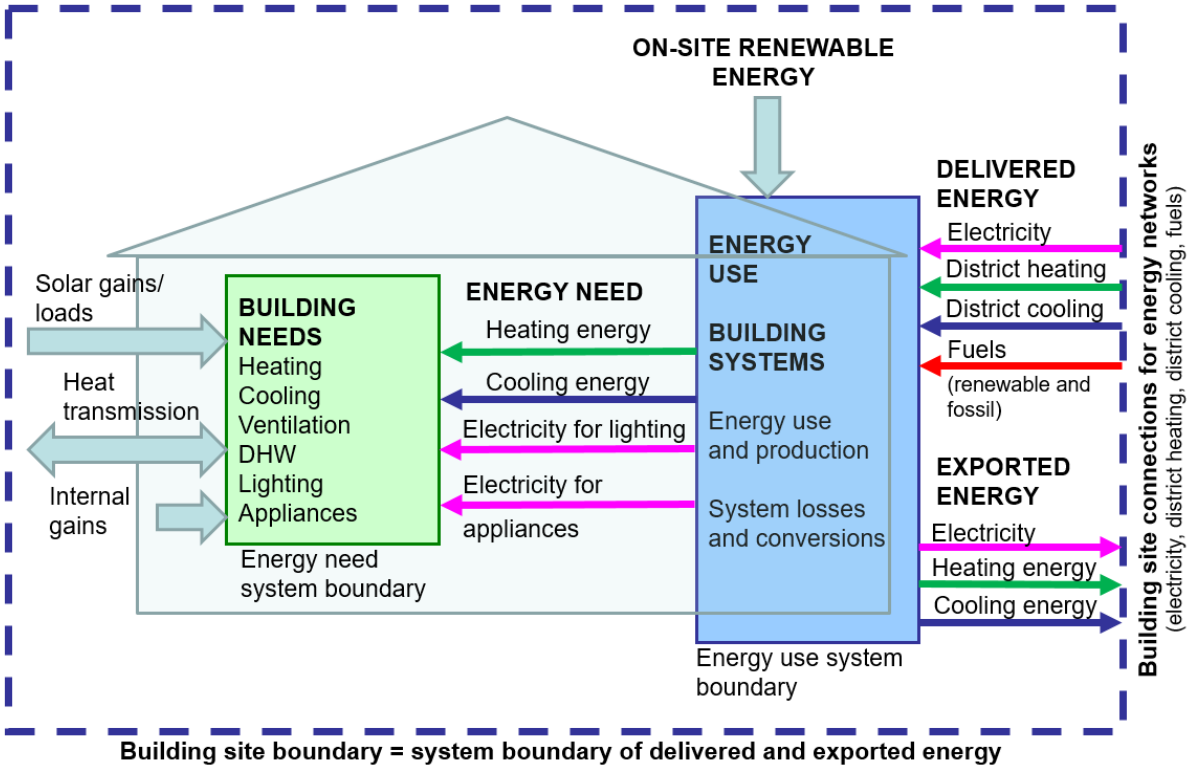


Figure 3.4.1: System boundaries for energy need, energy use, delivered energy, exported energy, and on-site produced renewable energy [3]

The EPI value results from the net purchased energy multiplied by the relevant primary energy factors (f). The calculation for delivered energy is based on hourly time step data (except for simplified calculations available for detached houses). The national requirements for nZEB building and primary energy factors are shown in Table 3.4.2 and Table 3.4.3.

Table 3.4.2: Maximal primary energy requirements for different building types, according to national regulations [1]

Building type	**EPI value requirement, kWh/(m^2 a)**		
	nZEB (class A)	Low energy building (class B)	Renovation of the existing building (class C)
Small residential buildings (detached house, row house): a) net heated area <120 m^2 b) net heated area 120-220 m^2 and row house	 145 120	 165 140	 185 160

c) net heated area >220 m^2	100	120	140
Multi-apartment buildings	105	125	150
Military barracks	170	200	250
Office buildings, libraries, and research buildings	100	130	160
Accommodation building, hotel	145	170	220
Commercial buildings	130	150	210
Public buildings	135	160	220
Commerce buildings and terminals	160	190	230
Educational buildings	100	120	160
Pre-school institutions for children	100	120	165
Healthcare buildings	100	130	170
Warehouse	65	80	100
Industrial building	110	140	170
Buildings with high energy consumption	820	850	950

Table 3.4.3: Primary energy factors (f) according to Estonian regulations [1]

Energy carrier	**f**
Electricity	2.0
District heating *	0.9
Efficient district heating	0.65
District cooling **	0.4
Efficient district cooling	0.2
Natural gas, oil, coal, peat, solid fossil fuel	1.0
Wood, bio-fuel	0.75

EPI value calculation

The calculation methodology includes the following factors [1]:

- Thermal transmittance of building envelope, linear and point thermal transmittance of thermal bridges, and air leakage
- Indoor air temperature
- DHW demand
- Ventilation
- Thermal loads from occupant, light, appliances, hot water, and solar heat
- Thermal and electrical energy use for spaces heating, ventilation heating, DHW system
- Electricity use for ventilation system (fan and pump), lighting, equipment
- On-site energy generation: with photovoltaic (PV) panels, solar thermal collectors, wind
- Heat recovery from wastewater and/or ventilation.

The EPI value is calculated according to the following equation (1):

$$EPI = \frac{f_{DH.PF}\, Q_{DH} + \sum_i \quad f_{F.PF}\, Q_F + f_{E.PF}\, Q_E}{A_{net}} \qquad (1)$$

where $f_{DH.PF}$ is the primary energy factor for district heating, dimensionless; Q_{DH} is the annual district heating energy use, kWh/a; $f_{F.PF}$ is the primary energy factor for fuel, dimensionless; Q_F is the annual fuel use, kWh/a; $f_{E.PF}$ is the primary energy factor for electricity, dimensionless; Q_E is the annual electricity use, kWh/a; A_{net} is the net heated building area, m^2.

Heat losses from building envelope, thermal bridges, ventilation heat losses, system efficiency calculation method, and onsite electricity production are given in detail at regulation [3].

Ventilation and temperature setpoints

The EPI value needs to be calculated using specific values for ventilation outdoor airflow rate as well as the room temperature heating and cooling limit temperature shown in Table 3.4.4.

Table 3.4.4: Ventilation outdoor airflow rates, heating and cooling setpoints for different building types [1]

Building type	**Outdoor airflow rate**	**Heating setpoint, °C**	**Cooling setpoint, °C**

	$dm^3/(s\ m^2)$		
Small residential buildings (detached houses) net heated area <120 m^2	0.5	21	27
Small residential buildings (detached house, row house) net heated area ≥120 m^2	0.42	21	27
Multi-apartment buildings	0.5	21	27
Military barracks	0.5	21	27
Office buildings, service buildings, libraries, and research buildings	2.0	21	25
Accommodation buildings, hotels	1.0	21	25
Commercial buildings	2.0	21	25
Public buildings	2.0	21	25
Sports facilities	2.0	18	25
Commerce buildings and terminals	2.0	18	25
Educational buildings	3.0	21	25
Day-care centers, pre-school institutions for children	2.0	21	25
Healthcare buildings	2.0	21	25
Industrial buildings	0.9	20	27
Warehouses	0.35	15	27

Building usage rates, internal heat gains, electricity, and DHW use

Daily and weekly operational hours, usage rates for lighting, appliances, and occupants need to be accounted for to calculate the annual energy consumption of the building. The detailed information is given in Table 3.4.5.

Table 3.4.5: Building usages rates, internal thermal loads, and heat gains for different building types [3]

Building type	Operation Hours	h/day	Day/week	Usages rate	Lighting W/m^2	Appliance W/m^2	Occupant W/m^2	DHW kWh/(m^2 a)
Small residential buildings (detached house) net heated area <120 m^2	00:00 – 24:00	24	7	Lighting 0.1 Other 0.6	6	3	3	30
Small residential buildings (detached house, row house) net heated area 120-220 m^2	00:00 – 24:00	24	7	Lighting 0.1 Other 0.6	6	2.4	2	25
Small residential buildings (detached house) net heated area >220 m^2	00:00 – 24:00	24	7	Lighting 0.1 Other 0.6	6	2	1.4	20
Apartment building	00:00 – 24:00	24	7	Lighting 0.1 Other 0.6	8	3	3	30
Military barracks	00:00 – 24:00	24	7	0.4	10	2	10	35
Office building, library and science	07:00 – 18:00	11	5	0.55	10	12	5	6

building								
Accommodation building, hotel	00:00 – 00:00	24	7	0.4	10	1	4	30
Commercial building	12:00 – 22:00	10	7	0.4	19	4	14	23
Public building	08:00 – 22:00	14	7	0.5	14	0	5	20
Commerce building and terminal	07:00 – 21:00	14	7	0.55	19	1	5	4
Educational buildings	08:00 – 16:00	8	5	0.5	12	8	14	10
Day-care center, a pre-school institution for children	07:00 – 19:00	12	5	0.4	12	4	8	15
Health care facility	07:00 – 20:00	13	5	0.6	10	4	8	12
Industrial building	07:00 – 19:00	12	5	0.55	12	12	4	0
Warehouse	00:00 – 00:00	24	7	0.2	10	0	0	6

Energy use for lighting and appliances is taken from the national regulation [3] and is to be multiplied with the national PE factor to obtain the PE use for lighting and appliances. The following equation is used to estimate the energy use for lighting and appliances.

$$Q = kP\frac{\tau_d}{24}\frac{\tau_w}{7}\frac{8760}{1000} \quad (2)$$

where, k is the utilization factor defined for lighting and appliances for the specific building type, dimensionless; P is the thermal load of lighting and appliances, W/m^2;

τ_d is the number of hours of building use per 24 hours, h; τ_w is the weekly building use in days, d. The net heating energy for domestic hot water is given as a default value depending on the building type.

Building air leakage

The leakage rate is calculated from the following equation:

$$q_{v,leakage} = \frac{q_{50}}{3600\,x}\,A_{env} \tag{3}$$

where, $q_{v,leakage}$ is leakage airflow rate, m^3/s; q_{50} is building air permeability at 50 Pa of air pressure over the building envelope, $m^3/(h\ m^2)$; A_{env} is the building envelope area, m^2; x is a coefficient dependent on the building height: 35 for a single-story building, 24 for a two-story building, 20 for three and four-storied buildings, 20 and 15 for higher buildings (the coefficient accounts for 3m for story height).

If the building air permeability is not to be measured or verified during or after the building process, then only base values can be used for the EPI calculation (Table 3.4.6). It is possible to use q_{50} value of 1.5 $m^3/(h\ m^2)$ in the EPI calculations, however, then the building leakage rate is mandatory to be measured (blower door test) or declared/verified via adequate methods.

Table 3.4.6: Base values for building envelope air permeability [3]

Building type	**Air permeability rate q_{50}, $m^3/(h\ m^2)$**	
	The new building, substantial renovation	Renovation, existing building
Residential building	4.0	6.0
Non-residential building	2.5	4.0

Alternative simplified compliance assessment method

The simplified method can be used in the case of small residential buildings for proving compliance with the limit value of EPI. The designed technical systems for the building must comply with the following requirements:

- The main heat source for space heating and DHW must be a ground-source heat pump, air-to-water heat pump, wood-based boiler, district heating, or gas-condensation boiler;
- The temperature efficiency of the ventilation system heat recovery must be at least 0.8;

- The ventilation system-specific fan power (SFP) must be lower than 2.0 kW/(m^3 s).

For the purposes of the simplified assessment, it is possible to use an MS excel based calculation tool.

Requirements for the building envelope

The building envelope must be sufficiently airtight and insulated. When determining the insulation suitable for the building, the factors to be taken into consideration are energy performance requirements, maintenance, thermal comfort, and the avoidance of condensation and mold growth on thermal bridges, inner surfaces, and structural elements.

In order to maintain a comfortable thermal environment in the building, the thermal transmittance of its envelope, in general, may not exceed 0.65 W/(m^2K). If the doors or windows have a higher thermal transmittance value, thermal comfort must be ensured with a heating system solution.

The average leakage rate of the building envelope may not exceed the value used in the energy calculation performed to prove the building's compliance with the minimum requirements for energy performance.

Summertime overheating calculation procedure

If no cooling is installed, a dynamic temperature simulation for critical rooms is required in order to comply with summer temperature requirements. The requirement is regarded as complied with if, during the period from 1 June to 31 August, the indoor temperature does not exceed the limit temperature (the cooling setting) by more than 150-degree hours (°Ch) in residential buildings (base temperature 27 °C) and by more than 100 °Ch in non-residential buildings (base temperature 25 °C). In the case of educational and research buildings (except daycare facilities and pre-school institutions for children, educational and research buildings), the assessment time period is set from 1 May to 15 June and from 15 August to 30 September. In this case, the buildings are presumed to be closed from 15 June to 15 August. The cooling period may in some buildings be longer than the period referred to above, but this is not taken into account when assessing compliance with the temperature excess requirement. The energy needed for cooling and the energy use of the cooling system is calculated in respect of the entire cooling period.

An exception for detached houses, there the compliance may be alternatively shown with tabulated values for solar shading, window sizes, and window airing (4 key performance values).

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

No climatic zones in energy calculation. National test reference year.

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

NZEB primary energy minimum requirements are reported in Table 3.4.6, set for 14 building categories and in single-family houses divided into 3 according to floor area.

CO_2 is currently not included in energy calculation, because everything is based on primary energy.

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m^2/a for heating demand. Could this become the case in your country? and why?

PassivHaus methodology has been seen as outdated because Estonian dynamic energy simulation (and temperature simulation for overheating) based methodology is more advanced. The methodology is also based on inner dimensions and linear thermal bridges, net floor area, etc. not compliant with PassivHaus

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity, heating and cooling balance. If you have a climate contrast (for example heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

Estonia belongs to the coldest climate zone of the EU, climate is heating-dominated. However, all non-residential buildings are equipped with cooling systems, because of the short time cooling needed in summer. With a good design of passive measures, cooling energy use is very small. Table 3.4.7 is an example of the model energy balance of typical buildings fulfilling nZEB requirements.

Table 3.4.7: Model energy balance of typical buildings fulfilling nZEB requirements

					heat source, district heat			0.9										
	Primary energy factors				heat source, gas			0.95										
	Electricity	2			space heating em&distribution			0.97										
	Gas	1			cooling			3.5										
	District he	0.65			SFP			1.5										
									Gas	District heat					W/o PV			
kWh/m2 a	Lighting	Appliance	Ventilatio	Space he	Supply air	DHW	Cooling	Fans and	Heating	Heating	Cooling	Delivered	PE	PE	B class	PV	Self-consu	A class
			l/s m^2	need	heating	need+dist	need	pumps	delivered	delivered	delivered	total	gas	district he	low-energ	generation	PV el., %	NZEB
Detached house <120 m2	5.3	22.5	0.50	40	6	30	0	8.6	75.0	79.2	0.0	117.4	**160**	**136**	165	22.2	45	145
Detached house 120 - 220 m	5.3	18.0	0.42	38	5	25	0	7.5	67.6	71.3	0.0	103.4	**139**	**118**	140	25.0	40	120
Detached house >220 m2	5.3	15.0	0.42	32	5	20	0	7.5	55.8	58.9	0.0	88.6	**121**	**104**	120	28.6	35	100
Apartment building	7.0	22.5	0.42	26	4.5	30	0	6.0	59.8	63.1	0.0	99.9	**140**	**121**	125	18.2	55	105
Office	15.8	18.9	2.0	25	9	6	10	11.8	42.9	45.3	2.9	92.3	**142**	**128**	130	16.7	90	100
Shopping and terminal	53.4	2.8	2.0	5	10	4	35	21.5	20.2	21.3	10.0	107.9	**196**	**189**	190	16.7	90	160
Hotel	35.0	3.5	1.0	25	13	30	10	14.4	72.4	76.4	2.9	128.2	**184**	**161**	170	17.9	70	145
Restaurant	27.7	5.8	2.0	25	10	23	15	15.4	61.8	65.3	4.3	115.1	**168**	**149**	150	16.7	60	130
Public building	35.8	0.0	2.0	35	10	20	0	18.7	69.6	73.4	0.0	124.0	**178**	**157**	160	15.6	80	135
Educational building (school)	13.0	8.7	3.0	30	15	10	5	10.5	58.9	62.1	1.4	92.5	**126**	**108**	120	16.7	60	100
Daycare center	15.0	5.0	2.0	35	10	15	8	12.4	64.3	67.9	2.3	99.0	**134**	**114**	120	13.3	75	100
Health care center	20.3	8.1	2.0	30	10	12	10	13.3	55.7	58.8	2.9	100.3	**145**	**127**	130	17.6	85	100
Barrack (military)	35.0	7.0	1.5	30	17	35	10	20.2	87.3	92.1	2.9	152.4	**218**	**190**	200	18.8	80	170
Industrial building	20.6	20.6	0.9	30	10	6	10	6.0	49.4	52.1	2.9	99.6	**150**	**134**	140	16.7	90	110
Warehouse	17.5	0.0	0.35	24	7	0	0	5.1	33.4	35.3	0.0	56.0	**79**	**68**	80	18.8	40	65
appliances electricity in reside	0.7																	
year	8760	h																
school summer holiday	1464	h																
school hours	7296	h																

Calculated for gas and district heating (easier to achieve nZEB because of lower PE factor). Class B must be achieved without PV production. Required PV production to achieve nZEB (class A) is calculated for the case if the building will exactly fulfill class B requirements without PV. With actual PE values in the table (slightly below B class) slightly less PV would be needed. If class A would be achieved without PV then PV is not needed, but this is not realistic in most cases. Note also that non-EPBD appliances are included in the energy balance / nZEB requirements, i.e. calculated energy is intended to be equal with measured operational energy if the building use is typical.

4.b. Can you reach nearly zero heating demand?

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity in regard to the electric or thermal demand?

5. What is the thermal comfort limit for nZEBs in your country?

We have EVS-EN 16798-1:2019+NA:2019, so it includes the Estonian national annex. For new buildings indoor climate Category II requirements apply, National Annex specifies some additional air velocity requirements and blocks the use of the adaptive comfort model.

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBS.*

5.a.2. Cite the reference, and share the reference in pdf format if possible.

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.4.8: Overheating assessment in Estonia

Country	Estonia
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	No.
Do you have a specific comfort calculation approach for heatwaves?	No (just simulation with TRY).
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	Yes / No (we expect to revise TRY in every 10 years).
Occupant type and representation	
What is your comfort standard?	EVS-EN 16798-1:2019 NA:2019
For which building types?	Residential and commercial.
Does your method embrace the four occupant categories (I, II, III, IV)? *	I, II, III (IV is not defined).
How do you represent occupancy presence in the simulation model?	Hourly occupancy profiles are defined in the regulation.
Comfort model	
What is your overheating indicator?	150 Kh > 27 °C in residential buildings 100 Kh > 25 °C in non-residential buildings
Is your comfort model based on an adaptive or static method?	The above criteria may be classified as adaptive, but cooling systems are sized with static.

What are your overheating thresholds? and according to which standard are those thresholds defined?	150 Kh > 27 °C in residential buildings 100 Kh > 25 °C in non-residential Apply for rooms with human occupancy
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	No.
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air conditioned chairs, electric heating mattresses…)?	Yes (whatever you have you can simulate if your simulation tool is capable of that – most common IDA-ICE is quite flexible).
<u>Simulation model</u>	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Dynamic (for single-family, an Excel calculator may be used as an alternative)
Is your overheating calculation based on a single or multizone model?	Multizone. But an apartment may be simulated with open doors. Both single zone (one apartment as one zone) or multizone (main rooms modeled) approach is specified.
Does your calculation distinguish sleeping rooms from other living areas?	Upon energy modeler choice because two approaches are specified.
<u>Mandatory envelope requirements</u>	
Does your method oblige the installation of external shading?	No.
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	Rule of thumbs are provided for single-family: - WWRxg ≤ 0.2 - WWR ≤ 0.4

	- window to floor ratio ≤ 0.15 - effective openable windows are fraction ≥ 0.1 If these four conditions are met for living rooms and bedrooms, no temperature simulation is needed.
Does your method recommend a g-value? If yes, what is the limit?	Yes. For single-family: WWRxg ≤ 0.2
* we are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

5.c.1. What are the overheating criteria for nZEBs in your country?

5.c.2. What is the overheating risk for nZEB (highly insulated) in your climate?

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

5.d. Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?

6. What is the minimum renewables threshold for nZEB in your country?

Because of the non-renewable primary energy requirements, no specific RES is specified. The use of RES makes it just easier to achieve PE requirements. Class A (NZEB) and Class B (Low energy) are set so that B needs to be achieved without onsite electricity generation (solar collector accepted). This is an additional requirement for NZEB. It is thought that Class A will be then achieved by adding PV, but all other efficiency and RES measures can be also used.

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

7. What is the construction quality for nZEBs in your country?

Generally, very high. Building leakage test is not mandatory but required in practice if energy simulation is done with default q50 value of 1.5 m3/(h m2). For the use permit, EPC needs to be re-simulated with a measured value.

NZEB is generally an integrated design, a mix of passive and active measures. To be successful, a university level of education in architecture, HVAC, and energy is needed – Estonia is one of these lucky countries where this is well available. We can be especially proud of the energy modeler qualification.

9. REFERENCES / KEY PUBLICATIONS:

[1] "REHVA nZEB Task Force and CEN EPBD. Technical definition for nearly zero energy buildings. REHVA Journal, (03)," 2013.

[2] Estonian Government Ordinance No. 63: "Hoone energiatõhususe miinimumnõuded" [Minimum requirements for buildings energy performance] (in Estonian), RT I, 2018, redacted 25.08.2019.

[3] Estonian Government Ordinance No. 58: "Hoone energiatõhususe arvutamise metoodika" [Calculation methodology for building energy efficiency] (in Estonian), RT I, 2015, redacted 25.08.2019.

3.5. HUNGARY

1. **Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.**

Table 3.5.1 nZEB status in Hungary

Legislation [1]	
Definition nZEB available	Yes
Min. threshold set	Yes
Subsidy retrofitting towards nZEB	No
Min. Energy efficiency PE use intensity ($kWh/m^2.a$)	100/90/85 depends on building type
Min. perf. Threshold heating demand ($kWh/m^2.a$)	No
Min. perf. Threshold cooling demand ($kWh/m^2.a$)	No
Life Cycle Assessment	No
CO_2	No
Airtightness	No
Heating Cooling Balance	
Natural ventilation possible	Yes
Technical System Min. performance requirements	No
Thermal Comfort Limits	
Climate Zones	Not specified in the code. 5 in ASHRAE 90.1.
Overheating risk	Yes
Thermal comfort Standard	Yes
Efficiency vs Renewable Threshold	25%

RES (%)	
Construction Quality	
Available materials	Medium
Available knowledge	Medium

2. **Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.**

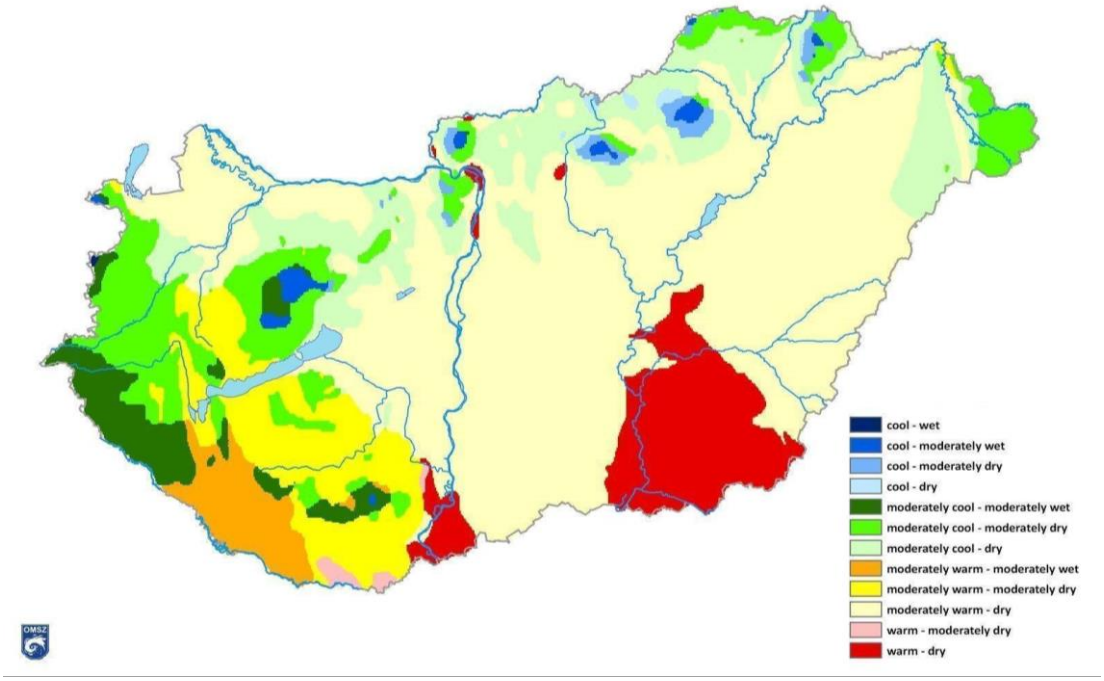


Figure 3.5.1 - The climatic regions in Hungary (after György Péczely)

https://www.met.hu/en/eghajlat/magyarorszag_eghajlata/altalanos_eghajlati_jellemzes/altalanos_leiras/

3. **What is the minimum energy efficiency threshold for nZEB in your country?**

There is an agreement in Europe to use the end-use and primary energy use intensity indicator to reflect the depletion of fossil fuels and proportional CO_2 emissions. The EPBD recast introduced the concept of nZEB implying, for new buildings, very high energy performances and low energy needs that must be suppressed by renewable energy sources harvested on-site, after the end of 2020.

a. *In your country what is the minimum energy efficiency threshold regarding end-use and primary energy use intensity and CO_2 emissions?*

According to [1] – Annex 6, section III, there are three building types where a specific minimum energy efficiency threshold is set for primary energy use:

- residential buildings (without lighting energy use): 100 kWh/m^2.a;
- office buildings and commercial buildings with maximum net 1000 m2 (with lighting use, in case of active cooling): 90+10 kWh/m^2.a;
- Educational facilities and other buildings containing typically lecture halls or exhibition spaces (with lighting use): 85 kWh/m^2.a.

For other building types, a calculation methodology is given to be used to determine the threshold.

~~***b.** If there is no minimum threshold, which threshold do you suggest for your country and why?*~~

***c.** Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m^2.a for heating demand. Could this become the case in your country? and why?*

The PassivHaus Standard heating demand threshold can be generally achieved on the Hungarian climate with a significant surplus in investment cost in the case of residential buildings. Therefore, it is not widely acceptable to apply those values.

4. **What is the Heating-Cooling balance for nZEB in your country?**

The heating and cooling demand balance are very important for high-performance buildings. In cooling or heating-dominated climates, building designers seek through bioclimatic and passive strategies to deal with only one acclimatization system to reduce cost and achieve maximum possible comfort.

***a.** Describe your countries' climate, seasonal intensity, and heating and cooling balance. If you have a climate contrast (for example heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.*

Average heating degree days for Hungary were 2547 in 2020 (averaged from 1979 to 2020: 2850) whereas cooling degree days were 70 (averaged from 1979 to 2020: 80). Therefore, it can be stated that the climate is clearly heating-dominated.

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Heating_and_cooling_degree_days_-_statistics&stable=0#By_Member_State

***b.** Can you reach nearly zero heating demand?*

c. *Should we opt for highly airtight envelopes or medium airtight envelopes in your country?*

Highly airtight envelopes would ensure minimizing heating and cooling demand. However, mechanical ventilation is still not obligatory in buildings and therefore very rarely installed due to the high investment costs, especially in residential buildings. Therefore, until mechanical ventilation cannot be prescribed on a national level for new construction NZEBs, the fresh air and occupant wellbeing aspect overrule the aspects of energy-saving and would lean to the direction of medium airtight envelope buildings to ensure a minimum level of air change during the nights when window opening is not possible.

d. *What is the influence of the heating/cooling balance on your energy supply network capacity regarding the electric or thermal demand?*

The electric energy supply network is stable and can handle the demand peaks today. However, the annual electric energy demand peaks are clearly associated with building energy use. There are usually two electricity demand peaks during the year. The first one is during the coldest days in winter which is due to the electric need for mainly thermal heating systems (e.g.: pumps). This peak is in the evening hours when the higher comfort temperature is at the same time with the residential lighting and plug load use. The second peak is during the summer when the daily average external temperatures are higher and are registered in the middle of the day (around 1:30 pm). Lately, there is a tendency that this peak is shifting towards the evening hours as residential renewable generation is more and more widespread and therefore, electricity generation from solar radiation is covering most of the household cooling energy demand. [2]

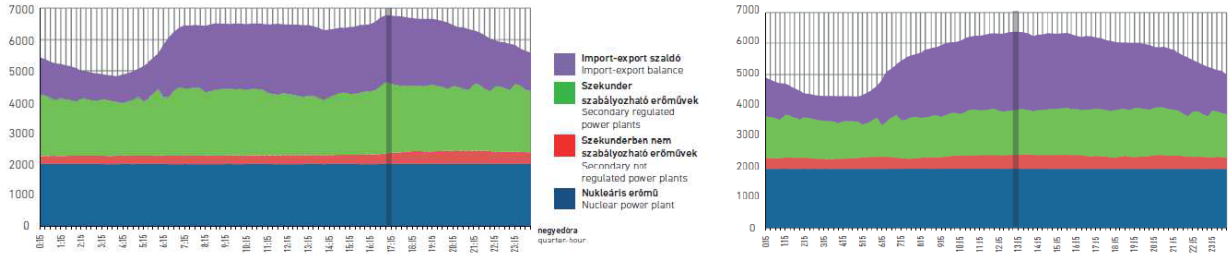


Figure 3.5.2 – Daily gross energy demand profile on Jan 11, 2017 (left) and June 28, 2017 (right), MW (source: Hungarian electricity supply system data, 2017) [2]

5. What are the Thermal comfort limits for nZEB in your country?

In 2019, the European Committee for Standardization (CEN) introduced the European standards EN 16798, which suggests the adoption of the Fanger's PMV/PPD model for mechanically heated and/or cooled buildings and Humphreys and Nicol's adaptive model for buildings without mechanical cooling systems. In 2008, the PassivHaus standard required comfort levels complying with the static

model of EN 15251 / 16798 respecting the following rule: the number of hours over 25°C may not exceed 5% of the time working. This criterion is verified by using a dynamic simulation. In Eastern Europe, there are no studies that investigated the correlation between the variations of minimum performance threshold and suitable or fit to purpose comfort models in continental climates.

a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBS.*

Indoor temperatures (operative) are required to comply with EN 15251 in both heating and cooling seasons.

Table 3.5.2: basic data that can be taken into account for the design of the building technology system

1. táblázat: Az épülettechnikai rendszer tervezéséhez figyelembe vehető légállapot adatok *

Az épület vagy a helyiség funkciója	A minimális belső hőmérséklet fűtésnél, °C	Hőmérséklet tartomány fűtésnél, °C	A maximális belső hőmérséklet hűtésnél, °C (amennyiben van gépi hűtés)	Hőmérséklet tartomány hűtésnél, °C
Lakóépület, huzamos tartózkodásra szolgáló helyiségek (szobák, étkező hálószoba stb.)	20	20-25	26	23-26
Lakóépület: egyéb helyiségek (konyha, tároló stb.)	16	16-25	-	-
Iroda (cellás vagy egyterű) Konferenciaterem Előadó, osztályterem Étterem/büfé	20	20-24	26	23-26
Óvoda	22	22-24	26	23-26
Áruház	16	16-22	25	21-25

Megjegyzés: A táblázatban levő hőmérsékletek operatív hőmérsékletet jelentenek.

a.2. *Cite the reference, and share the reference in pdf format if possible.*

The standard is cited here in the regulation: [1] Annex 1, V. Table 1. (online version available: https://net.jogtar.hu/jogszabaly?docid=a0600007.tnm)

a.3. *Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.*

The static model is used and only for indoor operative temperature. The relative humidity is not mentioned in the decree. Fresh air volume is determined by the decree, no standards are referenced.

a.4. *Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.*

Table 3.5.3: Thermal comfort and overheating requirements in Hungary

Country	Hungary	*France*	*Belgium*
Climate and weather data			

Is comfort dependent on national geographic climate zones? If yes, list them.	No	*Yes: H1a, H1b, H1c, H2a, H2b, H2c, H2d, H3*	*Yes: Brussels, Flanders, Wallonia*
Do you have a specific comfort calculation approach for heatwaves?	No	*No*	*No*
Do you take into account the urban heat island effect?	No	*No*	*No*
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No	*No*	*No*
Occupant type and representation			
What is your comfort standard?	EN 15251	*ISO 7730* *EN 15251*	*EN 15251*
For which building types?	Residential, commercial, education, dining, kindergarten, sales	*Residential and commercial*	*Residential and commercial*
Does your method embrace the four occupant categories (I, II,	No	*Yes*	*No*

III, IV)? *			
How do you represent occupancy presence in the simulation model?	No simulation required		*Deterministic (living and sleeping zones and schedules)*
Comfort model			
What is your overheating indicator?	q_b: average internal heat gains for occupied periods	*DIES (durée d'inconfort d'été statistique): statistical summer discomfort duration*	$I_{overh} = \sum_{m=1}^{12} Q_{excess\ norm,m}$ *where* $Q_{excess\ norm,\ m}$ *is the excess of heat gains in relation to the indoor set-point temperature for the month m.*
Is your comfort model based on an adaptive or static method?	Static	*Mixed: adaptive and static for sleeping rooms*	*Static*
What are your overheating thresholds? and according to which standard are those thresholds defined?	qb < 10 W/m^2 AND Δtb,summer < 3 K (heavy bldg.) Δtb,summer < 2 K (lightweight bldg.)	● *all living spaces except sleeping rooms depend on an adaptive model* ● *maximum 28°C operative temperature in sleeping rooms* *& EN 15251*	*Recommended range: 1000 Kh <* I_{overh} *< 6500 Kh* *& EN 15251*
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode	No	*I don't know*	*No*

buildings?			
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air conditioned chairs, electric heating mattresses…)?	No	*No*	*No*
Simulation model			
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Static. A dynamic, hourly model is optional.	*Dynamic model & hourly calculations*	*Brussels: Static (Passive House Standard)* *Flanders and Wallonia: quasi-dynamic with 12 simulation steps (ISO 13790)*
Is your overheating calculation based on a single or multizone model?	The static calculation for relevant zones.	*Multizone model*	*Multizone model*
Does your calculation distinguish sleeping rooms from other living areas?	No	*Yes*	*Yes*
Mandatory envelope requirements			
Does your method oblige the installation of	No, only recommended.	*No*	*No*

external shading?			
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No	*No*	*No*
Does your method recommend a g-value? If yes, what is the limit?	Active cooling can be used only in case g<0,3 at non-north-facing and roof windows.	*No*	*No*
* We are focusing on category II occupants for new buildings and renovated buildings			

b. *Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.*

Fuel poverty is sadly still a very relevant issue in Hungary. Many research projects have been conducted on the topic in recent years. A local energy policy institute and methodological center, Energiaklub among many other energy-related topics, has focused on fuel poverty problems locally for more than 30 years now. Their recent research was published online [3] and states that it is difficult to estimate the share of households in a country that are affected by the problem because there is neither a national nor EU-level definition for the term yet. In 2020, the EU published a report on the topic [4] which estimated the number of EU citizens affected to be 82 million. According to the 2019 utility data in Hungary, 10.2% of households had unpaid energy bills and approximately 5,4% of the households were not able to reach the desired heating set point in their home. [5]

c.1. *What are the overheating criteria for nZEBs in your country?*

The energy code sets a maximum threshold to avoid overheating which is the average internal heat gains for occupied periods (qb). The requirement is that the internal heat gains for occupied periods cannot exceed 10 W/m^2 and the daily average temperature difference between indoor and outdoor should be below 3 K in case of heavy buildings and 2 K for lightweight buildings.

c.2. *What is the overheating risk for nZEB (highly insulated) in your climate?*

In Hungary, predominantly heavy-weight buildings are built for residential purposes, therefore, overheating risk is estimated to be lower. However, external shading use is not prescribed in the local energy code, therefore, designers should pay attention to using appropriate window-to-wall ratio and shading systems.

c.3 *How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.*

See above.

d. *Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?*

Historically, no buildings required active cooling systems in Hungary as summer night temperatures reached free cooling levels and nocturnal ventilation was applied which ensured passive cooling of the buildings. However, with climate change, summers became warmer and at the same time, there was a tendency to increase window sizes without appropriate shading. Therefore, recently, active cooling has started to be a standard feature of new-built residential and also commercial buildings to ensure comfort during summer periods.

6. What is the minimum renewables threshold for nZEB in your country?

Energy efficiency and renewable energy technologies provide important opportunities to reduce greenhouse gas emissions. Efficiency is a policymaking principle that recognizes the central role that cost-effective energy savings can play in meeting energy, climate, and economic goals.

25% of Ep (yearly primary energy demand).

a. *Is it easier in your country to invest in renewables than investing in energy efficiency? And why?*

The most common renewable energy source in Hungarian residential buildings is solar radiation. NZEB criteria prescribe very high energy-efficiency levels for new constructions and major renovations which is a great investment for builders on its own. Fulfilling the 25% threshold of renewable production is usually done by installing the minimum number of PV panels. If there is a possibility to invest more, the expansion of the PV plant is a cheaper choice, and also new types of subsidies are announced to be implemented later this year. Therefore, it can be stated that nowadays it is easier to invest in renewable energy after fulfilling NZEB energy efficiency requirements.

b. *Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that*

threshold be? 30, 50, or 70% of the demand?

For now, 25% is a threshold which increased the budget extremely for new buildings in recent years. Therefore, the acceptability is very low. At the same time, professionals suggest increasing energy efficiency and thus reducing energy demand further instead of producing a larger share of larger primary energy use from renewables.

c. *Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?*

With the residential PV plant uptake, the energy grid started to be threatened and it is highly encouraged to use locally produced energy during production hours. It is still unclear what the policies are going to be to ensure transition in this area, for example applying demand-side management or daily/hourly fee structures. In 2020 October, it was announced that from 2024 the currently applied energy supplier-local PV owner contract structure (yearly balance pay-off) is going to be changed for a gross feed-in tariff system. Also, the national climate change strategy [6] accounts for an increased level of electrification in Hungary in the upcoming years. Therefore, many energy suppliers have started to prepare a strategy to handle the problem of energy supply safety. In conclusion, it can be stated that currently Hungary is in a transitional phase in this regard. There is also a national smart meter implementation project running in Hungary which has the aim of evaluating the potential in the widespread smart meter installations. [7] It is very promising and would be a large step forward to collect more information on energy-related occupant behavior and therefore, would provide a clearer sight for policy-makers on household energy efficiency.

7. What is the construction quality for nZEB in your country?

NZEBs require high construction quality through new construction technologies, high-tech components, specialized competencies, and high-level expertise. To achieve NZEBs, the use of energy-efficient technologies and materials is necessary. These technologies and materials must respond to the exigencies of the NZEBs and satisfy the NZEB market demand.

The local energy code does not require any measurements after construction (blower door test of the thermal camera). There is a statement required to be signed by the construction manager stating that the building was constructed according to the design documentation in good quality. [8] This statement is the quality assurance applied in the construction process.

a. *Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?*

Low-tech nZEB solutions are more preferable due to lower investment costs and also for their more environmentally friendly nature. In Hungary, utility rates are kept relatively low due to national policies on fighting energy poverty. Besides, its success in tackling the problem, unfortunately, affected the return on investment rates of pricier energy efficiency solutions. Professionals agree that design teams and also manufacturers are ready to fulfill NZEB energy efficiency requirements. However, builders and investors need to invest more and think in a longer term than earlier.

b. *What are the main barriers to high-quality nZEB construction in your country?*

Local universities provide state-of-the-art training for all disciplines of NZEB designers (architects, structural engineers, building service engineers, and electrical engineers). Therefore, the main obstacle is the investment cost and very low return on investment of energy-efficient technologies and materials.

8. **What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below** :

Table 3.5.4: Minimum requirements for energy efficiency, renewable Energy threshold onsite in Hungary

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
	Overall energy use: 75 kWh/m2,a		NONE: A very low EE threshold should be enforced which can be either reached by a highly energy-efficient building with extremely low energy demand, or by a less energy efficient one equipped with renewables.

REFERENCES

[1] Hungarian transposition of EPBD: TNM Ministry Decree No. 7/2006 (V.24); Government Decree 176/2008 (VI. 30.) on The Determination of Building Energy Parameters; Governmental Decree 264/2008. (XI. 6.), (n.d.).

[2] F. Kft., Report on the Electricity Supply Network Climate-Specific Evaluation in Hungary - A MAGYARORSZÁGI VILLAMOSENERGIA-ELLÁTÁS ÉGHAJLATI SZEMPONTÚ ÉRTÉKELÉSE, MBFSZ Serv. (2019).

[3] Energiaklub, Fuel poverty article collection, (n.d.). https://energiaklub.hu/cikk/koszen-papir-kinyilt-tarsadalmi-ollo-4947.

[4] S. Bouzarovski, H. Thomson, Towards an inclusive energy transition in the European Union : Confronting energy poverty amidst a global crisis Energy Poverty Observatory, Luxembourg, 2020. doi:10.2833/103649.

[5] EU-SILC, Inability to keep home adequately warm, (n.d.). http://appsso.eurostat.ec.europa.eu/nui/show.do?query=BOOKMARK_DS-056346_QID_-245E23C4_UID_-3F171EB0&layout=TIME,C,X,0;GEO,L,Y,0;HHTYP,L,Z,0;INCGRP,L,Z,1;UNIT,L,Z,2;INDICATORS,C,Z,3;&zSelection=DS-056346INCGRP,TOTAL;DS-056346UNIT,PC;DS-056346HHTYP,TOTAL;DS-056346INDICATORS,OBS_FLAG;&rankName1=HHTYP_1_2_-1_2&rankName2=TIME_1_0_0_0&rankName3=UNIT_1_2_-1_2&rankName4=GEO_1_2_0_1&rankName5=INDICATORS_1_2_-1_2&rankName6=INCGRP_1_2_-1_2&sortC=ASC_-1_FIRST&rStp=&cStp=&rDCh=&cDCh=&rDM=true&cDM=true&footnes=false&empty=false&wai=false&time_mode=ROLLING&time_most_recent=false&lang=EN&cfo=%23%23%23%2C%23%23%23.%23%23%23.

[6] Ministry of Innovation and Technology, National Climate Change Strategy - második Nemzeti Éghajlatváltozási Stratégia, 2018.

[7] M. Horváth, J.N. Adams, Z. Deme Bélafi, L. Czétány, Z. Szalay, S. Várnagy, A. Reith, T. Csoknyai, Large scale smart meter data assessment for energy benchmarking and occupant behaviour profile development, IOP Conf. Ser. Earth Environ. Sci. 323 (2019) 012121. doi:10.1088/1755-1315/323/1/012121.

[8] TNM Ministry decree 176/2008 on The Certification of Building Energy Parameters - TNM, 176/2008. (VI. 30.) Korm. rendelet az épületek energetikai jellemzőinek tanúsításáról, (2008). https://net.jogtar.hu/jogszabaly?docid=a0800176.kor.

3.6. LATVIA

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.6.1: nZEB status in Latvia

Legislation	
Definition nZEB available	Yes.
Min. threshold set	Yes.
Subsidy retrofitting towards nZEB	No.
Min. Energy efficiency PE use intensity (kWh/m^2.a)	Non-renewable primary energy is taken into consideration. Value depends on the type and size of the buildings. For nZEB min. energy efficiency PE use intensity varies in the range between 95 **kWh/m^2** – 170 **kWh/m^2**
Min. perf. Threshold heating demand (kWh/m^2.a)	Value depends on the type and size of the buildings. For nZEB, these values vary in the range between 40 **kWh/m^2** – 60 **kWh/m^2.** Min. perf. The threshold heating demand for residential buildings with an area large than 250m^2 is 40 kWh/m$^{2.}$ And for residential and non-residential buildings with areas 50 – 120 m2 - 60 kWh/m^2
Min. perf. Threshold cooling demand (kWh/m^2.a)	Not directly defined. Just as total non-renewable primary energy consumption should not exceed normative values.
Life Cycle Assessment	In case it is not possible to reach the nZEB level. Calculated following LVS EN 15459-1:2020
CO_2	Normative values, as well as maximal, are not defined.
Airtightness	Not directly in the definition of nZEB.

	Airtightness is defined in the building code on the Energy Performance of Building envelope. Values 1.5m^3/m^2h at 50Pa are set for buildings equipped with mechanical ventilation and heat exhaust.
Heating Cooling Balance	
Natural ventilation possible	Yes
Technical System Min. performance requirements	Not set up for nZEB. Technical system minimum performance requirements are defined for A+ buildings.
Thermal Comfort Limits	
Climate Zones	Cold zone.
Overheating risk	Yes
Thermal comfort Standard	The assessment of an nZEB shall assume that the indoor temperature conditions during the heating period are at least at the level of category II and during the non-heating period at least at the level of category III by the standard LVS EN 16798-1: 2019 nZEB must have an assessed overheating risk indicator following the standard LVS EN ISO 52016-1: 2017
Efficiency vs Renewable Threshold **RES (%)**	No.
Construction Quality	
Available materials	Not defined
Available knowledge	Not defined

Table 3.6.2: Requirements for the Microclimate of Work Premises Depending on Physical Load

No.	Time of the year	Work category	Air temperature (°C)	Relative air humidity (%)	Air movement rate (m/s)
1.	The cold time of the year (average air temperature outside work premises + 10 °C or lower)	I*	19.0–25.0	30–70	0.05–0.15
		II**	16.0–23.0	30–70	0.1–0.3
		III***	13.0–21.0	30–70	0.2–0.4
2.	Warm time of the year (average air temperature outside work premises exceeding + 10 °C)	I*	20.0–28.0	30–70	0.05–0.15
		II**	16.0–27.0	30–70	0.1–0.4
		III***	15.0–26.0	30–70	0.2–0.5

* Category I: the work is not associated with physical efforts or requires very slight or slight physical efforts (for example, all doers of mental work, work with different control panels, work performed while seated, standing or moving, movement of light items (up to 1 kg)).

** Category II: work associated with medium or great physical efforts (for example, permanent lifting and movement of weights (up to 10 kg), welding, metal processing works).

*** Category III: heavy work (for example, permanent lifting and movement of weights (greater than 10 kg)).

However, the latest revision on energy performance calculation considers EN 16798-1 comfort categories.

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

Latvian building code on building climatology does not provide climate division in climatic areas. It provides average data on climate parameters for 22 cities. The main provided data includes average heating temperature, length of the heating season, and data on relative humidity, winter and summer design temperatures.

Figure 1 Cities with available climatic data for calculation of energy performance

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

CO2 emissions are not regulated. The non-renewable primary energy is shown in Tables 1 and 2.

Table 1 Minimum level of non-renewable primary energy consumption for residential buildings

Energy performance class of buildings	Residential buildings		Single-family houses, apartment buildings, cohabitation houses of different social groups, collaborative housing
	heated area, m^2		
	from 50 to 120	from 120 to 250	> 250
A+ **nZEB**	≤ 65	≤ 65	≤ 65
A	≤ 110	≤ 100	≤ 95

nZEB			
B	≤ 140	≤ 130	≤ 125
C	≤ 160	≤ 155	≤ 145
D	≤ 200	≤ 190	≤ 165
E	≤ 230	≤ 210	≤ 180
F	≤ 260	≤ 260	≤ 220
G	> 260	> 260	> 220

Table 2 Minimum level of non-renewable primary energy consumption for non-residential buildings

Energy performance class of buildings	Offices, educational institutions, sports facilities	Hospitals, hotels, restaurants	Wholesale and retail buildings
A+ **nZEB**	≤ 90	≤ 130	≤ 120
A **nZEB**	≤ 110	≤ 170	≤ 150
B	≤ 160	≤ 240	≤ 190
C	≤ 210	≤ 280	≤ 215
D	≤ 250	≤ 320	≤ 230
E	≤ 300	≤ 380	≤ 300
F	≤ 400	≤ 450	≤ 400
G	virs 400	virs 450	virs 400

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m^2/a for heating demand. Could this become the case in your country? and why?

A minimum performance threshold of 15kWh/m^2/a for heating demand will not be adopted. The main reason is the cold climate and extra construction costs. Due to relatively cheap energy prices, such value is not cost-optimal.

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity, heating, and cooling balance. If you have a climate contrast (for example, heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated, heating-dominated, and heating and cooling-dominated.

Latvia is a heating-dominated country.

4.b. Can you reach nearly zero heating demand?

Yes.

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

It is highly recommended to ensure the airtightness of the external building envelope.

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity concerning the electric or thermal demand?

Currently, it is not considered. In general, the cooling energy consumption of the single-family house is 5 to 8 kWh/m^2, while the heating need is 40 – 60 kWh/m^2.

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBs.*

- EN ISO 7730:2006-05 – Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort by calculating the PMV and PPD index and criteria for local thermal comfort.
- EN 15251:2012-12 – Input parameters for the indoor climate for the design and evaluation of the energy efficiency of buildings - indoor air quality, temperature, light and acoustics.

5.a.2. Cite the reference, and share the reference in pdf format if possible.

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

It should be used when cooling loads are not considered for building energy certification.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.6.3: Overheating assessment in Latvia

Country	Latvia
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	No.
Do you have a specific comfort calculation approach for heatwaves?	No.
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No
Occupant type and representation	
What is your comfort standard?	EN ISO 7730:2006 EN 16798-1:2019
For which building types?	All.
Does your method embrace the four occupant categories (I, II, III, IV)? *	Yes
How do you represent occupancy presence in the simulation model?	It is not defined.
Comfort model	
What is your overheating indicator?	Kelvin hours (K · h)

Is your comfort model based on an adaptive or static method?	Static.
What are your overheating thresholds? and according to which standard are those thresholds defined?	for various types of single-family houses, apartment buildings, and office buildings, the operating temperature above 27 ° C shall not exceed 150 Kelvin hours (K · h) in the period from 1 May to 30 September; the operating temperature of social housing and hospitals of various social groups above 25 ° C shall not exceed 100 Kelvin hours (K · h) in the period from 1 May to 30 September; The operating temperature of the premises in the buildings of educational institutions above 25 ° C shall not exceed 150 Kelvin hours (K · h) in the period from 1 May to 15 June and from 15 August to 30 September.
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	No.
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air conditioned chairs, electric heating mattresses…)?	No.
<u>Simulation model</u>	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Static, in some cases quasi-dynamic. Calculation time step: monthly or hourly.
Is your overheating calculation based on a single or multizone model?	Multizone (but not mandatory).

Does your calculation distinguish sleeping rooms from other living areas?	It is possible but not mandatory
<u>Mandatory envelope requirements</u>	
Does your method oblige the installation of external shading?	No.
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No.
Does your method recommend a g-value? If yes, what is the limit?	No.
* We are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

Till the end of 2021, there wasn't any sign of possible fuel poverty. However, late uncertainties in natural gas supply and electricity import from Belarus and Russia have caused revision on current support to install local renewable energy systems.

5.c.1. What are the overheating criteria for nZEBs in your country?

It was overheating hours.

5.c.2. What is your climate's overheating risk for nZEB (highly insulated)?

The overheating risk for nZEBs is moderate.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

Bot any specific tool is directly mentioned. Usually, the use of a Passive house planning package uses IDA-ICE in some rare cases.

5.d. Can we rely on passive cooling or must we include active cooling systems for nZEBs in your country?

Mechanical cooling is included for all types of buildings. However, dynamic energy simulation can be used to prove the efficiency of passive cooling.

In practice, dynamic energy simulation is not widely used for single-family houses. Thus energy performance certificates usually include mechanical cooling. It should

be noted that mechanical cooling doesn't critically impact overall performance.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

Investing in energy efficiency is much easier. The main reason is a more predictable amount of energy savings; well know technologies and sufficient experience of all involved parties.

Government offers grants and subsidies for retrofitting the multiparent building, mainly including thermal insulation. Also, in the case of multiapartment budlings, it is almost impossible to find common agreement on energy use and distribution within multiapartment buildings.

Due to the extreme increase in energy prices, several supporting grants for installing renewable energy sources are under consideration.

6.b. Would you recommend imposing an on-site minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?

30%. Due to climate specifics and a few sunny days during the winter, the bigger share of renewable energy is not cost-optimal. A bigger share also leads to energy overproduction and waste in the summertime.

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

Regulations and policies are not sufficiently ready for encouraging energy-producing buildings. The only electric grid is ready for small energy producers (households, not industry). Since prices have been growing since the autumn of 2021, the interest in on-site electricity production is growing. However, the electricity grid operator is planning to revise current tariffs, including services for prosumers.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

high-tech skills for nZEBs are vitally important. nZEBs are very low energy consuming buildings. Thus any uncontrolled air infiltration, thermal bridges, and HVAC proper design and control significantly increase energy consumption. Even a slight increase in 5 kWh/$m^{2,}$ which is not essential for regular buildings, is essential for nZEBs.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

There is a lack of house owners' general knowledge of nZEB principles and limited financial resources. Also, there is a lack of skilled labor.

8. What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold on-site):

Table 30: EE and RES recommended for Latvia

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
nZEB	50	20	30%

9. REFERENCES / KEY PUBLICATIONS:

- Latvian building code "Building climatology" https://likumi.lv/ta/id/307966-noteikumi-par-latvijas-buvnormativu-lbn-002-19-eku-norobezojoso-konstrukciju-siltumtehnika
- Latvian building code "heating and ventilation of residential and public buildings" https://likumi.lv/ta/id/274815-noteikumi-par-latvijas-buvnormativu-lbn-231-15-dzivojamo-un-publisko-eku-apkure-un-ventilacija-

- Labour Protection Law https://likumi.lv/ta/id/26020-darba-aizsardzibas-likums
- Baranova, D., Sovetnikov, D., & Borodinecs, A. (2018). The extensive analysis of building energy performance across the baltic sea region. Science and Technology for the Built Environment, 24(9), 982-993. doi:10.1080/23744731.2018.1465753
- Baranova, D., Sovetnikov, D., Semashkina, D., & Borodinecs, A. (2017). Correlation of energy efficiency and thermal comfort depending on the ventilation strategy. Paper presented at the Procedia Engineering, 205 503-510. doi:10.1016/j.proeng.2017.10.403 Retrieved from www.scopus.com
- Borodinecs, A., Geikins, A., & Prozuments, A. (2020). Energy consumption and retrofitting potential of Latvian unclassified buildings doi:10.1007/978-981-32-9868-2_27 Retrieved from www.scopus.com
- Borodinecs, A., Prozuments, A., Zajacs, A., & Zemitis, J. (2019). Retrofitting of fire stations in cold climate regions. Magazine of Civil Engineering, 90(6), 85-92. doi:10.18720/MCE.90.8
- Borodinecs, A., Zemitis, J., Sorokins, J., Baranova, D. V., & Sovetnikov, D. O. (2016). Renovation need for apartment buildings in Latvia. Magazine of Civil Engineering, 68(8), 58-64. doi:10.5862/MCE.68.6
- Odineca, T., Borodinecs, A., Korjakins, A., & Zajecs, D. (2019). The impacts of the exterior glazed structures and orientation on the energy consumption of the building. Paper presented at the IOP Conference Series: Earth and Environmental Science, 290(1) doi:10.1088/1755-1315/290/1/012105 Retrieved from www.scopus.com
- Prozuments, A., Borodinecs, A., Odineca, T., & Nemova, D. (2020). Long-term buildings' space heating estimation method doi:10.1007/978-3-030-42351-3_47 Retrieved from www.scopus.com
- Tihana, J., Odineca, T., Borodinecs, A., Gendelis, S., & Jakovics, A. (2019). Optimal properties of the external building envelope for minimization of overheating. Paper presented at the IOP Conference Series: Earth and Environmental Science, 390(1) doi:10.1088/1755-1315/390/1/012046 Retrieved from www.scopus.com
- Zemitis, J., & Borodinecs, A. (2019). Energy-saving potential of ventilation systems with exhaust air heat recovery. Paper presented at the IOP Conference Series: Materials Science and Engineering, 660(1) doi:10.1088/1757-899X/660/1/012019 Retrieved from www.scopus.com.

3.7. LITHUANIA

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.7.1: nZEB status in Lithuania

Legislation	
Definition nZEB available	Yes.
Min. threshold set	Yes.
Subsidy retrofitting towards nZEB	Yes.
Min. Energy efficiency PE use intensity (kWh/m^2.a)	Yes, for all-purpose buildings. For single-family nZEB not more than $546 \cdot A_p^{-0,2}$ (kWh/m^2.a) and for multifamily nZEB not more than $307 \cdot A_p^{-0,07}$ (kWh/m^2.a) with A_p the heated area of the building (m²).
Min. perf. Threshold heating demand (kWh/m^2.a)	Yes, for all-purpose buildings. For single-family nZEB, not more than $451 \cdot A_p^{-0,39}$ (kWh/m^2.a), and for multifamily nZEB, not more than $197 \cdot A_p^{-0,23}$ (kWh/m^2.a) with A_p the heated area of the building (m²).
Min. perf. Threshold cooling demand (kWh/m^2.a)	Normative requirement: there must be no need to cool the building. If there is a need to cool the building, then regardless of whether the building has a cooling unit or not, the building is assigned primary energy consumption.
Life Cycle Assessment	No.
CO_2	Yes.
Airtightness	Yes.
Heating Cooling Balance	
Natural ventilation possible	Yes.
Technical System Min. performance requirements	The efficiency of the recuperators must be at least 0.80 (if the microclimate and air quality have special hygiene

	requirements and therefore separate flow recuperators are installed, their efficiency must be at least 0.68). The amount of electricity used by the recuperator fans must not exceed 0.45 Wh/m³. This requirement does not apply to storage, garage, and industrial buildings.
Thermal Comfort Limits	
Climate Zones	Lithuania has one climate zone.
Overheating risk	Yes/No. Comfort standards are not taken into account in the energy performance calculations of buildings. These calculations assume that the average indoor temperature of most buildings should be not higher than 24 C during the non-heating season. We are using EN 13790.
Thermal comfort Standard	ISO 7730, but this standard is used for design purposes only. When assessing nZEB comfort conditions are not evaluated according to this standard.
Efficiency vs Renewable Threshold **RES (%)**	More than 50 %.
Construction Quality	
Available materials	No requirements.
Available knowledge	No requirements.

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

Lithuania has only one climate zone (see Figure 3.7.1).

Figure 3.7.1: Climate zone of Lithuania

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

At present, all new buildings must be A + energy, efficiency class. From 2021-01-01, the requirement is A ++ (NZEB). CO_2 emissions are calculated, but there are no normative and regulatory requirements for them. They are regulatory requirements for primary energy consumption mentioned in Table 3.7.1.

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m^2/a for heating demand. Could this become the case in your country? and why?

PassivHaus evaluates the building along with user behavior. Our valuation methodology is based only on the valuation of a building in its typical use. The influence of consumer behavior on energy consumption is eliminated. We think that we will not use the PassivHaus methodology in Lithuania.

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity, heating, and cooling balance. If you have a climate contrast (for example heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

Lithuania is not divided into different climate regions or climate zones. The average standard monthly temperatures are used for the design of buildings and the assessment of energy performance.

4.b. Can you reach nearly zero heating demand?

Yes.

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

Buildings of the relevant energy efficiency class in Lithuania must meet the normative tightness requirements (see Table 3.7.2 below).

Table 3.7.2: Normative tightness requirements in Lithuania

No.	Purpose of the building	Energy performance class of the building	$n_{50.N}$, (1/h)
1.	Residential, administrative, scientific, and medical	C	2,00
		B	1,50
		A	1,00
		A+, A++	0,60
2.	Catering, trade, culture, hotels, services[1)], sports, transport[1)], special[1)] and leisure	C, B	2,00[2)]
		A	1,50[2)]
		A+ or A++	1,00[2)]
3.	***Notes:*** [1)] for heating premises of services, transport, and special-purpose buildings, where a gate is installed between these premises and external or any type of unheated premises (greenhouse, glazed galleries, unheated building, unheated insulated premises), no sealing requirements shall be imposed. [2)] in the case of service, transport, and special-purpose buildings, this requirement applies to that part of the building where there is no gate between the heated premises and the outside or any type of unheated premises (greenhouse, glazed galleries, unheated building, unheated insulated premises).		

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity concerning the electric or thermal demand?

As the number of renovated buildings increases, the heat supply networks become

too powerful. As a result, their potential is being used less and less. Recently, heating networks are being modernized in many places and switching to low-temperature heat supply.

As the level of insulation of buildings increases, the need for cooling buildings increases. This need is also exacerbated by architectural tendencies to install large areas of glazing in buildings. As the demand for cooling increases, so does the need for electricity. In addition, there is a noticeable trend of increasing the use of heat pumps and recuperators in buildings. It also increases electricity needs. So far, there are no problems with the electricity supply, but we may face them in the future.

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBS.*

During the preparation of the first Lithuanian methodology for calculating the energy performance of buildings (2005), data on room temperatures in winter and summer periods were taken and used from Annex C of the working document of the new draft standard EN ISO 13790: 2004. These temperatures complied with the limits set by the Lithuanian Hygiene Standards Methodology HN 42: 2004 for the standard values of the ambient temperature of thermal comfort in the premises of residential and public buildings. Subsequently, to ensure the continuity and stability of the methodology for assessing the energy performance of buildings, these temperatures were not changed. Although Lithuania's various hygiene standards have been constantly improved since 2004 and the limits of indoor ambient temperature values have been adjusted, the calculated indoor temperatures in the winter and summer periods set in the methodology for calculating the energy performance of buildings remained within the comfort limits set by new hygiene standards.

In Lithuanian climatic conditions, it is possible to design buildings in such a way that there was a very low energy demand for cooling. Therefore, when setting the regulatory requirements for the energy performance of buildings, it was assumed that there should be no need for cooling in buildings. The EN ISO 13790: 2008 standard is used to calculate the energy demand for cooling in Lithuania. The calculation methodology in this standard for calculating the thermal energy demand for cooling a building has been transferred to Annex 2 of the Lithuanian Construction Regulation STR 2.01.02: 2016. If the average building temperature calculated under this standard rises above 24 ° C, the energy consumption for cooling the building shall be calculated. These consumptions are calculated regardless of whether the building has cooling equipment or not. If there is no cooling equipment, the cooling unit with EER = 2.8 is estimated in the calculations. If cooling equipment is available, the EER of this equipment shall be assessed. The energy consumption of cooling a building increases the consumption of non-renewable primary energy and total primary energy in the building and therefore reduces the energy performance of the building.

Meanwhile, the consumption of renewable primary energy by refrigeration equipment, which could improve the ratio between the consumption of renewable and non-renewable energy in the building, is not included in the calculation of this ratio.

5.a.2. Cite the reference, and share the reference in pdf format if possible.

The requirements of the following Lithuanian hygiene norms were taken into account when assessing the overheating of the premises:

- HN 42-2009 “Microclimate of residential and public premises”
- HN 69: 2003 “Thermal comfort and sufficient thermal environment in work premises. Parameter normative values and measurement requirements ”
- HN 21: 2011 “School implementing general education programs. General Health Safety Requirements ”
- HN 123: 2013 “Health safety requirements for sports club services”
- HN 111: 2001 “Boarding school for children with special needs. Hygiene norms and rules ”

The calculation methodology used in Lithuania to assess the overheating of premises and to calculate the energy demand for cooling buildings (this methodology corresponds to EN ISO 13790: 2008) can be found in the construction technical regulation STR 2.01.02: 2016 in Annex 2.

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.7.3: Overheating assessment in Lithuania

Country	Lithuania
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	No. Lithuania has one climate zone.
Do you have a specific comfort calculation approach for heatwaves?	No
Do you take into account the urban heat island effect?	No
Does your overheating methodology take into account future climate	No

change weather files with extreme scenarios?	
Occupant type and representation	
What is your comfort standard?	ISO 7730, but this standard is used for design purposes only. Comfort standards are not taken into account in the energy performance calculations of buildings. These calculations assume that the average indoor temperature of most buildings should be 20 C during the heating season and not higher than 24 C during the non-heating season.
For which building types?	For all building types.
Does your method embrace the four occupant categories (I, II, III, IV)? *	Yes
How do you represent occupancy presence in the simulation model?	This is left to the discretion of the designers.
Comfort model	
What is your overheating indicator?	Building zones (when individual building zones are excluded from the calculations) or the average indoor temperature of the whole building during the non-heating season. This temperature must not exceed 24 C for most buildings.
Is your comfort model based on an adaptive or static method?	Static
What are your overheating thresholds? and according to which standard are those thresholds defined?	Maximum 24°C for most.
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	No

Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air conditioned chairs, electric heating mattresses…)?	No
Simulation model	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Static. The calculation timestep is one month.
Is your overheating calculation based on a single or multizone model?	Single zone for all buildings.
Does your calculation distinguish sleeping rooms from other living areas?	No
Mandatory envelope requirements	
Does your method oblige the installation of external shading?	No
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No
Does your method recommend a g-value? If yes, what is the limit?	No, g-values depend on the type of glazing.
* we are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

There is no shortage of fuel in Lithuania. NZEB can be achieved by using energy from heating networks, using renewable electricity, using biofuels, using high-efficiency heat pumps. The use of natural gas is widespread in Lithuania, but with them, NZEB can be achieved only by using efficient gas boilers with absorption heat pumps.

5.c.1. What are the overheating criteria for nZEBs in your country?

Comfort standards are not taken into account in the energy performance calculations of buildings. We are using EN ISO 13790:2008. The calculation methodology in this

standard for calculating the thermal energy demand for cooling a building has been transferred to Annex 2 of the Lithuanian Construction Regulation STR 2.01.02: 2016. If the average building temperature calculated following this standard rises above 24 ° C, the energy consumption for cooling the building shall be calculated. These consumptions are calculated regardless of whether the building has cooling equipment or not. If there is no cooling equipment, the cooling unit with EER = 2.8 is estimated in the calculations. If cooling equipment is available, the EER of this equipment shall be assessed. The energy consumption of cooling a building increases the consumption of non-renewable primary energy and total primary energy in the building and therefore worsens the energy performance of the building. Meanwhile, the consumption of renewable primary energy by refrigeration equipment, which could improve the ratio between the consumption of renewable and non-renewable energy in the building, is not included in the calculation of this ratio.

5.c.2. What is the overheating risk for nZEB (highly insulated) in your climate?

The risk of overheating in the Lithuanian climate arises if large glazing areas are installed in buildings without sun protection.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

We are using ISO 13790 to calculate the overheating. If the temperature exceeds the one specified in the Lithuanian regulation, the primary energy consumption for cooling the building is automatically estimated. In Lithuania, the normative requirement is that there must be no energy demand for cooling the building.

5.d. Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?

Passive cooling is not evaluated yet.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

There are no barriers to any of the investments. Both investments increase the energy efficiency of the building.

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?

More than 50 percent of the energy consumed in buildings (i.e. heating + cooling of

buildings + electricity consumption of ventilation systems) must come from renewable sources. 50 percent is calculated by dividing the total renewable energy consumed in the building by the non-renewable energy consumption for heating + cooling + ventilation of the building.

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

There are Lithuanian regulations and policies ready for encouraging energy-producing buildings. The energy grid is ready for this.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

If NZEB is built in cities with heating networks, there is no need to use any high technology. It is enough to connect the buildings to the heating networks. If buildings are built in areas without heat networks, then there is a need to use heat pumps, solar power plants, and so on. It all depends on the real situation.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

There are no obstacles.

8. What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold onsite):

Table 3.7.4: EE and RES recommended thresholds for Lithuania

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
All-purpose buildings	Currently, the prevailing design tendencies are to install large glazing areas in buildings. This is caused by increased energy consumption for heating buildings and even in cold climate zones, additional energy	In Lithuanian climatic conditions, buildings must be designed in such a way that they do not require energy to cool the buildings. For this reason, the standard energy consumption for cooling buildings	In Lithuanian climatic conditions, about 800 Wh of electricity can be extracted from a 1 kW solar power plant per year. The use of solar electricity in buildings is becoming very popular in

	demands increase for cooling in buildings. For this reason, the consumption of thermal energy for heating buildings must be limited. In Lithuania, the normative thermal energy consumption for heating buildings was determined assuming that the share of windows in building facades can be 25-30%. We believe that in a cold climate, such an approach to the starting point for standardization is acceptable. In this case, the current design trends for buildings with large glazing areas were taken into account, but these trends were partially limited. For example, for an NZEB apartment building with a heated area of 2000 m², the standard thermal energy consumption for heating a building is 34 kWh / m² per year, and for a one-apartment	has been adopted at 0 kWh / m² per year. The cost of cooling buildings for all energy efficiency classes of buildings is calculated regardless of whether the building has cooling equipment or not. If there is no cooling equipment, the cooling unit with EER = 2.8 is estimated in the calculations. If cooling equipment is available, the EER of this equipment shall be assessed. The cost of cooling a building increases the consumption of non-renewable primary energy and total primary energy in the building and therefore worsens the energy performance of the building. Meanwhile, the consumption of renewable primary energy by refrigeration equipment, which could improve the ratio between the	Lithuania. Due to legal restrictions on the power of solar power plants, the electricity produced in them is usually sufficient for heating, electrical appliances, and lighting of a building that meets the NZEB thermal insulation properties, but not for a hot water system. The efficiency of using solar water heaters is limited by the low ambient temperature during the heating season of buildings. The use of biofuel boilers in buildings is not allowed in all areas, only a very small number of buildings have the possibility to use electricity from wind and hydroelectric power plants. Other renewable energy alternatives are heat pumps, gas boilers with absorption heat pumps and heat energy from heat

	building of 100 m², 75 kWh / m² per year. Given that buildings may not have recuperation systems and that biofuel boilers that are not as efficient as gas boilers, heat networks or heat pumps may be used to heat buildings, the existing regulatory requirements are acceptable.	consumption of renewable and non-renewable energy in the building, is not included in the calculation of this ratio. We believe that the current standardization principle, which limits energy consumption by cooling buildings, is acceptable. The effectiveness of the above-mentioned standardization principle is proved by practical situations when designers turn to us to explain the reasons why the desired energy efficiency class is not achieved. Analysis of their projects often shows that this situation is due to large areas of glazing, which cause increased heat inflows and high energy consumption to cool buildings. In these cases, it is only possible to achieve the required energy efficiency class by reducing window	networks (but it should be noted here that heat networks are not everywhere). These problems make it difficult to cover more than half of the building's total energy consumption from renewable sources. Currently, the Lithuanian norms require the NZEB building that the total renewable primary energy consumed in the building must account for more than half of the primary energy consumed for heating the building + building ventilation equipment + cooling the building. It is not yet required to use more than half of the renewable energy in the building's hot water system, building electrical appliances, and lighting. The requirement to

		areas and/or installing effective sun protection measures.	build only NZEB buildings will take effect from 2021. We believe that in the future, depending on the real situation and when the construction market will fully master the design and construction of NZEB buildings that meet the current requirements, these requirements can be increased. At present, i.e. two months before the requirements come into force to build only NZEB buildings, there is some concern in the construction market.

Additional information:

In Lithuania, the energy performance class of a building is determined according to compliance with the following regulatory requirements:

1. the values of the energy efficiency indicators C1 (describing the energy efficiency of the building for heating, cooling and electricity for indoor lighting) and C2 (describing the energy efficiency of the hot water system) of the building (part thereof);

2. compliance of the specific heat loss of the building partitions with the regulatory requirements;

3. compliance of the technical indicators of recuperators with the regulatory requirements;

4. compliance of structures separating parts of the building with autonomous heating systems to the standard level of insulation;

5. compliance with the tightness of the building with the regulatory requirements;

6. compliance of thermal energy consumption for heating the building with regulatory requirements;

7. compliance of the primary energy consumption of the building with the regulatory requirements;

8. compliance of the share of energy from renewable sources with regulatory requirements (this requirement only applies to NZEB buildings).

None of these requirements take precedence. The building of the relevant energy performance class must meet all the established requirements. If a building does not meet any of the regulatory requirements, it is assigned a lower energy performance class.

The standard heat and primary energy consumption depend on the heated area of the building. The standard cost in each case is calculated according to the formulas specified in the norms by estimating the heated area Ap (m^2) of the building. E.g. For 1-2 apartment buildings, the thermal energy consumption must not exceed the values indicated in Table 3.7.5:

Table 3.7.5: Thermal energy consumption threshold in Lithuania

B	A	A+	A++
$864 \cdot A_p^{-0,36}$	$568A_p^{-0,37}$	$516 \cdot A_p^{-0,39}$	$451 \cdot A_p^{-0,39}$

Also, e.g. For 1-2 apartment buildings, the primary energy consumption must not exceed the values given in Table 3.7.6:

Table 3.7.6: Primary energy consumption threshold in Lithuania

C	B	A	A+	A++
$1237 \cdot A_p^{-0,25}$	$821 \cdot A_p^{-0,22}$	$665 \cdot A_p^{-0,21}$	$622 \cdot A_p^{-0,21}$	$546 \cdot A_p^{-0,2}$

9. REFERENCES / KEY PUBLICATIONS.

- Construction technical regulation STR 2.01.02: 2016 “Design and certification of the energy performance of buildings” (STR 2.01.02: 2016 “Pastatų energinio naudingumo projektavimas ir sertifikavimas“).
- Šadauskienė, Jolanta; Šeduikytė, Lina; Paukštys, Valdas; Banionis, Karolis; Gailius, Albinas. The role of airtightness in the assessment of building energy performance: a case study of Lithuania // Energy for sustainable development. Amsterdam: Elsevier. ISSN 0973-0826. 2016, vol. 32, p. 31-39. DOI: 10.1016/j.esd.2016.02.006. [Science Citation Index Expanded (Web of Science); Scopus; Current Contents / Engineering, Computing & Technology] [IF: 2,790; AIF: 4,886; IF/AIF: 0,571; Q2 (2016, InCites JCR SCIE)]

- Monstvilas, Edmundas; Stankevičius, Vytautas; Karbauskaitė, Jūratė; Burlingis, Arūnas; Banionis, Karolis. Hourly calculation method of building energy demand for space heating and cooling based on steady-state heat balance equations // Journal of Civil Engineering and Management / Vilnius Gediminas Technical University, Lithuanian Academy of Sciences. London, Vilnius : Taylor & Francis, Technika. ISSN 1392-3730. 2012, Vol. 18, no. 3, p. 356-368. [IF: 2,016; AIF: 1,595; IF/AIF: 1,263; Q1 (2012, InCites JCR SCIE)]
- Monstvilas, Edmundas; Banionis, Karolis; Stankevičius, Vytautas; Karbauskaitė, Jūratė; Bliūdžius, Raimondas. Heat gains in buildings – limit conditions for calculating energy consumption = Šilumos pritekėjimai pastatuose – būtinos ribinės sąlygos šilumos režimui skaičiuoti // Journal of Civil Engineering and Management / Vilnius Gediminas Technical University, Lithuanian Academy of Sciences. Vilnius : Technika. ISSN 1392-3730. 2010, Vol. 16, no. 3, p. 439-450. [Science Citation Index Expanded (Web of Science); Scopus; METADEX] [IF: 3,711; AIF: 1,482; IF/AIF: 2,504; Q1 (2010, InCites JCR SCIE)]
- Tamašauskas, Rokas; Monstvilas, Edmundas; Bliūdžius, Raimondas; Banionis, Karolis; Miškinis, Kęstutis. Comparison of calculation methods of renewable energy generated by electric heat pumps // Journal of sustainable architecture and civil engineering = Darnioji architektūra ir statyba / Kaunas University of Technology. Kaunas : Technologija. ISSN 2029-9990. 2015, vol. 11, iss. 2, p. 41-51. DOI: 10.5755/j01.sace.11.2.9986. [Index Copernicus]
- Bliudzius, R.; Banionis, K.; Levinskyte, A.; Geleziunas, V. Experience of implementation of energy performance requirements for buildings in Lithuania // International conference on sustainable materials, systems and structures – SMSS 2019: Energy efficient building design and legislation: Rovinj, Croatia, 20-22 March 2019 / edited by Marina Bagarić, Ivana Banjad Pečur, Hartwig M. Künzel. Paris : RILEM, 2019. ISBN 9782351582176. eISBN 9782351582183. p. 188-195. (RILEM proceedings (PRO) ; vol. 128).
- Jonkutė, G.; Norvaišienė, R.; Banionis, K.; Monstvilas, E.; Bliūdžius, R. Management of carbon dioxide emissions in residential buildings through energy performance certification in Lithuania // 14th conference on sustainable development of energy, water and environment systems, (SDEWES), October 1-6, 2019, Dubrovnik, Croatia: book of abstracts. Zagreb : Faculty of Mechanical Engineering and Naval Architecture. ISSN 1847-7186. eISSN 1847-7178. 2019, SDEWES2019.0941, p. 455.

3.8. POLAND

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.8.1: nZEB status in Poland

Legislation	
Definition nZEB available	Yes
Min. threshold set	Yes
Subsidy retrofitting towards nZEB	No
Min. Energy efficiency PE use intensity (kWh/m^2.a)	Attia et al. 2021
Min. perf. Threshold heating demand (kWh/m^2.a)	In Poland, the required maximum Primary Energy is calculated both for heating, ventilation, and domestic hot water: ● residential single-family buildings: 70, ● residential multifamily buildings: 65, ● residential collective buildings: 75, ● public buildings 45, ● health care buildings 190, ● outbuildings, warehouse, and production buildings 70. Note that there is only a requirement for Primary Energy, not for Final or Utility Energy.
Min. perf. Threshold cooling demand (kWh/m^2.a)	Maximal values of Primary Energy for cooling purposes are calculated from the formulas, it is interpreted only if the building is equipped with the system for cooling: ● residential single and multifamily 5· $A_{f,C}/A_f$, ● residential collective buildings, public buildings, healthcare buildings, outbuildings, warehouse and production buildings 25· $A_{f,C}/A_f$. where A_f is the area of rooms with

	regulated air temperature (m^2) and $A_{f,C}$ is the area of rooms with cooling air temperature (m^2).
Life Cycle Assessment	No
CO_2	Despite it is not needed, our software used for energy calculations always gives information about CO2 emission, what is more, local communities can give the requirements regarding the heat sources to be used by the community, for example, it is forbidden in Cracow to burn coal and wood.
Airtightness	Yes: maximal n_{50} is required, (3.0/h for natural ventilation and 1.5/h for mechanical ventilation buildings), but the airtightness tests are only recommended.
Heating Cooling Balance	
Natural ventilation possible	Yes. But with the new requirements for EP for heating/ventilation / hot water, it is not possible to implement natural ventilation in most cases.
Technical System Min. performance requirements	'Ecodesign' + requirements regarding the isolation of pipes + safety requirements.
Thermal Comfort Limits	
Climate Zones	Poland is divided into 5 climate zones, but it has nothing in common with the thermal comfort requirements. We do not have thermal comfort limits, you can find only one sentence in our building law: 'The building should be designed and constructed in such a way as to reduce the risk of overheating the building in the summer.'
Overheating risk	Yes, if we can consider that the requirement for total energy transmittance of solar radiation of windows and glass

	and transparent elements fulfill this risk.
Thermal comfort Standard	Hard to answer, we do not have our own standard, if we assess the thermal comfort we are using the ISO 7730 standard 'Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria. We have to provide the minimum temperatures and volume of ventilation air in the rooms, depending on the utility purpose of the room according to national standards. Since 2019 another standard is implemented: PN-EN 16798-1:2019-06 'Energy performance of buildings -- Ventilation for buildings -- Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting, and acoustics -- Module M1-6'. It is like a guideline on how to assess thermal comfort.
Efficiency vs Renewable Threshold **RES (%)**	-
<u>Construction Quality</u>	
Available materials	High and medium.
Available knowledge	High and medium, depending on the designer and the company. If the average for the whole country, I think that is medium.

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

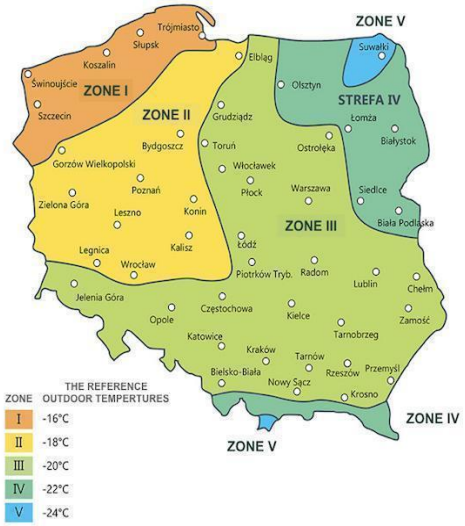


Figure 3.8.1: Climate zones of Poland

Source: https://ebrdgeff.com/poland/poradnik/modernizacja-systemu-grzewczego/

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

In Poland, the required maximum Primary Energy is calculated both for heating, ventilation, and domestic hot water:

- Residential single-family buildings 70,
- Residential multifamily buildings 65,
- Residential collective buildings 75,
- Public buildings 45,
- Health care buildings 190,
- Outbuildings, warehouse, and production buildings 70.

Note that there is only a requirement for Primary Energy, not for End or Use Energy. We do not have a threshold regarding CO2 emission.

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m2/a for heating demand. Could this become the case in your country? and why?

For few years our government supported the program of low-energy buildings NF15 and NF40, the numbers meant the Use Energy consumption for heating and ventilation (without hot water). The program was not successful so it was finished

earlier. Firstly because the support was only to the credit and you were not supported if you invested your own cash. Secondly, the requirements were not easy to fulfill.

In my opinion, the 15 kWh/m^{2}a passive standard will not be easy to implement in Poland. For sure, it could be trendy, but most Polish investors think now that they are constructing passive houses if they installed a heat pump instead of a fireplace.

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity and heating and cooling balance. If you have a climate contrast (for example heating-dominated cities and cooling-dominated cities) , provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

Polish climate is different depending on the localization.

Zone V including the Suwałki region in the north and the Tatra Mountains in the south is heating-dominated. Zone IV including Olsztyn and other cities is also rather heating-dominated. What is important is that Zones V and IV are forest-lakes-agriculture regions (and mountains in the south), which means that the compensation of nature has a very big influence on the climate and human perception of it. Olsztyn is surrounded by forest as the only city in Poland in such a scale. It means that we have at least half an hour less solar radiation than other places per day. The vegetation season is 2-3 weeks shorter than in the middle or south Poland. Of course, in a new block of flats which are situated in the city deserts (without trees) there is a need for cooling, even in Olsztyn, but not in the countryside.

Zone III and II need both heating and cooling, especially from Toruń to the south there is a need for cooling.

Zone I despite being considered to be the warmest doesn't need cooling as much as the south of Poland. I would say 70% for heating, 30% for cooling in the June-August period. The influence of the Baltic Sea is very big there.

4.b. Can you reach nearly zero heating demand?

In my opinion not. It is possible to reach nearly zero in the apartment having a lot of heat from neighbors and equipment, but not in the single-family houses.

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

For ages airtightness was penalized in Poland. The view on the building envelope was that 'building has to breathe'. In my opinion our country's regulations max. n_{50}=3.0/h for buildings with natural ventilation and n_{50}=1.5/h for those with

mechanical ones are good, but it is not respected (airtightness tests are not obligatory). In most of the existing buildings with natural ventilation that we tested the n_{50} factor was highly exceeded. In most of the new buildings (natural or mechanical ventilation) the n_{50} was correct. Our main problems are the windows and roofs. Windows are typically installed without sealing, roofs are constructed with the ventilation gap above the mineral wool insulation (without wind barrier on the insulation layer). The joint of the roof and knee walls are leaky. Poland should put more effort to achieve the airtightness of windows and roofs and it will make very big progress in the thermal protection of buildings.

We should also remember that most of our houses are naturally ventilated and it means the need for air supply. It is very difficult to persuade designers, engineers, building users, that air should be supplied in a controlled way.

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity in regard to the electric or thermal demand?

The energy supply networks for thermal demand exist in most of the Polish cities. In Olsztyn 75% of the citizens have a connection to the city network, I think that in other bigger cities, the situation is similar. We do not have any problems with the network capacity, crashes do happen, but performance is fine (prices not always).

We also do not have any problem with the electric network. In the hottest period (usually 2 weeks a year) we hear that the electric plants are not as efficient as they should be because of the lack of water needed to cool the electric plants, but I never heard that there was a lack of electricity after 1989. From time to time, after strong wind approx. 100,000 to 200,000 households stay even few days without electricity until overhead lines are repaired.

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBs.*

In 2019, the standards EN 16798 were implemented in Poland. In Poland, standards are not mandatory, but the guidelines described therein must be met. It means that EN 16798 rules are now obligatory. There is no national annex to these standards, which means that we are at the very beginning of using them.

Every Polish building must fulfill the criteria of the government document called ‘Warunki techniczne jakim powinny odpowiadać budynki oraz ich usytuowanie’ (Eng. ‘Technical conditions to be met by buildings and their location’). There are described the requirements for max. total energy transmittance of solar radiation of windows and glass and transparent elements.

5.a.2. Cite the reference, and share the reference in pdf format if possible.

Technical conditions to be met by buildings and their location: ‘Obwieszczenie Ministra Inwestycji i Rozwoju z dnia 8 kwietnia 2019 r. w sprawie ogłoszenia jednolitego tekstu rozporządzenia Ministra Infrastruktury w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie. Dz.U. 2019 poz. 1065’:
https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20190001065/O/D20191065.pdf

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

We usually use the Fanger model. EN 15251 was implemented and obligatory only for a short period, so from 2019 the rules of EN 16798 are obligatory and it means that we should use the adaptive comfort model. The implementation of EN 16798 is very new, so Polish engineers have to meet the criteria and methods from this standard to start using them.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.8.2: Overheating assessment in Poland

Country	Poland
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	No.
Do you have a specific comfort calculation approach for heatwaves?	No.
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No.
Occupant type and representation	
What is your comfort standard?	ISO 7730 EN 16798
For which building types?	Residential and non-residential.

Does your method embrace the four occupant categories (I, II, III, IV)? *	If you mean the categories of occupant expectations of the indoor environmental quality: yes, it is implemented in EN 16798.
How do you represent occupancy presence in the simulation model?	Deterministic (living and sleeping zones and schedules).
Comfort model	
What is your overheating indicator?	We do not have any.
Is your comfort model based on an adaptive or static method?	Static / Adaptive It looks like both after implementation of EN 16798.
What are your overheating thresholds? and according to which standard are those thresholds defined?	We do not have any.
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	No
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air conditioned chairs, electric heating mattresses…)?	No.
Simulation model	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	-
Is your overheating calculation based on a single or multizone model?	-
Does your calculation distinguish sleeping rooms from other living areas?	-
Mandatory envelope requirements	

Does your method oblige the installation of external shading?	External or internal – both are allowed.
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	We have the limitation for the minimal fenestration: in a room intended for people purposes, the ratio of the window area to the floor area should be at least 1: 8, while in another room, where daylighting is required for reasons of use - at least 1:12.
Does your method recommend a g-value? If yes, what is the limit?	Yes. No more than 0.35 during summertime.
* we are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

Due to official data from 2016 14.1% of Polish households in single family houses met fuel poverty. It was 3% less than in 2013, but due to actual energy prices in the market (Feb 2022), the problem may be higher again.

(https://www.gov.pl/attachment/6c6e6567-5f87-4e7a-bf5b-03861670888c)

At least 600 000 Polish pensioners have no more than 270 EUR per month. We should also include unemployment and those who work with the lowest wage. It will give the group of at least 2 500 000 adult people (add children) who have a big problem deciding if they can buy food, medicaments or fuel. If they do not have money on the base needs, they will not think about the nZEB renovation of homes.

5.c.1. What are the overheating criteria for nZEBs in your country?

We do not have overheating criteria.

5.c.2. What is the overheating risk for nZEB (highly insulated) in your climate?

The risk is the biggest in the new buildings, highly insulated and not massive (Attia et al. 2021). Poland is still dominated by large fenestration of buildings. Even in the North of Poland it influences overheating of the highly insulated buildings. The risk is lower in the massive constructions due to thermal load, the lowest risk is in single-family houses where the floors on the ground influence thermal inertia.

I live in a block of flats, made of concrete with 12 cm EPS insulation on the walls. Windows directed to North and South. The block is equipped only with natural ventilation. In the hottest period of the year (usually no longer than 2 weeks) our

temperature inside is 28-32°C. A similar problem is in almost every insulated block of flats, doesn't matter if it is a new or old one.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

We do not evaluate overheating risk of any building in Poland.

5.d. Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?

In massive constructions, not highly insulated, passive cooling is rather enough, but in light active cooling is needed.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

Now it is easier to invest in renewables. There is the government. program for co-financing the PV panels, the program is called 'Mój prąd' (Eng. My electricity) and it is a subsidy of 5 000 PLN (1 100 EUR) to a new installation of PV in the residential houses. The intention is that you are donating this electricity to the public grid. It is especially interesting for householders, because another program 'Prosument' allows the householders to take free from the electricity grid 80% of the electric power that they produce during a year. For most houses, it means that they are installing PV in the amount of power more than 100% of the house needs. It costs around 20-30 000 PLN (4 400 – 6 600 EUR), so 25-17% you can get back and you are more or less without electricity costs for a longer period of time. From the mid of 2022 the program will be modified and first analysis show that it will be less friendly for new PV investments.

There was a program of co-financing solar-heating water panels. It was very popular and the result was that even those who didn't accept the rules of the program (there were chosen producers and bank credits), decided on the panel installation in the new and existing houses.

We are still during the national program of co-financing thermomodernization of buildings. The program is called 'Czyste powietrze' (Eng. Clean air) and is dedicated to emission reduction. Most of the beneficiaries are interested in replacing the old fireplaces with new ones. New gas boilers and air heat pumps are dominated in this program.

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50 or 70% of the demand?

If you mean ‘onsite’ as a dedication to a single building – definitely not. I would impose very hard emission restrictions and allow householders to decide how they will operate with heat-producing. Not every renewable energy source is possible in every region of Poland, especially for private consumption.

If we consider the whole country, I would recommend using only these energy sources which are available regionally. 80% of Poland’s area has good geothermal conditions (see Figure 3.8.2). Some regions, like the Tatra Mountains region, use it for district heating purposes. In many regions, it has not even started.

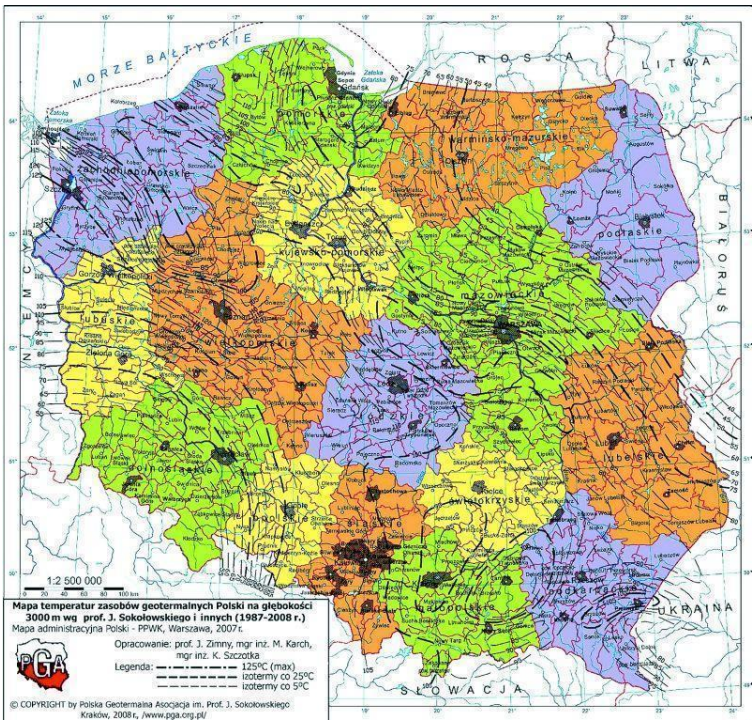


Figure 3.8.2: Map of geothermal resources temperatures in Poland

source: http://pga.org.pl/geotermia-zasoby-polskie.html

Agriculture areas dispose of the plants and animal wastes for biogas purposes. Forest areas dispose of biomass.

From the embodied energy calculations we can see that only: geothermal, biomass, and biogas are environmentally friendly energy sources. Thus, I would recommend using them as much as possible, but with economic profitability.

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

In the mid-2010s’ we started the prosumer program for producing and selling energy to the energy grid. Poland is divided into 4 electricity regions, so every region has its own specific agreements and rate for energy selling by prosumers. Now, the most popular is producing energy from PV and passing it to the national electric grid. You can use 80% of what you produced for free. You can also consume what you

produce by yourself.

Problems occur for the houses which are at the end of the grid – inverters do not operate well there and you will rather not pass the energy to the grid.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

In my opinion – both. The first question which should be always asked is about embodied energy of the materials and technologies. If we have to spend more energy on producing than saving after using them – it is completely meaningless.

We can always consider replacing the materials with those which are of low technology, but which are environmentally friendly. We can use natural materials as thermal insulation (if the fire safety is ensured), etc.

We should always address high quality of workmanship; it is 70% of success. I still remember the wooden frame house of my colleague in Norway. It is definitely energy efficient, even though the only thermal insulation is about 15 cm of mineral wool. Every detail of the house was made with the best quality – the joints of membranes, the filling of insulations, etc.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

The financial barrier. Private production or storage buildings are rather constructed with high-technology, it is some kind of investment for the company/owner. Private residential buildings are rather constructed with the cheapest possible technology. Most of the residential buildings are financed with credits. The rules for credits are so cruel, that the only dream of bank customers is to pay the credit and be free. The average time of credit payment is 30 years. It makes people not enthusiastic about buying high-tech, expensive technologies. For sure, people are investing in mechanical ventilation, good technology boilers, etc., but many times they do not have enough money to invest in good quality drivers to operate with this technology.

8. What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold onsite):

Table 3.8.3: EE and RES recommended thresholds for Poland

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
Residential	end-use energy of	Cannot say – we do not have the	None

buildings	60 kWh/m^{2}a	threshold before	

9. REFERENCES / KEY PUBLICATIONS:

- Attia, S., Kosiński, P., Wójcik, R., Węglarz, A., Koc, D., & Laurent, O. (2021). Energy efficiency in the polish residential building stock: A literature review. Journal of Building Engineering, 103461.
- Obwieszczenie Ministra Inwestycji i Rozwoju z dnia 8 kwietnia 2019 r. w sprawie ogłoszenia jednolitego tekstu rozporządzenia Ministra Infrastruktury w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie.
- Zimny J. 2006. Potential of geothermal energy in Poland and Germany - state for the year 2005. Environment Protection Engineering Vol. 32 (1), pp. 209-217.

3.9. ROMANIA

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.9.1: nZEB status in Romania

Legislation	
Definition nZEB available	Yes. (Muresan and Attia 2017)
Min. threshold set	Yes.
Subsidy retrofitting towards nZEB	Yes.
Min. Energy efficiency PE use intensity (kWh/m^2.a)	Yes.
Min. perf. Threshold heating demand (kWh/m^2.a)	≤ 70 for Class A, 70 … 117 for Class B, 117 … 173 for Class C, 173 … 245 for Class D, 245 … 343 for Class E, 343 … 500 for Class F, and > 500 for Class G
Min. perf. Threshold cooling demand (kWh/m^2.a)	≤ 20 for Class A, 20 … 50 for Class B, 50 … 87 for Class C, 87 … 134 for Class D, 134 … 198 for Class E, 198 … 300 for Class F, and > 300 for Class G

Life Cycle Assessment	Yes.
CO_2	Yes.
Airtightness	Yes.
Heating Cooling Balance	
Natural ventilation possible	Yes.
Technical System Min. performance requirements	No.
Thermal Comfort Limits	
Climate Zones	Five (I…V).
Overheating risk	Yes.
Thermal comfort Standard	Yes.
Efficiency vs Renewable Threshold **RES (%)**	≥ 30%
Construction Quality	
Available materials	High / Medium
Available knowledge	High / Medium

Currently, the energy performance in the Romanian building sector is regulated by Law 372/2005 (Parlamentul Romaniei, 2005) amended and supplemented by several normative acts, the last of which is Law 101/2020 (Parlamentul Romaniei, 2020). This law aims to promote measures to increase the energy performance of buildings, taking into account the external climatic and location conditions, indoor comfort requirements, optimal cost level, and energy performance requirements. Increasing the energy performance of buildings by designing new buildings with low energy consumption and by thermal rehabilitation of existing buildings are recognized as actions of major interest in the context of energy saving in buildings, improving the built environment, and protecting the environment. Through this law, the nearly zero energy building (nZEB) is defined as a building with a very high energy performance, where the energy demand is almost equal to zero or is very low and is covered in a proportion of at least 30%, with energy from renewable sources, including energy from renewable sources produced on-site or within a radius of 30 km from the GPS

coordinates of the building, starting in 2021. This share will be further established by the Romanian Government decision for the periods 2031-2040, 2041-2050, and after 2051.

The Romanian legislation is in line with the Directive 2010/31/EU of the European Parliament and the Council of the European Union (2010) amended in 2018 by the Directive (EU) 2018/844 of the European Parliament and the Council of the European Union (2018). Thus, after 31 December 2018 all buildings (newly built or majorly refurbished) occupied and owned by public authorities were nZEBs and by 31 December 2020, these types of buildings must comply with nZEB standards. Besides this category, the existing building stock, residential and non-residential, both public and private, is subject to a long-term renovation strategy developed by the Romanian Ministry of Public Works, Development and Administration (2020) aiming to its gradual transformation into a built environment with a high level of energy efficiency and decarbonization by 2050, facilitating cost-effective transformation of the existing buildings in nZEBs.

To increase the energy performance and the renewable energy share in the building sector, several financial incentives have been adopted in Romania.

The Government Emergency Ordinance no. 18/2009 (Guvernul Romaniei, 2009), recast in 2012, aiming at reducing through renovation the yearly thermal energy demand of the multifamily buildings below 100 kWh/m^2, established subsidies of 60% covered from the state budget and 30% from the local public funds reducing thus the financial effort of the private owners to only 10%.

The Government Emergency Ordinance no. 69/2010 (Guvernul Romaniei, 2010), recast in 2011, aiming at increasing the energy efficiency of both multi- and single-family buildings through the renovation of the building envelope as well as of the building facilities (including the implementation of renewable energy systems) funded by bank loans with governmental guarantees up to 90% of the costs decreasing thus the owner initial contribution to only 10%.

Since 2010 the Governmental Programme “Green House " has been implemented to encourage the implementation of renewable-based heating systems subsidizing the costs of solar thermal, heat pump, and biomass systems for individuals (Table 3.9.2). According to the Romanian Environment Fund Administration, between 2010 and 2017 over 30,000 Greenhouse projects were completed with a total of 180,000,000 lei (approx. 40,000,000 euro) for individuals.

Table 3.9.2: Subsidies for renewable energy systems for individuals

Renewable energy system type	**Subsidies in lei**		
	2010*	**2011****	**2016*****

Solar thermal systems	6000	6000	
Unpressurized solar thermal systems			3000
Pressurized solar thermal systems			6000
Heat pump systems	8000		
Heat pump systems (excluding air-air heat pump systems)		8000	8000
Biomass systems	6000	6000	6000
* Order 950/2010 (Ministerul mediului si padurilor, 2010)			
** Order 1274/2011 (Ministerul mediului si padurilor, 2011)			
*** Order 1817/2016 (Ministerul mediului, apelor si padurilor, 2016)			

A similar Green House program was launched in 2015 for administrative-territorial units, public institutions, and religious units willing to implement conversion systems of renewable energy sources (solar, geothermal, wind, hydro, and biomass) for which the subsidy can cover 90% of the investment costs. The subsidies range between 500,000 lei and 4,000,000 lei for administrative-territorial units corresponding to their number of inhabitants (between 3000 and over 100,000 inhabitants), 2,000,000 lei for public institutions, and 500,000 lei for religious units.

In 2018, a new program was introduced by the Romanian Ministry of environment subsidizing the implementation of photovoltaic systems with a minimum capacity of 3 kWp for individuals (Ministerul mediului, 2018a). Through this program, each individual is granted 90% of the installation cost, the grant is limited to 20,000 lei. According to the Romanian Environment Fund Administration, 13,952 projects were registered at the end of October 2020. Besides the incentives, this program allows the individuals to feed in the national grid the electrical energy not used for self-consumption for which it is entitled to receive a price regulated by the Romanian Energy Regulatory Authority, with an average value of 251.21 lei/MWh during 2019.

A similar program was introduced to fully cover the implementation costs of photovoltaic systems for isolated households (Ministerul mediului, 2018a). The household must be located at a distance from an electrical grid greater than 2 km and the photovoltaic system should have a capacity higher than 1 kWp to receive an incentive of 25,000 lei. The administrative-territorial units are the beneficiary of these grants and according to the Romanian Environment Fund Administration, 880 projects were registered at the end of October 2020.

The most recent program of the Romanian Environment Fund Administration was launched in September 2020 subsidizing energy efficiency measures in single-family houses (Ministerul mediului si padurilor, 2020). Non-reimbursable financing between 40,000 and 70,000 lei can be obtained if the set of energy-efficiency indicators are reached (Table 3.9.3).

Table 3.9.3: Subsidies granted for each set of energy-efficiency indicators

Energy-efficiency indicators	**MU**	**Subsidies [lei]**		
		40,000	**55,000**	**70,000**
Exterior walls (after thermal insulation) ● **maximum heat transfer coefficient** ● **corrected thermal resistance**	U' [W/m2K] R' [m2K/W]	≤ 0.56 ≥ 1.80	≤ 0.40 ≥ 2.50	≤ 0.35 ≥ 2.85
Roof (after thermal insulation) ● **maximum heat transfer coefficient** ● **corrected thermal resistance**	U' [W/m2K] R' [m2K/W]	≤ 0.20 ≥ 5.00	≤ 0.17 ≥ 5.85	≤ 0.14 ≥ 7.14
Doors and windows (exterior, new) ● **maximum heat transfer coefficient** ● **corrected thermal resistance**	U' [W/m2K] R' [m2K/W]	≤ 1.30 ≥ 0.77	≤ 1.10 ≥ 0.90	≤ 0.90 ≥ 1.11
Reduction of the total final energy consumption, compared to the situation prior to the project implementation	[%]	≥ 40	≥ 50	≥ 60
Reduction of the equivalent emission index, compared to the situation prior to the project implementation	[%]	≥ 40	≥ 50	≥ 60
Mechanical ventilation system with heat recovery	_	optional	optional	mandatory

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

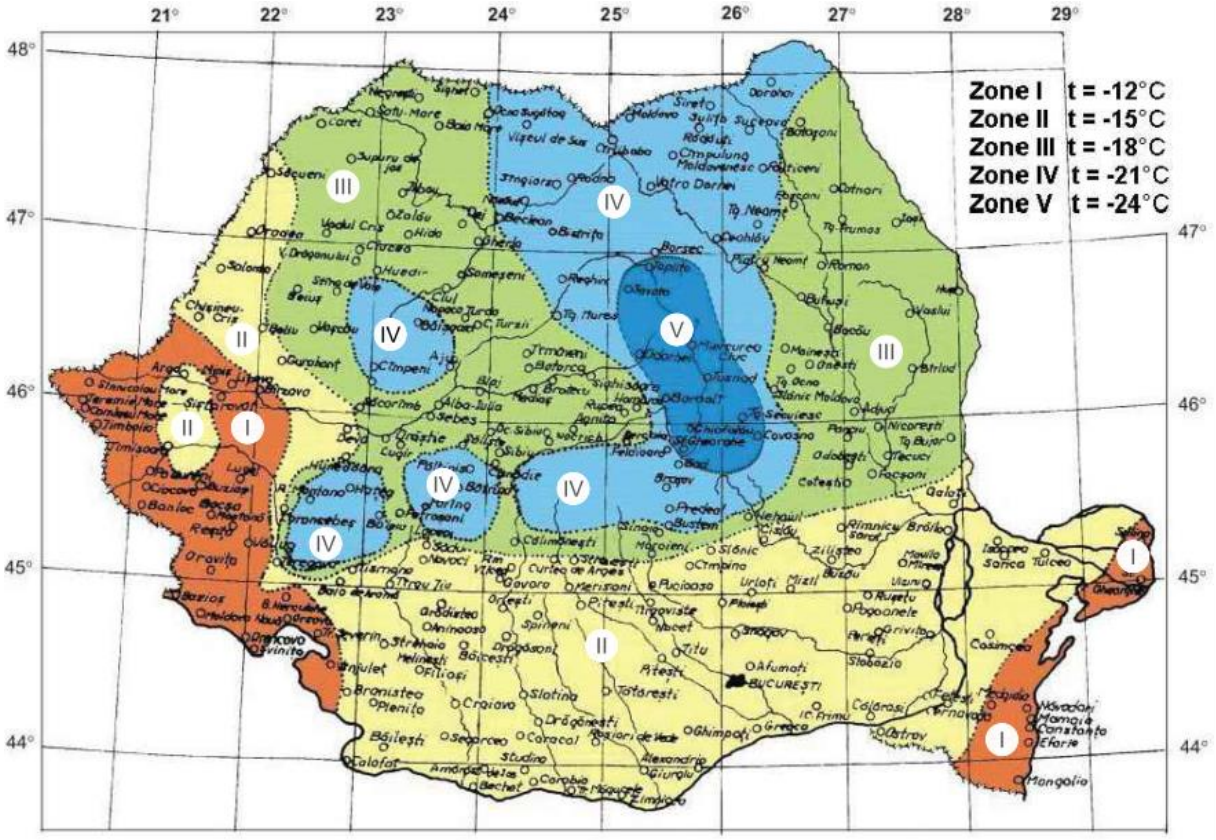


Figure 3.9.1: Climate zones of Romania

Source : Ministerul Dezvoltarii Regionale si Administratiei Publice, 2016.

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

The minimum energy efficiency threshold regarding the primary energy use intensity and CO_2 emissions of nZEBs in Romania are differentiated depending on the climatic zone and the building type as presented in Table 3.9.4 (Ministerul Dezvoltarii Regionale si Administratiei Publice, 2016).

Table 3.9.4: Minimum EE threshold regarding PE use intensity and CO_2 emissions in Romania

Building type	Yearly Values	Zone I (-12°C)	Zone II (-15°C)	Zone III (-18°C)	Zone IV (-	Zone V (-

					21°C)	24°C)
Single-family buildings	PE kWh/m^2	98	111	145	189	217
	CO_2 kg/m^2	24	30	40	42	54
Multi-family buildings	PE kWh/m^2	93	100	111	127	135
	CO_2 kg/m^2	25	27	30	35	37
Office buildings	PE kWh/m^2	45	57	69	83	89
	CO_2 kg/m^2	12	15	19	24	24
Educational buildings	PE kWh/m2	92	115	136	170	185
	CO_2 kg/m2	24	30	37	49	53
Hospitals	PE kWh/m2	76	97	115	142	167
	CO_2 kg/m2	21	26	32	41	48

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

The minimum thresholds are presented in Table 3.9.4.

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m^2/a for heating demand. Could this become the case in your country? and why?

Currently, there is a Passive House Association of Romania pre-affiliated to the International Passive House Association and 22 Passive Houses included in the Passive House Database, among which 11 are certified, demonstrating thus the possibility of compliance with the Passive House Standard in Romania.

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity, heating, and cooling balance. If you have a climate contrast (for example, heating-dominated cities and cooling-dominated cities) , provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

Romania has a temperate-continental climate. According to Eurostat, Romania has

heating-dominated cities with heating degree days ranging between 1676 and 3179 in 2019, while the number of cooling degree days was significantly lower, between 3 and 299.

4.b. Can you reach nearly zero heating demand?

Nearly zero heating demand can be reached only through energy-efficiency measures followed by the implementation of a renewable energy mix (e.g., ground-coupled heat pump, solar collectors, and photovoltaic modules), considering that the electrical energy produced by the photovoltaic system during summer is fed in the national grid to be recovered in the heating season to drive the heat pump (Visa et al, 2020).

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

Because of the high number of heating degree days, a highly airtight envelope is recommended to reduce the heating energy consumption. For large buildings, the energy from the exhausted air must be recovered to the fresh air.

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity concerning the electric or thermal demand?

Most Romanian cities still have thermal energy supply networks, and these networks were developed only for heating.

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBs.*

In Romania, thermal comfort is addressed in several standards and normative:

- SR EN ISO 7730:2006 establishes the methodology for the analytical determination and interpretation of thermal comfort by calculating the PMV and PPD indices and specifying the local thermal comfort criteria based on the room characteristics (surfaces, thermal insulation), the thermal resistance of the clothing, and metabolic heat (Asociatia de Standardizare din Romania, 2006)
- Normative I5-2010 for the design, execution, and operation of ventilation and air conditioning installations establishes, based on the calculated values off PMV and PPD indices, four ambient categories: I - High level recommended for occupied spaces very sensitive and fragile, which have specific requirements, such for example sick, disabled, young children, people in age; II - Normal level recommended for new or renovated buildings; III - Moderately

acceptable level, recommended in existing buildings and IV - Level other than the above; recommended to be accepted for limited periods

- SR EN 16798-1:2019 is the most recent development in the field of the energy performance of buildings. This standard focuses on setting new rules and requirements for indoor environmental parameters for the thermal environment, indoor air quality, lighting, and acoustics and explains how to use these parameters for building system design and energy performance calculations. In terms of thermal comfort, it relies on ASHRAE 55 and ISO 7730 standards.

5.a.2. Cite the reference, and share the reference in pdf format if possible.

The Standards cannot be shared. The Normative is attached.

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

The assessment methodology is based on Fanger static comfort model

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.9.5: Overheating in Romania

Country	Romania
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	Yes: I, II, III, IV and V.
Do you have a specific comfort calculation approach for heatwaves?	No.
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No.
Occupant type and representation	
What is your comfort standard?	SR EN 7730:2006

	SR EN 16798-1:2019
For which building types?	Residential and commercial.
Does your method embrace the four occupant categories (I, II, III, IV)? *	No.
How do you represent occupancy presence in the simulation model?	The entire building is considered either continuously or intermittently used.
Comfort model	
What is your overheating indicator?	Only through PMV indices calculated through SR EN 7730:2006.
Is your comfort model based on an adaptive or static method?	Static.
What are your overheating thresholds? and according to which standard are those thresholds defined?	Operating temperature values between 20 and 27°C for different destinations and ambient categories according to SR EN ISO 16798-1:2019.
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	Yes.
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air-conditioned chairs, electric heating mattresses…)?	No.
Simulation model	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Static / Quasi-dynamic / Dynamic Hourly simulations.
Is your overheating calculation based on a single or multizone model?	Single zone / Multizone
Does your calculation distinguish sleeping rooms from other living areas?	Yes.

Mandatory envelope requirements	
Does your method oblige the installation of external shading?	The installation of external/internal shading devices is recommended but not mandatory.
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No, a window to floor ratio is imposed to ensure a minimum level of natural light with values between 1/3 and 1/14 according to the room destination (STAS 6221-89).
Does your method recommend a g-value? If yes, what is the limit?	Yes. Values range between 0.30 and 0.68 W/m3 K depending on the number of floors of the building (between 10 or higher and 1) and the envelope surface to building volume ratio (between 0.15 and higher than 1.10) according to C107-2005.
* we are focusing on category II occupants for new and renovated buildings	

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

According to EU Energy Poverty Observatory (2020), Romania's concerted effort to improve existing building stock through programs partially funded by the European Union may have contributed to a decrease in energy poverty in recent years. Thus, the population unable to keep the home adequately warm has significantly decreased since 2008 from 24.4% to 9.6% in 2018, comparable with the EU average (7.3%). Meanwhile, the arrears on utility bills increased between 2008 and 2013, reaching 29.7%, followed by a considerable decrease to 14.4% in 2018, while the respective EU average is significantly lower at 6.6%. The population share that spends a high part of their income on energy expenditure is 16.9%, slightly higher than the EU average which is 16.2%. In this context, the willingness to pay for nZEB may be reduced, incentives from the government being required.

5.c.1. What are the overheating criteria for nZEBs in your country?

There are no specific overheating criteria for nZEBs in Romania. SR EN ISO 16798-1:2019 establishes operating temperature values between 20 and 27°C depending on the building destination and ambient categories.

5.c.2. What is the overheating risk for nZEB (highly insulated) in your climate?

An experimental assessment of the overheating in an nZEB, the Laboratory building L7 of the R&D Institute of the Transilvania University of Brasov (cold mountain area), was performed by Moldovan et al. (2017). A 228 m2 open office with Eastern and western curtain walls was kept without any cooling in 2013 to evaluate the overheating. To measure the indoor temperature, 31 wireless temperature sensors were installed, and the measurements were performed every five minutes. The results showed that the indoor temperatures exceeded the comfort threshold of 24°C in the period May – to September. Given the occurrence of the overheating of nZEB in a cold mountain area, it is expected that this will happen in areas with higher temperatures.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

TRNSYS simulations performed to evaluate the overheating occurring in an NZEB, the Laboratory building L7 of the R&D Institute of the Transilvania University of Brasov were experimentally validated (Moldovan et al., 2017). Thus, TRNSYS simulations based on in-field climatic data are recommended.

5.d. Can we rely on passive cooling or must include active cooling systems for nZEBs in your country?

In the above study (Moldovan et al., 2017), natural night ventilation allowed significant savings in cooling energy consumption during 2014, as high as 97% in June, 73% in July, 33% in August, and 82% in September, proving that passive cooling could be effective three months in the Summer but active cooling must be included.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

As shown in (Moldovan et al., 2014), it is recommended to first apply the energy-efficiency measures before implementing renewable energy systems. For an office building situated in Brasov (mountain climate), the reduction of the thermal energy demand from 90 to 50 kWh/m^2/year significantly lower the costs of a renewable-based energy mix consisting of a ground-coupled heat pump, solar thermal collectors, and photovoltaic modules from 92 to 31 euro/m^2 when a RES share of 70% is targeted and from 62 to 22 euro/m^2 for a 50% RES share (Moldovan et al., 2014).

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50 or 70% of the demand?

A RES share of 50% would be recommendable but only after the energy-efficiency measures are implemented to reduce energy requirements (Visa et al., 2017).

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

Several regulations and policies are in place promoting measures to increase the amount of energy obtained from renewable sources. A Green Certificate Trading System has been in force since 2008, and the eligible renewable energy sources are Hydro with an installed capacity lower than 10 MW, wind, solar, geothermal, biomass, and biogas. In 2018, a new governmental program was developed to subsidize the implementation of photovoltaic systems with a minimum capacity of 3 kWp for individuals. Each individual is granted 90% of the installation cost through this program. The grant is limited to 20,000 lei. Besides the incentives, this program allows the individuals to feed the electrical energy not used for self-consumption into the national grid. It is entitled to receive a price regulated by the Romanian Energy Regulatory Authority, with an average value of 251.21 lei/MWh during 2019.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

Renewable-based energy mixes with high-tech components are necessary when developing nZEBs, and a high level of expertise is required in all phases: design, implementation, operation, and maintenance of nZEBs.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

Among the barriers in implementing high-quality nZEB in Romania, the main ones are:

- The large share of the old buildings, with low energy efficiency, usually owned by an aging population
- High initial costs of the renewable energy systems
- Scarce subsidization of investments in renewable energy systems

8. What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold onsite):

Based on an algorithm developed by Moldovan and Visa (2017) for evaluating the share of the nZEB energy demand that can be covered with renewable energy produced on-site or nearby, the EE and RES thresholds obtained for the climatic conditions of Basov, Romania are presented in Table 3.9.6.

Table 3.9.6: EE and RES recommended thresholds for Romania

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
Single-family buildings	62.51 kWh/m^2/year	-	63 %
Multi-family buildings	32.98 kWh/m^2/year	-	50.7 %

Moreover, a new concept of Nearly Zero Energy Community (nZEC) was proposed and detailed by Visa et al. (2017) as a community with high energy performance buildings, and at least 50% of their energy demand is covered by renewables implemented in or near the community.

9. REFERENCES / KEY PUBLICATIONS:

- Asociatia de Standardizare din Romania. (1989). “STAS 6221-89, “Constructii civile, industriale si agrozootehnice. Iluminatul natural al incaperilor. Prescriptii de calcul.” Bucuresti, Romania.
- Asociatia de Standardizare din Romania. (2006). “SR EN ISO 7730:2006 – Ambiante termice moderate. Determinarea analitica si interpretarea confortului termic prin calculul indicilor PMV si PPD si specificarea criteriilor de confort termic local”, Bucuresti, Romania.
- Asociatia de Standardizare din Romania. (2007a). “SR EN ISO 14040:2007, Management de mediu. Evaluarea ciclului de viata. Principii si cadru de lucru.” Bucuresti, Romania.
- Asociatia de Standardizare din Romania. (2007b). “SR EN ISO 14044:2007, Management de mediu. Evaluarea ciclului de viata. Cerinte si linii directoare.” Bucuresti, Romania.
- Asociatia de Standardizare din Romania. (2007c). “SR EN ISO 15251:2007 – Ambiante termice moderate. Determinarea analitica si interpretarea confortului termic prin calculul indicilor PMV si PPD si specificarea criteriilor de confort termic local”, Bucuresti, Romania.
- Asociatia de Standardizare din Romania. (2019). “SR EN ISO 16798-1:2019, “Performanta energetica a cladirilor. Ventilarea cladirilor. Partea 1: Parametrii ambientali pentru proiectare si evaluarea performantei energetice a cladirilor, privind calitatea aerului interior, confortul termic, iluminatul si acustica. Modul M1-6.” Bucuresti, Romania.
- EU Energy Poverty Observatory. (2020). “Member State Report Romania”. available at: https://www.energypoverty.eu/sites/default/files/downloads/observatory-documents/20-06/extended_member_state_report_-_romania.pdf
- Guvernul Romaniei. (2009). “Ordonanta de urgenta nr. 18 din 4 martie 2009 privind cresterea performantei energetice a blocurilor de locuinte”. Monitorul Oficial nr. 155 din 12 martie 2009.
- Guvernul Romaniei. (2010). “Ordonanta de urgenta nr. 69 din 30 iunie 2010 privind reabilitarea termica a cladirilor de locuit cu finantare prin credite bancare cu garantie guvernamentalt”. Monitorul Oficial nr. 443 din 1 iulie 2010.
- Ministerul Dezvoltarii Regionale si Administratiei Publice. (2006). “Metodologie de calcul al performantei energetice a cladirilor. Partea I – Anvelopa cladirii. Indicativ Mc 001/1”.
- Ministerul Dezvoltarii Regionale si Administratiei Publice. (2016). “ORDIN nr. 386 din 28 martie 2016 pentru modificarea si completarea Reglementarii tehnice "Normativ privind calculul termotehnic al elementelor de constructie ale cladirilor", indicativ C 107-2005, aprobata prin Ordinul ministrului transporturilor, constructiilor si turismului nr. 2.055/2005”. Monitorul Oficial nr. 306 din 21 aprilie 2016
- Ministerul Lucrarilor Publice, Dezvoltarii si Administratiei (2020). “Strategia nationala de renovare pe termen lung pentru sprijinirea parcului national de cladiri rezidentiale si nerezidentiale, atat publice cat si private intr-un parc imobiliar cu un nivel ridicat de eficienta energetica si decarbonat pana in 2050”.
- Ministerul Mediului si Padurilor. (2010). “Ordin Nr. 950/2010 pentru aprobarea Ghidului de finantare a Programului privind instalarea sistemelor de incalzire care utilizeaza energie regenerabila, inclusiv inlocuirea sau completarea sistemelor clasice de incalzire”. Monitorul Oficial nr. 409 din 18 iunie 2010

- Ministerul Mediului. (2018a). “Ordinul 1287/2018 pentru aprobarea Ghidului de finantare a Programului privind instalarea sistemelor de panouri fotovoltaice pentru producerea de energie electrica, in vederea acoperirii necesarului de consum si livrarii surplusului in reteaua nationala”. Monitorul Oficial nr. 1061 din 14 decembrie 2018
- Ministerul Mediului. (2018b). “Ordinul 1305/2018 pentru aprobarea Ghidului de finantare a Programului privind instalarea de sisteme fotovoltaice pentru gospodariile izolate neracordate la reteaua de distributie a energiei electrice”. Monitorul Oficial nr. 17 din 08 ianuarie 2019
- Ministerul Mediului, Apelor si Padurilor. (2016). “Ordin Nr. 1817/2016 pentru aprobarea Ghidului de finantare a Programului privind instalarea sistemelor de incalzire care utilizeaza energie regenerabila, inclusiv inlocuirea sau completarea sistemelor clasice de incalzire, beneficiari persoane fizice”. Monitorul official nr. 747 din 26 septembrie 2016
- Ministerul Mediului si Padurilor. (2011). “Ordin Nr. 1274/2011 pentru aprobarea Ghidului de finantare a Programului privind instalarea sistemelor de incalzire care utilizeaza energie regenerabila, inclusiv inlocuirea sau completarea sistemelor clasice de incalzire”. Monitorul Oficial nr. 310 din 5 mai 2011
- Ministerul Mediului si Padurilor. (2020). “Ordin Nr. 1438/2020 pentru aprobarea Ghidului de finantare a Programului privind efectuarea de lucrari destinate cresterii eficientei energetice in locuinte unifamiliale, beneficiari persoane fizice”. Monitorul Oficial nr. 678 din 30 iulie 2020
- Ministerul Transporturilor, Constructiilor si Turismului. (2005). “Ordin nr. 2055/2005 pentru aprobarea Reglementarii tehnice "Normativ privind calculul termotehnic al elementelor de constructie ale cladirilor", indicativ C 107-2005”. Monitorul Oficial nr. 1124 din 13 decembrie 2005
- Ministry of Regional Development and Public Administration. (2013). Plan for increasing the number of nearly Zero Energy Buildings (nZEB) Romania – Background elements”.
- Moldovan, M., Visa, I. (2017). ”Renewable Energy Systems for a Multi-family Building Community”, Cham, Switzerland, Springer, 129-147.
- Moldovan, M., Visa, I., Ciobanu, D. (2014). ” Towards nZEB—Sustainable solutions to meet thermal energy demand in office buildings”, Cham, Switzerland, Springer, 115-133.
- Moldovan, M., Visa, I., Duta, A. (2017). :” Enhanced Sustainable Cooling for Low Energy Office Buildings in Continental Temperate Climate”, Journal of Energy Engineering, 143(5), 1-12.
- Muresan, A. A., & Attia, S. (2017). Energy efficiency in the Romanian residential building stock: A literature review. Renewable and Sustainable Energy Reviews, 74, 349-363.
- Parlamentul Romaniei. (2005). “Legea nr. 372/2005 privind performanta energetica a cladirilor”. Monitorul Oficial, Partea I nr. 1144 din 19 decembrie 2005
- Parlamentul Romaniei. (2020). “Legea nr. 101/2020 pentru modificarea si completarea Legii nr. 372/2005 privind performanta energetica a cladirilor”. Monitorul Oficial, Partea I nr. 579 din 01 iulie 2020
- The European Parliament and the Council of the European Union. (2010). “Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings”. Official Journal of the European Union L 153/13.
- The European Parliament and the Council of the European Union. (2018). “Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency”. Official Journal of the European Union L 156/75.
- Visa, I., Duta, A., Moldovan, M., Burduhos, B. (2017). „Implementing renewable energy systems in nearly zero energy communities”. Cham, Switzerland: Springer, 3-24.

- Visa, I., Duta, A., Moldovan, M., Burduhos, B., Neagoe, M., (2020). „Solar energy conversion systems in the built environment”. Cham, Switzerland: Springer

3.10. SLOVAKIA

1. Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.

Table 3.10.1: nZEB status in Slovakia

Legislation	
Definition nZEB available	Yes. A building with almost zero energy demand means a building with very high energy efficiency. Almost zero or very little energy is needed to use such a building must be provided by effective thermal protection and, to a large extent, energy from renewable sources onsite or nearby [1].
Min. threshold set	Yes. Depends on the type of the building (8 categories).
Subsidy retrofitting towards nZEB	Yes. To intensify family houses construction with almost nearly zero energy demand, it is proposed to introduce a new purpose of contributing to family houses, namely a contribution to a family house with almost nearly zero energy demand, which should motivate family home owners to build such family houses. The support concerns the insulation of older and new family houses with almost zero energy needs. Basic conditions for contributing to a new family house: - family house meets the requirements for energy efficiency of buildings with almost zero energy demand - primary energy in class A0

	- the envelope of the building meets the requirements for buildings with almost zero energy demand Municipalities and cities that prepare investment projects in energy efficiency and renewable energy sources can use a grant from ELENA funds to prepare these projects. ELENA finances technical support costs to prepare major investment programs in regions and cities eligible for European Investment Bank funding (including costs related to tender preparation, feasibility studies, market research, investment plans, energy audits, etc.). The ELENA (European Local Energy Assistance) program is funded by the Intelligent Energy Europe II (IEE II) program.
Min. Energy efficiency PE use intensity (kWh/m^2.a) (this indicator is required mandatory after construction of a building, the primary output of Energy certificate)	Yes. Mandatory values from 1 January 2021 for all buildings like nZEBs [2]. They depend on the building type, 8 categories: - detached houses ≤ 54 - apartment buildings ≤ 32 - office buildings ≤ 61 - school buildings and school facilities ≤ 34 - hospital buildings ≤ 98 - hotel and restaurant buildings ≤ 82 - sports halls and other buildings for sports ≤ 46 - buildings for wholesale and retail services ≤ 107
Min. perf. Threshold heating demand (kWh/m^2.a) (this indicator should be met when designing of a	Yes. When designing a building, there are specific criteria for achieving the required energy efficiency of the building. Depending on

building) *Note: There is a slight discrepancy in the Slovak regulation in this regard because finally, this indicator has not to be fulfilled after construction because primary energy is a key output.* *Note: Another three energy consumption sites are. Domestic hot water, ventilation and cooling, and lighting.*	a building type and shape factor (SF), specific heating demand is calculated in this regard for 8 categories STN 73 0540-2/Z1+Z2 [3]. Two performance thresholds are defined as target values, required maximum (Max.) and recommended (Rec.) It should be noted that initially, recommended values should be mandatory. However, this was changed and finally softened in 2019. After construction of a building, min. the performance threshold applies for heating energy use (kWh/m^{2}a), representing one of the four sites of energy consumption following Decree no. 364/2012 Coll. [2]. - detached houses ≤ 43 - apartment building ≤ 27 - office building ≤ 28 - school building and school facilities ≤ 28 - hospital ≤ 35 - hotel and restaurant ≤ 36 - sports halls and other buildings for sports ≤ 33 - buildings for wholesale and retail services ≤ 33
Min. perf. Threshold cooling demand (kWh/m^2.a)	No. Only energy use is calculated in the stage of Energy Certificate [2], and depending on a building type, only 4 categories are available for it to be evaluated: - detached houses – no - apartment buildings – no

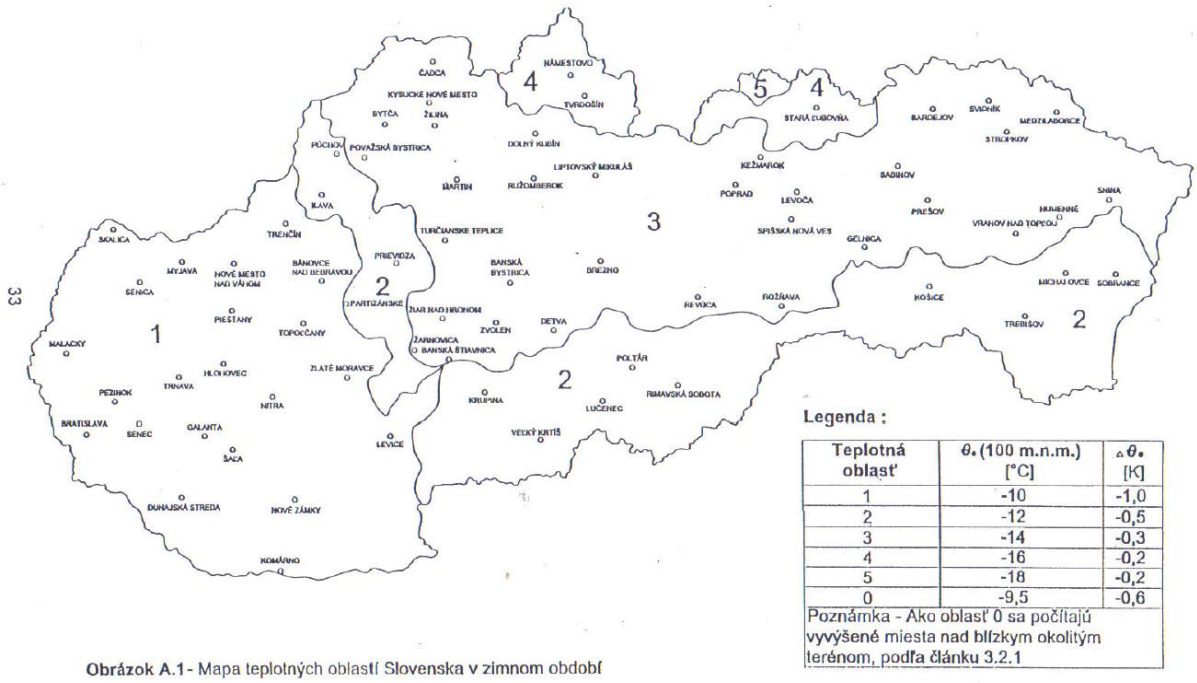
	- office buildings ≤ 15 - school buildings and school facilities – no - hospital buildings ≤ 26 - hotel and restaurant buildings ≤ 14 - sports halls and other buildings for sports – no - buildings for wholesale and retail services ≤ 33
Life Cycle Assessment	No. Only if the building is certified by LEED, BREEAM.
CO_2	No. Only information of a total value is calculated within the Energy Certificate as one of the indicators provided.
Airtightness	No
Heating Cooling Balance	
Natural ventilation possible *Note: similarly to remark on min perf. threshold on heating demand, there is a slight discrepancy in the Slovak methodology in this regard, because finally, this indicator may not be fulfilled after construction and one can have a building with natural ventilation if the primary energy threshold is achieved.*	No. In the designing phase of a building, it is needed to meet with required indicators on the energy performance of the building and heating demand, where natural ventilation does not fit with this criteria and it requires mechanical ventilation (centralized or decentralized units) with heat recovery. However, in real operation use, the user can ventilate its building naturally.
Technical System Min. performance requirements	Min. 60% efficient ventilation system with heat recovery is recommended.
Thermal Comfort Limits	
Climate Zones	No climate zone for thermal comfort calculations. However, there are 5 (6) zones for calculations of thermal parameters of

	buildings/structures according to standard STN 730540-3 [4].
Overheating risk	Yes. The overheating thresholds are set in Decree no. 259/2008 Coll. (for housing) and Decree no. 99/2016 Coll. (for work environment). These thresholds are mandatory for all buildings independently on nZEBs.
Thermal comfort Standard	Yes. This corresponds similarly with the previous answer.
Efficiency vs Renewable Threshold **RES (%)**	No.
Construction Quality	
Available materials	High.
Available knowledge	Medium concerning the stakeholders involved. The knowledge of experts in this field is high. The knowledge of designers and contractors is average. The knowledge of the general public is low.

2. Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.

There are different approaches for the climatic areas in Slovakia that depend on the purpose of particular building physics, thermal, and/or energy evaluation. Depending on the purpose, various input parameters can be used in this regard.

Slovakia is divided into five (six) zones depending on outdoor winter design temperature, e.g. when assessing building envelope structures. This is not applied for energy performance calculations, where normalized values are used for the whole country (see. 4.a.).



Obrázok A.1 - Mapa teplotných oblastí Slovenska v zimnom období

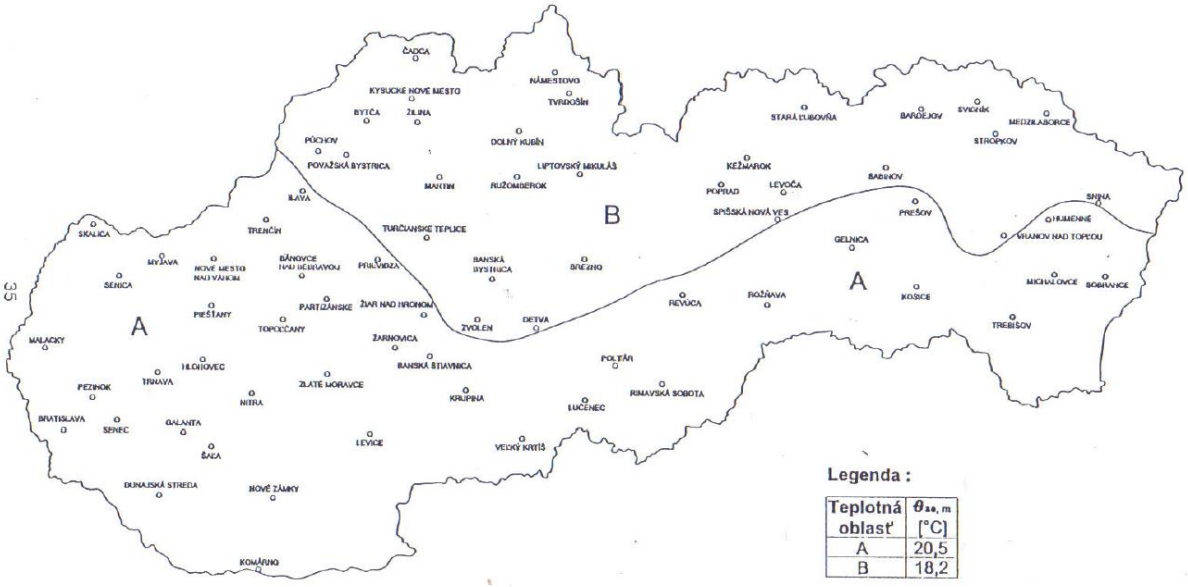
Figure 3.10.1: Temperatures areas in Slovakia in winter

Here is the translated legend:

Table 3.10.2: Temperatures areas in Slovakia in winter (legend)

Climatic zone	θ_e (100 MSL) [°C]	gradient $\Delta\theta_e$ [K] above 100 MSL
1	- 10.0	- 1.0
2	- 12.0	- 0.5
3	- 14.0	- 0.3
4	- 16.0	- 0.2
5	- 18.0	- 0.2
0	- 9.5	- 0.6
0 - elevated slope and mountain ridge areas (50 m above the plain, valley or basin)		

The thermal stability of a room in the summer period is based on a standard related to the thermal protection of buildings (STN 73 0540-3) [4].



Obrazok A.3 - Mapa teplotných oblastí Slovenska v letnom období

Figure 3.10.2: Temperature areas in Slovakia in summer

The average daily air external temperature $\Delta\theta_{ae,m}$ = 20.5°C for climatic zone A, $\Delta\theta_{ae,m}$ = 18.2°C for climatic zone B [4].

3. What is the minimum energy efficiency threshold for nZEBs in your country?

3.a. In your country, what are the minimum energy efficiency thresholds regarding end-use and primary use intensity and CO_2 emissions?

The national plan (Act no. 5555/2005 § 4b) [1] contained the measures and procedures needed to increase the number of buildings with almost zero energy demand, with a distinction between individual building categories. The implementation of the measures and procedures of the national plan ensures that buildings with almost zero energy demand shall be built:

- a) after 31 December 2018, for all new buildings used by or owned by public authorities, and
- b) from 31 December 2020 for all new buildings.

The Directive 2010/31/EU was implemented by Act no 300/2012 Coll., and introduced primary energy as a global energy performance indicator. This amended Act no. 555/2005 Coll. and has also first established a definition of an nZEB. Numerical indicators have been set for nZEB for eight building categories, two residential and six non-residential. For residential buildings, a minimum threshold for energy use on heating is set at 43 kWh/m^2/a for detached houses along with a PE of 54 kWh/m^2/a and at 23 kWh/m^2/a for apartment buildings along with a PE of 32 kWh/m^2/a. See Note 1. No cooling threshold has been set. Several more

requirements are required to be fulfilled in the designing phase of a building, regarding minimum thermal protection standards of building envelope structures, average heat transfer coefficient of whole building envelope structures, and specific heat demand for heating (depending on the shape factor), etc. CO_2 emissions are calculated in total for Energy certificate purposes. Primary energy indicators [2] for all building categories are shown in 1.

The target is 32.5% to increase energy efficiency. The upper limit of energy class A0 for the global indicator for buildings with almost zero energy demand is 0.25 Rr in place with the required provision of energy from renewable sources. If a building with almost zero energy demand dissipates or stores energy, it is classified in subclass A0+.

New guideline is provided by the MINISTRY OF TRANSPORT AND CONSTRUCTION OF THE SLOVAK REPUBLIC, valid from February 1st of, 2022. When energy certification - classification of a building into energy class A0, two conditions must be met at the same time:

1. global indicator - primary energy must be less than or equal to the value determined by the upper limit of energy class A0,

2. the building must have a renewable energy source in at least one place of its energy consumption (heating/cooling and/or domestic hot water and/or any kind of electricity production from renewable sources).

3.b. If there is no minimum threshold, which threshold do you suggest for your country and why?

Leaders set a target for the EU to reduce annual energy consumption by 20% by 2020. In 2018, the clean energy package set a new target for all Europeans to reduce energy consumption by at least 32.5% by 2030.

The main quantified energy and climate targets for 2030 are, across the Union, to achieve a reduction in greenhouse gas emissions of at least 40% compared to 1990 (individual Member States have fixed shares according to local conditions), a binding target at Union level is achieved a share of energy from renewable sources (hereinafter "RES") in gross final energy consumption of at least 32%, with the share of RES in transport in each Member State being at least 14%, the national contribution to energy efficiency at least 32.5%, and interconnection of electrical systems at the level of at least 15%.

The main quantified targets of the NECP within the Slovak Republic by 2030 are to reduce greenhouse gas emissions for non-ETS sectors by 20% (the share was increased from a flood level of 12%). The share of RES is submitted for the interdepartmental comment procedure for the year 2030 in 19.2% and alternatively 20% (increased from the flood declared 18%), while in both cases, the required

target of 14% RES in transport is met. The elaborated measures for achieving the national contribution of the Slovak Republic in the field of energy efficiency show values slightly lower (30.3%) than the European target of 32.5%. The industry and building sectors will be key to achieving the goals. The interconnection of electricity systems is already above 50% and will continue to be so in 2030 that the target of at least 15% will be met.

Reference: The Integrated National Energy and Climate Plan for 2021-2030 were prepared following Regulation (EU) No 182/2011 of the European Parliament and of the Council 2018/1999 on Energy Union Governance and Climate Action, Bratislava, 2020. available: https://www.mhsr.sk/uploads/files/zsrwR58V.pdf.

Note 1: At present, there is in the legislative process a proposal to amend the relevant decree governing the law on the energy performance of buildings meaning that key performance indicators are planned to be significantly changed. For instance, for residential buildings, a new minimum threshold for energy use on heating is planned to be changed to 60 kWh/m^2/a for detached houses along with a PE of 76 kWh/m^2/a and at 37 kWh/m^2/a for apartment buildings along with a PE of 44 kWh/m^2/a. However, extensive comments by various stakeholders are currently taking place against this proposal.

3.c. Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m2/a for heating demand. Could this become the case in your country? and why?

Particular thresholds for primary energy are well-established in Slovak legislation [2] that need to be fulfilled after building construction, whereas an expected energy efficiency is evaluated during the designing process (see. Table 3.10.3 below). That is also why there is no PassivHaus Standard adopted yet in Slovakia at the regulation level and/or on the level of standardization. Therefore, it could not become, in my opinion. Besides, it should be noted that there are third-party initiatives (commercial and market spheres) that try to adopt this concept for its certain market potential, which means at the optional basis of investors and developers. A specific criterion for achieving the building's required (supposed) energy efficiency is applied.

Table 3.10.3: Min. performance threshold heating demand according to [3]

Building category	**SF**	**From 1.1.2013**	**From 1.1.2016**	**Target value From 1.1.2021**	
				Max	Rec
Heating demand	1/m	kWh/m^2.a			

Detached house	0.7	81.4	40.7	40.7	20.4
Apartment building	0.3	50.0	25.0	25.0	12.5
Office building	0.3	53.5	26.8	26.8	13.4
School building and school facilities	9.3	53.2	27.6	27.6	13.8
Hospital	0.3	66.3	33.2	33.2	16.5
Hotel and restaurant	0.4	67.4	33.7	33.7	16.9
Sports halls and other buildings for sports	0.3	63.0	31.5	31.5	15.8
Buildings for wholesale and retail services	0.5	61.7	30.9	30.9	15.5
SF – shape factor, Max. – maximum, Rec. - recommended					

4. What is the heating-cooling balance for nZEBs in your country?

4.a. Describe your countries' climate, seasonal intensity and heating, and cooling balance. If you have a climate contrast (for example, heating-dominated cities and cooling-dominated cities), provide your recommendations for the 3 following options: cooling-dominated zones, heating-dominated zones, Heating and cooling-dominated zones.

In Slovakia, the most energy from residential buildings is consumed for heating. Thus, adequate thermal protection of a building is a highly important measure to achieve the nZEB standard. Concerning thermal comfort and energy performance, building envelope structures of heated and/or air-conditioned spaces have to meet standard (required) values under STN 73 0540-2/Z1+Z2 [3]. Still, Slovakia can be considered a heating dominant zone (especially for the residential sector). However, with higher thermal protection, many households may suffer from summer overheating due to climate change, especially in larger cities such as Bratislava, Košice, or Nitra (Eastern and southwestern regions). This leads to cooling/urban heat island issues in highly urbanized areas. Also, if it is focused on particular buildings or building typologies, heating is more likely related to housing, while cooling becomes an issue related to offices, shopping centers, etc.

To give a more general insight, e.g. for energy performance calculation purposes, there are normalized values for the whole country (Slovakia) applied following [4]. It represents 212 heating days (or more specifically, 3422 heating degree days and average air temperature of 3.86°C) for the calculation of energy performance

(heating season), while 153 cooling days (or more specifically, only 184 cooling degree days and average air temperature of 17.4°C) for the cooling season at the same time. This may indicate that heating zones mostly dominate Slovakia in terms of normalized evaluation of energy performance of buildings. The reason is that normalized evaluation does not tend to favor a particular building due to its location. In other words, all are comparable independently of the particular location.

However, the difference between cities, regions, and municipalities might be slightly higher in a more realistic view. There are about 3000 - 4500 heating degree days when different locations are compared simultaneously (the value varies depending on region). Considering this aspect, the outdoor climatic conditions may have a certain role in calculating the heating and cooling demand for a particular location. There are some studies available on this matter [5], that tried to evaluate energy performance indicators by applying climatic conditions according to STN EN ISO 13790/NA [6] as compared to the normalized values [4]. One particular district (Kežmarok) is concerned in this study, and the heating demand calculation is provided. Results identify (see. figure below), that all municipalities in the evaluated district had significantly more unfavorable (colder) climatic conditions than the standardized climatic conditions according to STN 73 0540-3 [4] (representing 3422 K.day heating degree days), for which the energy efficiency is stated in the energy certificate of the building or at the project evaluation stage when minimum energy performance requirements need to be fulfilled.

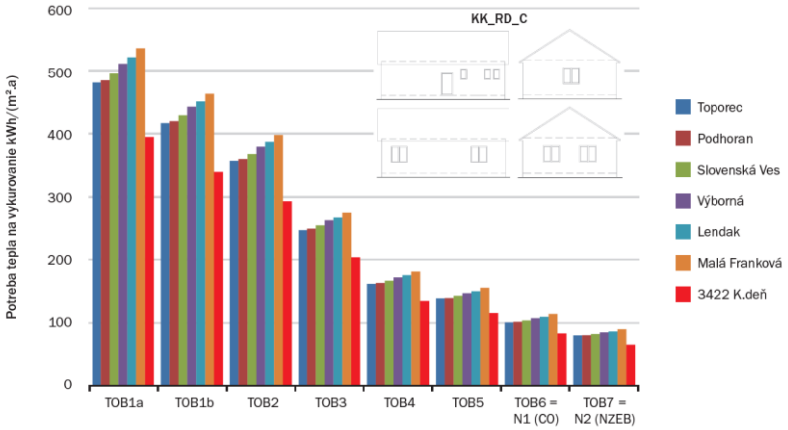


Figure 3.10.3: Example of a comparison of heating demand fr specific climatic conditions of representative municipalities in Kežmarok district and heating demand for normalized climatic conditions of 3422 K.day (heating degree days), a case of the simple detached house for different levels of thermal protection (TOB) [5]

4.b. Can you reach nearly zero heating demand?

Yes. Nearly zero heating demand is reached in Slovak legislation and relevant standards. However, as aforementioned, from 1 January 2021, the nZEB is mandatory for all building types. tTo motivates stakeholders. There was also a subsidy program addressing this, especially for new buildings, though they had to meet some specific criteria (applied exclusively for detached houses with no more

than 200 m2 of floor area, etc.). The applicant could receive a subsidy of 8,000 €. This was valid until 31 December 2020, and currently, it is a basic standard.

4.c. Should we opt for highly airtight envelopes or medium airtight envelopes in your country?

The high airtight envelope is feasible in the Slovak region. The standard determines the total breathability of the building envelope as the value n50 of the total air exchange intensity at a pressure difference of 50 Pa. The airtightness of the building is greater the smaller this value. However, it would be better to prefer medium airtight due to the average construction knowledge of construction workers.

4.d. What is the influence of the heating/cooling balance on your energy supply network capacity concerning the electric or thermal demand?

Half of the EU's energy is used for heating and cooling. 45% of energy for heating and cooling in the EU is used in the housing sector, 37% in industry, and 18% in services. Buildings (and the people who live in them) are the first consumers of heating and cooling. Space heating accounts for more than 80% of heating and cooling consumption in colder climates. In warmer climates, space cooling is most important, and the industry is growing. People need the most energy to heat their homes, which accounts for up to two-thirds of final energy consumption in the housing sector. Electricity used for lighting and power supply accounts for 14% of total energy consumption.

Energy is mostly used for domestic heating (68.3%), followed by water heating (14.8%), lighting (11.7%), cooking (5.6%), and air conditioning (0.1%). The largest uses of natural gas (64.5%), followed by secondary heat (26%), electricity (5.7 percent), renewable energy (1.9%), solid fuels (1.4%), and petroleum products (0.4%).

In Slovakia, it is mostly heated. Together with cooling, they ensure thermal comfort. Therefore, they must be in balance. In this respect, it also affects electricity.

5. What is the thermal comfort limit for nZEBs in your country?

5.a.1. *Explain shortly the reference standards used in your country to evaluate thermal comfort in nZEBS.*

There is no particular standard specifically focused on nZEB. In Slovakia, for all buildings, the mandatory indoor air quality and temperature-humidity microclimate requirements are defined in Decree no. 259/2008 Coll [7] (residential building or housing). It defines the required ventilation rate in rooms without harmful pollutants and with smoking restrictions, with long-term occupation by people with metabolic activity within the classes 0 to 1a (relaxed lying or sitting or standing with minimum activity). For non-residential or work, Decree no. 99/2016 Coll [8] applies (describing

health protection conditions at work), which defines working conditions (e.g., in the range of optimal and minimum/maximum temperature values) based on the work classes (1 to 4*).*

5.a.2. Cite the reference, and share the reference in pdf format if possible.

STN EN 16798-1: 2019 Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting, and acoustics - Module M1-6 [9]

STN 73 0540-2 – Thermal protection of buildings. Thermal performance of buildings and components.

STN EN ISO 13790/NA: 2010 – Energy performance of buildings

Legislation:

Decree no. 259/2008 Coll. [7] and *Decree no. 99/2016 Coll.* [8]

Standards:

STN EN 16798-1 [9]*, TNI CEN/TR 16798-2* [10]*, STN EN ISO 7730* [11]

5.a.3. Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (like EN 15251 / 16798)? Explain.

STN EN 16798 standard series (localization of EN 16798) is valid and applicable in Slovakia. According to STN EN 16798-1 [9], both static and adaptive models can be used. However, national regulations consider only the PMV/PPD model.

5.a.4. Please fill out the following table regarding overheating in your country. Feel free to elaborate on your answers.

Table 3.10.4: Overheating assessment in Slovakia

Country	Slovakia
Climate and weather data	
Is comfort dependent on national geographic climate zones? If yes, list them.	Yes. Mild climate zone - most of the Slovak Republic. 3 Climate areas: - warm region - south (Danubian Lowland) - cold area - north (high mountains)

	- mild area
Do you have a specific comfort calculation approach for heatwaves?	No.
Do you take into account the urban heat island effect?	No.
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	No.
Occupant type and representation	
What is your comfort standard?	ISO 7730 STN EN 16798-1
For which building types?	Residential and commercial.
Does your method embrace the four occupant categories (I, II, III, IV)? *	Yes.
How do you represent occupancy presence in the simulation model?	It is possible (not mandatory) to include occupants' schedules for energy calculations (e.g. Annex C STN EN 16798-1).
Comfort model	
What is your overheating indicator?	If the room operative temperature is above the limits as defined in relevant standards and national regulations: IoH;ztc,m ISO 52016-1
Is your comfort model based on an adaptive or static method?	Static.
What are your overheating thresholds? and according to which standard are those thresholds defined?	Based on Decree no. 259/2008 Coll. and 99/2016 Coll. The limit depends on the type of activity (several categories of activity are defined) as optimal and maximum values (more details see

	Figure 3.10.4 below).
Is there a distinction between naturally ventilated, air-conditioned, and mixed-mode buildings?	Yes, if STN EN 16798-1 is used. No, if a national regulation is used.
Does your model take into account local personalized heating/cooling & ventilation systems (ceiling fans, air-conditioned chairs, electric heating mattresses…)?	No.
<u>Simulation model</u>	
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Dynamic model & hourly calculations.
Is your overheating calculation based on a single or multizone model?	Single zone. The assessment is performed only for a “critical room”.
Does your calculation distinguish sleeping rooms from other living areas?	Yes.
<u>Mandatory envelope requirements</u>	
Does your method oblige the installation of external shading?	No. However, specific conditions may apply (see c.2.).
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	No. However, specific conditions may apply (see c.2.).
Does your method recommend a g-value? If yes, what is the limit?	No
* We are focusing on category II occupants for new and renovated buildings	

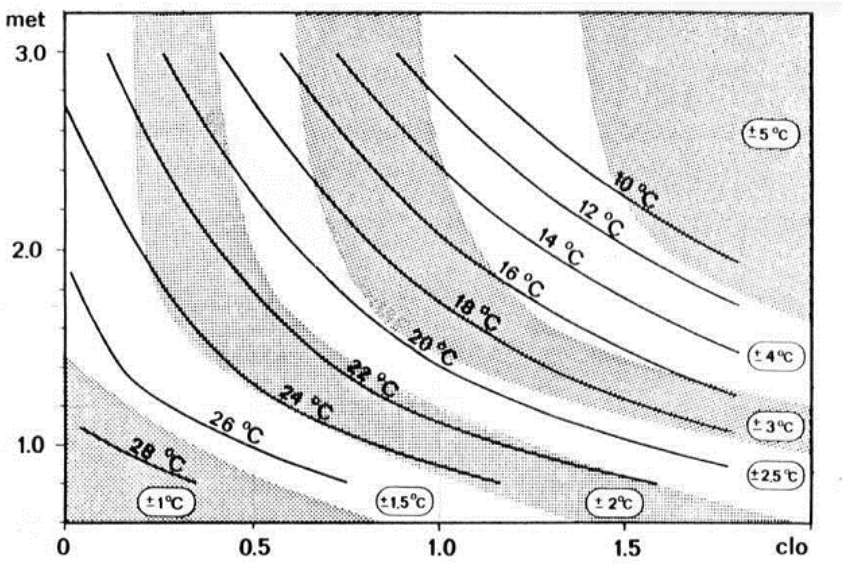


Figure 3.10.4: Areas of optimal and maximum operative temperature depending on clothing (clo) and activity (met) - 1 met = 58.2 W.m^{-2}; 1 clo = 0.155 m^{2}.W.K^{-1}

5.b. Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.

A definition of energy poverty is already established under Act No. 250/2012 Coll. [12] as a status when average monthly expenditures of household on the consumption of electricity, gas, heating, and hot water production represent a substantial share of the household's average monthly income. According to EU SILC 2017, there were 12.4 % of the population in Slovakia at-risk-of-poverty (more than 650 thousand persons) [13]. In addition, according to qualified estimates, more than 20% of household income is spent on housing, which is just below the European Union average [14]. A large part of the cost is energy. In 2019, the last discussed government document on the protection of consumers in energy poverty suggested 10% of the energy expenditure from the average household income. Based on a recently published report on this matter, the Regulatory Office for Network Industries recommends some suggestions [15]. It is necessary to deal with the insufficient degree of thermal performance of residential and family houses. The provision of adequate housing for certain social groups, such as pensioners, is equally important as well. Social changes have led to retirees living alone in two-generation households today. The costs in such houses represent a really large part of their expenses. In particular, the support of energy efficiency should be the preferred approach. This should reflect lower energy bills as well as better energy availability for low-income groups long term.

5.c.1. What are the overheating criteria for nZEBs in your country?

Overall, there are no particular requirements on nZEBs in this relation in terms of Slovak legislation. Overheating criteria are valid for all building types, independently on the nZEB. Again, it should be noted that from 1 January 2021, nZEB will be

standard in Slovakia. The valid and relevant standards are STN EN 16798-1 and STN EN ISO 7730. However, the most important documents are national regulations. The comfort limit is based on these regulations' PMV/PPD model. The limit depends on the type of activity (several categories of activity are defined). This means, for instance, that for sleeping and reclining, the upper limit in occupied rooms is 26°C in winter and 28°C in summer. It is 24°C in winter and 27°C in summer for light activity.

5.c.2. What is the overheating risk for nZEB's (highly insulated) in your climate?

There is no reliable source on this matter; however, it can be considered in general that the more thermal protection used, the higher the overheating risk may occur. The risk could be quite high because designers and stakeholders (especially residential buildings) still focus on maximizing the thermal protection of a building and winter solar gains (to meet heating demand). However, completely neglect summer thermal comfort (external shading, passive cooling, air conditioning, etc.). Therefore, summer overheating is considered a highly relevant issue and will be further emphasized by ongoing climate change. There are currently various initiatives, even at the level of strategic government documents, addressing this by promoting green infrastructure, green roofs and facades, greenery in general, etc.

5.c.3. How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.

Overall, overheating/cooling is not commonly and adequately addressed in Slovak buildings during the designing process. Under Decree no. 259/2008 Coll., the evaluation of the temperature-humidity microclimate must be objective either based on measured values or if the following conditions are reached:

- a) the calculation proves compliance with the requirements for thermal performance of building structures and for the thermal stability of the room according to the relevant technical standards,
- b) in the winter season, the heating system ensures optimal microclimatic conditions,
- c) the total area of the building openings does not exceed 40% of the area of the envelope structures of the room,
- d) openings oriented to the Sun shall have an installation of external shading.

This means that buildings are not necessarily subjected to more detailed analysis, and the conditions mentioned above can be applied to address this issue easily and be simplified.

5.d. Can we rely on passive cooling or include active cooling systems for nZEBs in your country?

Following Slovak regulation [7], in areas intended for the long-term stay of people, optimal conditions of the thermal-humidity microclimate need to be ensured in the

warm and cold periods of the year. The assumption of optimal microclimatic conditions should be achieved by the proper building design; if the design (solution) of the building does not allow it, these conditions must be ensured by technical equipment (heating and/or cooling system). Generally speaking, a concept of no cooling system installed should be preferred.

6. What is the minimum renewables threshold for nZEB in your country?

6.a. Is it easier in your country to invest in renewables than investing in energy efficiency? And why?

Even though energy efficiency includes renewables itself, it is easier to invest in renewables because the country supports renewable sources with subsidy programs, and their intervention in the renovation of buildings is less financially demanding. So, as a first step, it is necessary to ensure the quality of building structures, a high-efficiency energy source, and support for energy production from renewable sources. It is highly important to specify this issue in terms of what kind of building it concerns and the condition of the building. There is now a significant increase in support of energy efficiency and renewables in our country. Their use is 100% in practice.

6.b. Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?

It would be strongly recommended. Currently, Slovak legislation directly defines the direct use of RES, but its percentage use is not strictly specified (see. section 3a). This support is reflected in the global indicator, the primary energy. Moreover, in the initial version of Act no. 555/2005 Coll., it was directly mentioned that it is necessary to ensure the support of energy from RES at 50%. RES is not only the production of thermal energy, solar, wind, biomass, and heat pumps but also the production of energy by combined heat production, which is used mainly in centralized heat supply. Thus, I would recommend imposing an onsite minimum of 50% renewable threshold for energy production produced from RES.

6.c. Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?

Energy producing buildings have been encouraged in the past. However, trading in production and sales alone was not an effective way. In addition to efficiency itself, such Off-Grid systems may significantly affect the production plan of large electricity companies. Thus, economic indicators can be difficult to plan and estimate properly. A potential in energy-producing buildings can be viewed as a separate neighborhood or zone, where buildings within that zone itself will share energy.

7. What is the construction quality for nZEBs in your country?

7.a. Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?

Passive or zero houses cannot work without modern technology: the necessary mechanical ventilation with heat recovery, extremely well-insulated windows... That is why we should instead turn to high-tech solutions. A high-tech building design in construction approaches is feasible in Slovakia. However, low-tech solutions would be less demanding from investment and operation expenses. It would be best to combine both approaches to design. This means that passive thermal energy strategies should be preferred for residential buildings. Low-tech solutions such as insulation from straw blocks, wool, and cork from renewable sources, are suitable choices.

7.b. *What are the main barriers to high-quality nZEB construction in your country?*

There are some barriers regarding the know-how of professionals and the number of architects and engineers that can deal with new technologies and standards. The primary barrier lies in education and training. The second is the existing construction market barriers reflecting the current macro-economic, social and demographic situation, all of which are from the construction sector environment. However, there have already been some initiatives to support both professionals and builders very recently; first, like Horizon 2020 project ingREeS (see. http://www.ingrees.eu/en/), which has delivered a system of training for middle and senior-level engineers and construction professionals in the area of energy efficiency and use of renewable resources in buildings in the light of achievement of the EU 2020 energy targets. Second, initiatives such as BUILD UP SKILLS SLOVAKIA and SLOVEDU (see. https://www.buildup.eu/en/skills/bus-projects/SK and https://ec.europa.eu/energy/intelligent/projects/en/projects/build-skills-sk), that concerned with the national qualification and training scheme for on-site workers in the field of buildings focused on energy efficiency and use of renewables in buildings.

8. What should be (your recommendation) the minimum EE and RET in your country? Fill in the table below (EE energy efficiency, RET Renewable Energy Threshold onsite):

Table 3.10.5: EE and RES recommended thresholds for Slovakia

Category	**EE threshold**		**RES threshold**
	Heating	**Cooling**	
Residential, e.g, Detached house + required air recuperation and air quality	25 kWh/m^2.a	10 kWh/ m^2.a	50% / for example - heat pump with COP min. 4 is adequate to meet such criteria.

9. REFERENCES / KEY PUBLICATIONS:

1. Zakon 378/2019 Z.z. ktorým sa mení a dopĺňa zákon č. 555/2005 Z. z. o energetickej hospodárnosti budov a o zmene a doplnení niektorých zákonov v znení neskorších predpisov (Act. no 378/2019 Coll. of amending Act no. 555/2005 Coll. on the energy performance of buildings and on the amendment of certain laws as amended) from 16 October 2019.

2. Vyhláška č. 364/2012 Z.z. ktorou sa vykonáva zákon č. 555/2005 Z. z. o energetickej hospodárnosti budov a o zmene a doplnení niektorých zákonov v znení neskorších predpisov (the Decree no. 364/2012 Coll. implementing Act No. 555/2005 Coll. on the energy performance of buildings and on the amendment of certain laws as amended by Decree no. 35/2020 from 11 February 2020), Bratislava, Ministry of Transport and Construction of the Slovak Republic

3. Standard STN 73 0540-2/Z1+Z2. (2019). Tepelná ochrana budov Tepelnotechnické vlastnosti stavebných konštrukcií a budov Časť 2: Funkčné požiadavky (Thermal protection of buildings. Thermal performance of buildings and components. Part 2: Functional requirements), Bratislava: Slovak Office for Standardization, Metrology and Testing, 36 p. (not available without a fee) (in Slovak)

4. Standard STN 73 0540-3. (2012) Tepelná ochrana budov Tepelnotechnické vlastnosti stavebných konštrukcií a budov Časť 3: Vlastnosti prostredí a stavebných výrobkov (Thermal protection of buildings. Thermal performance of buildings and components. Part 3: Properties of the building environment and products), Bratislava: Slovak Office for Standardization, Metrology and Testing, 68 p. (not available without a fee) (in Slovak)

5. J. Bendžalová, D. Muškátová. (2020). Metodika na stanovenie potreby energie a potenciálu energetických úspor v sektore budov. Metodický postup pre tvorbu regionálnych nízkouhlíkových stratégií, Priatelia Zeme-CEPA (in Slovak)

6. Standard STN EN ISO 13790/NA. (2010) Energetická hospodárnosť budov. Výpočet potreby energie na vykurovanie a chladenie (Energy performance of buildings. Calculation of energy use for space heating and cooling)

7. Vyhláška č. 259/2008 Z.z. o podrobnostiach o požiadavkách na vnútorné prostredie budov a o minimálnych požiadavkách na byty nižšieho štandardu a na ubytovacie zariadenia (Decree no. 259/2008 Coll. About the details of the requirements for the indoor environment of buildings and of the minimum requirements for lower standard dwellings and accommodation), Bratislava, Ministry of Health of Slovak Republic, from 18. June 2008

8. Vyhláška č. 99/2016 Z.z. o podrobnostiach o ochrane zdravia pred záťažou teplom a chladom pri práci (Decree no. 99/2016 Coll. About the details on details of the protection of health against heat and cold at work), Bratislava, Ministry of Health of Slovak Republic, from 27. January 2016

9. Standard STN EN 16798-1. (2019). Energetická hospodárnosť budov. Vetranie budov. Časť 1: Vstupné údaje o vnútornom prostredí budov na navrhovanie a hodnotenie energetickej hospodárnosti budov – kvalita vzduchu, tepelný stav prostredia, osvetlenie a akustika. Modul M1-6 (Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics - Module M1-6)

10. TNI CEN/TR 16798-2. (2019) Energetická hospodárnosť budov. Vetranie budov. Časť 2: Interpretácia požiadaviek v EN 16798-1. Vstupné údaje o vnútornom prostredí budov na navrhovanie a hodnotenie energetickej hospodárnosti budov – kvalita vzduchu, tepelný stav prostredia, osvetlenie a akustika. (Modul M1-6), (Energy performance of buildings - Ventilation for buildings - Part 2:

Interpretation of the requirements in EN 16798-1 - Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (Module M1-6))

11. Standard STN EN 7730. (2005) Ergonómia tepelného prostredia. Analytické určovanie a interpretácia tepelnej pohody pomocou výpočtu ukazovateľov PMV a PPD a kritérií miestnej tepelnej pohody. (Ergonomics of thermal environment – Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria).

12. Zákon č. 250/2012 Z. z. o regulácii v sieťových odvetviach (Act. no 250/2012 Coll. on regulation in network industries), from 31 August 2012.

13. R. Vlačuha, Y. Kováčová. (2018). EU SILC 2017 Indikátory chudoby a sociálneho vylúčenia EU SILC 2017 Poverty indicators and social exclusion Štatistický úrad Slovenskej republiky 2018. ISBN 978-80-8121-624-4 (online)

14. R.Filčák, D.Dokupilová. (2019). Concept of Energy Poverty in Slovakia. Prognostické práce – Foresight, Analysis and Recommendations / PP – FAR, 11 (1), 21-45. DOI: https://doi.org/10.31577/PPFAR.2019.11.002

15. Energetická chudoba a zraniteľní odberatelia v energetickom sektore v Európe. Prehľad výskumných projektov v európskych štátoch. (2016) (Energy poverty and vulnerable consumers in the energy sector in Europe. Overview of research projects in European countries). Odbor regulácie kvality a analýz, Úrad pre reguláciu sieťových odvetví (Regulatory Office for Network Industries) http://www.urso.gov.sk/sites/default/files/Energeticka-chudoba-a-zranitelni-odberatelia-vEU_2016.pdf

- Zákon č. 555/2005 Z. z.Zákon o energetickej hospodárnosti budov a o zmene a doplnení niektorých zákonov.
- Dostupné online: https://www.epi.sk/zz/2005-555
- STN 73 0540-2: 2012 Tepelná ochrana. Tepelnotechnické vlastnosti stavebných konštrukcií a budov. Časť 2: Funkčné Vlastnosti.
- STN 73 0540-3: 2012 Tepelná ochrana. Tepelnotechnické vlastnosti stavebných konštrukcií a budov. Časť 3: Vlastnosti prostredí a stavebných výrobkov.
- https://www.sksi.sk/buxus/docs/anotacie/Urad_SKSI/2017_Workshop_EHB_Illith.pdf
- Prezentácia – Sedláková – Tepelná ochrana budov
- http://www.nzeb.sk/prispevok-na-rodinny-dom-s-takmer-nulovou-potrebou-energie/
- https://www.economy.gov.sk/energetika/energeticka-efektivnost/podpora-pre-mesta-a-obce/moznosti-financovania-pripravnych-projektov
- N. Polčák 2001: Vybrané kapitoly z klimatológie, UMB FPV KKE
- Moňoková, Andrea, and Silvia Vilčeková. "Multi-criteria analysis of ten single family houses regarding environmental impacts." MATEC Web of Conferences. Vol. 310. EDP Sciences, 2020.
- Vyhláška č. 364/2012 Z. z.Vyhláška Ministerstva dopravy, výstavby a regionálneho rozvoja Slovenskej republiky
- Integrovaný národný energetický a klimatický plán na roky 2021 - 2030 spracovaný podľa nariadenia EP a Rady (EÚ) č. 2018/1999 o riadení energetickej únie a opatrení v oblasti klímy, Bratislava, 2020.
- Dostupné online: https://www.mhsr.sk/uploads/files/zsrwR58V.pdf
- STN EN 15 603 Energetická hospodárnosť budov. Celková potreba energie a definície energetického hodnotenia (730712).
- Integrovaný národný energetický a klimatický plán na roky 2021 - 2030 spracovaný podľa nariadenia EP a Rady (EÚ) č. 2018/1999 o riadení energetickej únie a opatrení v oblasti klímy, Bratislava 2019.

- Dostupné online: https://ec.europa.eu/energy/sites/ener/files/documents/sk_final_necp_main_sk.pdf
- https://www.setri.sk/overenie-vzduchovej-priepustnosti-fasady/
- Oznámenie komisie Európskemu parlamentu, rade, Európskemu hospodárskemu a sociálnemu výboru a výboru regiónov. Stratégia EÚ týkajúca sa vykurovania a chladenia, 2016
- Dostupné online:
- https://eur-lex.europa.eu/legal-content/SK/ALL/?uri=CELEX:52016DC0051
- https://www.asb.sk/stavebnictvo/technicke-zariadenia-budov/energie/moznosti-zmiernenia-tepelnej-nepohody-v-budovach-s-lahkym-obalovym-plastom-na-baze-dreva
- Tepelná pohoda vo vykurovaných priestoroch, D. Petráš a kolektív, JAGA, 2005.
- Dostupné online:
- https://www.asb.sk/stavebnictvo/technicke-zariadenia-budov/vykurovanie/tepelna-pohoda-vo-vykurovanych-priestoroch
- https://euractiv.sk/section/energetika/news/podiel-energie-z-obnovitelnych-zdrojov-na-slovensku-vzrastol-o-pol-percentualneho-bodu/
- Keppl J., a kol., Rukoväť udržateľnej architektúry, ISBN 978-80-971205-1-1, SKA, Bratislava, 2013
- Dostupné online: https://issuu.com/lukas.sip/docs/rua_32mbl

APPENDIX 1: QUESTIONAIRE

Instructions Provide a 4-8 page review regarding the challenges and status of nZEB in your country. Develop your paragraphs to answer the following questions and sub-questions. Local references, studies, graphs, or case studies examples are highly appreciated. Please cite the key reference with your text and provide a list of references at the end of the document. The questions below are indicative; please try your best to answer them. Also, feel free to elaborate and explore other key concepts or concerns. You are welcome to exceed the 4-page limit if you like. Do not hesitate to ask contractors, architects, mechanical engineers, and developers to provide the best snapshot picture or overview of your country's situation. Please send me the file in word format.

Author(s): Please indicate your author name and your affiliation as you would like to have it on the paper.

Overview of the challenges of nearly zero energy buildings (nZEB) in Eastern European Countries & Overview of overheating calculation methods in European building energy codes and standards

Aim and Purpose: This paper aims to overview the technical and societal challenges of applying nZEB in Eastern Europe. The cost challenge is excluded from this study. The focus should be on current or future EPBD regulation in your country. The goal is also to provide an overview of the overheating calculation methods accordingly to European building energy codes and standards.

1. **Please fill out the following table regarding nZEB status in your country. Feel free to develop the answers.**

Legislation	
Definition nZEB available	Yes / No
Min. threshold set	Yes / No
Subsidy retrofitting towards nZEB	Yes / No
Min. Energy efficiency PE use intensity ($kWh/m^2.a$)	
Min. perf. Threshold heating demand ($kWh/m^2.a$)	
Min. perf. Threshold cooling demand ($kWh/m^2.a$)	
Life Cycle Assessment	Yes / No
CO_2	Yes / No
Airtightness	Yes / No
Compactness requirement or indicator	Yes / No
Heating Cooling Balance	
Cost optimality approach	Yes / No
Reference building	Yes / No

Natural ventilation possible	Yes / No
Mechanical ventilation requirements	
Technical System Min. performance requirements	
Thermal Comfort Limits	
Climate Zones	
Overheating risk	Yes / No
Thermal comfort Standard	Yes / No
Efficiency vs Renewable Threshold RES (%)	
Construction Quality	
Available materials	High / Medium / Low
Available knowledge	High / Medium / Low

2. **Please provide a map of the climatic areas in your country. Cite the source and make sure to share a high-resolution document.**

3. **What is the minimum energy efficiency threshold for nZEB in your country?**

There is an agreement in Europe to use the end-use and primary energy use intensity indicator to reflect the depletion of fossil fuels and proportional CO_2 emissions. The EPBD recast introduced the concept of nZEB, implying, for new buildings, very high energy performances and low energy needs that must be suppressed by renewable energy sources harvested on site after the end of 2020.

a. *In your country, what are the minimum energy efficiency threshold regarding end-use and primary energy use intensity and CO^2 emissions?*

b. *If there is no minimum threshold, which threshold do you suggest for your country and why?*

c. *Several European countries opt to comply with the PassivHaus Standard to guarantee a minimum performance threshold of 15kWh/m2/a for heating demand. Could this become the case in your country? and why?*

4. **What is the Heating-Cooling balance for nZEB in your country?**

The heating and cooling demand balance are significant for high-performance buildings. In cooling or heating-dominated climates, building designers seek bioclimatic and passive strategies to deal with only one acclimatization system to reduce cost and achieve maximum possible comfort.

a. *Describe your countries' seasonal climate intensity and heating and cooling balance. If you have a climate contrast (for example, heating-dominated cities and cooling-dominated cities), provide your recommendations for the three following options: Cooling dominated zones, Heating dominated zones, Heating and Cooling dominated zones.*

b. *Can you reach nearly zero heating demand?*

c. *Should we opt for highly airtight envelopes or medium airtight envelopes in your country?*

d. *What is the influence of the heating/cooling balance on your energy supply network capacity regarding the electric or thermal demand?*

5. What is the Thermal comfort limits for nZEB in your country?

In 2019, the European Committee for Standardization (CEN) introduced the European standards EN 16798, which suggests adopting the Fanger's PMV/PPD model for mechanically heated and/or cooled buildings and Humphreys and Nicol's adaptive model for buildings without mechanical cooling systems. In 2008, the PassivHaus standard required comfort levels complying with the static model of EN 15251 / 16798 respecting the following rule: the number of hours above 25°C may not exceed 5% of the time working. This criterion is verified by using a dynamic simulation. In Eastern Europe, no studies investigated the correlation between the variations of minimum performance threshold and suitable or fit-to-purpose comfort models in continental climates.

a.1. *Explain the reference standards used in your country to evaluate thermal comfort in nZEBS.*

a.2. *Cite the reference.*

a.3. *Is the comfort assessed based on a static comfort model (like Fanger) or an adaptive comfort model (EN 15251 / 16798)? Explain.*

a.4. *Please fill out the following table regarding overheating in your country. Feel free to develop your answers.*

Country		*France*	*Belgium*
Climate and weather data			
Is comfort dependent on national geographic climate zones? If yes, list them.	Yes / No	*Yes: H1a, H1b, H1c, H2a, H2b, H2c, H2d, H3*	*Yes: Brussels, Flanders, Wallonia*
Do you have a specific comfort calculation approach for heatwaves?	Yes / No	*No*	*No*
Do you take into account the urban heat island effect?	Yes / No	*No*	*No*
Does your overheating methodology take into account future climate change weather files with extreme scenarios?	Yes / No	*No*	*No*
Occupant type			
What is your comfort standard?		*ISO 7730* *EN 15251*	*Passive House (Brussels)* *ISO 13790 (Flanders & Wallonia)*

Does your method embrace the four occupant categories (I, II, III, IV)? *	Yes / No	*Yes*	*No*
Comfort model			
What is your overheating indicator?		*DIES (durée d'inconfort d'été statistique): statistical summer discomfort duration*	$I_{overh} = \sum_{m=1}^{12} Q_{excess\ norm,m}$ *where* $Q_{excess\ norm,\ m}$ *is the excess of heat gains to the indoor set-point temperature for month m*
Is your comfort model based on an adaptative or static method?	Static / Adaptive	*Mixed: adaptive and static for sleeping rooms*	*Static (Brussels), adaptive (Flanders & Wallonia)*
What are your overheating thresholds?		● *all living spaces except sleeping rooms depend on an adaptative model* ● *maximum 28°C operative temperature in sleeping rooms*	*Recommended range: 1000 Kh <* I_{overh} *< 6500 Kh*
Does your model consider local, personalized heating/cooling & ventilation systems (ceiling fans, air-conditioned chairs, electric heating mattresses…)?	Yes / No	*Yes*	*No*
Simulation model			
Is your calculation based on a static/quasi-dynamic/dynamic model? What is the calculation timestep?	Static / Quasi-dynamic / Dynamic	*Dynamic model & hourly calculations*	
Is your overheating calculation based on a single or multizone model?	Single zone / Multizone	*Multizone model*	
Does your calculation distinguish sleeping rooms from other living areas?	Yes / No	*Yes*	

Envelope			
Does your method oblige the installation of external shading?	Yes / No	*No*	*No*
Does your method oblige the limitation of the window to wall ratio? If yes, what is the limit?	Yes / No	*No*	*No*
Does your method set an expected G-value? If yes, what is the limit?	Yes / No	*No*	*No*

b. *Do you have fuel poverty problems in your country that might influence the nZEB objective? Explain.*

c.1. *What are the overheating criteria for nZEBs in your country?*

c.2. *What is the overheating risk for nZEB's (highly insulated) in your climate?*

c.3 *How do you evaluate overheating risk in nZEBs in your country? Please share the calculation method and overheating hours limit threshold.*

d. *Can we rely on passive cooling, or must we include active cooling systems for nZEBs in your country?*

6. What is the minimum renewables threshold for nZEB in your country?

Energy efficiency and renewable energy technologies provide essential opportunities to reduce greenhouse gas emissions. Efficiency is a policymaking principle that recognizes the central role of cost-effective energy savings in meeting energy, climate, and economic goals.

a. *Is it more accessible in your country to invest in renewables than in energy efficiency? And why?*

b. *Would you recommend imposing an onsite minimum renewable threshold for energy production produced (from renewable sources)? How much should that threshold be? 30, 50, or 70% of the demand?*

c. *Are regulations and policies ready for encouraging energy-producing buildings in your countries? Is your energy grid ready for that?*

7. What is the construction quality for nZEB in your country?

NZEBs require high construction through new technologies, high-tech components, specialized competencies, and high-level expertise. To achieve NZEBs, the use of energy-efficient technologies and materials is necessary. These technologies and materials must respond to the exigencies of the NZEBs and satisfy the NZEB market demand.

a. *Should we address high-tech nZEB solutions or low-tech nZEB solutions? How and why?*

b. *What are the main barriers to high-quality nZEB construction in your country?*

8. **What should be (your own recommendation) the minimum EE and RET in your country? Fill in the table below** (EE energy efficiency, RET Renewable Energy Threshold onsite):

Category	EE threshold		RES threshold
	Heating	Cooling	

9. **Please list the key publications I should mention concerning your overview (APA style is recommended). Don't forget the national standard in the mother tongue language of your country.**