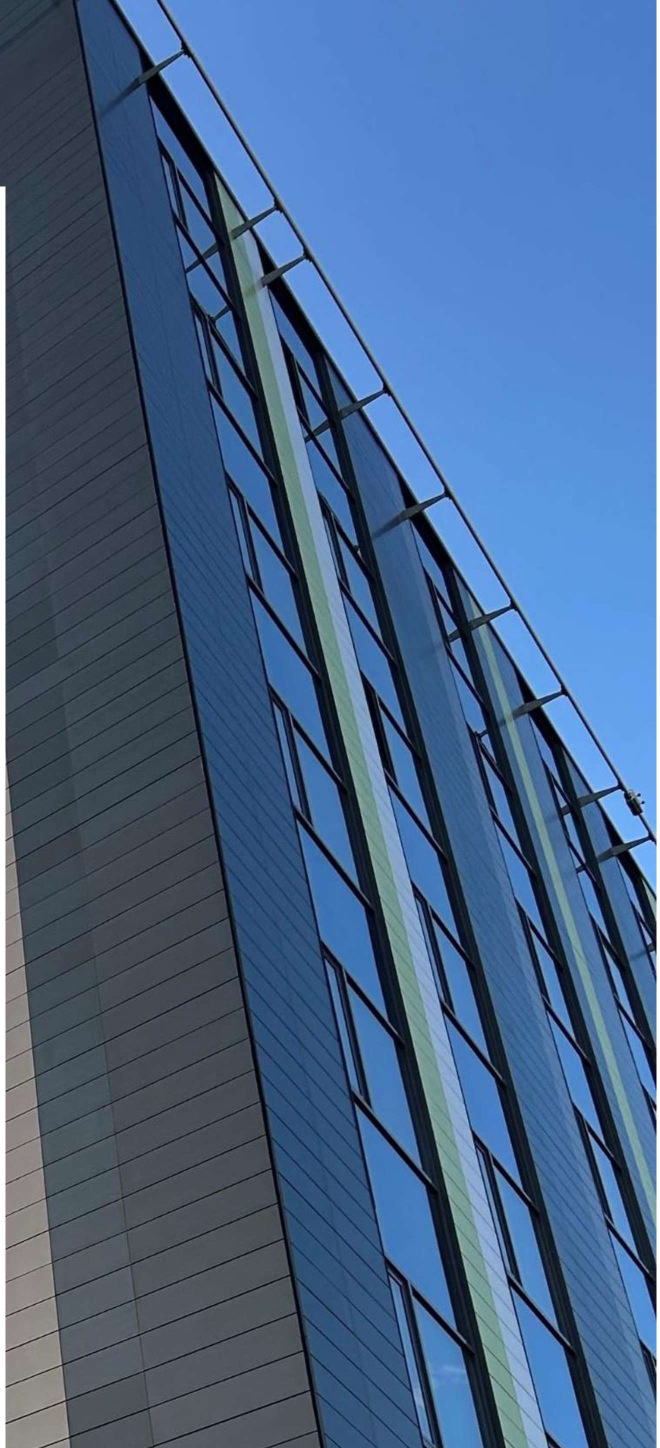

Methodology for determining 15% and 30% of the most energy efficient buildings in Lithuania

REPORT
2023

VILNIUS TECH
Vilniaus Gedimino technikos universitetas

Vilnius Gediminas Technical University

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1. INTRODUCTION

The European Commission, by launching the European Green Deal in 2020, has announced the goal of making the European Union the world's first climate-neutral continent by 2050. As part of this ambition, Taxonomy Regulation (EU) 2020/852 has been adopted with the aim of stimulating private sector investment in sustainable green projects to facilitate the implementation of the European Green Deal.

The Taxonomy Regulation establishes a classification system consisting of a list of environmentally friendly economic activities. It helps banks and other financial institutions understand whether the company they finance is sustainable and meets the highest environmental standards.

On 4 June 2021, the European Commission adopted Delegated Regulation (EU) 2021/2139 supplementing the Taxonomy Regulation by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives (hereinafter, the Delegated Regulation).

Section 7.7 of Annex 1 to the Delegated Regulation sets out the technical screening criteria for determining the conditions under which the acquisition of a building qualifies as contributing substantially to climate change mitigation or causing no significant harm. One of the criteria contributing substantially to climate change mitigation is that the building is within the top 15% of the national or regional building stock expressed as operational Primary Energy Demand (PED). Similarly, if the building is within the top 30% of the national or regional building stock expressed as operational Primary Energy Demand (PED), the criterion of causing no significant harm is considered to be met.

As it is mandatory for financial institutions to assess the indicator of operational Primary Energy Demand (PED) when lending to their customers, the Lithuanian Banking Association has commissioned the development of a methodology for determining 15% and 30% of the most energy efficient national building stock of Lithuania to assist its members in meeting this obligation.

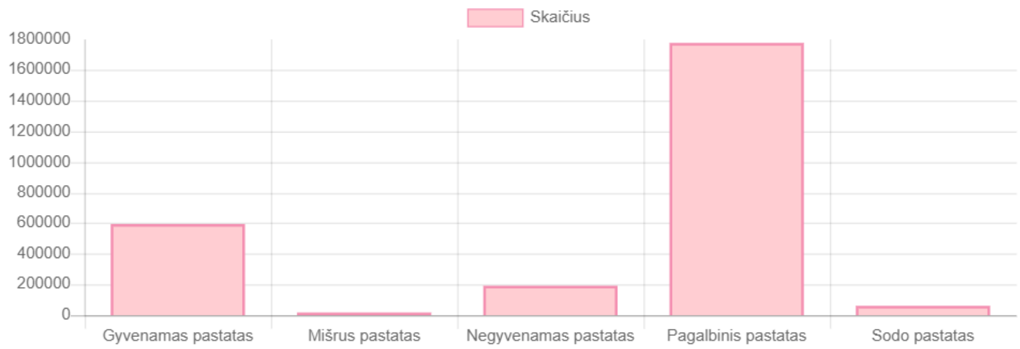
1.1. Purpose

The purpose of this study is to develop a methodology based on which it would be possible to determine 15% and 30% of the most energy efficient residential and non-residential buildings in Lithuania following the requirements of Taxonomy Regulation (EU) 2020/852[1] and its implementing legislation (Commission Delegated Regulation (EU) 2021/2139[2]).

- The methodology for determining 15% and 30% of the most energy efficient national building stock of Lithuania expressed as operational Primary Energy Demand (PED) is based on appropriate evidence.
- For determining operational Primary Energy Demand (PED), the methodology for determining 15% and 30% of the most energy efficient buildings in Lithuania uses data from available and reliable data sources (e.g., data centres).
- The performance of the relevant property must be comparable to the performance of the national stock built before 31 December 2020.

1.2. Building stock in Lithuania

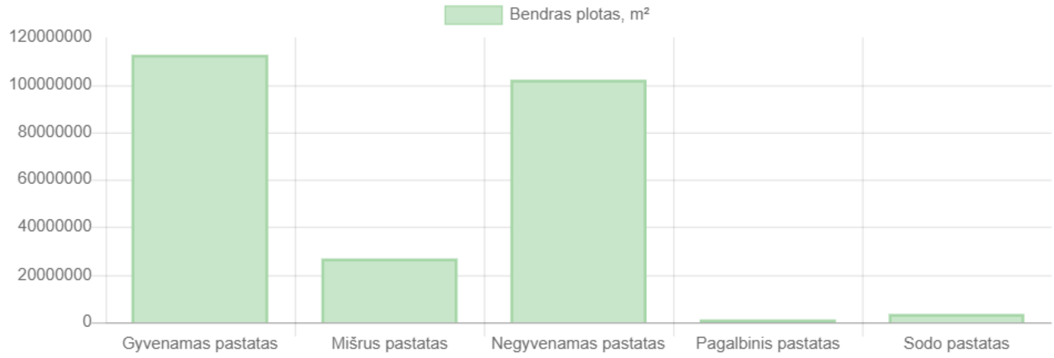
According to the data of the State Enterprise Centre of Registers[3] (data of January 2023), Lithuania has a total of 2.6 million buildings, 800,000 of which are residential and non-residential buildings (Fig. 1.1). However, when looking at the building stock by floor area (Fig. 1.2), residential and non-residential buildings make up most of the buildings.



Number				
Residential building	Combined building	Non-residential building	Auxiliary building	Garden building

Fig. 1.1. Building stock in Lithuania by number of buildings

[1] https://eur-lex.europa.eu/legal-content/LT/TXT/PDF/?uri=CELEX:32020R0852&from=EN
[2] https://eur-lex.europa.eu/legal-content/LT/TXT/PDF/?uri=CELEX:32021R2139&from=EN
[3] Data of the Centre of Registers



Total floor area, m²				
Residential building	Combined building	Non-residential building	Auxiliary building	Garden building

Fig. 1.2. Building stock in Lithuania by floor area

This study assesses residential and non-residential buildings, which are divided into 6 groups according to the purposes identified in the technical task (Fig. 1.3)

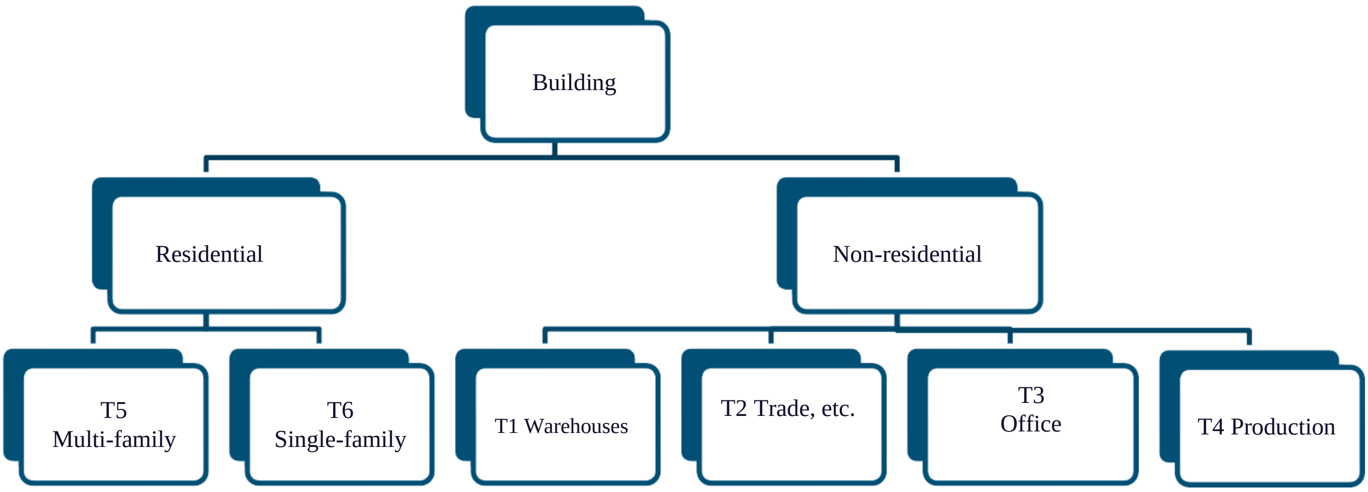


Figure 1.3. Classification of buildings by purpose

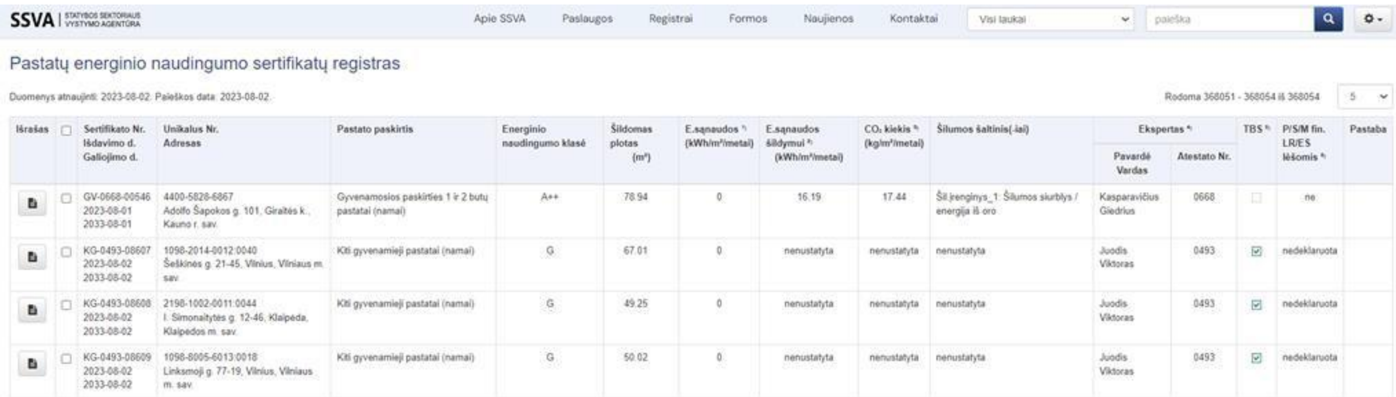
The classification of buildings by purpose is necessary to take into account the different assumptions for energy use in a building, which are determined by the specificity of the purpose.

1.3. Data sources

In Lithuania, energy supply companies collect actual building energy consumption data, but much of this data is not publicly available. Only monthly heat consumption of multi-family houses is publicly available on the websites of heat supply companies.

In Lithuania, data of (design) energy needs of all certified buildings are collected, but not all indicators specified in the certificate are made public. Primary energy demand, although calculated and included in the certificate since 2012, is not published in the Register.

For the above reasons, **15% and 30% of the most energy efficient buildings in Lithuania can only be determined on the basis of the data in the Energy Performance Certificate (EPC)**, i.e. the design energy demand which is made public in the Register of the Construction Sector Development Agency (CSDA)[4]. A snapshot of the data contained in the Register is shown in Figure 1.4. In January 2023, 358,000 energy performance certificates were registered in Lithuania, of which almost 176,000 were standard apartment certificates (SAC).



SSVA | STATYBOS SEKTORIAUS VYSTYMO AGENTŪRA   Apie SSVA   Paslaugos   Registrai   Formos   Naujienos   Kontaktai   Visi laukai   paieška

Pastatų energinio naudingumo sertifikatų registras

Duomenys atnaujinti: 2023-08-02. Paieškos data: 2023-08-02.

Rodoma 368051 - 368054 iš 368054   5

Išrašas		Sertifikato Nr. Išdavimo d. Galiojimo d.	Unikalus Nr. Adresas	Pastato paskirtis	Energinio naudingumo klasė	Šildomas plotas (m²)	E.sąnaudos ¹⁾ (kWh/m²/metai)	E.sąnaudos šildymui ²⁾ (kWh/m²/metai)	CO_2 kiekis ³⁾ (kg/m²/metai)	Šilumos šaltinis(-iai)	Ekspertas ⁴⁾ Pavardė Vardas	Atestato Nr.	TBS ⁵⁾	P/S/M fin. LR/ES lėšomis ⁶⁾	Pastaba
		GV-0668-00546 2023-08-01 2033-08-01	4400-5828-6867 Adolfo Šapokos g. 101, Giraitės k., Kauno r. sav.	Gyvenamosios paskirties 1 ir 2 butų pastatai (namai)	A++	78.94	0	16.19	17.44	Šil.įrenginys_1: Šilumos siurblys / energija iš oro	Kasparavičius Giedrius	0668		ne	
		KG-0493-08607 2023-08-02 2033-08-02	1098-2014-0012:0040 Šeškinės g. 21-45, Vilnius, Vilniaus m. sav.	Kiti gyvenamieji pastatai (namai)	G	67.01	0	nenustatyta	nenustatyta	nenustatyta	Juodis Viktoras	0493	☑	nedeklaruota	
		KG-0493-08608 2023-08-02 2033-08-02	2198-1002-0011:0044 I. Simonaitytės g. 12-46, Klaipėda, Klaipėdos m. sav.	Kiti gyvenamieji pastatai (namai)	G	49.25	0	nenustatyta	nenustatyta	nenustatyta	Juodis Viktoras	0493	☑	nedeklaruota	
		KG-0493-08609 2023-08-02 2033-08-02	1098-8005-6013:0018 Linksmoji g. 77-19, Vilnius, Vilniaus m. sav.	Kiti gyvenamieji pastatai (namai)	G	50.02	0	nenustatyta	nenustatyta	nenustatyta	Juodis Viktoras	0493	☑	nedeklaruota	

Construction Sector Development Agency   About CSDA   Services   Registers   Forms   News   Contacts   All fields   Search

Register of Building Energy Performance Certificates

Data updated: 02/08/2023. Date of search: 02/08/2023.

Extract		Certificate No. Date of issue Valid until	Unique No. Address	Building purpose	Energy performance class	Heated floor area (m²)	Energy use ¹⁾ (kWh/m²/year)	Energy use for heating ²⁾ (kWh/m²/year)	CO_2 emissions ³⁾ (kg/m²/year)	Heat source(s)	Expert ⁴⁾ Name Surname	Attestation certificate No.	SAC ⁵⁾	P/S/M fin. LR/EU funds ⁶⁾*	Note
		GV-0668-00546 2023-08-01 01/08/2033	4400-5828-6867 Adolfo Šapokos g. 101, Giraitės k., Kauno r. sav.	Residential single- and double-family buildings (houses)	A++	78.94	0	16.19	17.44	Heating installation_1: Heat pump/energy from air	Kasparavičius Giedrius	0668		no	
		KG-0493-08607 2023-08-02 02/08/2033	1098-2014-0012:0040 Šeškinės g. 21-45, Vilnius, Vilniaus m. sav.	Other residential buildings (houses)	G	67.01	0	N/A	N/A	N/A	Juodis Viktoras	0493		not declared	
		KG-0493-08608 2023-08-02 02/08/2033	2198-1002-0011:0044 I. Simonaitytės g. 12-46, Klaipėda, Klaipėdos m. sav.	Other residential buildings (houses)	G	49.25	0	N/A	N/A	N/A	Juodis Viktoras	0493		not declared	
		KG-0493-08609 2023-08-02 02/08/2033	1098-8005-6013:0018 Linksmoji g. 77-19, Vilnius, Vilniaus m. sav.	Other residential buildings (houses)	G	50.02	0	N/A	N/A	N/A	Juodis Viktoras	0493		not declared	

Fig. 1.4. A snapshot of data in the CSDA Register

[4] Building Register of the Construction Sector Development Agency

* The design and/or construction and/or modernisation of the building financed from the budget of the Republic of Lithuania and/or the European Union

The distribution of certificates by building purpose and energy performance class is shown in Annex 1, Table 1p.1.

Due to changes in methodologies in 2012 and 2016, the certificates differed in their assessment of the total energy consumption of the building and the only indicator, the measurement methodology of which can be reliably based, was energy use for heating (kWh/m2/year).

1.4. Changes in energy performance certification since the start of certification

Energy performance certification of buildings in Lithuania started in December 2005 when the Ministry of Environment of the Republic of Lithuania approved Technical Construction Regulation STR 2.01.09:2005 “Energy performance of buildings. Certification of energy performance”[5]. The 2005 Regulation assessed the total energy use per square metre of the useful floor area of a building, kWh/(m2×year), which was calculated by adding together heat and electricity without any primary energy transformation factors. However, certificates were valid for a maximum of 10 years and all certificates issued under the first regulation between 2005 and 2012 are no longer valid and must be renewed for real estate transaction purposes.

The concept of primary energy was introduced in 2012 with the enactment of Technical Construction Regulation STR 2.01.09:2012 “Energy performance of buildings. Certification of energy performance”[6]. Since 2012, the energy performance certificate contains the estimated *non-renewable primary energy* use per square metre of the heated floor area of a building (part of it) per year and the estimated *renewable primary energy* (i.e. energy from renewable sources) use per square metre of the heated floor area of a building (part of it) per year. The Regulation has also introduced in energy performance certificates the calculation of the annual carbon dioxide (CO_2) emissions of a building (part of it) during its operation.

The Regulation has not been amended since 2016, only new versions have been issued (STR 2.01.02:2016 “Design and certification of the energy performance of buildings”[7] – hereafter referred to as the Technical Regulation), maintaining the treatment of renewable and non-renewable primary energy. However, changes to the requirements for higher energy performance classes have led to

[5] https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.268553
[6] https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.268553
[7] https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.268553

new indicators for determining the energy performance class.

From 2020 onwards, the Technical Regulation introduces a new indicator for determining the energy performance class – *primary energy use per square metre of the heated floor area of a building (part of it) per year*. This indicator is calculated by summing the estimated renewable and non-renewable primary energy use per square metre of the heated floor area of a building (part of it) per year. Therefore, when assessing the primary energy indicated in the energy performance certificate, it is necessary to pay attention to the year in which the certificate was issued and which primary energy is included in the calculations.

1.5. Classification of residential and non-residential buildings

The classification of buildings according to the technical task is different compared to the classification of the Centre of Registers and of the Technical Regulation, therefore the analysed equivalents and groupings are given in Table 1.1.

Table 1.1. Classification of buildings

Classification by technical task	Classification of the Centre of Registers	Classification under the Technical Regulation[8]
T1 warehouses	Manufacturing, industrial, storage, transport, and garage buildings	Warehousing
T2 trade, etc.	Hotel, commercial, services, catering, and leisure buildings	Hotel + Commercial + Services + Catering + Leisure buildings
T3 administrative/office buildings	Office buildings	Office buildings
T4 production buildings, etc.	Manufacturing, industrial, storage, transport, and garage buildings	Garage, manufacturing and industrial + Transport buildings
T5 multi-family buildings	Residential buildings (three or more apartments)	Other residential buildings + Other residential (houses) + Other residential buildings (houses)
T6 single-family houses	Residential (single- and double-family) buildings	Residential single- and double-family buildings (houses)

Annex 1, Table 1p.2 provides numerical data on the scopes of the building sector and certified buildings.

[8] STR 2.01.02:2016 “Design and certification of the energy performance of buildings”

2. METHODOLOGY

2.1. Brief description of the methodology

Based on the current situation, the indicators of operational primary energy demand for identifying the 15% and 30% threshold of the most energy efficient buildings are determined in the study by the following steps (Fig. 2.1):

1. Primary data analysis: the analysis of the full sample of certified buildings by purpose, energy performance class, floor area, and the number of buildings.
2. Data filtering (cleaning and sample preparation): elimination of A++ class buildings from the sample (according to the requirements of the Taxonomy Regulation), elimination of buildings with SACs (standard apartment certificates, which are issued formally and do not give any reliable information about the energy performance of a building), elimination of buildings with unspecified or "0" energy use for heating, elimination of buildings with updated certificates, i.e. only the data of new certificates is analysed.
3. Identification of 15% and 30% of the best performing buildings in terms of energy use for heating. The number of buildings within 15% and 30% of the most energy efficient certified buildings is determined from the data sample produced. As the sample of certified buildings covers a wide range of building classes, it is assumed that the sample of certified buildings reflects the overall situation of the building stock and is sufficient to determine limit values. Taking into account the specificities of the Technical Regulation's methodology, it is additionally verified whether the heat pump (HP), as a source, affects limit values. Annual limits of energy use for heating by building group are set for 15% and 30% of the most energy efficient buildings.

Calculating the indicator of operational primary energy demand. This indicator, with limit values for heating, is calculated by summing *the energy used for heating, hot water, ventilation, cooling and adding the building's electricity for lighting and other uses*. Heating uses are determined according to Table 3.1, while energy for ventilation, hot water and electricity for other uses is determined in accordance with the Technical Regulation.

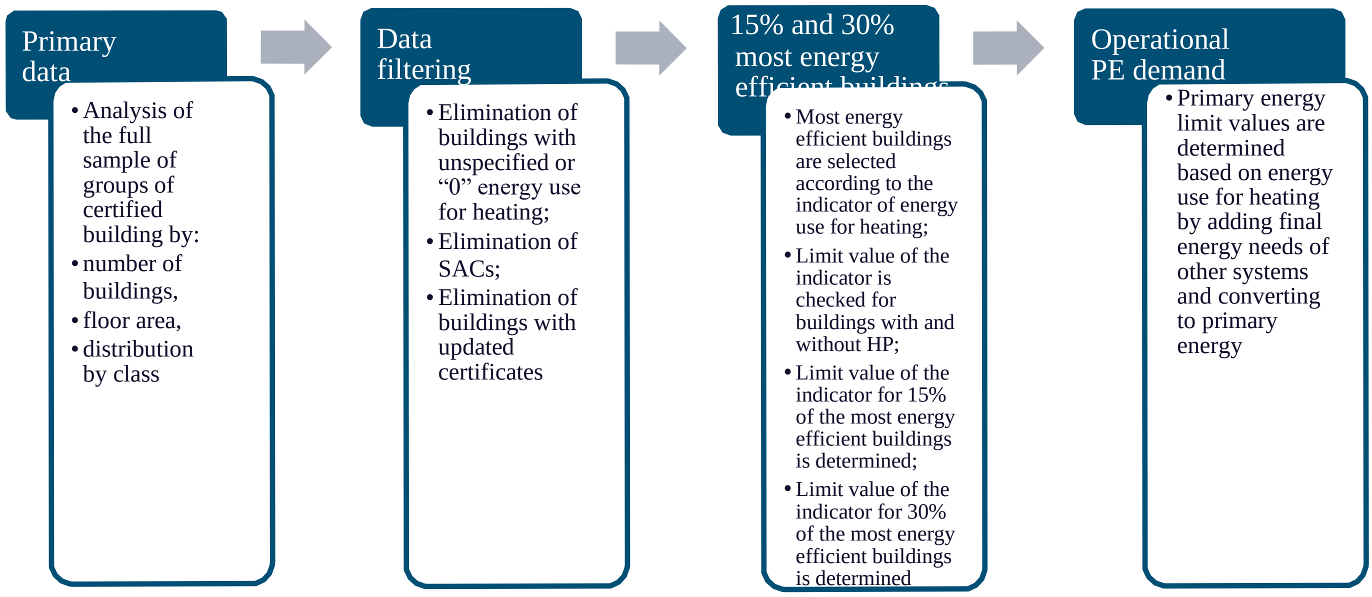


Figure 2.1. General methodological scheme

Values of energy use for cooling are not regulated and are therefore adopted on the basis of a separate literature analysis. The aggregated energy use for heating of a building is converted to primary energy applying the non-renewable primary energy factor of the heat source (*fPRn*) and the aggregated electricity consumption of a building is converted to primary energy (Fig. 2.2).

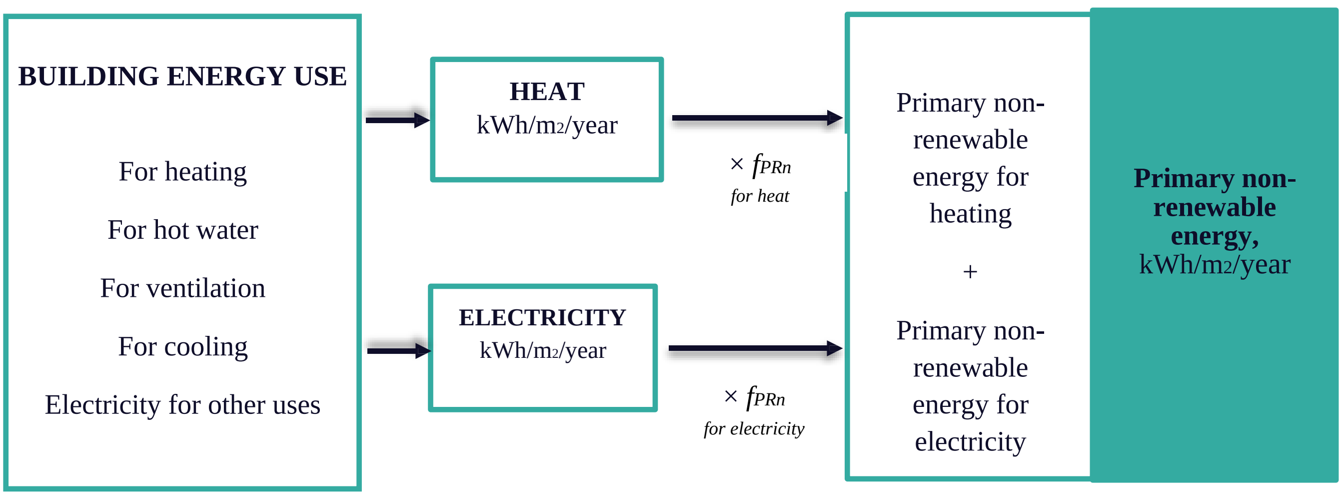


Figure 2.2. Calculation of the indicator of non-renewable primary energy (operational primary energy demand)

The methodological assumptions are described in more detail in Sections 2.2 and 2.4.

2.2. Assumptions for calculating the final energy

2.2.1. Heat for heating and domestic hot water

Based on the methodology described above, energy use for heating (final energy) for all building groups (T1 to T6) is determined on the basis of the design values available in the CSDA Register of Energy Performance Certificates, after first eliminating certificates without or "0" values of energy use for heating, A++ building data, and updated certificates. The data for A++ buildings is eliminated because the technical task of the methodology (based on the Taxonomy Regulation) specifies to assess buildings constructed before 31 December 2020. Although A++ buildings were already built before 31 December 2020, this eliminates buildings that meet the NZEB (*Nearly zero energy building*) requirements.

For each group of buildings, the number of buildings within 15% and 30% of the most energy efficient buildings is determined from the developed data sample and the limit value of energy use for heating is set, additionally taking into account the differences between buildings with and without heat pumps to verify that a heat pump is not a prerequisite for a building to be among the most efficient buildings.

For multi-family buildings (group T5), the data analysis is more detailed, as this segment of buildings has certification specificities and is socially sensitive.

Peculiarities of assessing multi-family buildings. Based on Eurostat[9] data, almost 60% of Lithuania's population lives in multi-family buildings. According to the data of the Centre of Registers, there are almost 42,000 multi-family buildings in Lithuania, which is one of the largest segments in the country in terms of floor area (Annex 1, Table 1p.1). The vast majority of multi-family buildings (about 88%) were built before 1993 without the use of thermal insulation materials, thus a large part of the building stock in this segment is in poor technical condition.

To prioritise and accelerate the process of renovation of buildings with the lowest energy efficiency, in 2013 municipalities attributed the buildings which consume more than 150 kWh/m2 of thermal energy per year to the most inefficient multi-family buildings.[10]

[9] EUROSTAT
[10] Long-term Renovation Strategy of Lithuania

Multi-family buildings, according to the Technical Regulation, can be certified both individually for each flat and as a whole building (the number of buildings does not equal the number of possible certificates). In real estate transactions, a certificate must be presented at the time of the transaction, so for flats that do not have certificates, the Centre of Registers issues a standard apartment certificate (SAC), i.e. the flat is formally assigned to the worst energy performance class G, without any calculation being carried out. 195,050 certificates have been registered in the CSDA database for multi-family buildings, of which 175,960 are SACs, which does not provide any real comparative information on the building's energy performance. Without eliminating SACs from the data sample to be assessed, 15%, i.e. about 105,000 properties of this type, should be classified as the most efficient, although only about 9% of the total number of properties are certified according to the Technical Regulation's methodology, which, if A++ class multi-family buildings are excluded, would result in a total of just over 17,000 properties. Therefore, the assessment of the sample together with SACs is incorrect.

It is assumed that the reliable data sample is limited to buildings certified according to the Technical Regulation, reflecting the overall performance situation of this group of buildings, as the sample to be assessed is dominated by buildings from class B to F (Fig. 2.3).

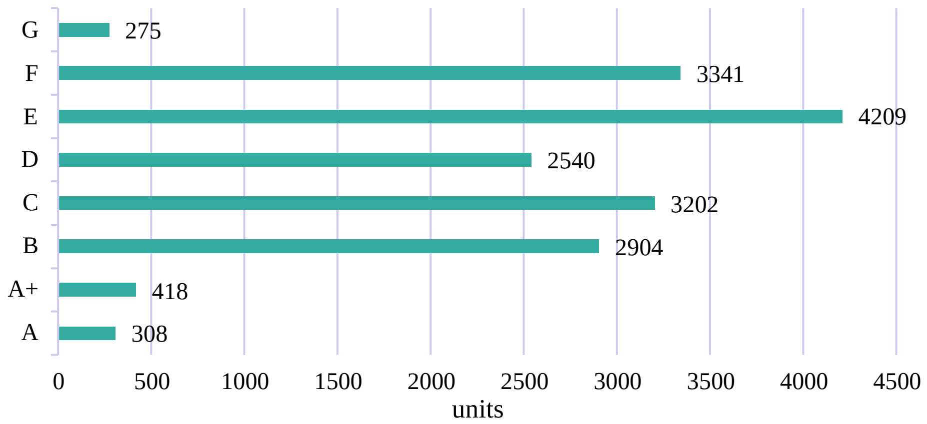


Fig. 2.3. Distribution of the sample of multi-family/flat certificates by class

In addition, the correctness of the assumption is verified on the basis of heat suppliers' data on actual energy uses in multi-family buildings. Based on LŠTA (Lithuanian District Heating Association[11]) data, there are around 700,000 flats in Lithuania supplied with district heating, of which:

- around 118,000 flats are in very poor condition;
- around 409,000 flats are in old, Soviet-built, uninsulated multi-family buildings;

[11] Lithuanian District Heating Association

• around 47,000 flats are partially modernised;

• around 71,000 flats are fully renovated;

• around 57,000 flats are new multi-family buildings.

This conditional breakdown of buildings according to actual heat uses, as provided by heat suppliers shows a similar trend, i.e. that most buildings are in poor condition (Fig. 2.4).

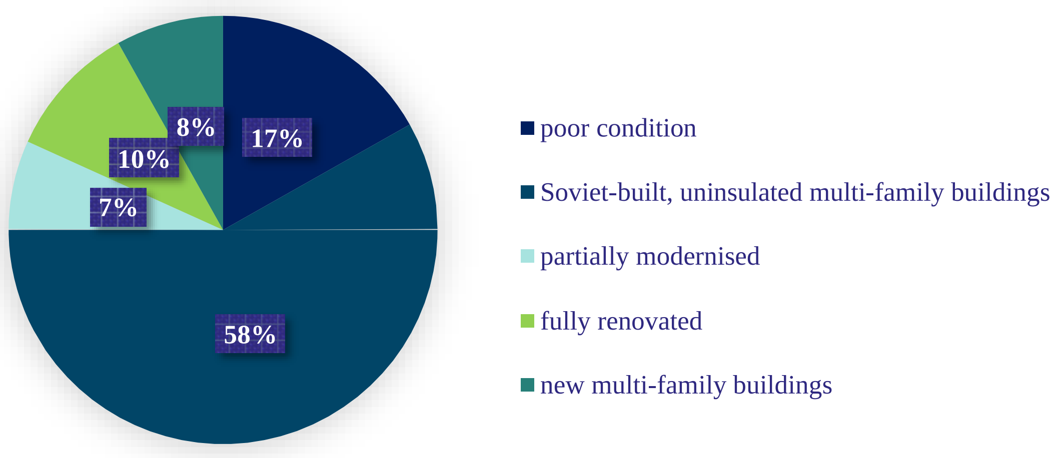


Fig. 2.4. Distribution of flats by condition

The condition of a building is determined by its energy use for heating (Fig. 2.5).

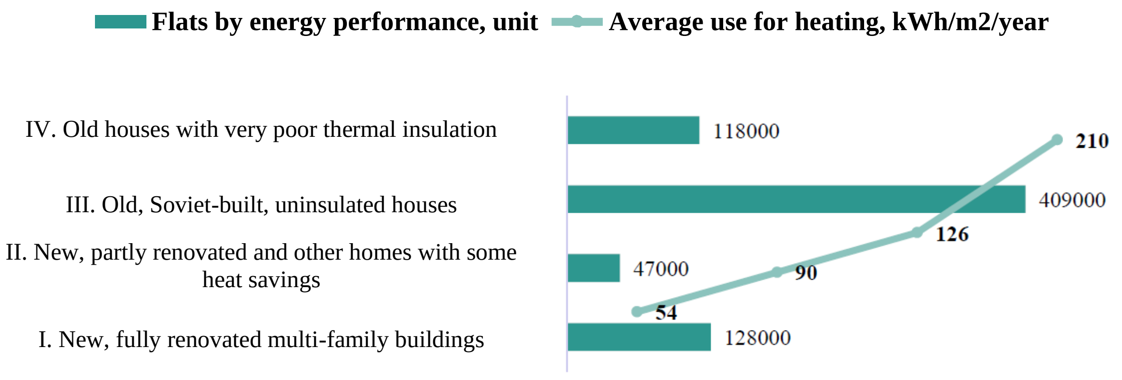


Fig. 2.5. Actual average energy use for heating in multi-family buildings by condition

Based on actual consumption, it can be assumed that buildings with uses for heating exceeding 90 kWh/m2 should no longer be within the most efficient buildings. The final energy limit values for heating in 15% and 30% of [the most energy efficient] buildings are more accurately determined on the basis of energy data of certified buildings, in the same way as for other buildings.

The energy use for domestic hot water is assessed for each purpose [of buildings] according to Table 2.4 of the Technical Regulation. The values for energy for domestic hot water for each purpose [of buildings] are given in Annex 2.

2.2.2. Electricity consumption for lighting and other uses, ventilation, and cooling

The ventilation system in a building is one of the electricity consumers. For the assessment of energy use for ventilation in 15% of the most efficient buildings, it has been assumed that the ventilation systems in these buildings comply with the requirements for an energy efficiency class A ventilation system, where the capacity of the recuperator ventilators in the ventilation system should not exceed 0.75 Wh/m^3 (under the Technical Regulation).

30% of the most efficient buildings were assessed as having lower ventilation system efficiency, assuming that the electricity consumption of the recuperator ventilators should not exceed 1 Wh/m^3. Air volumes and other characteristics of the ventilation system were assumed to be the same for both 15% and 30% of the most energy efficient buildings; assessment indicators are shown in Annex 2, Table 2p.1.

The calculation of the final electricity consumption takes into account the energy use of the electrical equipment in the heated areas of the building and the electricity consumption for lighting in the heated areas, according to the electricity consumption for the different purposes of the buildings, as provided in the Technical Regulation. The electricity consumption per square metre of the area of a building for each of the purposes considered in this study is given in Annex 2, Table 2p.1.

The same electricity consumption is applied to both 15% and 30% of the most energy efficient buildings, because the electricity demand for lighting and other equipment in existing buildings depends mainly on the behaviour of the users and not on the energy performance of the building, and the Technical Regulation does not differentiate electricity demand by class.

Lithuania does not separately regulate energy needs for cooling, so their values are based on Aalborg University's 2022 report "Nordic-Baltic NZEBs"[12], which puts the cooling demand for non-residential buildings at 30 kWh/m^2·per year. It is assumed that cooling equipment energy efficiency for cooling is EER=3, then the electricity demand for cooling is 10 kWh/m^2·per year. Based on the Technical Regulation, after applying f_{PRn} – non-renewable primary energy factor (2.3), primary energy demand for cooling is 23 kWh/m^2·per year. For residential buildings, the calculation is similar (Table 2.1) and is compared with the indicators in Poland.

[12] https://build.dk/Assets/Nordic-Baltic-NZEBs/Nordic-Baltic-NZEBs.pdf

Table 2.1. Electricity demand for cooling in residential and non-residential buildings

Buildings				f_{PRn}	Lithuania	Poland
	Cooling demand, kWh/m² per year	Energy efficiency for cooling EER	Electricity demand for cooling, kWh/m² per year		PE for cooling, kWh/m² per year	Maximum allowed PE for cooling, kWh/m² per year
Non-residential buildings	30	3	10	2.3	23	25
Residential buildings	15	3	5	2.3	12	25

2.3. Definition of primary energy, European methodologies for calculating and assessing primary energy

In this subsection, Table 2.2 sets out the definitions of primary energy used in the existing directives, guidelines, recommendations, and regulations.

Table 2.2. Definition of primary energy

Seq. No.	Document	Definition of primary energy
1.	**DIRECTIVE** 2010/31/EU on the energy performance of buildings (recast)	**Primary energy** means energy from renewable and non-renewable sources which has not undergone any conversion or transformation process. **The energy performance of a building** shall be expressed in a transparent manner and shall **include** an energy performance indicator and **a numeric indicator of primary energy use**, based on <u>primary energy factors per energy carrier</u>, which may be based on national or regional annual weighted averages or a specific value for on-site production.
2.	**DIRECTIVE** 2012/27/EU on energy efficiency	**Primary energy consumption** means gross inland consumption, excluding non-energy uses.
3.	**REGULATION** (EU) No. 244/2012 on the energy performance of buildings by establishing a comparative	3. CALCULATION OF THE PRIMARY ENERGY DEMAND RESULTING FROM THE APPLICATION OF SUCH MEASURES AND PACKAGES OF MEASURES TO A REFERENCE BUILDING 1. The energy performance is calculated in accordance with the

Seq. No.	Document	Definition of primary energy
	methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements	common general framework provided in Annex I to Directive 2010/31/EU. 2. Member States shall calculate the energy performance of measures/packages/variants by calculating, for the nationally defined floor area, first the energy needed for heating and cooling. Subsequently the delivered energy for space heating, cooling, ventilation, domestic hot water and lighting systems is calculated. 3. <u>Energy produced onsite **SHALL BE DEDUCTED** from the primary energy demand and delivered energy.</u> 4. Member States shall calculate the resulting primary energy use using primary energy conversion factors established at national level. They shall report to the Commission the primary energy conversion factors in the reporting referred to in Article 6 of this Regulation.
4.	**GUIDELINES** 2012/C 115/01 accompanying Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements	***Primary energy* for a building** is the energy used to produce the energy delivered to the building. It is calculated from the delivered and exported amounts of energy carriers, using primary energy conversion factors. **Primary energy** includes *non-renewable energy* and *renewable energy*. If both are taken into account it can be called <u>**total primary energy**</u>. For the purpose of <u>the cost-optimal evaluation</u>, <u>*the non-renewable part of primary energy*</u> is considered. It has to be noted that this does not contradict the definition of *primary energy* given in the Directive — for overall building performance, both the non-renewable part and the total quantity of primary energy related to building operation should be reported. The corresponding primary energy (conversion) factors are to be set at national level, taking into account Annex II to Directive 2006/32/EC.

Seq. No.	Document	Definition of primary energy
		5. CALCULATION OF THE PRIMARY ENERGY DEMAND RESULTING FROM THE APPLICATION OF MEASURES AND PACKAGES OF MEASURES TO A REFERENCE BUILDING Calculation of **energy performance** from **net energy needs** to **primary energy use** 5. Calculation of the delivered energy for each energy carrier as sum of energy uses (not covered by renewable sources). 6. Calculation of the primary energy associated with the delivered energy, using national conversion factors. 7. Calculation of the primary energy associated with energy exported to the market (e.g. generated by renewable sources or co-generators on-site). 8. Calculation of primary energy as the difference between the two previous calculated amounts: (6) — (7). *Calculation example* Energy calculation results: — fuel energy use for space heating is 25 kWh. (m^2 a): 20/0.80, — fuel energy use for hot water is 2.5 kWh (m^2 a): (5 - 3)/ 0.80, — electric energy use for space cooling results in 20 kWh (m^2 a): 35/1.75, — delivered fuel energy is 27.5 kWh/(m^2 a): 25 + 2.5, — delivered electric energy is 31 kWh/(m^2 a): 7 + 10 + 20 - 6, — primary energy is 105 kWh(m^2 a): 27.5 + (31/0.4), — primary energy associated with energy exported to the market is 22.5 kWh (m^2 a): 9/0.4, — net primary energy is 82.5 kWh(m^2 a): 105 - 22.5.
5.	**RECOMMENDATION** (EU) 2016/1318 on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy	(6) ‘**Energy need**’, ‘**delivered energy**’ and ‘**net primary energy**’ should be read according to the definitions laid down in Delegated **Regulation (EU) No 244/2012** and its accompanying **Guidelines**. (33) **The integrated energy performance of a building** corresponds to **the amount of net primary energy** needed to meet the different needs

Seq. No.	Document	Definition of primary energy
	buildings	associated with its typical use and must reflect the heating energy needs and cooling energy needs, domestic hot water needs and built-in lighting. As a result, in addition to the quality of insulation of the building, **an integrated performance** considers heating installations, cooling installations, energy for ventilation, lighting installations, position and orientation of the building, heat recovery, active solar gains and other renewable energy sources. Under Annex I(3) to the Regulation, the calculation of energy performance starts with the calculation of final energy needs (6) for heating and cooling, and ends with the calculation of **the net primary energy**. The 'direction' of the calculation goes from the building's needs to the source (i.e. to the primary energy). Projecting the 2020 prices and technologies, benchmarks for the energy performance of NZEB are in the following ranges for the different EU climatic zones (32): Nordic: - **Offices**: **55–70** kWh/(m².y) **of net primary energy** with, typically, 85–100 kWh/(m².y) of primary energy use covered by 30 kWh/(m².y) of on-site renewable sources. - **New single family house**: **40–65** kWh/(m².y) **of net primary energy** with, typically, 65–90 kWh/(m².y) of primary energy use covered by 25 kWh/(m².y) of on-site renewable sources. Under the EPBD, Member States can use their own national primary energy factors to transform the final delivered energy into primary energy and calculate building energy performance. The primary energy use must be calculated using primary energy factors specific to each energy carrier (e.g. electricity, heating oil, biomass, district heating and cooling). The accompanying guidelines to the Delegated Regulation recommend using the same 2.5 primary

Seq. No.	Document	Definition of primary energy
		energy factor for delivered and for exported electricity. Energy produced on-site (used on-site or exported) reduces the primary energy needs associated with delivered energy. The end **objective of the energy performance calculation** is **<u>to determine the annual overall energy use in net primary energy</u>**, which corresponds to energy use for heating, cooling, ventilation, hot water and lighting. The establishment of **numeric benchmarks for** NZEB **primary energy use indicators**, at EU level, is most useful when the values to be compared with these benchmarks result from **<u>transparent calculation methodologies</u>**. Standards (31) are currently under finalisation to allow for transparent comparison of national and regional calculation methodologies.
6.	**REGULATION** (EU) 2021/2139 on the establishment of a framework to facilitate sustainable investment	**7. CONSTRUCTION AND REAL ESTATE ACTIVITIES** (**Annex I_**contributing substantially to climate change mitigation) **7.1. Construction of new buildings** 1. **The Primary Energy Demand (PED)**(281) is the calculated amount of energy needed to meet the energy demand associated with the typical uses of a building expressed by **<u>a numeric indicator</u> of total primary energy use** in kWh/m2 per year and based on the relevant <u>national calculation methodology</u> and as displayed on the Energy Performance Certificate. **7.7. Acquisition and ownership of buildings** 1. For buildings built **before 31 December 2020**, the building has at least **an Energy Performance Certificate (EPC) class A**. As an alternative, the building is within the top **<u>15%</u>** of the national or regional building stock expressed as **<u>operational Primary Energy Demand (PED)</u>** and demonstrated by adequate evidence, which at least compares the performance of the relevant asset to the

Seq. No.	Document	Definition of primary energy
		performance of the national or regional stock built before 31 December 2020 and at least distinguishes between residential and non-residential buildings. **7. CONSTRUCTION AND REAL ESTATE ACTIVITIES** (**Annex II_**contributing substantially to climate change**)** **7.1. Construction of new buildings** **The Primary Energy Demand (PED)**(571) is the calculated amount of energy needed to meet the energy demand associated with the typical uses of a building expressed by a numeric indicator of total primary energy use in kWh/m² per year and based on the relevant national calculation methodology and as displayed on the Energy Performance Certificate (EPC). **7.7. Acquisition and ownership of buildings** For buildings built **before 31 December 2020**, the building **has at least an Energy Performance Certificate (EPC) class C**. As an alternative, the building is within the top **<u>30%</u>** of the national or regional building stock expressed as **<u>operational Primary Energy Demand (PED)</u>** and demonstrated by adequate evidence, which at least compares the performance of the relevant asset to the performance of the national or regional stock built before 31 December 2020 and at least distinguishes between residential and non-residential buildings.
7.	**Construction Technical Regulation STR** 2.01.02:2016 “Energy performance design and certification of buildings”	**Primary energy** means energy from renewable and non-renewable sources which has not undergone any conversion or transformation process; Paragraph **93.2** >> **2.594-2** Formula QPR=QPRr+QPRn >> Table 2.51. Normative primary energy use of C, B, A, A+ and A++ energy performance class buildings (parts thereof), where *PR* means total primary energy; *PRn* means primary energy from non-renewable energy sources; *PRr* means primary energy from renewable energy

Seq. No.	Document	Definition of primary energy
		sources.

According to the data and insights from the comparative analysis of the 2022 report "*Nordic-Baltic NZEBs*", the challenge of comparing national energy performance assessment methodologies across EU countries remains (Table 2.3).

Table 2.3. Maximum allowed primary energy demand for a 150 m² single-family house and a 3000 m² office building in five EU Member States.

Country	Unit of measure	Single-family residential	Office
Denmark	kWh/m².y	36.7	41.3
Estonia	kWh/m².y	120	100
Finland	kWh/m².y	123.5	100
Latvia	kWh/m².y	50	45
Lithuania	kWh/m².y	**200.4**	**143.7**

Table 2.3 shows that the maximum allowed primary energy demand for a 150 m² single-family house and a 3000 m² office building exceeds 4 and 3.2 times, respectively. This difference reflects the different methodologies used to assess energy performance. For Lithuania, the total primary energy is given as the sum of the renewable and non-renewable parts of primary energy, while in other countries only the value of non-renewable primary energy is given.

Table 2.4 presents the main aspects of the methodologies for calculating and assessing primary energy in EU countries, showing that some countries use primary energy indicators to determine the energy performance of buildings, while others use primary energy amounts.

Table 2.4. European methodologies for calculating and assessing PE of buildings (the study conducted in 2020)

Seq. No.	Country	Requirements
1.	**Lithuania**	In Lithuania, the energy performance class of a building is determined in accordance with the monthly calculation method set out in Annex 2 to the Technical Regulation, according to the values of the following indicators: • the value of the building's energy performance indicator C1, which describes the efficiency of non-renewable primary energy for heating, ventilation, cooling, and lighting; • the value of the building's energy performance indicator C2, which describes the efficiency of non-renewable primary energy for domestic hot water; • the estimated specific heat loss of the building envelope; • the performance of a mechanical ventilation with recuperation system; • the thermal performance of building partitions and inter-storey slabs; • building airtightness; • the thermal energy use for heating the building; the method for determining the heat transfer coefficients of linear thermal bridges; • the share of the building's energy consumption from renewable sources.
2.	**Latvia[13]**	In Latvia, the energy performance calculation methodology is applicable for new and reconstructed or renovated buildings, as well as for existing buildings. The energy performance calculation methodology includes thermal comfort, indoor air quality, infiltration, thermal bridges, and shading devices. The energy performance calculation methodology uses the primary energy factor for the non-renewable part. The latest revision of Latvian legislation has replaced the total primary energy factor with a non-renewable energy factor. Latvian legislation does not require mandatory installation of on-site renewable energy generation. This is indirectly regulated by the amount of non-renewable primary energy consumed.

[13] https://epbd-ca.eu/wp-content/uploads/2022/10/Implementation-of-the-EPBD-in-the-Republic-of-Latvia-%E2%80%93-Status-in-2020.pdf

Seq. No.	Country	Requirements
3.	**Poland**[14]	In Poland, for the assessment of building energy performance, the index of annual non-renewable primary energy demand (EP) in kWh/(m2·year), which is necessary to check whether the building meets the minimum requirements is determined. Non-renewable primary energy factors are given in the national regulation. A maximum energy performance index value [kWh/(m2·year)], which determines the annual non-renewable energy demand for space heating, ventilation, cooling and domestic hot water and for built-in lighting, is applied.
4.	**Estonia**[15]	In Estonia, the current energy performance legislation includes the definition of low-energy buildings and NZEB buildings. The minimum energy performance requirements of low-energy buildings and NZEB buildings are expressed as **a primary energy performance indicator (EPI)**. The energy performance calculation takes into account the energy needs for space heating, domestic hot water, cooling, lighting, ventilation, and electrical appliances. The primary energy use of a building is determined by multiplying the delivered energy by the primary energy factors of the energy carriers from which the exported energy multiplied by the same factors are deducted.
5.	**Sweden**[16]	In Sweden, the energy performance of a building is expressed as the **primary energy number** (kWh/m²·per year). The calculation of the primary energy number of a building is based on the **delivered** (purchased) **energy** for different energy carriers multiplying each of them with a corresponding weighting factor (**VF**). Delivered (purchased) energy includes annual energy supplied to the building for heating, comfort cooling, domestic hot water and electricity for the building itself. Swedish national construction regulations allow the reduction of energy consumption through the use of solar, wind, ground, air or water energy generated in a building or on its land plot and used for heating, comfort cooling, hot water and electricity for the building itself. The geographical adjustment factor (Fgeo) corrects the heating demand.

[14] https://epbd-ca.eu/wp-content/uploads/2022/10/Implementation-of-the-EPBD-in-Poland.pdf
[15] https://epbd-ca.eu/wp-content/uploads/2022/10/Implementation-of-the-EPBD-in-Estonia.pdf
[16] https://epbd-ca.eu/wp-content/uploads/2022/10/Implementation-of-the-EPBD-in-Sweden.pdf

<table>
<tr><th>Seq. No.</th><th>Country</th><th>Requirements</th></tr>
<tr><td></td><td></td><td>

$$EP_{pet} = \frac{\sum_{i=1}^{6}\left(\frac{E_{uppv,i}}{F_{geo}} + E_{kyl,i} + E_{tvv,i} + E_{f,i}\right) \times VF_i}{A_{temp}}$$

where: $\boldsymbol{EP_{pet}}$ is the primary energy number (kWh/m²·per year); $\boldsymbol{E_{uppv}}$ is the energy demand for heating (kWh/year); F_{geo} is the geographical adjustment factor; $\boldsymbol{E_{kyl}}$ is the energy demand for comfort cooling (kWh/year); $\boldsymbol{E_{tvv}}$ is the energy demand for hot water (kWh/year); $\boldsymbol{E_f}$ is auxillary energy (kWh/year); $\boldsymbol{VF_i}$ is a corresponding weighting factor per energy carrier; $\boldsymbol{A_{temp}}$ is the area of a building where a comfortable heat is maintained (m²).

Weighting factors (Vfi) used for calculating the primary energy number under Boverket’s Building regulations (BBR 29):

<table>
<tr><th>Energy carrier</th><th>Weighting factors (VFi)</th></tr>
<tr><td>El (VFel) – Electricity</td><td>1.8</td></tr>
<tr><td>Fjärrvärme (VFfjv) – District heating</td><td>0.7</td></tr>
<tr><td>Fjärrkyla (VFfjk) – District cooling</td><td>0.6</td></tr>
<tr><td>Fasta, flytande och gasformiga biobränslen (VFbio) – Biofuel (oil, gas, solid)</td><td>0.6</td></tr>
<tr><td>Fossil olja (VFolja) – Fossil oil</td><td>1.8</td></tr>
<tr><td>Fossil gas (VFgas) – Fossil gas</td><td>1.8</td></tr>
</table>

Table 3. Weighting factors (Table 9:2b, BBR 29)
</td></tr>
<tr><td>6.</td><td>Finland[17]</td><td>Energy performance is based on overall primary energy consumption (kWhE/m² per year), taking the energy source (primary resource factor) into account. The Building Code encourages the use of renewable energy sources and district heating, which have better weighting factors than other energy sources. Other renewable sources (e.g., solar heat and power) are taken into account when calculating a building’s primary energy needs. National regulations encourage the use of renewable energy sources and district heating, which have better primary energy factors than other energy sources.</td></tr>
</table>

[17] https://epbd-ca.eu/wp-content/uploads/2021/07/Implementation-of-the-EPBD-in-Finland-%E2%80%93-2020.pdf

The study “Nordic-Baltic NZEBs” showed that two sets of requirements need to be included in the requirements for comparing national energy performance assessment methodologies applied in EU Member States: with and without renewable energy generation, as is the case in Denmark and Estonia. In Estonia, the primary energy requirements apply to a building without taking into account on-site renewable energy generation and to a building using renewable energy sources.

Taking into account the above definitions of primary energy and the requirements for the determination of primary energy in the energy performance assessment methodologies of other EU Member States, we recommend using a **numeric benchmark – the indicator of operational primary energy demand**, for assessing 15%/30% of energy efficient buildings, which incorporates the non-renewable part of primary energy (for use in the assessment of the cost-optimality of the building) and which is in line with the requirements of the methodology for calculating the primary energy under Guidelines 2012/C 115/01:

Indicator of operational primary energy demand = Delivered energy × *conversion factor*

2.4. Assumptions for calculating primary energy

For 15% and 30% of the most efficient buildings in Lithuania, the primary energy assumptions were chosen not according to the most dominant but according to the most polluting sources of energy. The conversion factors given in the Technical Regulation were used for both non-renewable primary energy and total primary energy (Table 2.18 of the Technical Regulation).

In all cases, the assessment of primary energy for electricity was based on the average factor of different electricity generation methods. The values of the factors are shown in Table 2.5.

Heat sources were selected according to the predominant sources in each group of buildings. For building groups T2, T3, and T5, the heat source assessed was district heating networks. The transformation factors are based on the Lithuanian average for district heating. For building groups T1, T4, and T6, the heat source assessed was natural gas. The values of the transformation factors of heat sources are given in Table 2.5.

Table 2.5. Primary energy factor values used in this study. The values are under Table 2.18 of the Technical Regulation

Seq. No.	Source of energy	f_{PRn}, unit	f_{PRr}, unit	M_{CO2}, kg_{CO2}/kWh
8.	Natural gas[3.18]	1.1	0	0.22
10.	Average of different electricity generation	2.3	0.2	0.42
14.	Heat from district heating (Lithuania average)	0.62	0.63	0.10

For the primary energy calculations, the conversion factors shown in Table 2.5 according to Table 2.18 of the Technical Regulation were used to calculate both renewable and non-renewable energy.

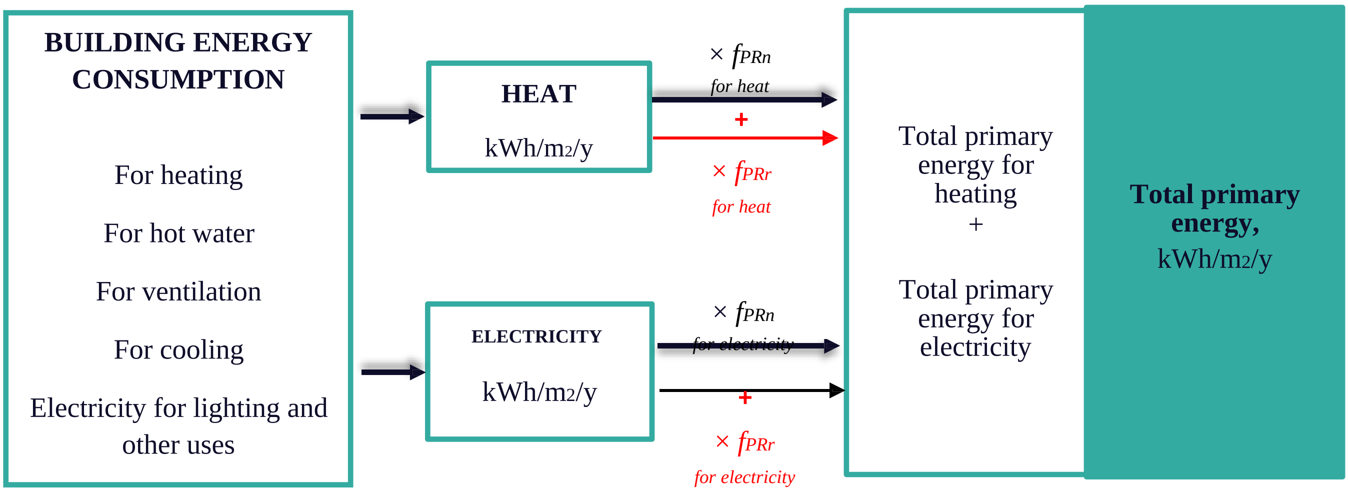


Figure 2.5. Calculation of total primary energy

To calculate the total primary energy performance indicators, the thermal and electricity uses are multiplied by the aggregated renewable (*fPRr*) and non-renewable (*fPRn*) energy conversion factors, as shown in Figure 2.5. For the total primary energy calculations, the conversion factors shown in Table 2.5 according to Table 2.18 of the Technical Regulation were used to calculate both renewable and non-renewable energy.

Although the methodology provides an assessment scheme in terms of both the indicator of operation primary energy (non-renewable energy) and the total primary energy (renewable and non-renewable energy), based on the analysis of EU and national legislation and examples from other countries, it is recommended that 15% and 30% of the most efficient buildings should be assessed according to the indicator of operational primary energy.

3. Results

3.1 Energy use for heating

Based on the methodology described in Section 2, 15% and 30% of the most efficient buildings have been identified for each building group and limit values of energy use for heating have been set, which are presented in Table 3.1 and are further used to calculate the primary energy indicators.

Table 3.1. Limit energy use for heating in the most efficient buildings

Group	Purpose under the Regulation	Total sample to be analysed (filtered data), unit	Sample of the most efficient buildings, unit		Energy use for heating of the most efficient buildings, kWh/m^2/y	
			15%	*30%*	*15%*	*30%*
T1	Warehousing	934	140	280	**45**	**65**
T2	Hotel + Commercial + Services + Catering + Leisure buildings	8,000	1,200	2,400	**38**	**71**
T3	Office buildings	6,210	932	1,863	**69**	**120**
T4	Garage, manufacturing and industrial + Transport buildings	2,938	440	881	**58**	**103**
T5	Other residential buildings + Other residential (houses) + Other residential buildings (houses)	17,197	2,580	5,159	**53**	**80**
T6	Residential single- and double-family buildings (houses)	133,583	20,038	40,075	**55**	**101**

Tables 3.2 and 3.3 show the distribution of the most efficient buildings by energy performance class for each building group. As can be seen, the critical part of the sample consists of buildings up to class B, but buildings with lower energy performance classes may also have low energy needs for heating. One of the reasons for this is that energy use for heating according to the Technical Regulation is only one of the indicators that determine the energy performance class of a building, and failure to comply with any of

the intermediate mandatory indicators (airtightness, U-value of the building envelope, specific heat loss, the efficiency of the ventilation system, etc.) results in a correspondingly lower energy performance class.

The original assumption, based on actual uses, that the limit of energy use for heating of the most efficient multi-family buildings may not exceed 90 kWh/m2/year has also been confirmed. The established limit values for heating for multi-family buildings show that new or fully renovated buildings will fall within 15% of the most efficient buildings, while 30% of the most efficient buildings will also include the majority of partially renovated buildings and buildings with some energy savings may also be assigned to this building stock (see Fig. 2.5).

Table 3.2. Energy use for heating of 15% of the most energy efficient buildings, breakdown by class

Class	T1	T2	T3	T4	T5	T6
A	25	131	90	27	295	2,918
A+	47	351	93	64	403	9,108
B	59	582	395	282	1,244	7,103
C	8	73	135	40	567	586
D	0	41	163	7	64	262
E	1	6	26	12	3	10
F	0	15	24	7	3	51
G	0	1	5	1	1	0
TOTAL	**140**	**1,200**	**932**	**440**	**2,580**	**20,038**

Table 3.3. Energy use for heating of 30% of the most energy efficient buildings, breakdown by class

Class	T1	T2	T3	T4	T5	T6
A	30	164	90	33	308	4,730
A+	60	433	93	74	418	11,997
B	168	1,244	596	544	2,485	20,533
C	13	223	337	121	1,755	1,893
D	5	200	484	41	163	691
E	3	52	115	34	14	42
F	1	81	137	30	14	181
G	**0**	3	11	4	2	3
TOTAL	**280**	**2,400**	**1,863**	**881**	**5,159**	**40,075**

3.2. Primary energy

Based on the assumptions presented in Section 2, the indicator of operational primary energy demand has been calculated to estimate the non-renewable energy demand in the building. This indicator has been calculated for 15% and 30% of the most energy efficient buildings in Lithuania and is presented in Table 3.4. In parallel, the indicator of the total primary energy is also provided.

Table 3.4. Primary energy values for the most efficient buildings (15% and 30%)

Purpose	15% most efficient		30% most efficient	
	Indicator of operational primary energy	Total primary energy	Indicator of operational primary energy	Total primary energy
T1	77	80	100	102
T2	133	174	155	221
T3	121	177	153	241
T4	135	140	185	190
T5	142	197	161	232
T6	146	152	198	204

3.3. Recommendations on assessing the energy performance of buildings

For assessing 15% and 30% of the most energy efficient buildings, it is recommended to use the indicators of operational primary energy shown in Table 3.4.

When assessing the indicator of operational primary energy in the Energy Performance Certificate of a building, it should be noted in which year (i.e. which version of the Technical Regulation was in force that year) the Energy Performance Certificate was issued, due to the changes in the methodology of the Technical Regulation, as discussed above.

From 2020 onwards, for certificates prepared by NRG6 (energy performance certification programme for buildings) or later versions, the renewable and non-renewable estimated primary energy values are provided separately on the second page of the certificate (Fig. 3.1). The indicator of operational primary energy in these certificates is therefore the estimated non-renewable energy use.

For the period 2012 to 2020, when NRG3 to NRG5 versions were used for certification, the primary non-renewable energy (equivalent to the indicator of operational primary energy) was provided on the first page of the certificate (Fig. 3.2).

ANNUAL INDICATOR VALUES PER SQUARE METRE OF THE HEATED FLOOR AREA OF A BUILDING (PART OF IT):			
Primary energy use of a building (part of it):			
Normative primary energy use, kWh/(m^2.y):	99.70		
Estimated primary energy use, kWh/(m^2.y):	55.57		
Estimated non-renewable primary energy use, kWh/(m^2.y):	30.10		
Estimated renewable primary energy use, kWh/(m^2.y):	25.47		
Value of the ratio of the estimated annual renewable primary energy use to the annual non-renewable primary energy use, unit:	2.24		
Energy use for heating a building (part of it):	Normative	Reference	Estimated
Non-renewable primary energy, kWh/(m^2.y):	63.07	90.63	5.77
Renewable primary energy, kWh/(m^2.y):	-	-	13.85
Thermal energy, kWh/(m^2.y):	48.52	69.19	2.50
Energy use for cooling a building (part of it):	Normative	Reference	Estimated
Non-renewable primary energy, kWh/(m^2.y):	0	0	1.77
Renewable primary energy, kWh/(m^2.y):	-	-	0.52
Thermal energy, kWh/(m^2.y):	°	°	4.04
Energy use for domestic hot water:	Normative	Reference	Estimated
Non-renewable primary energy, kWh/(m^2.y):	49.45	94.98	12.77
Renewable primary energy, kWh/(m^2.y):	-	-	6.30
Thermal energy, kWh/(m^2.y):	38.04	61.67	5.53
Electricity use in a building (part of it):	Normative	Reference	Estimated
Total non-renewable primary energy use, kWh/(m^2.y):	23.00	23.00	29.36
Total renewable primary energy use, kWh/(m^2.y):	-	-	15.41
Total electricity use, kWh/(m^2.y):	10.00	10.00	12.75

Figure 3.1. An image of the second page of the energy performance certificate issued in 2020 or later with the marked indicator of operational primary energy (estimated non-renewable primary energy use)

Estimated annual indicator values per square metre of the heated floor area of a building (part of it):	
Non-renewable primary energy use, kWh/(m^2.y):	58.69
Renewable primary energy use, kWh/(m^2.y):	109.69
Value of the ratio of the annual renewable primary energy use to the annual non-renewable primary energy use, unit:	14.11
Thermal energy use for heating a building, kWh/(m^2.y):	6.46
Thermal energy use for cooling a building, kWh/(m^2.y):	5.83
Thermal energy use for domestic hot water, kWh/(m^2.y):	12.59
Total electricity use, kWh/(m^2.y):	15.98
Electricity use for indoor lighting, kWh/(m^2.y):	2.70
Building CO2 emissions, kgCO2/(m^2.y):	11.16

Figure 3.2. Image of the first page of the Energy Performance Certificate for the period 2012 to 2020 with the marked indicator of operational primary energy (non-renewable primary energy use)

3.4 Comparison of established values with the values of neighbouring countries

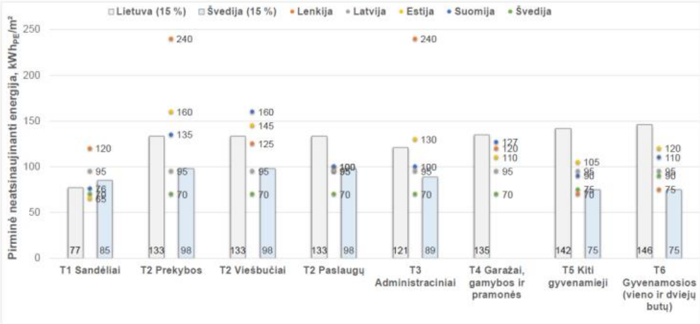
This subsection compares the values of the indicator of operational (non-renewable) primary energy of 15% of the most efficient buildings in Lithuania with:

- the energy performance indicators for new buildings as defined in the national regulations of neighbouring countries in a cold climate zone (see Table 3p.1);
- the primary energy number of 15% of the most energy efficient buildings in Sweden (see Table 3p.2).

The energy performance assessment indicators of neighbouring countries selected for comparison are expressed in terms of primary non-renewable energy values (see Table 2.4), therefore the values of the PE indicators in Figures 4.1 and 4.2 are equivalent and can be compared with each other. Figure 4.1 compares the primary non-renewable energy values for 15% of the most energy efficient buildings in Lithuania with the regulated PE values in other neighbouring countries.

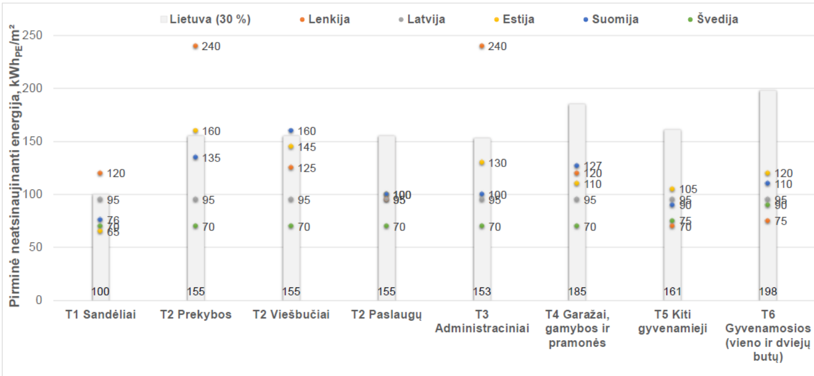
The comparison in Figure 4.1 of the primary non-renewable energy values for 15% of the most energy efficient buildings in Lithuania and Sweden shows that in the case of Lithuania, these values are 26%, 26%, and 49% higher for T2 and T3, T5, and T6, respectively. In the case of Lithuania, the limit values of primary non-renewable energy for 15% of the most energy efficient buildings are higher, because the primary energy conversion factor for electricity is higher in Lithuania (2.3) compared to Sweden (1.8). Sweden has a higher renewable energy use, which, when taken into account in the overall energy balance, results in a lower amount of delivered energy, which has a direct impact on the decrease in the value of primary non-renewable energy. Also, the primary non-renewable energy values of 15% of the most energy efficient buildings in Lithuania are higher than the regulated values of the non-renewable part of PE for new buildings, with the exception of T2 and T3 in the individual cases of Poland, Estonia, Finland, and T1 for Poland and Latvia. The fact that in some cases higher PE values have been set for new buildings of certain purpose in Poland, Estonia, Finland, and Latvia shows that increasing the renewable part of energy consumed in buildings is not strictly regulated and promoted. Poland has the highest primary energy conversion factor for electricity, i.e. 3.0, which makes the primary non-renewable energy values of T2 commercial and T3 office buildings stand out in the context of this comparison.

Figure 4.2 compares the primary non-renewable energy values for 30% of the most efficient buildings in Lithuania with the regulated PE values in other neighbouring countries.



Lithuania (15%)	Sweden (15%)	Poland	Latvia	Estonia	Finland	Sweden	
Primary non-renewable energy, kWhPE/m²							
T1 Warehouses	T2 Commerce	T2 Hotels	T2 Services	T3 Office	T4 Garages, production and industrial	T5 Other residential	T6 Residential (single- and double-family)

Figure 4.1. Comparison of primary non-renewable energy values for 15% of the most energy efficient buildings in Lithuania and Sweden and for new buildings in other countries



Lithuania (30%)	Poland	Latvia	Estonia	Finland	Sweden		
Primary non-renewable energy, kWhPE/m²							
T1 Warehouses	T2 Commerce	T2 Hotels	T2 Services	T3 Office	T4 Garages, production and industrial	T5 Other residential	T6 Residential (single- and double-family)

Figure 4.2. Comparison of primary non-renewable energy values for 30% of the most energy efficient buildings in Lithuania and for new buildings in other countries

Figure 4.2 shows that the primary non-renewable energy values of 30% of the most efficient buildings in Lithuania are higher than the regulated values of the non-renewable part of PE for new buildings, with the exceptions of T2 and T3 in the individual cases of Poland, Estonia, Finland, and T1 for Poland.

3. CONCLUSIONS AND PROPOSALS

- Based on the analysis of EU and national legislation and examples from other countries, it is recommended that 15% and 30% of the most energy efficient buildings should be assessed according to the indicator of operational primary energy which corresponds to the estimated non-renewable primary energy use in the national certification scheme.

- It is recommended that the Lithuanian Banking Association apply to the CSDA for presenting the indicator of estimated non-renewable primary energy use in the public Register of Building Energy Performance Certificates, which would simplify building valuation procedures during transactions.

Appendix 1

Table 1p.1. Certificates issued, by building purpose and energy performance class

Purpose	Energy performance class									Total certified, unit	Of which SACs, unit
	A++	A+	A	B	C	D	E	F	G		
Office buildings	4	94	90	735	807	1554	1373	1597	441	6,695	
Swimming pools		7	4	11	7	8	2	1	1	41	
Garage, manufacturing and industrial buildings	35	74	35	779	455	235	625	679	247	3164	
Medical treatment buildings	11	15	8	280	243	222	173	190	26	1168	
Residential single- and double-family buildings	1043	12011	4746	28825	9724	6086	15936	25677	3161	107209	
Residential single- and double-family buildings		7	14	5603	9408	3206	5121	4543	2856	30758	
Other residential buildings				451	508	159	197	2	3	1320	
Other residential buildings (houses)			1						4	5	4
Other residential buildings (houses)	51	431	320	2339	2049	499	1942	3287	125198	136116	125024
Other residential buildings (houses)			3	615	1219	2178	2442	112	51040	57609	50932
Cultural buildings	1	3	10	145	156	174	98	123	29	739	
Catering buildings	4	14	12	75	101	64	168	189	55	682	
Educational buildings	4	26	26	410	777	382	351	409	84	2469	
Service buildings	11	70	29	254	133	122	201	350	196	1366	
Recreational buildings	5	71	45	568	373	227	196	253	133	1871	
Commercial buildings	41	194	76	942	492	398	682	1020	450	4295	
Warehousing buildings	24	78	39	448	132	67	140	123	63	1114	
Special-purpose buildings	3	7	5	76	73	52	86	53	18	373	
Sports facilities, excluding swimming pools	2	11	7	100	45	46	18	20	12	261	
Transport buildings	2	4	2	42	28	21	27	11	16	153	
Hotel buildings	2	118	10	254	72	64	57	49	17	643	
Total certified, unit	1243	13235	5482	42952	26802	15764	29835	38688	184050	358051	175960

Table 1p.2. Data from the Centre of Registers and certification volumes for the analysed groups of buildings

	Building purpose	Quantity of buildings according	Total certified (excl. SACs)	Total floor area of the property according	Floor space of certified buildings (excl. SACs),
T1 + T4*	Warehouses	73,942	1,114	46,264,229	2,862,536
	Production, etc.		3,317		5,454,803
T2	Trade, etc.	20,700	8,857	11,754,310	6,269,631
T3	Office	10,496	6,695	10,652,110	6,579,256
T5	Multi-family houses	41,785	19,090 **	61,049,748	26,091,428
T6	Single-family houses	564,412	137,967	74,510,776	17,507,242

** T1 and T4 are not distinguished separately according to the data of the Centre of Registers*

*** Certificates cannot be compared with registered buildings, as a certificate can be issued for both a building and an apartment separately.*

Appendix 2

Table 2p.1. Assumptions for calculating final energy

Purpose	Annual thermal energy demand for hot water per 1 m2 of a building, kWh/m2	Annual electricity use per floor area unit of a building, kWh/m2	Outside air volume for ventilating 1 m2 of a building, m3/(hm2)	Daily occupancy time (monthly average), h	Operating time per year, h	Electricity use for ventilation per year in 15% of the most energy efficient buildings, kWh/m2	Electricity use for ventilation per year in 30% of the most energy efficient buildings	Electricity use for ventilation, kWh/m2
T1	1.4	6	0.3	6	2,100	0.4725	0.63	5
T2	20	30	1.2	12	4,200	2.205	2.94	10
T3	10	20	0.7	6	2,100	1.1025	1.47	10
T4	10	20	0.7	6	2,100	1.1025	1.47	5
T5	20	30	0.7	12	4,200	2.205	2.94	10
T6	10	20	0.7	12	4,200	2.205	2.94	10

Appendix 3

Table 3p.1. Values of energy performance indicators for new buildings defined in the national regulations of selected neighbouring EU Member States

Country	Building purpose	Indicator	Energy performance indicator value			Estimated energy flows
			Maximum primary energy (PE) value	Energy performance class according to certification	NZEB * (*L, AP excl.)	
Estonia	Residential (single-family)), <120 m^2	kWhE/m2	145		89.4	H, C, V, HW, L, AP, Eaux
	Residential (single-family and terraced houses), 120-220 m^2	kWhE/m2	120		73.4	
	Residential (single-family and terraced houses), >220 m^2	kWhE/m2	100		59.5	
	Residential (multi-family)	kWhE/m2	105		45.9	
	Barracks	kWhE/m2	170		85.9	
	Offices, libraries, research buildings	kWhE/m2	100		62.11	
	Accommodation building, hotel	kWhE/m2	145		138	
	Commercial	kWhE/m2	130		118	
	Public	kWhE/m2	135		135	
	Trade buildings and terminals	kWhE/m2	160		154	
	Educational buildings	kWhE/m2	100		82.6	
	Pre-school education institutions for children	kWhE/m2	100		90	
	Healthcare buildings	kWhE/m2	100		83.7	
	Warehouses	kWhE/m2	65		54.0	
	Industrial	kWhE/m2	110		68.7	
	Buildings with high energy consumption	kWhE/m2	820		NA	
Latvia	Residential, non-residential	kWhPE/m2	95			H, C, V, HW, L
Sweden	Residential (single-family), ≤50 m^2 Atemp	kWhE/m2· Atemp	NA	Class A EP ≤ 50 Class B 50 ≤ EP ≤ 75 Class C 75 ≤ EP ≤ 100 Class D: 100 ≤ EP ≤ 135 Class E 135 ≤ E ≤ 180 Class F 180 ≤ E ≤ 235 Class G 235 ≤ E		H, C, HW, Eaux (V+L+AP)
	Residential (single-family), >50-90 m^2 Atemp		100			
	Residential (single-family), >90-130 m^2 Atemp		95			
	Residential (single-family), >130 m^2 Atemp		90			
	Residential (multi-family)		75			
	Non-residential		70			
	Non-residential ≤50 m^2 Atemp		NA			
Finland	Residential (single-family), Anet<150 m^2	kWhE/m2	200-0.6 Anet	Class A E ≤ 75		H, C, V, HW, L, AP, Eaux
	Residential (single-family), 150≤Anet≤600 m^2	kWhE/m2	200-0.6 Anet	Class B 76 ≤ E ≤ 100		

Country	Building purpose	Indicator	Energy performance indicator value			Estimated energy flows
			Maximum primary energy (PE) value	Energy performance class according to certification	NZEB * (*L, AP excl.)	
	Residential (single-family), Anet>600 m²	kWhE/m2	92	Class C 101 ≤ E ≤ 130 Class D 131 ≤ E ≤ 160 Class E 161 ≤ E ≤ 190 Class F 191 ≤ E ≤ 240 Class G 241 ≤ E		
	Residential (terraced houses, double-family up to 2 floors)	kWhE/m2	105			
	Residential (multi-family)	kWhE/m2	90			
	Offices	kWhE/m2	100			
	Shops	kWhE/m2	135			
	Hotels	kWhE/m2	160			
	Schools, day care centres	kWhE/m2	100			
	Sports facilities	kWhE/m2	100			
	Hospitals	kWhE/m2	320			
	Other buildings	kWhE/m2	NA			
	Cost-optimal deviation (new construction)	kWhE/m2	76-127			
Poland	Residential (single-family)	kWhPE/m2	70 (H,V,HW) 5·Af,C/Af (C) 0 (L)			H, C, V, HW, L
	Residential (multi-family)	kWhPE/m2	65 (H,V,HW) 5·Af,C/Af (C) 0 (L)			
	Hotels, dormitories	kWhPE/m2	75 (H,V,HW) 25·Af,C/Af (C) 25 (L), t0< 2500 50 (L), t0≥ 2500			
	Non-residential	kWhPE/m2	190 (H,V,HW) 25·Af,C/Af (C) 25 (L), t0< 2500 50 (L), t0≥ 2500			
	Healthcare	kWhPE/m2	45 (H,V,HW) 25·Af,C/Af (C) 25 (L), t0< 2500 50 (L), t0≥ 2500			
	Industrial, heated warehouses, livestock farming buildings	kWhPE/m2	70 (H,V,HW) 25·Af,C/Af			

Country	Building purpose	Indicator	Energy performance indicator value			Estimated energy flows
			Maximum primary energy (PE) value	**Energy performance class according to certification**	**NZEB *** (*L, AP excl.)	
			(C) 25 (L), t0< 2500 50 (L), t0≥ 2500			

where H means heating, C means cooling, V means ventilation, HW means hot water, L means lighting, AP means electrical appliances, E_{aux} means auxiliary electricity for technical systems, t_0 means operating time of the lighting system [h/year], A_f means heated floor area [m²], $A_{f,C}$ means cooled area [m²]

Table 3p.2. Primary energy number of 15% of the most energy efficient buildings in Sweden for different building types[18]

Building purpose	Limit value of the primary energy number, (kWh/m2Atemp·per year)
Multi-family buildings	75
Office and administrative buildings	89
Schools	98
Hotels, guesthouses and dormitories	98
Restaurants	94
Daycare institutions	92
Continuous care institutions	96
Shopping centres	98
Food shops and warehouse premises	83
Other shops and warehouse premises	85

[18] Analysis of the primary energy number of buildings within 15% of the most energy efficient buildings in Sweden (14/12/2021)