PLAN FOR INCREASING THE NUMBER OF NEARLY ZERO ENERGY BUILDINGS

NEARLY ZERO ENERGY BUILDINGS (NZEB) ROMANIA

BACKGROUND ELEMENTS

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I. INTRODUCTION

Buildings are an essential element of EU energy efficiency policy, as they are responsible for approximately 40% of final energy consumption and for 36% of greenhouse gas emissions. Better energy efficiency of the existing building stock is essential not only for achieving the national medium-term objectives for energy efficiency, but also for achieving the long-term objectives of the strategy concerning climate change and the transition to a competitive economy with low carbon dioxide emissions by 2050.

Directive 2010/31/EU on the energy performance of buildings is the main EU legal instrument for improving the energy efficiency of buildings. A key element of the Community legislative act refers to the requirements concerning buildings whose energy consumption from conventional sources is almost zero.

Pursuant to Article 9(1) of Directive 2010/31/EU, the Member States '*shall ensure that:*

(a) *by 31 December 2020, all new buildings are nearly zero-energy buildings; and*

(b) *after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.*'

Moreover, Article 9(2) lays down that Member States must develop policies and take measures such as the setting of targets in order to stimulate the transformation of existing buildings that are refurbished into nearly zero-energy buildings.

Construction may be considered one of the most dynamic fields of the national economy in the period of 2003–2008, maybe even the most dynamic one, due to the high level of privatisation (already more than 99.7% majority private-owned companies in 2010).

Furthermore, it is one of the main engines that 'push' the other sectors in terms of both driving the production of building materials and driving other industrial, commercial activities, etc., and also by setting up new infrastructure, of a non-residential nature, engineered constructions, as well as residential buildings, with direct influences on other sectors.

II. PROPOSAL FOR A DEFINITION AND IMPLEMENTATION OF NZEBs IN ROMANIA

II.1. Prerequisites of the proposed solutions

1. The time horizons are correlated with the National Sustainable Development Strategy (2008)

2. The values in the graphics are maximum thresholds of the primary energy pertaining to the operation of the buildings constructed as of the horizons mentioned.

3. The minimum admissible Energy Performance of Buildings and the maximum admissible CO_2 releases can be established on the basis of the annual number of calculated heating degree days.

4. The proposed values are supported by the Cost-Optimal analysis and by the classification of the building into a district solution implying both the modernisation of the heating supply systems and adaptation to the global climate changes that will affect Romania. The Report of the *European Environment Agency* (EEA) no 2 (2012) certifies that Romania is one of the countries that will be most exposed in the future to significant climate changes, in particular with regard to the increase of the mean exterior temperature in summer days and the expansion of the summer season (Fig. 1).

Cluster/stimuli	Northern-central Europe	Northern–western Europe	Northern Europe	Southern–central Europe	Mediterranean Europe
Change in annual mean temperature	+	+	++	++	++
Decrease in number of frost days	––	–	––	––	–
Change in annual mean number of summer days	+	+	0	++	++
Relative change in annual mean precipitation in winter months	+	+	++	0	–
Relative change in annual mean precipitation in summer months	–	–	0	––	––
Change in annual mean number of days with heavy rainfall	0	+	+	0	–
Relative change in annual mean evaporation	+	0	+	0	–
Change in annual mean number of days with snow cover CDSC	–	0	––	0	0

Note: Key: ++ Strong increase; + Increase;
0 Insignificant stimulus for the characterisation of the cluster;
– Decrease; –– Strong decrease.

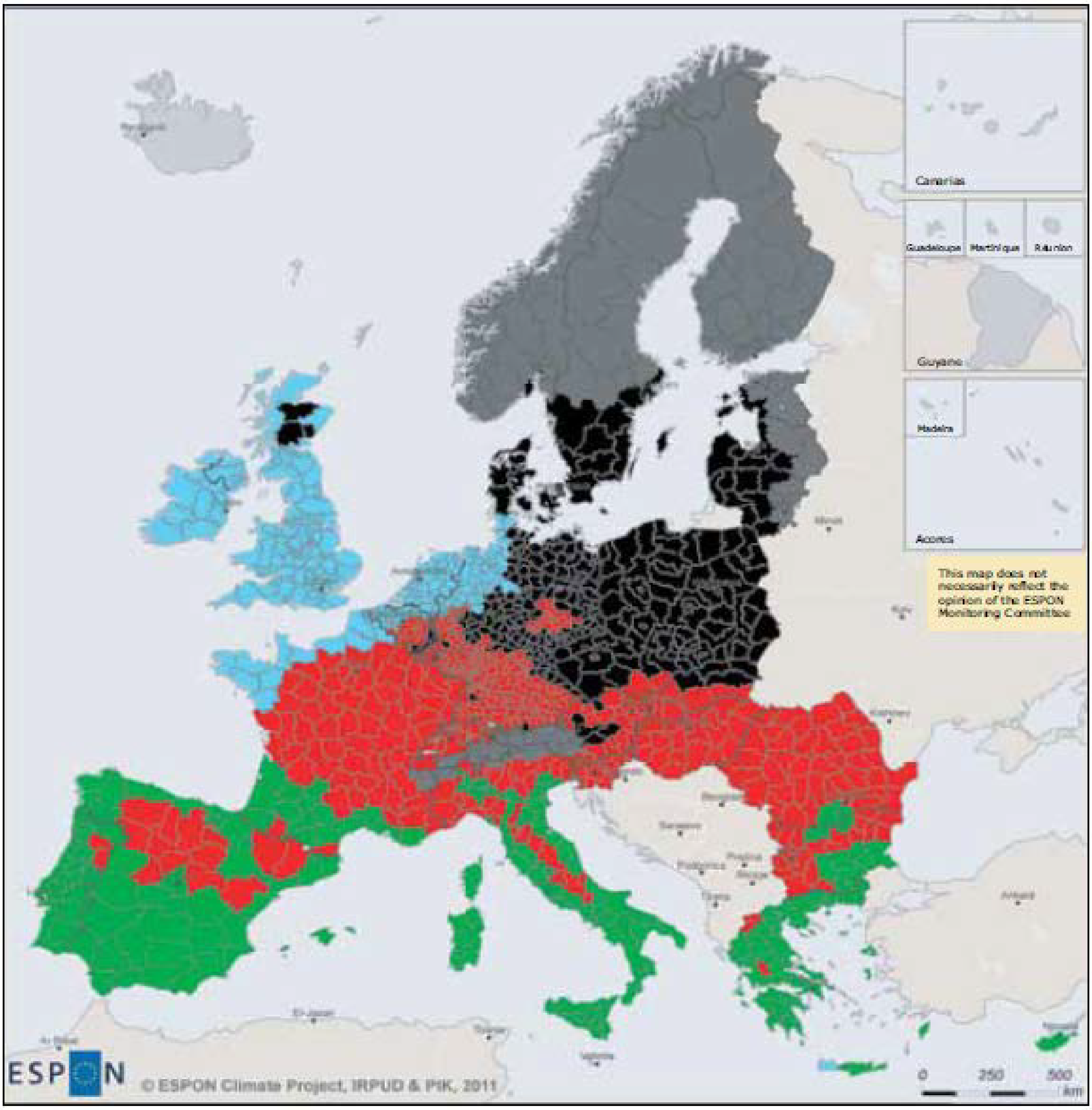

Fig. 1. Evolution of the climate in Europe – Report of the *European Environment Agency* (EEA) no 2 (2012)

Definition of 'Nearly Zero Energy Building' (NZEB)

The prerequisites and the objectives of Directive 31/2010/EU reveal a new concept of building that has to lead, in time, reduced consumption of energy from fossil sources as well as the protection of the natural and built environment. The design and construction of nearly zero energy buildings have to take into consideration the following realities of the built environment in Romania:

- Nearly zero energy buildings are characterized by *low consumption of energy from fossil sources* and use renewable (non-fossil) sources of energy, *in a proportion established through the procedure defining the minimum requirements, in accordance with the provisions in Articles 4 and 5 of Directive 31/2010/EU;*
- For both new and existing buildings included in national and local energy modernisation programmes, the aim is to ensure that *the technical solutions adopted meet the minimum cost-related requirements* set up in accordance with the provisions of Delegated Regulation (EU) No 244/2012;
- *The proportion of new buildings in urban and rural areas in terms of energy balance is markedly lower than the proportion of existing buildings*, considering the pre-crisis construction rhythm of approximately 50 000 flats/year, with a useful floor area of approximately 5 800 000 m^2 as compared to the approximately 598 000 000 m^2 of existing buildings. Consequently, the national programmes intended to reach the targets of the Europe 2020 European Strategy (A strategy for a smart, sustainable and inclusive growth) focus on the rehabilitation and modernisation of existing buildings. The technical solutions adopted must meet the *minimum cost-related requirements, with a margin of adaptation over time of maximum 15%*;
- Depending on the characteristics of the existing building stock in Romanian urban areas, where 69% of the buildings are less than 60 years old, in particular condominium-type housings and non-residential buildings, *the technical solutions for energy rehabilitation and modernisation will be differentiated*, in terms of actual energy performance, *on the basis of climate zones and application time horizons, and the planning of the modernisation works will seek to achieve the targets established in the National Sustainable Development Strategy (2008) and in the Europe 2020 European Strategy for 2020, in relation to the 1990s* (for greenhouse gas emissions*) and to 2005* (for the reduction of primary energy consumption and the increase of the share of RES in

ensuring the energy requirements of buildings). The share of new buildings will become significant after 2020;

- *The road map* concerning the requirements for nearly zero-energy buildings *will be a realistic decision based on a practical definition of the concept of Nearly Zero-Energy New Buildings, as a component of urban settlements, and not a singular achievement with purely demonstrative value*. Consequently, *the energy and environment parameters adaptable to the new buildings will be defined in relation to the current minimum requirements imposed on new buildings and to climate restrictions and regional technologies. The definition of nearly zero-energy buildings is based on compliance with two components that determine the energy performance of a building*, as follows:

  – *building architectural configuration compliant with sustainable development principles* and in particular with minimising the impact on the natural environment, including the zonal microclimate;

  – *provision of the necessary energy utilities, in particular from district/zonal urban networks, provided their energy efficiency is compatible with the energy performance of the new NZEBs*. Equipping the buildings with non-fossil sources of renewable energy (placed either on the building or on the land related to the building) will be analysed very carefully in the stage of an urban zonal project, in terms of impact on the natural environment, on the one hand, and of economic efficiency pertaining to the building, on the other hand. *The solution study will contain a comparative analysis of the equipment with own energy sources connected to district systems for efficient energy supply*. The principles of Sustainable Development, implying both freedom levels with regard to housing quality and minimisation of the impact on the natural environment, will be taken into consideration;

- Beside the above, the technical solutions included in the projects of the new buildings (both housing and non-residential types) refer both to the energy configuration of the buildings and the adaptation of the indoor and district systems to the requirements of high energy performance. *The following are considered: BAT* (Best Available Technologies) *systems for heating and electricity supply ensuring low temperature heating and high temperature cooling of spaces, systems using the enthalpy of the fluids evacuated from the building, as well as architectural and urban planning solutions that reduce the impact of urban heat islands* (point 4, Fig. 1). For this purpose, *the excessive and exclusive equipping of the buildings with photovoltaic panels and with solar panels for water/air heating requires careful management in the context of the district or zonal solutions*. The replacement of the current heating distribution points and district heating plants with high-efficiency cogeneration equipment ensuring both heating and cooling in the summer is a certain source of reduction of the primary energy for urban settlements. The use of wind, solar and geothermal energy implies developments adjacent to urban areas, which do not affect the microclimate of urban settlements. *The building may ensure optimum management of energy sources depending on its own energy profile and on the diurnal/seasonal management of the energy sources* (for example, the inclusion of nanocomposite-type Phase-Change Materials – PCM, with a thermal storage function, in the building structure, as well as equipping the building with units for seasonal thermal storage through a controlled undercooling process contribute to a significant reduction of the consumption of energy from fossil sources). On the other hand, it is recommended that non-residential buildings (for example, big commercial centres) be equipped with high-efficiency cogeneration facilities and that thermal and electric energy be used in building operation processes. The use of green certificates may be a solution for the promotion of systems made up of district network associated with renewable energy sources without an impact on the natural environment of urban settlements;

- The design and construction of new buildings will be based on *the construction of precast building elements*, which are practically without heat bridges, benefit from plant control of technical characteristics, and on the typing of architectural design, with differences between the types of buildings and climate zones;
- One aspect that is little mentioned when defining NZEBs is *the empirical validity of the NZEB quality*. Ensuring that an NZEB building genuinely merits the name can be achieved through two converging means, as follows:

  – the use of dynamic calculation methods with hour or sub-hour time steps and of climate parameters pertaining to the standard climate year corrected, in the case of urban settlements, for the impact of urban heat islands; the use of corrected climate parameters may have a strong influence on the type of technical solutions adopted in the architectural solutions, especially solutions that are adequate for the summer period in areas affected by marked climate change;

  – equipping the buildings with actual energy performance monitoring devices and devices for the conversion of the measured values through climate and energy type corrections;
- *For new buildings with nearly zero fossil energy consumption, the energy integrated in the building materials, as well as the energy involved in the building construction and demolition processes*, which tends to hold a significant share in the building energy balance, *cannot be overlooked*. For this purpose, rules leading to a reduction of the

integrated energy impact on the energy balance of the energy efficient buildings will be developed;

- The practical application of the principles mentioned above cannot be realised without the *specialised training of both building designers and energy auditors who take part in the building energy configuration stage, as well as in the granting of energy performance certificates to this type of building*.

The points above detail the proposed definition of the concept of *nearly zero-energy building* from design to execution and operation.

II.2. Scenarios used for assessing the Energy Performance of Buildings between the current status and nearly zero-energy buildings, by type of building – performance figures pertaining to the buildings in Bucharest (climate zone II) and Braşov (climate zone IV)

Variants and selected measures

Measure	Reference case (CS)	Variant C 107/2010	Additional package (SP)
Roof insulation	1.124 W/m²K	0.25 W/m²K	0.21 W/m²K
Insulation of vertical opaque wall	1.236 W/m²K	0.625 W/m²K	0.303 W/m²K
Windows	2.56 W/m²K (double)	1.30 W/m²K (thermo-insulating)	1.03 W/m²K (thermo-insulating)
Building-related measures (thermal capacity)	266 060 J/m²K	266 060 J/m²K	266 060 J/m²K
Heating system	Boiler, district network	Boiler, district network	Boiler, district network
Domestic hot water (DHW)	Boiler, district network	Boiler, district network	Boiler, district network
Ventilation system (including night ventilation)	natural	natural – organised natural ventilation, mobile blinds (in summer, hours of occupation)	natural – organised natural ventilation, mobile blinds (in summer, hours of occupation)
Space cooling system	split equipment EER = 2.5	split equipment, ventilo convectors EER = 2.7	split equipment, ventilo convectors, radiating systems, adsorption systems Br-Li. EER = 3.5
RES-based measures	–	solar installation (DHW in summer), photovoltaic panels	solar installation (DHW in summer), photovoltaic panels, geothermal source
Change of the energy factor	-	-	High-efficiency cogeneration/trigeneration
Type of indoor lighting	incandescent lighting	economical lighting	economical lighting (LEDs)

II.2.1. OFFICE AND PUBLIC ADMINISTRATION BUILDINGS

Current status (CS):

CS 1 – incandescent lighting, district heating, without thermostatic radiator valves, without blinds and without natural ventilation;

CS 2 – incandescent lighting, district heating, without thermostatic radiator valves, with blinds and with natural ventilation;

CS 3 – incandescent lighting, own boiler, with thermostatic radiator valves, with blinds and with natural ventilation;

CS 4 – economical lighting, own boiler, with thermostatic radiator valves, with blinds and with natural ventilation.

Thermal protection according to C 107/2010:

C 107–1 – economical lighting, district heating, with thermostatic radiator valves, with blinds and with natural ventilation;
C 107–2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;
C 107–3 – economical lighting, district heating, with thermostatic radiator valves, with heat recovery from exhaust air, with blinds and with natural ventilation;
C 107–4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;
C 107–5 – economical lighting, boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation.

Thermal protection according to the Superior Package (SP):

SP 1 – economical lighting, district heating, with thermostatic radiator valves, with blinds and with natural ventilation;
SP 2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;
SP 3 – economical lighting, district heating, with thermostatic radiator valves, with heat recovery from exhaust air, with blinds and with natural ventilation;
SP 4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;
SP 5 – economical lighting, boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation.

A total of **14 variants** for **Bucharest** and the same for **Braşov**.

Technical solutions and technical performance figures by time horizon, at present (starting from 2010), on 31 December 2018, 2020 and 2050

A. Value tables

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Braşov										
OFFICE BUILDINGS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
CS 1	241.48	46.47	**346.32**	0.00	0.00	0.00	0.00	65.20	19.05	**84.25**
2005-2010										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	108.24	16.70	**144.42**	0.00	0.00	0.00	0.00	29.23	6.85	**36.07**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-2	82.25	4.68	**88.76**	0.00	12.07	0.00	72.06	22.21	1.92	**24.13**

Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
SP 3	39.43	4.68	**48.93**	0.00	17.78	0.00	79.16	10.65	1.92	**12.57**
Horizon 2050 (high-efficiency cogeneration)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
SP 5	26.40	4.68	**20.18**	4.74	17.78	15.23	79.18	7.13	1.92	**9.05**

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Bucharest										
OFFICE BUILDINGS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
CS 2	139.09	51.29	**263.74**	0.00	0.00	0.00	0.00	37.55	21.03	**58.58**

2005-2010 (without renewable energy sources)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	67.35	19.05	**112.55**	0.00	0.00	0.00	0.00	18.18	7.81	**25.99**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-3	47.56	4.68	**56.49**	0.00	20.80	0.00	81.10	12.84	1.92	**14.76**
Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
PS3	24.51	4.85	**35.49**	0.00	20.08	0.00	80.56	6.62	1.99	**8.61**
Horizon 2050 (high-efficiency cogeneration)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 5	16.96	2.08	**10.50**	0.00	20.08	22.10	92.00	4.87	0.83	**5.70**

B. Graphical representation

Variation of the specific primary energy pertaining to the operation of the new office and public administration buildings at time horizons 2019, 2030, 2050

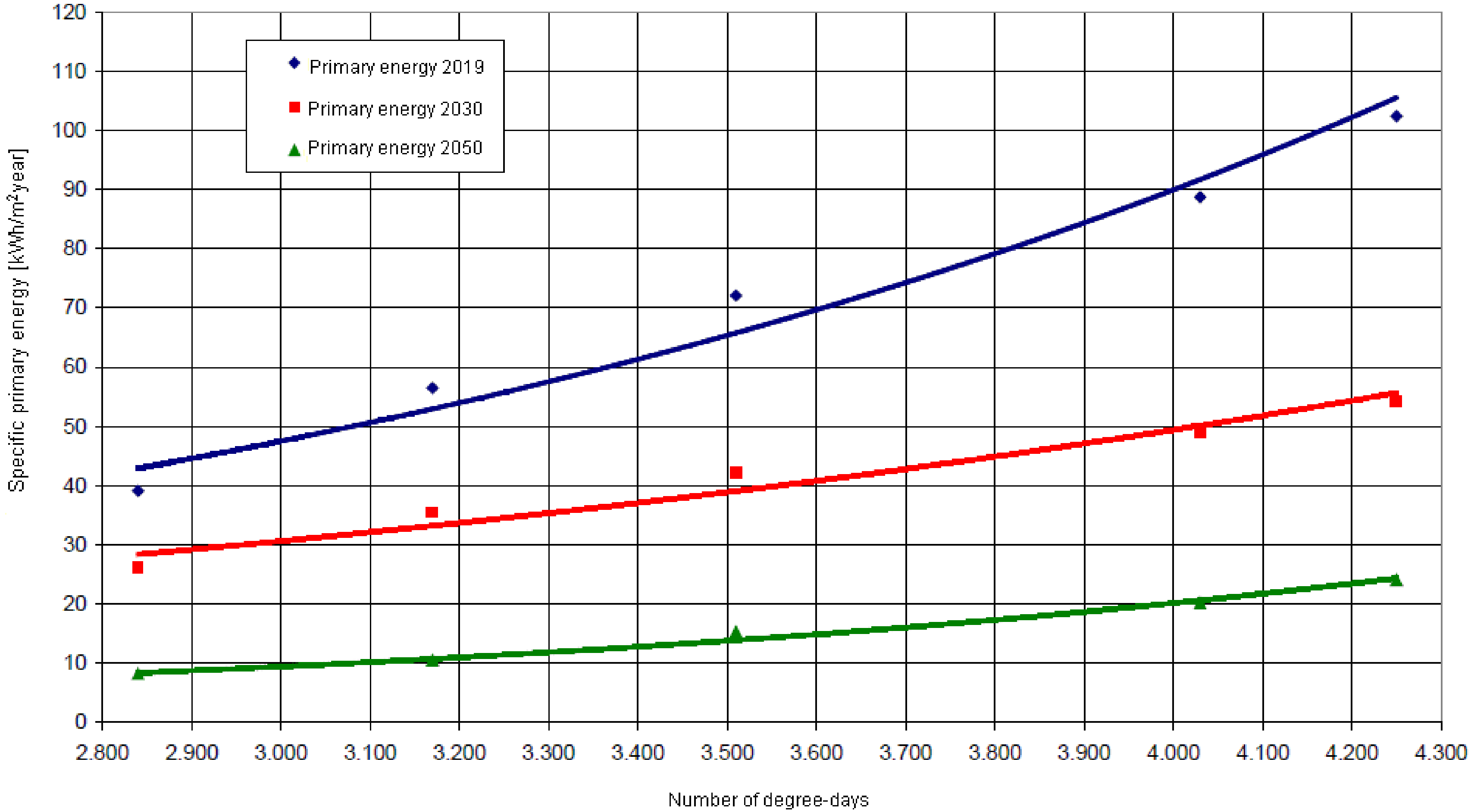

Fig. 2. Variation of the specific primary energy pertaining to the operation of the new office and public administration buildings, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

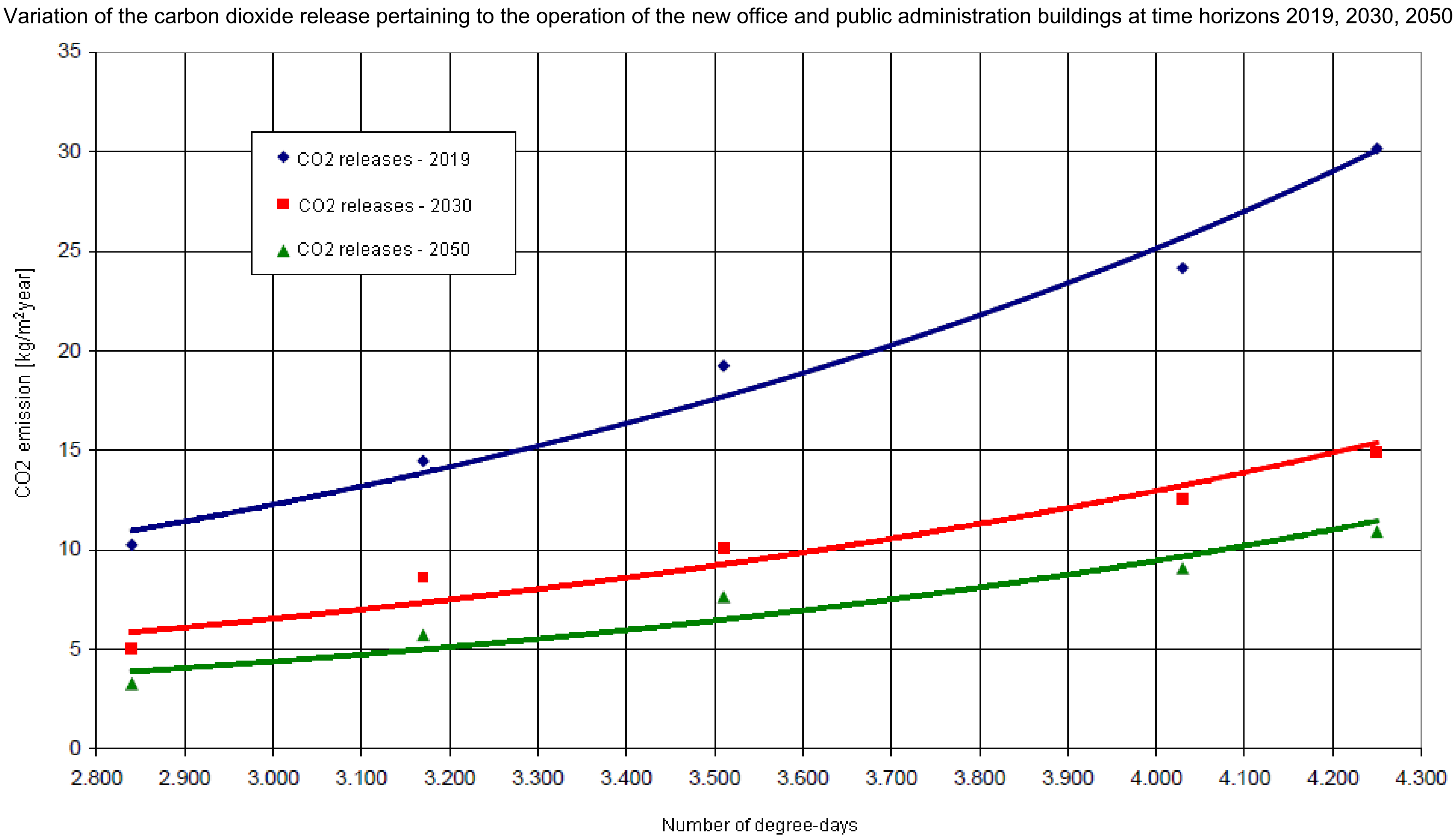

Fig. 3. Variation of the CO_2 emissions pertaining to the use of the new office and public administration buildings, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

Example for the use of the graphs for the assessment of the admissible limit values of the specific primary energy pertaining to the *office and public administration* building type and for the maximum admissible CO_2 releases pertaining to the operation of the buildings mentioned:

1. Input data:

Place where the building will be constructed: **Miercurea Ciuc** (winter climate zone **V**)
Annual number of calculated degree-days (according to SR 4839/1997, tab. 2): **4 250**

2. Calculated values:

Time horizon: 31 December 2018 (acc. to Article 9 of Directive 31/2010/EU)
Primary energy: ≤ 103.76 kWh/m^2year
CO_2 emissions: ≤ 30.51 kg/m^2year

Time horizon: 2020 (acc. to Article 9 of Directive 31/2010/UE)
Primary energy: ≤ 55.81 kWh/m^2year
CO_2 emissions: ≤ 15.32 kg/m^2year

Time horizon: 2050 (acc. to Article 9 of Directive 31/2010/UE)
Primary energy: ≤ 22.10 kWh/m^2year
CO_2 emissions: ≤ 11.55 kg/m^2year

II.2.2. EDUCATIONAL BUILDINGS

Current status (CS):

CS 1 – incandescent lighting, district heating, without thermostatic radiator valves;
CS 2 – incandescent lighting, district heating, with thermostatic radiator valves;
CS 3 – incandescent lighting, own boiler, with thermostatic radiator valves;
CS 4 – economical lighting, own boiler, with thermostatic radiator valves.

Thermal protection according to C 107/2010:
C 107–1 – economical lighting, district heating, with thermostatic radiator valves;
C 107–2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights;

C 107–3 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with heat recovery from exhaust air;

C 107–4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights;

C 107–5 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with heat recovery from exhaust air.

Thermal protection according to the Superior Package (SP):

SP 1 – economical lighting, district heating, with thermostatic radiator valves;

SP 2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights;

SP 3 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with heat recovery from exhaust air;

SP 4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights;

SP 5 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with heat recovery from exhaust air.

A total of **14 variants** for **Bucharest** and the same for **Braşov**.

NOTE: The energy performance of school-type buildings will be analysed exclusively during the cold season. If the heating season exceeds the duration of the school year (15 September–20 June), only the values pertaining to the school year duration will be taken into consideration.

Technical solutions and technical performance figures at time horizons (starting from 2010), 31 December 2018, 2020 and 2050

A. Value tables

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Braşov (climate zone IV)										
EDUCATIONAL BUILDINGS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
CS 2	309.85	15.40	**328.50**	0.00	0.00	0.00	0.00	83.66	6.31	**89.97**
2005-2010										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	185.22	14.11	**209.23**	0.00	0.00	0.00	0.00	50.01	5.79	**55.80**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-2	171.37	4.68	**171.64**	0.00	9.43	0.00	66.83	46.27	1.92	**48.19**

Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
C 107-3	65.59	4.68	**73.26**	0.00	17.80	0.00	79.19	17.71	1.92	**19.63**
Horizon 2050										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
SP 3	49.85	4.68	**58.62**	0.00	17.62	0.00	79.01	13.46	1.92	**15.38**

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Bucharest (climate zone II)										
EDUCATIONAL BUILDINGS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
CS 2	194.03	16.71	**224.22**	0.00	0.00	0.00	0.00	52.39	6.85	**59.2**

2005-2010 (without renewable energy sources)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participati on of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	119.45	16.45	**154.19**	0.00	0.00	0.00	0.00	32.25	6.75	**39.00**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participati on of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-2	110.59	4.68	**115.11**	0.00	11.77	0.00	71.55	29.86	2.20	**31.78**
Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participati on of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-3	43.89	5.37	**54.88**	0.00	20.08	0.00	78.91	11.85	2.20	**14.05**
Horizon 2050 (cogeneration)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participati on of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
PS3	34.67	5.65	**47.04**	0.00	20.08	0.00	78.06	9.36	2.31	**11.68**

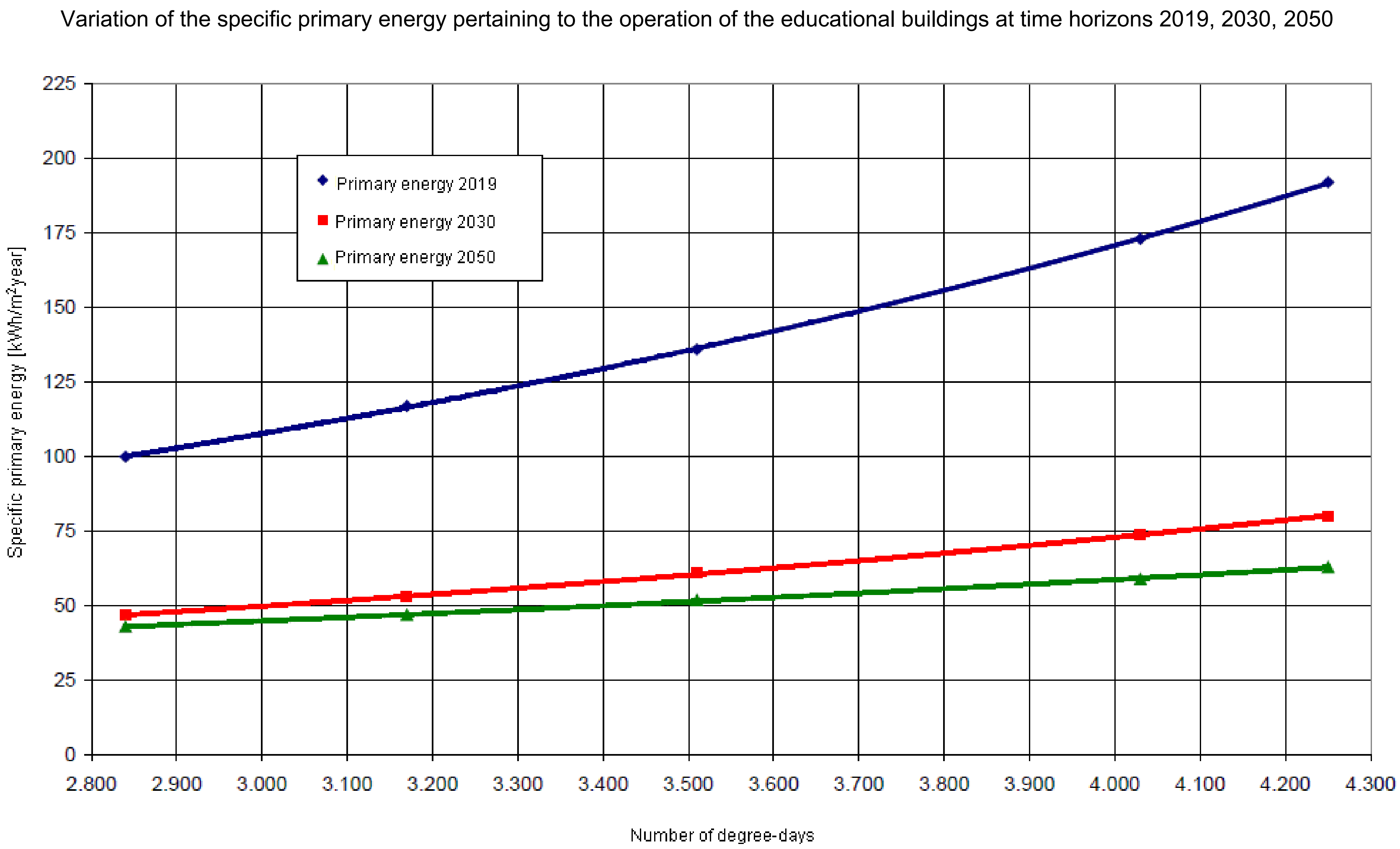

Fig. 4. Variation of the primary energy pertaining to the use of the educational buildings, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

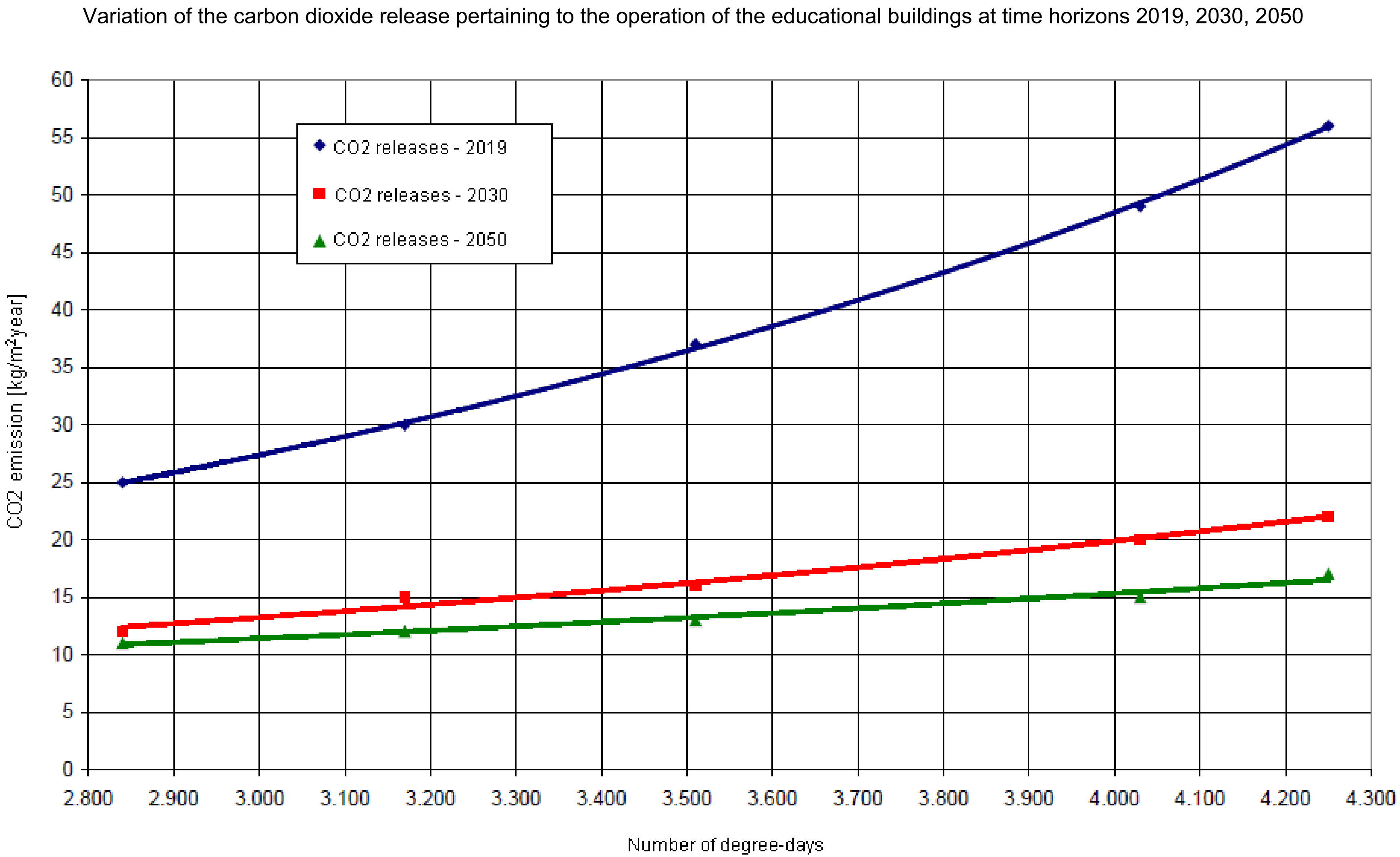

Fig. 5. Variation of the CO_2 emissions pertaining to the use of the educational buildings, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

The graphs for the assessment of the admissible limit values of the specific primary energy pertaining to the educational buildings and for the maximum admissible CO_2 releases pertaining to the operation of this type of building will be used similarly to the graphs for office and public administration buildings.

II.2.3. HEALTH CARE BUILDINGS (HOSPITALS)

Current status (CS):

CS 1 – economical lighting, district heating, without thermostatic radiator valves, without blinds and without natural ventilation;

CS 2 – economical lighting, own boiler (block boiler), with thermostatic radiator valves, without blinds and with natural ventilation;

CS 3 – economical lighting, new own boiler (disconnected from district heating), without thermostatic radiator valves, with blinds and with natural ventilation.

Thermal protection according to C 107/2010:

C 107–1 – economical lighting, district heating, with thermostatic radiator valves, with blinds and with natural ventilation;

C 107–2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

C 107–3 – economical lighting, district heating, with thermostatic radiator valves, with heat recovery from exhaust air, with blinds and with natural ventilation;

C 107–4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

C 107–5 – economical lighting, boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation.

Thermal protection according to the Superior Package (SP):

SP 1 – economical lighting, district heating, with thermostatic radiator valves, with blinds and with natural ventilation;

SP 2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

SP 3 – economical lighting, district heating, with thermostatic radiator valves, with shutters for winter nights, with heat recovery from exhaust air, with blinds and with natural ventilation;

SP 4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

SP 5 – economical lighting, boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation.

A total of **13 variants** for **Braşov** and **Bucharest**.

Technical solutions and technical performance figures at time horizons (starting from 2010), 31 December 2018, 2020 and 2050

A. Value tables

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Braşov (climate zone IV)										
HEALTH CARE BUILDINGS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
CS 1	575.80	13.56	**571.02**	0.00	0.00	0.00	0.00	155.47	5.56	**161.03**
2005-2010										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
C 107-1	265.24	13.56	**282.20**	0.00	0.00	0.00	0.00	71.62	5.56	**77.18**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
C 107-3	146.79	4.68	**148.78**	66.23	14.31	31.09	75.36	39.63	1.92	**41.55**

Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 5	83.23	4.68	**109.64**	66.23	14.67	44.31	75.81	22.47	1.92	**24.39**
Horizon 2050										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 3	73.24	4.68	**80.38**	66.23	14.67	47.48	75.81	19.78	1.92	**21.69**

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Bucharest (climate zone II)										
HEALTH CARE BUILDINGS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
CS 1	381.14	15.96	**396.28**	0.00	0.00	0.00	0.00	102.91	6.54	**109.45**

2005-2010 (without renewable energy sources)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	187.29	16.04	**216.20**	0.00	0.00	0.00	0.00	50.57	6.58	**57.14**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-3	90.62	4.68	**96.54**	66.23	16.79	42.22	78.21	24.47	1.92	**26.39**

Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 5	51.60	4.68	**72.64**	66.23	15.11	56.20	76.36	13.93	1.92	**15.85**
Horizon 2050 (cogeneration)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 3	45.41	4.68	**54.49**	66.23	15.11	59.32	76.36	12.26	1.92	**14.18**

B. Graphical representation

Variation of the specific primary energy pertaining to the operation of the health care buildings at time horizons 2019, 2030, 2050

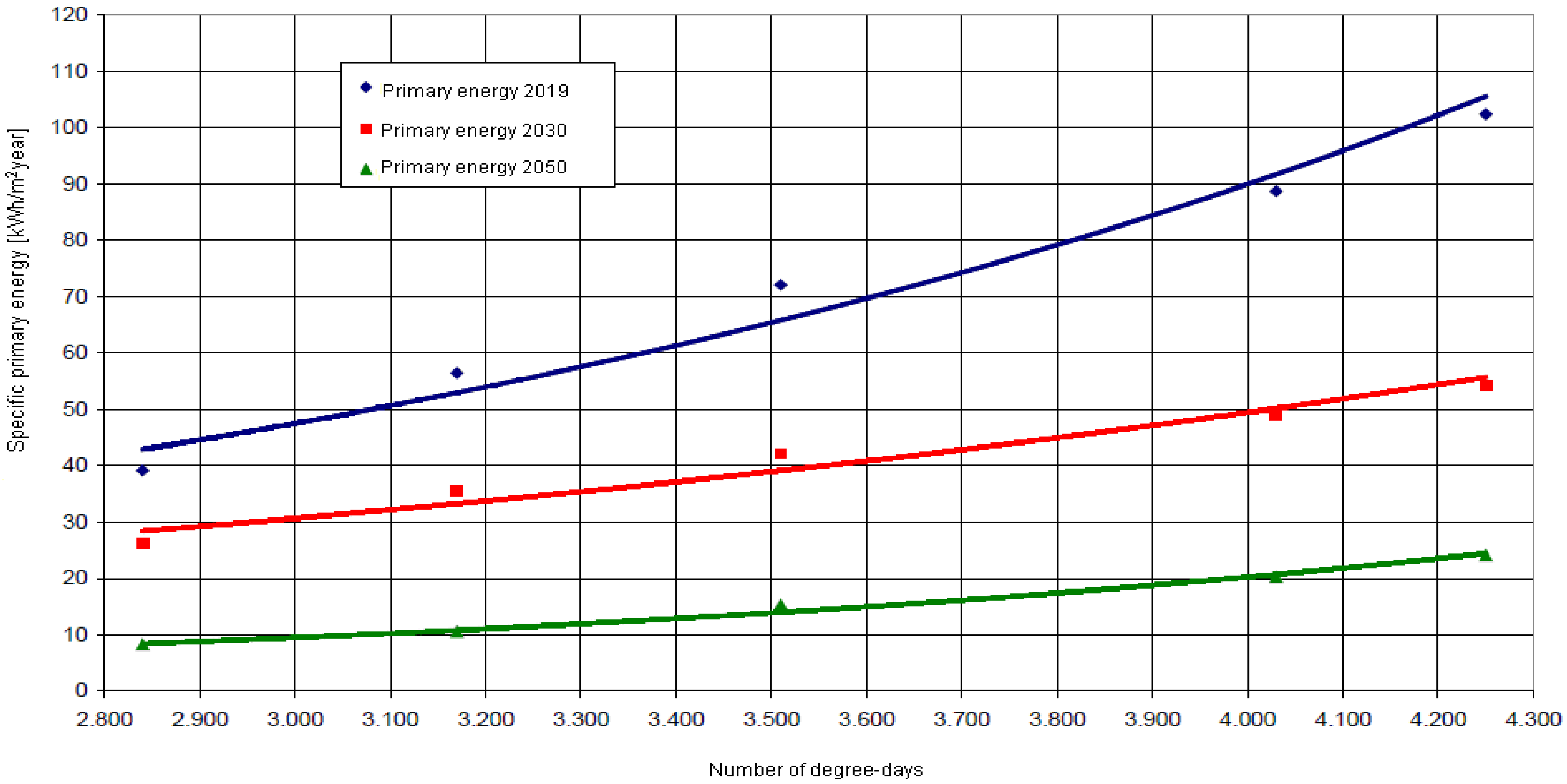

Fig. 6. Variation of the primary energy pertaining to the use of the health care buildings, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

Variation of the carbon dioxide release pertaining to the operation of the health care buildings at time horizons 2019, 2030, 2050

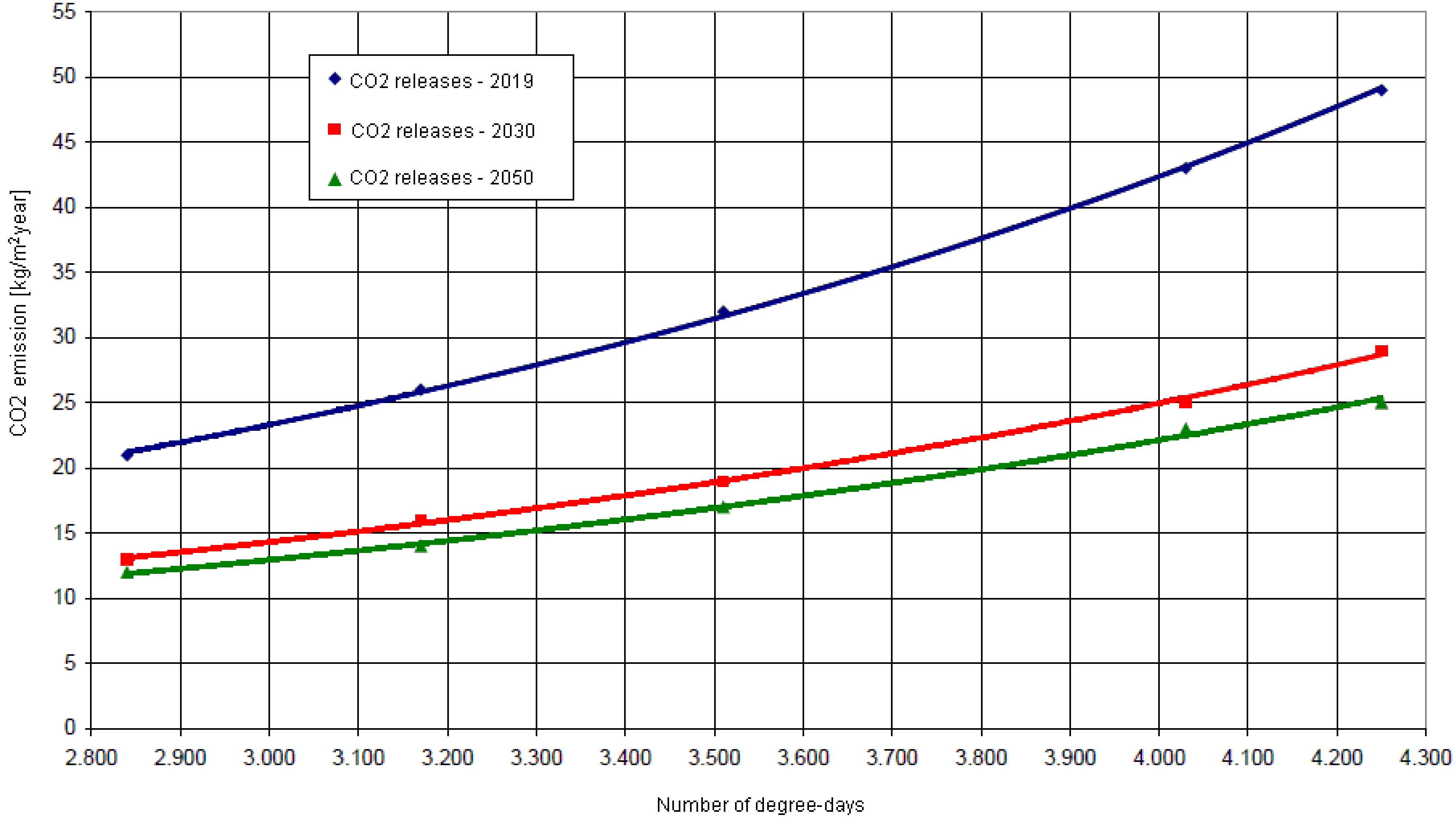

Fig. 7. Variation of the CO_2 emissions pertaining to the use of the health care buildings, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

The graphs for the assessment of the admissible limit values of the specific primary energy pertaining to the health care buildings and for the maximum admissible CO_2 releases pertaining to the operation of this type of building will be used similarly to the graphs for office and public administration buildings.

II.2.4. APARTMENT BLOCKS

Current status (CS):

CS 1 – incandescent lighting, district heating, without thermostatic radiator valves, without blinds and without natural ventilation;

CS 2 – incandescent lighting, district heating, without thermostatic radiator valves, with blinds and with natural ventilation;

CS 3 – incandescent lighting, own boiler (block boiler), with thermostatic radiator valves, with blinds and with natural ventilation;

CS 4 – incandescent lighting, new own boiler (disconnected from district heating), with thermostatic radiator valves, with blinds and with natural ventilation.

Thermal protection according to C 107/2010:

C 107–1 – economical lighting, district heating, with thermostatic radiator valves, with blinds and with natural ventilation;

C 107–2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

C 107–3 – economical lighting, district heating, with thermostatic radiator valves, with heat recovery from exhaust air, with blinds and with natural ventilation;

C 107–4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

C 107–5 – economical lighting, boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation.

Thermal protection according to the Superior Package (SP):

SP 1 – economical lighting, district heating, with thermostatic radiator valves, with blinds and with natural ventilation;

SP 2 – economical lighting, district heating, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

SP 3 – economical lighting, district heating, with thermostatic radiator valves, with shutters for winter nights, with heat recovery from exhaust air, with blinds and with natural ventilation;

SP 4 – economical lighting, boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

SP 5 – economical lighting, boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation.

A total of **14 variants** for **Bucharest** and the same for **Braşov**.

Technical solutions and technical performance figures at time horizons (starting from 2010), 31 December 2018, 2020 and 2050

A. Value tables

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Braşov (climate zone IV)										
APARTMENT BLOCKS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
CS 1	303.68	17.38	**327.96**	0.00	0.00	0.00	0.00	81.99	7.13	**89.12**
2005-2010										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	168.22	7.22	**175.36**	0.00	0.00	0.00	0.00	45.42	2.96	**48.38**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-3	122.72	4.68	**126.39**	0.00	9.67	0.00	67.39	33.13	1.92	**35.05**

Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 2	82.74	7.22	**95.87**	59.08	0.00	41.66	0.00	22.34	2.96	**25.30**
Horizon 2050										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 5	47.65	4.68	**68.01**	59.08	9.67	55.36	67.39	12.86	1.92	**14.78**

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Bucharest (climate zone II)										
APARTMENT BLOCKS – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
CS 1	238.45	18.82	**271.07**	0.00	0.00	0.00	0.00	64.38	7.72	**271.07**

2005-2010 (without renewable energy sources)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	121.90	7.52	**133.06**	0.00	0.00	0.00	0.00	32.91	3.08	**35.99**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-3	93.34	4.68	**100.00**	0.00	9.81	0.00	67.71	25.47	1.92	**27.39**
Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-2	58.37	7.52	**73.97**	58.97	0.00	50.26	0.00	15.76	3.08	**18.84**
Horizon 2050 (cogeneration)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 5	25.92	4.68	**42.52**	59.09	9.86	69.51	67.82	7.00	1.92	**8.92**

B. Graphical representation

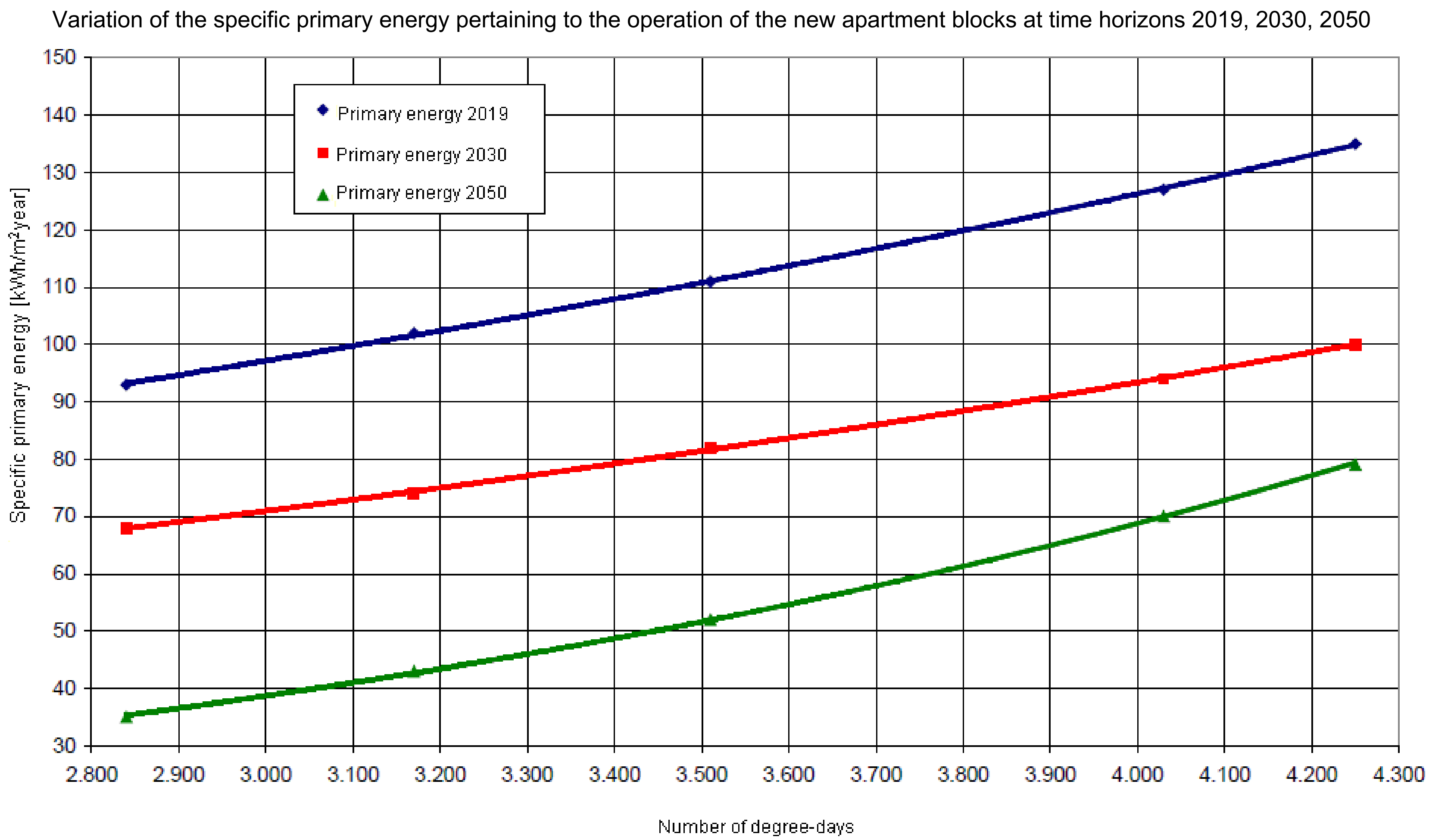

Fig. 8. Variation of the primary energy pertaining to the use of apartment blocks, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

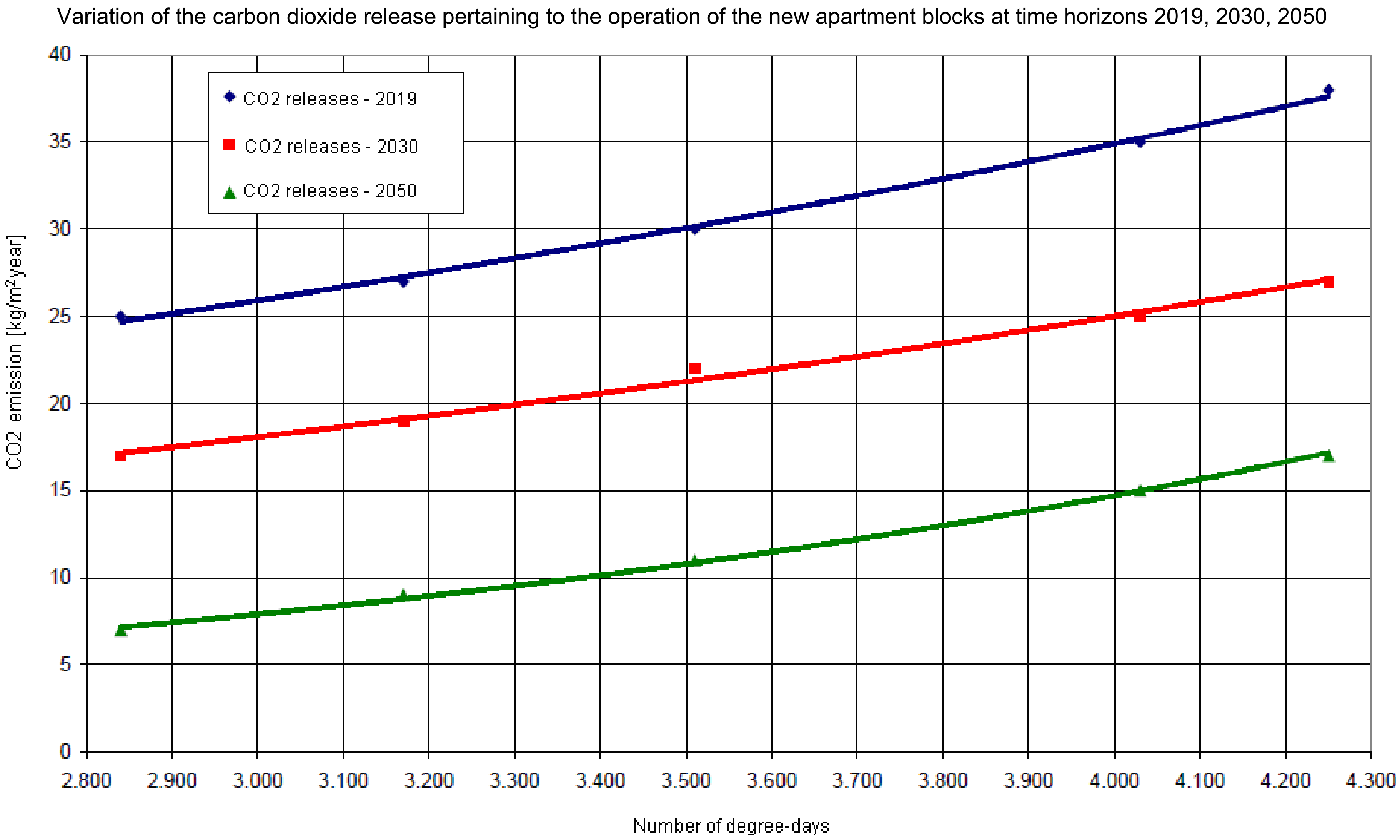

Fig. 9. Variation of the CO_2 emissions pertaining to the use of apartment blocks, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

The graphs for the assessment of the admissible limit values of the specific primary energy pertaining to the educational buildings and for the maximum admissible CO_2 releases pertaining to the operation of this type of building will be used similarly to the graphs for office and public administration buildings.

II.2.5. SINGLE-FAMILY HOUSES

Current status (CS):

CS 1 – incandescent lighting, old boiler, without thermostatic radiator valves, with blinds and with natural ventilation;

CS 2 – economical lighting, new own boiler, with thermostatic radiator valves, with blinds and with natural ventilation.

Thermal protection according to C 107/2010:

C 107–1 – economical lighting, new boiler, with thermostatic radiator valves, with blinds and with natural ventilation;

C 107–2 – economical lighting, new boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

C 107–3 – economical lighting, new boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with blinds and with natural ventilation;

C 107–4 – economical lighting, new boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation.

Thermal protection according to the Superior Package (SP):

SP 1 – economical lighting, new boiler, with thermostatic radiator valves, with blinds and with natural ventilation;

SP 2 – economical lighting, new boiler, with thermostatic radiator valves, with insulated shutters for winter nights, with blinds and with natural ventilation;

SP 3 – economical lighting, new boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with blinds and with natural ventilation;

SP 4 – economical lighting, new boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with blinds and with natural ventilation;

SP 5 – economical lighting, new boiler, with thermostatic radiator valves, with heat recovery from exhaust air, with insulated shutters for winter nights, with ventilated solar space, with blinds and with natural ventilation, with solar radiation collector – DHW.

A total of **11 variants** for **Bucharest** and the same for **Braşov**.

Technical solutions and technical performance figures at time horizons (starting from 2010), 31 December 2018, 2020 and 2050

A. Value tables

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Braşov (climate zone IV)										
SINGLE-FAMILY HOUSES – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
CS 2	715.85	7.23	**856.49**	0.00	0.00	0.00	0.00	193.28	2.96	**196.24**
2005-2010										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
C 107-1	375.74	7.23	**458.55**	0.00	0.00	0.00	0.00	101.45	2.96	**104.41**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[kWh/m²an]	[%]	[%]	[kg/m²an]	[kg/m²an]	[kg/m²an]
C 107-4	255.46	13.23	**333.54**	0.00	0.00	0.00	0.00	68.97	5.42	**74.40**

Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 3	209.24	13.23	**279.47**	0.00	0.00	0.00	0.00	56.49	1.92	**61.92**
Horizon 2050										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 5	165.94	4.68	**206.41**	26.11	8.55	13.59	64.62	44.80	1.92	**46.72**

Packages of technical solutions with the evolution of the Energy Performance of Buildings towards NZEB – Bucharest (climate zone II)										
SINGLE-FAMILY HOUSES – new buildings										
Before 2005										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
CS 2	475.79	8.71	**579.50**	0.00	0.00	0.00	0.00	128.46	3.57	**132.04**

2005-2010 (without renewable energy sources)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-1	254.75	7.59	**317.94**	0.00	0.00	0.00	0.00	68.78	3.11	**71.89**
Horizon 31 December 2018										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
C 107-4	181.16	13.67	**247.77**	0.00	0.00	0.00	0.00	48.91	5.60	**54.52**
Horizon 2020										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 3	153.07	13.42	**214.26**	0.00	0.00	0.00	0.00	41.33	1.92	**46.83**
Horizon 2050 (cogeneration)										
Solution Code	**Thermal energy**	**Electric energy**	**Primary energy**	**Solar thermal**	**Solar electric**	**Participation of solar thermal**	**Participation of solar electric**	**CO2 – thermal**	**CO2 – electric**	**CO2 – total**
U.M.	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[kWh/m^{2}an]	[%]	[%]	[kg/m^{2}an]	[kg/m^{2}an]	[kg/m^{2}an]
SP 5	113.51	4.68	**145.07**	29.01	8.74	20.35	65.13	30.65	1.92	**32.57**

B. Graphical representation

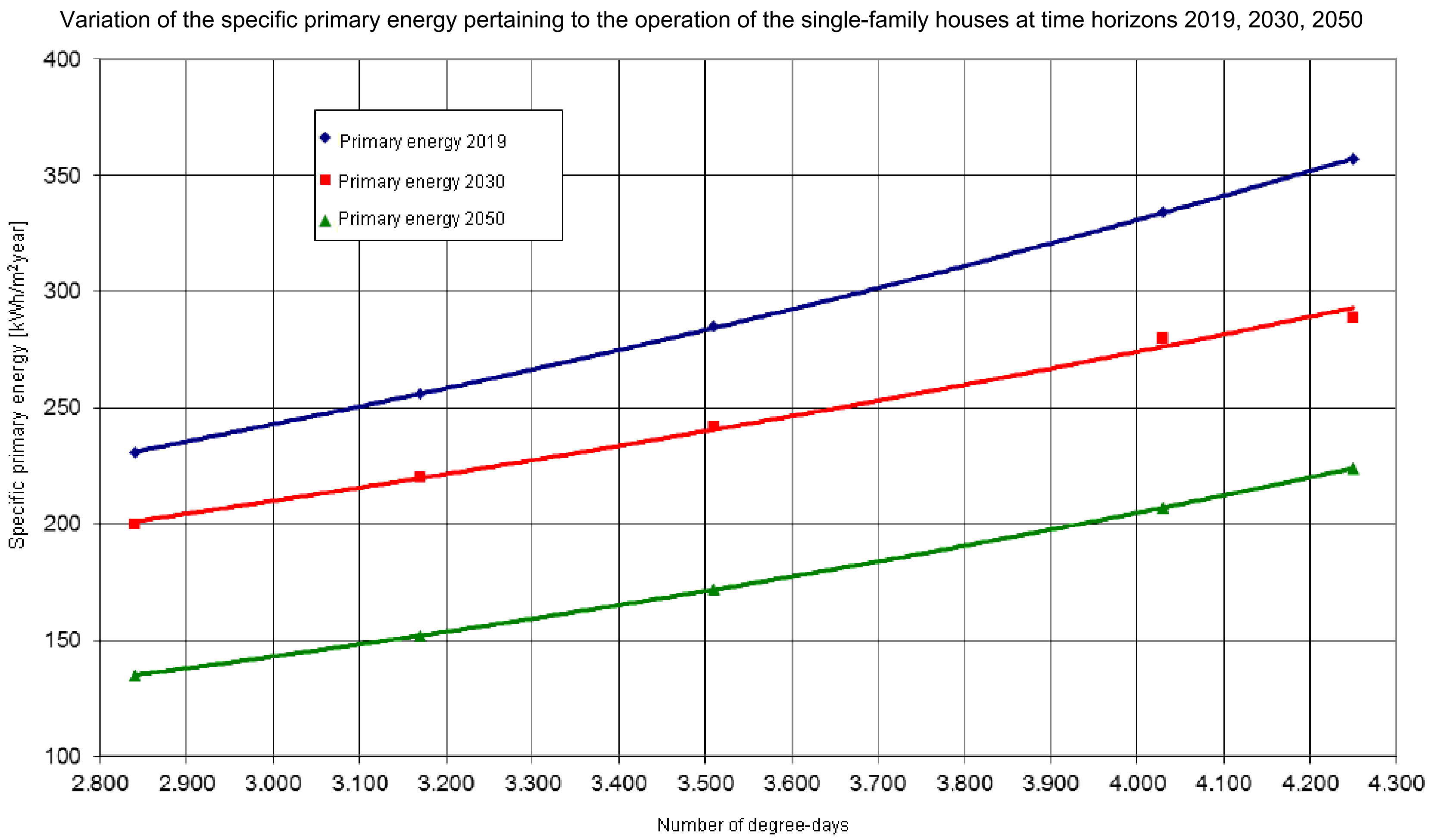

Fig. 10. Variation of the primary energy pertaining to the use of single-family houses, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

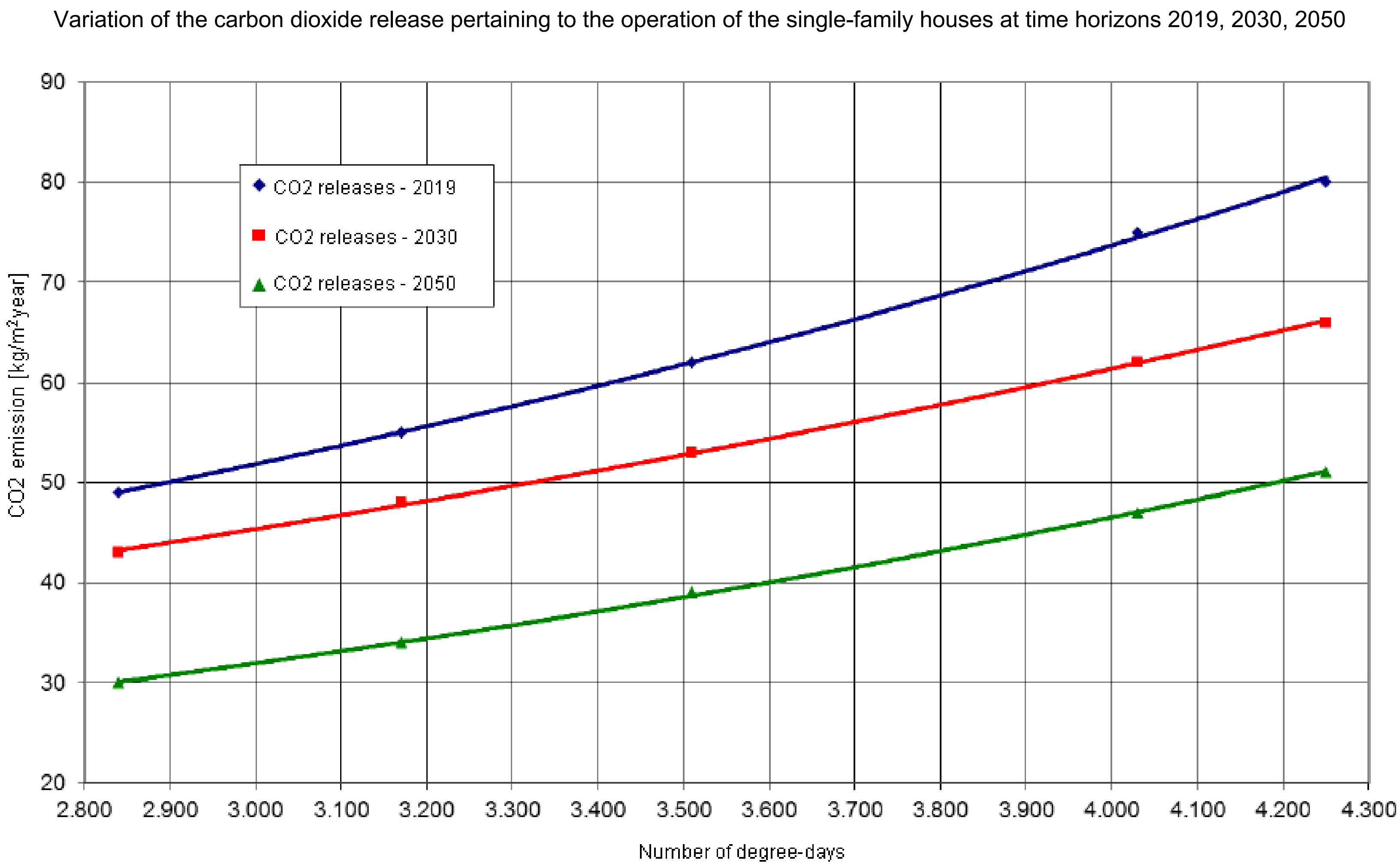

Fig. 11. Variation of the CO_2 emissions pertaining to the use of single-family houses, depending on the number of degree-days in the municipality where the buildings will be located (SR 4839-97) and on the time horizon from which they will be designed

The graphs for the assessment of the admissible limit values of the specific primary energy pertaining to the single-family houses and for the maximum admissible CO_2 releases pertaining to the operation of this type of building will be used similarly to the graphs for office and public administration buildings.

Maximum admissible limit values for the primary energy and the CO_2 emissions pertaining to building operation processes – broken down by type of building and winter climate zone in Romania

Climate zone	Horizon	OFFICE BUILDINGS		EDUCATIONAL BUILDINGS		HEALTH CARE BUILDINGS		COLLECTIVE HOUSING		INDIVIDUAL HOUSING	
		Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]
I	Before 2005	227	48	182	46	313	84	243	64	474	102
	2005-2010	102	24	135	32	190	48	117	31	271	59
	31dec. 2018	50	13	100	25	79	21	93	25	231	49
	2020	32	7	47	12	59	13	68	17	200	43
	2050	10	5	43	11	47	12	35	7	135	30
II	Before 2005	268	60	230	61	402	112	270	70	514	136
	2005-2010	113	25	153	39	214	57	132	36	317	70
	31dec. 2018	58	15	117	30	95	26	102	27	256	55
	2020	36	8	53	15	71	16	74	19	220	48
	2050	12	6	47	12	54	14	43	9	152	34

Climate zone	Horizon	OFFICE BUILDINGS		EDUCATIONAL BUILDINGS		HEALTH CARE BUILDINGS		COLLECTIVE HOUSING		INDIVIDUAL HOUSING	
		Primary energy [kWh/m²year]	CO_2 releases [kg/m²year]	Primary energy [kWh/m²year]	CO_2 releases [kg/m²year]	Primary energy [kWh/m²year]	CO_2 releases [kg/m²year]	Primary energy [kWh/m²year]	CO_2 releases [kg/m²year]	Primary energy [kWh/m²year]	CO_2 releases [kg/m²year]
III	Before 2005	295	68	266	72	461	130	289	78	693	159
	2005-2010	125	29	174	46	241	66	150	41	372	83
	31dec. 2018	69	19	136	37	115	32	111	30	285	62
	2020	40	10	61	16	85	19	82	22	242	53
	2050	15	7	52	13	63	17	52	11	172	39
IV	Before 2005	349	85	334	92	576	164	326	89	872	200
	2005-2010	147	38	212	58	290	81	182	50	476	109
	31dec. 2018	88	24	173	49	154	43	127	35	334	75
	2020	49	13	74	20	114	25	94	25	280	62
	2050	20	9	59	15	80	23	70	15	207	47
V	Before 2005	391	98	379	106	662	190	354	99	991	227
	2005-2010	157	43	230	64	314	87	198	55	528	122

Climate zone	Horizon	OFFICE BUILDINGS		EDUCATIONAL BUILDINGS		HEALTH CARE BUILDINGS		COLLECTIVE HOUSING		INDIVIDUAL HOUSING	
		Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]	Primary energy [kWh/m^{2}year]	CO_2 releases [kg/m^{2}year]
	31dec. 2018	98	28	192	56	174	49	135	38	357	80
	2020	53	14	80	22	129	29	100	27	298	66
	2050	22	11	63	17	89	25	79	17	224	51

For the time horizon of 31 December 2018 and for climate zone II (representative for the urban environment), the relations for the estimation of the maximum admissible specific primary energy, by type of building and building compactness rate, are the following:

Type of building	**Specific primary energy [kWh/m^{2}year]**	**Rapid calculation relation [kWh/m^{2}year]**
Offices	$64 \cdot exp\left(-0{,}035 \cdot \frac{V}{A}\right)$	$63 - 2 \cdot \frac{V}{A}$
Educational	$132 \cdot exp\left(\ 0{,}0475 \cdot \frac{V}{A}\right)$	$130 \quad 5{,}3 \cdot \frac{V}{A}$
Health care	$102 \cdot exp\left(-0{,}0385 \cdot \frac{V}{A}\right)$	$112 - 9 \cdot \frac{V}{A}$
Apartment blocks	$115 \cdot exp\left(\ 0{,}044 \cdot \frac{V}{A}\right)$	$114 \quad 4{,}4 \cdot \frac{V}{A}$
Single-family houses	$288 \cdot exp\left(-0{,}1355 \cdot \frac{V}{A}\right)$	$278 - 26{,}75 \cdot \frac{V}{A}$

V – free volume of the occupied spaces [m^3]

A – surface of the construction elements with an envelope function [m^2]

- On the basis of the values of the synthetic indicators for energy and environmental performance presented in the table above, the energy referential can be established with validity at different time horizons, and strategies for meeting the targets in the National Sustainable Development Strategy and in the Europe 2020 European Strategy can be studied.

- Concerning the strategy for the implementation of Directive 31/2010/EU, it is necessary to make certain methodological remarks to be considered when establishing the physical and financial dimension of the implementation strategy during the period of 2014–2020, as follows:

  – the energy performance of buildings in reference year 2005 can be determined by using the specific primary energy values in the column ‘before 2005’, by using the useful floor areas of buildings, according to official statistics, by type of residential and non-residential building and by urban and rural location of the buildings, in accordance with the statistical data;

– climate zone II can be used as a representative zone in Romania for developing the strategy and background scenarios;

– concerning the rural environment, 96.4% of the buildings are individual buildings and use solid fuel (wood) for heating, which is not registered as fossil energy consumption, but may be included in the national energy balance as a renewable energy source;

– concerning the urban environment, approximately 24% of the total of 330 681 000 m^2 of useful floor area [National Statistics Institute (INS) 2011] pertaining to housing represent single-family houses and the remaining 76% represent condominium-type buildings;

– concerning the primary energy used for thermal and electric processes pertaining to habitation, the values resulting from the *data in the summary table* are comparable: 5 791 thousand toe/year for condominiums and 4 074 thousand toe/year for single-family houses;

– non-residential buildings total at approximately 62 515 000 m^2 of useful floor area (approximately 20% of the area pertaining to habitation buildings) and an estimated primary energy consumption of 1 236 thousand toe/year;

– the resulting cumulated primary energy consumption is 10 535 toe/year, which only deviated by 3.1% from the value of 10 221 thousand toe/year reported at national level (Build Up Skills Romania 2012);

– the current building thermal rehabilitation programme, which is hypothetically applied to 70% of the apartment blocks in the period of 2014–2020 (approximately 458 200 habitations rehabilitated/year, a value which is practically impossible to achieve in relation to the average rhythm of the thermal rehabilitation works carried out to date, totalling approximately 20 000 habitations/year), generates a primary energy consumption reduction potential of 2 087 thousand toe/year for 2020 as compared to the current energy consumption mentioned above, which represents 19.7%, namely the target of the Europe 2020 European Strategy (19%), but which is below the target of the National Sustainable Development Strategy (24%);

– the above simplified estimation ignores apartments already subject to thermal rehabilitation, whose useful floor area totals at approximately 2 500 000 m^2, that is, less than 1% of the useful floor area of the apartments in the condominium-type buildings, which is less than 0.8% of the useful floor area of the habitations in the urban environment. Moreover, the new buildings, which represent an additional energy consumption as compared to the 2005 reference, are also ignored;

– considering the above, beside the financial efforts for the thermal rehabilitation of the collective buildings, at least two additional measures are necessary, as follows:

- increase of the energy efficiency of the district utility supply systems from less than 45% at present to approximately 75–80% by promoting high-efficiency cogeneration (ANRE task);

- establishing a legislative framework facilitating the thermal rehabilitation of individual buildings (by transitioning from the use of stoves to equipment with central heating installations and by reducing the thermal flow dissipated especially through envelope mobile transparent elements and the borders adjacent to unheated bridges and to the ground);

– beside the above, it is necessary to develop relevant energy-related educational programmes for the population through both video and audio media, and through eloquent demonstrative events (technological parks, comparative monitoring of current buildings and modernised buildings, demonstration of the savings that can be made through rehabilitation and modernisation concerning both the utility supply systems and buildings – with a minimum impairment of habitation comfort, etc.).