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RESOLUTIONS OF THE ROMANIAN GOVERNMENT

THE GOVERNMENT OF ROMANIA

RESOLUTION
for the approval of the National Energy Efficiency Action Plan[1]

Pursuant to Art. 108 from the Constitution of Romania, revised and republished, and to Art. 19(1) of Law No. 121/2014 on energy efficiency,

the **Government of Romania** adopts the present resolution.

Sole article. – The National Energy Efficiency Action Plan, included in the Annex which is an integral part of the present Resolution, is hereby approved.

PRIME MINISTER,
VICTOR-VIOREL PONTA

Countersigned by:
Minister of Energy, Small and Medium Enterprises and Business Environment
Andrei Dominic Gerea
For the Minister of Regional Development and Public Administration,
Sirma Caraman,
State secretary.
Minister of Public Finance,
Darius-Bogdan Vâlcov
Minister of Transport,
Ioan Rus
Minister of European Funds,
Eugen Orlando Teodorovici
Minister of Economy,
Trade and Tourism,
Mihai Tudose
Minister of Environment, Waters and Forests,
Graţiela Leocadia Gavrilescu
Minister of Education and Scientific Research,
Sorin Mihai Cîmpeanu
Minister of Foreign Affairs,
Bogdan Lucian Aurescu

Bucharest, February 25th 2015
No. 122

ANNEX

[1] Government Resolution No. 122/2015 was published in the Official Journal of Romania, Part I, No. 169 from March 11th 2015 and it is also reproduced in this bis number.

NATIONAL ENERGY EFFICIENCY ACTION PLAN

VERSION OF 2014

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ABBREVIATIONS

RDA – Regional Development Agency
PA – Priority Axis
ANRE – National Energy Regulatory Agency
ANRSC – *National Regulation Authority* for the *Public Utilities* Community *Services*
ARCE – Romanian Agency for Energy Conservation
EBRD – The European Bank for Reconstruction and Development
CNP – The National Commission for Forecast
CPT – Own Technological Consumption
EED – Energy Efficiency Directive 2012/27/EU
EE – Energy Efficiency
ENTSO-E – European Network of Transmission System Operators for Electricity
ESCO – Energy Services Company
EU ETS – EU Emissions Trading System
CF – Cohesion Fund
ERDF – *European Regional Development Fund*
***EERF** – Energy Efficiency Romanian Fund*
***GPRS** – General Packet Radio Service*
***SM**E – Small and Medium-size Enterprise*
***NIS** – National Institute of Statistics*
***LT** – Low tension*
***LED** – Light Emitting Diode*
***MRDPA** – Ministry of Regional Development and Public Administra*tion
ME – Ministry of Economy
MOECC – Ministry of the Environment and Climate Change
MT – Medium Tension
PO – Programme Operator
OPEX – Operational Expenditure
DSO – Gas Distribution System Operator
TO – Thematic Objective
CCM – Competitive Contract Market
CMBC - Centralized Market for Bilateral Contracts
EB – Electricity Balancing Market
IEM – Intraday Electricity Market
NEM - Next-day Electricity Market
PES – Primary Energy Savings
GDP – Gross Domestic Product
PLC – Power Line Carrier
NEEAP – National Energy Efficiency Action Plan
NRP – National Reform Programme
EDN – Electricity Distribution Networks
ETN – Electricity Transmission Networks
SACET – District *Heating* Supply System
GDS – Gas Distribution System
EEA – European Economic Area
SM – Smart Metering
NES – National Energy System
AS – Ancillary services
ST – Steam Turbine
GT – Gas Turbine

EU – European Union
GVA – Gross Value Added

1. Introduction

Following Romania's accession to the European Union in 2007, the Government of Romania adopted the National Reform Programme for 2007-2010 which sets the priorities for the development of the country, taking into account the guidelines of the Lisbon Strategy of the European Union for growth and jobs, aiming at reducing the gaps compared to other member states of the European Union.

Thus, for Romania, the **National Reform Programme (NRP)** represents the framework for defining and enforcing economic development policies in line with the EU policies, which allow concentration of efforts and national resources to modernize Romanian economy and society, and support economic and social convergence with the other EU member states.

In June 2010, the Government of Romania approved **the final values for the national targets**, as reflected in the NRP, in agreement with the European targets set with the enactment of *Europe 2020* Strategy, taking into account the already assumed financial agreements and the national peculiarities. For each national target within the NRP, measures/courses of actions have been established, budgets have been allocated, and the institutions responsible for these targets have been appointed.

Romania drafted **NRP 2011-2013** with the purpose of both ensuring the continuity of the reforms from the previous stage (2007-2010) and meeting the requirements in the reports made in the financial support programmes provided by international financial institutions.

Naturally, *NRP 2014* continues the reforms assumed in NRP 2011-2013 and puts forth new reforms, derived from both the targets of *Europe 2020 Strategy* and the main documents of the European Semester. As such, NRP includes, besides the newly identified actions, some of the actions already under implementation (for example, those referring to the conditions Romania has to comply with in relation to international financial institutions and the ex-ante conditions for the financial period 2014-2020).

Drafting and implementing NRP 2014 coincides with the economic recovery, therefore it is a major opportunity to implement the budgetary and structural reform measures, which will increase the capacity of the Romanian economy to deal with global competitive pressure, to attract foreign direct investments and to create new jobs.

The economic development of Romania has been closely linked to economic development at global and EU level, and has occurred in an extremely complex international environment, affected by the global economic crisis.

The analysis of the evolution of the Gross Domestic Product (GDP) between 2005 and 2013 shows that the Romanian economy was in recession between 2009 and 2010, and rebounded from recession in 2011, reaching a GDP growth rate of 3.5% in 2013 (**table 1.1**).

Table 1.1 Evolution of GDP between 2005 and 2012

Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
GDP [billion euros]	79.75	97.79	124.65	139.76	128.27	124.4	131.51	131.68
GDP [billion euros 2005]	79.75	86.05	91.47	98.14	91.67	90.66	92.74	93.30
Annual GDP growth rate [%]	4.2	7.9	6.3	7.3	-6.6	-1.1	2.3	0.6
Population [mil. inhabitants]	21319	21193	20882	20537	20367	20246	20147	20095
GDP/capita [Euro/capita]	3770	4614	5970	6805	6298	6144	6528	6552

(Source: National Institute of Statistics – Romanian Statistical Yearbook - collections)

The positive evolution of the Romanian economy between 2000 and 2008 led to a growth of 3.56 times of the gross domestic product per capita, and this indicator has declined during 2009-2010 and then increased again after 2011, but still remained below the average of EU-27, which means that Romania has to make important progress in its economic development in order to converge with the EU average (24,425 euro/capita in 2010).

The structural adjustment of the Romanian economy between 2005 and 2012 led to a contribution of 47.78% of the industry, the agriculture and the construction sector to the Gross Value Added (GVA) in 2012, as compared to 67.8% in 1990. There is a relatively steady growth tendency of the utilities sector contribution up to 2006, at the expense of other branches of the economy. **Table 1.2** shows the evolution of GVA by sectors between 2000 and 2012. It is noted that in the 2000-2007 economic growth period, the industry and the agriculture sector reduced their contribution to the GVA at the expense of the construction and utilities sectors. These tendencies didn't hold in the economic crisis period.

Table 1.2 Evolution of Gross Value Added (GVA) structure between 2000 and 2012 [%]

Indicator	2000	2005	2007	2008	2009	2010	2011	2012
TOTAL GVA of which:	100	100	100	100	100	100	100	100
Industry	29.02	28.1	27.45	25.8	26.75	31.85	32.93	32.36
Agriculture	12.06	9.52	6.51	7.43	7.16	6.4	7.46	5.59
Constructions	5.35	7.39	10.29	11.92	11.71	10.24	9.22	9.83
Utilities	53.57	54.99	55.75	54.85	54.3	51.51	50.39	52.22

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

The evolution of the different Romanian industries depends on the overall economic development but also on the EU policies in this field and the global social and economic context. Table 1.3 shows the evolution of the contribution of different industries to the Gross Value Added (GVA) between 2000 and 2011; it should be noted that the processing industry holds the largest share (about 76%). The food, beverage and tobacco industry (about 20%), the transport industry (about 11%), the energy industry (about 12-15 %), the metallurgic industry (about 8%) also have important contributions to the GVA.

Table 1.3 Evolution of the contribution of different industries to GVA [%]

Indicator	2000	2005	2008	2009	2010	2011
TOTAL GVA of which:	100.00	100.00	100.00	100.00	100.00	100.00
Mining industry	7.98	5.28	4.38	4.9	5.84	4.42
Processing industry	80.68	85.39	85.41	82.2	76.17	75.39
Food, beverage and tobacco industry	24.57	24.35	23.17	22.1	19.48	18.81
Manufacture of textile, clothing and leather products	8.15	9.1	7.3	6.4	7.46	8.32
Manufacture of wood, paper and printing products	9.44	7.01	6.36	6.3	5.44	5.65
Manufacture of coke and refined petroleum products	3.78	5.00	3.98	2.87	1.11	2.27
Manufacture of chemical substances and products	6.08	6.24	2.53	2.07	1.13	1.37
Manufacture of *basic pharmaceutical* products and pharmaceutical preparations	0.00	0.00	0.83	1.19	0.19	0.27
Manufacture of rubber and plastic products and other non-metallic mineral products	0.00	3.81	8.18	7.11	3.41	3.25
Metallurgical and metal products industry	7.48	7.42	8.57	6.55	8.04	7.28
Manufacture of computers, electronic and optical products	12.26	5.59	3.21	3.59	5.75	4.34
Manufacture of electronic equipment	0.00	0.00	3.56	3.42	3.73	3.54
Manufacture of machinery and equipment n.e.c	0.00	4.32	3.07	3.06	3.00	2.45
Transport industry	4.21	8.46	10.57	13.62	11.23	12.27
Other industrial activities n.e.c	4.73	4.09	4.09	3.93	6.2	5.57
Production and supply of electricity, thermal energy, gas, hot water and air conditioning	10.00	8.52	8.21	10.16	13.06	15.12
Water supply distribution, sanitation, waste management and decontamination activities	1.35	0.81	2.00	2.71	4.92	5.07

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

The social and economic development of Romania during the economic crisis and afterwards had an impact on energy consumption and its structure.

Table 1.4 shows the evolution of domestic primary energy consumption between 2007 and 2012 and its structure.

Table 1.4 Evolution of domestic primary energy consumption [ktoe]

Year	2007	2008	2009	2010	2011	2012
Domestic primary energy consumption, of which	**39159**	**39799**	**34328**	**34817**	**35648**	**34851**
Coal	10064	9649	7436	6911	8147	7552
Petroleum and petroleum products	9658	9719	8331	7855	8472	8303
Natural gas	12862	12476	10642	10897	11187	10924
Firewood and agricultural waste	3275	3710	3742	3982	3458	3654
Hydroelectric energy	1195	1115	1164	1573	1242	1312
Nuclear energy	1890	2752	2881	2850	2880	2811
Other fuels	194	352	107	723	225	244
Non-conventional energy sources	21	26	25	26	37	51

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

Table 1.5 shows the growth in primary energy resources consumption between 2010 and 2012 due to an increase in hydroelectric energy and wind energy production. Natural gas (about 31%) holds the greatest share in primary energy consumption; petroleum (about 24%) and coal (about 20-24%) come next. As seen in the table below, coal consumption showed the greatest fluctuations between 2007 and 2012.

Table 1.5 Evolution of the structure of primary energy consumption between 2007 and 2012

Year	Coal		Petroleum		Natural gas		Electricity		Other		TOTAL [Ktoe]
	Ktoe	%	Ktoe	%	Ktoe	%	Ktoe	%	Ktoe	%	
2007	10.064	25.70	9.658	24.66	12.862	32.85	1.195	3.05	5.38	13.74	39.159
2008	9.649	24.24	9.719	24.42	12.476	31.35	1.115	2.80	6.84	17.19	39.799
2009	7.436	21.66	8.331	24.27	10.642	31.00	1.164	3.39	6.755	19.68	34.328
2010	6.911	19.85	7.855	22.56	10.897	31.30	1.573	4.52	7.581	21.77	34.817
2011	8.147	22.85	8.472	23.77	11.187	31.38	1.242	3.48	6.6	18.51	35.648
2012	7.552	21.67	8.303	23.82	10.924	31.34	1.312	3.76	6.76	19.4	34.851

Due to its limited primary energy resources, in Romania the domestic production of energy has remained more or less constant at about 27-28 million toe. Without the contribution from renewable energy sources, these numbers will gradually drop in the following years.

The evolution of domestic primary energy production between 2007 and 2012 is shown in **Table 1.6**, from which the following conclusions are drawn:

- Natural gas holds the main share in the domestic primary energy production. But, because natural gas production is decreasing due to the decline of gas reserves, its share in the overall production dropped from 33.2% in 2007 to 32.3% in 2012;
- Petroleum production has also decreased, reaching a share of only 14.3% in the total production in 2012. Thus, petroleum has become the third energy carrier in Romania's energy production, after coal which is second;

Table 1.6 Evolution of primary energy production [ktoe]

Year	2007	2008	2009	2010	2011	2012
Primary energy production, of which:	27300	28861	28034	27428	27468	27112
Total coal, of which: - Other types of hard coal - Lignite - Brown coal	6858 902 5933 23	7011 979 5985 47	6447 751 5718 8	6795 821 5946 28	6663 730 5933 0	6346 654 5692 0
Firewood and agricultural waste	3304	3750	3838	3900	3476	3795
Crude oil	4651	4619	4390	4186	4129	3891
Natural gas	9075	8982	8964	8705	8724	8770
Other fuels	127	240	98	88	152	159
Unconventional energy sources	21	26	25	26	37	50
Hydroelectric energy	1370	1481	1361	1769	1407	1290
Nuclear energy	1894	2752	2881	2841	2880	2811

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

- Fossil fuels (coal, crude oil, natural gas) hold a major share (70.1% in 2012) in primary energy production;

- Firewood and agricultural waste hold an important share in domestic energy production. This underlines the importance of developing modern technologies in order to produce and use biomass for energy production (mainly thermal energy).

Considering the high exploitation costs of renewable energy sources, it is highly unlikely that, on the medium term, renewable resources will fully cover the increase in primary energy consumption and the decrease in internal production, which will lead to a growth in imports.

In order to meet consumption demands, Romania has imported relatively significant amounts of energy (**table 1.7**)

Table 1.7 Import of main energy carriers [ktoe]

Year	2007	2008	2009	2010	2011	2012
Import of primary energy, of which:	17399	16324	11235	11239	11570	11615
Coal (including coke)	3021	2550	1013	1221	1101	1233
Petroleum and petroleum products	9812	10073	8471	7955	7769	7766
Natural gas	3904	3567	1614	1834	2489	2321
Electricity	109	79	56	66	89	121

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

The evolution of primary energy export is shown in T**able 1.8.**

Table 1.8 Export of energy carriers in ktoe

Year	2007	2008	2009	2010	2011	2012
Export of primary energy, of which:	4901	5565	4600	3992	4124	3620
Coal	47	17	14	50	24	13
Petroleum products	4565	5103	4332	3654	3811	3264
Electricity	289	445	254	262	253	99

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

The evolution of primary energy imports and exports shows a decline in both total imports and total exports between 2007 and 2012. In 2012, petroleum and natural gas represent more than 64% of all imports.

Primary energy imports exceed almost three times exports, Romania being a net importer.

Dependency on primary energy imports (**Table 1.9**) continuously increased between 2000 and 2008, from about 22% in 2000 to 27.1% in 2008, reaching a peak of 31.9% in 2007, the year prior to the start of the economic crisis. Between 2009 and 2012, the dependency on imports dropped to almost 20% due to the decrease in economic activity as a result of the recession.

Table 1.9 Dependency on primary energy import to cover domestic consumption

Year	MU	2007	2008	2009	2010	2011	2012
Import – export balance	ktoe	12498	10759	6635	7247	7446	7995
Domestic primary energy consumption	ktoe	39159	39658	34328	34817	35648	34851
Dependency rate	%	31.9	27.1	19.3	20.8	20.9	18.2

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

The discovery of new possible and likely gas reserves depends on the investments made in the field of geological exploration by local producers and by companies operating in Romania, as well as on the success rate of exploration wells, that is discovering new reserves. It is expected that, by identifying new reserves and by implementing new exploration – research – exploitation technologies, there will be an increase in resources and reserves.

In the short and medium term, reliable oil and natural gas reserves could be increased by implementing new strategies that lead to a growth in the degree of recovery in reserves and new projects for deep water and off-shore exploration on the continental shelf of the Black Sea.

Furthermore, in the medium and long term, the development of unconventional gas resources (shale gas) will receive special attention. The research in this field has barely begun and an estimate of these resources will be possible only after the beginning of exploitation over the next period.

Table 1.10 shows the evolution of primary and final energy consumption between 2007 and 2012. The share of final energy consumption in total primary energy consumption grew in 2008 as compared to 2000, as a result of the improvement of energy efficiency. A growth in the share of final energy consumption in primary energy consumption was also seen between 2007 and 2012, its proportion reaching 65.3% in 2012. This growth is partially due to the improvement of energy efficiency and partially to the structural changes in national economy.

Table 1.10 Evolution of energy consumption between 2007 and 2012 [ktoe]

Year	2007	2008	2009	2010	2011	2012
Primary energy consumption	**39159**	**39658**	**34328**	**34817**	**35648**	**34851**
Final energy consumption, of which in:	**24658**	**25002**	**22387**	**22739**	**22750**	**22766**
- Industry	9075	8544	6202	6613	6618	6346
- Constructions	554	571	410	407	474	450
- Transport	4729	5399	5377	5107	5313	5351
- Residential	7559	8089	8037	8124	7883	8095
- Agriculture	260	293	385	391	433	499
- Utilities	2481	2106	1976	2097	2029	2025

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

Between 2007 and 2008, the GDP (expressed in terms of constant prices, Euro 2005) grew by 7.3% but primary energy consumption and final energy consumption grew only by 1.3% and 1.4%, respectively. In conclusion, economic growth and energy consumption growth are no longer interconnected.

Between 2011 and 2012, the GDP (expressed in terms of constant prices, Euro 2005) grew by approximately 2.9% but primary energy consumption decreased by 0.1% and final energy consumption increased by 0.1%.

Between 2007 and 2012, there were changes in the structure of final energy consumption. Thus, the share of the industry consumption decreased from 36.8% in 2007 to 27.9% in 2012. The share of the residential consumption grew from 30.3% in 2007 to 35.6% in 2012, exceeding its share in the industry. The share of the transport consumption grew from 19.2% in 2007 to 23.5% in 2012. There is also a growth in the share of the utilities consumption from 8.4% in 2008 to 8.8% in 2012.

If we are to analyze the evolution of macroeconomic energy consumption indicators (**Table 1.11**), we find that primary energy consumption per capita, which had grown between 2000 and 2008 at an average annual rate of 1.68%, reaching the value of 1.931 toe, dropped during the crisis period to 1.685 toe (2009), below the EU-27 average (3.375 toe/capita in 2011).

The evolution of primary and final energy intensity during the crisis period does not allow drawing conclusive conclusions regarding the growth of energy efficiency, in line with the second National Energy Efficiency Action Plan (2011-2013).

The industry energy intensity decreased by 42% between 2007 and 2012 due to energy efficiency growth measures, but also due to the restructuring that took place during the crisis period.

Taking into account the energy intensity of the Romanian economy, it is mandatory to continue the policies and measures aimed at increasing energy efficiency, which in its turn ensures a sustainable development.

Table 1.11 Evolution of energy macroeconomic indicators between 2007 and 2012

Year	2007	2008	2009	2010	2011	2012
Primary energy consumption per capita [toe/capita]	1.875	1.931	1.685	1.719	1.769	1.734
Primary energy intensity [toe/1000 euro 2005]	0.428	0.404	0.374	0.384	0.384	0.373
Final energy intensity [toe/1000 euro 2005]	0.269	0.254	0.244	0.251	0.245	0.244
Industry energy intensity [toe/1000 euro 2005]	0.361	0.336	0.252	0.230	0.216	0.210

(Source: National Institute of Statistics – collections and Table 1.1)

Table 1.12 shows the evolution of electricity production in Romania between 2007 and 2012 as well as the structure of production. It should be noted that there is an increase in electricity production in wind power plants as a result of the implementation of the National Action Plan for Renewable Energy Sources.

Table 1.12 Evolution of electricity production [GWh]

Year	2007	2008	2009	2010	2011	2012
Electricity production, of which:	61680	64956	58016	60979	62216	59047
- **Hydroelectric energy**	15970	17196	15807	20243	12337	14946
- **Wind energy**	0	5	9	306	1387	2640
- **Photovoltaic solar energy**	0	0	0	0	0	8
- **Nuclear energy**	7710	11224	11752	10624	11749	11467
- **Thermoelectric energy**, of which:	38000	36531	30448	28806	34134	32595
• Coal	25100	25824	21727	20675	24751	22926
• Gaseous hydrocarbons	11560	9921	7632	7253	8366	8698
• Liquid hydrocarbons	760	568	877	500	498	427
• Renewable energy sources	580	218	212	378	519	544

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

Based upon exploitation data sent by producers, the following were assessed according to Government Resolution No. 219/2007:

- Electricity and thermal energy production by cogeneration of each energy producer who owns cogeneration units, based on the calculation method in Annex II of Directive 2004/8/EC;
- (Electric/thermal) cogeneration capacities;

- Fuel quantities;

- Energy produced by high-efficiency cogeneration and savings arising from the use of cogeneration, determined according to Annex III of Directive 2004/8/CE (**Table 1.13**).

There is a growth tendency in electric and thermal energy production by independent producers for industrial use, but its share remains low.

Table 1.13 Domestic electricity and thermal energy production in cogeneration between 2007 and 2012

Year	Total energy produced in cogeneration units	Energy produced by cogeneration (Annex II Directive 2004/8/EC)	of which in:		Cogeneration energy s hare in total domestic production	Effective thermal energy in cogeneration units (Annex II Directive 2004/8/EC)	of which in:	
			Power plants	Independent producers			Power plants	Independent producers
	TWh	TWh	TWh	TWh	%	PJ	PJ	PJ
2007	14.23	6.62	5.65	0.97	10.7	73.2	61.7	11.6
2008	14.06	6.21	5.24	0.97	9.6	71.5	58.6	12.9
2009	12.33	6.26	5.4	0.86	10.8	66.3	54.7	11.6
2010	11.93	6.54	5.38	1.16	10.8	69.0	53.5	15.5
2011	13.47	7.28	6.01	1.27	11.9	71.9	55.0	16.9
2012	14.69	8.98	7.41	1.57	15.2	78.4	59.97	18.73

(Source: ANRE reports from 2007-2012)

In 2011, electricity and thermal energy cogeneration capacities were installed as shown in **Table 1.14** by technologies. It can be concluded from this table that the installed electric capacity of cogeneration units in the National Energy System (NES) was of about 4454 MWe at the end of 2011, of which only 1900 MWe represents high-efficiency cogeneration capacity. More than 70% of installed capacities are more than 25 years old and about half of them are over 35 years old. Most of the capacities are oversized and about 80% of them are used for urban heating. In 2011 new cogeneration capacities of 60 MWe were put into operation.

Table 1.14 Electricity and thermal energy installed cogeneration capacity in 2011

Cogeneration technology	**Maximum capacity (MW)**	
	Electrical - gross	**Thermal - net**
Combined cycle	186.25	187.83
TG with heat recovery	116.14	186.29
Internal combustion engines	104.42	97.43
Back-pressure ST	810.98	3468.80
Condensing ST with steam inlet	3237.00	6471.98
Other heating technologies	0.13	0.47
TOTAL	**4454.92**	**10412.50**

(Source: ANRE report)

Table 1.15 shows the quantity of fuels used to produce electricity and thermal energy by cogeneration between 2007 and 2012.

Table 1.15 Quantity of fuels used to produce electricity and thermal energy by cogeneration between 2007 and 2012

Year	Total fuel used in cogeneration units	Fuel used in cogeneration (Annex II Directive 2004/8/CE)	of which:				
			Coal	Burning oil	Natural gas	Renewable and wastes	Other fuels
	PJ	PJ	%	%	%	%	%
2007	221.4	122.8	38.2	8.3	52.8	0.0	0.7
2008	216.8	118.1	39.5	6.3	52.8	0.0	1.4
2009	188.6	112.4	39.8	6.9	49.7	0.5	3.1
2010	186.1	117.3	38.6	3.8	50.8	1.9	4.9
2011	200.4	124.3	38.2	3.5	52.4	2.0	3.9
2012	222.8	138.2	38.3	3.7	51.8	2.1	4.1

(Source: ANRE Report)

The use of high-efficiency cogeneration resulted in energy production and primary energy savings as shown in **Table 1.16** for the period 2007-2011. Primary energy savings are determined in comparison with the separate production of energy.

Table 1.16 Electricity production and primary energy savings by high-efficiency cogeneration between 2007 and 2011

Year	Energy in high-efficiency cogeneration (Annex III Directive 2004/8/EC)	Fuel consumption in high-efficiency cogeneration (Annex III Directive 2004/8/EC)	Absolute PES value (Annex III Directive 2004/8/EC)	PES (Annex III Directive 2004/8/EC)
	TWh	PJ	PJ	%
2007	4.4	67.9	10.5	13.4
2008	3.7	62.4	9.2	12.8
2009	3.5	49.6	8.2	14.2
2010	3.3	47.5	8.0	14.5
2011	3.4	43.3	8.3	16.0

(Source: ANRE Report)

From April 2011 the bonus-type support scheme for the promotion of cogeneration based on the useful heat demand came into effectiveness.

The evolution of final energy consumption for the period 2007-2012 is shown in **table 1.17** resulting the following:

Table 1.17 Final energy consumption [GWh]

Year	2007	2008	2009	2010	2011	2012
Final energy consumption, of which:	40949	41775	37605	41317	42714	42383
- Industry	21758	21993	17214	19734	20392	19685
- Constructions	934	842	793	967	691	720
- Transport	1463	1401	1383	1355	1424	1228
- Residential	10039	10040	11021	11329	11577	12035
- Agriculture and forestry	539	555	493	671	761	820
- Utilities	5720	6432	6526	7581	7869	7895

(Source: National Institute of Statistics – Romanian Energy Balance - collections)

- The final energy consumption grew from 40949 GWh in 2007 to 41775 GWh in 2008 (2%), dropping to 37605 GWh in 2009, a crisis year, and grew up to 42383 (about 13%) in 2012;

- The main share in final energy consumption is held by the processing industry (52.6% in 2008 and 46.4% in 2012). This share decreased in 2009, a crisis year, to 45.8%;

- The most significant growth in final energy consumption was in the utilities sector, from 13.99% in 2007 to almost 18.6% in 2012;

- Final energy consumption grew in the residential sector as well, from 25% in 2008 to over 28% in 2012.

- The share of final energy consumption in agriculture and forestry remained relatively constant (1.3%) between 2007 and 2009 and then it began to increase, reaching 1.9% in 2012.

Table 1.18 shows the evolution of final energy consumption per capita and final energy intensity between 2007 and 2012. There is a growth tendency of final energy consumption per capita, reaching a value of 2011 kWh, which is 2.6 times less than the EU average in 2011 (5502 kWh/capita).

Table 1.18 Evolution of energy indicators between 2007 and 2012

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Final energy consumption per capita [kWh/capita]	1961	2034	1846	2040	2120	2109
Final energy intensity [kWh/1000 euro 2005]	447.6	425.7	410.2	455.7	460.6	454.2
Share of electricity consumption in final energy consumption [%]	14.3	14.4	14.5	15.6	16.1	16.0

The share of electricity consumption in the final energy consumption showed a growing tendency between 2007 and 2012. Nevertheless, both this share and the reduced consumption per capita reflect low penetration level of electricity in social and economic activities.

The evolution of final energy intensity between 2007 and 2012 reflects the need to continue the energy efficiency growth measures.

2. Overview of National Targets regarding energy and achieved savings

2.1 National energy efficiency targets for 2020, as required by Art. 3 (1) of EED

The indicative national energy efficiency target is based on primary energy consumption.

Romania's indicative national energy efficiency target is to achieve primary energy savings of **10 million toe** by 2020, which would mean a reduction in forecasted primary energy consumption (52.99 million toe) through the PRIMES 2007 model for a realistic scenario of **19%.**

Reaching this target means that in 2020 primary energy consumption and final energy consumption will reach 42.99 million toe and 30.32 million toe, respectively.

According to data communicated by the NIS for 2012, the primary energy consumption was 34.85 million toe.

In May 2014, The National Forecast Commission presented the growth rate of GDP in **Table 2.1** in the Scenario for the Convergence Programme 2014-2017. Taking into account these growth rates of GDP between 2014 and 2017 and an average growth rate of GDP of 3.3% between 2018 and 2020, the forecast of primary energy consumption and final energy consumption for the period 2014-2020, without taking any energy efficiency growth measures, is shown in **Table 2.2.**

Table 2.1 Projection of Gross Domestic Product

Year	2012	2013	2014	2015	2016	2017
Gross Domestic Product [billion lei]	586.7	628.6	662.3	698.6	736.9	778.2
Real growth [%]	0.6	3.5	2.5	2.6	3.0	3.3

Table 2.2 Forecast of primary energy consumption [ktoe]

Year	2012	2016	2020
Primary energy consumption	34851	37890	44150
Energy sector consumption	2960	3050	3300
Losses	1343	1340	1340
Non-energy consumption	1953	2555	3850
Final energy consumption, of which:	22766	27095	31960
- Industry	6346	8350	9750
- Constructions	450	545	730
- Transport and telecommunications	5351	6250	8050
- Residential	8095	8800	9500
- Agriculture, forestry and fishing	499	700	880
- Utilities	2025	2370	3050

According to this forecast, in order for Romania to fulfill its commitment, that is, a consumption of 42.99 Ktoe, the primary energy reduction target in 2020 is 1.15 million toe. To limit the final energy consumption to 30.32 million toe in 2020, the reduction target of this consumption is 1.64 million toe in 2020.

Table 2.3 shows energy savings that are going to be achieved between 2014 and 2020 through the measures in the National Action Plan, in order to meet Romania's target and the provisions of Directive 2012/27/EU.

Table 2.3 Energy savings between 2014 and 2020

Political measures	2014	2015	2016	2017	2018	2019	2020	Total
Energy supply system – transformation. transmission and distribution								
• National Investment Plan								
• OTC reduction in EDN	0.01 ktoe	0.01 ktoe	0.01 ktoe	0.01 ktoe	0.01 ktoe	0.01 ktoe	0.02 ktoe	0.08 ktoe
• OTC reduction in ETN	0.001 ktoe	0.001 ktoe	0.001 ktoe	0.001 ktoe	0.001 ktoe	0.002 ktoe	0.002 ktoe	0.009 ktoe
• Intelligent metering				0.001 ktoe	0.004 ktoe	0.005 ktoe	0.005 ktoe	0.015 ktoe
• Promotion of high-efficiency cogeneration	0.005 ktoe	0.02 ktoe	0.03 ktoe	0.035 ktoe	0.04 ktoe	0.05 ktoe	0.06 ktoe	0.240 ktoe
• Continuation of the "District heating between 2006 and 2015 – heat and comfort" program	0.022 ktoe	0.024 ktoe	0.026 ktoe	0.028 ktoe	0.031 ktoe	0.034 ktoe	0.037 ktoe	0.202 ktoe
Energy efficiency in the industry								
• EE in the industry in EU-ETS	0.14 ktoe	0.14 ktoe	0.14 ktoe	0.14 ktoe	0.14 ktoe	0.14 ktoe	0.14 ktoe	0.980 ktoe
• Energy audit and energy management	0.05 ktoe	0.05 ktoe	0.05 ktoe	0.05 ktoe	0.05 ktoe	0.05 ktoe	0.05 ktoe	0.05 ktoe
Energy efficiency in the residential sector								
• Thermal rehabilitation of apartment blocks	0.035 ktoe	0.058 ktoe	0.074 ktoe	0.087 ktoe	0.090 ktoe	0.098 ktoe	0.102 ktoe	0.544 ktoe
• Thermal rehabilitation of single-family residences	0.008 ktoe	0.029 ktoe	0.043 ktoe	0.059 ktoe	0.067 ktoe	0.071 ktoe	0.079 ktoe	0.356 ktoe
• Purchase of high-performance electric equipment	0.008 ktoe	0.014 ktoe	0.05 ktoe	0.075 ktoe	0.100 ktoe	0.105 ktoe	0.110 ktoe	0.462 ktoe
• Energy audit and energy management	0.001 ktoe	0.003 ktoe	0.007 ktoe	0.009 ktoe	0.013 ktoe	0.017 ktoe	0.02 ktoe	0.07 ktoe

Political measures	2014	2015	2016	2017	2018	2019	2020	Total
Energy efficiency in the service sector								
• Thermal rehabilitation of government buildings		0.003 ktoe	0.004 ktoe	0.004 ktoe	0.004 ktoe	0.004 ktoe	0.004 ktoe	0.023 ktoe
• Purchase of high-performance electric equipment and appliances for government buildings	0.001 ktoe	0.001 ktoe	0.001 ktoe	0.0015 ktoe	0.0015 ktoe	0.002 ktoe	0.002 ktoe	0.01 ktoe
• Thermal rehabilitation of public buildings (such as mayor's offices and schools)	0.002 ktoe	0.005 ktoe	0.010 ktoe	0.012 ktoe	0.015 ktoe	0.017 ktoe	0.02 ktoe	0.081 ktoe
• Purchase of high-performance electric equipment and appliances for public buildings		0.005 ktoe	0.005 ktoe	0.005 ktoe	0.005 ktoe	0.01 ktoe	0.01 ktoe	0.04 ktoe
• Rehabilitation of public lighting	0.001 ktoe	0.003 ktoe	0.005 ktoe	0.008 ktoe	0.009 ktoe	0.01 ktoe	0.12 ktoe	0.048 ktoe
• Rehabilitation of public water supply networks				0.001 ktoe	0.001 ktoe	0.001 ktoe	0.001 ktoe	0.004 ktoe
• Thermal rehabilitation of buildings (such as offices and commercial spaces)			0.009 ktoe	0.05 ktoe	0.05 ktoe	0.05 ktoe	0.05 ktoe	0.209 ktoe
• Purchase of high-performance electric equipment and appliances for the service sector	0.001 ktoe	0.0015 ktoe	0.002 ktoe	0.003 ktoe	0.0045 ktoe	0.005 ktoe	0.006 ktoe	0.023 ktoe
• Improvement of energy services/ESCO market					0.141 ktoe	0.200 ktoe	0.300 ktoe	0.641 ktoe
Transport sector								
• Renewal of the vehicle fleet (cars and goods vehicles)	0.024 ktoe	0.045 ktoe	0.045 ktoe	0.045 ktoe	0.045 ktoe	0.045 ktoe	0.045 ktoe	0.294 ktoe

Political measures	2014	2015	2016	2017	2018	2019	2020	Total
• Modernization of urban public transport	0.0196 ktoe	0.0196 ktoe	0.0196 ktoe	0.0196 ktoe	0.0196 ktoe	0.0196 ktoe	0.0196 ktoe	0.137 ktoe
• Extension of the subway in Bucharest						0.02 ktoe	0.033 ktoe	0.053 ktoe
• Modernization of the rail network	0.012 ktoe	0.017 ktoe	0.017 ktoe	0.017 ktoe	0.017 ktoe	0.017 ktoe	0.017 ktoe	0.114 ktoe
• Modernization of the shipping system	0.0005 ktoe	0.0005 ktoe	0.0005 ktoe	0.0005 ktoe	0.0005 ktoe	0.0005 ktoe	0.0001 ktoe	0.004 ktoe
• Modernization of the air transport system	0.0003 ktoe	0.0007 ktoe	0.0007 ktoe	0.0007 ktoe	0.0008 ktoe	0.0009 ktoe	0.0009 ktoe	0.005 ktoe
• Alternative mobility	0.005 ktoe	0.01 ktoe	0.02 ktoe	0.065 ktoe	0.100 ktoe	0.100 ktoe	0.145 ktoe	0.445 ktoe
TOTAL	**0.3464 ktoe**	**0.4603 ktoe**	**0.5938 ktoe**	**0.8273 ktoe**	**1.0599 ktoe**	**1.184 ktoe**	**1.3915 ktoe**	**5.863 ktoe**

3. Policies and measures for the implementation of Directive 2012/27/EU

3.1 Horizontal measures

Improving energy efficiency is one of the top priorities established by the energy strategy of Romania considering its major contribution to ensuring security of supply to consumers, sustainable development and competitiveness, as well as to saving energy resources and reducing greenhouse gas emissions. Because of the intensity of primary energy in Romania, there is a need to adopt certain measures in compliance with Directive 2012/27/EU by maximizing the performances of the existing policies and adopting new measures for the future.

3.1.1 Energy efficiency obligation schemes and alternative measures

In compliance with Art. 7 paragraph (1) of Directive 2012/27/EU, in order to reach the energy efficiency goals, new energy savings must be achieved each year from January 1st, 2014 to December 31st, 2020, of 1.5% of the annual energy sales to the end consumers of all energy distributors or all retail energy sales companies by volume, averaged over the three year period prior to January 1st, 2013. The sales of energy by volume used in transport may be partially or fully excluded from this calculation.

Based on the final energy consumption presented in **table 1.10,** the following average consumption values were determined for the period 2010 – 2012:

- Final energy consumption – 22,725 thousand toe
- Final energy consumption for transport – 5,257 thousand toe
- Final energy consumption excluding transport – 17,495 thousand toe.

Therefore the aggregate energy savings required to ensure the achievement of the committed target for the period 2014 – 2020 should be of **7,347.9 thousand toe.**

Romania has chosen to use the methodology established in Art. 7 paragraph (2) letter (a) for calculating the energy savings estimated to be obtained during the seven-year obligation term (January 1st, 2014 – December 31st, 2020).

Based on this calculation, the aggregate energy savings for the period 2014 – 2020 in order to achieve the committed is **5,817.1 thousand toe.** This accounts for 79% of the value of the energy savings calculated according to Art. 7 paragraph (1) of Directive 2012/27/EU, subject to the requirements under Art. 7 paragraph (3).

The energy efficiency increase potential, given the final energy consumption, is detailed in **Table 3.1,** taking into consideration the consumption share of the various sectors in the overall consumption registered for 2010. The conclusion is that the savings measures should be focused on the sectors with the highest potential to reduce the final energy consumption.

Table 3.1 Estimated potential for reducing the final energy consumption by sectors

Sector	Share of the sector's consumption in the final energy consumption of 2010 [%]	Reduction potential of the final energy consumption [%]
Industry	31	13
Buildings	36	41.5 (up to 60% in public lighting)
Transport	22	31.5
Services	11	14

(Source: EBRD, ANRE)

The analysis conducted by the interinstitutional working group, consisting of entities with responsibilities in implementing energy efficiency measures, has revealed that it is not appropriate to introduce an obligation scheme in accordance with Article 7(1) of Directive 2012/27/EU.

The economic restructuring carried out and the period of economic crisis and post-crisis have determined a significant reduction in the primary energy consumption, considering also the energy efficiency improvement measures implemented in accordance with the second NEEAP.

In these circumstances, 'alternative' policy measures have been adopted with the following financial support: own resources, bank loans, EU funds, grants etc. State aid will be granted in accordance with the European and national laws in the field.

The Ministry of European Funds intends to achieve the thematic objectives related to energy efficiency improvement in the 2014-2020 period, under the following programmes:

- Large Infrastructure Operational Programme;
- Regional Operational Programme.

The Large Infrastructure Operational Programme for 2014-2020 (European Regional Development Fund - ERDF, Cohesion Fund-FC) has the following thematic objectives:

- TO 7 Promoting sustainable transport and removing bottlenecks in key network infrastructures;
- TO 6 Preserving and protecting the environment and promoting resource efficiency;
- TO 5 Promoting climate change adaptation, risk prevention and management;
- TO 4 Supporting the shift towards a low-carbon economy in all sectors.

The Large Infrastructure Operational Programme includes priority axes in the following fields: Transport Infrastructure, Environment and Climate Change, Clean Energy and Energy Efficiency. Some examples of investments in energy efficiency improvement to be financed under priority axes are:

- Promoting clean energy and energy efficiency to support a low-carbon economy
- Improving energy efficiency in the district heating system in selected cities
- Intelligent and sustainable electricity and natural gas transmission systems

The following investments will be financed under the Priority Axis 'Promoting clean energy and energy efficiency to support a low-carbon economy':

- development and upgrading of electricity and heat generation capacities in biomass power stations and of heat generation capacities in geothermal power stations; consolidation of electricity distribution networks to take energy from renewable sources in safe operation of SEN (the National Energy System);
- building of high efficiency cogeneration power plants for own consumption by enterprises;
- implementation of smart distribution for residential consumers of electricity (demonstration projects carried out by the 8 regional electricity distributors);
- consumption monitoring in industrial sites through smart energy consumption monitoring systems.

The eligible beneficiaries of these priority axes will be local public authorities, electricity distribution operators, CN Transelectrica SA, SN Transgaz SA, companies operating in the industrial sector, private companies.

The Regional Operational Programme for 2014-2020 has 9 thematic objectives, and the following objectives relate to energy efficiency improvement:

- TO - Supporting the shift towards a low-carbon economy;
- TO - Preserving and protecting the environment and promoting resource efficiency.

The thematic objective ‘Supporting the shift towards a low-carbon economy’ includes the following priority axes: PA ‘Energy efficiency in public buildings’ and PA ‘Sustainable development’.

The priority axis ‘Sustainable development’ (allocated budget of EUR 2 654 million) targets the following activities:

- Energy efficiency in residential buildings, including measures to strengthen them;
- Investment in public lighting;
- Measures for urban transport (running tracks, cycle lanes/purchase of environmentally friendly/electric transport means etc.).

Funding granted under agreements signed between the Swiss Government and the Romanian Government.

- CHF 37 million for 4 cities (Arad, Suceava, Cluj, Brașov) for 10 projects in the field of sustainable energy – building envelopment, public lighting, green public transport;

- CHF 4.8 million, the Fund for sustainable energy actions – in the process of signing, Intermediary Body: MDRAP – EEA (European energy award) accreditation, thermal rehabilitation, public lighting, urban planning, including renewable energy supply – beneficiaries: small and medium municipalities/poor towns;

- CHF 24.39 million grant for loans to SMEs – the purpose of the project is to grant loans in 4 priority sectors: production, healthcare services, tourism, marketing of specific energy saving systems/equipment and of systems/equipment using renewable energy sources to streamline SMEs activities. The Intermediary Body is the Ministry of Energy, Small and Medium-sized Enterprises and Business Environment – Directorate for the Implementation of Programmes for Small and Medium-sized Enterprises.

In order to improve the energy efficiency of buildings, Law No 238/2013 on the approval of Government Emergency Ordinance No 63/2012 amending and supplementing Government Emergency Ordinance No 18/2009 on the improvement of the energy efficiency of residential buildings was adopted. The interventions works to improve the energy performance in homes built according to designs developed between 1950 and 1990, the methods of financing, as well as the obligations and responsibilities of public administration authorities and owners’ associations are determined in accordance with the aforementioned law.

The Romanian Government considers efficiency improvement in the electricity and heat generation field to be important. To achieve this goal, the Government adopted GD No 1096/2013 approving the mechanism of transitional allocation of greenhouse gas emission certificates free of charge to electricity producers, for the 2013-2020 period, including the National Investment Plan. This plan, which is presented in Annex 3 of GD, includes investments for the upgrading of the energy sector under Commission Decision C(2012) 4564 final of 6 July 2012 and Commission Decision C(2012) 8776 final of 5 December 2012. The investments included in the National Investment Plan receive a grant amounting to 25% of the eligible expenditure, under financing agreements.

The beneficiaries of the investments included in the National Investment Plan are required to report annually to the Department of Energy on the investment stage and the results regarding the reduction of fuel consumption which leads to a reduction in carbon dioxide emissions.

The Romanian Energy Efficiency Fund operates in accordance with Government Emergency Ordinance No 188/2002 ratifying the Agreement between the Romanian Government and the International Bank for Reconstruction and Development, Government Emergency Ordinance No 124/2001 on the establishment, organisation and functioning of the Romanian Energy Efficiency Fund, and Law No 287/2002 approving Government Emergency Ordinance No 124/2001. This is a public body, legally incorporated, financially independent and autonomous.

The main activity of the Romanian Energy Efficiency Fund consists in managing the funds from the Global Environment Fund granted to Romania through the International Bank for Reconstruction and Development, and financing investment projects intended to improve Romania's energy efficiency. The activity is conducted in direct correlation with the priorities of the national energy efficiency policy.

The fundamental mission carried out by the Romanian Energy Efficiency Fund follows three major axes:

- Demonstrate the profitability of investments in energy efficiency with the funded projects;
- Attract the Romanian banking sector and the private one in co-financing;
- Raise political decision-makers' awareness of the allocation of resources and/or financial and fiscal incentives.

Since it is complementary to the traditional actors in the Romanian banking sector which are interested in supporting investment programmes in different economic sectors, the Fund is strongly motivated to create its own financing niche by attracting potential beneficiaries and helping them remove the obstacles to financing energy efficiency projects through customer-oriented professional services. Currently, the Romanian Energy Efficiency Fund has on-going financing agreements totalling around USD 14 million.

The analysis of the portfolio of agreements financed by the Romanian Energy Efficiency Fund reveals the following:

- According to its own estimates, for USD 1 invested there are financial benefits of USD 0.28 and a possible profit of USD 0.03 from the trading of CO_2 emission reductions (at minimal quotations of EUR 133 for 1 toe and EUR 4 for 1 tonne of CO_2);
- The private sector invests in energy efficiency; 1 USD lent by the Fund attracts USD 2 (from banks, own revenues and emission trading);
- Project portfolio diversification and the increasing loan volume for co-financing have raised the interest of the banking sector in cooperating with the Fund to jointly co-finance energy efficiency projects.

3.1.2 Energy audits and energy management systems

Law No 199/2000 regarding the efficient use of energy requires energy audits to be conducted for economic operators whose annual energy consumption exceeds 1000 toe (tonnes of oil equivalent) and for the local public administration authorities of cities with more than 20 000 inhabitants, so that they may develop their own energy efficiency programmes that include short- and long-term measures.

Law No 199/2000 also requires the monitoring of large consumers as part of the Energy Management Programme in industry.

Romania has not introduced voluntary agreements as a tool to promote energy efficiency in industry.

According to point 3.3 of part 2 of Annex XIV to Directive 2012/27/EU, the National Energy Efficiency Action Plans shall include:

(a) the number of energy audits carried out in the previous period;

(b) the number of energy audits carried out in large enterprises in the previous period;

(c) the number of large companies in their territory, with an indication of the number of those to which Article 8(5) is applicable.
The current National Energy Efficiency Action Plan analyses data up to the end of 2012, when GO 22/2008 was in force.
According to point 3.3 of part 2 of Annex XIV to Directive 2012/27/EU, the National Energy Efficiency Action Plans shall include:
(a) the number of energy audits carried out in the previous period;
(b) the number of energy audits carried out in large enterprises in the previous period;

(c) the number of large companies in their territory, with an indication of the number of those to which Article 8(5) is applicable.

The current National Energy Efficiency Action Plan analyses data up to the end of 2012, when GO 22/2008 was in force.

In 2002, Order of the Ministry of Industry and Resources (MIR) No 245/2002 approved the Regulation for the certification of the personnel working in the field of energy management and the Regulation for the authorisation of natural and legal persons having the right to draw up energy balance sheets.

In 2003, decisions of the President of the Romanian Agency for Energy Conservation (ARCE) approved Guidelines for the training and examination of trainees in drawing up energy balance sheets, energy management and procedures for monitoring the drawing up of energy balance sheets.

The provisions of Law No 199/2000 were later included in Government Ordinance No 22/2008 which transposed Directive 32/2006/EC on energy end-use efficiency and energy services.

Pursuant to GO No 22/2008, in order to implement the national energy efficiency policy, economic operators whose annual energy consumption exceeded 1000 toe were required to:

- Have a natural or legal person authorised by ANRE (National Energy Regulatory Authority) conduct an annual energy audit based on which energy efficiency improvement measures would be determined and implemented;
- Draw up an energy efficiency improvement plan that would include short-, medium- and long-term measures;
- Appoint an energy manager certified by ANRE in accordance with the laws in force or sign a management agreement with a natural or legal person providing energy services that was accredited under this order;
- Report on energy consumption by submitting to ANRE the Total Annual Energy Consumption Declaration and the Energy Analysis Questionnaire by 30 April each year;
- Submit their own Energy Efficiency Programme to ANRE by 30 September each year, duly updated. Such programme had to include measures designed to improve the energy efficiency expected to be achieved, structured by three time horizons, depending also on the size of the investments needed:
    - Short-term measures, with low investment costs or no investment costs, intended mainly for the organisation and proper functioning of the energy system;
    - Medium-term measures aimed at investments in energy upgrades, recoverable in 3 to 6 years;
    - Long-term measures, aimed at major technological changes, replacement of production lines and processes, with significant impact on energy consumption.

Economic operators with annual energy consumption between 200 and 1000 toe were required to draw up, every 2 years, an energy audit conducted by a natural or legal person authorised by ANRE, based on which energy efficiency improvement measures would be determined and implemented.

The final energy consumers - legal entities listed above were required to have an energy consumption metering, recording and monitoring system and provide to ANRE, upon request, information on energy consumption and energy efficiency indicators.

In addition, GO No 22/2008 required local public administration authorities of cities with more than 20 000 inhabitants to develop energy efficiency improvement programmes that would include short- and long-term measures (3-6 years) aiming at investment programmes for which feasibility studies would be prepared.

The purpose of those audits was to cover a relevant part of industrial consumers. Around 600 consumers with annual energy consumption of over 1000 toe, and between 900 and 1000 consumers with annual energy consumption between 200 and 1000 toe were identified.

Pursuant to the current Romanian legislation on energy efficiency, a large number of enterprises, which are not small and medium-sized enterprises (SMEs), have already conducted annual or biannual energy audits. The enterprises which have not been subject to the legislation until now (consumers of less than 200 toe/year) will be monitored by December 2015.

The obligation to initiate programmes that encourage SMEs to carry out energy audits can be found in the transposition of Directive 2012/27/EU and rests with the Ministry of Energy, Small and Medium-Sized Enterprises and Business Environment.

The tools to ensure that large companies perform energy audits regularly are:

- The database containing the industrial energy consumers which will form the basis for national energy efficiency improvement programmes in accordance with the national strategy in the field. This database includes the List of consumers that use more than 1000 toe/year, data from energy efficiency improvement programmes, reporting documents (Consumption Declarations and Energy Analysis Questionnaires). This database is a key element in identifying an investment portfolio and launching initiatives for cooperation with national and international financial institutions to create specific funding sources;
- The monitoring of large consumers which provides important data on the energy situation of industrial consumers;
- Spot checks conducted by the Directorate-General for Control under ANRE and application of penalties, where appropriate, for non-compliance with the law.

ANRE draws up an Annual Energy Efficiency Inspection Plan that targets the equipment and device market (energy labelling) and monitors compliance with GO No 22/2008. **Table 3.2** shows the number of checks carried out by ANRE between 2010 and 2012.

Table 3.2 Number of checks carried out by ANRE between 2010 and 2012

Year	Number of checks on equipment and device labelling	Number of checks on energy efficiency			
		TOTAL	Economic operators consuming more than 1000 toe	Economic operators consuming between 200 and 1000 toe	Public Administration Authorities
2010	78	117	117	0	0
2011	80	170	170	0	0
2012	65	230	122	100	8

Following the checks carried out in 2011 and 2012, notices were processed, finding and sanctioning reports were drawn up, and fines totalling RON 79 100 were applied in 2011 and RON 226 800 in 2012.

In 2012, in addition to the checks performed in the territory, monitoring activities were carried out, consisting in:

- processing and centralising data on annual energy consumption (declarations and questionnaires) from 223 economic operators in the jurisdiction of the Bucharest Territorial Office;
- updating of database on economic agents with annual energy consumption of more than 1000 toe;
- centralising the data received from the Territorial Offices on economic operators with annual energy consumption of more than 1000 toe which did not have yet certified energy managers;
- processing of data on energy efficiency measures completed or in progress, as transmitted by economic operators under annual programmes of energy efficiency measures.

According to ANRE Order No 38/2013, all the criteria laid down in Annex VI of Directive 2012/27/EU on energy efficiency were taken over.

Consumers that integrate the energy management system may develop and implement an energy policy, establish objectives, targets and action plans, and notify to ANRE the option to be exempted from the Directive on auditing.

Energy efficiency improvement programmes are synthesised by ANRE, as the monitoring of the energy managers' activity includes creating a database with information extracted from these Programmes.

3.1.3 Metering and billing

The use of smart meters ensures a more accurate energy consumption billing based on actual consumption and enables making decisions regarding incentive pricing systems to flatten the load curve and reduce the billed amount.

The electricity and gas law (Law No 123/2012) requires the existence of a meter in each power consumption point. Meters are owned by distribution operators, which are responsible for the operation and maintenance thereof, even if sometimes these activities are outsourced. The meters are read at least once a year (as required by the regulatory authority; however, distribution operators usually read them once every three months). Customers have the possibility to read meters themselves, in which case the billed amount is the consumption reported by the customer or the estimated consumption.

A similar situation is in the gas market, where every point of consumption must have a meter. In the case of apartment buildings, there may be a meter for each entrance of the building or for the entire building, and the distribution of costs or the determination of the individual consumption by customer/apartment is the responsibility of the residents' association.

The situation is similar also in the field of heat, having its own characteristics. Meters are installed where pipes enter the building. Here too, the residents' association distributes the costs or divides the consumption, but each customer/apartment must be equipped with individual water meters that indicate the water consumption based on which costs are distributed. However, these meters are mandatory only for water consumption, not heat, and consumers who do not possess a heat meter will usually pay the difference between the billed amount of the building/entrance and the consumption reported by the customers who have individual meters.

In many cases, apartments do not have individual heat meters, thus causing a lack of transparency on the payments that individual consumers need to make to pay the total bill of the owners' association. Moreover, district heating companies are not transparent with regard to the level of heat consumption.

Point 2 of ANNEX I to Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC states that “Member States shall ensure the implementation of intelligent metering systems that shall assist the active participation of consumers in the electricity supply market. The implementation of those metering systems may be subject to an economic assessment of all the long-term costs and benefits to the market and the individual consumer or which form of intelligent metering is economically reasonable and cost-effective and which timeframe is feasible for their distribution”. Such assessment should have taken place by 3 September 2012. Subject to that assessment, Member States or any competent authority they designated should have prepared a timetable with a target of up to 10 years for the implementation of intelligent metering systems. Where roll-out of smart meters was assessed positively, at least 80 % of consumers would have been equipped with intelligent metering systems by 2020.

The provisions of the aforementioned Directive are transposed into Electricity and Gas Law No 123/2012; Article 66 ‘Intelligent metering systems’ of this law states:

- (1) “ANRE shall assess the implementation of intelligent metering systems in terms of long-term costs and benefits to the market, profitability, and feasible implementation timeframe.

- (2) If the assessment referred to in paragraph (1) reveals that the implementation of intelligent metering systems is advantageous for the operation of the energy market, ANRE approves a timetable for the implementation of intelligent metering systems so that 80% of customers will have intelligent metering systems by 2020”.

In order to assess the long-term costs and benefits to the market, the study ‘Intelligent Metering in Romania’ was conducted on 3 September 2012 with the support of the European Bank for Reconstruction and Development (EBRD), which established the feasibility of implementing smart meters, including a cost-benefit analysis to assess the possibility of rolling-out smart meters on the electricity, gas and heat markets in Romania.

The study indicates that implementing intelligent metering in the electricity sector has the potential to be a profitable investment due to the benefits from reducing grid losses and operating costs for utilities.

In the gas sector, there is a risk that the benefits do not cover all the costs related to the implementation of smart meters. The benefits of reducing gas losses are much lower than the benefits in the electricity sector and the reduction in operating costs does not justify significant investments. If we assume that the pace of installation of gas meters will be rather slow, then the opportunity analysis for the gas sector may be slightly positive. In addition, investing in smart meters may be more profitable for certain utilities if the internal synergies in the purchasing and installation processes are explored.

At this stage, major benefits can be achieved in the heating sector by installing individual meters, while the additional benefits deriving from the installation of smart heat meters are minor. Moreover, benefits in this sector may be achieved by installing technologies for home networks and energy management systems, whether or not smart meters are installed.

The additional arguments for the implementation of smart electricity meters are the benefits to the entire Romanian society, which may result from the installation of smart grids, based on a smart metering infrastructure. Significant reductions in electricity consumption and CO_2 emissions may be achieved by providing information on consumption either on central Internet portals, which consumers can access on the Internet, or directly on the devices available in consumption points. In addition, ‘demand response’ solutions can help reduce peak consumption by using information from smart meters and the communication channel provided by the smart metering infrastructure.

In these circumstances, ANRE Order No 91/2013 on the implementation of intelligent metering systems for electricity was developed and approved.

Before ANRE Order No 91/2013, there were pilot projects in Romania which focused on the installation of automatic meter reading equipment, as opposed to the more complex advanced metering management systems and advanced metering infrastructure. Such projects included:

- Installation of advanced metering management systems to approximately 1300 households and small economic operators (low voltage consumers); the meters communicated via electrical lines combined with fibre optics and GPRS;
- Starting a remote reading system for about 8000 households and small economic operators, using GPRS as communication infrastructure;
- Installation of advanced metering management systems to nearly 13 000 households and small economic operators; communication was via PLC (from low voltage to medium voltage), and consumption was measured every 60 minutes;
- An automatic reading system, installed to about 35 000 economic operators, using GPRS communication.

Such pilot projects in Romania were implemented especially to customers – legal persons that used medium voltage, had an automatic reading system installed, or even a more sophisticated version, thus enabling remote monitoring of consumption.

In the gas sector, automatic reading systems have been installed only to 3000 consumers so far.

It is estimated that in 2012 only 1% of electricity consumers and 0.1% of gas consumers benefited from intelligent metering.

For each distribution operator to assess the costs required for investments in intelligent metering systems and the specific aspects of distribution networks in order to determine the final conditions of implementation, it is necessary to have pilot projects implemented in 2014, period in which optimal technical solutions adapted to the type of consumers, electricity distribution infrastructure and communications infrastructure will be finalised. These projects must cover both urban and rural areas with large technological consumptions, areas with electricity grids requiring significant upgrading, and urban and rural areas with relatively good or recently upgraded grids. The results obtained from the implementation of pilot projects may form the basis for possible adjustments of the plans regarding the implementation of intelligent metering systems for the 2015-2020 period, which will contain the structure, size and schedule of the final plan for the implementation of intelligent electricity metering systems.

Based on the proposals of concession-holder distribution operators, by 31 December 2015 ANRE will approve the national timetable for the implementation of intelligent metering systems, which will include the dates of the implementation stages and the national plan for the implementation of intelligent metering systems regarding the works to be carried out by each concession-holder distribution operator, the value of such works, funding sources, and measures to inform end customers.

The purpose of ANRE Order No 91/2013 is to determine:

- The mandatory and optional functionalities to be met by the intelligent metering systems for electricity which will be implemented in Romania;

- How the intelligent metering systems for electricity will be implemented (planning and scheduling for the 2014-2010 period, integration with the investment plans of those responsible for implementation);
- How the implementation process of intelligent metering systems for electricity will be monitored during implementation (implementation monitoring and reporting indicators, reporting frequency).

The level of expenditure, the level of losses in electricity grids, the volume of investments in grids are indicators of the quality of distribution/transmission which are monitored in order to be improved following the implementation of intelligent metering systems in Romania.

We mention that, once intelligent metering systems (IMS) for electricity are implemented, it should be easier to monitor and improve the functioning and operating grid parameters that help improve energy efficiency, such as: reduction of own technical and non-technical technological consumption, duration of power cuts, number of incidents, voltage drops, level of expenditure, volume of investments in grids, reduction of operating costs related to remote reading and connection/disconnection of the consumption point.

There are also positive effects for grid operators: a more effective monitoring of the electricity transmitted and distributed, grid status monitoring, reduction of operating costs related to reading, connection, disconnection of the consumption point (where applicable).

It should be mentioned that the benefits resulting from the implementation of intelligent metering systems will be reflected in the final consumer's ability to manage the energy consumption, thus leading to a more efficient use and saving of energy, access to advanced pricing systems, easy switch from one supplier to another, given the opening of the electricity market.

Electricity suppliers also benefit from the advantages of intelligent metering by applying advanced pricing systems, thus leading to the optimisation of the electricity consumption billing for the consumer.

It should be mentioned that grid operators are required to post relevant data on the implementation of intelligent metering systems on their webpages, for information purposes.

Depending on the option of the final customer, holder of a smart meter, the final customer can be the beneficiary of a single bill for all utilities, i.e. consumption of electricity, gas, heat, hot water.

As regards the energy efficiency criteria for grid tariffs, regulations have been developed, such as ANRE Order No 72/2013 approving the Methodology for setting tariffs for electricity distribution, which stipulates that "For investments in the implementation of intelligent metering systems, a regulated rate of return (RRR) shall be applied at the end of the regulation period, increased by 0.5 percentage points, subject to a reduction by 1 percentage point in the own technological consumption compared to the target approved for low voltage".

In conclusion, intelligent metering will have a direct impact on:

- the need to improve energy efficiency, through increased transparency in metering information and by stimulating consumers to change their consumption habits accordingly;
- the pressure of regulatory authorities to lower costs, by reducing losses and costs of meter reading and through a better identification of the necessary investments;
- the reaction to increasing demand, by educating consumers to reduce consumption at peak load;
- environmental care, as power peak load reduction will lead to lower production and use of plants with high emissions of carbon dioxide;

- the security of supply, by introducing flexible industrial infrastructures and minimising the number of power stations needed, as well as by increasing the production share in power stations operating at the base of the load curve.

3.1.4 Consumer information programmes and training programmes

Consumer information programmes and training programmes are particularly important to ensure efficient implementation of policies and measures using appropriate financial and technical resources.

In the 2014 National Reform Programme, the Romanian Government states that, in the 2013 campaign to inform the population and businesses on the importance of improving energy efficiency, ANRE organised 8 seminars in 6 cities (Iași, Timișoara, Brașov, Cluj, Galați Bucharest) attended by approximately 370 trainees and presented EU Directive 27/2017, the general objectives of the energy efficiency policy in Romania, energy efficiency issues in public and residential buildings, issues related to funding facilities, issues concerning the thermal rehabilitation of buildings, etc.

It should be mentioned that ANRE has an important role in informing consumers and stimulating training.

To promote energy performance contracting to municipalities, ANRE held working meetings with the EBRD advisory team and the European PPP Expertise Centre (EPEC) representatives. ANRE also held an online seminar (webinar) on energy performance contracting.

The case studies related to projects co-financed from the State budget are disseminated on the ANRE website and in the meetings with consumers. Thus, between 2006 and 2009 the National Programme provided co-financing through allocations from the State budget to investment projects for energy efficiency improvement and use of renewable energy, whose direct beneficiaries were local authorities; pilot projects were developed in the following areas:

- works for the rehabilitation and improvement of district heating systems in terms of generation, transmission and distribution (zonal thermal power stations, block thermal power stations, thermal substations, equipment of stations with efficient heating modules and/or machinery: steam and/or hot water boilers, heat exchangers, pumps, etc.);
- works for the generation of power in cogeneration systems (cogeneration plants, installation of cogeneration groups with heat engines);
- works for the upgrading and expansion of heat transmission and distribution networks in primary circuit and secondary circuit (heating lines, outdoor heating and hot water networks);
- works for the automation of operation of systems and installations and heat metering for final consumers connected to district heating systems;
- works for the use of renewable energy sources (solar energy, geothermal energy, biomass energy - sawdust and other wood waste);
- works for the replacement of the fuel used to generate heat;
- upgrading of indoor and outdoor public lighting;
- thermal rehabilitation of public buildings and use of local RES potential.

All case studies were presented at meetings with industrial consumers.

The participation of Romanian entities in international projects is important as it ensures optimal dissemination of results, by presenting case studies and experiences of EU countries.

ANRE is concerned with raising energy consumers' awareness of the needs and possibilities to reduce energy consumption, highlighting the benefits of energy audits. Thus, the IEE project 'Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe – REMODECE' aimed to monitor energy consumption and carbon emissions in the residential sector and an assessment was made of energy savings that could be achieved with the existing means through efficient use of appliances or by removing/reducing standby consumption.

The main purpose of the IEE project 'Monitoring Electricity Consumption in the Tertiary Sector - EL TERTITY' was to assess energy consumption in public buildings, aiming to collect detailed and reliable information on energy consumption and identify energy efficiency improvement options.

The outcomes of these projects were disseminated on the ANRE website.

To improve energy efficiency in low-income households and communities in Romania, a project funded by the United Nations Development Programme - Global Environment Fund provides specialisation of architects, building engineers, qualified auditors through training courses and postgraduate courses in energy efficiency of buildings. Training courses are held also in RDAs for around 250 participants. The information activity will be carried out by creating seven information points that will highlight the sustainable insulating materials available locally.

The funding programme 'Sustainable Energy Financing Facility' (RoSEFF) is currently active and supports SMEs in Romania to invest in energy efficiency and renewable energy by providing technical and financial facilities. In 2013, RoSEFF together with Business Advisory Services (BAS) in Romania and ANRE organised several training programmes on 'Practical solutions to reduce energy costs for SMEs'.

SC IPA SA's participation as partner in the international project 'Promoting Industrial Energy Efficiency – PINE' funded by the Intelligent Energy Europe Programme aims mainly at improving energy efficiency in industrial SMEs (manufacturing) through audit programmes and providing further technical professional advice for the implementation of customised measures. The expected final results are:

- uptake of effective cost-cutting measures to improve the energy efficiency of SMEs;
- increased investment in highly energy efficient machinery and equipment;
- improved energy management to exploit the energy saving potential.

ANRE has become involved in promoting the development of an energy services market in Romania by participating in the European Energy Service Initiative - EESI project co-financed by the Intelligent Energy Europe programme. The events organised under this project were attended by over 120 representatives of local and central authorities, companies engaged in the energy rehabilitation of public buildings through Energy Performance Contracting (EPC). Issues related to the legislative framework and European experiences (advanced forms of EPC, case studies) were presented. Documents were drawn up under the project, enabling local authorities to initiate investment projects based on the performance contracting-type financial mechanism. Those documents were posted in the Romanian section of the www.european-energy-service-initiative.net website and included: definitions, auditing procedure, contract sample, baseline, tender documents, financing systems, case studies, pilot projects implemented in Romania.

In 2008, the Ministry of Regional Development and Housing (currently the Ministry of Regional Development and Public Administration) published the brochure 'Thermal rehabilitation of apartment blocks. 100% thermal comfort with only 20% valuation works' under the National Programme developed with local public administration authorities, stating the following:

- Why thermal rehabilitation was necessary;
- What thermal rehabilitation involved;

- How much thermal rehabilitation cost;
- The role of the local public authority was;
- The steps to be taken by owners' associations;
- How the national programme (actions) worked;
- Interventions;
- Energy performance certificate of a home;
- Ideas to save energy.

This brochure is available on the website of the Ministry of Regional Development and Public Administration (www.mdrap.ro).

Between 2015 and 2020, when the Intelligent Metering System (IMS) is to be implemented, final consumers must be informed of the mandatory and optional functionalities of smart meters, how the energy consumption is monitored, and billing frequency. Proper information ensures the achievement of benefits deriving from the use of smart meters.

3.1.5 Availability of qualification, accreditation and certification systems

Qualification, accreditation and certification systems are created in Romania, as there is a constant concern for training.

In 2009, for industry, GD No 409/2009 approved the detailed rules for the implementation of GO No 22/2008 and Order of the Ministry of Economy No 1767/2009 approved and revised the Regulation for the authorisation of energy auditors and the Regulation for the certification of energy managers.

In 2010, after ARCE was included as department within ANRE, Order of the National Energy Regulatory Authority No 42/2010 approved and revised the Regulation for the authorisation of energy auditors and the Regulation for the certification of energy managers by appointing ANRE to replace ARCE as the competent authority for the authorisation of energy auditors.

In 2011, Order No 34/2011 amended and supplemented the Regulation for the certification of energy managers, approved by Order No 42/2010, as follows:

Energy managers, certified natural persons, are:

- Employees under individual employment contracts of economic operators that consume more than 1000 toe/year (in-house experts);
- Employees under individual employment contracts of a company providing energy services which signs an energy management agreement with economic operators that consume more than 1000 toe/year;
- Sole traders (PFA) that can sign an energy management agreement with economic operators that consume more than 1000 toe/year.

Companies providing energy services may sign energy management agreements with economic operators that consume more than 1000 toe/year only if they have at least one energy manager certified in accordance with the law, employed under an individual employment contract.

In 2013, Order No 38/2013 approved and revised the Regulation for the authorisation of energy auditors and the Regulation for the certification of energy managers and accreditation of companies providing energy services (repealing Order No 42/2010) by introducing minimum criteria for energy audits, including those conducted as part of energy management systems (according to Annex VI of Directive 2012/27/EU).

There are already more than 13 years of experience in implementing the quality assurance system for auditors by authorising them. In the case of in-house experts, the same authorisation procedure will apply as for independent experts.

To improve energy management in industry, an important activity to certify energy managers and authorise energy auditors is carried out within ANRE. Thus, 215 energy auditors were authorised and 339 energy managers were certified from 2010 to 2012 at the meetings of the Technical Secretariat and of the Committee for the authorisation of energy auditors and the certification of energy managers.

There is a Record of energy auditors and energy managers by counties and Bucharest posted on www.anre.ro.

ANRE is concerned with raising the training level of certified managers and improving the preparation of presentation files for examination and re-examination. To this end, in 2011 ANRE organised three seminars attended by 120 certified managers working in energy-intensive industrial enterprises. Those seminars were held as follows:

- In Iași, for the activity area of Iași and Galați territorial offices;
- In Sibiu, for the activity area of Sibiu, Cluj and Târgu Mureș territorial offices;
- In Bucharest, for the activity area of Bucharest and Brașov territorial offices.

Such seminars should be held also between 2015 and 2020.

For the authorisation of energy auditors, natural persons must obtain the certificate of completion of the training course in the conduct and analysis of energy audits.

Two classes of audits are defined in **Table 3.3.**

Table 3.3 Audit Classes

CLASS	**TYPE OF ENERGY AUDIT**		
	Electricity audit	**Heating audit**	**Complex audit**
I	Pi ≤ 1000 kW	Pi ≤ 2000 kW	Pi ≤ 3000 kW
II	Pi > 1000 kW	Pi > 2000 kW	Unlimited

There are 10 higher education institutions approved by ANRE to organise such training. The conditions to be met by these institutions (trainers) in order to be approved can be found in Decision No 57/2003 and are included in the new version of Order No 38/2013 under the chapter 'Conditions for approval of trainers'.

The Curriculum of the three modules is under review:

- Module I - Fundamentals of electricity/heating – 15 hours (5 hours of theory/10 hours of practice)
- Module II - Electrical/non-electrical measurements – 20 hours (10 hours of theory/10 hours of practice)
- Module III - Preparation and analysis of electricity/heating audits – 25 hours (15 hours of theory/10 hours of practice)

Courses will be structured in 3 modules; their duration will be 10 hours/module. Of the total 60 hours of training, 30 hours will be allocated to theoretical training and 30 hours to practical training.

Theoretical training envisages the approval of distance education using an e-learning platform that enables flexibility for the future auditors in choosing the institution where they will attend the courses.

Practical training envisages the approval of direct education at the institution, where the auditors who completed the theoretical training carry out activities in the form of practical courses, case studies and analyses, etc.

ANRE is of the opinion that energy efficiency improvement programmes should include, where appropriate, actions in the following main directions:

- Promote the use of the most efficient energy technologies that are economically and environmentally viable;
- Encourage funding of investments in energy efficiency through participation of the State or the private sector;
- Promote high-efficiency cogeneration and measures needed to improve energy efficiency in heat generation, transmission and distribution systems;

- Promote the use of renewable energy sources by final consumers;
- Set up departments specialised in energy efficiency at the appropriate levels, which will have personnel able to develop, implement and monitor energy efficiency programmes;
- Reduce environmental impact.

As regards buildings, Directive 2010/31/EU on the energy performance of buildings (recasting Directive 2002/91/EC) transposed in the national legislation by Law No 372/2005 on the energy performance of buildings, republished, requires inter alia the energy certification of buildings, document prepared by specialists – natural persons certified by the Ministry of Regional Development and Public Administration. The purpose of the energy performance certificate is to inform building owners and potential buyers or tenants about the energy consumptions in buildings.

Pursuant to Law No 372/2005, republished, and Article 3(4) in conjunction with point A(i) of Annex No 3 to Law No 200/2004 on recognition of diplomas and professional qualifications for regulated professions in Romania, as subsequently amended and supplemented, the Ministry of Regional Development and Public Administration certifies energy auditors for buildings on the basis of the ‘Regulation for the certification of energy auditors for buildings’, as approved by Order of the Minister for Regional Development and Tourism No 2237/2010, as subsequently amended.

According to the certification regulation, natural persons who meet the requirements of the regulation and pass the exam are certified as energy auditors for buildings, by professional levels, in constructions and installations, carry out their activity as sole traders or employees of legal entities, in compliance with the laws in force, and have the following competencies:

a) Energy auditor for buildings, professional level I, in the specialties constructions and installations – symbol AE Ici, draws up energy performance certificates for all categories of buildings referred to in Article 7(1) of Law No 372/2005, republished, which are being built, undergoing thermal rehabilitation, sold or rented;
b) Energy auditor for buildings, professional level II, in the specialties constructions and installations – symbol AE IIci, draws up energy performance certificates for single-family houses and apartment blocks that are being built, and for single-family houses and apartments within apartment blocks that are being sold or rented.

In order to reduce energy consumption and limit CO_2 emissions in buildings, Law No 372/2005, republished, also requires energy inspections of heating and air-conditioning systems in buildings/building units, in accordance with the technical regulations in force at the time of inspections, by technical experts certified by the Ministry of Regional Development and Public Administration based on the Guidelines for the technical-professional certification of specialists in constructions, as approved by Order of the Minister for Public Works, Transport and Housing No 777/2003, as subsequently amended and supplemented.

The list of certified energy auditors for buildings and certified technical experts is posted on the www.mdrap.ro website, by counties and Bucharest.

State control on the uniform enforcement of the laws on the energy performance of buildings and inspection of heating/air-conditioning systems is carried out by the State Inspectorate for Construction based on a procedure approved by Order of the Minister for Regional Development and Public Administration No 3152/2013.

3.1.6 Energy services

The national energy saving policy has focused in particular on stimulating the different categories of consumers to invest in energy efficiency improvement projects, which is an important element in stimulating the demand for services.

Energy services companies and providers can play a greater role in Romania. Energy Services companies (ESCO) can help to create a functioning market for energy efficiency and remove current obstacles. They can also have a very important role in attracting third-party investment capital to complement public funds and in improving the level of technical expertise. The Romanian energy services market, currently underdeveloped, needs active and constant stimulation from local and central State authorities. Efficient support to energy services companies involves overcoming the relatively sceptical attitude of Romanian consumers towards energy efficiency and access to such services.

EU policies and European debates on ESCO can help define a more effective framework for these companies. Local authorities can be a key element in increasing the role of energy services companies on the Romanian market.

ESCOs are normally associated with the concept of energy performance contract under which they are paid based on the achieved energy savings. So far, their operation is not regulated. It is necessary to improve the legislative framework for ESCO schemes and promote energy performance contracting to municipalities by 2016. The following steps must be taken in order to implement this measure:

- Formulate, in cooperation with EBRD experts, recommendations on improving the legislative framework for the implementation of energy efficiency contracting;
- Carry out, in cooperation with EPEC (European PPP Expertise Centre), the promotion actions included in the Energy Performance Contracting Campaign (EPCC).

3.1.7 Savings from horizontal measures

The analysis of energy efficiency improvement programmes presented to ANRE following audit programmes shows annual energy savings of approximately 50 000 toe to energy-intensive consumers in the metallurgical, building materials, chemical etc. industries.

After 2016, annual energy savings of about 15 000 toe in the 2017-2020 period are expected under the programme for the installation of smart meters.

The final consumer information programmes will help change the attitude towards energy consumption, energy savings resulting in the sectors in which final consumers operate and make decisions, as well as in the residential sector.

3.1.8 Funding of horizontal measures

Horizontal measures are financed from own resources and European funds.

3.2 Energy efficiency measures in buildings

Buildings are a central element of the Romanian Government's policy on energy efficiency, given that the national energy consumption in the residential and tertiary sector (offices, commercial areas and non-residential buildings) together account for 45% of the total energy consumption (**Figure 3.1**).

Figure 3.1 *Total energy consumption by category of buildings*
(Source: www.mdrap.ro)

Energy efficiency improvement in existing buildings is essential not only for achieving national energy efficiency objectives in the medium term, but also for achieving the long-term objectives of the strategy on climate change and transition to a competitive low-carbon economy by 2050.

In Romania, the built area is 493 000 000 m^2, 86% of which is represented by residential buildings. Of the 8.1 million housing units, single-family houses predominate, accounting for 61% of them. Almost 47.5% of all homes are located in rural areas. In rural areas, 95% of housing units are individual (single-family) houses.

In urban areas, 72% of housing units are in apartment blocks (which have on average about 40 apartments per block). More than 60% of apartment blocks consist of Ground floor + 4 floors, and 16% of Ground floor + 10 floors.

Romania has a significant number of buildings, built mainly from 1960 to 1990, with low thermal insulation due to the fact that, before the energy crisis of 1973, there were no regulations on the thermal protection of buildings and enclosure elements, and they are no longer suitable for the purpose for which they were built. The final energy consumption in these buildings varies between 150 and 400 kWh/m^2/year.

It is also noted that the buildings built in early 1990s have a low energy performance (150-350 kWh/m^2/year), but those built after 2000 have a higher energy performance (120-230 kWh/m^2/year).

In non-residential buildings, the final energy consumption varies between 120 and 400 kWh/m^2/year depending on the building category (offices, education, culture, healthcare, tourism, commerce, etc.).

Given this situation, in accordance with Article 4 of Directive 2012/27/EU, a strategy has been developed to mobilise investments in the renovation of residential and commercial buildings, both public and private, existing at national level.

3.2.1 Strategy for mobilising investments in the renovation of residential and commercial buildings, both public and private, existing at national level - version 1

The strategy for mobilising investments in the renovation of residential and commercial buildings, both public and private, existing at national level, presented in **Annex B**, has been developed following the steps shown in **Figure 3.2.**

STEP 1 – Stakeholders and information	• Identification of the main stakeholders • Identification of information sources
STEP 2 – Technical and economic assessment	• Characterisation of real property • Economic assessment of potential renovations • Quantification of investment requirements
STEP 3 – Policy evaluation	• Detailed assessment of obstacles • Development of a comprehensive policy package
STEP 4 – Development and consultation	• Draft renovation strategy • Consultation on the draft strategy
STEP 5 – Publication and implementation	• Publication of the final strategy • Initiation of the policy implementation process • Determination of the monitoring and assessment process • Revision and updating of the strategy every 3 years

Figure 3.2 *The steps identified for strategy development*
(Source: www.mdrap.ro)

The strategy has the following primary roles:

- Stimulate debate among key stakeholders on the development and implementation of the strategy to reach a consensus on policies and initiatives aiming to improve energy performance in buildings;
- Encourage all stakeholders to adopt ambitious and appropriate attitudes, intended to improve the quality of residential and commercial buildings, in order to provide immediate and long-term benefits to building owners and support the economy.

The strategy proposes an approach in steps to mobilise investments in long-term renovation of existing residential and commercial buildings, both public and private. It is worth noting that this is a major challenge and an important commitment because:

- jobs can be created, which are needed now and in the decades to come;
- living conditions in buildings and workspaces can be improved;
- dependence on external energy suppliers can be reduced;
- natural resources and well trained human capital can be used optimally, and in this context modern and energy efficient buildings, adapted to the 21st century and the years to come, can be provided.

Thus, a substantial reduction of energy consumption in buildings can be considered achievable, in steps, only through a combination of energy efficiency measures and implementation of the use of renewable energy sources in and on buildings.

The successive key steps identified and proposed for the renovation of buildings in Romania are:

- STEP 1 - Establish the conditions whereby major renovations can become a target within 5 years;

- STEP 2 - Technological development, with regard to building renovation, which can provide the means to achieve a substantial reduction in energy consumption and nearly zero-energy buildings from classical sources, within approximately 15 years;
- STEP 3 - Thorough renovation of buildings within 15 years.

3.2.2. Other measures to promote the energy efficiency of buildings

The measures to promote the energy efficiency of buildings are different depending on representative buildings (existing/new). The following types are under consideration:

- Condominium-type residential buildings (apartment blocks);
- Single-family residential buildings;
- Office/administrative buildings;
- Educational buildings;
- Healthcare buildings.

Energy is used in buildings for heating and cooling, hot water and food preparation, ventilation, lighting and other uses of electricity; there are various methods to provide these services.

Pursuant to Directive 2010/31/EU on the energy performance of buildings, research has been conducted on the methodology framework for calculating the optimal costs for representative buildings (existing/new).

For each type of representative building, the optimal cost was calculated based on the energy efficiency measures scenarios considered. The buildings were considered to be located in cities/towns in winter climate zones II and IV (for existing buildings) and II (for new buildings), and the energy response was shaped based on the hourly climate parameters of a year's climate structure typical for Bucharest and Brașov (existing buildings) and for the city of Bucharest (new buildings).

Tables 3.4, 3.5, 3.6, 3.7, 3.8, 3.9 and 3.10 show solutions for the improvement of energy performance in existing buildings, overall costs calculated from a macroeconomic and financial viewpoint for those solutions, and the optimal cost for each type of building existing according to MDRAP document 'Research on the methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements' posted on the www.mdrap.ro website.

Table 3.4 Solutions for energy performance improvement, overall costs calculated from a macroeconomic/financial viewpoint, and optimal cost - existing public buildings, office type, climate zone II

Measure	**Reference building in current state (SA1)**	**Reference building in current state, equipped with blinds and economic lighting (SA2)**	**Reference building insulated in accordance with C107/2010 (C107-1)**	**Reference building insulated in accordance with C107/2010, equipped with heat recovery system and shutters (C107-2)**	**Reference building insulated in accordance with C107/2010, equipped with heat recovery system, shutters, solar panels and photovoltaic panels (C107-3)**	**Reference building, highly insulated (PS1)**	**Reference building, highly insulated, equipped with shutters and heat recovery system (PS2)**	**Reference building, highly insulated, equipped with shutters, heat recovery system, solar panels and photovoltaic panels (PS3)**

Roof insulation	1.099 W/m^{2}K	1.099 W/m^{2}K	0.25 W/m^{2}K	0.25 W/m^{2}K	0.25 W/m^{2}K	0.21 W/m^{2}K	0.21 W/m^{2}K	0.21 W/m^{2}K
Wall insulation	1.441 W/m^{2}K	1.441 W/m^{2}K	0.625 W/m^{2}K	0.625 W/m^{2}K	0.625 W/m^{2}K	0.303 W/m^{2}K	0.303 W/m^{2}K	0.303 W/m^{2}K
Windows	2.646 W/m^{2}K (double glazing)	2.646 W/m^{2}K (double glazing)	2.00 W/m^{2}K (thermally insulated glazing)	2.00 W/m^{2}K (thermally insulated glazing) and thermally insulated shutters for unoccupied hours in wintertime	2.00 W/m^{2}K (thermally insulated glazing) and thermally insulated shutters for unoccupied hours in wintertime	1.30 W/m^{2}K (thermally insulated glazing)	1.30 W/m^{2}K (thermally insulated glazing) and thermally insulated shutters for unoccupied hours in wintertime	1.30 W/m^{2}K (thermally insulated glazing) and thermally insulated shutters for unoccupied hours in wintertime
Share of glass area in the total building envelope	30.85%	30.85%	17.42%	17.42%	17.42%	17.42%	17.42%	17.42%
Building-related measures (thermal mass etc.)	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (including night-time ventilation)	Unorganised natural ventilation	Natural - unorganised natural ventilation, movable blinds (summertime, occupied hours)	Natural - unorganised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation, infiltrations, movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation, infiltrations, movable blinds (summertime, occupied hours)	Natural - unorganised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation, infiltrations, movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation, infiltrations, movable blinds (summertime, occupied hours)

Measure	**Reference building in current state (SA1)**	**Reference building in current state, equipped with blinds and economic lighting (SA2)**	**Reference building insulated in accordance with C107/2010 (C107-1)**	**Reference building insulated in accordance with C107/2010, equipped with heat recovery system and shutters (C107-2)**	**Reference building insulated in accordance with C107/2010, equipped with heat recovery system, shutters, solar panels and photovoltaic panels (C107-3)**	**Reference building, highly insulated (PS1)**	**Reference building, highly insulated, equipped with shutters and heat recovery system (PS2)**	**Reference building, highly insulated, equipped with shutters, heat recovery system, solar panels and photovoltaic panels (PS3)**
Space cooling system	Split systems – EER = 2.5	Split systems – EER = 2.5	Split systems – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7	Split systems – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7
RES-based measures	-	-	-	-	Solar system for hot water in summertime and photovoltaic panels	-	-	Solar system for hot water in summertime and photovoltaic panels
Lighting type	Incandescent lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall cost (lei/m^2) - macroeconom	2861.63	1965.39	1431.6	1370.07	1609.52	1405.09	1430.42	1684.55

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Overall cost (lei/m^2) - financial	3247.91	2190.96	1647.88	1621.57	1949.36	1650.96	1683.34	2052.16

Table 3.5 Solutions for energy performance improvement, overall costs calculated from a macroeconomic/financial viewpoint, and optimal cost - existing educational buildings, climate zone II

Measure	**Reference building in current state (SA1)**	**Reference building in current state, equipped with blinds and economic lighting (SA2)**	**Reference building in accordance with C107/2010 (C107-1)**	**Reference building in accordance with C107/2010, equipped with heat recovery system and shutters (C107-2)**	**Reference building insulated in accordance with C107/2010, equipped with heat recovery system, shutters, solar panels and photovoltaic panels (C107-3)**	**Reference building, highly insulated (PS1)**	**Reference building, highly insulated, equipped with shutters and heat recovery system (PS2)**	**Reference building, highly insulated, equipped with shutters, heat recovery system, solar panels and photovoltaic panels (PS3)**
Roof insulation	0.888 W/m^{2}K	0.888 W/m^{2}K	0.228 W/m^{2}K	0.22 W/m^{2}K	0.22 W/m^{2}K	0.187 W/m^{2}K	0.187 W/m^{2}K	0.187 W/m^{2}K
Wall insulation	1.477 W/m^{2}K	1.477 W/m^{2}K	0.456 W/m^{2}K	0.456 W/m^{2}K	0.456 W/m^{2}K	0.241 W/m^{2}K	0.241 W/m^{2}K	0.241 W/m^{2}K
Windows	2.564 W/m^{2}K (double glazing)	2.564 W/m^{2}K (double glazing)	2.000 W/m^{2}K (thermally insulated glazing)	1.409 W/m^{2}K (thermally insulated glazing)	1.409 W/m^{2}K (thermally insulated glazing)	1.417 W/m^{2}K (thermally insulated glazing)	1.085 W/m^{2}K (thermally insulated glazing)	1.085 W/m^{2}K (thermally insulated glazing)
Share of glass area in the total building envelope	16.37%	16.37%	16.37%	16.37%	16.37%	16.37%	16.37%	16.37%

Measure	**Reference building in current state (SA1)**	**Reference building in current state, equipped with blinds and economic lighting (SA2)**	**Reference building in accordance with C107/2010 (C107-1)**	**Reference building in accordance with C107/2010, equipped with heat recovery system and shutters (C107-2)**	**Reference building insulated in accordance with C107/2010, equipped with heat recovery system, shutters, solar panels and photovoltaic panels (C107-3)**	**Reference building, highly insulated (PS1)**	**Reference building, highly insulated, equipped with shutters and heat recovery system (PS2)**	**Reference building, highly insulated, equipped with shutters, heat recovery system, solar panels and photovoltaic panels (PS3)**
Building-related measures (thermal mass etc.)	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (including night-time ventilation)	Natural ventilation	Unorganised natural ventilation, movable blinds (summertime, occupied hours)	Unorganised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system - mechanical ventilation, movable blinds (summertime, occupied hours)	Heat recovery system - mechanical ventilation, movable blinds (summertime, occupied hours)	Unorganised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system - mechanical ventilation, movable blinds (summertime, occupied hours)	Heat recovery system - mechanical ventilation, movable blinds (summertime, occupied hours)
Space cooling system	Split systems – EER = 2.5	Split systems – EER = 2.5	Split systems – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7	Split systems – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7
RES-based measures	-	-	-	-	Solar system for hot water in	-	-	Solar system for hot water in

					summertime and photovoltaic panels			summertime and photovoltaic panels
Lighting type	Incandescent lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall cost (lei/m^2) - macroeconomic	2830.84	2414.16	1935.39	1647.12	1748.12	1698.56	1705.07	1800.55
Overall cost (lei/m^2) - financial	3157.78	2666.68	2192.21	1946.66	2126.06	1956.76	2032.76	2201.70

Table 3.6 Solutions for energy performance improvement, overall costs calculated from a macroeconomic/financial viewpoint, and optimal cost - existing healthcare buildings, climate zone II

Measure	**Reference building in current state (SA1)**	**Reference building in current state, organised natural ventilation, use of blinds in the hot season, passive finishing, own boiler (SA2)**	**Reference building insulated in accordance with C107/2010, use of blinds in the hot season, passive finishing (C107-1)**	**Reference building insulated in accordance with C107/2010, use of blinds in the hot season, passive finishing, equipped with shutters and heat recovery system (C107-2)**	**Reference building insulated in accordance with C107/2010, use of blinds in the hot season, passive finishing, shutters and heat recovery system, solar panels and photovoltaic panels (C107-3)**	**Retrofitted building, natural ventilation and blinds in summertime (PS1)**	**Retrofitted building, natural ventilation and blinds in summertime, equipped with shutters and heat recovery system (PS2)**	**Retrofitted building, natural ventilation and blinds in summertime, equipped with shutters and heat recovery system, solar panels and photovoltaic panels (PS3)**
Roof insulation	0.868 W/m^{2}K	0.868 W/m^{2}K	0.162 W/m^{2}K	0.162 W/m^{2}K	0.162 W/m^{2}K	0.162 W/m^{2}K	0.162 W/m^{2}K	0.162 W/m^{2}K
Wall insulation	1.419 W/m^{2}K	1.419 W/m^{2}K	0.454 W/m^{2}K	0.454 W/m^{2}K	0.454 W/m^{2}K	0.312 W/m^{2}K	0.312 W/m^{2}K	0.312 W/m^{2}K
Windows	2.739 W/m^{2}K (double glazing)	2.739 W/m^{2}K (double glazing)	1.349 W/m^{2}K (thermally insulated glazing)	0.978 W/m^{2}K (thermally insulated glazing)	0.978 W/m^{2}K (thermally insulated glazing)	1.090 W/m^{2}K (thermally insulated glazing)	0.827 W/m^{2}K (thermally insulated glazing)	0.827 W/m^{2}K (thermally insulated glazing)
Share of glass area in the total building envelope	14.59%	14.59%	14.59%	14.59%	14.59%	14.59%	14.59%	14.59%
Building-related measures (thermal mass etc.)	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (including night-time ventilation)	Unorganised natural ventilation	Natural – organised natural ventilation, movable blinds (summertime, occupied hours)	Natural – organised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system + mechanical ventilation - movable blinds (summertime, occupied hours)	Heat recovery system + mechanical ventilation - movable blinds (summertime, occupied hours)	Natural – unorganised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system + mechanical ventilation - movable blinds (summertime, occupied hours)	Heat recovery system + mechanical ventilation - movable blinds (summertime, occupied hours)
Space cooling system	Split systems – EER = 2.5	Split systems – EER = 2.5	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7	Split systems – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7
RES-based measures	-	-	-	-	Solar system for hot water in summertime and photovoltaic panels	-	-	Solar system for hot water in summertime and photovoltaic panels
Lighting type	Incandescent lighting	Incandescent lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall cost (lei/m^2) - macroeconomic	5313.01	4679.99	339.94	3167.10	2399.19	3106.82	2940.17	2206.70
Overall cost (lei/m^2) - financial	5982.34	5268.98	3929.47	3711.39	2845.91	3636.38	3488.53	2659.00

Table 3.7 Solutions for energy performance improvement, overall costs calculated from a macroeconomic/financial viewpoint, and optimal cost - existing residential buildings, apartment block type, climate zone II

Measure	**Reference building in current state (SA1)**	**Reference building in current state, organised natural ventilation, use of blinds in the hot season, economic lighting (SA2)**	**Reference building in accordance with C107/2010 (C107-1)**	**Reference building in accordance with C107/2010, equipped with heat recovery system and shutters (C107-2)**	**Reference building in accordance with C107/2010, equipped with heat recovery system, shutters, solar panels and photovoltaic panels (C107-3)**	**Retrofitted building, natural ventilation and blinds in summertime (PS1)**	**Retrofitted building, blinds in summertime, equipped with shutters and heat recovery system (PS2)**	**Retrofitted building, blinds in summertime, equipped with shutters and heat recovery system, solar panels and photovoltaic panels (PS3)**
Roof insulation	2.726 W/m^{2}K	2.726 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K
Wall insulation	1.208 W/m^{2}K	1.208 W/m^{2}K	0.429 W/m^{2}K	0.429 W/m^{2}K	0.429 W/m^{2}K	0.218 W/m^{2}K	0.218 W/m^{2}K	0.218 W/m^{2}K
Windows	2.564 W/m^{2}K (double glazing)	2.564 W/m^{2}K (double glazing)	2.000 W/m^{2}K (thermally insulated glazing)	1.289 W/m^{2}K (thermally insulated glazing)	1.289 W/m^{2}K (thermally insulated glazing)	1.289 W/m^{2}K (thermally insulated glazing)	0.899 W/m^{2}K (thermally insulated glazing)	0.899 W/m^{2}K (thermally insulated glazing)
Share of glass area in the total building envelope	12.53%	12.53%	12.53%	12.53%	12.53%	12.53%	12.53%	12.53%
Building-related measures (thermal mass etc.)	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (including night-time ventilation)	Natural ventilation	Organised natural ventilation, blinds (summertime, occupied hours)	Organised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation - movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation - movable blinds (summertime, occupied hours)	Natural – unorganised natural ventilation, movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation - movable blinds (summertime, occupied hours)	Heat recovery system, mechanical ventilation - movable blinds (summertime, occupied hours)
Space cooling system	Split systems – EER = 2.5	Split systems – EER = 2.5	Split systems – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7	Split systems – EER = 2.7	Radiant cooling – EER = 2.7	Radiant cooling – EER = 2.7
RES-based measures	-	-	-	-	Solar system for hot water in summertime and photovoltaic panels	-	-	Solar system for hot water in summertime and photovoltaic panels
Lighting type	Incandescent lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall cost (lei/m^2) - macroeconomic	2888.16	2699.98	1669.29	1652.96	1523.07	1672.40	1690.08	1558.27
Overall cost (lei/m^2) - financial	3175.19	2950.71	1867.67	1889.85	1833.09	1890.21	1949.12	1890.25

Table 3.8 Energy modernization solutions, overall costs calculated from a macroeconomic/financial point of view and optimal costs – existing residential buildings, single-family buildings, climate zone II

Measure	Reference building in the current stage (CS1)	Reference building in the current stage with blinds and efficient lighting (CS2)	Reference building according to C107/2010 (C107-1)	Reference building according to C107/2010 equipped with heat recovery system, shutters and boiler (C107-2)	Reference building according to C107/2010 equipped with heat recovery system, shutters, boiler, solar panels and photovoltaic panels (C107-3)	Reference building with superior insulation (SI1)	Reference building with superior insulation with shutters and heat recovery system (SI2)	Reference building with superior insulation with shutters, heat recovery system, solar panels and photovoltaic panels (SI3)
Roof insulation	0.895 W/m^2K	0.895 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K
Wall insulation	0.939 W/m^2K	0.939 W/m^2K	0.398 W/m^2K	0.398 W/m^2K	0.398 W/m^2K	0.165 W/m^2K	0.165 W/m^2K	0.165 W/m^2K
Windows	2.326 W/m^2K (double)	2.326 W/m^2K (double)	1.299 W/m^2K (thermally insulated)	0.500 W/m^2K (thermally insulated)	0.50 W/m^2K (thermally insulated)	1.298 W/m^2K (thermally insulated)	0.452 W/m^2K (thermally insulated)	0.452 W/m^2K (thermally insulated)
Share of window area of total building envelope	5.13%	5.13%	5.13%	5.13%	5.13%	5.13%	5.13%	5.13%
Building-related measures (such as thermal mass)	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K
Heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system
Domestic hot water	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system
Ventilation system (incl. night ventilation)	natural	natural organized ventilation, mobile blinds (summer, hours of use)	natural organized ventilation, mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	natural – natural organized ventilation, mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)
Space cooling system	split equipment –	split equipmen	split equipmen	split equipment	split equipment	split equipmen	split equipment	split equipment

	EER = 2.5	t – EER = 2.5	t – EER = 2.7	– EER = 2.7	– EER = 2.7	t – EER = 2.7	– EER = 2.7	– EER = 2.7
Measures based on RES					solar installation for ACM during the summer and photovoltaic panels			solar installation for ACM during the summer and photovoltaic panels
Lighting type	Incandescent lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall costs (RON/m^2) – macroeconomic	6047.64	5147.07	3529.49	3067.44	3222.08	3363.05	2907.06	3063.25
Overall costs (RON/m^2) – financial	6590.61	5614.51	3962.38	3500.44	3747.85	3818.97	3363.46	3612.53

Table 3.9 Energy modernization solutions, overall costs calculated from a macroeconomic/financial point of view and optimal costs – existing residential buildings, apartment blocks, climate zone IV

Measure	Reference building in the current stage (CS1)	Reference building in the current stage with blinds and efficient lighting (CS2)	Reference building according to C107/2010 (C107-1)	Reference building according to C107/2010 equipped with heat recovery system, shutters and boiler (C107-2)	Reference building according to C107/2010 equipped with heat recovery system, shutters, boiler, solar panels and photovoltaic panels (C107-3)	Reference building with superior insulation (SI1)	Reference building with superior insulation with shutters and heat recovery system (SI2)	Reference building with superior insulation with shutters, heat recovery system, solar panels and photovoltaic panels (SI3)
Roof insulation	2.726 W/m^{2}K	2.726 W/m^{2}K	0.243 W/m^{2}K	0. 243 W/m^{2}K	0. 243 W/m^{2}K	0. 243 W/m^{2}K	0. 243 W/m^{2}K	0. 243 W/m^{2}K
Wall insulation	1.208 W/m^{2}K	1.208 W/m^{2}K	0.429 W/m^{2}K	0.429 W/m^{2}K	0.429 W/m^{2}K	0. 218 W/m^{2}K	0.218 W/m^{2}K	0.218 W/m^{2}K
Windows	2.564 W/m^{2}K (double)	2. 564 W/m^{2}K (double)	2.000 W/m^{2}K (thermally insulated)	1.289 W/m^{2}K (thermally insulated)	1.289 W/m^{2}K (thermally insulated)	1.298 W/m^{2}K (thermally insulated)	0.899 W/m^{2}K (thermally insulated)	0.899 W/m^{2}K (thermally insulated)
Share of window area of total building envelope	14.42%	14.42%	14.42%	14.42%	14.42%	14.42%	14.42%	14.42%
Building-	266.060	266.060	266.060	266.060	266.060	266.060	266.060	266.060

related measures (such as thermal mass)	J/m²K	J/m²K	J/m²K	J/m²K	J/m²K	J/m²K	J/m²K	J/m²K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Domestic hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (incl. night ventilation)	natural	natural organized ventilatio n, mobile blinds (summer, hours of use)	natural organized ventilation , mobile blinds (summer, hours of use)	heat recovery system, mechanica l ventilation – mobile blinds (summer, hours of use)	heat recovery system, mechanica l ventilation – mobile blinds (summer, hours of use)	natural – natural organized ventilatio n, mobile blinds (summer, hours of use)	heat recovery system, mechanica l ventilation – mobile blinds (summer, hours of use)	heat recovery system, mechanica l ventilation – mobile blinds (summer, hours of use)
Space cooling system	split equipment – EER = 2.5	split equipmen t – EER = 2.5	split equipmen t – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipmen t – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7
Measures based on RES				photovoltai c panels	solar installation for ACM during the summer and photovoltai c panels		photovoltai c panels	solar installation for ACM during the summer and photovoltai c panels
Lighting type	Incandesce nt lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall costs (RON/m²) – macroeconomi c	3505.36	3724.04	2132.83	1882.31	1912.46	2041.39	1645.59	1751.85
Overall costs (RON/m²) – financial	3844.20	4058.01	2368.29	2074.85	2257.12	2289.53	2046.97	2176.74

Table 3.10 Energy modernization solutions, overall costs calculated from a macroeconomic/financial point of view and optimal costs – existing residential buildings, single-family buildings, climate zone II

Measure	Reference building in the current stage (CS1)	Referenc e building in the current stage with blinds and efficient	Reference building according to C107/201 0 (C107-1)	Reference building according to C107/201 0 equipped with heat	Reference building according to C107/2010 equipped with heat recovery	Referenc e building with superior insulation (SI1)	Reference building with superior insulation with shutters and heat	Reference building with superior insulation with shutters, heat

		lighting (CS2)		recovery system, shutters and boiler (C107-2)	system, shutters, boiler, solar panels and photovoltaic panels (C107-3)		recovery system (SI2)	recovery system, solar panels and photovoltaic panels (SI3)
Roof insulation	0.895 W/m^2K	0.895 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K
Wall insulation	0.939 W/m^2K	0.939 W/m^2K	0.398 W/m^2K	0.398 W/m^2K	0.398 W/m^2K	0.165 W/m^2K	0.165 W/m^2K	0.165 W/m^2K
Windows	2.326 W/m^2K (double)	2.326 W/m^2K (double)	1.299 W/m^2K (thermally insulated)	0.500 W/m^2K (thermally insulated)	0.50 W/m^2K (thermally insulated)	1.298 W/m^2K (thermally insulated)	0.452 W/m^2K (thermally insulated)	0.452 W/m^2K (thermally insulated)
Share of window area of total building envelope	5.13%	5.13%	5.13%	5.13%	5.13%	5.13%	5.13%	5.13%
Building-related measures (such as thermal mass)	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K
Heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system
Domestic hot water	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system	Own heating system
Ventilation system (incl. night ventilation)	natural	natural organized ventilation, mobile blinds (summer, hours of use)	natural organized ventilation, mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	natural – natural organized ventilation, mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)
Space cooling system	split equipment – EER = 2.5	split equipment – EER = 2.5	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7
Measures based on RES					solar installation for ACM during the summer and			solar installation for ACM during the summer and

					photovoltaic panels			photovoltaic panels
Lighting type	Incandescent lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall costs (RON/m^2) – macroeconomic	8106.19	6504.79	4245.26	3481.06	37013.06	3826.17	2653.15	3125.11
Overall costs (RON/m^2) – financial	8812.59	7078.13	4737.09	3948.47	4275.10	4332.09	3559.53	3681.53

Tables 3.11, 3.12, 3.13, 3.14 and **3.15** show solutions for new, energetically efficient buildings, which, according to Article 9 of Directive 2010/31/EU, by January 1st, 2021 should fall within the energy efficiency class for nearly zero-energy buildings; these tables also show overall costs calculated from a macroeconomic and financial point of view for these solutions, and optimal costs for each type of existing buildings according to a document of the Ministry of Regional Development and Public Administration (MRDPA) "Research on the methodological framework for the calculation of optimal costs related to minimum energy performance requirements for buildings and their envelope elements" (www.mdrap.ro).

Table 3.11 Design solutions for energy efficient buildings, overall costs calculated from a macroeconomic and financial point of view for those solutions and optimal costs – new office-type buildings, climate zone II

Measure	Building according to C107/2010 (P1)	Building according to C107/2010 with low window area, equipped with shutters and heat recovery system (P2)	Building according to C107/2010 with low window area, equipped with shutters, heat recovery system, solar panels and photovoltaic panels (P3)	Building with superior insulation with shutters and heat recovery system (P4)	Building with superior insulation with shutters, heat recovery system, solar panels and photovoltaic panels (P5)	Building according to C107/2010 with high window area, equipped with heat recovery system (P6)	Building according to C107/2010 with high window area, equipped with heat recovery system and shutters (P7)	Building according to C107/2010 with high window area, equipped with heat recovery system, shutters, solar panels and photovoltaic panels (P8)	Building with superior insulation with high window area, equipped with shutters and heat recovery system (P9)	Building with superior insulation with high window area, equipped with shutters, heat recovery system, solar panels and photovoltaic panels (P10)
Wall insulation	0.61589 W/m^{2}K									
Roof insulation										
Windows	1.9937 W/m^{2}K (double)		(thermally insulated)							
Share of window area of total building envelope	17.61%									
Building-related measures (such as thermal mass)	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Domestic hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system	Centralized heat supply system
Ventilation system (incl. night ventilation)	natural, mobile blinds (summer, hours of use)	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use)	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system
Space cooling	split equipme	radiant cooling	radiant cooling	radiant cooling	radiant cooling	radiant cooling	radiant cooling	radiant cooling	radiant cooling	radiant cooling

system	nt – EER = 2.7	– EER = 2.7	– EER = 2.5	– EER = 2.5	– EER = 2.7	– EER = 2.7	– EER = 2.7	– EER = 2.7	– EER = 2.7	– EER = 2.7
Measures based on RES			solar installati on for ACM during the summer and photovol taic panels		solar installati on for ACM during the summer and photovol taic panels			solar installati on for ACM during the summer and photovol taic panels		solar installati on for ACM during the summer and photovol taic panels
Lighting type	Economi c lighting	Economi c lighting	Economi c lighting	Economi c lighting	Economi c lighting	Economi c lighting	Economi c lighting	Economi c lighting	Economi c lighting	Economi c lighting
Overall costs (RON/m^2) – macroeconomic	3016.13	2573.95	2673.12	3018.23	3117.14	2829.50	2770.0	2665.40	4054.47	4163.65
Overall costs (RON/m^2) – financial	3745.66	3199.65	3812.50	3752.48	3885.34	3516.51	3443.48	3651.64	5051.15	5164.01

Table 3.12 Design solutions for energy efficient buildings, overall costs calculated from a macroeconomic and financial point of view for those solutions and optimal costs – new educational buildings, climate zone II

Measure	Building according to C107/2010 (P1)	Building according to C107/2010 with shutters and heat recovery system (P2)	Building according to C107/2010 with shutters, heat recovery system and photovoltaic panels (P3)	Building with superior insulation (P4)	Building with superior insulation with shutters and heat recovery system (P5)	Building with superior insulation with shutters, heat recovery system and photovoltaic panels (P6)
Wall insulation	0.5857 W/m^{2}K	0.5857 W/m^{2}K	0.5857 W/m^{2}K	0.3124 W/m^{2}K	0.3124 W/m^{2}K	0.3124 W/m^{2}K
Roof insulation	0.2279 W/m^{2}K	0.2279 W/m^{2}K	0.2279 W/m^{2}K	0.2049 W/m^{2}K	0.2049 W/m^{2}K	0.2049 W/m^{2}K
Windows	2.0000 W/m^{2}K (thermally insulated)		(thermally insulated)			
Share of window area of total building envelope	16.36%	16.36%	16.36%	16.36%	16.36%	16.36%
Building-related measures (such as thermal mass)	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Domestic hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (incl. night ventilation)	natural, unorganized, mobile blinds (summer, hours of use)	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use)	mechanical, mobile blinds (summer, hours of use), heat recovery system	mechanical, mobile blinds (summer, hours of use), heat recovery system
Space cooling system	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.5	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7
Measures based on RES			photovoltaic panels		photovoltaic panels	
Lighting type	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall costs (RON/m^2) – macroeconomic	3211.42	2951.27	2725.95	3060.46	3120.16	2894.84
Overall costs (RON/m^2) – financial	4008.39	3701.62	3383.30	3823.52	3911.77	3593.45

Table 3.13 Design solutions for energy efficient buildings, overall costs calculated from a macroeconomic and financial point of view for those solutions and optimal costs – new buildings for health care purposes, climate zone II

Measure	Building according to C107/2010 (P1)	Building according to C107/2010 with shutters and heat recovery system (P2)	Building according to C107/2010 with shutters, heat recovery system, solar panels and photovoltaic panels (P3)	Building with superior insulation with heat recovery system (P4)	Building with superior insulation with shutters and heat recovery system (P5)	Building with superior insulation with shutters, heat recovery system and photovoltaic panels (P6)
Roof insulation	0.2432 W/m^2K	0. 2432 W/m^2K	0. 2432 W/m^2K	0. 2432 W/m^2K	0. 2432 W/m^2K	0. 2432 W/m^2K
Wall insulation	0.5809 W/m^2K	0.5809 W/m^2K	0.5809 W/m^2K	0. 2954 W/m^2K	0. 2954 W/m^2K	0.2954 W/m^2K
Windows	2.0000 W/m^2K (thermally insulated)		(thermally insulated)			
Share of window area of total building envelope	12.53%	12.53%	12.53%	12.53%	12.53%	12.53%
Building-related measures (such as thermal mass)	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Domestic hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (incl. night ventilation)	natural, unorganized ventilation, mobile blinds	natural, unorganized ventilation, mobile blinds	heat recovery system + mechanical ventilation – mobile blinds	heat recovery system + mechanical ventilation – mobile blinds	heat recovery system + mechanical ventilation – mobile blinds	heat recovery system + mechanical ventilation – mobile blinds
Space cooling system	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7
Measures based on RES			solar installation for ACM during summer and photovoltaic panels			solar installation for ACM during summer and photovoltaic panels
Lighting type	Economic	Economic	Economic	Economic	Economic	Economic

	lighting	lighting	lighting	lighting	lighting	lighting
Overall costs (RON/m^2) – macroeconomic	5347.71	5121.30	5008.48	5042.34	5024.79	5088.35
Overall costs (RON/m^2) – financial	6491.07	6221.39	6039.16	6124.47	6100.06	6151.97

Table 3.14 Design solutions for energy efficient buildings, overall costs calculated from a macroeconomic and financial point of view for those solutions and optimal costs – new residential buildings, apartment blocks, climate zone II

Measure	Building according to C107/2010 (P1)	Building according to C107/2010 with shutters and heat recovery system (P2)	Building according to C107/2010 with shutters, heat recovery system, solar panels and photovoltaic panels (P3)	Building with superior insulation (P4)	Building with superior insulation with shutters and heat recovery system (P5)	Building with superior insulation with shutters, heat recovery system and photovoltaic panels (P6)
Roof insulation	0.1975 W/m^{2}K	0.1975 W/m^{2}K	0.1975 W/m^{2}K	0.1967 W/m^{2}K	0.1967 W/m^{2}K	0.1967 W/m^{2}K
Wall insulation	0.5566 W/m^{2}K	0.5566 W/m^{2}K	0.5566 W/m^{2}K	0.3969 W/m^{2}K	0.3969 W/m^{2}K	0.3969 W/m^{2}K
Windows	2.0000 W/m^{2}K (thermally insulated)		(thermally insulated)			
Share of window area of total building envelope	14.59%	14.59%	14.59%	14.59%	14.59%	14.59%
Building-related measures (such as thermal mass)	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K	266.060 J/m^{2}K
Heating system	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Domestic hot water	District heating system	District heating system	District heating system	District heating system	District heating system	District heating system
Ventilation system (incl. night ventilation)	natural, unorganized ventilation, mobile blinds	natural, unorganized ventilation, mobile blinds	heat recovery system + mechanical ventilation – mobile blinds	heat recovery system + mechanical ventilation – mobile blinds	heat recovery system + mechanical ventilation – mobile blinds	heat recovery system + mechanical ventilation – mobile blinds
Space cooling system	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7

Measures based on RES			solar installation for ACM during summer and photovoltaic panels			solar installation for ACM during summer and photovoltaic panels
Lighting type	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall costs (RON/m^2) – macroeconomic	3638.21	3517.78	3742.16	3683.41	3624.92	3849.30
Overall costs (RON/m^2) – financial	3968.41	3830.58	4101.74	4024.94	3963.60	4234.78

Table 3.15 Design solutions for energy efficient buildings, overall costs calculated from a macroeconomic and financial point of view for those solutions and optimal costs – new single-family buildings, climate zone II

Measure	Building according to C107/2010 with heating system (P1)	Building according to C107/2010 with shutters and heat recovery system, connected to cogeneration system and ventilated space (P2)	Building according to C107/2010 with shutters, heat recovery system, connected to cogeneration system and ventilated space, solar panels and photovoltaic panels (P3)	Building with superior insulation (P4)	Building with superior insulation with shutters, heat recovery system and heating system (P5)	Building with superior insulation with shutters, heat recovery system, solar panels and photovoltaic panels (P6)
Roof insulation	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K
Wall insulation	0.398 W/m^2K	0.398 W/m^2K	0.398 W/m^2K	0.165 W/m^2K	0.165 W/m^2K	0.165 W/m^2K
Windows	1.299 W/m^2K (thermally insulated)		(thermally insulated)			
Share of window area of total building envelope	5.13%	5.13%	5.13%	5.13%	5.13%	5.13%
Building-related measures (such as thermal mass)	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K	266.060 J/m^2K
Heating system	Own heat supply system	Regional cogeneration	Regional cogeneration	Own heat supply system	Own heat supply system	Regional cogeneration
Domestic hot water	Own heat supply system	Regional cogeneration	Regional cogeneration	Own heat supply system	Own heat supply system	Regional cogeneration
Ventilation system (incl. night ventilation)	natural, unorganized ventilation, mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation, mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	natural – natural ventilation, organized, mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)	heat recovery system, mechanical ventilation – mobile blinds (summer, hours of use)
Space cooling system	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7
Measures based on RES		ventilated solar space	solar installation for ACM during summer and photovoltaic panels, ventilated solar space			solar installation for ACM during summer and photovoltaic panels, ventilated solar space

Lighting type	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting	Economic lighting
Overall costs (RON/m^2) – macroeconomic	4657.26	4360.42	4610.07	4634.64	4453.86	4624.64
Overall costs (RON/m^2) – financial	5078.75	4574.09	4752.08	4968.67	4719.96	4667.89

3.2.3 Nearly zero-energy buildings (NZEBs) definition and energy configuration

A nearly zero-energy building means a building with low energy consumption from conventional energy sources, which uses renewable energy sources in a proportion determined using a procedure for determining minimum requirements in accordance with the provisions of Articles 4 and 5 of Directive 2010/31/EU.

For both new buildings and existing buildings, included in national and local energetic modernization programs, the objective is to use technical solutions that comply with minimum requirements in terms of costs, determined in accordance with the provisions of Delegated Regulation 244/2012/EU.

The energy and environmental parameters that can be adapted to new buildings are defined by reference to both current minimum requirements for new buildings and regional climatic and technological restrictions. The definition of a nearly zero-energy building is the result of observing two components that are conditional upon the energy performance of a building as follows:

- architectural configuration of the building in compliance with the principles of sustainable development and especially by minimizing the impact on the natural environment, including on the regional microclimate;
- providing energy utilities, especially from district/regional urban networks, provided that their energy performance is compatible with energy performance of new NZE buildings.

Equipping buildings with renewable energy sources placed either on the building or the land owned by the building, should be very carefully analyzed at the regional urban project stage in terms of the impact on the natural environment, on the one hand, and the building itself, on the other hand.

A NZEB building, designed in Romania, climate zone II, shall be characterized by maximum intensity of primary energy use according to **table 3.16**.

Table 3.16 Maximum admissible value of the gross primary energy related to supply processes of energy utilities (thermal energy ad electricity) by building type and optimal cost range

Building type	Optimal cost range [kWh/m^{2}year]	Maximum admissible value NZEB [kWh/m^{2}year]
Public office building	62-100	57
Residential building, apartment blocks	56-112	100
Single-family residential building	155-230	111

Table 3.16 shows three values of maximum admissible energy intensity for including these three abovementioned types of buildings into the NZEB class, these being the most representative ones from a social and energy point of view. The physical significance of the values in this table is that these are admissibility limits which should be verified when the design of a NZEB building is developed. Compliance with these values is a precondition for including the design of a building in the NZEB class. The condition necessary depends on the energy required to heat the rooms at the end consumer, while the sufficiency condition is given by the compliance with the maximum admissible duration for recovering the additional investment with reference to the building designed in accordance with Standard C 107/2010 based on the saving achieved by applying solutions specific to NZEB buildings. The entire validation analysis is carried out using climate data for a typical climatic year for the region to which the settlement belongs where the NZEB building is to be built.

Energy sources are of two types:

- Sources that are included in the district heating system and which supply a specific building with energy (such as hydroelectric, solar, high-efficiency cogeneration, geothermal, and windmills);
- Individual sources of the real estate which includes the building (such as solar heat sources, solar electric, heat pumps, windmills, biomass, and fuel cells).

As a result of analyzing the solutions of NZEB buildings, by reference to the newly configured buildings according to the Standard in force (C 107/2010), the economic efficiency of the technical solutions and the recovery time of the investments have been determined in comparison with conventional buildings. This analysis targeted especially the impact of the utilities supply system, passive energy management solutions and equipping the building with renewable energy sources (such as thermal solar panels, photovoltaic panels and water-to-water heat pumps). For all three types of buildings analyzed, installing photovoltaic panels and the equipment necessary to use for household purposes has been considered (monophasic 220V; such as inverter and accumulation system). These photovoltaic panels have a solar energy capture efficiency of 15% and are placed on building roofs. For all cases, the azimuth is south. The angle formed by the panels with the horizontal plane has been determined to maximize the solar energy captured during the year on the free exposed unit area. The global solar radiation intensity values have been obtained by processing the hourly values specific to a typical climatic year.

These results are summarized in **Table 3.17.**

Table 3.17 Examples of NZEB buildings – economic and energy performance (return of investment period compared to conventional buildings built according to Standard C 107/2010)[2]

Building type	Area of photovoltaic panels [m^2]	Performance indicators	Energy sources			
			Water-to-water heat pump	Natural gas thermal heating systems	Current cogeneration	High-efficiency cogeneration
Public office	250	Primary energy [kWh/m^{2}year]	**42.95**	**52.96**	**46.23**	**28.26**

[2] Note:

- Cells marked with X do not meet the minimum condition for inclusion in the NZEB class;
- Values marked with red are accepted if the admissible additional investment recovery period is exceeds the maximum value of 10 years;
- Values in bold represent NZEB buildings.

building, climate zone II (≤57 kWh)		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]	141.93	141.93	124.14	124.14
		Covering electric energy consumption using PFV [%]	35.85	52.54	52.54	52.54
		Covering total energy consumption using solar energy [%]	35.85	20.74	23.28	23.28
		Recovery period [year]	**10.0**	**9.2**	**7.8**	**7.8**
	1500	Primary energy [kWh/m^{2}year]	**-77.05**	**-67.04**	**-73.77**	**-91.74**
		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]	141.93	141.93	124.14	124.14
		Covering electric energy consumption using PFV [%]	215.05	315.23	315.23	315.23
		Covering total energy consumption using solar energy [%]	215.08	124.44	139.65	139.65
		Recovery period [year]	**8.5**	**8.5**	**7.8**	**7.8**
Residential building, apartment blocks, climate zone I (≤93 kWh)	50	Primary energy [kWh/m^{2}year]	~~135.55~~	~~146.82~~	~~132.78~~	89.44
		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]	~~216.46~~	~~216.46~~	~~188.85~~	188.85
		Covering electric energy consumption using PFV [%]	~~11.41~~	~~20.23~~	~~20.23~~	20.23
		Covering total energy consumption using solar energy [%]	~~11.41~~	~~5.70~~	~~6.55~~	6.55
		Recovery period [year]	~~14.2~~	~~11.8~~	~~10.5~~	10.5
	300	Primary energy [kWh/m^{2}year]	**48.30**	**59.57**	**45.52**	**2.19**
		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]	216.46	216.46	188.85	188.85
		Covering electric energy consumption using PFV [%]	68.43	121.39	121.39	121.39
		Covering total energy consumption using solar energy [%]	68.43	34.21	39.29	39.29
		Recovery period [year]	**9.3**	**8.4**	**8.1**	**8.1**
Residential building, apartment blocks, climate zone II	50	Primary energy [kWh/m^{2}year]	~~142.86~~	~~154.76~~	~~139.93~~	94.18
		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]	~~224.70~~	~~224.70~~	~~193.34~~	193.34

(≤100 kWh)		Covering electric energy consumption using PFV [%]	8.85	16.08	16.08	16.08
		Covering total energy consumption using solar energy [%]	8.85	4.36	5.01	5.01
		Recovery period [year]	16.0	14.0	11.5	11.5
	300	**Primary energy [kWh/m²year]**	**73.54**	**85.43**	**70.61**	**24.85**
		Primary energy according to Standard C 107/2010 [kWh/m²year]	224.70	224.70	193.34	193.34
		Covering electric energy consumption using PFV [%]	53.08	96.45	96.45	96.45
		Covering total energy consumption using solar energy [%]	53.08	26.14	30.08	30.08
		Recovery period [year]	**11.1**	**10.2**	**9.4**	**9.4**
Residential building, apartment blocks, climate zone III (≤111 kWh)	50	Primary energy [kWh/m²year]	142.48	154.57	139.49	92.96
		Primary energy according to Standard C 107/2010 [kWh/m²year]	229.04	229.04	196.94	196.94
		Covering electric energy consumption using PFV [%]	9.78	17.91	17.91	17.91
		Covering total energy consumption using solar energy [%]	9.78	4.79	5.52	5.52
		Recovery period [year]	14.4	12.0	10.0	10.0
	300	Primary energy [kWh/m²year]	**65.24**	**77.34**	**70.61**	**15.73**
		Primary energy according to Standard C 107/2010 [kWh/m²year]	229.04	229.04	196.94	196.94
		Covering electric energy consumption using PFV [%]	58.69	107.45	107.45	107.45
		Covering total energy consumption using solar energy [%]	58.69	2876	33.13	33.13
		Recovery period [year]	**9.8**	**9.0**	**8.4**	**8.4**
Residential building, apartment blocks, climate zone IV(≤127 kWh)	50	Primary energy [kWh/m²year]	150.62	163.70	147.40	97.07
		Primary energy according to Standard C 107/2010 [kWh/m²year]	243.86	243.86	207.55	207.55
		Covering electric energy consumption using PFV [%]	8.03	15.24	15.24	15.24

		Covering total energy consumption using solar energy [%]	8.03	3.85	4.45	4.45
		Recovery period [year]	14.9	12.0	9.2	9.2
	300	Primary energy [kWh/m^{2}year]	**84.89**	**97.98**	**81.67**	**31.34**
		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]	243.86	243.86	207.55	207.55
		Covering electric energy consumption using PFV [%]	48.16	91.44	91.44	91.44
		Covering total energy consumption using solar energy [%]	48.16	23.10	26.69	26.69
		Recovery period [year]	**11.4**	**9.7**	**8.5**	**8.5**
Single-family residential building, climate zone II (≤111 kWh)	3	Primary energy [kWh/m^{2}year]		146.79		
		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]		291.84		
		Covering electric energy consumption using PFV [%]		18.56		
		Covering total energy consumption using solar energy [%]		45.26		
		Recovery period [year]		11.7		
	18	Primary energy [kWh/m^{2}year]		**18.37**		
		Primary energy according to Standard C 107/2010 [kWh/m^{2}year]		291.84		
		Covering electric energy consumption using PFV [%]		111.37		
		Covering total energy consumption using solar energy [%]		71.17		
		Recovery period [year]		**9.5**		

3.2.4 Savings arising from measures addressing energy efficiency in buildings

The Multi-annual National Program on increasing the energy efficiency of apartment blocks built between 1950 and 1990 and individual residences shall be continued during the 2014-2020 period.

Having regard to the experience gained during 2011-2012, when works on blocks with a total number of approx. 55,000 apartments per year were granted financing in the country, energy savings of about 0.544 million toe are estimated for the 2014-2020 period according to the data in Table 2.3.

Considering that a single-family residence consumes 24% more energy per m^2 on average than an apartment in a block of apartments, the heating system of single-family buildings should also be renovated at a fast pace, which will allow for energy savings of 0.356 million toe between 2014 and 2020 according to the data in Table 2.3.

Replacing the equipment (such as household appliances and lighting systems) in residential buildings with high-performance equipment will contribute to energy savings of 0.462 million toe between 2014 and 2020 according to the data in Table 2.3.

An energy audit and an energy management audit carried out in the residential sector will contribute to energy savings of 0.07 million toe between 2014 and 2020 according to the data in Table 2.3.

3.2.5 Financing energy efficiency measures in buildings

Energy efficiency measures in buildings are financed in accordance with the details described in Section 3.1.1.

3.3 Energy efficiency measures at public bodies

Directive 2012/27/EU recognizes the importance of implementing measures to increase the energy efficiency of existing buildings owned or occupied by the public administration. According to Article 5(1) of this Directive, each Member State shall ensure that, as from 1 January 2014, 3% of the total floor area of heated and/or cooled buildings owned and occupied by its central government is renovated each year to meet at least the minimum energy performance requirements that it has set in application of Article 4 of Directive 2010/31/EU.

The 3% rate shall be calculated for the total floor area of buildings with a total useful floor area over 500 m^2 owned and occupied by the central government of the Member State concerned that, on 1 January of each year, do not meet the national minimum energy performance requirements set in application of Article 4 of Directive 2010/31/EU. This threshold shall be lowered to 250 m^2 as of 9 July 2015.

3.3.1 Government buildings

The Ministry of Regional Development and Public Administration (MRDPA), which implements government policies aimed at increasing the energy efficiency of buildings, issued Order No 3466/2013 on compiling an inventory of the buildings heated and/or cooled, owned and occupied by the central government, and making the inventory available to the public and setting up data banks on energy efficiency. According to the provisions of this Order, by 21 December 2013, the owners/administrators of the buildings owned and occupied by the central government authorities (ministries, other specialized bodies subordinated to the government or the ministries or autonomous authorities) shall draw up an inventory and publish on its site the buildings heated and/or cooled with a total useful floor area over 500 m^2, so by 31 December 2013, the central inventory of the buildings heated and/or cooled, owned by the central administration, with a total useful floor area over 500 m^2, is drawn up and published. This provision was applied, and at the present a document entitled “Inventory of buildings heated and/or cooled, owned and occupied by the central administration, with a total useful floor area over 500 m^2”, dated 31 December 2013 and updated on 25 March 2014, is made available on the MDRAP site (www.mdrap.ro). According to this document, this inventory contains a number of 2953 buildings heated and/or cooled with a total useful floor area over 500 m^2, that is, a total useful floor area of 6.74 million m^2.

Table 3.18 shows the results of this inventory by owner/tenant of these public buildings.

Table 3.18 Inventory of heated and/or cooled buildings with a total useful floor area over 500 m^2, owned and occupied by the central administration

Authorizing body	Technical data	
	Useful area	Built-in area at ground level
	[m^2]	[m^2]
House of Deputies	188,172	58,132
Ministry of Foreign Affairs	8,893	3,774
Ministry of Internal Affairs	1,387,998.57	626,462.70
Ministry of Agriculture and Rural Development	14,029.27	6,635.45
Ministry of Home Defense	343,776.4	-
Ministry of Culture	369,124	116,057
Ministry of Regional Development and Public Administration	2,6491.17	14,964.07
Ministry of Economy	45,735.55	20,830.89
Ministry of Education	963,849.64	376,643.01
Ministry of Public Finances	491,756.49	201,488.20
Ministry of Justice	683,693.20	344,657.8
Ministry of Environment and Climate Changes	110,038.63	53,182.96
Ministry of Labor, Family, Social Protection and Elderly	112,342.36	47,508.13
Ministry for Information Society	6,980.0	1,780.0
Ministry of Health	717,230.27	262,416.41
Ministry of Youth and Sport	366,736.56	232,187.22

National Agency of Land Registry and Real Estate Publicity	55,114.66	19,540.98
National Anti-Doping Agency	773.00	262.00
National Authority for Restitution of Real Estates	2,420.40	555.00
National Authority for Sanitary Veterinary Care and Food Safety	106,749.83	48,138.81
National Commission for Controlling Nuclear Activities	1,500.00	500.00
National Institute of Statistics	16,235.17	5,514.62
National Office for the Registry of State Secretes	3,710.39	1,473.07
Autonomous State Society "Management of State Protocol Properties"	249,182.17	124,581.19
State Secretary for Religious Cults	1,568.00	452.00
Romanian Academy	64,540.00	15,500.00
National Health Insurance Fund	77,351.77	27,945.65
National Audiovisual Council	1,518.32	2,200.00
National Council for the Study of the Archives of the "Securitate"	6,837.00	3,728.00
Superior Council of the Judiciary	5,156.71	2,258.52
Court of Auditors of Romania	33,861.73	14,312.18
Supreme Court of Cassation and Justice	5,312.00	1,103.00
Romanian Intelligence Service	269,932.00	90,987.00
TOTAL **of which:**	**6,739,167.26**	**2,726,453.86**
- office buildings	4,204,797.12	1,634,313.19

- educational buildings	1,125,999.85	393,268.46
- health care buildings	584,846.73	962,822.50
- other public buildings	823,523.56	5,391,001.72

(Source: www.mdrap.ro)

According to Article 5(1) of EED, as from 1 January 2014, the ministries, other specialized bodies subordinated to the Government or ministries, or the autonomous authorities have pursued actions to renovate a floor area of 202.2 thousand m^2, which represents 3% of the total floor area of heated and/or cooled buildings owned and occupied by its central government each year in order to meet at least the minimum energy performance requirements set out in Article 4 of Directive 2010/31/EU. These actions will generate estimated primary energy savings of 44,194 GWh/year (3,800 toe). During 2014-2020, an estimated energy saving of 22,800 toe will be achieved.

3.3.2 Buildings of other public bodies

In addition to the buildings of the central public administration, local governments also have buildings belonging to the following:

- County councils and the institutions subordinated to them;
- Local councils of municipalities, towns and villages, and the institutions subordinated to them. The estimated number of the buildings belonging to the local public administration is shown in **Table 3.19**. The number of units included in the categories of education, health, culture and sport is indicative only, taking into account the continuing restructuring and privatization process.

Table 3.19 Estimated number of local government buildings

Destination of the building	Category	Number of units
Public administration	Prefectures and county councils	84
	Town halls and local councils in towns	326
	Town halls and local councils in villages	2861
Education	Schools and high schools	5,982
	Kindergartens	1498
	Higher education	624
	Dormitories and boarding houses	14,927
Health	Hospitals	503
	Outpatient clinics and dispensaries	515
	Nurseries	297
	Medical practices	36,502
	Pharmacies and laboratories	13,049
	Nursing homes	403
Culture	Public libraries	3,429
	Theatres	158
	Movie theatres	68
	Museums	687
Sport buildings	Sport halls, leisure facilities, and swimming pools	4700

(Source: www.mdrap.ro)

Of the total area of 67,200,000 m^2 of non-residential buildings, an area of approx. 27,000,000 m^2 represents the area of the buildings belonging to local governments.

In terms of the energy performance of the existing buildings, it should be noted that the final energy consumption is 200-350 kWh/m^2 and 200-400 kWh/m^2 per year for educational and cultural buildings and health care buildings, respectively.

As regards the energy performance of the educational or health care buildings, described in Annex B, these buildings should be thermally rehabilitated to increase their energy efficiency. The thermal renovation of these buildings will ensure an estimated energy saving of 11,600 toe on average each year.

3.3.3 Purchasing by public bodies

Products and services are purchased in accordance with the requirements set out in Directive 2010/30/EU **on the indication by energy labelling and Directive 2009/125/EC on eco-design, the Energy Star Regulation 106/2008/EC on office equipment.**

Thus, public procurement of products, buildings and services will be carried out so as to ensure high energy efficiency by meeting the standards listed in Annex III of Directive 2012/27/EU. All procurement procedures will be operated by taking into account the return on investments and ensuring a loyal competition.

3.3.4 Savings arising from measures in central government and other public bodies

The thermal insulation program for government buildings (2014-2020) will generate energy savings of approx. 0.023 million toe according to the data in Table 2.3.

The procurement of goods and services for government buildings between 2014 and 2020 will generate energy savings of 0.01 million toe according to the data in Table 2.3.

The thermal insulation program for the local public administration and the procurement of goods and services for them will generate energy savings of 0.121 million toe between 2014 and 2020 according to Table 2.3.

Furthermore, local public authorities will implement public lighting modernization programs in order to both improve service quality and reduce energy invoices. These modernization programs will generate energy savings for the whole country of 0.048 million toe between 2014 and 2020 according to the data in Table 2.3.

The programs aiming at the rehabilitation and modernization of public water supply systems, which have been implemented in different localities, will generate energy savings for the whole country of 0.004 million toe between 2014 and 2020 according to the data in Table 2.3.

The programs aiming at the thermal rehabilitation of buildings in the public service sector and the procurement of goods and services will generate energy savings of 0.232 million toe between 2014 and 2020 according to Table 2.3.

After 2016, as a result of the legislative clarifications to stimulate ESCO activities, energy savings of approx. 0.641 million toe will be achieved through the ESCO market between 2018 and 2020.

3.3.5 Financing energy efficiency measures in public bodies

Energy efficiency measures in the buildings of public organizations are financed from both the central budget and the funds of the Regional Operative Program AP3 in compliance with the details in Section 3.1.1.

3.4 Energy efficiency measures in industry

The industry is a complex area that comprises large energy intensive industrial consumers (such as metallurgy, the building materials industry and the chemical industry) and small, but energy intensive energy consumers (such as the food industry, the beverages industry, the tobacco industry, the wood processing industry, and the paper and paper products making industry). In 2012, the final energy consumption of the first category and the second category amounted to 69% and approx. 22% of the total industry consumption, respectively.

3.4.1 Main measures addressing energy efficiency in industry

Romania has taken part in the European Union Emissions Trading Scheme (EU-ETS) since its accession on January 1st, 2007, having the responsibility of establishing rules to implement the scheme, including establishing the maximum number of certificates at national level and the allocation method used. Thus, for 2007 and the 2008-2012 period, the National Allocation Plan for the allocation of the emission certificates establishes the total number of emission certificates allocated at national level and for each installation, subject to the provisions of Government Order No 780/2006 on drawing up the emission certificates marketing scheme, as subsequently amended and supplemented. In 2013, there were 201 commercial societies that submitted Annual EU-ETS Monitoring Reports in the electric and thermal energy production sector, in refineries, in the metallurgical industry, ferrous metal processing industry, building materials industry (e.g. cement, lime, ceramics and glass), paper and paper products industry (cellulose and paper).

For the period between 2013 and 2020, Article 10(c) of Directive 2009/29/EC, amending Directive 2003/87/EC, provides for the possibility of free transitory allocations of greenhouse certificates for electric energy production with the condition to improve technology or to implement some clean technologies. Having regard to this derogation approved by the EC for Romania, the Government of Romania adopted Government Resolution No 1096/2013 approving the non-transitory free emission certificates allocation mechanism for electricity producers for the period between 2013 and 2020, including the National Investment Plan, named in Annex 3.

Participation in the EU-ETS marketing scheme allows for a reduction of emissions, and thus also ensures an increase in the economic efficiency of the entities in order to be competitive on the market, which implicitly leads to an increase in energy efficiency.

These societies have an energy consumption that exceeds 1,000 toe and are required to perform an energy audit and an energy management audit in accordance with Government Order No 22/2008.

In the industrial sector, the energy audit and energy management scheme audit should be continued to increase energy efficiency.

3.4.2 Savings arising from industry measures

Based on the reports on the energy audits conducted in the societies of the industry and the energy efficiency increase programs, an energy saving of 0.35 toe is expected between 2014 and 2020 according to the data in **Table 2.3.**

Furthermore, for large energy consumer industries (such as metallurgy and the building materials industry), monitored according to EU-ETS, measures shall be taken to increase energy efficiency that will lead to energy savings of approx. 140,000 toe each year according to the data in Table 2.3, which means almost 3.2% of the annual consumption for 2012 of the metallurgical industry, the chemical industry and the industries involved in the manufacturing of other products from ferrous metals (4,383,754 toe).

3.4.3 Financing of energy efficiency measures in industry

Investments aimed at increasing energy efficiency in the industry may be financed from *own resources,* the *Romanian Energy Efficiency Fund* and *other financing programs.*

RoSEFF is a financing program of 60 million euros developed by the European Union (EU) and the European Bank for Reconstruction and Development (EBRD). Thus, RoSEFF provides financing for SMEs to invest in energy efficiency and renewable energy by granting:

- loans through Participating Financial Institution (such as BRD and BCR);
- free technical consulting by Tractebel Engineering;
- EU grants.

At this time, 66 RoSEFF investments are being or have already been implemented. Total financing amounts to 13.9 million euros.

The ***RO 05 "Energy Efficiency"*** Program is financed by the Financial Mechanism of the European Economic Area (EEA, 2009-2014) and is aimed at increasing energy efficiency in the industrial sectors, in particular industries with high level of pollution and energy consumption. The responsibility of administering and implementing the program lies with the Implementation Unit/Program Operator (PO) within the Department for Industrial Policies and Competitiveness of the Ministry of Economy in accordance with Order No 2462/2013 of the Ministry of Economy.

Projects financed by the Financial Mechanism EEA 2009-2014 should be in line with the national strategic priorities of Romania and should comply with relevant EU and national legislation. These should demonstrate convincingly an optimization of resources, while the resulting energy saving should be significant and quantified. Each euro spent in the Program should generate energy savings.

The specific objective of the Program is to increase energy efficiency in the industrial sector, and especially in industries with a high level of pollution and energy consumption.

Eligible applicants should include small and medium-sized enterprises (SMEs) in the industrial sectors in accordance with the provisions of Law No 346/2004, and their activities should not include sectors excluded from the State Aid Scheme/De Minimis Applicable Scheme. The following sectors shall not be given grants/are not eligible: fishing and aquaculture, naval constructions, food industry, coal industry, synthetic fibers, export activities and preferential use of national products compared to those imported, in accordance with the provisions of the State Aid Scheme/De Minimis Applicable Scheme.

SMEs should implement a project aimed at improving energy efficiency and energy saving in the industry in line with Emergency Government Order No 22/2008 on energy efficiency and promotion of renewable energy at the end users.

A partnership between SMEs from Romania and societies/partners from donating states (Kingdom of Norway, Iceland and Liechtenstein) is much appreciated and encouraged. The projects can be submitted in partnerships if both the beneficiary and the partner are eligible applicants for the areas affected by the project and the objectives of the program are met.

The total value of the subsidy/grant for the Energy Efficiency Program for Romania amounts to 8 million euros plus a share of 15% (1,411,765 euros) co-financed from national funds.

A project will be eligible for the Program if it proposes, develops and applies at least one measure to improve energy efficiency; packages of measures aimed at improving energy efficiency will be accepted. Priority shall be given to all projects that ensure the greatest reduction of carbon emissions compared to the financial resources allocated to the subsidy program (tCO_2/1,000 euro) depending on their scores.

Energy efficiency shall be measured by an institution/society authorized by ANRE as part of a power audit based on the measurements made using measurement instruments for the representative periods of the technological flow, at the set technological capacities, before the selection and implementation of the project.

The project promoter will specify the efficiency value obtained after the implementation of the project in a statement that will be submitted together with the documents necessary to obtain the subsidy:

- Reducing the estimated impact on the environment in tCO_2/year
- Estimated energy saved in MWh/yea
  r

Eligible applicants should, for example, make investments which have an impact on:

- Improving the energy efficiency of electrically operated systems (such as, increase in the use of electronic control systems, variable speed drives, integrated application programming, frequency converters, electrical engines with high efficiency, replacement of the entire actuation systems with a more efficient system);
- Replacing outdated and oversized equipment (for example, electric power transformers, compressors and motors);
- Improving the energy efficiency of heating and cooling systems (for example, using heat pumps, replacing existing boilers with new and more efficient boilers, modernizing industrial heating/cooling systems);
- Improving the energy efficiency of lighting systems (for example, replacing existing lamps with new and more efficient ones, using digital control systems, motion sensors for lighting systems);
- Improving the energy efficiency of refrigeration systems (for example, replacing existing units with new and more efficient devices, introducing systems for industrial waste heat recovery);
- Improving the energy efficiency of heating systems by introducing heating systems that use thermal energy from renewable sources and by reducing the fuel (such as gas and crude oil) quantity used;
- Improving energy efficiency by modernizing production installations;
- Improving energy management at the level of industrial platforms;
- Systems for industrial waste heat recovery.

3.5 Energy efficiency measures in transport

3.5.1 Introduction

Romania has a national transport system (infrastructure and means of transportation) with a functional structure and services rendered that largely meet the medium standards of conventional European transport systems.

The strategic framework on sustainable transport policy in Romania has been brought in line with European policy defined in the White Book of transport.

As regards transport, Romania holds a key position at the eastern border of the EU, as a transit area for both the eastern-western (connection to Asia via Black Sea) and northern-southern direction (from the Baltic Sea to the Mediterranean Sea). Three of the TEN-T priority axes cross Romania.

The transport sector will be developed in close connection with the economic and social development of Romania. The transport sector is one of the most important sectors in terms of both energy consumption and the impact on environment.

In order to define the measures and policies to be adopted between 2014 and 2020 to increase energy efficiency in Romania's transport sector, the following information shall be presented for the 2007-2012 period:

- evolution of goods trade routes by the 4 modalities of transport (by rail, road, inland shipping and oil pipelines) (**Table 3.20**);
- evolution of the routes of passengers in interurban and international transport (**Table 3.21**);
- evolution of the routes of passengers both in localities and interurban (**Table 3.22**);
- evolution of the vehicle fleet (**Table 3.23**).

Table 3.20 Evolution of trade routes between 2007 and 2012 [1000 mil. km]

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Rail transport	15.8	15.2	11.1	12.4	14.7	13.5
Road transport	59.5	56.4	34.3	25.9	26.3	29.6
Inland shipping	8.2	8.7	11.8	14.3	11.4	12.5
Oil pipelines	1.9	1.7	1.2	1.0	0.9	0.8
TOTAL	**85.3**	**82.0**	**58.4**	**53.6**	**53.4**	**56.4**

(Source: National Institute of Statistics – Romanian Statistical Yearbook - collections)

Table 3.21 Passenger routes in interurban and international transport between 2007 and 2012 [1000 mil. passengers km]

Modes of transport/Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Rail transport	7.5	7.0	6.1	5.4	5.1	4.6
Road transport	12.2	20.2	17.1	15.8	15.5	16.9
Inland shipping	0.023	0.021	0.02	0.015	0.018	0.017
TOTAL	**19.7**	**27.2**	**23.3**	**21.3**	**20.6**	**21.5**

(Source: National Institute of Statistics – Romanian Statistical Yearbook - collections)

Table 3.22 Evolution of passenger routes between 2000 and 2010 [1000 mil. passengers km]

Modes of transport/Year	2000	2005	2006	2007	2008	2009	2010
Cars	51	61	64.1	67.5	70.50	75.5	75.3
Buses and minivans	12.0	11.8	11.7	12.2	13.9	12.8	12.0
Lands	11.6	8.0	8.0	7.5	7.0	6.1	5.4
Trams and subways	6.0	6.6	6.8	6.9	7.0	7.1	7.1
TOTAL	**80.6**	**87.4**	**90.6**	**94.1**	**98.4**	**101.5**	**99.8**

(Source: National Institute of Statistics – Romanian Statistical Yearbook - collections)

Table 3.23 Evolution of motor vehicle fleet between 1990 and 2012 [thousands of units]

Modes of transport/Year	2000	2005	2006	2007	2008	2009	2010	2011	2012
Cars	2778	3364	3221	3554	4027	4245	4320	4335	4487
Buses and minivans	40.7	39.3	32.3	35.8	41.5	41.2	40.9	40.9	42.0
Goods vehicles	427.2	493.8	457.0	587.4	645.3	661.9	667.2	696.3	719.9
Mopeds and motorcycles	239.2	197.4	43.8	56.5	71.8	80.0	85.2	90.1	95.4

(Source: National Institute of Statistics – Romanian Statistical Yearbook - collections)

Local public passenger transport has been continuously declining since 1990. The number of localities with urban passenger transport has been steadily decreasing from 115 in 2000 to 95 in 2007. At the same time, the length of simple lines for the public transport infrastructure (trams and trolleys) shows the same steadily descending tendency in the last decade, and decreased by 10% and 51% for trams and trolleybuses, respectively, between 2000 and 2010. The number of vehicles showed different evolutions, the number of trams and trolleybuses has steadily decreased (a reduction by 25% in the number of trams in the 2000-2009 period), and there has been an increase by approx. 10% in the number of buses and minivans between 2000 and 2009.

The subway, a mode of transport specific to Bucharest, the capital of Romania, showed limited positive changes between 2000 and 2009 in terms of both the length of railway lines (approx. 6%) and the vehicles in inventory (approx. 21%). Nevertheless, it is necessary to take up an increasing number of passengers and to build new subway lines to help decongestion of the surface traffic and achieve sustainable transport.

3.5.2 Main measures addressing energy efficiency in transport

Energy efficiency measures in transport fall into two categories: general measures and specific measures for each modality of transport.

The General Master Transport Plan and the Strategy for the Development of the National Transport System shall address the multimodal approach, and shall aim at ensuring conditions to develop an efficient, sustainable and safe transport system and specify a flow of realistic and mature projects by prioritizing investments in the financial circuit 2014-2020.

The general measures shall be applied in compliance with the requirements of Government Resolution No. 22/2008, presented in Section 3.1.2. Furthermore, it is also taken into account the requirement that the economic agents and local and central public administrative units that have motor vehicles should monitor and manage fuel consumption in order to reduce their use.

3.5.2.1 Rail transport

The measures specific to rail transport are as follows:

- Implementation of an electricity telemanagement system and a compensation system of the power factor at the electricity traction substations;
- Introduction of LED light-signalling units;
- Introduction of efficient exterior lighting in railway station;
- Modernization of the passenger railway transport by purchasing rolling stock with high energy performance:
  - renewal of the rolling stock and equipment fleet in the maintenance halls;
  - electric locomotives modernized to improve efficiency and reliability;
  - modernization of electric locomotives by implementing push-pull and ETCS equipment;
  - equipping LDE locomotives with devices to improve the efficiency of fuel consumption (by reducing engine idle times and by increasing the efficiency of traction diesel engines);
  - locomotive and passenger train monitoring application.
- Reduction of the energy consumption in the basic traction activity of freight trains by:
  - modernization of some electric diesel locomotives with new generation MTU 12V 4000 R84 engines with a 13.5% lower specific fuel and oil consumption than current 12 LDA engines;
  - increasing the proportion of electric traction to the exclusion of diesel engines and strict compliance of the instructions on loading of trains for each traffic section;
  - technical rehabilitation of fix equipment for testing brakes used in the train building technological process;
  - resizing the equipment used to keep diesel locomotives, ancillary diesel supply and water softeners installations in warm state.

The measures specific to buildings owned by companies are as follows:

- Reduction of fuel consumption recorded by the National Rail Freight Company “CFR Marfa SA” by:
  - thermal rehabilitation and modernization of buildings and production and administrative areas;
  - modernization of thermal energy production and transport systems for buildings and technological needs;
  - relocation of areas in which the personnel carries out their activity to reduce energy consumption for heating these areas during winter;
  - replacement of oversized power transformers in the power transformation stations which supply low-activity units.
- Reduction of fuel consumption recorded by the National Passenger Rail Company “CFR Marfa SA” by:
  - thermal rehabilitation and modernization of buildings depending on the importance and dimensions of the stations and heating sources;
  - modernization of inside and outside lighting system of stations.

3.5.2.2. Ship transport

The measures specific to inland shipping are as follows:

- Application of Chapter 4 (Ship Energy Efficiency) in Annex VI of the MARPOL Convention;
- Modernization of electric outside lighting network by replacing classic 259 W lamps with LED 110 MW light fittings;

- Increasing the energy efficiency of the inside and outside lighting systems of hydrotechnical nodes of shipping channels (locks in Agigea, Cernavodă and Ovidiu, ports in Basarabi and Medgidia, waiting ports in Agigea, Cernavodă and Ovidiu);
- Modernization and upgrading of HERCULES multifunctional tug vessel;
- Modernization and re-motorization of R/M Perseus ship.

Measures specific to buildings owned by companies:

- Thermal rehabilitation of the Administrative Building and Technical Building at the seat of the company;
- Restoration of the thermal insulation of the existing buildings in the hydro-nodes (command towers in locks in Agigea, Cernavodă, Ovidiu and Năvodari, buildings of the naval stations in Medgidia and Basarabi, main storage building, administrative building in Cernavodă lock, compressor station building in locks in Agigea and Cernavodă, thermal power plant in Agigea);
- General repairs of classrooms and offices in CERONAV headquarter at str. Baba Novac No 101, Constanța;
- Building a new CERONAV headquarter, the subunit in Galati;
- General repairs of inside lighting system in the headquarters at Baba Novac and Pescarilor;
- Improving the efficiency of the inside lighting system in the Maritime Station by replacing R63 bulbs with economic 21W bulbs.

3.5.2.3 Road transport

The measures specific to road transport are as follows:

- The National Program for Renewing the Vehicle Fleet to replace old cars with high emission level and high specific consumption;
- Freight optimization;
- Promotion of "clean motor vehicle" and stimulation of their production. To encourage the purchase of such motor vehicles, Emergency Order No 40/2011 on the promotion of clean and energy efficient road transport vehicles, as amended by Emergency Order No. 9/2013 on the eco stamp for motor vehicles, provides for an eco-ticket for each electric motor vehicle;
- Reduction of road transport by promoting inter-modal transport, increasing the use rate of public transport and optimizing public transportation means (such as trains and buses) and the infrastructure necessary for a good operation of these means.

3.5.2.4 Urban public transport

- Modernization of the subway transport in Bucharest by upgrading the electric train fleet and lighting installations in public areas;
- Carrying out a Study on the optimization of public transport in cities in order to extend and improve it;
- Encourage alternative transport modalities (such as cycling, car-pooling or car-sharing) through urban planning and the development of an appropriate infrastructure for cycling (bike lanes, storage racks, special subway and train wagons/compartments for bikes) and extension of pedestrian areas, especially in large urban agglomerations;
- Increasing the rate of public transportation rate by optimizing public transportation means (buses, trolleybuses or trams) and the infrastructure necessary for their good operation, and extending the subways system by competing Section 1 Mai – Laminorului; completing Section Taberei Road – University – Pantelimon; competing Section Victoriei Square – Baneasa Airport – Henri Coandă Airoport, replacing the fleet with expired useful life (50% of the current fleet), increasing traffic frequency and equipping new lines with trains.

3.5.3 Savings arising from transport measures

The measures taken between 2014 and 2020 to increase efficiency energy in rail transport will generate savings of 114,000 toe according to the data in Table 2.3 that represent an average saving of 16,000 toe (electricity and diesel) each year which means approx. 4% of the current energy consumption.

The measures taken to increase efficiency energy in shipping will generate annual fuel savings of 550 toe between 2014 and 2019 which represent approx. 1% of consumption in 2012 and 1,000 toe in 2020 according to the data in Table 2.3.

Renewing the vehicle fleet, optimizing the public transport and freight routes in cities, and using alternative transportation means will generate gas and diesel savings of approx. 60,000 toe each year, which represent 1.2% of the consumption by road transport in 2012 according to the data in Table 2.3.

As regards air transport, an energy saving of approx. 5,000 toe is expected between 2014 and 2020 according to the data in Table 2.3, which represents approx. 3% of the consumption by air transport in 2012.

Using alternative transportation means will generate energy savings of approx. 445,000 teo according to the data in Table 2.3. These data have been evaluated in the "Final Report – Recommendations for 3rd NEEAP".

3.5.4 Financing energy efficiency measures in transport

Investments to increase energy in transport can be financed from own funds, bank credits and European funds described in details in Section 3.1.1.

3.6 Energy efficiency measures in heating and cooling services

3.6.1 Providing heating and cooling services

According to the statistics collected in 2012, approx. 87.2% of the energy is used by the population to heat residences and domestic hot water and to prepare food, and only 12.8% is used for lighting and powering electric and electronic appliances. Thus, in this year, an energy consumption of 7,079,467 toe ensured heating from the following sources:

- Natural gases: 2,569,261 toe (36.3%);
- Fire wood: 328,379 toe (46.4%);
- Thermal energy 959,517 toe (13.6%);
- Unconventional energy sources: 12,793 toe (0.2%);
- Other fuels (liquid hydrocarbons and coal) (3.5).

It results that 86.4% and 100% of heating and cooling services, respectively, have been realized in a decentralized manner.

As regards the existing cooling systems, an increase was found in the use of splinter ventilation fans using electricity in residential, administrative and service-sector buildings.

In Romania, Law No. 325/2006 regulates the activities specific to public heating supply services used for heating and preparing domestic hot water, and the production, transmission, distribution and supply of heat in a centralized system in an efficient manner and at quality standards with a view to the optimum use of the energy resources and in compliance with the environment protection standards.

The public thermal energy supply service in a centralized system is ensured at the level of regional administrative units under the management, coordination and responsibility of the operators and authorities of local public administration. This service aims at ensuring the thermal energy for heating and preparing domestic hot water for the population, public institutions, social and cultural objectives and economic operators.

The public thermal energy supply service (SACET) is provided by means of specific technical and urban infrastructure owned in the public or private domain of the local public administration or the community association for development. The National Regulatory Authority for the Public Utilities Community Services (ANRSC) is a public institution subordinated to MDRAP and is responsible, among others, for the regulation and monitoring of SACET.

After the 1990s, the number of localities, which have benefited from district thermal energy production and distribution systems, has steadily decreased. **Figure 3.3** shows the evolution of the number of localities with district thermal energy supply systems.

Number of localities with district thermal energy supply systems

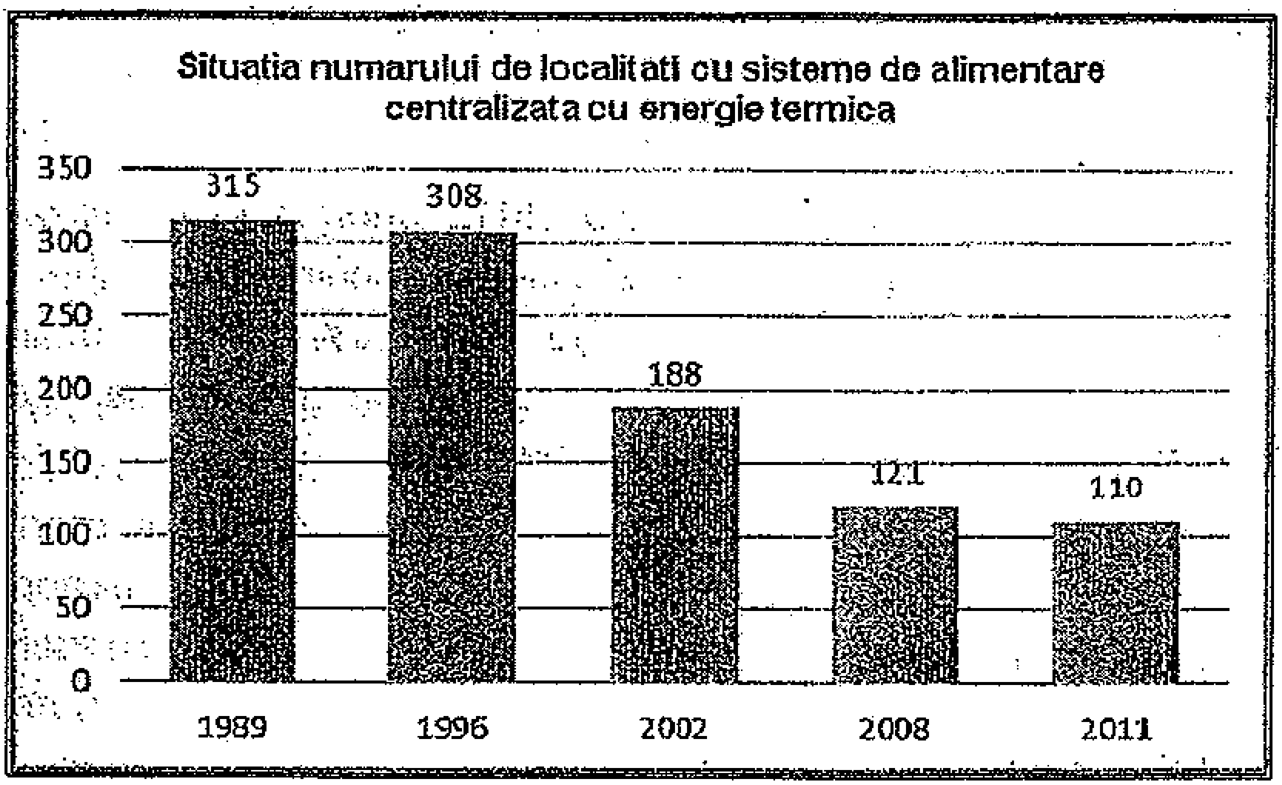

Figure 3.3 *Evolution of the number of localities with district heating systems*
(Source: ANRSC – State of the thermal energy district distribution service)

Table 3.24 shows the evolution of the number of apartments connected to the District heating systems (SACET) between 2007 and 2011.

Table 3.24 Evolution of the number of apartments connected to District heating systems (SACET) between 2007 and 2011

	2007	2008	2009	2010	2011
Total number of apartments	1,658,238	1,647,881	1,595,175	1,550,402	1,488,293

(Source: ANRSC – State of the thermal energy district distribution service)

The above table highlights that the total number of apartments connected to district heating systems steadily decreased between 2007 and 2011, and a number of 1,488,293 apartments were supplied with thermal energy at the end of 2011.

The evolution of disconnections and reconnections to district heating systems is presented in **Table 3.25.**

Table 3.25 Evolution of disconnections and reconnections to district heating systems between 2007 and 2011

	2007	2008	2009	2010	2011	Total
Disconnected apartments	41,878	40,064	32,582	59,035	70,432	243,991
Reconnected apartments	4,299	5,329	5,894	3,009	10,013	28,544

(Source: ANRSC – State of the thermal energy district distribution service)

The data presented suggest that, although during the first three years of the period analyzed, the number of disconnections from the district heating system showed a decreasing tendency, this number increased quit a lot relative to the beginning of the period during the last two year. In terms of the number of reconnections to the district heating system, after a slight increase during the first three years of the period analyzed, the number of apartments reconnected in 2011 was over twice as high as in 2007 and over three times as high as in 2010.

On May 31st 2014, a number of 1,327, 608 apartments were supplied with thermal energy by SACET, of which 93.6% of apartments are located in urban areas, while 6.8% of them are in rural areas; their distribution in Romania is shown in **Figure 3.4**.

Apartments connected to SACET on May 31st 2014

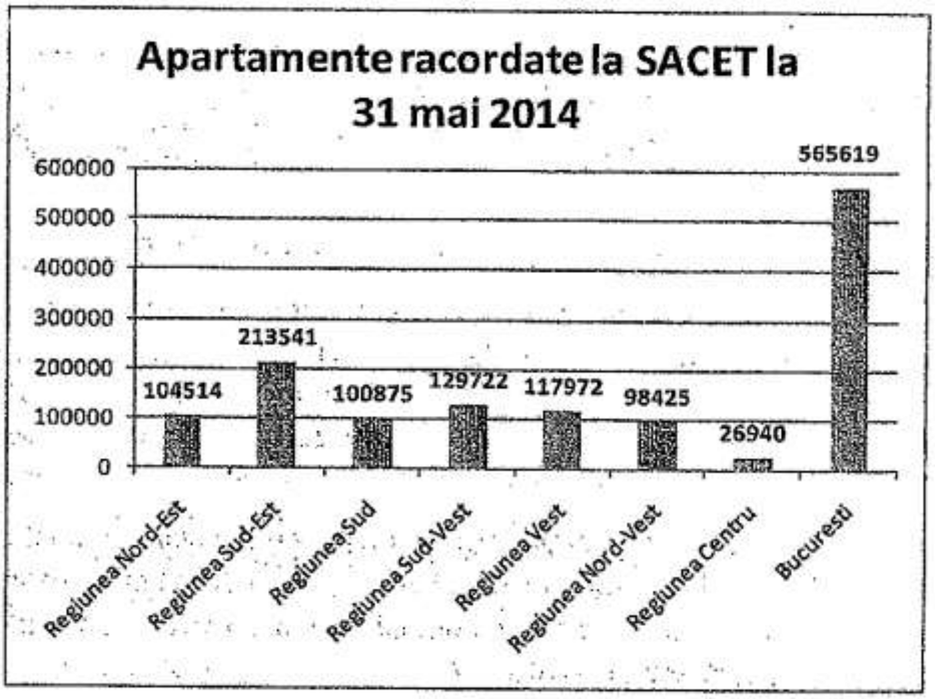

Figure 3.4 Territorial distribution of apartments connected to district heating systems
(Source: www.anrsc.ro)

At the end of May 2014, the rate of disconnections was 0.12% of the total number of apartments connected, while the rate of connections of new apartments was 0.05%. This process led to maintaining in operation of only 73 SACET-type systems, compared to 104, to which a number of 1,658,238 apartments were connected, as shown by the records of ANRSC for the end of 2007.

Compared to the units which are directly monitored and controlled by ANRSC, there is an important number of heating plants/cogeneration plants and related heating distribution networks at national level, owned by companies, used for heating/cooling administrative, commercial or residential buildings.

As regards the annual quantities of distributed thermal energy, these quantities steadily decreased between 2007 and 2012 as a result of the climate conditions which led to an increase in the outside temperatures, on the one hand, and the number of consumers, on the other hand.

Table 3.26 shows the evolution of thermal energy production in Romania between 2007 and 2012.

Table 3.26 Evolution of thermal energy production between 2007 and 2012 (toe)

Year	2007	2008	2009	2010	2011	2012
Thermal energy production (including agricultural producers)	2,632,908	2,418,164	2,310278	2,366,783	2,362,958	2,172,506

(Source: National Institute of Statistics –Energy Balance and Structure of Energy Equipment – Collections 2007-2013)

Table 3.27 shows the evolution of final thermal energy consumption, total and by main activities in the national economy. It should be noted a 17% decrease in consumption between 2007 and 2012.

Table 3.27 Evolution of final thermal energy consumption (total energy consumption and main economic and social activities consumption) between 2007 and 2012 [ktoe]

Specification	2007	2008	2009	2010	2011	2012
Final thermal energy consumption by: - industry	307,741	323,493	237,571	282,640	291,391	278,874
- transport	23,349	16,342	13,696	4,837	1,682	2,248
- population	1,255,373	1,206,009	1,182,158	1,134,744	1,120,525	959,517
- agriculture and forestry	18,372	14,176	21,693	18,039	23,977	30,336
- services	216,640	235,165	193,910	214,077	225,135	234,266
Total	**1,821,475**	**1,795,185**	**1,649,028**	**1,654,337**	**1,662,710**	**1,505,041**

(Source: National Institute of Statistics –Energy Balance and Structure of Energy Equipment – Collections 2007-2013)

The largest thermal energy consumers supplied from the district systems is the residential sector (67.4% in 2011), followed by the industry (17.5% in 2011) and services (13.5% in 2011). The thermal energy consumption showed a significant decrease in the transport sector in 2011, which represented approx. 7.2% of the consumption in 2007.

All thermal energy production plants use fossil fuel (coal, natural gas and fuel oil) and wood biomass.

Table 3.28 shows the structure of resources used in thermal energy production between 2007 and 2012.

Table 3.28 Evolution of resource consumption for thermal energy production [ktoe]

Specification	2007	2008	2009	2010	2011	2012

Total energy resources, of which:	**2,640174**	**2,563,836**	**2,360,033**	**2,436,084**	**2,510,214**	**2,280,435**
Coal	683,707	651,183	591,001	640,872	700,395	647,256
Unconventional resources	20,989	29,115	29,552	45,843	77,252	67,325
Liquid hydrocarbons	229,699	189,602	238,573	258,927	288,405	194,554
Gaseous hydrocarbons	1,701,734	1,692,890	1,500,630	1,490,167	1,443,830	1,367,723
Other fuels	4045	1,046	277	275	332	248
Unconventional energy sources						3,329

(Source: National Institute of Statistics –Energy Balance and Structure of Energy Equipment, 2012)

As regards the fuels used in thermal energy production, hydrocarbons have an important proportion (69% in 2011, decreasing by approx. 2.8% and 4.2% compared to 2010 and 2007, respectively), while coal also has another major share (27.9% in 2011, increasing 2.9% compared to 2009). It is worth noting the increase in the proportion of unconventional energy resources in 2012.

The data presented show a decrease in the population's confidence in district heating systems and the occurrence of a phenomenon of mass disconnection of household consumers from these systems and the use of natural gas in individual heating systems and stoves.

The economic restructuring and closing some industrial enterprises as a result of the economic crisis have exacerbated the cogeneration crisis in Romania.

Directive 8/2004/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market has been implemented in the national legislation by Government Order No. 219/2007 on the promotion of cogeneration based on useful thermal energy.

Government Order No 1215/2009 laying down criteria and conditions necessary to implement the aid scheme for the promotion of high-efficiency cogeneration based on the demand for useful thermal energy, a bonus-type scheme has been implemented which is applied to producers with units with an installed electric capacity above 1 MW, as well as promotion has been made through regulated prices and the obligation of implicit suppliers to purchase energy in the case of producers and household consumers who own low-power cogeneration units or micro-cogeneration units.

This bonus-type scheme represents a state aid (No 437/2009), authorized by the European Commission as compatible with the common market according to Article 87(3) of the EC Treaty by Decision C(2009) 7085, which also lays down the conditions for granting this aid, including the obligation to submit annual reports on the application of this aid.

The application of the bonus type aid scheme began on April 1st 2011.

This bonus-type scheme is intended to promote combined heat and power systems (cogeneration) to encourage new investments in cogeneration technologies, and to replace/rehabilitate existing installations. This scheme may be accessed only for cogeneration installations which comply with the requirement to save primary energy compared to separate production, as established by Directive 2004/8/EC and Commission Decision 2007/74/EC (replaced by Decision 2011/877/EU), so aid can be granted only for electricity produced in high-efficiency cogeneration systems.

For each cogeneration configuration assigned by each producer, the quantities of electricity produced in high-efficiency cogeneration systems are determined for each year based on the values achieved, pursuant to Regulation on the qualification of the electricity produced in high-efficiency cogeneration systems, and on the verification and monitoring of fuel consumption and useful electricity and heat production in high-efficiency cogeneration systems, approved by Order No. 23/2010 of the ANRE President. This Order has been repealed by Order No. 114/2013 of the ANRE President on the approval of the Regulation on the qualification of the electricity produced in high-efficiency cogeneration systems and on the verification and monitoring of fuel consumption and useful electricity and heat production in high-efficiency cogeneration systems, which entered into force on December 21, 2013. In order to monthly estimate the energy quantities on a monthly basis for which bonuses can be obtained, this Qualification Regulation includes a simplified procedure applied monthly by ANRE that results in a decision based on which the aid scheme administrator, CN Transelectrica SA grants the monthly bonus.

The application of this aid scheme will lead to an increase in the efficiency of electricity and heat production, and encourages new investments. **Annex D** includes a list of electricity and heat cogeneration capacities that obtained final accreditation in May 2014.

3.6.2 Comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling

According to Article 14(1), it is necessary to carry out and notify to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling, containing the information set out in Annex VIII by December 31, 2015.

This evaluation shall include a cost-benefit analysis for alternative scenarios studied taking into account climatic conditions and technical and economic feasibility in accordance with the legislation in force.

In order to carry out this evaluation, the provisions of Article 14(1) of Law No. 121/2014 on energy efficiency should be complied with, and the authority of central public administration shall prepare and send to the European Commission a document describing the potential to use high-efficiency cogeneration and efficient district heating and cooling systems.

It should be emphasized that, according to Law No. 325/2006, the National Strategy on public heat supply service on a centralized basis is drawn up by the *Ministry of Regional Development and Public Administra*tion in cooperation with the Ministry of Economy and Ministry of the Environment and Climate Change, following consultations with representative non-governmental organizations.

According to Article 13, “the regulatory authorities with competencies in heat supply service are ANRSC and/or ANRE, as appropriate”, while Article 14 states that “these authorities shall ensure the access of central public administration authorities to the information necessary to develop strategies and policies”.

ANRSC shall develop a database to monitor SACETs and public heat supply service to carry out a comparative analysis of performance indicators. ANRE has a database with the list of electricity and heat cogeneration capacities with accreditation which are monitored by presenting quarterly reports.

In the evaluation of the potential to use high-efficiency cogeneration and efficient district heating and cooling systems, the local public administration authorities play an important role in particular with the following competencies:

- to ensure the continuity of public heat supply service at the level of regional administrative units;

- to draw up a program for thermal energy on an annual basis, linked with an energy efficiency program and approved by a resolution of the local or county council or the General Council of Bucharest, or a community association for development, as appropriate;
- to create an energy department in its own organization in accordance with the legislation;
- to approve the proposals on the local price of thermal energy to users, submitted by the service operators, in compliance with the legislation, within 30 days;
- to approve the local price to the population in compliance with the legislation;
- to approve the development, modernization and metering of SACET, which should include both financing sources and the time limits based on the data provided by the service operators;
- to ensure conditions for drawing up studies on the evaluation of the local potential of renewable energy resources and the feasibility studies on the exploitation of this potential;
- to control public thermal energy supply service in accordance with the legislation;
- to establish unit heating zones based on the feasibility studies on regional development, approved by a resolution of the local council, county council or the General Council of Bucharest, or the community association for development, as appropriate;
- to follow the establishment of SACET protection and safety zones by the service operator in compliance with the legislation;
- to follow the development and approval of programs for metering at the level of the main thermal connection of the thermal energy users connected to SACET;
- to follow that, in order to modernize and improve SACET, feasibility studies also analyze solutions for the supply of thermal energy produced in high-efficiency cogeneration or by exploiting local renewable resources.

The document on the evaluation of the potential to apply high-efficiency cogeneration and efficient district heating/cooling will include the following main elements (according to EED, Annex VIII), shown in **Table 3.29.**

Table 3.29 Main elements of the document for a comprehensive assessment of the national heating/cooling potential

No	Chapters	Reference
1	Energy demand for heating/cooling	2013
2	Evolution of the energy demand for heating/cooling for each year up to 2023	2013
3	The map of Romania in which the following information should be included: - areas where the energy demand for heating/cooling exceeds the consumption limit for which district heating systems are feasible - areas where the energy demand for heating/cooling exceeds total annual consumption limit - existing SACET-type infrastructure which supplies energy for heating/cooling	 municipalities and conurbations total annual consumption ≥ 20 MWh 2013

	- planned SACET/type which will supply energy for heating/cooling - existing areas where the amount of electricity produced from energy sources for heating/cooling exceeds an annual limit of ≥ 20 MWh - planned areas where the amount of electricity produced from energy sources for heating/cooling exceeds an annual limit of ≥ 20 MWh - existing areas where there are energy sources for heating/cooling which have waste incineration installations - planned areas where there are energy sources for heating/cooling which will have waste incineration installations - existing areas where there are energy sources for heating/cooling which have cogeneration installations[3]	2023 2013 2023 2013 2023 2013
	- planned areas where there are energy sources for heating/cooling which will have cogeneration installations[2]	2023
4	Identification of energy demand for heating/cooling which can be technically covered by efficient energy production systems (high-efficiency cogeneration installations, microgeneration, SACET)	2023
5	Identification of the potential for additional high-efficiency cogeneration (existing/resulting from rehabilitation works/new installations/modernization of the existing installations)	2023
6	Identification of the potential for efficient energy of the heating/cooling energy production infrastructure	2013
7	Development of strategies/policies/measures at local/regional level in order to balance demand and supply related to the energy produced in	2020 → 2030

[3] Combined cycle gas turbine with heat recovery, stream backpressure turbine, steam condensing extraction turbine, gas turbine with heat recovery, heat engine, microturbines, Stirling engines, fuel cells, steam engines, Rankine cycles for organic fluids or any other type of technologies or combinations thereof for simultaneous production of thermal energy and electricity.

	high-efficiency cogeneration for heating/cooling taking into account the following cases: - Increasing the proportion of cogeneration for heat (for heating/cooling) and electricity production - Development of the SACET infrastructure for heating/cooling mainly by developing high-efficiency cogeneration, heat recovery and using SRE - Installation of new thermal power and industrial equipment/installations which can become sources of residual heat by functioning, in systems that allow recovery and utilization for heating/cooling with maximum efficiency - Creation of bonus systems for placing new residential/industrial objectives (important thermal energy consumers) mainly in areas where there are systems with surplus thermal energy - Prioritization of connections to existing SACET of installations which may be sources of residual heat[4] - Creation of bonus systems to connect thermal energy consumers – residential/industrial users to existing SACET-type systems	
8	Proportion of high-efficiency cogeneration, established potential and recorded progress	annual
9	Estimation of the proposed primary energy savings	2013 → 2023
10	Existing initiatives/programs to support heating/cooling services of local/regional/national public authorities and available annual budget[5]	2013 → 2023

3.6.3 Additional measures for energy efficiency in heating and cooling services

For the 2014-2020 period, the National Plan of Investments provides for the creation of new high-efficiency cogeneration groups (Government Resolution No. 1096/2013), which could generate energy savings of 0.424 million toe in accordance with the data in Table 2.3.

During the 2014-2020 period, the “Heating and comfort 2006-2015” Program will be continued with the modernization of district heating systems. Thus, energy savings of 0.202 million toe will be generated according to the data in Table 2.3, the costs for heating and preparation of hot water will be significantly reduced, the potential renewable resources will be exploited on a local level, and pollutant emissions will be reduced.

[4] Thermoelectric and industrial installations, incineration installations/energetic use of waste
[5] Public support systems other than those for the evaluation of the state aid

3.7 Energy transformation, transmission, distribution, and demand response

Given the role energy plays in society and in all branches of the economy, it is necessary to create a modern energy sector in compliance with the principles of the European Union on the liberalization of electricity and natural gas market that is able to satisfy the demand of energy consumers both at the present and on medium and long term at an acceptable price, appropriate for a modern market economy and a civilized standard of life, at good quality and food safety conditions in line with the principles of sustainable development.

The Government of Romania pays particular attention to the development and operation of the National Energy System (NES) and the National Natural Gas Transport System.

The National Energy Regulatory Agency (ANRE) is assigned to regulate, monitor and control the operation of the energy sector and electricity and natural market under conditions of competition, transparency, efficiency and consumer protection, to implement and monitor energy efficiency measures at national level, and to promote the use of renewable energy sources by end-consumers. ANRE carries out its activity pursuant to the authority provided for by Law No 123 on electricity and natural gas and Law No 160/2012 on the organization and functioning of the National Energy Regulatory Agency; these laws transpose the provisions of the third legislative package of the European Union on the domestic energy market into national legislation.

3.7.1 Energy efficiency criteria in network tariffs and regulations

The existence of the electricity and natural gas markets imposed the preparation, completion and development of the regulatory framework necessary to the functioning and improvement of the electricity and natural gas market. As a consequence of the results obtained so far and the demands of the economic operators in this sector, regulations should be continuously amended. The section below describes the way in which existing regulations stimulate measures to increase energy efficiency in the electricity and natural gas market.

3.7.1.1 Electricity

ANRE has duties and powers in pricing of electricity:

- to develop and approve the calculation methods required to set regulated prices and tariffs;
- to approve prices and tariffs practiced by economic operators in the electricity sector on the regulated electricity market, tariffs for system, electricity transmission and distribution services, prices and tariffs practiced for activities and services related to heat cogeneration intended for the population, based on consultations in order to protect end consumers;
- to monitor the electricity market in order to evaluate its efficiency, transparency and competition based on its own regulations;
- to control how economic operators in the electricity sector comply with the regulations issued and the price and tariffs system in force, and to apply sanctions in case these are not complied with;
- to establish framework supply contracts both for economic operators concerning the sale, purchase, transport, system service and distribution of electricity, and for the sale of heat produced in cogeneration;
- to mediate pre-contractual disagreements in the electricity sector in accordance with its own procedures.

The transactions on the electricity market are conducted at wholesale or retail level.

The wholesale market includes all transactions performed between participants with the exception of the transactions with electricity end consumers, which are carried out on the retail market.

The model of the wholesale electricity market includes the following components:

- bilateral contracts (regulated, negotiated or concluded through bids on the centralized contract market);
- transactions entered into on the day-ahead market (DAM) where participants adjust their contractual position or in order to obtain a profit from the difference between contract prices and spot prices;
- balancing market (BM) which provides coverage of the differences between production notified and forecasted consumption, while participants assume financial responsibility for the imbalances recorded;
- intraday electricity market (IDM), a new transaction mechanism which allows participants access to a portfolio balancing market closer to the time of delivery and contributes to a reduction of imbalances.

In order to carry out transactions of contracts through transparent mechanisms on the competitive market, a centralized market of bilateral contracts have been organized, which includes two trading modalities: one which involves granting contracts are granted through public bid (PCCB) and one which involves granting contracts through a combined public bid and negotiation method (PCCB-NC).

The wholesale market also includes transactions carried out on the system technology service (STS) market and the interconnection capacities market with the electricity systems of neighbouring countries (ATC).

The system technology service (STS) market is a market on which contracts are entered into between qualified producers to supply each type of technology service and CN Transelectrica SA for making available to the NES, for payment, production capacities which can be mobilized upon a request made by the National Energy Dispatch (NED), subject to specific conditions regarding technical capabilities of the production units (according to the types of system services for which these were qualified); these contracts are reflected in the obligation to tender the abovementioned capacities on the balancing market, after which potential energy quantities produced/reduced will be subject to settlement on the balancing market.

Due to the electricity market, prices stabilize in a competitive environment between participants on the market, which covers the entire value chain, from production to the final electricity supply. This competitive environment boosts efficiency in electricity and thermal energy cogeneration with positive results in reducing specific fuel consumption.

At the present, there are consumers who choose their electricity supplier, and captive consumers (household and non-household consumers) who have not yet made use of their eligibility right.

For captive consumers, there is a pricing method which is the basis for establishing prices, while for non-captive consumers the price is established on the competitive market. Captive consumers are allowed to change their supplier, and thus to leave the regulated market if they so wish, but they are no further allowed to return to the captive status (on the regulated market).

ANRE provides that all costs of the supplier resulting from purchasing electricity to be supplied to captive consumers, transmission services (transmission tariff), system services (distribution tariff), taxes and excise duties are transferred on the end-customer, including any other justified costs related to electricity supply. Each of these components is regulated, including the profit margin of the supplier, set at 2.5% of the purchase price of the energy supplied.

The methodology for setting the prices and tariffs to end-consumers who do not make use of their eligibility right (ANRE Order No. 30/2012) has established the following principles:

- to determine the purchase basket of the regulated electricity quantities for suppliers of last resort;
- to determine the regulated electricity tariff scales for end-consumers who do not make use of their eligibility right;
- to determine the average regulated purchase price of electricity by suppliers of last resort for end-consumers who do not make use of their eligibility right;
- to determine the electricity tariff, called **Competitive Market Component,** applied by suppliers of last resort for end-consumers who do not make use of their eligibility right.

As of September 1, 2012, correlated with the schedule for the removal of feed-in tariffs (**Table 3.30**), suppliers of last resort have included in the invoices of end-customers who do not make use of their eligibility right a new tariff, called "Competitive Market Component", based on the purchase prices of electricity on the competitive market.

Table 3.30 Proposed schedule for the removal of regulated tariffs

Implementation data	Percentage of electricity purchased from the competitive market (non-household consumers) (%)	Percentage of electricity purchased from the competitive market (household consumers) (%)
September 1, 2012	15	0
January 1, 2013	30	0
April 1, 2013	45	0
July 1, 2013	65	10
September 1, 2013	85	10
January 1, 2014	100	20
July 1, 2014	100	30
January 1, 2015	100	40
July 1, 2015	100	50
January 1, 2016	100	60
July 1, 2016	100	70
January 1, 2017	100	80
July 1, 2017	100	90
December 31, 2013	100	100

"Pricing methodology for electricity sold by producers based on regulated contracts and quantities of electricity from regulated contracts concluded by producers with suppliers of last resort" (ANRE Order No. 83/2013) shall apply during the period scheduled for the removal of regulated tariffs, that is, by

December 31, 2017, and ANRE establishes obligations for electricity procedures to sell some firm electricity quantities based on regulated contracts on an annual basis, in order to provide for the following conditions:

- maintenance of reasonable and comparable values of regulated tariffs for the electricity supplied to household customers;
- gradual adjustment of average sale prices of electricity supplied to end-customers in the regulated system;
- step-wise reduction of electricity quantities sold by producers on the basis of regulated contracts.

New elements of this methodology are as follows:

- establishment of electricity quantities from regulated contracts by observing purchase percentages on the competitive market related to each step included in the *Schedule for the removal of regulated tariffs,* approved by the Memorandum of Understanding signed by the Government of Romania and the European Commission on March 13, 2012;
- limitation of the applicability of the provisions on the establishment/amendment/adjustment by ANRE of the electricity prices/quantities from regulated contracts at the latest by the date of concluding the Schedule for the removal of regulated tariffs (December 31, 2017);
- introduction of a priority order to establish obligations to sell some firm electricity quantities based on regulated contracts;
- establishment of a maximum limit for the annual electricity quantity that can be taken over under regulated contracts for producers who own/commercially exploit dispatchable nuclear energy and/or hydroelectric groups;
- optional take over, under a regulated contract, in the order of prices, of the electricity delivered from: dispatchable thermal power groups which benefit of the provisions of some Government Resolutions on the guaranteed access to power networks or the exemption from compliance with the structure of natural gas mixtures established/approved by ANRE; groups/power plants which benefit from the aid scheme using bonuses or green certificates;
- application of regulated prices established by specific regulations in the case of producers who benefit from the aid scheme using bonuses and in the case of producers who benefit from the alternative aid scheme of feed-in type;
- take into account in the calculation of the regulated average price, as appropriate, revenues obtained from system technology service contracts and revenues from thermal energy sales (established according to specific regulations);
- the possibility to take over some firm electricity quantities based on regulated contracts from producers who benefit from the green certificate aid scheme, at prices established according to the quote sent by them to ANRE, only if the prices offered are lower than or at most equal to the regulated price established for producers who have/commercially exploit dispatchable hydroelectric groups;
- make the procedure used to modify electricity quantities from regulated contracts more flexible.

The quantities and prices from regulated electricity purchase contracts shall be established on the basis of the following elements:

- hourly consumption forecast from that year, transmitted by suppliers of last resort to end-customers who have not yet used their eligibility right;
- hourly technological consumption forecast, sent by network operators for that year;
- hourly electricity quantities necessary to be provided by suppliers of last resort by purchasing them from producers based on the regulated contracts, determined on the basis of the level of deregulation from each step described in the Schedule for the removal of regulated tariffs;
- hourly electricity quantities supplied from dispatchable groups, resulting from running the PowerSym program for that year which specifies the priority of producers;
- estimated electricity quantities as produced in high-efficiency cogeneration and available to be supplied on the basis of the regulated contracts in that year, having regard to the provisions of the legislation and the regulation on trading by regulated electricity contracts subject to the bonus-type aid scheme;

- the level and structure of costs estimated by producers for that year, compared to both the level considered justified for each cost class at the previous approval of the regulated price, and the values achieved with a year before, taking into account the base described in justification memorandum.

The reference prices and the regulated prices for electricity applicable to electricity and heat cogeneration producers who are granted bonuses, the reference bonuses for electricity produced in high-energy cogeneration units and the reference prices for heat produced in cogeneration related to the three main types of fuel (solid fuel, natural gas from the transmission network, natural gas from the distribution network) shall be approved by ANRE for the entire period of application of the aid scheme.

The ANRE has established and communicated to each producer who participates in regulated contracts the justified level of average purchase price of the fuel for the next year on the basis of a detailed comparative analysis of the average fuel purchase price achieved during the current year and the estimates for the next year. These values are determined by taking into account the increases in the prices of each type of fuel based on a prudent estimation for the next year.

ANRE shall approve, by order, a contribution to promote high-efficiency cogeneration on an annual basis.

ANRE shall publish reports on the monitoring of aid scheme for the promotion of cogeneration, based on the useful thermal energy demand, on its webpage on a quarterly basis.

The ANRE has established and communicated to each producer who participates in regulated contracts the justified level of fix costs on the basis of a detailed comparative analysis of the fix costs taken into account when establishing previous regulated prices, fix costs achieved during the current year and the inflation rate estimated for the next year.

The ANRE shall establish and communicate to each producer who participates in regulated contracts the justified level of costs related to fuel on the basis of the established average fuel purchase price, the harmonized reference values of both separate electricity production efficiencies, approved by an order of the ANRE President and, as appropriate, global electricity and heat production efficiency of minimum 70%.

According to this methodology, the producers who produce electricity and heat in cogeneration are encouraged to adopt measures to increase energy efficiency.

ANRE is required to approve tariffs regulated by the network for services rendered by network operators to the benefit of the users of public electricity transmission and distribution systems, charged under regulated contracts for the electricity transmission and distribution service. These are as follows:

- tariffs for the electricity transmission service;
- tariffs for the electricity distribution service;
- tariffs for the system service;
- tariffs practiced by the operator of the electricity market.

The *“Methodology for establishing tariffs for the electricity transmission service”,* approved by ANRE Order No 53/2013, has not changed the main method for determining the tariffs for the transmission service compared to the second period of regulation, but represents an improved form of the stimulating methodology using income ceiling, applied by ANRE as of 2005. Thus, this methodology aims at:

- providing reasonable allocation of the resulting profit by increasing the efficiency in the transmission activity above the targets established by the competent authority, between the transmission operator and the system operator (CN Transelectrica SA) and the customers of the transmission service;
- a framework for the efficient functioning of CN Transelectrica SA;
- preventing the CN Transelectrica SA to obtain any possible advantages caused by its monopoly;
- promoting efficient investments in the electric transmission system;
- promoting some efficient maintenance and exploitation practices;
- efficiently using the existing infrastructure;
- continuously improving the quality of the transmission service;
- financial viability of CN Transelectrica SA;
- providing information on the regulation process in a public and transparent manner.

This Methodology envisages that the regulated annual revenues related to the transmission service are projected for the entire period of regulation (2014-2018) on the basis of both the costs forecast related to rendering the service deemed to be justified and the annual investment programs proposed by the CN Transelectrica SA and accepted by the ANRE.

This Methodology contains mechanisms to stimulate the efficiency of the electricity transmission service by promoting efficient investments in the electric transmission network, reducing own technological consumption (OTC), reducing operation and maintenance costs, and improving the quality of the service.

The transmission tariff is a block (annual) tariff that has two components: one to input energy in the networks and one to recover electricity from the networks. Different transmission tariff components are applied to different tariff zones depending on the impact of the input or recovery to/from the nodes of the electricity network, expressed in the nodal marginal cost of transmission. The transmission network has six areas of input (G) and eight areas of recovery (L) of electricity, as shown in **Figure 3.5.**

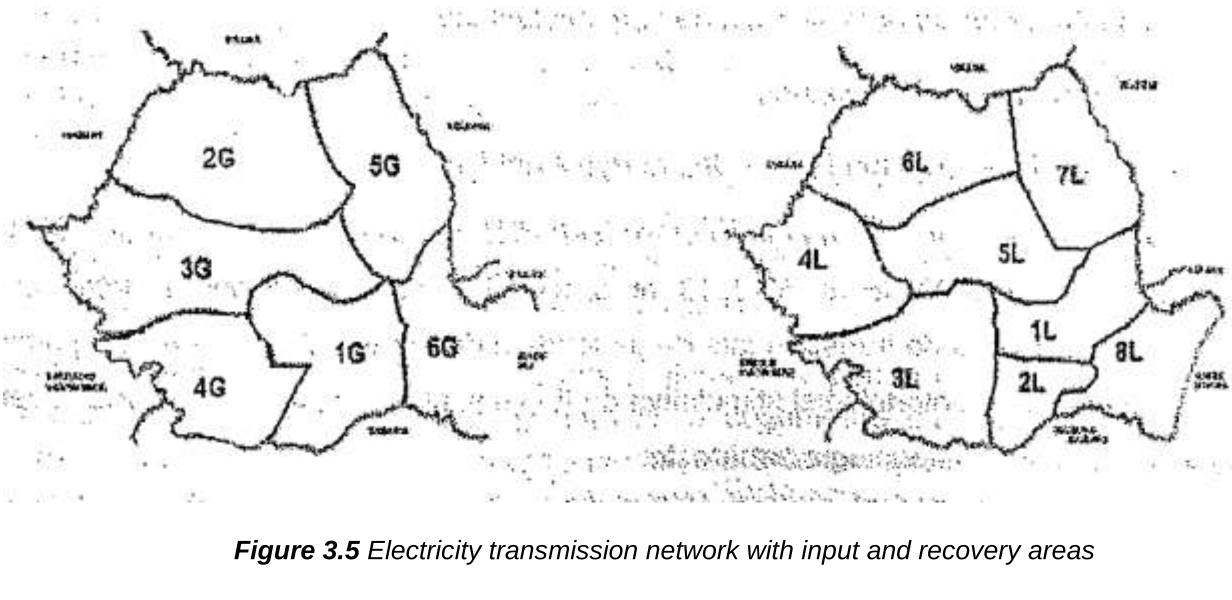

Figure 3.5 *Electricity transmission network with input and recovery areas*

The nodes of the power network are grouped in tariff areas as follows:

- the input areas of electricity to the network represent production node groups;
- the recovery areas of electricity from the network represent consumption node groups.

The criteria for grouping nodes into input/recovery areas of electricity to/from the network are as follows:

- marginal costs resulting from own technological electricity consumption are within a variation margin of ±20% compared with the regional average marginal cost related to own technological electricity consumption for minimum 70% of the number of nodes in the tariff area;
- distinctive network sections include, in full, one or more tariff areas.

The criteria for grouping nodes into electricity recovery areas also take into account relevant demarcations (e.g. counties) of the distribution networks.

The regional transmission tariff (for introducing electricity into the producer node or for extracting electricity from the consumer node) is calculated as the sum of the marginal cost resulting both from OTC and congestions at a specific node and an average node cost. Different transmission tariffs are applied in different tariff areas depending on the impact of the electricity input or recovery to/from the power network nodes. This impact is reflected in the marginal node cost of the transmission.

Having regard to the experience in applying this type of regulation, the main aspects completed, improved and clarified by the new Methodology are as follows:

- definition of an additional mechanism to stimulate reduction of the purchase price of OTC with the possibility to retain a share of the resulting efficiency gains;
- establish the criteria to prioritize the investment projects, the conditions for determining the normal regulated useful life of fix assets resulting from investments, and the conditions to record the additional investments compared to the approved investment plan in the regulated base of assets;
- inclusion of the provisions of Regulation No. 714/2009/EC and Regulation No. 838/2010/EU under which revenues and costs resulting from the application of the compensation mechanism between the transmission system operators and tariff regulated by transit are determined by the European network of electricity transmission system operators (ENTSO-E), and not by the ANRE;
- inclusion of the provisions of Regulation No. 347/2013/EU under which projects of European interest represent a particular category of essential investments that are financed from the revenues from the allocation of the interconnection capacity and other European funds;
- inclusion of the provisions of Regulation No. 714/2009/EC under which revenues obtained by the transmission system operator from the allocation of the capacity of interconnection lines are used to guarantee real availability of the capacity allocated and/or to maintain or increase interconnection capacities by investments in the transmission network and especially investments in new interconnection capacities.

CN Transelectrica SA is required to submit the Investment Plan to ANRE for approval on an annual basis with the justification for each investment project and its value by objective pursued such as:

- to replace aged fix assets;
- to reduce own technological consumption;
- to improve the quality of the transmission service
- to increase the transmission capacity of the power network;
- to increase the interconnection capacities, and so on.

CN Transelectrica SA prioritizes investment projects as follows:

a. **essential projects** for the purposes of investment projects aiming at creating essential non-current assets intended to provide safe operation of the NES transmission network, eliminate systematic congestions and ensure that the capacity of the transmission network to deal with energy flows in medium term that have to be transmitted via NES or neighbouring systems under safety and continuity conditions established by technical standards in force;

b. **necessary projects** for the purposes of investment projects aiming at creating necessary non-current assets designed to modernize the electricity transmission network, reduce own technological consumption, ensure the quality and performance of the transmission service according to the applicable norms and standards;

c. **justifiable projects** for the purposes of investment projects aiming at creating non-current assets which can be justified by expenditures generated compared to the benefit to the customers. Justifiable projects are as follows: replacement of existing equipment destroyed, deteriorated or obsolete for which no spare parts exist and on which appropriate maintenance cannot be carried out, modification of electric lines by increasing the voltage level, replacement of conductors/transformers to reduce OTC, doubling of circuits or transformers to improve operation safety or to reduce OTC.

The *“Methodology for establishing tariffs for the electricity transmission service provided by concession transmission operators”* was modified in 2003 and approved by ANRE Order No. 72/2013. This Methodology determines regulated tariffs during the third regulation period (2014-2018) and is a price cap stimulation methodology.

The application of this type of stimulation regulation provides:

- fair allocation of the gains resulting from increasing efficiency above the targets set by ANRE between the transmission operators and the beneficiaries of the distribution service;
- financial viability of the distribution companies;
- effective and efficient operation of the distribution companies;
- prevention of the abuse of dominant position of the distribution operator;
- promotion of efficient investments in the electricity distribution network;
- promotion of efficient electricity distribution network exploitation and maintenance practices;
- efficient use of existing infrastructure;
- safe operation of the distribution network;
- improvement of the quality of the distribution service;
- transparent approach of the regulation process;

According to the provisions of this Methodology, regulated annual revenues related to the distribution service are forecast for the entire regulation period (2014-2018) based on the cost projections proposed by operators and approved by ANRE. This Methodology describes mechanisms to stimulate the efficiency of the electricity distribution service by promoting efficient investments in the network, reducing OTC, reducing operation and maintenance costs and improving the quality of the service.

Distribution tariffs are block (annual) tariffs (RON/MWh) differentiated for three levels of voltage: high-voltage, medium-voltage and low-voltage. Distribution tariffs are approved by ANRE for each distribution operator taking into account the characteristics of the distribution networks in the consumption area.

For the third regulation period new provisions have been established, as well, compared to those applied during the second regulation period. Some of these new provisions emphasize the following:

- explicit obligations have been included concerning capital works and maintenance works within justified costs;
- regulated revenues are reduced if at least 80% of the investments in the annual program are not carried out;
- the regulated rate of return is the same for all operators and a return increase is granted for investments in the implementation of intelligent measurement systems;
- ANRE will adjust and set the level of controllable operation and maintenance costs, and OTC targets, as a result of an analysis process to compare operators based on the data and results of the activity from the first two regulation periods.

Furthermore, as of 2013, concession distribution operators purchase electricity to cover their own technological consumption in a competitive system, on the electricity market.

The Methodology approved by ANRE Order No. 72/2013 describes a mechanism to stimulate reduction of costs related to own technology consumption in electricity networks by recording an electricity purchase price in the regulated revenue linked to the provision of network services to cover OTC which would result from a procurement considered to be optimal on the competitive electricity market.

Obtaining the lowest purchase price implies both performing a forecast as precise as possible and the possibility to trade electricity to cover OTC on competitive markets at a time closest to the time of consumption.

In view of this aspect, ANRE has developed and submitted to public debate a draft order to approve the rules on trading electricity on the competitive electricity market for purchasing the electricity necessary to cover OTC in electricity network, applicable to both the transmission operator and the concession distribution operators.

Distribution tariffs should be applied under a distribution contract to all users connected to the electricity distribution network of the distribution operator in line with the voltage level at which electricity is introduced/extracted.

Distribution tariffs shall be approved by ANRE for each distribution operator and are unique for the distribution network owned by the operator.

ANRE shall verify the basis of distribution tariffs for each year of the regulation period. During this verification process, upon a request sent by the distribution operator for the regulation period, ANRE takes into account mainly the following:

- justified electricity quantity forecast to be distributed based on the indicator of economic growth projected by the National Commission for Forecast for that period;
- performance standards and other requirements imposed on distribution operator according to the legislation in force;
- stability of tariffs;
- OTC regulated for each voltage level according to the reduction plan approved by ANRE;
- optimal development of electricity distribution networks;
- the regulated rate of return applied to the regulated base of assets of the distribution networks;
- taxes set by central or local authorities of the distribution service;
- financial viability of the distribution operator.

The OTC reduction programs shall be proposed by distribution operators and are based on elements such as structure of the electricity distribution networks, volume of installations, structure of the electricity distributed by voltage level, electricity transmission in the distribution network and required estimated investment costs.

By October 1st of the reference year of the regulation period, distribution operators shall submit to ANRE an annual OTC reduction program by voltage level, coordinated with the annual investment programs related to the regulation period. This program specifies the OTC to be achieved by the distribution operator (called target OTC) for each year of the regulation period and each voltage level.

In this annual OTC reduction program, distribution operators shall consider that the target OTC for each voltage level for the first year of any regulation period should be lower than the OTC percentage achieved at that level of voltage and in the reference year of the period.

ANRE shall analyze annual OTC reduction programs and set OTC targets for each distribution operator. These OTC targets set shall be used, on an annual basis, both to forecast costs related to regulated OTC and to adjust revenues resulting from modifying the electricity quantities related to regulated OTC. ANRE is entitled to require the amendment of the annual OTC reduction program proposed by the distribution operator based on an analysis comparing the distribution operators and taking into account the target OTC for the reference year of the regulation period.

When approving the OTC reduction program by voltage levels, ANRE shall aim with priority at reducing OTC at low-voltage.

The efficiency gains achieved by the distribution operator for each voltage level as a result of an OTC lower than the approved target shall be left at the distribution operators' disposal in a proportion of 25% for high-voltage and medium-voltage levels, and 50% for low-voltage level.

Table 3.31 shows the evolution of own technological consumption reflected by ANRE in the tariffs in the 2008-2012 period for different distribution operators.

Table 3.31 Evolution of own technological consumption recognized by ANRE in the tariffs

Distribution operator	**Own technological consumption recognized by ANRE in the tariffs (%)**				
	2008	**2009**	**2010**	**2011**	**2012**
ENEL Distribution Banat	11.67	11.32	10.78	10.24	9.50
ENEL Distribution Muntenia	13.05	12.16	11.27	11.39	9.50
ENEL Distribution Dobrogea	10.70	10.39	10.07	9.75	9.50
CEZ Distribution Oltenia	10.27	10.20	10.20	10.20	9.50

Having regard to the impact of reactive power circulations on both the voltage levels in NES and own technological consumption, the "Methodology for establishing reactive power payment obligations and reactive power regulated price" (ANRE Order No. 33/2014) has been drawn up and shall be applied by the network operators to establish obligations to pay reactive power transmitted through settlement points of:

- the electricity consumption places;
- the electricity production places and the electricity and consumption places.

In line with this Methodology, the "neutral power factor" is defined as the limit power factor up to which the reactive power consumption has no significant impact on losses and reactive voltage/power regulation in the electricity network with an experimentally determined value of 0.92 and 1 for inductive mode and capacitive mode, respectively.

Electricity consumption at a power factor lower than the neutral power factor leads to an increase in energy and power losses in the electricity networks, and to a decrease in energy efficiency of the electricity networks.

This is why the obligations to settle and to pay reactive power represent a measure aimed at encouraging users to limit reactive power transit through the settlement points of the production/consumption places of public electricity networks by:

- ensuring null exchange of reactive power with the networks to which users are connected;
- a consumption at a power factor higher or equal to the neutral power factor;

- application of measures to compensate for the average power factor of the electricity consumed by installing specific equipment in the utilization installations the user owns.

The prices regulated for reactive electricity are approved by ANRE for the electricity transmission and distribution network on an annual basis. These regulated prices are established in view of the increase active power losses in public electricity networks as a result of the reactive power transit. The regulated price of reactive electricity approved by ANRE for the electricity transmission network and for all electricity distribution networks in the concession area of each concession distribution operator shall be established as 30% of the average estimated price of active power to cover own technological consumptions in networks, approved by ANRE for CN Transelectrica SA and for concession distribution operators.

In conclusion, it should be highlighted that the methods for establishing prices and tariffs in the electricity industry stimulate the improvement of efficiency in activities of the participants in the electricity market to reduce own technological consumptions. ANRE is required to monitor compliance with approved methodologies.

3.7.1.2 Natural gas

The duties and powers of ANRE are as follows:

- to develop, approve and apply regulations for organizing and operating the natural gas market concerning the provision of continuity of food supply and food safety using natural gas for consumers;
- to develop, approve and apply criteria and methods for approving prices and for establishing tariffs regulated in the natural gas industry;
- to develop and approve framework contracts for natural gas supply, framework contracts for providing storage, transmission and distribution services, and framework contracts for related activities carried out based on regulated tariffs;
- to develop and approve regulations and technical standards at national levels which establish technical safety criteria, minimum technical requirements on designing, execution and exploitation, necessary for efficient and safe functioning of the objectives in the natural gas industry;
- to monitor compliance with regulations on the organization and operation of the natural gas market; compliance with regulations on the access to conducts upstream, storage warehouses and transmission and distribution systems; application of regulations on the management and allocation of interconnection capacities together with the regulatory authority or authorities from the states where interconnection exists; the manner in which the problem of congested SNTGN TRANSGAZ SA capacities is solved; actual separation of accounts for storage, transmission, distribution and supply of natural gas and liquefied natural gas (LNG), liquefied petroleum gas (LPG), compressed natural gas for vehicles (CNGV) in order to avoid cross-subsidies between these products.

The pricing methodology for natural gases is based on a set of imperative rules that comply both with European provisions and international practices used to establish prices and tariffs.

The “Methodology for approving prices and establishing regulated tariffs in the natural gas industry” (ANRE Order No. 22/2012) aims at establishing:

- regulated tariffs in the natural gas industry at which regulated supply of natural gas is provided, hereinafter referred to as final regulated prices;
- regulated tariffs for natural gas transmission services in a transmission system;
- regulated tariffs for natural gas storage services in underground storage;
- regulated tariffs for natural gas distribution services in the distribution systems, hereinafter referred to as distribution tariffs in a transmission system.

As with the electricity market, ANRE shall also define clear principles for the natural gas market and detailed methodology on establishing tariffs for natural gas supply, transmission, transit, storage and distribution.

Final tariffs or prices for natural gas supply are divided into consumer categories: household consumers (including non-household consumers that produce heat in cogeneration plants and thermal energy plants for the population) and non-household consumers (other than those previously described) depending on their proportion in the final consumption basket compared to the natural gas from domestic production or from import.

As with the electricity market, the regulatory authority has proposed a liberalization schedule of natural gas prices, as of December 1, 2012, and July 1, 2013, for non-household consumers and household consumers, respectively. The market for non-household consumers and household consumers shall be fully liberalized by the end of 2014 and October 1, 2018, respectively.

Allocation of costs among regulated activities is based on the following principles:

- causality – costs are assigned in line with the activity that causes them;
- objectivity – costs are assigned on an objective basis, without following an interest or obtaining some undeserved benefits;
- transparency – allows the identification of the costs assigned for each activity;
- continuity – rules by which costs are assigned for activities are constantly applied in time.

In general, ANRE allows distribution operators to include all justified costs in the tariff.

In general, these costs shall include, primarily, operational costs (OPEX), the value of the initial regulated asset base multiplied with the unit cost of capital (also regulated), amortization of assets recognized by ANRE, and a gain or an increase in profitability.

OPEX also includes technological consumption calculated according to the norms, regulations or other regulations in force.

The technological consumption includes, within the limits accepted by ANRE, all consumptions of the operator, including losses and measurement differences with the exception of its electricity consumption. The difference between the costs related to the technological consumptions, obtained by the distribution/transmission/storage operator each year and the costs estimated and included in basic income, is regulated each year at the beginning of the regulation period taking into account the annual plan to reduce the technological consumption, as well, set at the beginning of the regulation period, and is used to adjust revenue each year. ANRE shall decide upon the annual value included in the formula used to adjust differences. Thus, the adjustments are obtained only to the extent to which economic efficiency is increased according to the targets set by ANRE.

The “Methodology to calculate the technological consumption from natural gas distribution system” (ANRE Order No. 18/2014) is intended to establish a uniform method to calculate technological consumption of natural gas in the distribution systems.

Technological consumption of a distribution system (DS) of natural gas is obtained by adding natural gas volumes purchased to:

- provide working pressure in a new DS, in new or rehabilitated line sections;
- increase working pressure in an existing DS;
- provide working pressure as a result of natural gas dissipation through defects of above-ground objectives in DS;
- provide working pressure as a result of technical difficulties in the DS;

- provide working pressure as a result of the permeability of polyethylene lines;
- compensate for the deviations recorded by the measurement equipment/system in the absence of devices to correct natural gas quantities.

The technological consumption shall be reported, transmitted and certified by distribution system operators (DSO) according to the provisions of the Methodology for monitoring the natural gas market, approved by Order No. 5/2013 of the ANRE President.

DSOs are required to send to ANRE to darag@anre.ro, in an editable electronic format, on a monthly basis, a file with all the details for each event that generated a calculation of volume according to this Methodology.

DSOs are required to have all fiscal documents on the purchase of the natural gas quantities necessary to ensure the technological consumption calculated according to the provisions of this Methodology and to provide for in the work contracts conditions under which all losses of natural gas generated by technical defects, during the warranty period, are supported by the contractor; the warranty period cannot be less than 2 years from the date of putting into operation of the object.

DSOs are required to take all necessary measures (including the modernization of the DS and/or intensification of the detection activity of natural gas losses) to ensure that the annual technological consumption calculated according to this Methodology converted in energy units, not to exceed a maximum limit accepted by ANRE.

Applying this Methodology will ensure correct determination of the technological consumption and adoption of the measures that are required to reduce this consumption in order to increase energy efficiency.

The above aspects indicate a constant concern for increasing energy on the natural gas market supported by approved tariff methodologies.

3.7.1.3 Thermal energy

Unlike the electricity and natural gas markets, the thermal energy market in Romania has two main regulatory authorities: ANRE for the heat produced in cogeneration and ANRSC (*National Regulation Authority* for the *Public Utilities* Community *Services) for heat produced from sources other than cogeneration.*

In general, thermal energy tariffs include justified heat production, transmission, distribution and supply costs, including costs for the development and modernization of the district heat supply system, technological losses, costs related to environment protection and a profit margin (of maximum 5%).

The methodology for establishing tariffs is similar to that used for electricity or natural gas. However, the tariffs for thermal energy are established at local level (city or village), and local reference prices are approved by regulatory authorities. Compared to local reference prices, local authorities may offer subsidies of different levels depending on certain factors (such as winter season and revenues of household consumers), which thus results in different prices at country level.

3.7.2 Facilitation and promotion of response to demand

After the entry into force of the new Law on electricity and natural gas No 123/2012, the structure of the wholesale electricity market has been substantially modified by the requirement to carry out transparent, public, centralized and non-discriminatory transactions on the competitive electricity market. Thus, new transactions between participants in wholesale electricity market and should be concluded exclusively as a result of participating in one of the centralized markets organized at the level of electricity market operator (SC OPCOM SA), the sole holder of an ANRE license to carry out that activity (PZU, PCCB with two trading methods and PI). In order to allow for the wide diversity of trading needs of the participants in the wholesale electricity market, at the level of the market operator the development of two other centralized market models are under development ("Organized framework for contracting electricity for large final customers" and "Centralized market of bilateral contracts of electricity with continuous double negotiation").

The energy committed on the balancing market is determined by dispatcher orders (accepted offers) received by producers.

On the wholesale electricity market there are transactions between different classes of participants (such as producers, suppliers and electricity distributors).

The size of the wholesale market is determined by all transactions concluded on this market by participants that exceed the quantity physically transmitted from production to consumption; transactions include resales to adjust contractual position and obtain financial benefits. Thus, the following transactions are concluded on the wholesale market: contracts regulated and negotiated between producers and suppliers, regulated contracts to ensure own technological consumption in the networks, contracts negotiated between either producers or suppliers (directly concluded or through brokerage platforms), contracts regulated between producers and contractual obligations concluded on centralized markets. Thus, participants on the electricity market have access to the centralized markets of bilateral contracts with the two trading methods under which contracts are awarded through public bid (PCCB) or a combined bidding and negotiation procedure (PCCB-NC), at the Electricity RING of the Romanian Commodities Exchange, on the day-ahead market, the balancing market and the intraday electricity market.

On the electricity market, there are also economic operators whose main activity is electricity supply; some of these operators are suppliers who carry out their activity only on the wholesale market and others who are suppliers with activity on the retail market (including implicit suppliers who operate both in the regulated segment and the competitive retail segment).

The structure of transactions of active suppliers only on the wholesale market is as follows:

- Purchases (imports, contracts negotiated with other suppliers, contracts negotiated with producers, transactions on the centralized market for contracts, transactions on other platforms and day-ahead market);
- Sales (exports, contracts negotiated with other suppliers, contracts negotiated with producers, transactions on the centralized market for contracts, transactions on other platforms and day-ahead market);

The structure of electricity purchases on the wholesale market of implicit suppliers (realized before the day of supply) to supply consumers in a regulated system, is as follows:

- regulated contracts with producers
- negotiated contracts
- CMC transactions
- intraday transactions
- DAM transactions

The balancing market is a component of the wholesale electricity market where producers can directly compete.

The competition between producers is also reflected in terms of ensuring of the reserves (STS) necessary for the safe operation of the energy system. Due to the different capabilities of the producers to provide different types of services, free competition between these producers cannot be balanced; as a result, it has been considered necessary to cover an important share of this market with regulated quantities and prices.

The day-ahead market is a voluntary market opened both for purchase and sale to all participants: producers, suppliers and network operators under the conditions laid down in applicable regulations.

The operation of the electricity market indicate that the requirements in Article 15(8) of Directive 2012/27/EU are complied with in terms of providing information upon request, and even aggregators are treated in a non-discriminatory manner based on their technical capacity.

3.7.3 Energy efficiency in network design and operation

3.7.3.1 Energy efficiency in the Electricity Transmission Networks design

In Romania, the Code of the Electricity Transmission Networks is applied, which set minimum technical rules and requirements for the participants in the electricity market aimed at ensuring safe and economic operation of NES.

This Code aims at:

a. establishing a set of rules and standards for ensuring access of users to ETN;

b. establishing a set of rules and standards for managing the NES by dispatcher;

c. establishing the responsibilities and obligations of CN Transelectrica and al ETN users;

d. specifying technical quality parameters in the management of ETN;

e. establishing management procedures by dispatcher for generator groups in accordance with the rules of the electricity market;

f. establishing the technical requirements for connecting to the ETN;

g. establishing the technical requirements for the dispatchable groups connected to the electricity distribution network;

h. establishing the principles of the development of ETN;

i. establishing the interfaces and information flows between CN Transelectrica SA and ETN users.

According to Article 123 in Section 4 “Planning the Development of the Electricity Transmission Networks”, planning the development of ETN aims at achieving the following objectives:

a. to ensure the development of ETC so as this is adequately sized for the transmission of the electricity expected to be produced, imported, exported and transited and to draw a long term development plan;

b. to ensure safe operation of ETC and to allow for electricity transmission at adequate quality levels in accordance with the provisions of this Code;

c. to materialize the results of the planning of the development by:

- initiating the procedures necessary to promote new investments in the ETN;
- evaluating long term marginal costs in each ETN node;
- supplying information necessary to develop transmission tariff systems.

The criteria used to size electricity compensation installations also includes a criterion under which sizing of installations that produce the reactive power necessary to optimize operation of NES in order to maintain tension in the admissible operation band and to reduce *own technologic consumption* in *normal operational state*, which is realized for a period of up to 5 years in case of maximum load of ETN (Article 134).

The efficiency of investments in ETN on short and medium term should be justified in the planning phase, at least on the basis of the updated recovery period, while one of the assessment criteria of benefits is the reduction of OTC.

The studies on long term (10 years) planning of ETN should include development solutions prioritized from an economic point of view, taking into account the criterion on increasing energy efficiency.

3.7.3.2 Energy efficiency in the Electricity Transmission Networks operation

The ANRE has set targets for CN Transelectrica SA to reduce the proportion of OTC in ETN of the total electricity transmitted, and the energy corresponding to these targets is purchased under regulated contracts, while related costs are included in the transmission tariff.

Failing to meet these targets leads to additional costs related to the energy necessary to cover OTC, which are not reflected in the transmission tariff and charged to the CN Transelectrica SA budget.

As of 2013, OTC expressed as total electricity loss was 1.031 TWh, which amounts to 2.52% of total sources and is higher than that recorded in 2012 (2.32% of total sources). This value exceeds the norm of 2%, approved by ANRE.

The evolution of OTC is the result of the evolution of several factors, such as power circulations due to the regional distribution of consumption and production, performance of equipment which constitute the network, weather factors and voltage level in NES.

The own technological consumption increases with the volume of electricity transmitted and with the distance between the production installations and the consumption places, and decreases with the increase in the voltage of the network when atmospheric humidity is low, but may increase if humidity is high.

The CN Transelectrica SA shall keep trying to reduce OTC in the network design phases, in operation programming and exploitation. The main measures applied are as follows:

- regional tariffs differentiated to stimulate the reduction of the distance between production installations and consumption places by market mechanisms;
- regulation of the network voltage correlated with atmospheric conditions;
- purchase of modern equipment with superior performance in terms of specific losses;
- introduction of node cost centers, which provide information concerning OTC-related costs allocated to each node of ETN and investment opportunities;

- management of ETN in installations.

The OTC in ETN depends mainly on the distance between production centers and consumption centers, that is, on the manner in which load coverage is distributed between the existing groups in NES and the volume and destination of international exchanges. **Figure 3.6** indicates that the production structure and the accounts had a favourable situation in 2007, 2008 and 2012, which led to a decrease of OTC share in the energy transmitted.

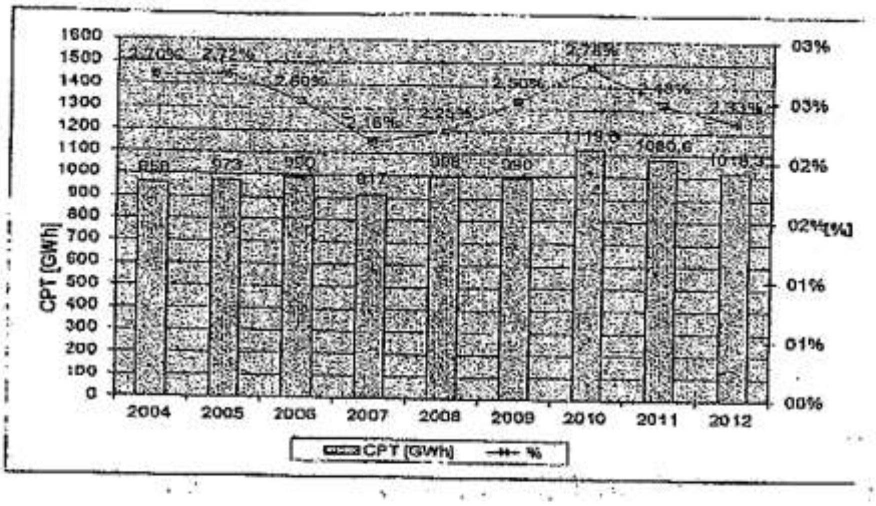

Figure 3.6 *Evolution of annual values of own technological consumption and its share in electricity transmitted*

Through its action to reduce OTC, CN Transelectrica SA aimed at both ensuring optimal programming of the operation mode and modernizing stations such as Bucharest South 400/220/110/10 kV, Brașov 400/110/m.t kV, Barboși 220/110/kV, Tulcea Vest 400/110/m.t kV, Domnești 400/110/m.t kV, and Ungheni 220/110 kV. Furthermore, CN Transelectrica SA replaced transformers, autotransformers and compensation coils, and switching to a voltage of 400 kV of the west line Porțile de Fier, Reșița, Timișoara and Arad.

3.7.3.3 Energy efficiency in Electricity Distribution Networks design

According to the Code of the Electricity Distribution Networks (EDN), the development and modernization of electricity distribution networks in NES are planned by each Distribution Operation.

The development of EDN is planned in line with that of the ETN, with a balance equilibrated for interconnected synchronous operation of all installations at a nominal frequency of 50 Hz and which is verified by CN Transelectrica SA during interconnected synchronous operation with other electricity systems.

The development of EDN is planned taken into account a safe and stable operation in compliance with the performance standard for the electricity distribution service and the application of the following principles:

- using available capacity of EDN up to its economic limit;
- choosing the development version with the highest economic efficiency;
- meeting the conditions imposed by the performance standard for the distribution service;
- ensuring economic functioning of the distribution networks with various loads;
- meeting the provisions of the security standards of the personnel, fire prevention provisions and the provisions of the environment protection legislation.

The sizing of EDN is verified according to the energy technical standards in force, having regards to the following 4 design criteria:

- economic criterion;
- criterion on long term thermal stability;
- criterion on thermal and dynamic stability during short circuit;
- criterion on admissible voltage drop.

The economic criterion is usually aimed at minimizing a set of costs updated for the same reference year, which sums up the investment efforts, annual costs to be paid for power and energy losses and subsequent annual exploitation costs and possible damages.

In order to size a 110 kV EDN with the possibility to operate in a loop system, the (n-1) criterion is also used. For lines that eliminate energy from power plants at this voltage level, these plants are considered with both maximum and minimum power in operation. For radial 110 kV lines and MT installations, reservation shall be established based on economic criteria.

Investments in EDN on the short and medium term are planned in a prioritized manner depending on the updated recovery duration.

The studies on long term (10 years) planning of EDN should include development solutions prioritized based on economic criteria.

3.7.3.4 Energy efficiency in Electricity Distribution Networks operation

The ANRE has set targets for the Distribution Operator to reduce OTC in EDN of the total electricity distributed, and the energy corresponding to these targets is purchased under regulated contracts, while related costs are included in the distribution tariff.

Failing to meet these targets leads to additional costs related to the energy necessary to cover OTC, which are not reflected in the distribution tariff and charged to the Distribution Operator's budget.

The analysis of OTC conducted at different distribution operators between 2008 and 2012 (**Table 3.31**) shows that the highest OTC occurs in low-voltage networks, while the lowest OTC occurs in high-voltage networks, which requires measures to reduce OTC, especially in low-voltage networks.

For the 2014-2018 period, ANRE has defined a regulated OTC for each voltage level in order to stimulate measures to reduce OTC correlated with the real situation of networks and the distribution of electricity consumption (**Table 3.32**).

Table 3.32 Evolution of own technological consumption, regulated by ANRE for the 2014-2018 period

Distribution Operator	Voltage level	Own technological consumption regulated by ANRE (%)				
		2014	2015	2016	2017	2018
ENEL Distribution Banat	HV	0.66	0.66	0.65	0.64	0.63
	MV	3.67	3.64	3.60	3.57	3.54
	LV	14.7	14.60	14.50	14.30	14.14
ENEL Distribution Muntenia	HV	0.63	0.62	0.61	0.60	0.59
	MV	3.52	3.51	3.47	3.44	3.40

	LV	16.04	16.00	15.96	15.64	15.34
ENEL Distribution Dobrogea	HV	1.72	1.72	1.72	1.71	1.71
	MV	2.48	4.47	4.45	4.35	4.24
	LV	13.25	13.24	13.23	13.22	13.21
CEZ Distribution Oltenia	HV	1.18	1.17	1.16	1.15	1.14
	MV	4.01	4.00	3.99	3.98	3.97
	LV	22.00	20.00	19.00	18.00	17.00
E.ON Distribution Moldova	HV	1.00	0.99	0.98	0.97	0.96
	MV	2.85	2.84	2.83	2.81	2.80
	LV	18.50	17.50	17.00	16.50	16.00
Electrica Distribution Muntenia North	HV	1.03	1.02	1.01	1.00	0.99
	MV	6.20	6.05	5.90	5.75	5.50
	LV	14.63	14.60	14.57	14.54	14.51
Electrica Distribution Transylvania South	HV	1.11	1.08	1.07	1.06	1.05
	MV	4.14	4.13	4.12	4.10	4.07
	LV	17.30	16.90	16.20	15.80	15.50
Electrica Distribution Transylvania North	HV	1.13	1.12	1.11	1.10	1.00
	MV	4.55	4.54	4.53	4.52	4.51
	LV	12.43	12.16	11.73	11.20	10.82

In order to reduce OTC, Distribution Operators carry out the modernization of medium and low-voltage networks by changing the section of conductors, abandoning tensions of 6 kV and 10 kV and switching to 20 kV, and replacing transformers with high losses that are inadequate for the consumption point with modern transformers that are appropriate for each consumption point, and mounting intelligent meters.

3.7.4 Savings arising from all energy supply measures

Table 3.33 shows energy savings generated by applying the measures which will be taken between 2014 and 2020 through investment programs approved by ANRE for 8 Distribution Operators.

Table 3.33 Reduction of own technological consumption in the Electricity Distribution Network between 2014 and 2020

No.	Distribution	Work	MU	2014-	Total estimated

	Operator			2020 Plan	reduction losses	
					MWh	toe
1	CEZ Distribution Oltenia	Modernization of MV network	km	630	58,150	5,000
		Modernization of LV network	km	728	4,410	379
		Replacement of transformers to reduce losses	pc	1075	2,200	189
		Mounting intelligent meters	pc	527,000	20,000	1720
		Total	-		84,760s	7,288
2	E.ON Distribution Moldova	Modernization of switchers in 110/20 kV transformers plots	pc		3710	319
		Modernization of LV network	km		18,000	1561
		Replacement of transformers to reduce losses			9,300	800
		Mounting intelligent meters			75,000	6450
		Total			106,170	9,130
3	ELECTRICA Distribution Muntenia North branch	Modernization of MV network		1,100	78,000	6,707
		Modernization of LV network		1,100	55,000	4,729
		Replacement of transformers to reduce losses		3,380	27,300	2,347
		Mounting intelligent meters		150,000	8,000	688
		Total			168,300	14,471
4	ELECTRICA Distribution Transylvania South branch	Modernization of MV network		800	70,000	6,019
		Modernization of LV network		1,100	55,000	4,729
		Replacement of transformers to reduce losses		2,900	23,400	2,012
		Mounting intelligent meters		200,000	10,000	860
		Total			158,400	12,620
5	ELECTRICA	Modernization of MV		1,350	75,000	6,449

	Distribution Transylvania South branch	network				
		Modernization of LV network		1,550	73,000	6,277
		Replacement of transformers to reduce losses		3,380	27,300	2,347
		Mounting intelligent meters		150,000	7,000	602
		Total			182,300	15,675
6	ELECTRICA Distribution Dobrogea ENEL Distribution Banat ENEL Distribution Muntenia	Modernization of MV network		3,100	140,467	12,078
		Modernization of LV network		4,500	175,055	15,052
		Replacement of transformers to reduce losses		2,700	34,960	3,006
		Mounting intelligent meters		550,000	54,428	4,680
		Total			404,910	34,816

Replacing some transformers and compensation coils between 2014 and 2020 contributes to the reduction of OTC at CN Transelectrica SA by approx. 2000 toe.

3.7.5 Financing of energy supply measures

Investments both by CN Transelectrica SA and Distribution Operators shall be financed from own funds and funds attracted. There is a possibility to provide support from European Funds in accordance with the specifications in Section 3.1.1.

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Annex A

Annual Report under the Energy Efficiency Directive

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A.1 National energy efficiency target for 2020

A.2 Key statistical data

A.1 National energy efficiency target for 2020

Romania's national indicative energy efficiency target for 2020 is to save **10 million toe** of primary energy, which represents a reduction of **19%** in the volume of primary energy consumption (52.99 million toe) forecast in the Primes 2007 model for the realistic scenario.

Achieving this target implies that in 2020 primary energy consumption will be 42.99 million toe, while total energy consumption will be 30.32 million toe.

A.2 Key statistical data

Table A.1.1 contains the statistical data for 2012.

Table A.1.1 - Statistical data on energy consumption in 2012

Key statistical data on energy consumption	Value
Total primary energy consumption	34 851 043 toe
Total final energy consumption	22 766 752 toe
Final energy consumption - industry	6 795 963 toe
Final energy consumption - transport	5 350 937 toe
Final energy consumption - households	8 095 408 toe
Final energy consumption - services	2 026 351 toe

Final energy consumption - agriculture and forestry	499 103 toe
Gross value added - industry	€34 352.8 million (2005)
Gross value added - services	€42 525.2 million (2005)
Gross value added - agriculture and forestry	€4 553.9 million (2005)
Average disposable income per household	RON 2 475.04 (monthly)
Total number of households	7 086 394
Gross domestic product	€93 300.2 million (2005)
Electricity generation from conventional thermal power plants	17 905 759 MWh
Electricity generation from cogeneration plants	14 690 000 MWh
Electricity generation from the nuclear power plant	11 466 236 MWh
Heat generation from conventional thermal power plants	0
Heat generation from cogeneration plants	3 062 610 toe
Fuel input for conventional thermal power plants	2 209 658 toe
Fuel input for cogeneration plants	5 320.464 toe [Translator's note: There is a decimal marker, in the original, between 0 and 4, but that might be an error. It is very likely that the intention was to write '5 320 464', not '5 320.464']
Fuel input for the nuclear power plant	2 811 013 toe
Heat generation from thermal plants for centralised heat distribution	2 172 506 toe
Fuel input for thermal plants for centralised heat distribution	2 280 435 toe
Losses from the transmission and distribution of energy	1 342 764 toe
Total passenger kilometres (pkm)	21 489 million pkm
Total tonne kilometres (tkm)	55 654 million tkm
Total population	20 095 996 inhabitants

(Source: National Institute of Statistics, Statistical Yearbook 2013, Energy balance and the distribution of energy facilities for 2012)

The total consumption of primary energy in 2012 represents 81% of Romania's 2020 target. Furthermore, the final energy consumption is 25% lower than the 2020 target. It follows that the measures included in the two energy efficiency action plans (2010-2010 [sic] and 2011-2013), aimed at increasing energy efficiency, have contributed to reductions in primary energy consumption and final energy consumption. These reductions were also influenced by the economic crisis that affected Romania in 2009-2010, and by the fact that the economic recovery has been accompanied by modest increases in energy consumption.

The transposition of Directive 2012/27/EU by the Law on energy efficiency provides the necessary conditions for implementing the measures aimed at increasing energy efficiency in all economic and social sectors.

To achieve the target adopted by Romania, it is important that the new energy efficiency action plan continue to provide for measures similar to those included in the earlier plans.

Annex B

Strategy for mobilising investments in the renovation of residential and commercial buildings existing at national level, both public and private

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INTRODUCTION

Buildings are a central element of the policies of EU Member States on energy efficiency, as they account for approximately 40 % of the final energy consumption and 36 % of greenhouse gas emissions.

At national level, energy consumption in the household sector and the tertiary sector (offices, business premises and other non-residential buildings) represents 45 % of the total energy consumption. The total energy consumption broken down by building category is presented in Figure 1.

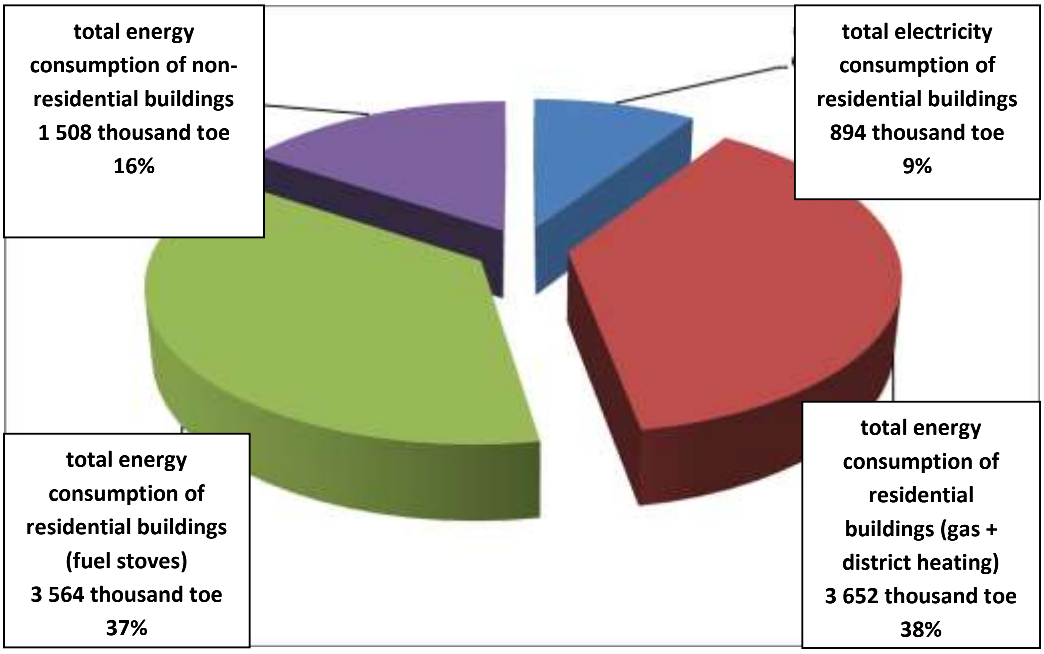


Figure 1 – Energy consumption of buildings: 2005-2010 average (residential buildings), estimate (non-residential buildings)

(Source: URBAN-INCERC National R&D Institute for Construction, Urban Planning and Sustainable Spatial Development – INCD URBAN-INCERC)

Improving energy efficiency of the existing building stock is essential not only in order to achieve national objectives concerning medium-term energy efficiency, but also in order to attain the long-term national objectives of the strategy on climate change and moving toward a competitive low-carbon economy by 2050.

At a time when environmental, economic and social concerns become increasingly important due to climate change or changes jeopardising energy security, exhaustion of resources or the ability to pay energy bills, reducing energy consumption in the building sector has strategic importance, both at national and at international level. Besides efforts to build new buildings with low energy demands for traditional energy sources, it is essential to tackle the high levels of energy consumption of the existing buildings.

In the light of all these strategic concerns, EU policy on the energy consumption of buildings has been consolidated in recent years, first of all by recasting the Directive on the energy performance of buildings – EPBD, (Directive 2010/31/EU[6]) in 2010, and more recently by the Directive on energy efficiency – EED (Directive 2012/27/EU[7]) repealing the Directives on energy services and on the promotion of cogeneration. All these requirements, and others such as the necessity to take into consideration the use of renewable energy

[6] http://europa.eu/legislation_summaries/energy/energy_efficiency/en0021_ro.htm
[7] http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

sources for new buildings or those that are subject to major renovation (set out in the Directive on the promotion of the use of energy from renewable sources - Directive 2009/28/EC[8]), provide a framework that enables the implementation of policy measures aimed at reducing energy consumption, especially in the buildings sector.

Romania has an important stock of buildings, constructed mostly between 1960 and 1990, with a low degree of thermal insulation, as a result of the fact that prior to the 1973 energy crisis there had been no regulations in place concerning the thermal protection of buildings and perimeter sealing elements. Those buildings are no longer suitable for the purpose for which they were built.

The statistical data relating to energy consumption, available from the energy balance and the energy equipment inventory for the period 2008–2010[9] and for 2010 enable a breakdown of data on final consumption in the main sectors of the economy, as presented in Figures 2 and 3:

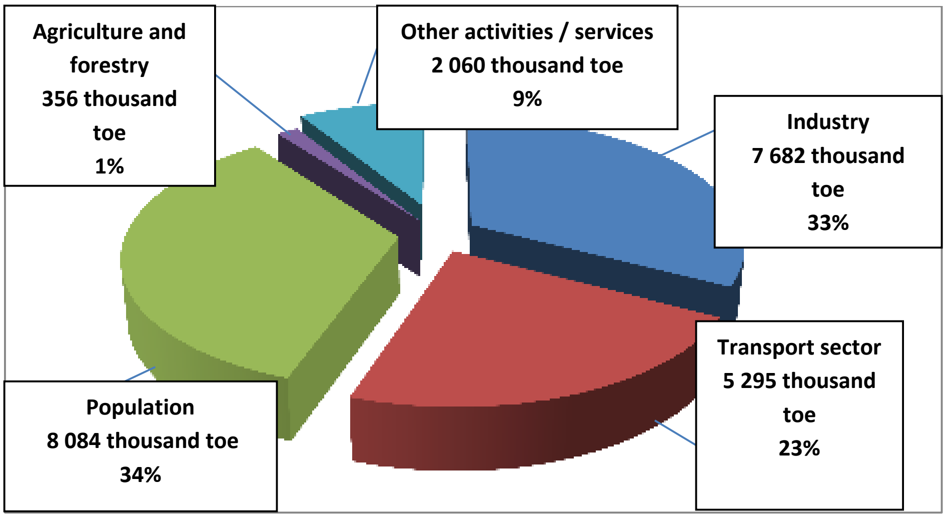


Figure 2 – Distribution of final energy consumption (2008–2010 average values)

(Source: Romanian National Institute of Statistics, INCD URBAN-INCERC)

[8] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:ro:PDF

[9] Romanian National Institute of Statistics (2002–2011), Energy balance and energy equipment inventory in 2008, 2009 and 2010.

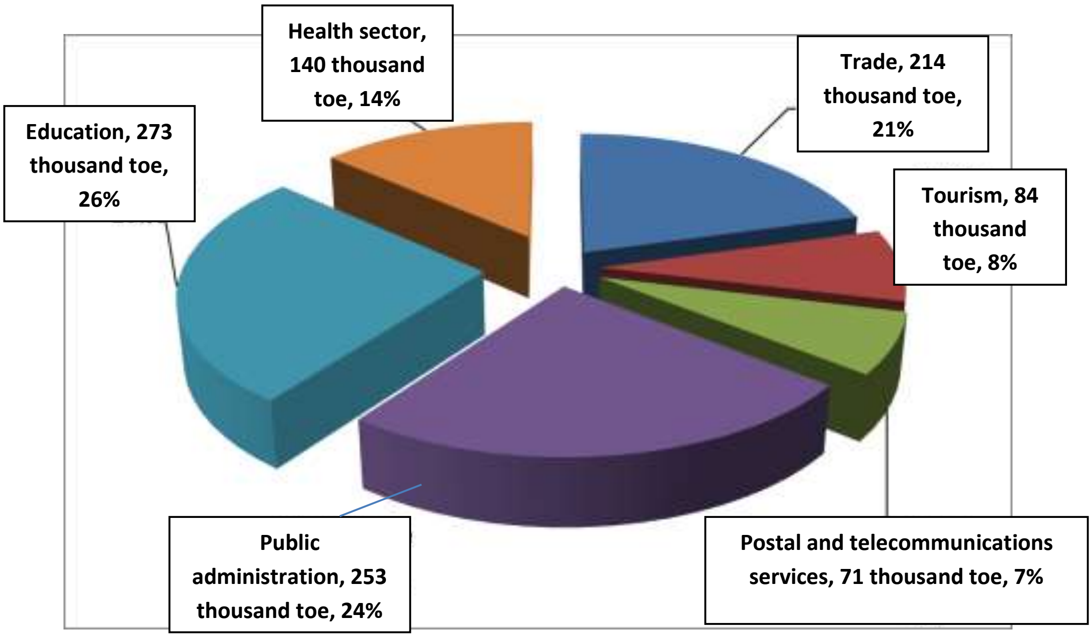


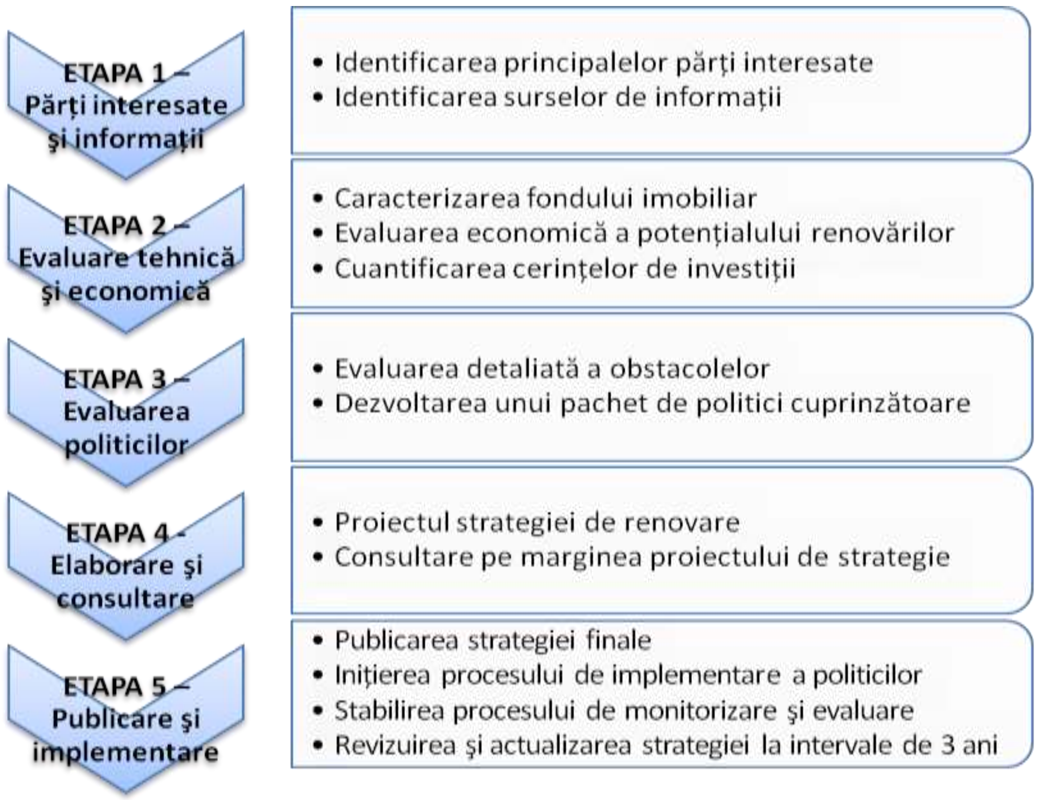
Figure 3 – Distribution of final energy consumption (2010) by category of non-residential buildings

(Source: Romanian National Institute of Statistics, INCD URBAN-INCERC)

AIM OF THIS STRATEGY

The Strategy for mobilising investments in the renovation of residential and commercial buildings, both public and private, hereinafter referred to as the Strategy, has been developed in line with the provisions of Article 4 of Directive 2012/27/EU on energy efficiency.

The phases for the renovation of existing buildings, as identified and presented in the 'BPIE guide to developing strategies for energy renovation of buildings' are presented in Figure 4:



Phase 1 – Identifying key stakeholders & information sources

- Identifying key stakeholders
- Identifying information sources

Phase 2 – Technical and economic assessment

- Building stock characterisation
- Economic assessment of renovation potential
- Quantification of investment requirements

Phase 3 – Policy assessment

- Comprehensive assessment of barriers
- Developing a comprehensive policy package

Phase 4 – Drafting and consultation

- Draft renovation strategy
- Consultation on draft strategy

Phase 5 – Publication and delivery

- Publishing the final strategy
- Commencing the policy implementation process
- Establishing monitoring and evaluation procedures

- Reviewing and updating the strategy every 3 years

Figure 4 – Phases determined for the development of the strategy

(Source: BPIE guide to developing strategies for energy renovation of buildings[10])

This Strategy has mainly the following roles:

- stimulating debate between stakeholders involved in the development and implementation of the strategy in order to reach a consensus concerning the steering of policies and initiatives aimed at enhancing the energy performance of buildings;
- encouraging all stakeholders to adopt ambitious and adequate attitudes aimed at the improvement of the quality of residential and business premises in order to ensure immediate and long-term benefits for building owners and to support the economy.

In order to illustrate the ambitious targets concerning the energy efficiency of buildings, **this Strategy proposes an approach in phases aimed at mobilising investments in the renovation of residential and commercial buildings, both public and private.** It should be noted that this is a major challenge and an equally important commitment as it will:

- create much needed employment now and for decades to come;
- improve living conditions in residential buildings and workplaces;
- reduce dependence on external energy suppliers;
- make best use of Romania's natural resources and highly skilled human resources, and in this context, a stock of modern and energy-efficient buildings can be achieved, fit for the 21st century and for the years to come.

Thus, a substantial reduction in energy consumption in buildings may be regarded as achievable, in phases, only through a combination of energy efficiency measures and deployment of renewable resources in and on buildings.

The key successive phases, as identified and proposed for the renovation of the national building stock, are as follows:

- PHASE 1 – Establishing conditions based on which **deep renovations may become a goal within five years;**
- PHASE 2 – Technological development in the renovation of buildings, which can provide the means for achieving a substantial reduction in energy consumption and attaining a level where buildings have a nearly-zero dependence on traditional energy within approximately 15 years;
- PHASE 3 – Deep renovation of buildings within 15 years.

[10] http://bpie.eu/renovation_strategy.html

EUROPEAN POLICY CONTEXT

As a significant contributor to EU energy consumption, utilisation of traditional energy resources and carbon emissions, the building sector is subject to numerous policies, strategies and long-term goals that seek to reduce its impact. The more general goals, such as those relating to environmental protection, have been formulated under the so-called '20-20-20' target, which is a set of three key objectives for 2020:

- 20 % reduction in EU greenhouse gas emissions compared with 1999 levels;
- 20 % increase in the share of energy produced from renewable resources in the EU;
- 20 % improvement in energy efficiency in the EU.

For the longer term, the EU has set objectives under a number of roadmaps to 2050. In the case of building sector, the main three roadmaps are the following:

- EU Roadmap for moving to a competitive low carbon economy in 2050 (COM, 2011a), which identifies the need to reduce carbon emissions by 88 %-91 % in the residential and services sector (collectively referred to as the real estate sector) by 2050, compared to 1990 levels;
- Energy Roadmap 2050 (COM, 2011b), according to which 'higher energy efficiency potential in new and existing buildings is key' in reaching a sustainable energy future and contributing significantly to reduced energy demand, increased security of energy supply and increased competitiveness;
- Roadmap for a Resource Efficient Europe (COM, 2011c), in which the building sector was identified as one of the top three sectors responsible for 70 %–80 % of overall impact on the environment. Constructing better buildings and optimising their use within the EU would result in a reduction of over 50 % in the quantity of raw materials extracted from the earth, and in a reduction of 30 % in water consumption.

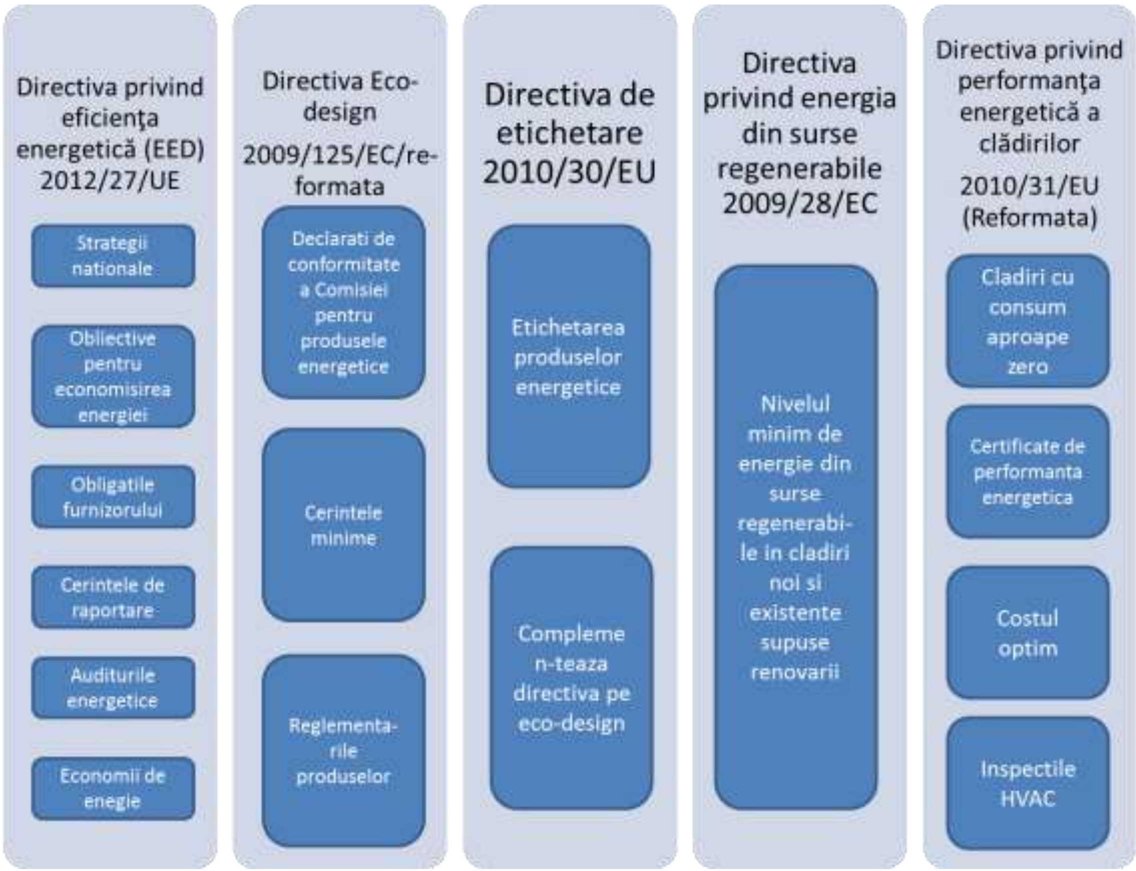
These roadmaps represent a long-term endeavour, which is not only desirable from a social and economic perspective, but also essential from an environmental perspective, in order to tackle the three challenges of climate change, energy security and exhaustion of resources.

European directives affecting the building sector

The main Directives relating to energy performance of the building stock are the following:

- Directive 2010/31/EU on the energy performance of buildings (EPBD);
- Directive 2012/27/EU on energy efficiency (EED);
- Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RED), which imposes minimum levels for the use of energy from renewable sources in new buildings and existing buildings undergoing major renovation.

EU regulations provide a common framework in which each Member State must lay down standards and performance levels concerning energy consumption in buildings, which apply equally to all building categories, both residential and non-residential.



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<tr><th>Directive 2012/27/EU on energy efficiency (EED)</th><th>Ecodesign Directive 2009/125/EC (recast)</th><th>Energy Labelling Directive

2010/30/EU</th><th>Directive 2009/28/EC on the promotion of the use of energy from renewable sources</th><th>Directive 2010/31/EU on the energy performance of buildings (recast)</th></tr>
<tr><td>National strategies</td><td rowspan="3">EC declaration of

conformity of energy-related products</td><td rowspan="6">Labelling of energy-related products</td><td rowspan="10">Minimum levels of energy from renewable sources in new buildings and existing buildings undergoing renovation</td><td rowspan="2">Nearly zero-energy buildings</td></tr>
<tr><td rowspan="3">Energy savings targets</td></tr>
<tr><td rowspan="3">Energy performance certificates</td></tr>
<tr><td rowspan="4">Minimum requirements</td></tr>
<tr><td rowspan="3">Supplier obligations</td></tr>
<tr><td rowspan="2">Cost optimality</td></tr>
<tr><td rowspan="4">Complementing the Ecodesign Directive</td></tr>
<tr><td>Reporting requirements</td><td rowspan="3">Product regulations</td><td rowspan="3">HVAC inspections</td></tr>
<tr><td>Energy audits</td></tr>
<tr><td>Energy savings</td></tr>
</table>

BENEFITS

The renovation of the existing building stock in order to increase the energy performance thereof is one of the most important and strategic investments that could be carried out. The key driver of EED is the achievement of the EU's 20 % energy saving target by 2020, and reaching the long-term environmental protection objectives, referred to in the roadmaps on energy efficiency and reduction of carbon emissions, while the benefits of such achievements have a major impact on various aspects of the economy and society.

Following several studies conducted in the field at international level, the impact of a sustainable energy renovation of buildings can be summarised as follows:

- **economic benefits** – the US Environmental Protection Agency estimates that the increased economic activity as a result of job creation and stimulation of investments generates 1.5 the value of savings in energy costs in the form of additional production capacities. The additional unquantified benefits are represented by the higher value of real estate properties[11];

- **societal benefits** – the improvement of energy efficiency in residential buildings has long been acknowledged by some of the Member States as an essential issue in order to ensure financially affordable heating for low-income families, and to tackle the issue of fuel poverty, which affects an estimated 10–25 % of the total EU population. Residential buildings fitted with a more efficient heating system also have health benefits, as they have fewer cold spots and air currents, less condensation and a reduced susceptibility to mould formation; in addition, indoor air quality is also better. Copenhagen Economics[12] estimate that the health benefits of energy renovation could have approximately the same value as the savings in energy costs. A draft assessment report by the UNDP/GEF[13] has found that, although in Romania there is no official definition of fuel poverty, it can be concluded that 'a large proportion of Romania's population is not able – in general and in normal conditions – to provide itself with sufficient levels of thermal comfort in the home, because of the high cost of heating relative to their income'.

- **environmental benefits** – buildings are the highest source of CO_2 emissions, and hence the largest contribution to climate change. The value of environmental benefits brought about by the renovation of buildings can be around 10 % of the savings in energy costs;

- **benefits for energy systems** – the savings made under maximum load in the energy systems following the energy renovation of buildings, including energy self-generation, have about the same value as the savings in energy costs, according to a study conducted by Ecofys[14]. These accrue to all users.

Quantification of the multiple benefits

By applying the following multipliers to savings in energy costs, the additional benefits for society may be almost five times the value of the savings in energy costs as a result of the energy renovation of buildings, as shown below:

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[11] Please also consult the model developed by BPIE, which indicates potential energy savings for businesses, households and public budgets, if the renovation strategy, and the renovation scenarios proposed there, are implemented.
[12] http://www.copenhageneconomics.com/publications/area-of-expertice/energy-climate
[13] http://www.undp.ro/libraries/projects/EE/Assesment%20Report%20on%20Fuel%20Poverty%20-%20DRAFT(1).pdf
[14] "Saving energy: bringing down Europe's energy prices for 2020 and beyond", Ecofys, 2013.

Benefit element	multiplier
1. Energy cost saving	1.0
2. Economic stimulus	1.5
3. Societal benefits (health benefits)	1.0
4. Benefits for energy systems	1.0
5. Environmental benefits	0.1
TOTAL additional BENEFITS for society	**4.6**

DRAWING UP THE STRATEGY

5.1. PHASE 1 – IDENTIFYING KEY STAKEHOLDERS AND INFORMATION SOURCES

Key stakeholders

The following national authorities have been identified as the ones that could play a key role in developing and implementing the strategy:

- Ministry of Regional Development and Public Administration (MDRAP) – responsible for transposing and implementing the EPBD, author of the first version of the long-term strategy for mobilising investments in the renovation of residential and commercial buildings, both public and private, provided for by the EED, managing the registration of energy performance certificates;
- Ministry of European Funds – coordination and management of EU structural instruments;
- Ministry of Energy, Small and Medium-Sized Enterprises and the Business Environment – coordination of the energy and energy resources fields at national level, and implementation of renewable energy sources in and on buildings;
- Ministry of the Environment and Climate Change (MMSC) –financing mechanisms under the Kyoto Protocol;
- National Energy Regulatory Authority (ANRE) – implications for energy services providers, including the role of energy efficiency obligations.

The following organisations were identified in the consultation process:

- Asociația Producătorilor de Materiale de Construcții din România (APMCR) [Association of Romanian Manufacturers of Construction Materials];
- Asociația Română a Antreprenorilor din Construcții (ARACO) [Romanian Builders' Association];
- Patronatul Societăților din Construcții (PSC) – [Association of Employers in the Romanian Building Sector];
- Asociația Inginerilor de Instalații din România (AIIR) – Association of Romanian Installation Engineers;

- Asociația Auditorilor Energetici pentru Clădiri din România – Association of Energy Auditors in
- Constructions (AAECR);
- Liga Asociațiilor de Proprietari Habitat – League of Habitat Owners Associations;
- Federația Asociațiilor de Proprietari din România – Federation of Property Owners Associations in Romania [15];
- Asociaţia Patronală Surse Noi de Energie – Association of Renewable Sources Producers (SunE);
- Asociația Municipiilor din România – Romanian Association of Cities;
- Asociația Oraşelor din România – Association of Romanian Towns (AOR);
- Societatea Română Geoexchange Romanian Geoexchange Society (SRG) – representing users of geothermal energy in buildings.

It should be mentioned that these organisations may be involved both in the strategy implementation phase and in the revision and update thereof, as required by EED.

Sources of information

The main sources of information used in drawing up this strategy were:

- Data hub of the Buildings Performance Institute Europe (BPIE) www.buildingsdata.eu - section on Romania, which includes data collected by BPIE through a survey conducted in 2011;
- The project called 'RENOVAREA ROMÂNIEI' – RENOVATING ROMANIA – A strategy for the sustainable energy renovation of Romania's building stock, developed by Buildings Performance Institute Europe (BPIE), which is the copyright holder thereof;
- The project called ENTRANZE, financed by Intelligent Energy Europe (www.entranze.eu) programme, in which BPIE is a project partner. The objective of the ENTRANZE project is to actively support policy making to achieve a fast and strong penetration of NZEB and renewable energy use within existing national building stocks;
- The project on Implementing Nearly Zero-Energy Buildings (NZEB) in Romania, National definition and roadmap, drawn up by BPIE (http://bpie.eu/low_energy_buildings_east_eu.html);
- The project entitled 'Build Up Skills Romania – Analysis of the National Status Quo', co-ordinated by the National R&D Institute for Construction, Urban Planning and Sustainable Administrative Development 'Urban-Incerc' (INCD URBAN-INCERC) (http://www.buildupskills.eu/național-project/romania; http://www.iee-robust.ro/);
- Romania's Second National Action Plan for Energy Efficiency;
- Romanian Statistical Yearbook;
- Census data.

[15] Owners living in apartment blocks (condominiums) are organised into homeowners' associations that are legally created in accordance with Romanian Law NO 230/2007 on the establishment, organisation and operation of homeowners' associations. A homeowners' association is defined as a legal person with legal authority to act, through elected or appointed representatives, on behalf of all of the co-owners in a condominium.

5.2 PHASE 2 –TECHNICAL AND ECONOMIC EVALUATION

5.2.1 Overview of the existing building stock

In Romania, the total building floor area is 493 000 000 m², 86 % of which represents residential buildings. Of the 8.1 million of dwellings, single-family homes are dominant, accounting for 61 % of the total.

The following can be stated with reference to the residential sector:

- 88.5 % of the dwellings are permanently inhabited;
- Almost half of the total number of all homes (47.5 %) are located in rural areas, which means that the proportion of rural population in Romania is above the European average;
- In rural areas, 95 % of the dwellings are individual (single-family) homes;
- In urban areas, 72 % of the dwellings are located in apartment blocks (which comprise an average of 40 apartments per block);
- Over 60 % of the apartment blocks have four storeys, while 16 % have ten;
- The dominant form of ownership is private ownership, which represents 84 % of the total building stock, 1 % being public property, and the remaining 15 % under some form of mixed ownership;
- Homes (apartments) in apartment blocks have an average heated area of 48 m², compared with 73 m² for single family homes.

In respect of age profile, the majority of residential buildings were built in the second half of the 20th century, especially during the period 1961–1980, as presented in figure 5. During this period, the vast majority of residential buildings in Romania were built without there being any specific thermal requirements for the building elements that form the building envelope, as illustrated in table 1. Thus, from the perspective of energy consumption, the existing residential building stock still has important potential in terms of raising the standards of energy performance, which highlights, therefore, the importance of developing an ambitious strategy for the renovation of residential buildings in Romania.

The analysis of the stock of residential buildings reveals that the energy used for heating represents approximately 55 % of the total energy consumption of apartments and up to 80 % in the case of individual houses. Depending on the climate zone, a single-family home consumes an average of 24 % more energy per m² as opposed to a home (apartment) in an apartment block[16].

[16]BPIE estimates based on the survey conducted for the BPIE report called *"European Buildings under the Microscope"*, 2011.

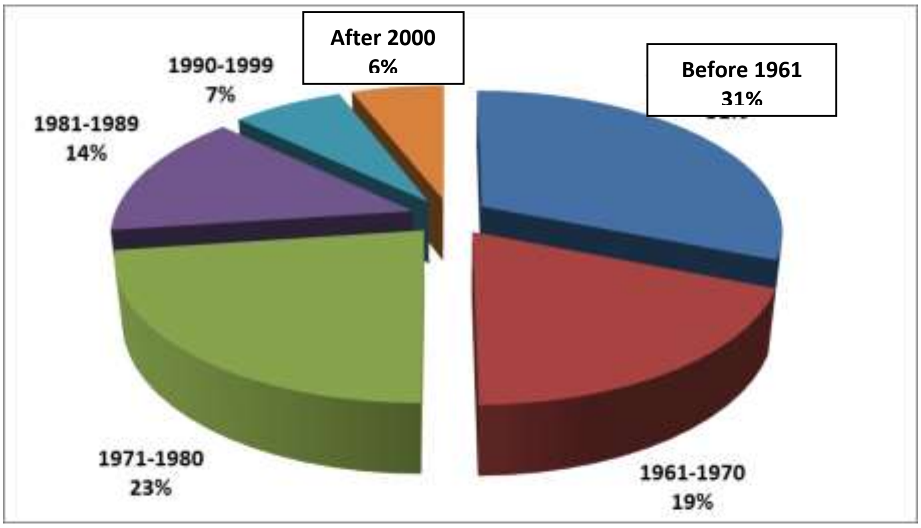


Figure 5 – Age profile of residential buildings (homes), by year of construction

(Source: Romanian National Institute of Statistics [17], INCD URBAN-INCERC[18])

Year of construction	Thermal characteristics U [W/(m²K)]		Final energy consumption (kWh/m² year)
	Vertical	Horizontal	
< 1910	1.40–2.00	0.90–1.80	150–400
1910–1929	1.40–2.00	0.90–1.80	150–400
1930–1944	1.40–2.00	0.90–1.80	150–400
1945–1960	1.40–2.00	0.90–1.80	150–400
1961–1970	1.35–1.90	0.90–1.80	150–400
1971–1980	1.35–1.90	0.90–1.80	150–400
1981–1989	1.25–1.60	0.90–1.80	150–400
1990–1994	1.10–1.50	0.90–1.80	150–350
1995–1999	0.80–1.10	0.90–1.80	140–280
> 2000	0.70–1.10	0.90–1.80	120–230

Table 1 – Energy performance characteristics – residential buildings (Source: INCD URBAN-INCERC)

[17]Romanian National Institute of Statistics (2002–2011). Web Page: TEMPO-Online time series, Economic Statistics, www.insse.ro;
[18]The project entitled '*Build Up Skills Romania – Analysis of the National Status Quo*', http://www.buildupskills.eu/national-project/romania; http://www.iee-robust.ro/

The total area of non-residential buildings is 67 200 000 m², and the structure of the non-residential building stock is presented in Figure 6 and Table 2:

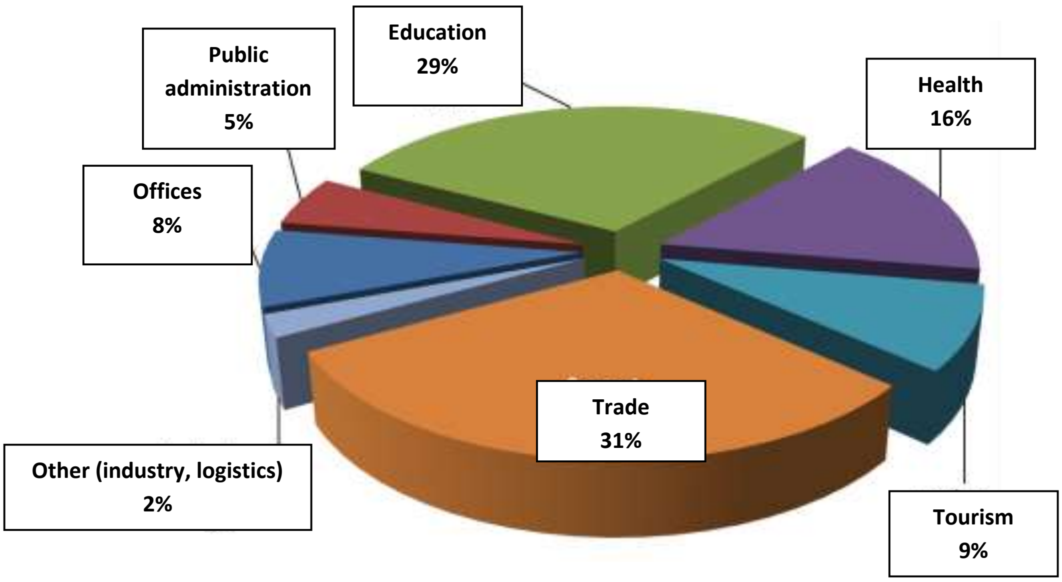


Figure 6 – Breakdown of the building stock according to building categories (m^2)
(Source: Romanian National Institute of Statistics[19], Colliers[20], INCD URBAN-INCERC[21], BPIE Data Hub[22])

Offices	16.3 %
Educational buildings	16.9 %
Hospitals	13.8 %
Hotels and restaurants	7.7 %
Sports facilities	7.0 %
Premises for wholesale and retail trade	27.2 %
Other non-residential buildings	11.1 %

Table 2 – Breakdown of the non-residential building stock according to the type of building
(Source: BPIE data hub)

The main characteristics relating to the energy performance of the existing non-residential building stock are presented in Table 3:

[19] Romanian National Institute of Statistics (2002–2011). Web Page: TEMPO-Online time series, Economic Statistics, www.insse.ro;
[20] Romania Real Estate Review (2011), Colliers International, Bucharest, Romania, www.colliers.com/country/romania/
[21] The project called *"Build Up Skills Romania – Analysis of the current situation"*, http://www.buildupskills.eu/national-project/romania; http://www.iee-robust.ro/
[22] http://bpie.eu/renovation_strategy.html

Building category	Thermal characteristic U [W/(m²K)]		Final energy consumption (kWh/m²year)
	Vertical	Horizontal	
Offices	0.70–1.50	0.35–1.30	120–250
Education, culture	0.70–1.50	0.35–1.30	200–350
Health	0.70–1.50	0.35–1.30	200–400
Tourism	0.70–1.50	0.35–1.30	150–300
Trade	0.70–1.50	0.35–1.30	150–300

Table 3 – Energy performance characteristics – non-residential buildings
(Source: INCD URBAN-INCERC)

Energy systems

Three main heating sources are prominent: biomass, gas and district heating (figure 7). Three out of four single-family houses have a biomass heating system, while over half of the apartment blocks are connected to a district heating network. Almost all (92 %) of the energy supplied by the district heating networks is delivered through cogeneration systems (CHP)[23]. Just over half of the energy supplied into district heating systems is from natural gas, while the rest is divided between petroleum products (26 %) and coal (20 %).

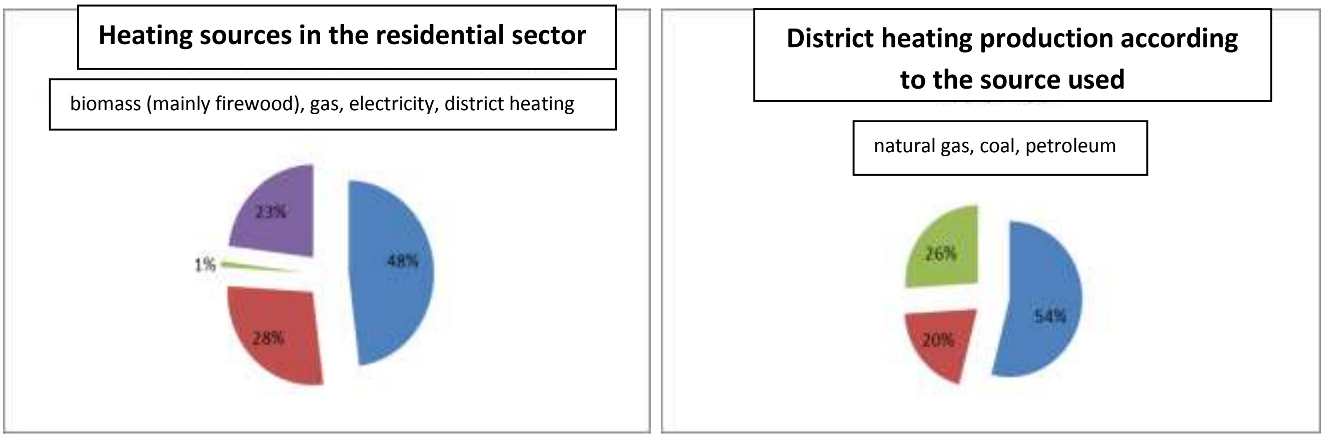


Figure 7 – Source of heating in the residential sector (Source: BPIE's Data Hub)

Residential sector

In the residential sector, thermal energy is used for heating and for producing domestic hot water. In general, the efficiency of such use of thermal energy is only 43 % (63 % in Bucharest)[24]. In rural areas, heating of individual rooms is still widespread, mainly by burning wood in furnaces. In urban areas, approximately 1.5 million dwellings are connected to district heating systems, however, in the last decade there has been a constant tendency of disconnection from district heating networks and switching to the use of independent gas boilers in each apartment. This phenomenon may be due to the numerous issues encountered in the old

[23] Euroheat & Power statistics http://www.euroheat.org.
[24] See the website of the TABULA project: http://www.building-typology.eu/

district heating systems, such as reduced efficiency (an improvement potential of 30 %), high carbon footprint and increasing prices (caused also by the ongoing policies for the reduction of heating subsidies)[25]. There is a general absence of metering systems both in apartment blocks and at individual level. However, there is an ongoing programme aimed at improving district heating networks and the metering and controlling systems for heating, which has reduced the number of disconnections from the network (PNAEE Romania).

Table 4, which is an adaptation after Euroheat & Power (http://www.euroheat.org/Romania-90.aspx), presents the key statistics for the use of district heating networks.

Breakdown of energy supply for district heating	
- Recycled heat including indirect use of renewable energy	91 %
- Direct renewable energy	0.31 %
- Other	8.3 %
Total district heating sales	49 095 TJ
(Total district heating sales in 2007)	56 110 TJ
Annual district heating sales turnover	EUR 713.84 million
Share of inhabitants served by district heating	19 %
Total length of district heating pipeline system	6 055 km
(Total length of district heating pipeline system in 2007)	7 611 km
Average district heating price	14.54 EUR/GJ
Number of district heating units	89
Total installed district heating capacity	13 619 MWth
Total investment in district heating	EUR 168 million
Estimated number of jobs in the district heating sector	19 360
Total district heated floor area	55 590 000 m^2
New connections to district heating	166 000
CO_2 emissions per TJ of district heating	81.7 tonnes CO_2/TJ
Total heating demand	243 367 TJ
Total share of CHP in national electricity output	10.9 %
CHP heating self-production	89 TJ

[25] 11 PWC Romania: Challenges and Opportunities for the Romanian district heating system, June 2011, available at: http://www.pwc.com/ro/en/publications/assets/assets_2011/Provocari_Oportunitati_Energie_Termica.pdf

Average energy consumption of buildings per m^2	0.883 GJ/m^2

TABLE 4 – Use of district heating networks in Romania in 2011, except if otherwise indicated (Source: Euroheat & Power)

Air-conditioning systems are becoming more widespread in the residential sector: the share of homes equipped with an air-conditioning system has risen from 0.4 % in 2000 to 5 % in 2010. On the other hand, there has been an increase in the installation of renewable energy systems for domestic use. According to the EurObserv'ER barometer concerning renewable energy[26], the total installed surface of solar thermal panels in Romania was around 144 000 m² in 2010, recording a 38.4 % increase compared to 2009. Most of this solar thermal capacity is installed in commercial buildings (including hotels) and to a lesser extent in residential buildings.

Due to the state of the buildings, mainly as a result of neglecting repairs, in particular in the case of apartment blocks in urban areas and partially also in the case of single-family houses in rural areas[27], approximately **58 % of the existing apartment blocks (about 2.4 million apartments) built before 1985 require thermal rehabilitation and modernisation.**

[26] 12 EurObserv’ER (2011): The state of renewable energy in Europe. 11th EurObserv’ER Report, available at: http://www.energiesrenouvelables.org/observer/stat_baro/barobilan/barobilan11.pdf
[27] UN ECE 2001; TrainRebuild 2012.

Non-residential sector

Non-residential buildings represent 18 % of total floor area and represent approximately 5 % of the total building stock. This includes most public buildings[28]. The spaces used by the public administration and the educational and commercial buildings represent together approximately 75 % of non-residential energy consumption (figure 9), each representing 20-25 % of the total.

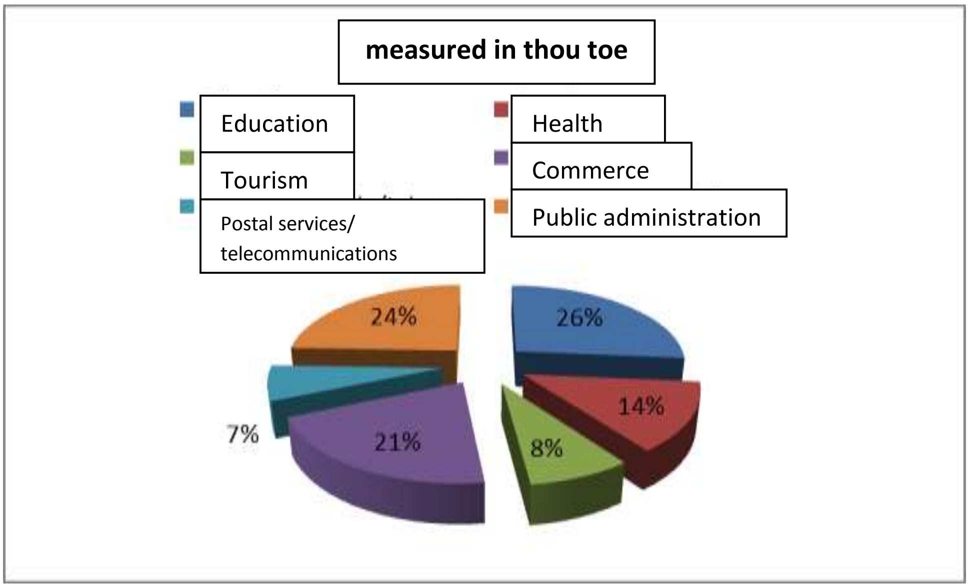


Figure 8 – Distribution of final energy consumption by type of non-residential building
(Source: INCD URBAN-INCERC)

In terms of energy performance, educational buildings (354 kWh/m^2 per year) stand out as the largest consumers of energy, with other sectors in the range 200–250 kWh/m2 per year (figure 9).

Note: These figures represent total energy consumption, including appliances and other energy-consuming systems.

Regulated energy-consuming systems are those covered by the Energy Performance of Buildings Directive, and include heating, cooling, ventilation, hot water and lighting. The energy consumption of appliances and other energy-consuming systems is covered by other policy areas, notably eco-design and sustainable procurement.

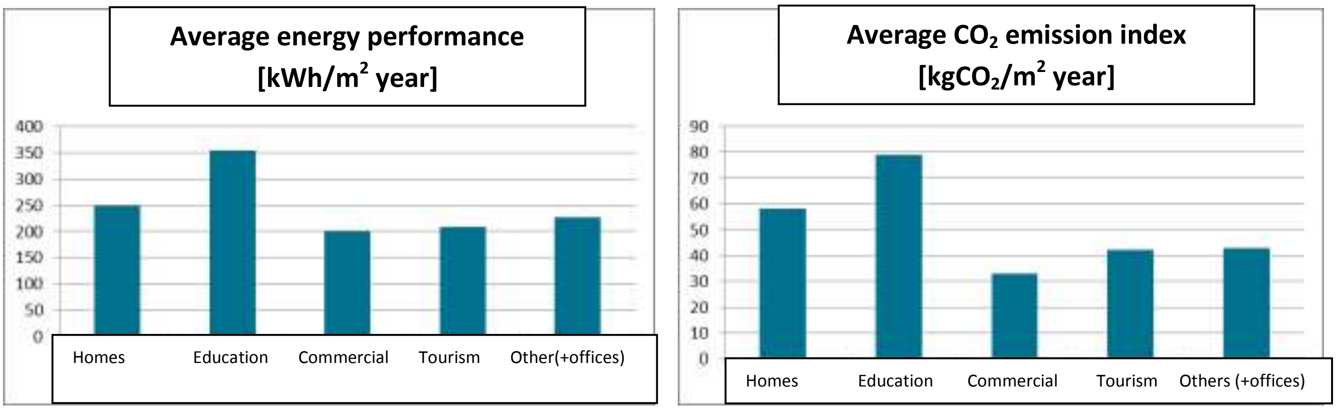
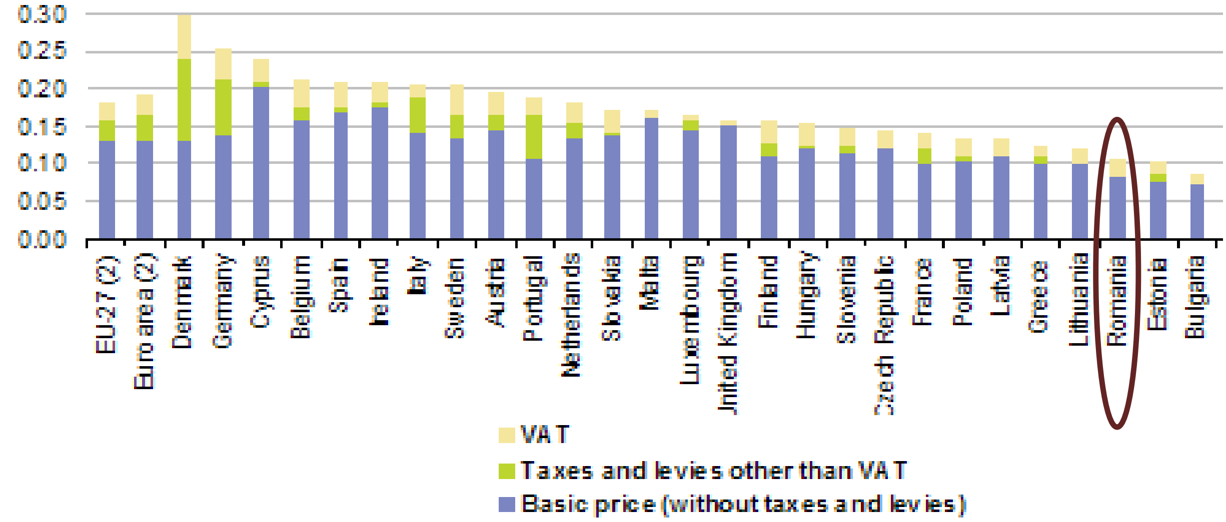


Figure 9 – Energy performance and CO_2 emissions by building sector
(Source: INCD URBAN-INCERC)

[28] Publicly owned housing represents a very small share of non-residential buildings.

Energy prices

Romania currently has some of the lowest energy prices in the EU, due to subsidies on both electricity and natural gas. The comparison is illustrated in figures 10 and 11 below for electricity and natural gas, respectively[29].



(1) Annual consumption: 2 500 kWh < consumption < 5 000 kWh.
(2) Provisional.
Source: Eurostat (online data code: nrg_pc_204)

Figure 10 – Electricity price comparison for households across the EU – 2011
(Source: Eurostat)

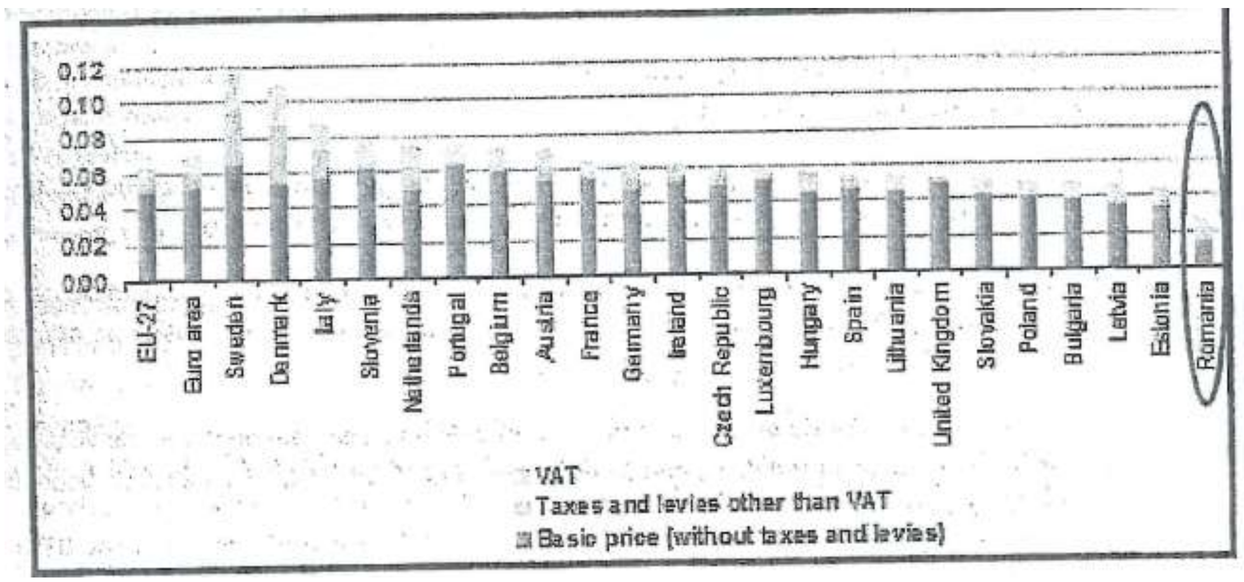


Figure 11 – Gas price comparison for households across the EU – 2011
(Source: Eurostat)

However, regulated prices are below market prices, reducing the incentive to adopt energy saving measures. ANRE[30] will develop a price comparison tool and set up a protection scheme for vulnerable customers.

[29] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Energy_price_statistics

The overview of the technical and economic potential of renovating Romania's building stock has been produced using the model of the BPIE study based on the model developed for the analysis of renovation potential in the EU, as published in 'Europe's Buildings under the Microscope'[31].

5.2.2 Identifying the solutions for renovation

To examine the scenarios illustrating the impact on energy consumption and CO_2 emissions at different levels (i.e. percentage of buildings renovated each year) and degrees of renovation (i.e. energy level achieved) in the residential and non-residential building sectors, up to 2050, a number of scenarios can be taken into consideration, illustrating the financial, economic, environmental, employment and energy consumption impact at different levels of uptake and degree of building renovation. The scenarios assess mainly the following outcomes, both annually and overall:

- Energy savings;
- Reductions in CO_2 emissions;
- Total investment required to implement renovation measures;
- Savings in energy costs;
- Impact on employment– the equivalent number of full time jobs created up to 2050;
- Cost-effectiveness indicators:
    - **Internal rate of return (IRR) –** based on the net savings each year (i.e. cost savings less investment required in a given year);
    - **Net savings to consumers –** the difference between lifetime savings in energy costs and lifetime investment. Both figures are net present values;
    - **Net savings to society,** including the value of externalities – the sum of the lifetime savings in energy costs and the value of externalities, less the lifetime investment. Both figures have a societal discount rate;
    - **Carbon abatement cost –** net lifetime societal savings divided by the lifetime carbon savings. A negative figure indicates a net benefit per ton of CO_2 saved.

Initial Data and Modelling Assumptions

The scenario for the renovation of buildings takes into consideration different input data for four building types:

- Single-family homes (SFH)
- Apartment blocks (MFH)
- Public buildings, (administrative buildings make up 5 % of all non-residential buildings[32])
- Commercial and industrial buildings.

[30] http://www.anre.ro/
[31] http://bpie.eu/eu_buildings_under_microscope.html
[32] Study on cost optimality in Romania

There are around 1 million abandoned homes in Romania[33], a consequence of strong migration and emigration trends in recent years. It is considered that the abandoned housing stock does not consume energy and is therefore excluded from the model.

The assumption is that, in future, an additional 0.1 % of the existing stock will be abandoned each year, for various reasons. Many abandoned homes are in rural areas, where there is a high share of renewable energy use (mostly firewood), while new buildings are constructed mainly in urban areas, which mostly depend on district heating or the natural gas network. There is thus reason to believe this will influence the evolution of the energy mix, causing slower decarbonisation than in the rest of the EU.

Variations in the building stock

The scenario allows for the following variations in the building stock:

- **Demolitions and abandoned buildings:** The total building stock is reduced by 0.2 % a year, half of which corresponds to the average demolition rate in 2005–2012 and the other half to abandoned buildings.

- **Heritage buildings:** Many buildings have historical, aesthetic and/or cultural value. As a consequence, planning authorities and other bodies may restrict the extent and type of renovation that can be undertaken. In practice, these buildings are not excluded because there will always be some energy saving measures that can be applied, even if it is not a total renovation. Minor and moderate renovations may often be feasible in the case of heritage buildings.

- **Recent renovations:** Some buildings may have undergone renovation in the recent past and this may make future renovation economically less attractive. The number of buildings renovated to a level that would prevent the application of further energy saving measures is likely to be very small, of the order of 1 % of the existing stock.

- **New buildings**: New buildings constructed between now and 2020 will probably be subject to renovation in the period up to 2050, even if only to replace heating, ventilation and air conditioning (HVAC) equipment. Also, as energy standards for renovation are tightened and new technologies become more widely available and affordable, these will increasingly be deployed on buildings constructed during this decade. The rate of new buildings is set at 0.85 % based on the 1990–2012 average useful floor area of finished homes. Beyond 2020 it is assumed that NZEB requirements under the recast of the EPBD will result in buildings achieving a level of energy performance that will not require further renovation (other than equipment replacement) to 2050.

Renovation variables

The main variables that influence the renovation of buildings are:

- The rate of renovation, expressed as a percentage (%) of the building stock in a given year;

- The depth of renovation, according to the four previously described levels:

    - minor,

    - moderate,

    - deep,

    - NZEB;

[33] 2nd NAPEE – Energy Efficiency Action Plan Romania EN – annex 2.4 p. 122.

- The cost of renovation, which itself varies with the depth of renovation.

Rate of renovation

The main variables concerning renovation rates and considered by this model are the speed at which renovation activity takes place, the percentage of stock to be renovated and the duration of the strategy.

Taking into account the above-mentioned assumption, this model proposes two main growth pathways: SLOW and MEDIUM. These are benchmarked against a BASELINE that assumes that the current renovation rate remains unchanged from today's rate (assumed to be 1 % per year).

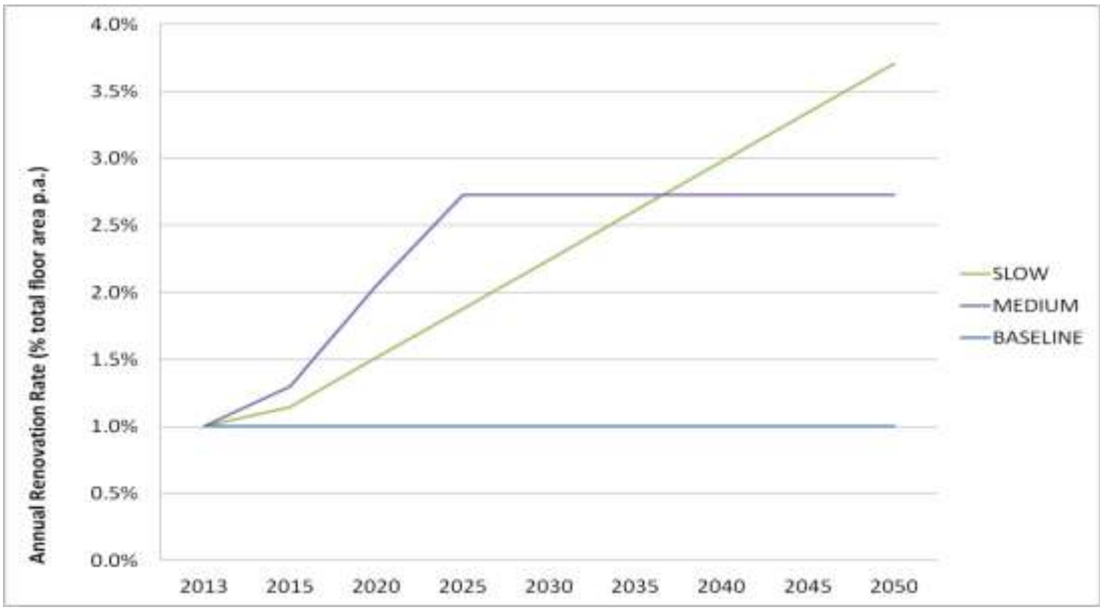


Figure 12 – Scenarios for pathways of renovation rates

In the case of residential buildings, the rate of renovation is determined so as to prioritise buildings constructed before 1960 and between 1961 and 1990, a great proportion of which are currently being renovated or are to be renovated between now and 2030.

Depth of renovation

There are three different scenarios for the depth of renovation: **shallow, intermediate** and **deep**, reflecting a progressive transition to renovations that achieve higher average savings, as illustrated in the chart below.

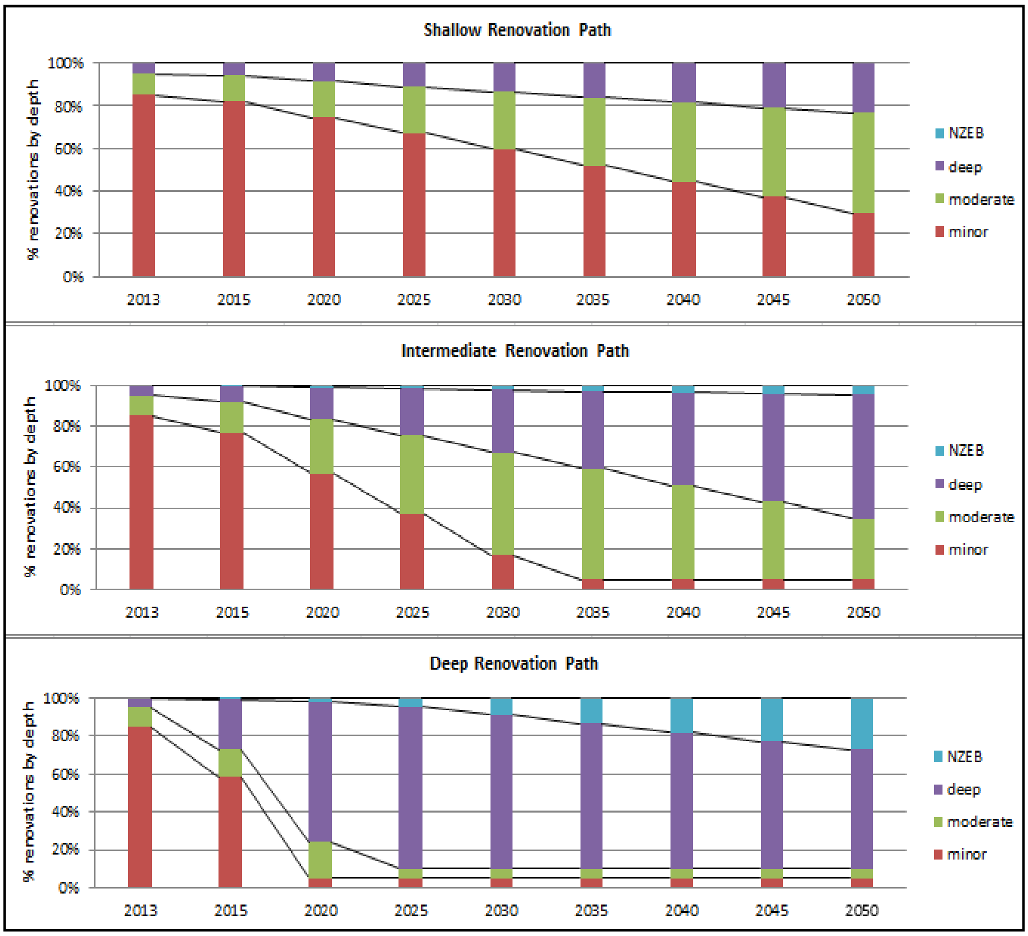


Figure 13 – Renovation depth

RENOVATION SOLUTIONS

In all scenarios, the assumed renovation activity is 'technology neutral'. In other words, no assumptions have been made regarding specific measures to be applied in order to achieve a particular level of energy savings. An ideal approach would be to consider the best package of measures that would achieve the maximum improvement in energy performance for each particular building type, taking into consideration also the location within Romania's climatic zones. The package could include a range of measures, including some or all of the following:

- Thermal insulation of the envelope (opaque part);
- Upgrading windows and doors;
- Solar shading – notably to reduce the air conditioning requirements;
- Reducing air infiltration;
- Upgrading the HVAC systems;
- Installing combined heat and power systems;
- Connection to district heating system;
- Installation of heat recovery units (for the air removed);

- Upgrading the interior lighting systems;
- Improved energy use control systems;
- Installation of energy equipment that uses energy from renewable energy sources (solar hot water installations, photovoltaic panels, heat pumps, biomass boilers, mini wind turbines, etc.).

Various renovation scenarios can be modelled based on combinations of renovation rates and renovation depths. For the purposes of this renovation strategy, four scenarios are considered:

- BASELINE – a continuation of current practice, i.e. predominantly minor renovations covering 1 % of the floor area per year and current rates of decarbonisation;
- MODEST – assumes the SLOW renovation rate and the SHALLOW renovation path;
- INTERMEDIATE – assumes the MEDIUM renovation rate and the INTERMEDIATE renovation path;
- AMBITIOUS – assumes the MEDIUM renovation rate and the DEEP renovation path.

RESULTS

The results are based on different renovation scenarios for the existing building stock up to 2050, as illustrated in table 5.

	SCENARIO	Baseline	Modest	Intermediate	Ambitious
Energy savings					
Energy savings in 2050	TWh/year	8.5	31.1	44.8	63.2
Energy savings in 2050 compared to 2010	%	8.3 %	30.4 %	43.8 %	61.8 %
Carbon Emissions*					
Annual CO_2 savings in 2050	$MtCO_2$/year	3	22	24	25
2050 CO_2 saved (% of 2010)	%	12 %	79 %	83 %	89 %
CO_2 abatement cost	€/tCO_2	-138	-40	-54	-70
Societal Benefits					
Employment generated	Average Jobs/year	4 403	15 854	24 888	39 736

* decarbonisation rate for the baseline scenario is the average decarbonisation rate in the EU since 1990. For the other scenarios, it is the rate required to achieve the EU 2050 Low Carbon Roadmap objectives.

TABLE 5 – Results of the scenario analysis

Example: Table 6 presents the energy savings for a building with a specific annual energy consumption of 211 kWh/m^2 and the energy performance following the application of the various energy efficiency scenarios.

Renovation type	Energy saving (%)	Annual specific energy savings (kWh/m^2/year)	Resulting energy performance (kWh/m^2/year)
Minor	15 %	32	179
Moderate	45 %	95	116
Deep	75 %	158	53
NZEB	95 %	200	11

TABLE 6 – Energy savings and resulting energy performance by renovation depth for an average nominal building consuming 211 kWh/m^{2}year

FINANCING THE MEASURES

It can be seen that, when considered over the economic life of the measures, all scenarios are cost effective in that the present values of the savings in energy costs considerably outweigh the investments. However, the difficulty remains that finance needs to be secured to make the initial investment, against a backdrop of modest means, coupled with low levels of motivation and awareness.

EU funds for efficient energy renovation of buildings[34]

Buildings are at the heart of the EU's strategy to achieve smart, sustainable and inclusive growth by 2020. Investing in efficient energy renovation of the EU building stock is a win-win-win solution for businesses, for households, and the environment. As a result, energy efficiency and the transition to a low-carbon economy feature as a core thematic objective for the upcoming 2014–2020 funding period. Partnership agreements and operational programmes must be aligned to that objective. The scope of eligibility for investments in the energy efficiency of buildings has also been expanded beyond the European Regional Development Fund (ERDF) to encourage investments also from the Cohesion Fund (which previously excluded the housing sector) and the European Social Fund (supporting the up skilling of the labour force for green jobs).

To maximise project impact on the ground and to achieve better integrated development, Member States are encouraged to combine various funds into 'Multi-Fund' Operational Programmes for the next funding period. Energy efficiency in buildings (both public and private) is upheld as a funding opportunity in several Funds: ERDF (mandatory minimum percentages), the Cohesion Fund (where public and private housing are fully eligible) and the European Social Fund (supporting the up skilling of the labour force for green jobs).

Information on the use of the Cohesion Fund to finance building renovation can be found in the 2014 publication 'Financing the energy renovation of buildings with Cohesion Policy funding'[35]. The European Commission's webpage 'Financing Energy Efficiency'[36] provides additional information on sources of funding.

[34] Adapted from the Renovate Europe Campaign leaflet on Structural Funds: http://www.renovate-europe.eu/uploads/Renovate%20Europe%20Structural%20Funds%20Leaflet.pdf
[35] http://ec.europa.eu/energy/efficiency/studies/doc/2014_guidance_energy_renovation_buildings.pdf
[36] http://ec.europa.eu/energy/efficiency/financing/financing_en.htm

The Regional Operational Programme for the period 2014–2020, financed from the European Regional Development Fund, includes priority axis 3 concerning the energy efficiency of public buildings, which has been allocated 300 million euros. This support from the European Union has the purpose of supporting energy efficiency and the use of renewable energy for public infrastructure, including in public buildings, and in the housing sector. The main expected results to be achieved through the promotion of investments with a view to improve energy efficiency in public buildings are a reduction in primary energy consumption in buildings, and a reduction in greenhouse gas emissions.

Furthermore, for the period 2014–2020, priority axis 4 for supporting urban development, which has among its investment priorities support for energy efficiency and use of renewable energy in public infrastructure, including in public buildings, and in the housing sector, has been allocated 852.63 million euros.

5.3 PHASE 3 – POLICY ASSESSMENT

5.3.1. Policies and incentives for the renovation of existing buildings

Romania has several policies affecting energy consumption, these include the following:

- The energy roadmap for Romania (Government Decision No 890/2003) aiming for a final electricity consumption level of 57.59 TWh in 2015;
- The strategy on renewable energy sources (Government Decision No 1535/2003) reinforced by the Renewable Energy Action Plan;
- The national strategy on energy efficiency (Government Decision No 163/2004);
- The national strategy on supplying heating to localities through district generation and distribution systems (Government Decision No 882/2004);
- The national programme 'Heating 2006–2015 - heating and comfort' (Government Decision No 462/2006) for the rehabilitation of the district heating systems and the thermal rehabilitation of buildings;
- The National Development Plan 2007–2013, in conjunction with the ERDF sector programmes and with three major sub-programmes on energy efficiency and sustainable energy, renewable energy sources and interconnection networks;
- Romania’s national energy strategy 2007–2020 (Government Decision No 1069/2007) aiming to reach a primary energy intensity of 0.32 in 2015 and 0.26 in 2020;
- The national strategy on the sustainable development of Romania – Horizons 2013–2020–2030 (Government Decision No 1460/2008).

Romania’s energy strategy for 2007–2020 includes a 2007 forecast of energy consumption, which does not take into consideration the impact of the economic crisis.

The main measures identified and included in the strategy in respect of buildings are:

- Intensifying the information campaigns for the general public and the business environment;
- Continuing the 'Heating 2006–2015 - heating and comfort' programme;
- Continuing the Programme for the improvement of the energy efficiency of apartment blocks;

- Extending the national programme for energy efficiency (rehabilitation of the heating system, rehabilitation of public buildings) for 2011–2015;

- Making energy performance certificates compulsory, starting from 2010, for residential buildings (i.e. single-family homes and apartments) that are sold or leased out;

- The enforcement by the central and local public authorities of legislation on energy efficiency and the promotion of the use of energy from renewable sources at the level of the end consumer.

5.3.2 Forecast perspectives for guiding investment decisions

Phase 3 of the renovation strategy is the development of an appropriate policy framework – an essential component for the successful delivery of a building energy renovation strategy. It requires a strategic appraisal of the barriers that have held back the market thus far, and a concerted effort to address those barriers in a co-ordinated fashion. The challenge is to design a policy framework that acts to remove barriers, while at the same time providing building owners, occupiers and investors with the right information, incentives and capability to take the necessary steps:

- **Financial instruments**: the use of fiscal instruments such as taxation, tax breaks or other incentives plays a very important role in sending signals to consumers as well as to market actors. Rules governing treatment of energy service companies (ESCOs) are important in determining whether or not a country has a thriving market for third party financing;

- **Energy**: Energy policy is usually dominated by supply-side concerns. Consequently, the role of demand side measures such as energy efficiency in buildings is often overlooked or underplayed, yet various international studies have shown that the energy saved through demand-side measures can be comparable to, or even exceed, the energy supplied by individual fuels.

- **Economy**: The economic crisis is still having a significant impact on the economy, but the view that measures to improve the environment are somehow detrimental to economic growth is erroneous. The programmes for boosting the energy performance of buildings clearly show that these investments are favourable to the development of the economy, while also creating jobs.

- **Environment/Climate Change**: While much of the focus is on the thermal rehabilitation of buildings, it cannot be ignored that they are the largest contributors to CO_2 emissions. Therefore, this has to be a priority domestic area of action.

- **Housing**: As in many other countries, issues such as housing quality, comfort and affordability are national concerns. Energy costs are a key component of housing costs, and the only long term, sustainable solution to providing affordable heating is through improving the energy performance of the housing stock.

- **Regional Development**: Regeneration and other regional development initiatives are often associated with cosmetic and infrastructure improvements, while energy-saving measures are rarely considered a high priority that could significantly influence the prioritisation of spending.

- **Health**: Whilst not an obvious policy area with a role to play in building renovation, the reality is that poor quality housing suffering problems such as under/overheating, condensation, mould growth and indoor air pollution leads to significant health issues which represent a cost to society in terms of lost working days and impact on health services.

5.3.3 Barriers

Three main types of barriers have been identified as being of most relevance to the building sector[37]:

- Legislation/Strategies
- Economic situation
- Skills, employment and education system

Table 7 below lists selected barriers under each of the three headings:

BARRIER TYPE: Legislative/Strategic
There are a number of ministries with overlapping responsibilities in the building sector, with a lack of correlation between them and their respective departmental regulations and laws
There is no common national strategy on the deployment of sustainable energy technologies and solutions
BARRIER TYPE: Economic
Financial crisis, insufficient funds to support building renovation works
Lack of private investment in the rehabilitation of residential and non-residential buildings
High costs of energy service companies (ESCOs)
Low demand for low energy building technologies, leading to higher prices
National tendency to 'maximise profit with minimum effort' instead of using the optimal cost method, resulting in sub-optimal execution of works
The high rate of unemployment and the period spent until re-employment
Energy prices (gas, electricity, etc.) vs. real prices (i.e. energy subsidies)
BARRIER TYPE: Skills, employment and education system
Lack of skilled workers or low levels of training in the use of new technologies designed for EE and RES

TABLE 7 – Assessment of barriers (simplified)

5.3.4 Developing policy solutions

Introducing a scheme of obligations for 2014–2016 may be considered as an option only in the event that the impact on energy prices[38] and best practices[39] shows that they can have significant benefits, i.e. net benefits to consumers far outweighing the modest increase in energy bills.

For an alternative approach, the following possible policy measures have been identified:

[37]The above list has been adapted from this presentation at Euro Constructii in 2012: http://euroconferinte.ro/prezentari/Tema1-17.pdf
[38] http://ec.europa.eu/energy/efficiency/eed/doc/article7/2013_ro_eed_article7_ro.pdf
[39]The Regulatory Assistance Project has produced numerous documents on EEOs, e.g. on global best practice http://www.raponline.org/document/download/id/5003.

- Establishment of an energy efficiency investment fund to tap into private funds, structural funds, auctioning revenues under EU ETS provisions and possibly the state budget;
- Conducting energy audits;
- Training of energy auditors;
- Consumer awareness-raising and advice campaigns, to raise awareness among households of the benefits of energy audits through energy advisory services in building energy;
- Regulations or voluntary agreements;
- Supporting the development of ESCOs, including developing the regulatory framework for the effective operation of the ESCO, developing the market of these companies and promotion of energy performance contracts by 2016.

These measures are aimed at improving the regulatory framework for building renovation and to mobilise investments in building renovation.

The full list of policy options is presented below, together with the proposals on relevance to the current situation:

TABLE 8 – Policy actions to support the renovation strategy

	INDICATIVE LIST OF POLICY INITIATIVES[40] (non-exhaustive)	APPLICABILITY UNDER THE RENOVATION STRATEGY
Strategies	Provide support for deep renovation of the building stock	**High** – Cross party and cross-society support for a renovation programme will help establish a climate that provides longer term certainty and confidence in the market
	Undertake systematic assessment of barriers to renovation in each segment of the market and develop policy responses to address each barrier	**High** – This strategy identifies some of the key barriers and possible solutions.
	Establish objective to eradicate fuel poverty through enhancing energy performance of the housing stock	**High** – Addressing the poor energy performance of housing of the many disadvantaged Romanian citizens would be a major boost to their quality of life.
	Develop comprehensive cross-policy targets that integrate with and contribute to achieving goals in related fields, e.g. sustainable urbanisation, resource efficiency, sustainable construction, etc.	To be examined in the next phase
	Establish a wide stakeholder group as a forum for consultation, policy formulation and feedback on practical issues and barriers to renovation	The stakeholders identified in this document could form the basis of an ongoing stakeholder forum.
	Demonstrate leadership through accelerated deep renovation of public buildings, thereby developing supply chain capacity and providing a knowledge base for private/commercial renovation activity	In addition to the target of 3 % per year for the central administration (Article 5 of EED) from 2014, **serious consideration** should be given to implementing a similar objective in the remainder of the public sector, commencing in 2015.

[40] SOURCE – BPIE Guide to Renovation Strategy Development.

Legislative & Regulatory	**INDICATIVE LIST OF POLICY INITIATIVES** **(non-exhaustive)**	**APPLICABILITY UNDER THE RENOVATION STRATEGY**
	Identifying triggers and developing relevant regulations that could be used to encourage, or require, improvements in building energy performance[41]	**High** – Any intervention in a building should be used as an opportunity to maximise improvement in the energy performance of a building element or technical system
	Drawing up a scheme of energy efficiency obligations that encourage deep renovation	This should be considered a **top priority** for the next phase.
	Facilitating the upgrading of all social housing to high energy performance levels	Not a priority given the limited amount of social housing in Romania
	Addressing restrictive practices concerning local deployment of low/zero carbon technologies to create a positive environment for the integration of renewable energy sources for buildings	**High** – renewable energy sources integrated into buildings should be actively supported, within the bounds of EU state aid rules
	Remove restrictive tenancy laws that create disincentives or otherwise inhibit improvements in energy performance	**High** – willing investors should not be prevented from undertaking renovation because of inappropriate legislation
	Imposing an obligation to improve the least efficient stock to higher energy performance levels, e.g. through restrictions on sale or rental of buildings in the lowest energy performance categories	To be considered in the next phase

[41]Examples of triggers: audits; issuing of energy performance certificates; boiler and air conditioning inspections; change of ownership or tenancy; change of building use; other building works (e.g. extensions).

	INDICATIVE LIST OF POLICY INITIATIVES (non-exhaustive)	APPLICABILITY UNDER THE RENOVATION STRATEGY
Technical	Developing renovation standards that are progressively and regularly strengthened in response to experience and new technological solutions	In accordance with the EPBD
	Analysing the potential of district heating systems that provide efficient, low carbon energy	**High** – take measures to improve the efficiency and public acceptability of the large number of existing district heating systems, and also to stem the tide of disconnections
	Ensuring proper monitoring and enforcement of compliance with building codes	In accordance with the EPBD
	Developing packaged solutions that can be readily replicated for similar building types	Establishing a database of technical solutions that serves as a learning point for future projects/investments
	Introducing quality certification for installations and products	In accordance with the EPBD
Fiscal/Financial	Securing sources of finance, including those identified in Article 20 of EED and EU/international funding sources, together with mechanisms that effectively leverage private capital	**Top priority** – maximising the absorption of EU Cohesion and Structural Funds under the 2014–2020 budget for deep renovation of buildings.
	Consideration of monetary value of co-benefits (e.g. health, employment) in public funding decisions	**High** – establishing a cross-ministerial group to assess the co-benefits from improvements in energy performance, and reflect the value in policy making in areas such as health and employment
	Developing funding options tailored to specific market segments, that provide a simple (one-stop-shop) and commercially attractive source of finance for deep renovation	**High** – the proposed Energy Efficiency Investment Fund could be developed as the main funding vehicle for renovation
	Developing mechanisms to encourage deep renovation via third party financing (TPF) e.g. ESCOs, EPCs	**High** – developing the regulatory framework for effective operation of the ESCO, developing the market of these companies and promotion of energy performance contracts by 2016
	Strengthening energy/carbon pricing mechanisms to send the right	For consideration in the next phase, once fossil subsidies have been

	economic signals	largely removed
	Removing fossil fuel subsidies to eliminate perverse incentives that discourage investment	Accessible – existing subsidies for electricity, gas and district heating are being progressively phased out
	Consider bonus-malus mechanisms, e.g. property taxation systems (which reward high energy performing buildings while penalising poorly performing ones) and energy pricing	To be considered in the next phase

Communication / Capacity Building	**INDICATIVE LIST OF POLICY INITIATIVES (non-exhaustive)**	**APPLICABILITY UNDER THE RENOVATION STRATEGY**
	Setting up publicly accessible databases demonstrating the energy performance of renovated buildings and providing information on how to undertake deep renovation	Medium – improved knowledge on renovation solutions will encourage replication
	Launching skills and training programmes covering the key professions and disciplines	**High** – implementing the findings from projects on the upskilling of fitters in renewable energy
	Establishing knowledge and experience-sharing networks across regions/Member States	Understanding how other Member States have addressed specific issues can help in their resolution within the Romanian context.
	Encouraging the development of local supply chain industry in order to maximise macro-economic benefits and minimise embedded CO_2 emissions	**High** – Maximising the economic potential for new employment in the manufacture and supply of low carbon solutions
	Developing promotional and dissemination activities that sensitise building owners to opportunities for deep renovation and that provide step-by-step support throughout the renovation process	**High** – The success of any policy is dependent on effective engagement with building owners both in the residential and in the non-residential sector.
	Communicating regularly and publicly on progress with the renovation strategy	**High** – Maximising the economic potential of the effective engagement with building owners both in the residential and in the non-residential sector.

R&D	Supporting research, development and demonstration projects relating to new and improved technologies and techniques for deep renovation, including how to scale up best practices to cover as many buildings as possible	Reviewing existing EU R&D initiatives and considering the scope for application of the results in Romania

5.4 CONCLUSIONS

5.4.1 Forecast perspectives for guiding investment decisions

The **renovation of buildings** represents a major opportunity to modernise the existing building stock in a sustainable way that provides multiple benefits for households, business and the public sector. A strategic approach can stimulate the market where the current fragmented initiatives have failed.

The building renovation strategy sets out a long term framework for the renovation of the existing building stock to very high levels of energy performance. To achieve this goal, it is necessary to enable building owners to undertake deep renovation of their buildings by creating the right market conditions and policy context for action. This process should involve the entire chain, from manufacturers of construction materials, builders and fitters to professional service providers.

Funding renovation is the key to success. There are significant European funding sources available that need to be brought to bear, and the Energy Efficiency Investment Fund should be designed to make it easier for those who invest in building renovation.

The policies that are considered the most important for the next three years are the following:

- Ensuring support for a national programme to renovate the building stock;
- Introducing in the thermal rehabilitation programmes, as a matter of priority, the housing of disadvantaged people, which would result in a major boost to their quality of life;
- Ensuring a 3 % renovation rate for central public administration buildings;
- Imposing high performance requirements for the replacement of envelope elements and technical components such as heating, ventilation and air-conditioning systems (HVAC);
- Providing support for the use of renewable energy in buildings;
- Continuing improvements in the efficiency and public acceptability of the large number of existing district heating systems;
- Developing an Energy Efficiency Obligation (EEO) scheme to support deep renovation for the period from 2017 onwards;
- Maximising the absorption of EU Cohesion and Structural Funds under the 2014–2020 budget for deep renovation of buildings;
- Designing the Energy Efficiency Investment Fund as the main funding vehicle for renovation;
- Developing the regulatory framework for the establishment and operation of ESCOs, develop the market of these companies and promote energy performance contracts;
- Modifying restrictive tenancy laws that create disincentives or otherwise inhibit improvements in energy performance;
- Encouraging the development of a home-grown local supply chain industry for the provision and implementation of renovation measures;

- Developing promotional and dissemination activities that sensitise building owners to opportunities for deep renovation and that provide step-by-step support throughout the renovation process;

- Establishing a stakeholder forum (comprising the organisations identified in this report) to assist in the implementation and ongoing refinement of the strategy.

In order to explore the impact of policy initiatives for improving the energy performance of buildings, several sets of policies were identified through the project entitled IEE ENTRANZE[42], which were assessed based on the INVERT (TU Vienna) and EE Lab (Fraunhofer ISI) simulation programs, while the macro-economic evolution developed under the project was drawn up using the POLES (ENERDATA) model.

According to the project results for Romania, three sets of policies for buildings were identified, which correspond to the three scenarios identified as achievable, as follows:

- **Policy set 1 (PS1) – BaU ('business as usual')**
- **Policy set 2 (PS2) – Growing-up**
- **Policy set 3 (PS3) – Market transformation**

The scenario developed took 2008 as year of reference ('no policies scenario').

Each of the identified sets of integrated policies was based on the following:

1. Technical regulations/energy performance requirements;
2. Education, training, qualification and compliance/quality control;
3. Information, motivation and guidance;
4. Economic instruments in support of building renovation;
5. Measures on primary energy, industry, research, technology and development;
6. Change in energy prices in the EU, i.e. slow change in energy prices – figure 14, and accelerated change in energy prices – figure 15.

[42] www.entranze.eu

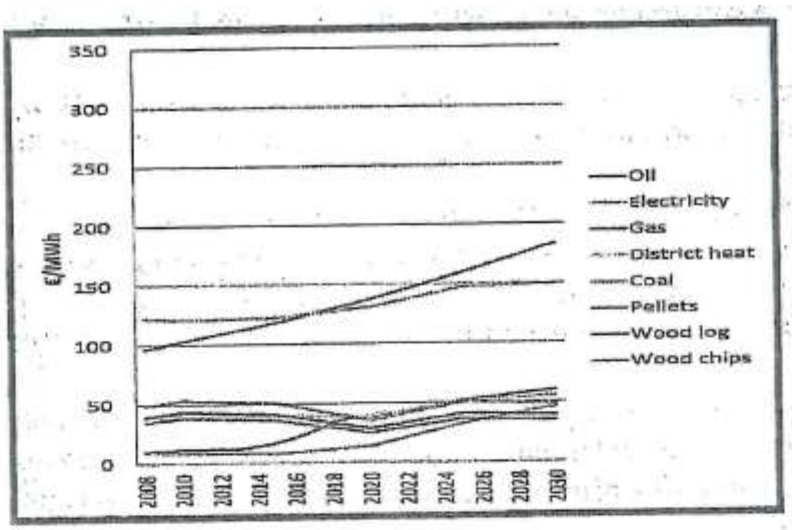


Figure 14: Scenario based on slow change in energy prices

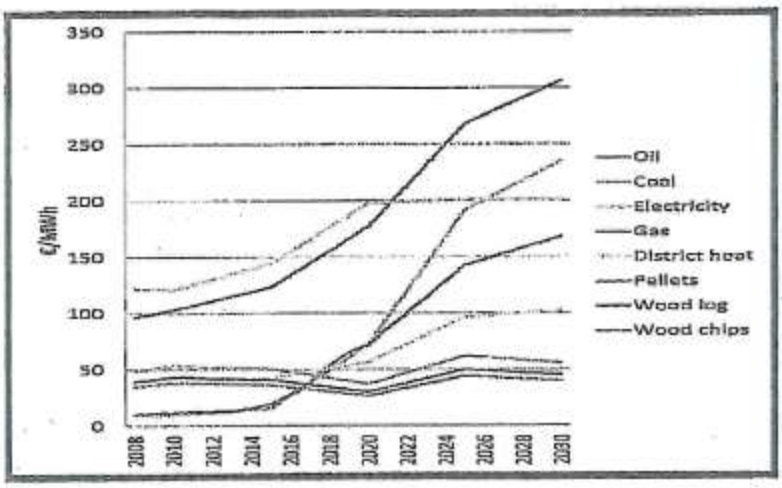


Figure 15: Scenarios based on accelerated change in energy prices

5.4.2 Economic instruments in support of improvements in the energy performance of buildings

The improvement of the energy performance of buildings entails higher investment costs even if the investment is amortised in time.

The improvement of energy performance at nearly zero consumption levels requires mixed measures for energy efficiency (increase in thermal insulation, ventilation etc.) and a high rate of renewable energy integration.

The benefits of passing to high energy performance levels in the construction and renovation of buildings are of two types:

- direct benefits to building owners/tenants, namely the reduction in energy bills and dependence on energy price variants, increased thermal/air comfort in buildings, reduction in respiratory diseases
- indirect benefits to society, namely the creation/consolidation of jobs in construction, increase in revenues to public local and national budgets as a result of a reduction in additional unemployment benefits, taxes, social and health insurance of employees and related businesses,

a reduction in investment requirements for new energy capacities and in fuel import/use for energy generation.

Economic instruments play a role in stimulating the market, by reducing the impact of the initial investment, and in spreading the investment risks between private and public according to the related benefits.

Economic supporting instruments need to be developed for the long term (e.g. 2030), have as final goal the transformation of the market (namely construction/renovation of buildings at NZEB level for commercial purposes), address all major categories of inhabitants and buildings, and be oriented towards clearly defined and quantifiable targets (e.g. renovation of all apartment blocks at an energy performance level of <40kWh/m^2year by 2050).

For the above reasons, economic supporting instruments must be integrated at a macro-economic level in order to enable the assessment of all benefits and the maximisation of the economic impact.

EU Cohesion Funds could have an important contribution in the transformation of the Romanian building stock, provided they are allocated and used.

Support instruments/programmes need to have a long-term predictability, with any change to be announced in a timely manner in order to provide a solid framework for investment, as well as to stimulate activities carried out within the programme (e.g. the number of applications for funding increases if applicants are made aware of any possible future reduction in the financial contribution available under the programme).

5.4.3 Measures for reducing the primary energy factor, stimulating the local relevant industry and supporting research and development

Improving energy efficiency in primary energy could significantly contribute to ensuring higher energy performance in buildings (estimated in primary energy as required by Directive 2012/27/EU on energy efficiency).

For these reasons, measures aimed at increasing the rate of (electric and thermal) energy supply from systems based on renewable energy have an important role. Similarly, an increase in the efficiency of district heating systems can have a significant contribution.

Stimulating the local industry for energy-efficient building materials and equipment and for renewable energy can have a major contribution to market transformation, increasing the competitiveness level of the industry and last, but not least, creating jobs.

Stimulating research on new techniques and technologies for the construction of buildings with low energy consumption or active/positive buildings (buildings that generate more renewable energy than the energy they consume) also has an important role in the development of know-how and in maintaining close contact with similar research in other EU Member States.

5.4.4 Energy savings and benefits

5.4.4.1 Energy consumption following renovation

The information below presents the energy consumption targets for the following building categories undergoing renovation works:

- Apartment blocks (MFH);
- Single-family homes (SFH)
- Office buildings, schools, hospitals and hotels.

The minimum energy consumption values proposed for the above mentioned building categories undergoing renovation works are expressed in primary energy, and the share of renewables is already included in the proposed values and is presented in table 9.

In the cases where the share of renewable energy is impossible to achieve in the building or in its surroundings, two alternative variants can be taken into consideration:

- purchase of renewable energy from the grid (e.g. purchasing electricity generated through renewable energy sources based on certificates of origin);
- achieving the minimum energy performance requirements exclusively through efficiency measures (possibly with a reduction of up to 15 %).

The estimates for energy consumption in buildings correspond to climate zone II, i.e. Bucharest, which is representative for Romania.

Table 9: Maximum specific energy consumption per year (compliance with the minimum energy performance requirements) for buildings in Romania [kwh/m^2/annum primary energy], and share of renewable energy (SRE) in meeting the primary energy needs of a building [%].

Type of building	Year	Policy set 1 (BaU)		Policy set 2 ('Growing-up')		Policy set 3 ('Transformation')	
		New*	Renovated*	New*	Renovated*	New**	Renovated**
Apartment blocks	2015	90	100	80	100	70	90
	2020	80	100	70 RES>30 %	90	60 RES>40 %	70 RES>20 %
	2030	70	80	60 RES>40 %	70	40 RES>50 %	50 RES>40 %
Individual houses	2015	150	180	130	150	90	110
	2020	120	150	100 RES>30 %	120	80 RES>40 %	90 RES>20 %
	2030	100	130	70 RES>40 %	90	40 RES>40 %	60 RES>40 %
Office buildings, schools, hospitals and hotels	2015	120	140	100	120	90	110
	2020	100	120	90 RES>20 %	100	70 RES>30 %	100 RES>20 %
	2030	80	100	70 RES>30 %	90	40 RES>40 %	60 RES>30 %

*heating energy only

**energy consumption in accordance with EPBD (energy for heating, cooling, ventilation, domestic hot water, auxiliary and lighting equipment, for non-residential buildings)

The analysis shows that the three policy sets will generate by 2030 primary energy savings of 24 %–33 % in the context of a slow change in energy prices and primary energy savings of 32 %–40 % in the context of an accelerated change in energy prices.

In the context of an accelerated change in energy prices, all simulated policy sets produce high energy savings by 2030. SP3 contributes to the reduction by a quarter of the final energy consumption in buildings.

For the energy mix in the final energy consumption for heating and hot water, the modelling of the three policy scenarios have led to the following results:

- Final energy consumption for heating and hot water from the district heating network shows a decreasing tendency: from 18.8 % in 2008 to 12–13 % in 2020 and to 8–10 % in 2030 (the highest reduction registered in PS3 in the context of an accelerated change in energy prices). This reduction is mainly the result of the decrease in energy requirements due to the national programme for the rehabilitation of apartment blocks.

- Solar thermal energy records a sensible increase in all scenarios, namely from 0.05 % of the final energy consumption in 2008 to approximately 5 % in 2030. Geothermal energy is on the rise from negligible values in 2008 to approximately 1–1.16 % in 2030. This is the result of the support programmes and is positively influenced by the more accelerated change in energy prices.

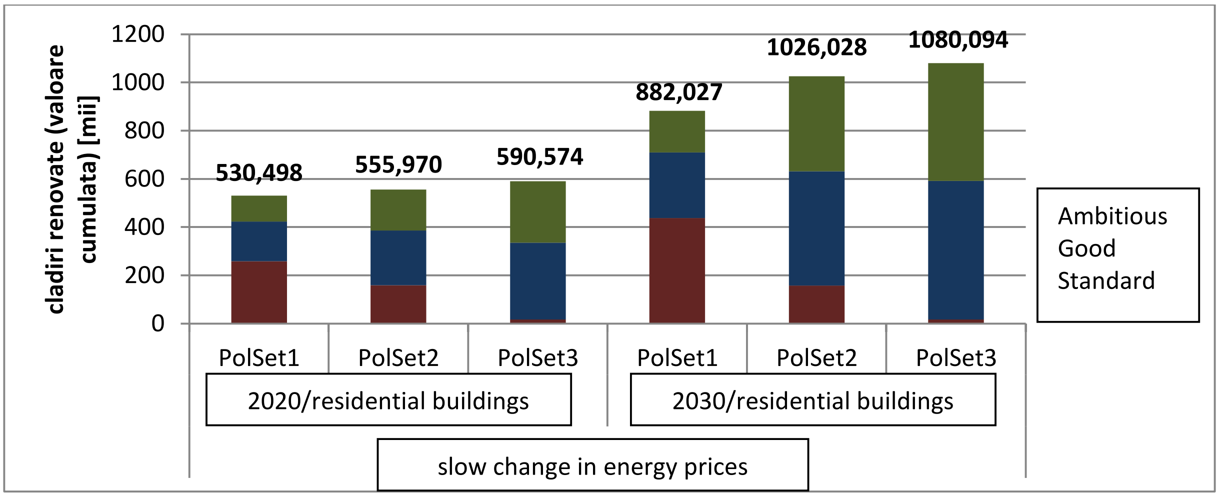
- Biomass consumption remains dominant throughout the assessed period, maintaining a relatively constant share (namely from 37.8 % in 2008 to 37.6–39.6 % in 2030) in the context of a slow change in energy prices and a relatively constant share relative to the energy generated in the context of an accelerated change in energy prices (namely from 32 060 GWh in 2008 to 33 754–31 433 GWh in 2030). This trend is explained by the promotion of efficient technologies for the use of biomass, which in the context of higher energy prices become more attractive on the market.

- Final coal consumption decreases from 0.78 % in 2008 to 0.08 %–0.13 % in 2030. Similarly, the consumption of petroleum products decreases from a share of about 6.28 % to a share of 1.7 %–1.9 % in the final energy consumption for 2030.

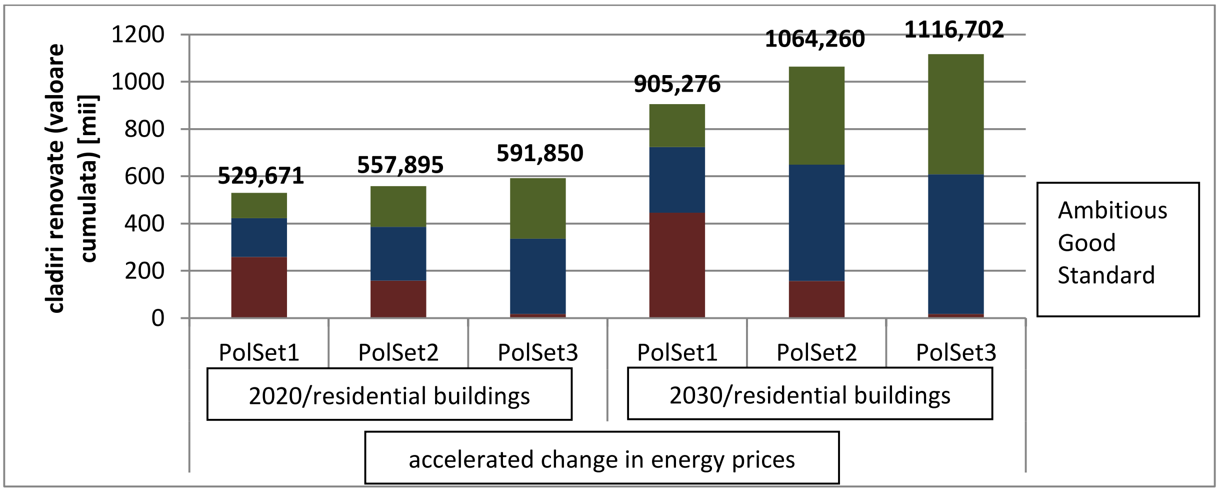
- Gas consumption preserves its leading position in all three scenarios, from approximately 33 % in 2008 to a slight rise (up to 39 %–41 %) by 2020, but later dropping to 30 %–39 % by 2030. The highest reduction is registered in the context of an accelerated change in energy prices in the case of the PS3 policy set.

- In all three scenarios, energy consumption slightly decreases until 2020 after which it registers a slow increase until 2030 while preserving a relatively similar share to that of 2008, namely 3 %–4 % of the final energy consumption for heating and hot water.

The results of the modelling of the policy sets for improving the energy performance of residential and non-residential buildings, depending on the evolution of energy prices, for the time frames up to 2020 and 2030, are presented in Figures 16 and 17.

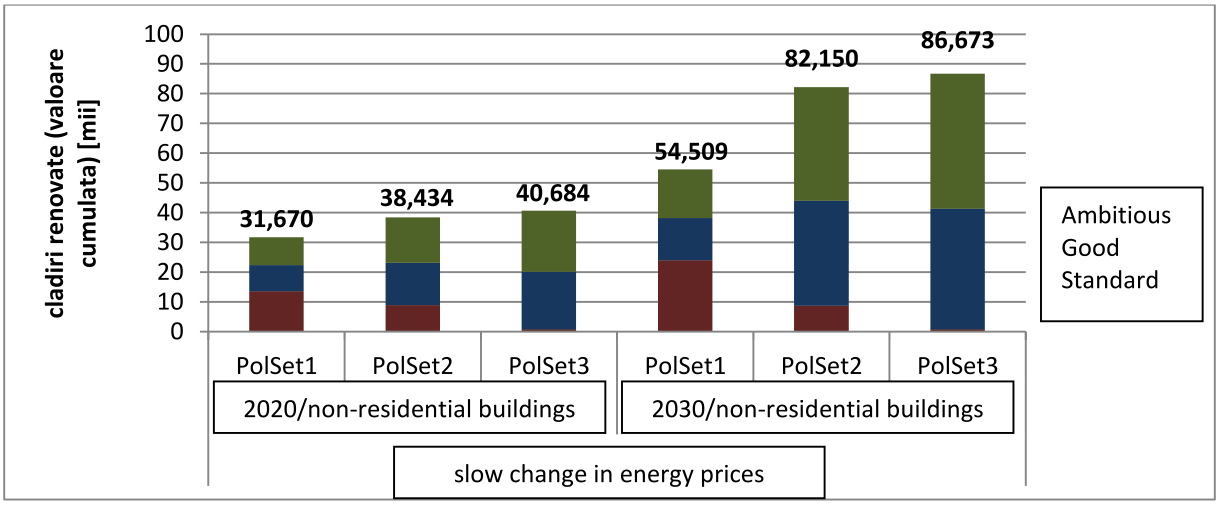


- renovated buildings (aggregate amount) [thousand]

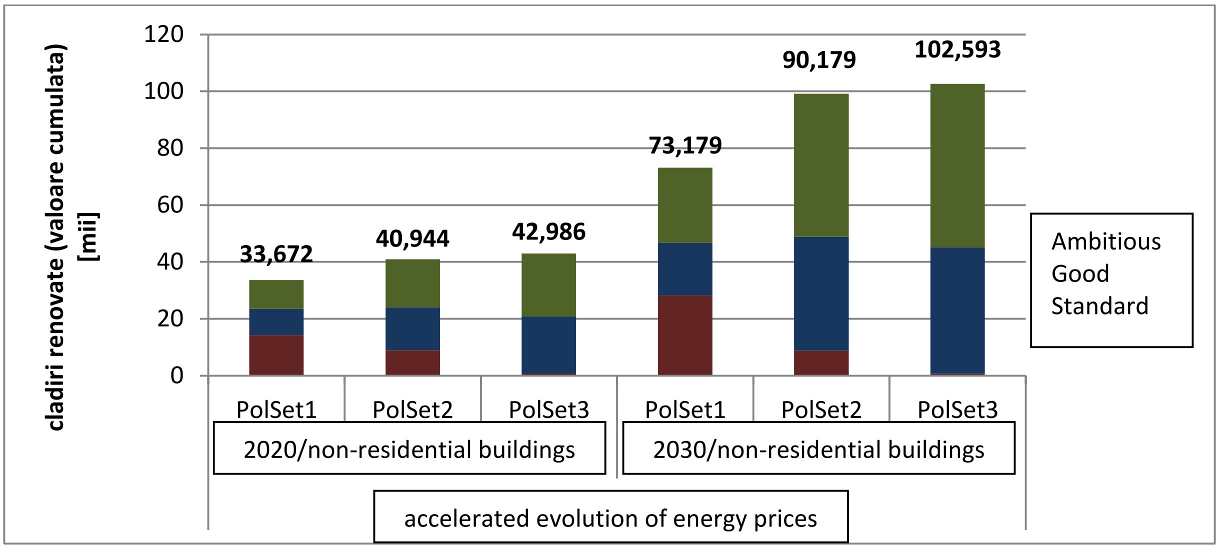


- renovated buildings (aggregate amount) [thousand]

Figure 16: Number of renovated residential buildings in all three scenarios, at different renovation levels and in the context of the two types of change in energy prices



- renovated buildings (aggregate amount) [thousand]

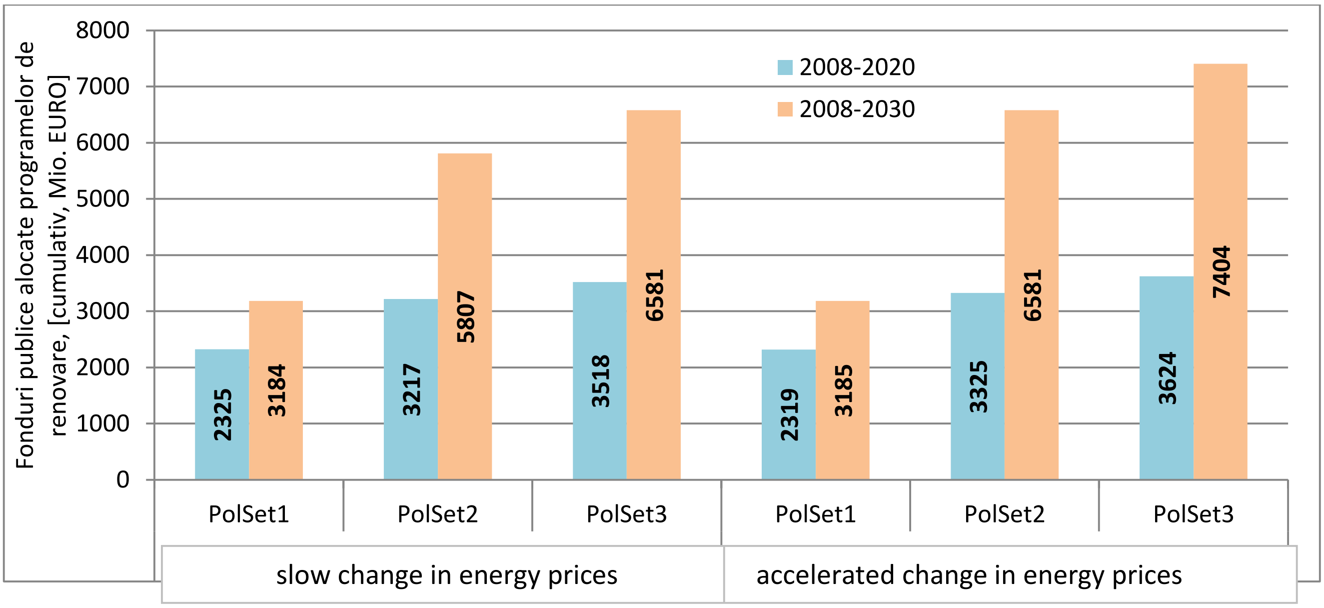


- renovated buildings (aggregate amount) [thousand]

Figure 17: Number of renovated non-residential buildings in all three scenarios, at different renovation levels and in the context of the two types of change in energy prices

The level of the estimated required public funding (based on modelling conducted under the ENTRANZE[43] project) for implementing the proposed policy sets is between 3.2 billion euros and 7.4 billion euros up to 2030, with an estimated annual average of between 144 and 336 million euros (figure 18). The public funding includes national, local and European sources of funding.

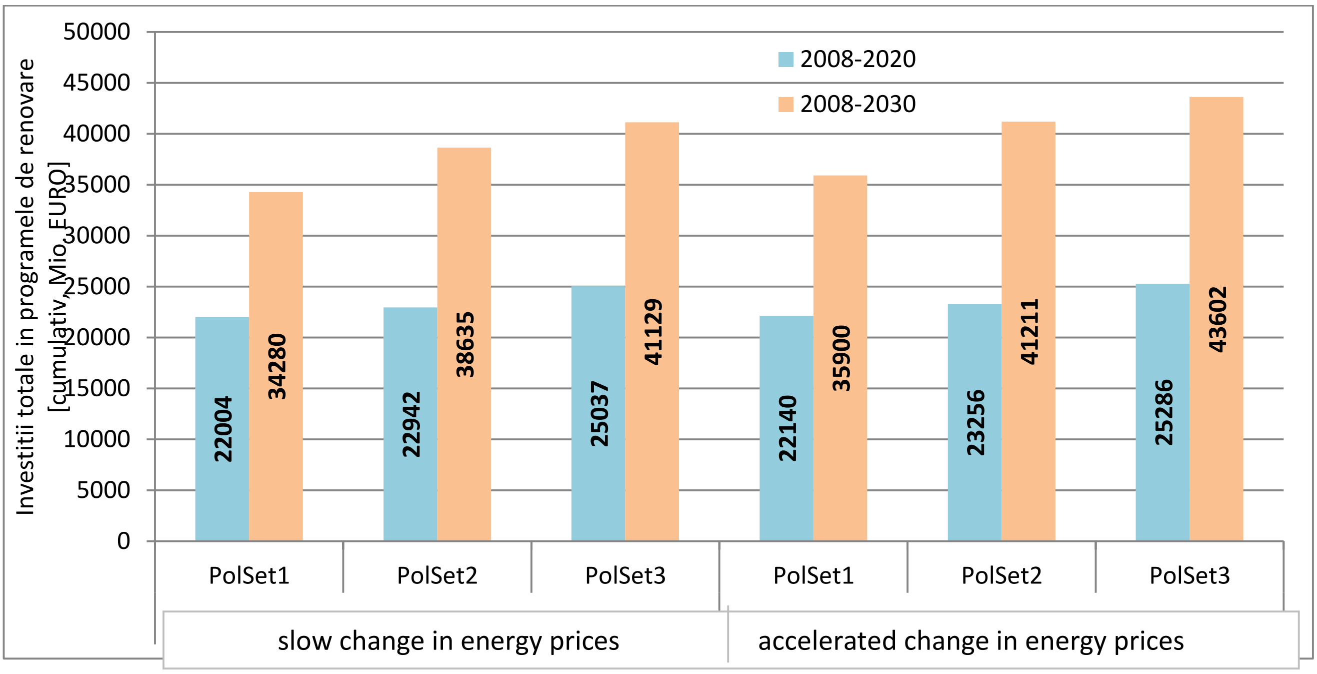
[43] www.entranze.eu



- Public funds allocated to renovation programmes [aggregate, million euros]

Figure 18: Public funds allocated to renovation programmes (aggregate values for the entire assessment period)

Total attracted investment corresponding to the proposed policy sets is between 34.3 and 43.6 billion euros until 2030, with an estimated annual average of between 1.56 and 2 billion euros (figure 19). It follows that the funds allocated to renovation programmes from public and EU budgets results in 6 to 10 times more investments at the level of building owners and local administrations.



- Total investment in renovation programmes [aggregate, million euros]

Figure 19: Total investment that could be attracted in renovation programmes (aggregate values for the entire assessment period)

5.4.4.2 Education, training, qualification and compliance/quality control

Compliance (verification/control/workers) of buildings with energy performance requirements is vital for buildings with very low energy consumption. The quality of execution becomes a key factor, because otherwise the result can be an expensive building with low energy performance. Therefore, the control of constructions for compliance with energy performance requirements needs to be duly consolidated.

In order to reach the high standard of designing and executing buildings with very low energy consumption (both new and renovated), it is necessary to up skill the workforce in the building sector, as well as the architects, designers and engineers involved in the construction/renovation of buildings.

Furthermore, it is important to achieve greater awareness among all involved stakeholders, including the general public (namely homeowners) regarding the benefits of energy efficiency in buildings and the available support instruments.

Other necessary measures include creating capacities for providing information, support and guidance in the construction and renovation of buildings with nearly zero energy consumption and simplifying administrative conditions/requirements.

Therefore, the policy sets (table 10) include measures for boosting compliance, education and up skilling of the workforce, and information-guidance for the stakeholders involved.

Table 10: Measures for boosting the level of compliance in constructions, training of the workforce and information and guidance for persons, businesses, construction companies and financial institutions

	Current state	Policy set 1	Policy set 2	Policy set 3
Quality compliance control				
Training, education and qualification	BUILD-UP Skills Strategy and QualiShell Training programmes through European projects (not officially integrated at national level).	Qualification programmes in professions lacking enough workforce. As of 2020, the introduction of qualification programmes for the building sector in order to adhere to the requirements for low energy consumption buildings.	Significant introduction, as of 2015, of training and qualification programmes in 'low-energy building' technologies for workers in the building sector	Significant introduction of training and qualification programmes for workers in the building sector, improvement of study programmes in general and higher education in order to take account of the introduction of low and positive energy consumption buildings as of 2015 for all categories (architecture, civil engineering, workers). Training of trainers and of those involved in the guidance and information of market players.
Information, motivation and guidance	No specific information or awareness raising regarding the energy performance of buildings, except for the promotion of national thermal rehabilitation programmes and projects with a limited impact. Limited information actions performed by associations of municipalities, cities, energy cities.	Better information and awareness raising mainly through support programmes Creation of a national programme for raising awareness among the general public, using EU cohesion funds	In addition to PS1: Development of a national information and guidance network in important cities: offices (within mayor's offices, energy agencies) offering information and guidance concerning the energy efficiency of buildings, as well as funding and other programmes. Development and promotion of several demonstrative projects in larger urban areas for the main residential and non-residential types of building	In addition to PS2: Development of 'one-stop-shop' information, guidance and orientation networks for all localities. Creation of 'online-expert' internet platforms and one-stop-shop for administrative formalities Development of demonstrative projects in all important regions of the country

ANNEX to the Strategy for mobilising investments in the renovation of residential and commercial buildings existing at national level, both public and private

Policy sets	Current state	Policy set 1 – BaU scenario	Policy set 2 – Growing-up scenario	Policy set 3 – Market transformation scenario
Economic instruments	National programme for the improvement of energy performance of residential buildings, funded from national funds and EU structural funds, in order to achieve a specific annual consumption for heating of less than 100kWh/m^2/year. Total budget of the programme: approximately 304 million euros (approximately 50/50 from national/EU budgets, plus a 40 % contribution from the local/municipal (CB) budget). Programme for the renovation of residential buildings financed through bank loans with government guarantees: • Current term of loan is 5 years. • Budget: depending on requests, based on a ceiling approved annually. The 'Casa Verde – Green House' programme for natural persons and public organisations (non-reimbursable funding for RES H/C for existing and new buildings) – approximately 200 million RON/year (≈44 million EUR/year), half of which is for residential buildings and the other half for public buildings) Programmes similar to the multiannual programme, carried out by some municipalities and aimed at	The same evolution of the existing programmes, with a sensible increase in budgets. The same approach, based on budgets established on a yearly basis. The national multiannual programme for the improvement of energy performance of apartment blocks will be allocated a global multiannual budget of approximately 600 million euros by 2020 and of 400 million euros by 2030.	National programme for the improvement of the energy performance of apartment blocks: • Reduction of the level of non-reimbursable funding: currently 80 % → 60 % in 2015, 40 % in 2020; maximum 25 % in 2030. • Low-income families would receive more than the rest (namely from currently 80 % → 70 % in 2015, maximum 55 % in 2020 and 35 % between 2020 and 2030) • Budget: A global budget of 1 billion euros by 2020 and a global budget of EU funding of 700 million euros between 2020 and 2030. Continuation of the rehabilitation programme through loans with government guarantees for the renovation of residential buildings (loans with subsidised interest rate of up to 80 % by 2015, up to 60 % by 2020 and up to 40 %	National programme for the improvement of the energy performance of apartment blocks: • Reduction of the level of non-reimbursable funding: currently 80 % → 40 % in 2015, maximum 25 % in 2020 and 15 % between 2020 and 2030. • Low-income families would receive more (currently 80 % → 60 % in 2015; maximum 35 % in 2020 and 25 % between 2020 and 2030) Budget: A global budget of 1 billion euros by 2020 and a global budget of 700 million euros between 2020 and 2030. Continuation of the rehabilitation programme through loans with government guarantees for the renovation of residential buildings (loans with interest rate subsidised up to 100 % by 2015, up to 70 % by 2020 and up to 30 % by 2030): • Extending the current term of loans from 5 years to 15-20

	the complete renovation of apartment blocks (for example, the programme from Sector 1 of Bucharest, with a loan from EIB) All of the above-mentioned national programmes have an annual budget, which varies according to the availability of the public budget.	Programmes similar to the multiannual programme, carried out by some of the municipalities (up to five).	by 2030): • Extending the current term of loans from 5 years to 10–15 years. • Subsidising the interest rate according to savings (0 % interest rate for NZEB, passive houses, energy-positive and similar buildings) • Continuing to integrate RES for heating/cooling as eligible measures (for the Casa Verde programme) • An annual budget of approximately. 100 million EUR Programme for the renovation of public buildings with two components: • non-reimbursable funding (from public funds, EU funds, financial institutions) for deep renovation and • an ESCO scheme for high-efficiency heating/cooling systems and RES for heating/cooling. • An annual budget of approximately. 150 million euros by 2020 and 100 million	years. • Subsidising the interest rate according to savings (0 % interest rate for NZEB, passive houses, energy-positive and similar buildings) • Continuing to integrate RES for heating/cooling as eligible measures (for the Casa Verde programme) • Introduction of a favourable loan type – a type of revolving fund (with low interest rates) to support co-funding of the renovation of apartment blocks under the national programme referred to above; • An annual budget of 120 million EUR Programme for the renovation of public buildings with two components: • non-reimbursable funding (from public funds, EU funds, financial institutions) for deep renovation • ESCO scheme for high-efficiency and RES H/C associated with an ESCO fund (an open fund, created from public and private

			EUR/year by 2030 (until 2020, 100 million euros are allocated for non-reimbursable funding and 50 million euros in an ESCO fund, while until 2030, 75 million euros are allocated for non-reimbursable funding and 25 million euros in an ESCO fund). The Casa Verde Programme is only for new buildings and facilities are granted depending on energy performance and RES for heating/cooling (for example for the funding of passive houses, nearly zero energy buildings and energy positive buildings). Budget: • residential sector: 75 million EUR/year by 2020 and 20 million EUR/year by 2030 • public sector: 75 million EUR/ year by 2020 and 20 million EUR/ year by 2030	funding) • An annual budget of approximately. 150 million EUR by 2030 (100 million EUR are allocated for non-reimbursable funding and 50 million EUR in an ESCO fund) The Casa Verde Programme is only for new buildings and facilities are allocated depending on energy performance and RES for heating/cooling, but not exclusively (more or less passive buildings with 55kW and 40kW – PassivHaus). Budget: • residential sector ≈100 million EUR/ year by 2030 • public organisations ≈100 million EUR/ year by 2030
Development of capacities, qualification and ensuring quality	There are no dedicated programmes for qualification in the field of building energy performance. The Build-Up Skills ROBUST and Quali-Shell projects for the identification/development of needs concerning the	As of 2015, a qualification programme for the building sector will be introduced with the aim of adhering to the requirements for buildings with low energy	Significant introduction of training and qualification programmes for workers in the building sector	Significant introduction of training and qualification programmes for workers in the building sector, improvement of study programmes in the general and the higher education

	qualification/training in professions related to building renovation.	consumption.		systems in order to build low and positive energy buildings as of 2015 for all categories (architecture, civil engineering, builders)
Information, motivation and guidance	No specific information or awareness-raising regarding the energy performance of buildings, except for the national programme for the improvement of energy performance of apartment blocks.	Better information and awareness-raising, mainly through the support programmes	A better information and awareness raising. Setting up of offices (within city halls, energy agencies) offering information and guidance concerning the energy efficiency of buildings, as well as funding and other programmes. Development and promotion of several pilot projects for the main types of residential and office buildings.	'One-stop-shop' information, guidance and orientation for all localities, and related internet platforms Development of various pilot projects in all important regions of the country
Measures for market transformation (supply side)	Use of renewable energy (such as large wind farms, solar-thermal and photovoltaic energy, to a lesser extent). The Green Certificates Scheme is focused on 'high' energy production. For RES heating/cooling in buildings there are no other support instruments (except for the Casa Verde Programme referred to above.) At present, district heating systems, which are to be found in urban areas, have a high carbon footprint and an efficiency potential of 30 %, presenting energy savings of 20 %–40 % for consumers. Some municipalities have put in place measures for the improvement of the efficiency of the district heating system (generation	Minor improvements in the district heating system (in terms of efficiency, namely 10 % gradually by 2030), a slight increase in the share of RES in district heating, especially in small towns A slightly higher integration rate of RES in heating/cooling in homes (mainly, solar-thermal energy and biomass pellets for the replacement, to a modest extent, of firewood): • existing homes: 5 % by 2020 and 20 % by	Significant improvements of the district heating system (gradual increase by 20 % of energy efficiency by 2030) increase in the share of RES in all cities. A higher integration rate of RES in heating/cooling in dwellings (mainly, solar-thermal energy and biomass pellets for the replacement, to a lesser extent, of firewood): • existing dwellings: 5 % by 2020 and 60 % by 2030, • new buildings:	Significant improvements in the district heating system (gradual increase by 30 % of energy efficiency by 2030), increase in the share of RES in all cities (40 %–50 % by 2030). A very high integration rate of RES in heating/cooling in homes (mainly, solar-thermal energy and biomass pellets for the replacement, to a modest extent, of firewood): existing homes: 10 % by 2020 and 70 % by 2030, new buildings: 15 % in 2015, 50 % by 2020 and 100 % by 2030. Support programmes and more favourable

	and distribution networks).	2030, • new buildings: 10 % in 2015, 20 % by 2020 and 100 % by 2030. 'Soft' support programmes at local level and/or more favourable conditions for the RES industry for heating/cooling and energy-efficient materials.	15 % in 2015, 30 % by 2020 and 100 % by 2030. Support programmes and more favourable conditions for the RES industry for heating/cooling and energy-efficient materials. Support for research, technology and development.	conditions for the RES industry for heating/cooling and energy-efficient materials Support for research, technology and development

Annex C

ENERGY PERFORMANCE OF NEARLY ZERO ENERGY BUILDINGS (NZEB)

Subject: Assessment of energy needs and consumption of buildings in the different climate zones in Romania; evaluating the share of energy from renewable energy sources that can be generated locally or close by; defining the minimum/maximum admissible threshold of required primary energy; examples of providing energy from renewable sources (summary of a six-month survey)

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Chapter I General overview

In respect of defining NZEBs, this document has two objectives that can, through changes in energy performance (resulting both from the replacement of existing buildings with new ones and the extension of urban areas by building new NZEBs, and from the improvement of the energy performance of existing buildings – both at the level of the building envelope and in terms of building engineering, associated with the improvement of district utility supply systems (heat generation and electricity)), modify the energy profile of an entire settlement and not just of one building. The first target consists of the definition of a new energy classification of buildings (new energy reference system) associated with the energy characteristics of both new and existing buildings. The second target consists of the definition of the energy configuration of buildings (new/existing, as classified in Law No 372/2005 (republished) and in Annex 1 to Directive 2010/31/EU) with reference to the envelope, installations and energy profile of the building.

In Europe, REHVA starts from the definition of different types of utility (energy vectors) specific to the operation of buildings. The scheme for the assessment of the Energy Performance of Buildings also includes the limit conditions for each building. Article 9 of Directive 2010/31/EU sets out conditions for the implementation of nearly zero energy buildings (NZEB), but it does not provide for definition criteria based on harmonised requirements and does not contain any additional information regarding the methodological framework for evaluating the Energy Performance of Buildings. The definition of this type of building must also include objective local characteristics (climate parameters). It follows that the actual objective is to lay down one or more methods for defining NZEBs, not to define NZEB buildings. The building is characterised by very high energy performance and the reference parameter is the primary energy indicator determined by calculation.

Chapter II Methodology for estimating the economic efficiency of the technical solutions for ensuring the achievement of the energy performance of NZEB buildings

The design and construction of a nearly zero energy building must take into consideration the following realities of the built environment in Romania:

A nearly zero energy building is characterised by **reduced consumption of energy from fossil sources** and it uses **energy from (non-fossil) renewable sources**, in a proportion established by the procedure for defining the minimum requirements, in accordance with Articles 4 and 5 of Directive 2010/31/EU;

In the case of both new and existing buildings included in national and local programmes of energy modernisation, the aim is that **the adopted technical solutions meet the minimum requirements related to costs**, determined in accordance with the provisions of Delegated Regulation (EU) No 244/2012;

- The roadmap for the **requirements specific to nearly zero energy buildings** has to be a realistic decision based on a practical definition of the notion of nearly zero energy building, as an element of urban settlements, not on a one-off and purely demonstrative exercise. Therefore, the energy and environmental parameters adaptable to the new buildings are defined in relation to the current minimum requirements imposed on new buildings and to **local climate and technological restrictions**. 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 the principles of sustainable development,** in particular in respect of minimising the impact on the natural environment, including the local microclimate;

  – **meeting energy needs, in particular from district urban/local networks, provided their energy efficiency is compatible with the energy performance of the new NZEBs.** Fitting buildings with non-fossil sources of renewable energy (placed either on the building or on the land belonging to the building) is to be analysed very carefully in the stage of drawing up a local urban plan, in terms of impact on the natural environment and the **economic efficiency of the building**. The report on the solutions must contain a comparative analysis of fitting buildings with their own energy sources or connecting them to efficient district energy supply systems. This has to take into account the principles of sustainable development, which imply both freedom levels with regard to housing quality and minimisation of the impact on the natural environment;

  – maximum admissible levels of primary energy from conventional sources (fossil fuels) and CO_2 emissions related to the operation of buildings, by type of building and winter climate zones in Romania, are presented in Table II.14;

  – to meet the total energy consumption of a nearly zero energy building, renewable (non-fossil) sources cover at least 10% of the building's calculated total primary energy.

This study addresses the analysis of the **economic efficiency of solutions for NZEB with reference to newly configured buildings in line with the regulation in force – C 107 / 2005**. The analysis deals in particular with the impact of utility systems, passive energy management solutions and fitting buildings with renewable energy sources (solar thermal panels, photovoltaic panels and water–water heat pumps). The findings reported in the previous stage of this study represent background references for the analysis of the economic efficiency of solutions for NZEBs. The subject matter of the analysis consists of three building types, namely **office buildings/public buildings** (with demonstrative impact), **apartment blocks and single-family buildings** (both with a maximum frequency of application in the future). The specification of the minimum cost range defining the minimum requirements and the phased association by time and climate zones of the maximum admissible energy characteristics for the classification of buildings as NZEB (in the form of net primary energy) is the result of the previous stage. The summary of these results is presented below.

II.1 Country report on the minimum requirements determined based on the application of the cost-optimal method – values by new and existing building types and climate zones

The dynamic modelling of heat and mass transfer processes for occupied spaces reveals the necessity of using systems that ensure high energy efficiency. Below, the charts showing changes in indoor and outdoor temperatures, and the heating or cooling requirements, are used to illustrate the impact of using high-performance equipment in order to reduce heat consumption. On the other hand, the architectural configuration of office buildings with reference to the degree of glazing of the building raises special issues for the definition of minimum requirements, because the glazing ratio has implications both for energy needs for artificial lighting and for the achievement of the required temperature.

Knowledge of the natural temperature conditions (free running temperatures) offers information concerning the intensity of discomfort in the summer season and the way of reducing the refrigeration load. Figure II.1 shows the natural temperature conditions for spaces in the main section of an office building with a normal glazing ratio (Rg = 26.64%).

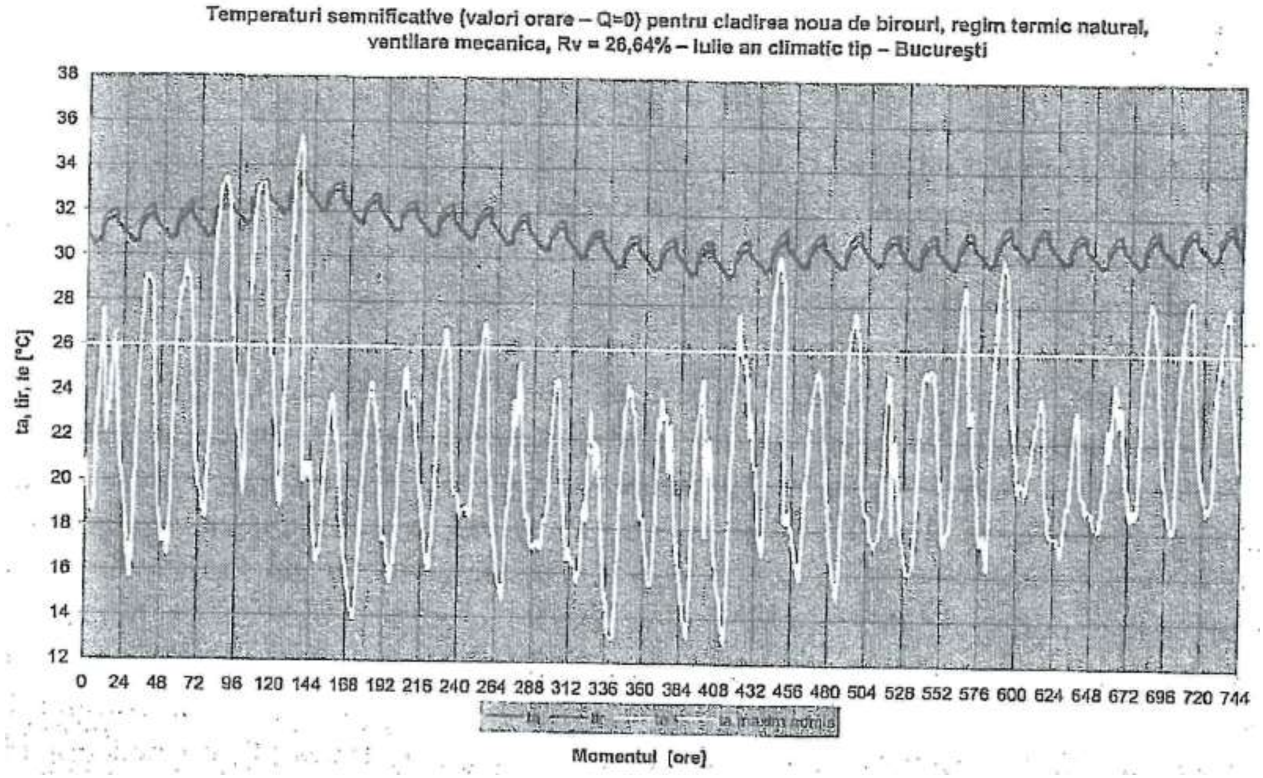

Figure II.1: Free running temperatures in a building with normal glazing - July, typical climate year

Key:
Horizontal: Significant temperatures (hourly values - Q=0) for a new office building, free running temperatures, mechanical ventilation, Rg = 26.64 % - July in a typical climate year - Bucharest
Bottom: Time (hours)

The energy required in order to cool the building has an average value of 4.36 kWh/m^{2}month (July), and the mechanical ventilation operates 403 hours/month (Figure II.2).

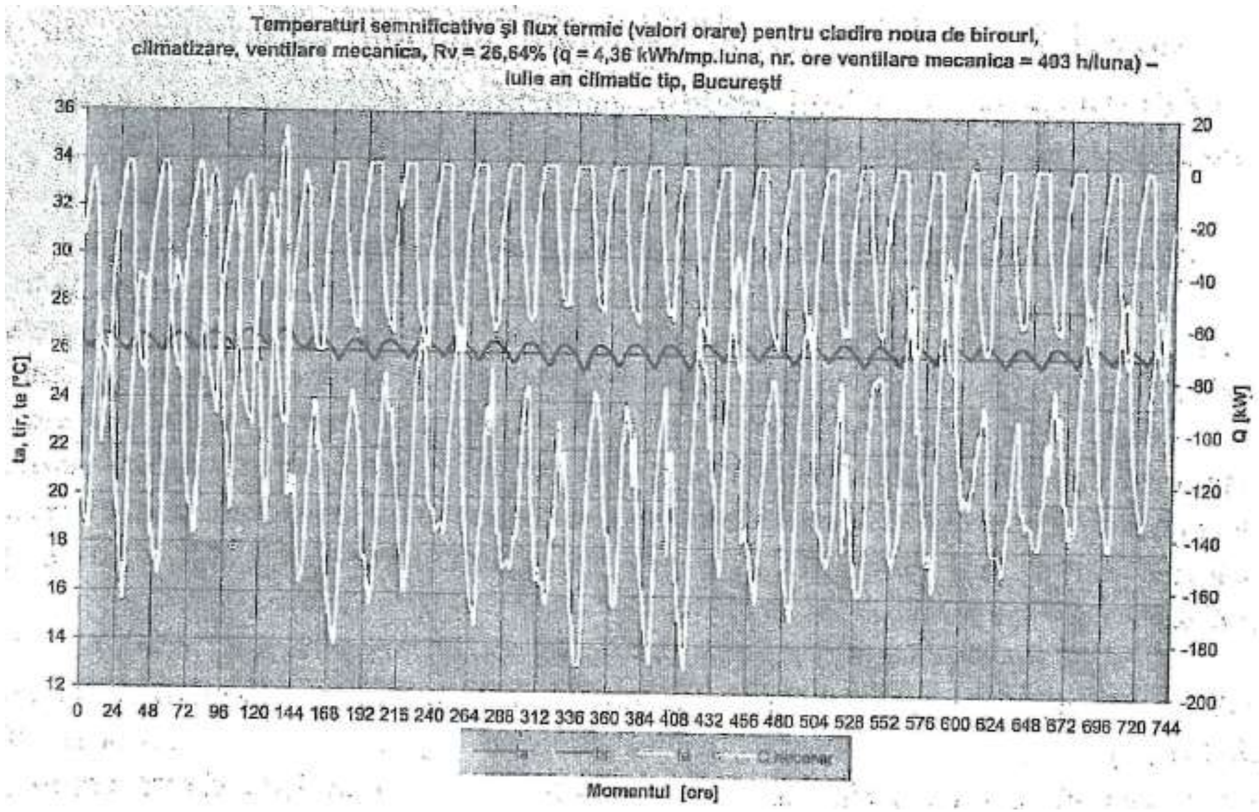

Figure II.2: Sensible cooling required in a building with normal glazing in July, in a typical climate year

Key:

Horizontal: Significant temperatures and heat flow (hourly values) for a new office building, air conditioning, mechanical ventilation, Rg = 26.64 % (q = 4.36 kWh/m^2month, number of hours of mechanical ventilation = 403 hours/month) - July in a typical climate year - Bucharest

Bottom: Time (hours)

Figure II.3 shows the free running temperatures for spaces in the main section of an office building with a high glazing ratio (Rg = 72 %). It can be immediately seen that there is significant discomfort compared with the case of a normal glazing ratio ($\Theta_{a.max.}$ = 36.3ºC, compared with 33.6ºC in the case of normal glazing), which will result in higher energy consumption in the summer season.

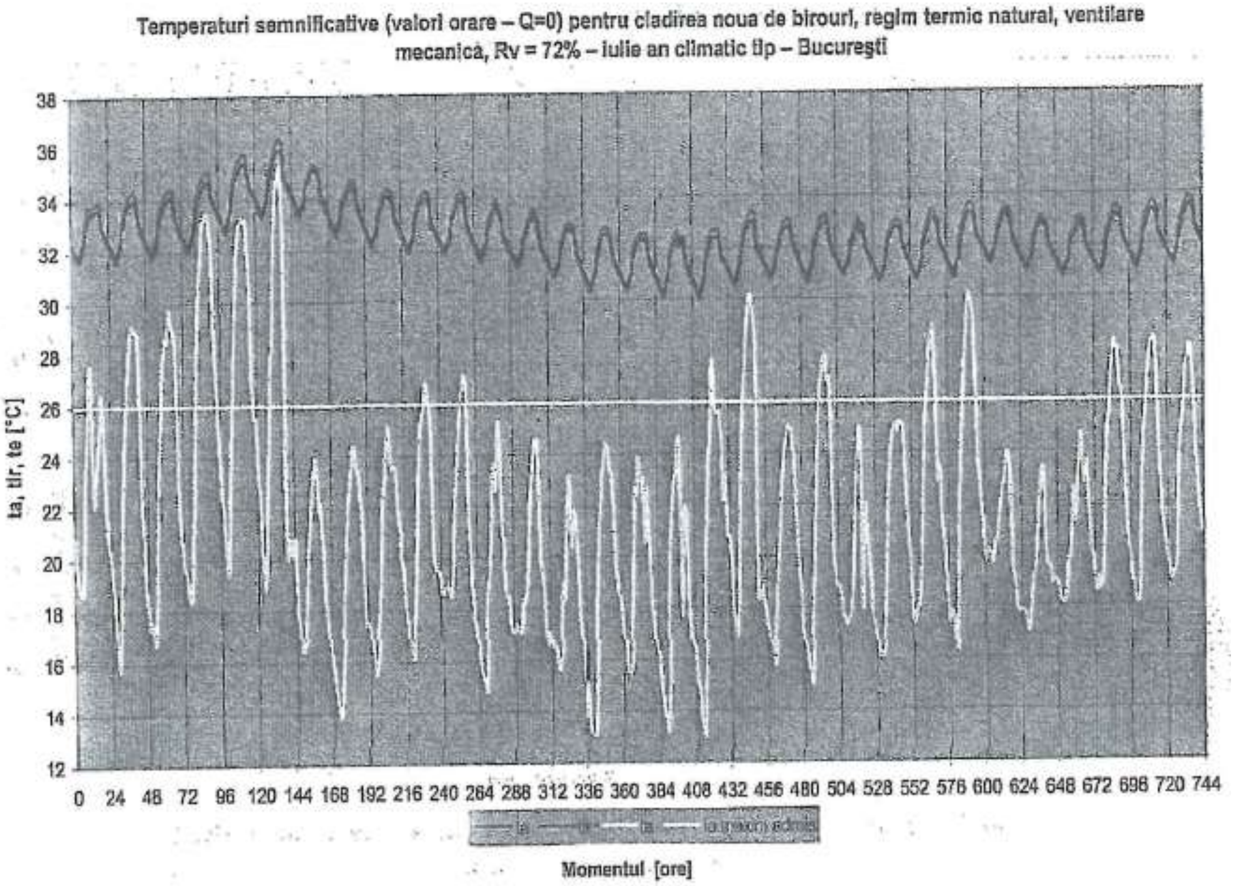

Figure II.3: Free running temperatures in a building with high glazing ratio - July, typical climate year

Key:
Horizontal: Significant temperatures (hourly values - Q=0) for a new office building, mechanical ventilation, Rg = 72 % - July, typical climate year - Bucharest
Bottom: Time (hours)

Where air conditioning is used, energy consumption for air conditioning is 6.84 kWh/m^{2}month, which is approximately 50% over the value specific to a building with normal glazing (figure II.4). Both in the case of a building with normal glazing and in that of a building with high glazing, similar measures were adopted in order to minimise the impact of solar radiation on the building's microclimate. One additional advantage specific to a building with normal glazing is the higher thermal capacity of interior building elements. The values in the charts used in this study assume identical thermal capacity, which indicates a virtual advantage in the case of a building with high glazing. The maximum cooling required by a highly-glazed building is 60 % more than in the case of a regularly-glazed building (159 kW compared with 98 kW). The cooling system used is a radiant cooling system, which is based on mechanical ventilation with exclusive flow to ensure the required share of fresh air and has, therefore, a lower level of power consumption. Cooling is based on using water at 14ºC, circulated through radiant panels in order to prevent condensation on radiant surfaces. Water is cooled using a heat pump the vaporiser of which is connected to mixed water-PCM collection tanks placed in the building's service basement. The heat pump's condenser ensures pre-heating of domestic hot water (in the event of excess hot water, the building's energy management system activates the complementary energy management program, which distributes excess hot water to neighbouring urban consumers).

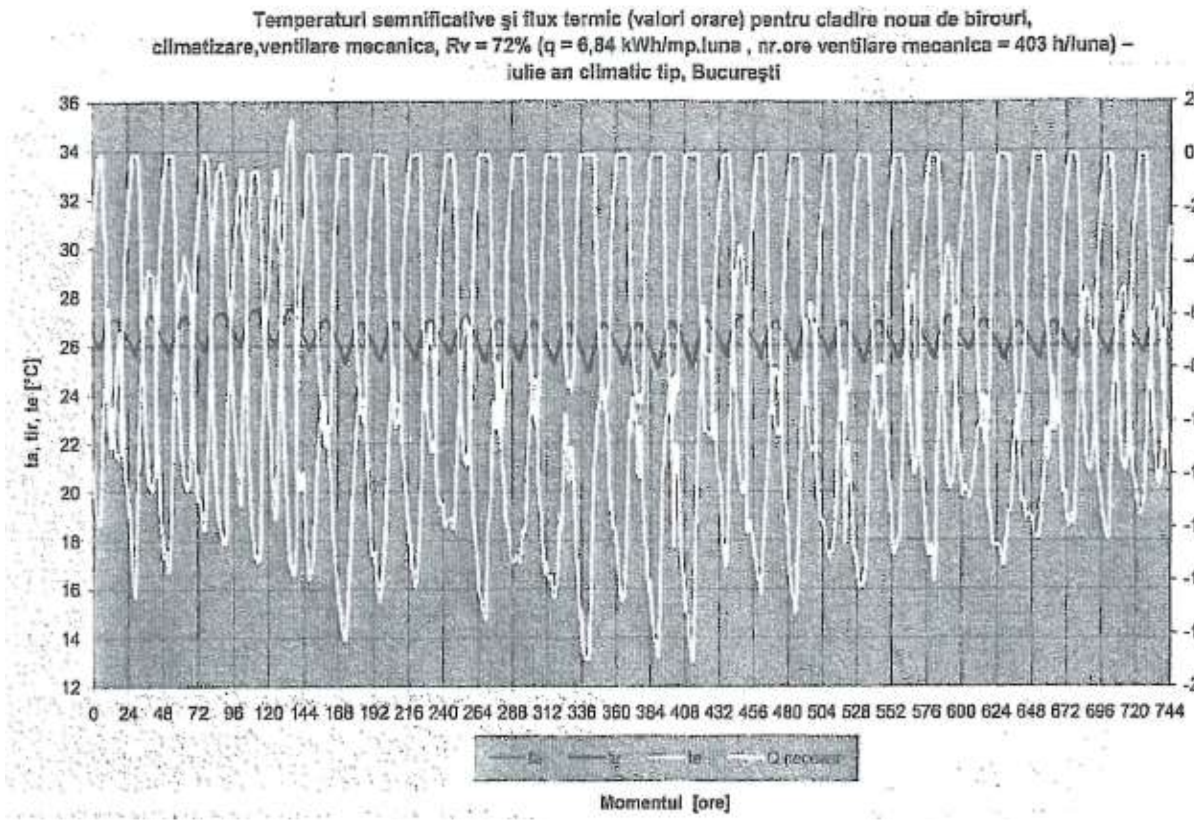

Figure II.4: Sensible cooling required in a building with high glazing - July, typical climate year

Key:
Horizontal: Significant temperatures and heat flow (hourly values) for a new office building, air conditioning, mechanical ventilation, Rg = 72 % (q = 6.84 kWh/m^{2}month, number of hours of mechanical ventilation = 403 hours/month) - July, typical climate year - Bucharest
Bottom: Time (hours)

The impact of natural ventilation on free running temperatures in a building with normal glazing, without temperature control, is presented in figure II.5. Natural ventilation is based on the operation of retractable skylights that limit the ventilation rate so as not to exceed 6 ac/h [air changes per hour]. At this ventilation rate, average air speed in the working area does not exceed the admissible limit of 0.30 m/s. Mechanical ventilation is complementary to natural ventilation. Natural ventilation is activated by the difference in temperature between indoor and outdoor air. In addition to the restriction regarding air speed in the working area, the temperature of inside air must not fall under the predetermined admissible minimum value (the numerical study imposed $\Theta_{a.min.}$ = 23ºC during the building's occupied hours and 21ºC during building vacancy hours). Natural ventilation has significant impact by maintaining acceptable indoor temperatures without activating the cooling system for 25 days of the 31 days of the month of July (the model assumed continuous operation of the building's systems). Mechanical ventilation is equivalent to using static heat recovery units. In practice, mechanical ventilation is active during the hours when outdoor temperature exceeds the indoor air temperature set at the maximum admissible comfort value

(26ºC). The minimum admissible air temperature (21ºC during vacancy hours and 23ºC during occupied hours) activates the controlled natural ventilation.

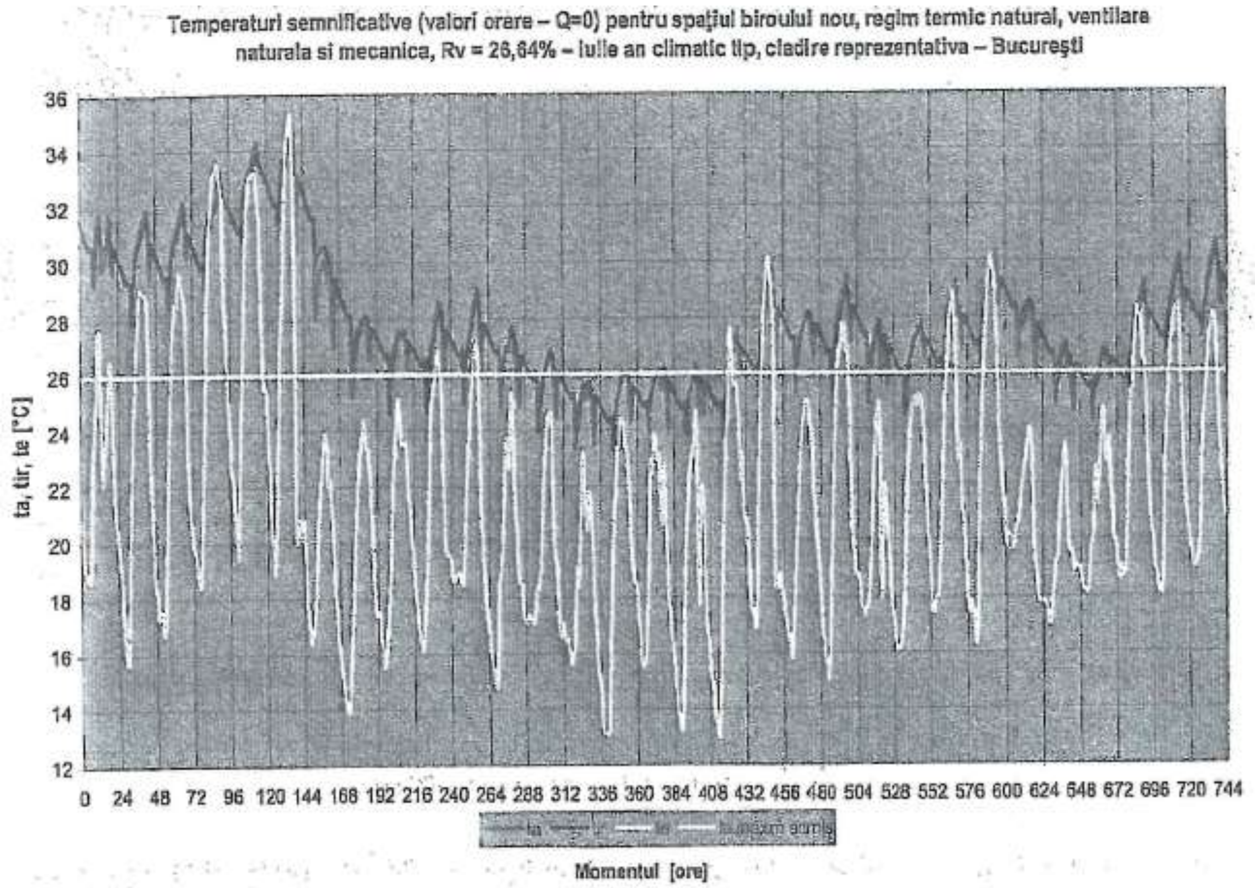

Figure II.5: Free-running temperatures in a building with normal glazing, natural ventilation - July, typical climate year

Key:
Horizontal: Significant temperatures (hourly values - Q=0) for new office space, free-running building, natural and mechanical ventilation, Rg = 26.64 % - July, typical climate year, representative building - Bucharest
Bottom: Time (hours)

Temperature control in the spaces in use, including by means of natural ventilation (the cooling system can operate in parallel to the natural ventilation system due to the limitation on the flow of outdoor air) - see figure II.6, leads to a significant reduction in the monthly required sensible cooling, to 2.65 kWh/m^{2}month from 4.36 kWh/m^{2}month, and the number of hours of mechanical ventilation is reduced to 112 hours/month, compared with 403 hours/month in the case of using exclusively mechanical ventilation. There is an increase of approximately 10 % in the maximum hourly required cooling. This increase is explained by the increase in the maximum temperature of indoor air during vacancy hours, and also by the use of mechanical ventilation to ensure proper building ventilation (hypothesis used exclusively for study purposes). This results in significant power savings both at the level of the heat pump and at that of the building ventilation system. There are additional costs relating to (secured) empty spaces for natural ventilation and the building's energy management system coordinating natural ventilation. It should be noted that the EER rating of the heat pump is 2.7 (the energy management system would significantly increase that value).

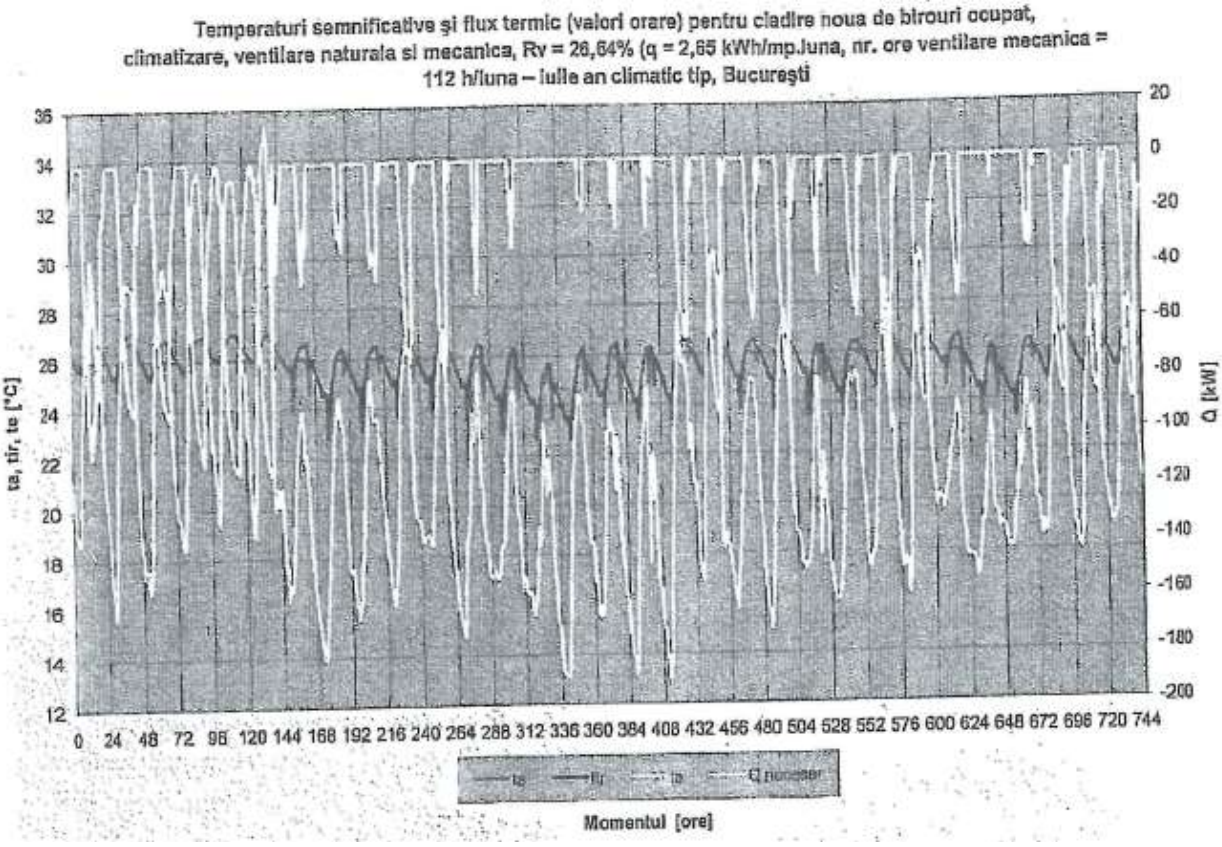

Figure II.6: Sensible cooling required in a building with normal glazing, natural ventilation - July, typical climate year

Key:
Horizontal: Significant temperatures and heat flow (hourly values) for a new office building during occupied hours, air conditioning, natural and mechanical ventilation, Rg = 26.64 % (q = 2.65 kWh/m^{2}month, number of hours of mechanical ventilation = 112 hours/month) - July, typical climate year - Bucharest
Bottom: Time (hours)

Figure II.7 shows the variation in free-running temperatures inside the building in the absence of air conditioning and when using natural ventilation in a highly glazed building. The ventilation conditions are similar to those described in the case of a building with normal glazing. There is a reduction in the number of hours of potential thermal discomfort, but this applies only to 15 days out of the 31 days under examination, compared to 25 days in the case of normal glazing. Temperature control in the spaces in use, including by means of natural ventilation (the cooling system can operate in parallel to the natural ventilation system due to the limitation on the flow of outdoor air) - see figure II.8, leads to a significant reduction in the monthly required sensible cooling, to 4.72 kWh/m^{2}month from 6.84 kWh/m^{2}month, and the number of hours of mechanical ventilation is reduced to 112 hours/month, compared with 403 hours/month in the case of using exclusively mechanical ventilation. There is an increase of approximately 12 % in the maximum hourly required cooling. This results in significant power savings both at the level of the heat pump and at that of the building ventilation system, compared with the exclusive use of mechanical ventilation.

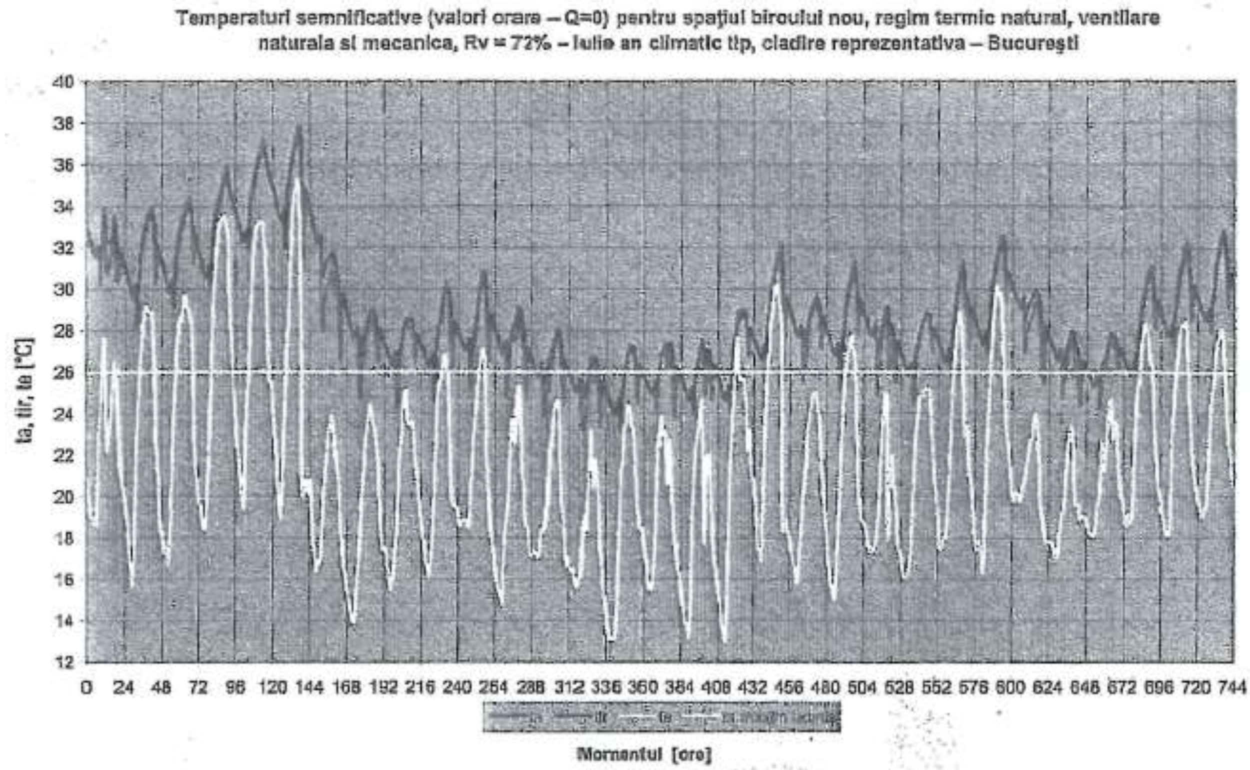

Figure II.7: Free-running temperatures in a highly glazed building, natural ventilation - July, typical climate year

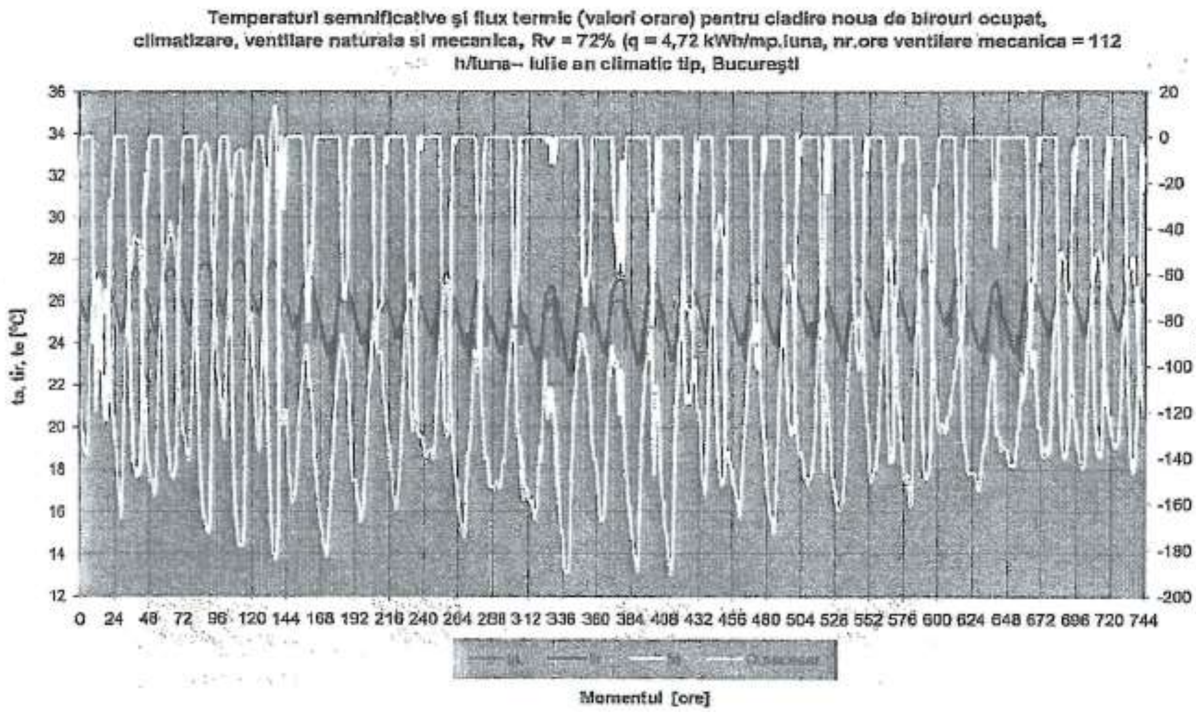

Figure II.8: Sensible cooling required in a highly-glazed building, with natural ventilation - July, typical climate year

Compared with a building with normal glazing, under similar operating conditions, the level of required cooling continues to be elevated (4.72 kWh/m^{2}month compared with 2.65 kWh/m^{2}month, which means 78 % additional energy). Figures II.9 and II.10 present a comparison of the building's energy performance for all thermal and power utilities under each of the two glazing options. In all the cases, a building with normal glazing is superior to a building with high glazing (for the entire year). Even the slight superiority of a highly-glazed building in respect of artificial lighting is only theoretical, because the users of such buildings create internal compartments that cancel the advantage of high glazing in respect of using natural light.

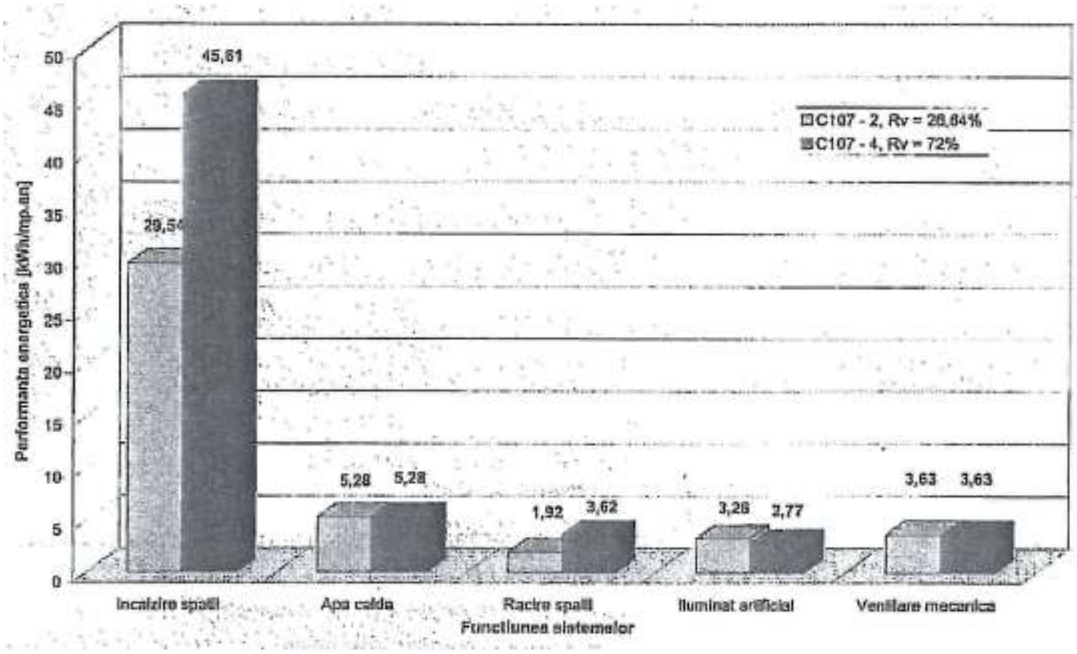

Figure II.9: Energy performance of a building under each of the two glazing options - comparison by type of utility

Key:

Rv = Rg [glazing ratio]

Horizontal: heating, hot water, cooling, artificial lighting, mechanical ventilation

Vertical: energy performance (kWh/m^{2}month)

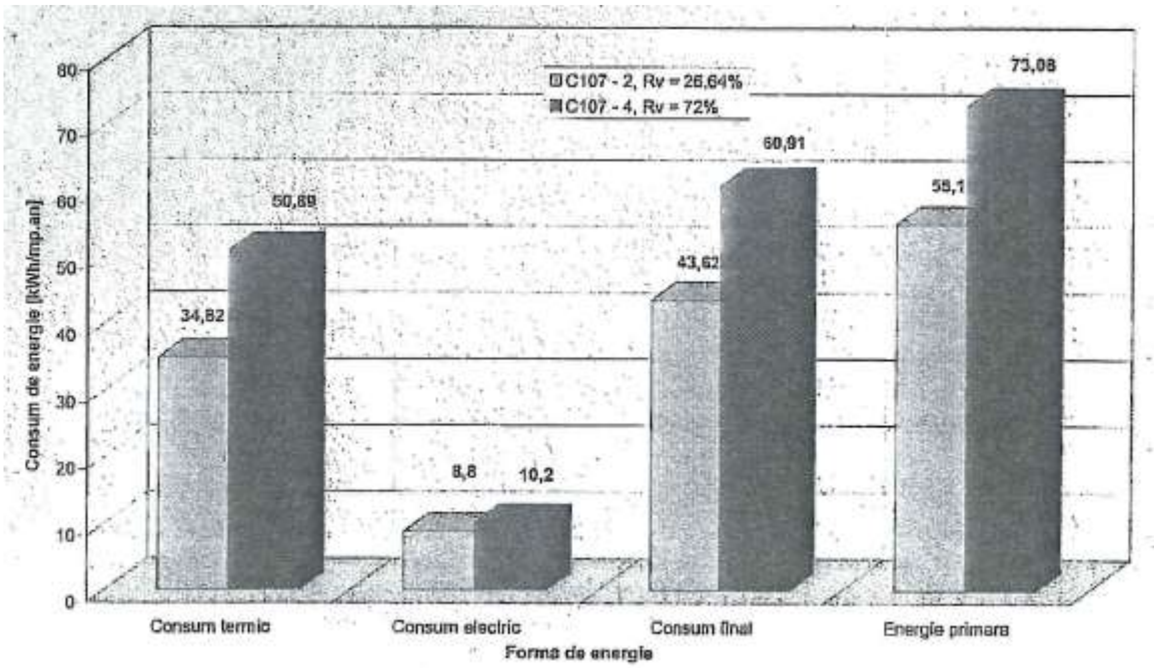

Figure II.10: Comparison of energy performance for power and thermal utilities, final consumption and primary energy

Key:
Rv = Rg [glazing ratio]
Horizontal: thermal energy consumption, power consumption, final consumption, primary energy
Vertical: energy performance (kWh/m^2month)

The datasheets below contain the data supporting the cost-optimal analysis for public office buildings and the conclusions of that analysis. They are followed by the datasheets for apartment blocks and single-family buildings. It should be noted that the calculated figures were submitted to the European Commission as country data. In addition to the technical sheets, the information below also includes the variation curves for optimal cost based on primary energy for the above mentioned types of building.

Office Buildings

Table II.1

Illustrative table listing selected significant variants/measures

Measure	Reference case	Variant C 107/2010 without shutters	Variant C 107/2010 with shutters and heat recovery	Variant C 107/2010 with shutters and heat recovery, SP, PVP	SP pack without shutters	SP pack with shutters and heat recovery	SP pack with shutters and heat recovery, SP, PVP
Roof insulation	1.099 W/m^2K	0.25 W/m^2K	0.25 W/m^2K	0.25 W/m^2K	0.21 W/m^2K	0.21 W/m^2K	0.21 W/m^2K
Wall insulation	1.441 W/m^2K	0.625 W/m^2K	0.625 W/m^2K	0.625 W/m^2K	0.303 W/m^2K	0.303 W/m^2K	0.303 W/m^2K
Windows	2.646 W/m^2K (double)	2.00 W/m^2K (thermo-insulating)	2.00 W/m^2K (thermo-insulating) and thermo-insulating shutters for vacant hours in winter	2.00 W/m^2K (thermo-insulating) and thermo-insulating shutters for vacant hours in winter	1.30 W/m^2K (thermo-insulating)	1.30 W/m^2K (thermo-insulating) and thermo-insulating shutters for vacant hours in winter	1.30 W/m^2K (thermo-insulating) and thermo-insulating shutters for vacant hours in winter
Share of window area of total building envelope	30.85 %	17.42 %	17.42 %	17.42 %	17.42 %	17.42 %	17.42 %
Building-related measures (thermal capacity, etc.)	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K
Heating system	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network
Domestic hot water	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network
Ventilation system (including night ventilation)	natural unorganised	natural – natural unorganised ventilation, mobile blinds (summer, occupied hours)	with heat recovery, mechanical ventilation, infiltration, mobile blinds (summer,	with heat recovery, mechanical ventilation, infiltration, mobile blinds (summer, occupied hours)	natural – natural unorganised ventilation, mobile blinds (summer,	with heat recovery, mechanical ventilation, infiltration, mobile blinds (summer,	with heat recovery, mechanical ventilation, infiltration, mobile blinds (summer,

Measure	**Reference case**	**Variant C 107/2010 without shutters**	**Variant C 107/2010 with shutters and heat recovery**	**Variant C 107/2010 with shutters and heat recovery, SP, PVP**	**SP pack without shutters**	**SP pack with shutters and heat recovery**	**SP pack with shutters and heat recovery, SP, PVP**
			occupied hours)		occupied hours)	occupied hours)	occupied hours)
Space cooling system	split equipment – EER = 2.5	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7
RES-based measures	-	-	-	Solar installations for DHW in the summer season and photovoltaic panels	-	-	Solar installations for DHW in the summer season and photovoltaic panels
Change of the energy factor	-	-	-	-	-	-	-
Type of lighting	incandescent lighting	economical lighting	economical lighting	economical lighting	economical lighting	economical lighting	economical lighting

This list of measures is purely illustrative.

For the building envelope: U in W/m^2K

For the system: efficiency

Several levels of improvement can be selected (for example: different thermal transmittance values for windows)

Table II.2

Calculation of energy requirements – public buildings

Measure/package/variant of measures (as described in Table II.1)	Energy requirements		Energy consumption [kWh/m^{2}year]					Energy delivered by source	Primary energy demand kWh/m^2,year	Energy reduction in primary energy compared with the reference building (current status SA1) %
	For heating	For cooling	Heating	Cooling	Ventilation	Domestic hot water	Lighting & Logistics			
Current status – SA1	124.12	36.55	142.82	14.62	-	6.12	45.68	E. distr. = 148.94 E. electric = 60.30	296.50	-
Current status – SA2	124.07	14.03	132.97	5.61	-	6.12	17.68	E. distr. = 139.09 E. electric = 23.29	190.38	**35.79**
Thermal protection C107/2010 – C 107-1	55.66	6.58	61.15	2.63	-	6.20	16.42	E. distr. = 67.35 E. electric = 19.05	112.55	**62.04**
Thermal protection C107/2010– C 107-2	22.40	6.50	29.62	2.63	5.71	6.20	16.42	E. distr. = 35.82 E. electric = 24.76	98.18	**66.88**
Thermal protection C107/2010 – C 107-3	22.40	6.50	26.06	2.63	5.71	6.20	16.42	E. distr. = 26.06 E. electric = 4.68	36.50	**87.69**

Measure / package/ variant (as described in Table 4)	Energy requirements		Energy consumption [kWh/m^{2}year]					Energy delivered by source	Primary energy demand kWh/m^2,a	Energy reduction in primary energy compared with the reference building (current status
	For heating	For cooling	Heating	Cooling	Ventilation	Domestic hot water	Lighting &			

							Logistics			SA1) %
Modernisation Package SP1	35.56	7.00	40.01	2.80	-	4.68	16.42	E. distr. = 44.69 E. electric = 19.22	91.92	**69.00**
Modernisation Package SP2	16.56	7.00	19.83	2.80	5.71	4.68	16.42	E. distr. = 24.51 E. electric = 24.93	88.11	**70.28**
Modernisation Package SP3	16.56	7.00	19.83	2.80	5.71	4.68	16.42	E. distr. = 19.83 E. electric = 4.85	31.14	**89.50**

Table II.3

Output data and global cost calculations

MACROECONOMIC

Variant / package / measure as presented in Table II.2	Initial investment costs (start year) [RON / m²]	Annual running costs		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON/m²]	Residual value [RON/m²]	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON/m²]	Global cost calculated [RON/m²]
		Annual maintenance costs [RON / m² per year]	Operational costs [RON / m² per year]	Energy cost [2] by fuel in the medium energy price scenario [RON/m²]							
				Thermal	Electric						
Current status SA1	0.00	100	0.00	1 298.47	1 153.85	309.31	0.00	0.03	50	0.00	2 861.63
Current status SA2	12.31	70.44	0.00	1 212.59	445.70	224.36	0.00	0.03	50	0.00	1 965.39
Thermal protection in accordance with C107/2010-1	268.86	87.21	0.00	587.14	364.56	123.82	47.73	0.03	50	0.00	1 431.60
Modernisation package C107/2010-2	437.89	87.21	0.00	281.27	473.86	89.85	47.73	0.03	50	0.00	1 370.07
Modernisation package C107/2010-3	1 084.39	165.71	0.00	227.22	89.55	42.66	47.73	0.03	50	0.00	1 609.52
Modernisation Package SP1	441.36	111.30	0.00	389.64	367.78	95.01	65.83	0.03	50	0.00	1 405.09
Modernisation Package SP2	610.39	87.21	0.00	213.68	438.93	80.21	65.83	0.03	50	0.00	1 430.42

[1] For residential and public buildings a calculation period of 30 years has been applied, while for non-residential commercial buildings at least 20 years.

[2] The (expected) effect of future price variation should be considered if the components are to be replaced during the calculation period.

Variant / package / measure as presented in Table II.2	Initial investment costs (start year) [RON / m²]	Annual running costs		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON/m²]	Residual value [RON/m²]	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON/m²]	Global cost calculated [RON/m²]
		Annual maintenance costs [RON / m² per year]	Operational costs [RON / m² per year]	Energy cost [2] by fuel in the medium energy price scenario [RON/m²]							
				Thermal	Electric						
Modernisation Package SP3	1 218.27	165.71	0.00	172.85	92.73	34.97	65.83	0.03	50	0.00	1 684.55

FINANCIAL

Variant / package / measure as presented in Table II.2	Initial investment costs (start year) [RON/m²]	Annual running costs		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON/m²]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON/m²]	Global cost calculated [RON/m²]
		Annual maintenance costs [RON/m² per year]	Operational costs [RON/m² per year]	Energy cost[2] by fuel in the medium energy price scenario [RON/m²]							
				Thermal	Electric						
Current status SA1	0.00	124.00	0.00	1 610.10	1 513.81	0.00	0.00	0.03	50	0.00	3 247.91
Current status SA2	15.26	87.35	0.00	1 503.61	584.74	0.00	0.00	0.03	50	0.00	2 190.95
Thermal protection in accordance with C107/2010-1	333.39	108.14	0.00	728.05	478.29	0.00	47.73	0.03	50	0.00	1 647.88

[1] For residential and public buildings a calculation period of 30 years has been applied, while for non-residential commercial buildings at least 20 years.

[2] The (expected) effect of future price variation should be considered if the components are to be replaced during the calculation period.

Variant / package / measure as presented in Table II.2	Initial investment costs (start year) [RON/m²]	Annual running costs		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON/m²]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON/m²]	Global cost calculated [RON/m²]
		Annual maintenance costs [RON/m² per year]	Operational costs [RON/m² per year]	Energy cost[2] by fuel in the medium energy price scenario [RON/m²]							
				Thermal	Electric						
Modernisation package C107/2010 -2	542.98	108.18	0.00	348.77	621.68	0.00	47.73	0.03	50	0.00	1 621.57
Modernisation package C107/2010 -3	1 344.64	205.48	0.00	281.75	117.49	0.00	47.73	0.03	50	0.00	1 949.36
Modernisation Package SP1	547.92	138.01	0.00	483.15	482.51	0.00	65.83	0.03	50	0.00	1 650.96
Modernisation Package SP2	756.88	108.14	0.00	264.96	553.66	0.00	65.83	0.03	50	0.00	1 683.34
Modernisation Package SP3	1 510.66	205.48	0.00	214.33	121.70	0.00	65.83	0.03	50	0.00	2 052.16

Table II.4

Comparison table for both new and existing buildings

Reference building (current status) kWh/m²,year	Cost-optimal range/level (from-to) (for a component-level approach in the relevant unit) kWh/m²,year	Current requirements for reference buildings kWh/m²,year	Gap %
296.50	62-100	112.55	12.55

Justification of the gap:

The current requirements concerning the envelope of the building are in accordance with regulation C107/2010 (currently used for the design of new buildings) and result in a primary energy value of 112.55 kWh/m^{2}year. The regulation in question contains no specifications concerning the systems of the building. Passing from the value of 112.55 kWh/m^{2}year to 98.18 kWh/m^{2}year (with reference to the primary energy) occurs as a result of fitting the building with mobile thermo-insulating shutters for vacant periods during winter and with a mechanical ventilation system with heat recovery (efficiency 72 %). The gap relative to the optimal range is eliminated.

Plan to reduce the non-justifiable gap:

For existing public buildings, solutions of type C 107 must be applied along with measures resulting from the optimal cost analysis, as mentioned above (C 107-2).

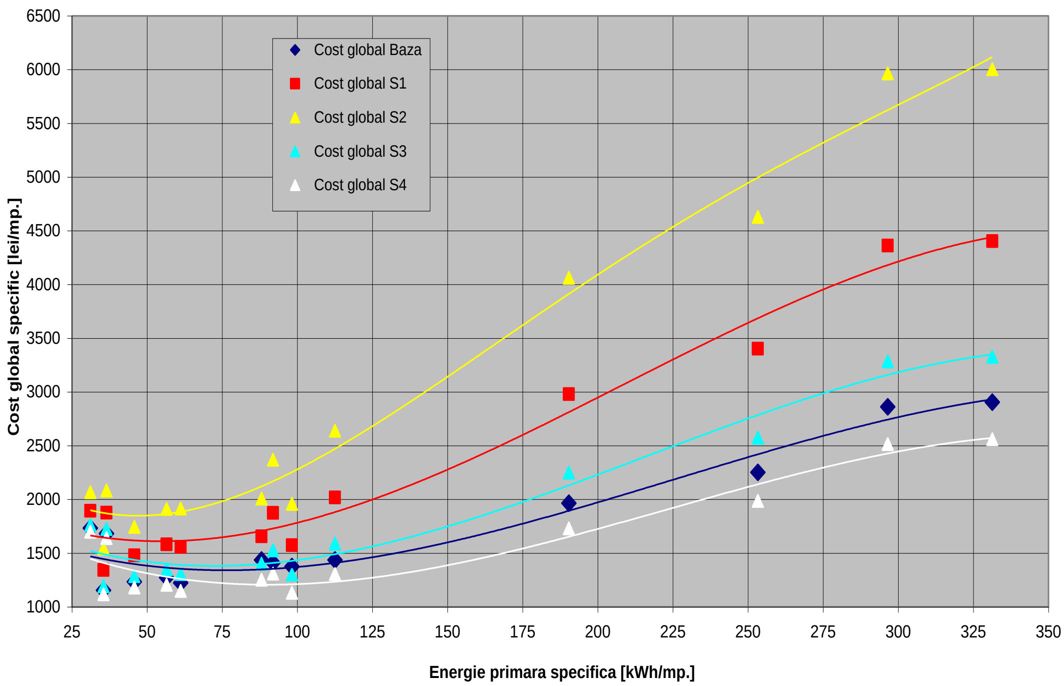

Figure II.11: Macroeconomic sensitivity analysis – office buildings, climate zone II

Key:

Horizontal: Specific primary energy [kWh/m^2]

Vertical: Specific global cost [RON/m^2]

Box: Global cost Base, Global cost S1, Global cost S2, Global cost S3, Global cost S4

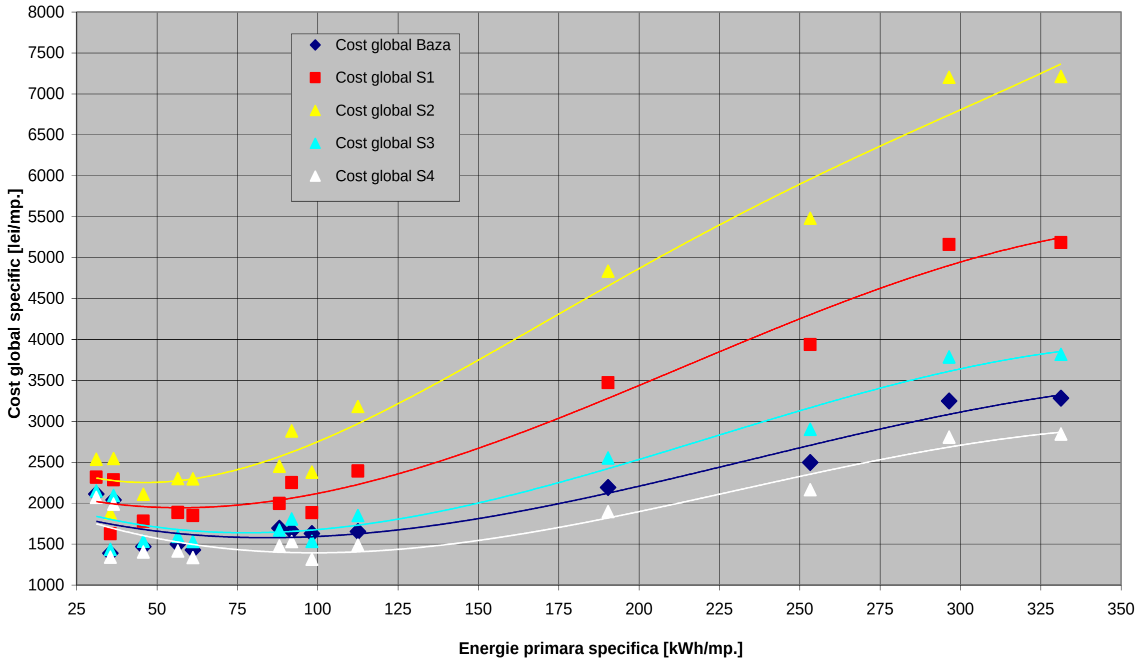

Figure II.12 Financial sensitivity analysis – office buildings, climate zone II

Key:

Horizontal: Specific primary energy [kWh/m^2]

Vertical: Specific global cost [RON/m^2]

Box: Global cost Base, Global cost S1, Global cost S2, Global cost S3, Global cost S4

Apartment blocks

Table II.5

Illustrative table listing selected variants/measures

Measure	Reference case	Variant C 107/2010 without shutters	Variant C 107/2010 with shutters and heat recovery	Variant C 107/2010 with shutters and heat recovery, SP, PVP	SP pack without shutters	SP pack with shutters and heat recovery	SP pack with shutters and heat recovery, SP, PVP
Roof insulation	2.726 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K	0.243 W/m^{2}K
Wall insulation	1.208 W/m^{2}K	0.429 W/m^{2}K	0.429 W/m^{2}K	0.429 W/m^{2}K	0.218 W/m^{2}K	0.218 W/m^{2}K	0.218 W/m^{2}K
Windows	2.564 W/m^{2}K (double)	2.000 W/m^{2}K (thermo-insulating)	1.289 W/m^{2}K (thermo-insulating)	1.289 W/m^{2}K (thermo-insulating)	1.298 W/m^{2}K (thermo-insulating)	0.899 W/m^{2}K (thermo-insulating)	0.899 W/m^{2}K (thermo-insulating)
Share of window area of total building envelope	12.53 %	12.53 %	12.53 %	12.53 %	12.53 %	12.53 %	12.53 %
Building-related measures (thermal capacity, etc.)	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K
Heating system	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network
Domestic hot water	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network	Boiler, district network
Ventilation system (including night ventilation)	natural	unorganised natural ventilation, mobile blinds (in summer, occupied hours)	with heat recovery, mechanical ventilation –mobile blinds (in summer, occupied hours)	with heat recovery, mechanical ventilation – mobile blinds (in summer, occupied hours)	natural – natural unorganised ventilation, mobile blinds (summer,	with heat recovery, mechanical ventilation –mobile blinds (in summer, occupied hours)	with heat recovery, mechanical ventilation – mobile blinds (in summer, occupied hours)

Measure	Reference case	Variant C 107/2010 without shutters	Variant C 107/2010 with shutters and heat recovery	Variant C 107/2010 with shutters and heat recovery, SP, PVP	SP pack without shutters	SP pack with shutters and heat recovery	SP pack with shutters and heat recovery, SP, PVP
					occupied hours)		
Space cooling system	split equipment – EER = 2.5	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7	split equipment – EER = 2.7	radiant cooling – EER = 2.7	radiant cooling – EER = 2.7
RES-based measures	-	-	-	solar installation for DHW in the summer season and photovoltaic panels	-	-	solar installation for DHW in the summer season and photovoltaic panels
Change of the energy factor	-	-	-	-	-	-	-
Type of lighting	incandescent lighting	incandescent lighting	economical lighting	economical lighting	economical lighting	economical lighting	economical lighting

This list of measures is purely illustrative.

For the building envelope: U in W/m^2K

For the system: efficiency

Several levels of improvement can be selected (for example: different thermal transmittance values for windows)

Table II.6

Calculation of energy requirements – apartment block

Measure/package/variant of measures (as described in Table II.5)	Energy requirements		Energy consumption [kWh/m²year]					Energy delivered by source	Primary energy demand kWh/m²,year	Energy reduction in primary energy compared with the reference building %
	For heating	For cooling	Heating	Cooling	Ventilation	Domestic hot water	Lighting & Logistics			
Current status – SA1	124.48	3.60	151.68	1.44	-	86.77	17.38	E. distr. = 238.45 E. electric = 18.82	271.07	-
Current status – SA2	129.16	0.74	157.32	0.30	-	86.77	7.22	E. distr. = 244.09 E. electric = 7.52	246.70	**8.99**
Modernisation package C107/2010 – C107-1	56.80	0.74	62.93	0.30	-	58.97	7.22	E. distr. = 121.90 E. electric = 7.52	133.06	**50.91**
Modernisation package C107/2010 – C107-2	27.48	0.74	31.75	0.30	6.98	58.97	7.22	E. distr. = 90.72 E. electric = 14.49	122.34	**54.87**
Modernisation package C107/2010 – C107-3	27.48	0.74	31.75	0.30	6.98	58.97	7.22	E. distr. = 31.75 E. electric = 4.68 E. electric = 7.57	41.79	**84.58**

Measure/package/variant of measures (as described in Table II.5)	Energy need		Energy consumption [kWh/m²year]					Energy delivered by source	Primary energy demand kWh/m²,a	Energy reduction in primary energy compared with the reference building %
	For heating	For cooling	Heating	Cooling	Ventilation	Domestic hot water	Lighting & Logistics			

Modernisation package – SP1	49.05	0.87	51.06	0.35	-	59.09	7.22	E. distr. = 110.15	122.27	**54.89**
Modernisation package – SP2	22.01	0.87	23.28	0.35	6.98	59.09	7.22	E. distr. = 82.37 E. electric = 14.54	114.71	**57.68**
Modernisation package – SP3	22.01	0.87	23.28	0.35	6.98	59.09	7.22	E. distr. = 23.28 E. electric = 4.68	33.91	**87.79**

Table II.7

Output data and global cost calculations

MACROECONOMIC

Variant / package / measure as presented in Table II.6	Initial investment costs (start year) [RON/m²]	Annual running cost		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON/m²]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON / m²]	Global cost calculated [RON/m²]
		Annual maintenance costs [RON/m² per year]	Operational costs [RON/m² per year]	Energy cost[2] by fuel in the medium energy price scenario [RON/m²]							
				Thermal	Electric						
Current status – SA1	0.00	100.75	0.00	1 039.41	360.16	343.42	0.00	0.03	50	0.00	2 883.16
Current status – SA2	11.55	87.87	0.00	2 128.02	143.83	328.60	0.00	0.03	50	0.00	2 699.86
Modernisation package C107/2010 – C107-1	203.40	87.87	0.00	1 062.74	143.83	171.45	56.99	0.03	50	0.00	1 669.29
Modernisation package C107/2010 – C107-2	351.92	87.87	0.00	790.89	277.30	144.97	56.99	0.03	50	0.00	1 652.96
Modernisation package C107/2010 – C107-3	939.81	166.95	0.00	276.78	89.55	49.97	56.99	0.03	50	0.00	1 523.07
Modernisation package – SP1	322.95	87.87	0.00	960.32	144.82	156.44	85.15	0.03	50	0.00	1 672.40

[1] For residential and public buildings a calculation period of 30 years has been applied, while for non-residential commercial buildings at least 20 years.

[2] The (expected) effect of future price variation should be considered if the components are to be replaced during the calculation period.

Variant / package / measure as presented in Table II.6	Initial investment costs (start year) [RON/m²]	Annual running cost		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON/m²]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON / m²]	Global cost calculated [RON/m²]
		Annual maintenance costs [RON/m² per year]	Operational costs [RON/m² per year]	Energy cost[2] by fuel in the medium energy price scenario [RON/m²]							
				Thermal	Electric						
Modernisation package – SP2	471.47	87.87	0.00	718.09	278.30	134.33	85.15	0.03	50	0.00	1 690.06
Modernisation package – SP3	1 059.77	166.96	0.00	202.92	89.55	39.07	85.15	0.03	50	0.00	1 558.27

FINANCIAL

Variant / package / measure as presented in Table II.6.	Initial investment costs (start year) [RON/m²]	Annual running cost		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON/m²]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON/m²]	Global cost calculated [RON/m²]
		Annual maintenance costs [RON/m² per year]	Operational costs [RON/m² per year]	Energy cost[2] by fuel in the medium energy price scenario [RON/m²]							
				Thermal	Electric						
Current status – SA1	0.00	124.93	0.00	2 577.74	472.54	0.00	0.00	0.03	50	0.00	3 175.19
Current status – SA2	14.32	108.95	0.00	2 638.74	188.70	0.00	0.00	0.03	50	0.00	2 950.71
Modernisation package C107/2010 – C107-1	252.21	108.95	0.00	1 317.80	188.70	0.00	56.99	0.03	50	0.00	1 867.67
Modernisation package C107/2010 – C107-2	436.39	108.95	0.00	980.71	363.81	0.00	56.99	0.03	50	0.00	1 889.85
Modernisation package C107/2010 – C107-3	1 165.37	207.02	0.00	343.21	117.49	0.00	56.99	0.03	50	0.00	1 833.09
Modernisation package – SP1	400.46	108.95	0.00	1 190.80	190.00	0.00	85.15	0.03	50	0.00	1 890.21
Modernisation package – SP2	584.63	108.95	0.00	890.43	365.11	0.00	85.15	0.03	50	0.00	1 949.12
Modernisation package – SP3	1 314.11	207.03	0.00	251.62	117.49	0.00	85.15	0.03	50	0.00	1 890.25

[1] For residential and public buildings a calculation period of 30 years is applied, while for non-residential commercial buildings at least 20 years.

[2] The (expected) effect of future price development should be considered if the components are to be replaced during the calculation period.

Table II.8

Comparison table for both new and existing buildings

Reference building (current status) kWh/m²,year	Cost-optimal range/level (from-to) (for a component-level approach in the relevant unit) kWh/m²,year	Current requirements for reference buildings kWh/m²,year	Gap %
271.07	56−112	133.06	18.80

Justification of the gap:

The current requirements concerning the envelope of the building are in accordance with regulation C107/2010 (currently used for the design of new buildings) and result in a primary energy value of 133.06 kWh/m^{2}year. In the regulation there are no specifications concerning the systems of the building. Passing from the value of 133.06 kWh/m^{2}year to 122.34 kWh/m^{2}year (with reference to the primary energy) occurs as a result of fitting the building with mobile thermo-insulating shutters for the vacant periods during winter and by providing it with a mechanical ventilation system with heat recovery (efficiency 72 %) for each housing unit individually. The gap relative to the optimal range becomes only 9.23 % < 15 %.

Plan to reduce the non-justifiable gap:

For existing apartment blocks, solutions by C 107 must be applied along with measures resulting from the aforementioned optimal cost analysis (C 107-2).

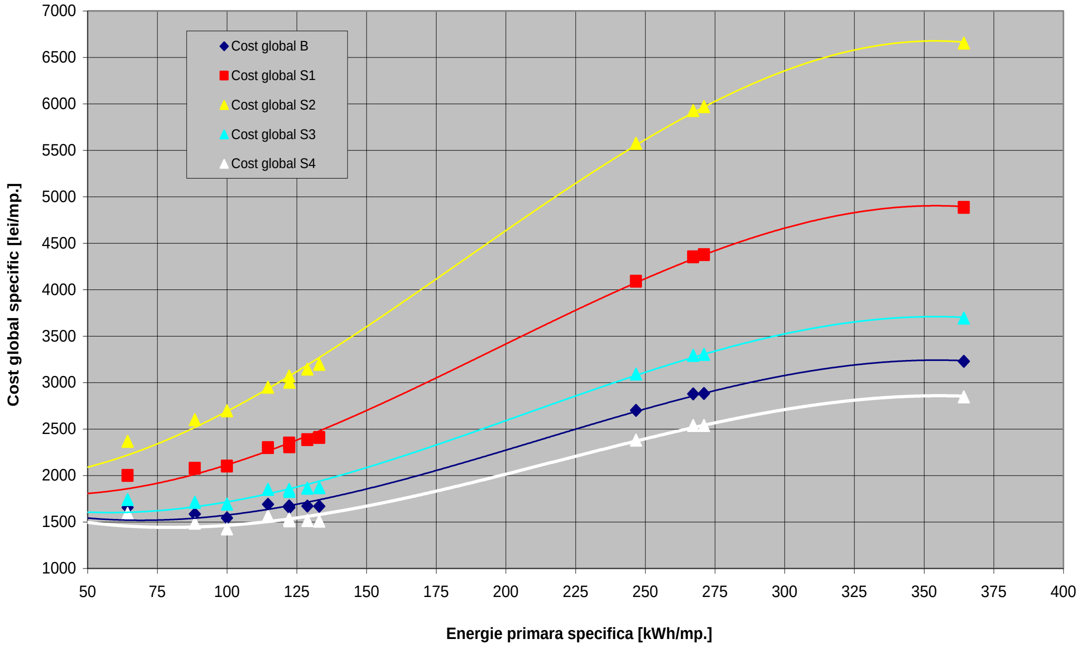

Figure II.13: Macroeconomic sensitivity analysis – apartment block, climate zone II

Key:
Horizontal: Specific primary energy [kWh/m^2]
Vertical: Specific global cost [RON/m^2]

Box: Global cost B, Global cost S1, Global cost S2, Global cost S3, Global cost S4

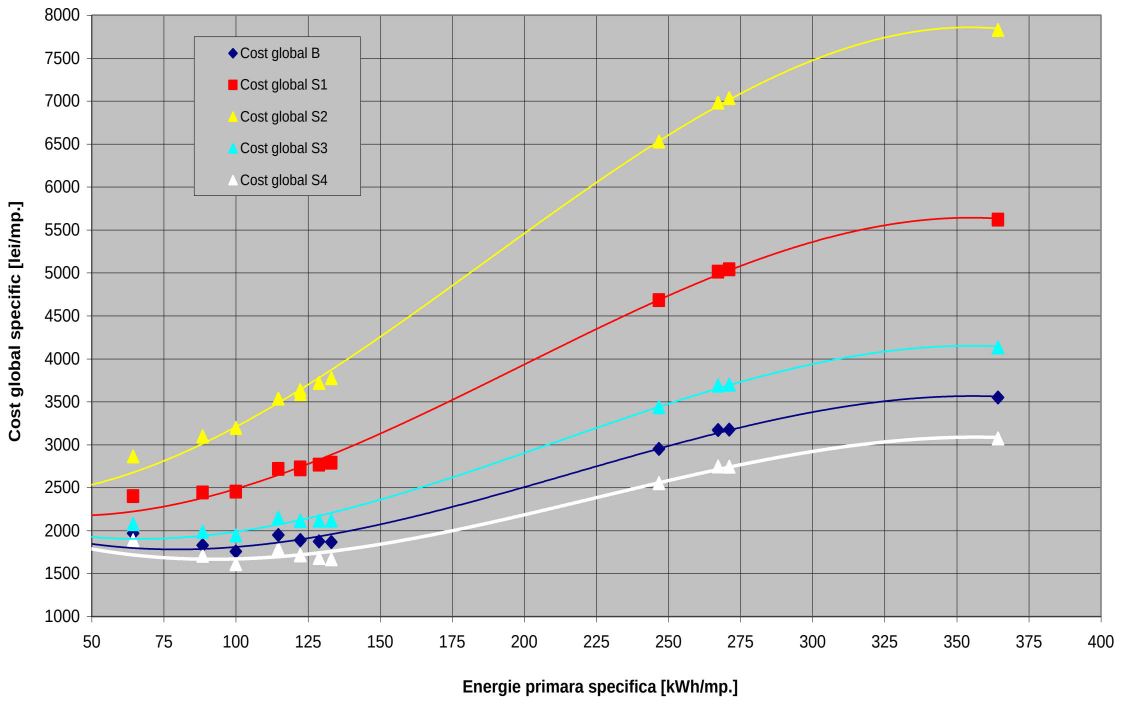

Figure II.14: Financial sensitivity analysis – apartment block, climate zone II

Key:

Horizontal: Specific primary energy [kWh/m^2]

Vertical: Specific global cost [RON/m^2]

Box: Global cost B, Global cost S1, Global cost S2, Global cost S3, Global cost S4

Single-family buildings

Table II.9

Illustrative table listing selected variants/measures

Measure	Reference case	Variant C 107/2010 without shutters	Variant C 107/2010 with shutters and heat recovery	Variant C 107/2010 with shutters and heat recovery, SP, PVP	SP pack without shutters	SP pack with shutters and heat recovery	Variant C 107/2010 with shutters, heat recovery, SP, PVP
Roof insulation	0.895 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K	0.157 W/m^2K
Wall insulation	0.939 W/m^2K	0.398 W/m^2K	0.398 W/m^2K	0.398 W/m^2K	0.165 W/m^2K	0.165 W/m^2K	0.165 W/m^2K
Windows	2.326 W/m^2K (double)	1.299 W/m^2K (thermo-insulating)	0.500 W/m^2K (thermo-insulating)	0.50 W/m^2K (thermo-insulating)	1.298 W/m^2K (thermo-insulating)	0.452 W/m^2K (thermo-insulating)	0.452 W/m^2K (thermo-insulating)
Share of window area of total building envelope	5.13 %	5.13 %	5.13 %	5.13 %	5.13 %	5.13 %	5.13 %
Building-related measures (thermal mass, etc.)	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K	266 060 J/m^2K
Heating system	Boiler	Boiler	Boiler	Boiler	Boiler	Boiler	Boiler
Domestic hot water	Boiler	Boiler	Boiler	Boiler	Boiler	Boiler	Boiler
Ventilation system (including night ventilation)	natural	unorganised natural ventilation, mobile blinds (in summer, occupied hours)	with heat recovery, mechanical ventilation –mobile blinds (in summer, occupied hours)	with heat recovery, mechanical ventilation – mobile blinds (in summer, occupied hours)	natural – organised natural ventilation, mobile blinds (in summer, occupied hours)	with heat recovery, mechanical ventilation – mobile blinds (in summer, occupied hours)	with heat recovery, mechanical ventilation –mobile blinds (in summer, occupied hours)
Space cooling system	split equipment – EER = 2.5	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7	split equipment – EER = 2.7
RES-based measures	-	-	-	solar installation	-	-	solar installation for

Measure	**Reference case**	**Variant C 107/2010 without shutters**	**Variant C 107/2010 with shutters and heat recovery**	**Variant C 107/2010 with shutters and heat recovery, SP, PVP**	**SP pack without shutters**	**SP pack with shutters and heat recovery**	**Variant C 107/2010 with shutters, heat recovery, SP, PVP**
				for DHW in the summer season and photovoltaic panels			DHW in the summer season and photovoltaic panels
Change of the energy factor	-	-	-	-	-	-	-
Type of lighting	incandescent lighting	economical lighting	economical lighting	economical lighting	economical lighting	economical lighting	economical lighting

This list of measures is purely illustrative.

For the building envelope: U in W/m^2K

For the system: efficiency

Several levels of improvement can be selected (for example: different thermal transmittance values for windows)

Table II.10.

Energy requirements – Single-family building

Measure/package/variant (as described in Table II.9)	Energy need		Energy consumption [kWh/m²year]					Energy delivered by source	Primary energy demand kWh/m²,year	Energy reduction in primary energy compared to the reference building %
	For heating	For cooling	Heating	Cooling	Ventilation	Domestic hot water	Lighting & Logistics			
Current status – SA1	320.51	3.70	465.78	1.48	-	91.50	17.42	E. therm. = 557.27 E. electric = 18.91	701.55	-
Current status – SA2	315.89	3.70	397.47	1.48	-	78.32	7.23	E. therm. = 475.79 E. electric = 8.71	579.50	**15.54**
Modernisation package C107/2010 – C107-1	167.45	0.89	202.54	0.36	-	52.21	7.23	E. therm. = 254.75 E. electric = 7.59	317.94	**53.66**
Modernisation package C107/2010 – C107-2	108.15	1.10	128.95	0.44	6.00	52.21	7.23	E. therm. = 181.16 E. electric = 13.67	247.77	**63.89**

Measure/package/variant (as described in Table II.9)	Energy need		Energy consumption [kWh/m²year]					Energy delivered by source	Primary energy demand kWh/m²,year	Energy reduction in primary energy compared to the reference building %
	For heating	For cooling	Heating	Cooling	Ventilation	Domestic hot water	Lighting & Logistics			

Modernisation package C107/2010 – C107-3	108.15	1.10	128.95	0.44	6.00	52.21	7.23	E. therm. = 152.15 E. electric = 4.68	190.28	**72.27**
Modernisation package – SP1	136.13	0.40	163.18	0.16	-	52.21	7.23	E. therm. = 215.39 E. electric = 7.39	271.37	**60.45**
Modernisation package – SP2	76.15	0.48	90.30	0.19	6.00	52.21	7.23	E. therm. = 142.52 E. electric = 13.42	201.91	**70.57**
Modernisation package – SP3	76.15	0.48	90.30	0.19	6.00	52.21	7.23	E. therm. = 113.51 E. electric = 4.68	145.07	**78.86**

Table II.11

Output data and global cost calculations

MACROECONOMIC

Variant / package / measure as presented in Table II.10	Initial investment cost (start year) [RON / m²]	Annual running cost		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON / m²]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON / m²]	Global cost calculated [RON / m²]
		Annual maintenance costs [RON / m² per year]	Operational costs [RON / m² per year]	Energy cost[2] by fuel in the medium energy price scenario [RON / m²]							
				Thermal	Electric						
Current status – SA1	49.78	24.02	0.00	4 858.41	361.80	753.62	0.00	0.04	50	0.00	6 047.64
Current status – SA2	62.81	140.60	0.00	4 148.01	166.73	628.92	0.00	0.04	50	0.00	5 147.07
Modernisation package C107/2010 – C 107-1	680.31	140.60	0.00	2 220.98	145.15	342.45	252.66	0.04	50	0.00	3 529.49
Modernisation package C107/2010 – C 107-2	826.18	140.60	0.00	1 579.40	261.58	259.68	252.66	0.04	50	0.00	3 067.44
Modernisation package C107/2010 – C 107-3	1 389.84	211.35	0.00	1 326.51	89.55	204.82	252.66	0.04	50	0.00	3 222.08
Modernisation package – SP1	911.80	140.60	0.00	1 877.82	141.39	291.44	326.67	0.04	50	0.00	3 363.05

[1] For residential and public buildings a calculation period of 30 years is applied, while for non-residential commercial buildings at least 20 years.

[2] The (expected) effect of future price development should be considered if the components are to be replaced during the calculation period.

Variant / package / measure as presented in Table II.10	Initial investment cost (start year) [RON / m2]	Annual running cost		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON / m2]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON / m2]	Global cost calculated [RON / m2]
		Annual maintenance costs [RON / m2 per year]	Operational costs [RON / m2 per year]	Energy cost[2] by fuel in the medium energy price scenario [RON / m2]							
				Thermal	Electric						
Modernisation package – SP2	1 057.66	140.60	0.00	1 242.48	256.82	209.50	326.67	0.04	50	0.00	2 907.06
Modernisation package – SP3	1 617.55	211.44	0.00	989.59	89.55	155.12	326.67	0.04	50	0.00	3 063.25

FINANCIAL

Variant / package / measure as presented in Table II.10	Initial investment cost (start year) [RON / m²]	Annual running cost		Calculation period[1] 20, 30 years		Cost of greenhouse gas emissions (only for the macroeconomic calculation) [RON / m²]	Residual value	Discount rate (different rates for the macroeconomic and for the financial calculation)	Estimated economic lifetime [years]	Disposal cost (where applicable) [RON / m²]	Global cost calculated [RON / m²]
		Annual maintenance costs [RON / m² per year]	Operational costs [RON / m² per year]	Energy cost[2] by fuel in the medium energy price scenario [RON / m²]							
				Thermal	Electric						
Current status – SA1	61.73	29.78	0.00	6 024.43	474.67	0.00	0.00	0.03	50	0.00	6 590.61
Current status – SA2	77.89	174.35	0.00	5 143.53	218.74	0.00	0.00	0.03	50	0.00	5 614.51
Modernisation package C107/2010 – C 107-1	843.58	174.35	0.00	2 754.02	190.43	0.00	252.66	0.03	50	0.00	3 962.38
Modernisation package C107/2010 – C 107-2	1 024.46	174.35	0.00	1 958.45	343.18	0.00	252.66	0.03	50	0.00	3 500.44
Modernisation package C107/2010 – C 107-3	1 723.41	262.08	0.00	1 644.87	117.49	0.00	252.66	0.03	50	0.00	3 747.85
Modernisation package – SP1	1 130.63	174.35	0.00	2 328.49	185.50	0.00	326.67	0.03	50	0.00	3 818.97
Modernisation package – SP2	1 311.50	174.35	0.00	1 540.67	336.93	0.00	326.67	0.03	50	0.00	3 363.46
Modernisation package – SP3	2 005.76	262.18	0.00	1 227.09	117.49	0.00	326.67	0.03	50	0.00	3 612.53

[1] For residential and public buildings a calculation period of 30 years has been applied, while for non-residential commercial buildings at least 20 years.

[2] The (expected) effect of future price variation should be considered if the components are to be replaced during the calculation period.

Table II.12

Comparison table for both new and existing buildings

Existing reference building (current status) kWh/m²,year	Cost-optimal range/level (from - to) (for a component-level approach in the relevant unit) kWh/m²,year	Current requirements for reference buildings kWh/m²,year	Gap %
701.55	**155−230**	317.94	51.27

Justification of the gap:

The current requirements concerning the envelope of the building are in accordance with regulation C107 / 2010 (currently used for the design of new buildings) and result in a primary energy value of 317.94 kWh/m^{2}year. In the regulation there are no specifications concerning the systems of the building. Passing from the value of 317.94 kWh/m^{2}year to 201.91 kWh/m^{2}year (with reference to the primary energy) occurs as a result of applying the Superior Package for thermal protection, fitting the building with mobile thermo-insulating shutters for the vacant night hours during the cold season and providing a mechanical ventilation system with heat recovery (efficiency 72 %) for each apartment. The gap relative to the optimal range is eliminated.

Plan to reduce the non-justifiable gap:

For existing apartment blocks, solutions of type C 107 must be applied along with measures resulting from the aforementioned optimal cost analysis (SP-2).

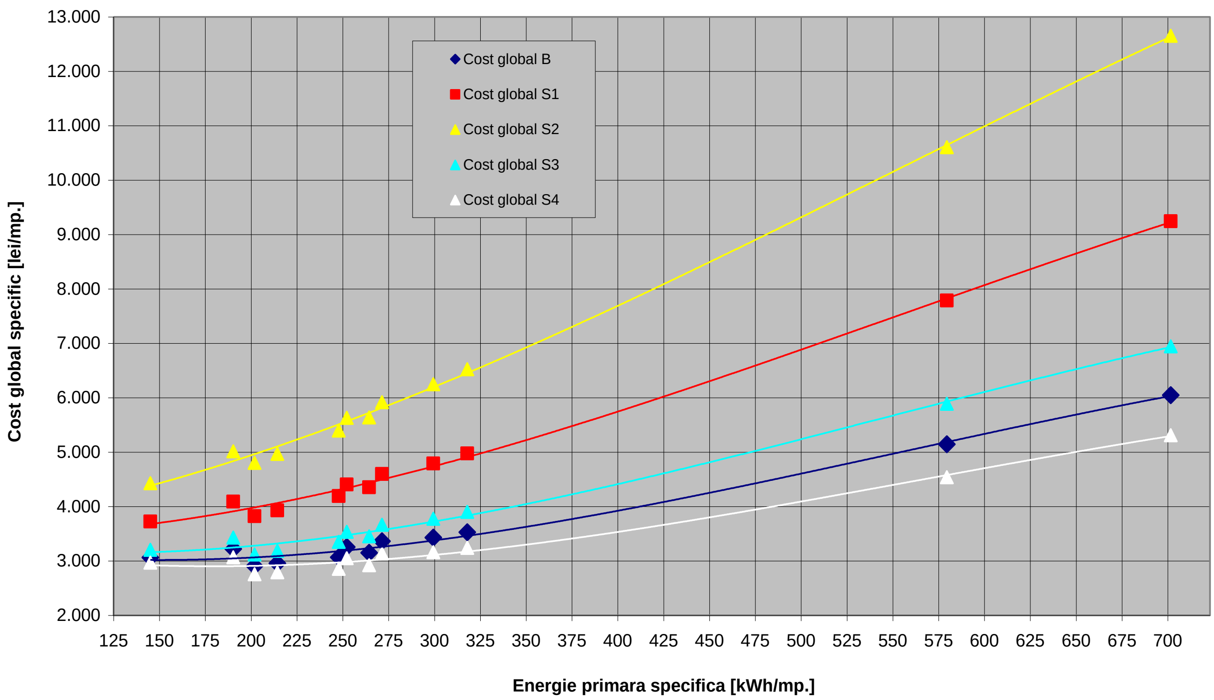

Figure II.15: Macroeconomic sensitivity analysis – single-family building, climate zone II

Key:

Horizontal: Specific primary energy [kWh/m^2]

Vertical: Specific global cost [RON/m^2]
Box: Global cost B, Global cost S1, Global cost S2, Global cost S3, Global cost S4

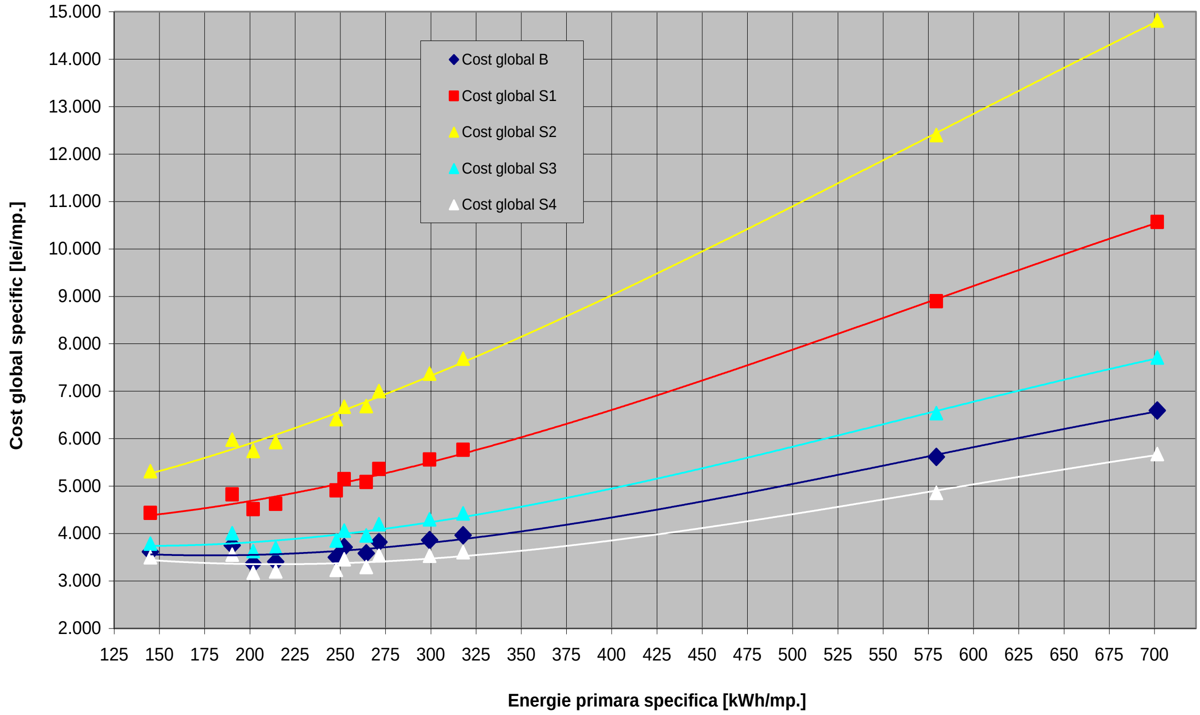

Figure II.16: Financial sensitivity analysis – single-family building, climate zone II

Key:
Horizontal: Specific primary energy [kWh/m^2]
Vertical: Specific global cost [RON/m^2]
Box: Global cost B, Global cost S1, Global cost S2, Global cost S3, Global cost S4

II.2 Country report on the minimum admissible energy performance for the classification of buildings as NZEB – evolution in the time interval up to 2020

The scenarios applied for the assessment of Energy Performance of Buildings in terms of the current status and nearly zero energy buildings (NZEB), by building types are displayed in Table II.13.

Table II.13

Variants and selected measures

Measure	Reference case (SA)	Variant C107/2010	Additional package (SP)
Roof insulation	1.124 W/m^{2}K	0.25 W/m^{2}K	0.21 W/m^{2}K
Insulation of vertical opaque wall	1 236 W/m^{2}K	0.625 W/m^{2}K	0.303 W/m^{2}K
Windows	2.56 W/m^{2}K (double)	1.30 W/m^{2}K (thermo-insulating)	1.03 W/m^{2}K (thermo-insulating)
Building-related measures (thermal capacity)	266 060 J/m^{2}K	266 060 J/m^{2}K	266 060 J/m^{2}K

Measure	Reference case (SA)	Variant C107/2010	Additional package (SP)
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, occupied hours)	natural –organised natural ventilation, mobile blinds (in summer, occupied hours)
Space cooling system	split equipment EER = 2.5	split equipment, air handlers EER = 2.7	split equipment, air handlers, radiant systems, absorption 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/tri-generation
Type of interior lighting	incandescent lighting	economical lighting	economical lighting (LEDs)

II.3 Maximum admissible values of primary energy and CO_2 emissions relating to the operation of buildings –by building type and winter climate zone in Romania

EPBD was correctly interpreted for office buildings for which the maximum admissible primary energy value is fixed at a reference value of 57 kW / m^{2}year, lower than the minimum value defining the minimum range of the global cost, namely 62 kW / m^{2}year. Even if the level of representativeness of office / administrative public buildings (in terms of energy consumption) in Romania is lower than the European average, any public building may serve as an example of best practice in the case of urban settlements.

In the case of apartment blocks, the value of 100 kWh/m^{2}year is more of a precaution in respect of the representativeness of this type of building.

This study methodologically completes the analysis that defined the maximum admissible limit values of NZEB in Romania by addressing economic efficiency as a criterion of admissibility for the construction of a NZEB.

Economic efficiency refers to the period for recovering the additional investment for a NZEB, as opposed to a C 107 building type (in accordance with the regulations in force regarding the construction of new buildings − C 107 / 2010) in terms of energy savings for the end consumer (both for the thermal and for the electric factor).

Table II.14.

Climate zone	Timeline	OFFICE BUILDINGS		BUILDINGS INTENDED FOR EDUCATION ACTIVITIES		BUILDINGS INTENDED FOR THE HEALTH CARE SYSTEM		COLLECTIVE RESIDENTIAL BUILDINGS		INDIVIDUAL RESIDENTIAL BUILDINGS	
		Primary energy [kWh/m^{2}year]	CO_2 emissions [kg/m^2 year]	Primary energy [kWh/m^2 year]	CO_2 emissions [kg/m^2 year]	Primary energy [kWh/m^2 year]	CO_2 emissions [kg/m^2 year]	Primary energy [kWh/m^2 year]	CO_2 emissions [kg/m^2 year]	Primary energy [kWh/m^2 year]	CO_2 emissions [kg/m^2 year]
I	2005-2010	102	24	135	32	135	48	117	31	271	59
	2015	75	21	115	28	135	37	105	28	131	36
	31/12/2018	50	13	100	25	79	21	100	25	115	31
	31/12/2020	45	12	92	24	76	21	93	25	98	24
II	2005-2010	113	25	153	39	214	57	132	36	317	70
	2015	93	27	135	37	155	43	112	30	147	42
	31/12/2018	57	15	120	25	97	27	105	28	121	34
	31/12/2020	57	15	115	30	97	26	100	27	111	30
III	2005-2010	125	29	174	46	241	66	150	41	372	83
	2015	110	28	154	39	171	49	130	36	172	48
	31/12/2018	69	19	136	37	115	32	122	34	155	41
	31/12/2020	69	19	136	37	115	32	111	30	145	40
IV	2005-2010	147	38	212	58	290	81	182	50	476	109
	2015	107	28	192	56	190	55	152	38	226	57
	31/12/2018	89	24	172	48	149	42	144	40	201	51

Climate zone	Timeline	OFFICE BUILDINGS		BUILDINGS INTENDED FOR EDUCATION ACTIVITIES		BUILDINGS INTENDED FOR THE HEALTH CARE SYSTEM		COLLECTIVE RESIDENTIAL BUILDINGS		INDIVIDUAL RESIDENTIAL BUILDINGS	
		Primary energy [kWh/m²year]	**CO_2 emissions [kg/m² year]**	**Primary energy [kWh/m² year]**	**CO_2 emissions [kg/m² year]**	**Primary energy [kWh/m² year]**	**CO_2 emissions [kg/m² year]**	**Primary energy [kWh/m² year]**	**CO_2 emissions [kg/m² year]**	**Primary energy [kWh/m² year]**	**CO_2 emissions [kg/m² year]**
	31/12//2020	83	24	170	49	142	41	127	35	189	42
V	2005-2010	157	43	230	64	314	87	198	55	528	122
	2015	127	29	210	58	214	58	178	48	248	78
	31/12/2018	98	28	192	56	174	49	152	38	229	57
	31/12/2020	89	24	185	53	167	48	135	37	217	54

As a consequence, the methodology for the admissibility of a building (either a new building or an existing building that is being renovated) defines the value of the planned building's own specific primary energy, provided that it is under the maximum admissible value, as presented in table II.14 in this study.

Figure II.17 presents the methodological flowchart for the theoretical validation of NZEBs. The analysis is based on three main calculation modules, as follows:

- **Module 1** – dynamic simulation with hourly step (both for new buildings and for similar buildings constructed in accordance with C 107 / 2010);
- **Module 2** – estimation of primary energy in scenarios based on fitting buildings with a thermo-insulating envelope, high-efficiency utility systems and a system acting as a renewable source of energy. The factors of conversion into primary energy apply to both forms of energy, while the value of primary energy represents the net value at building level. Hence, any connections to the urban networks for supplying fossil fuels and electricity are taken into consideration;
- **Module 3** – assessment of the period for recovering investment costs with reference to building C 107. A mamximum value is proposed depending on the national policy concerning the promotion of NZEB. It should be noted that the flowchart includes submodel 'Value analysis D_R' for the period for recovering additional investments. Thus, sensitive price components that can benefit from national policies for boosting the promotion of NZEB are highlighted.

The data included both in the technical datasheets of the buildings, in terms of **optimal cost**, and as a result of the definition of the maximum admissible values of **primary energy** related to supplying thermal and electric energy to NZEBs (climate zone II), was used to draw up the summary table below (table II.15).

Table II.15.

Building type	**Cost-optimal range [kWh/m^{2}year]**	**Maximum admissible values for NZEBs [kWh/m^{2}year]**
Public and office buildings	62-100	57
Apartment blocks	56-112	100
Single-family buildings	155-230	111

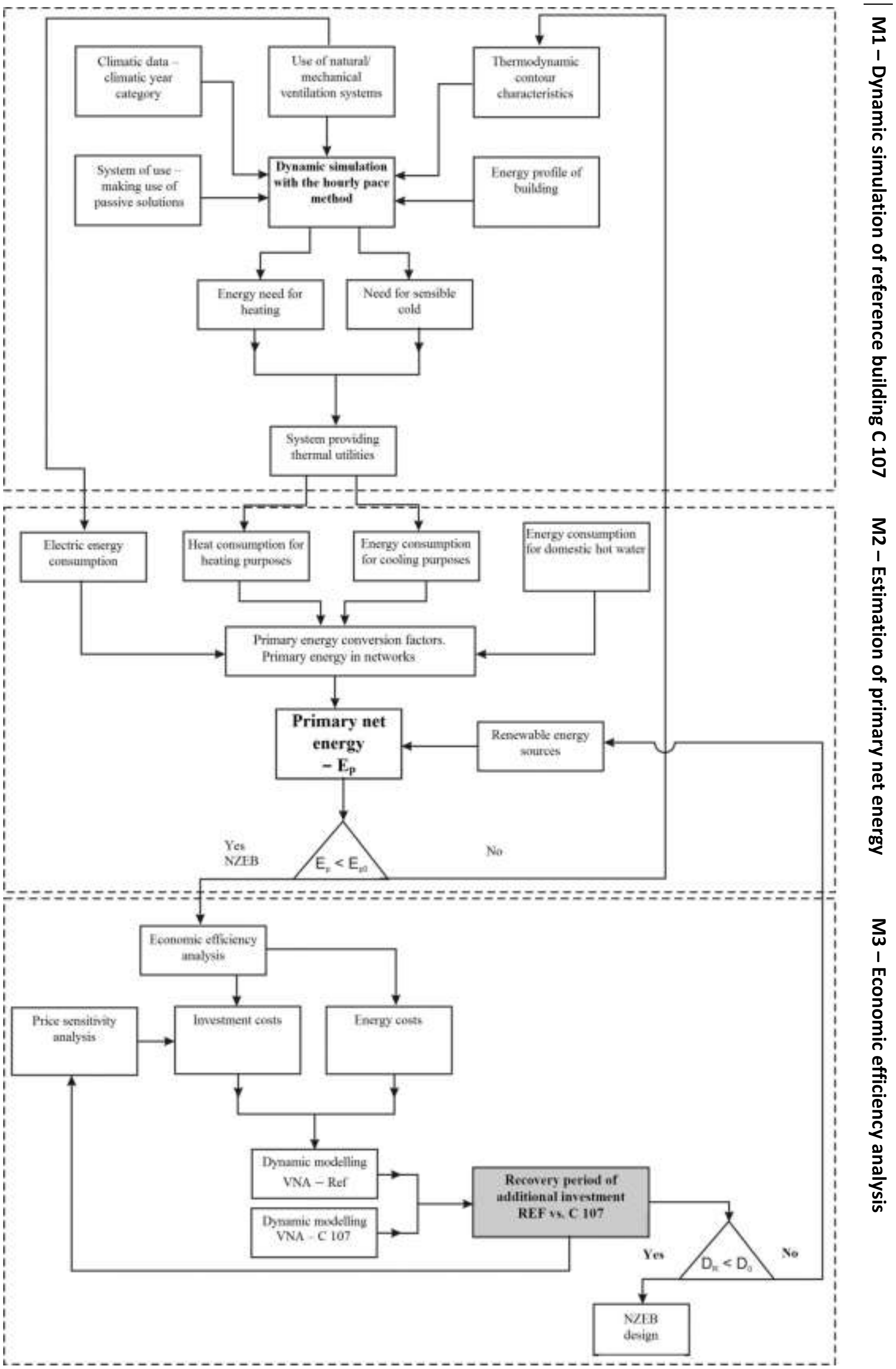

Figure II.17: Methodological flowchart for the theoretical validation of NZEBs

II.4 Estimation of the cost and benefit of technical solutions in accordance with the provisions of Article 9(6) of Directive 2010/31/EU − methodology

The numerical examples in this study are based on three of the most common (and therefore representative, in social and energy terms) types of building, as follows:

- office buildings, administrative buildings;
- apartment blocks;
- single-family buildings;

The method for the energy configuration of NZEBs is presented in the modular flowchart in figure II.17, and applies to all building types, as specified in point 1 in Annex I to Directive 2010/31/EU.

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Chapter III - Dynamic modelling and simulation of the reference buildings' energy response

III.1 Input data and dynamic modelling strategies for the energy behaviour of office buildings (climate zone II)

III.1.1 Thermophysical characteristics of the thermo-insulating materials used

The information below presents the thermophysical characteristics of the thermo-insulating materials used for the thermal protection of the building envelope.

1. Vertical exterior walls

Layer	Material	δ [m]	λ [W/kgK]	c [J/kgK]	p [kg/m³]
1	Rendering (lime-cement)	0.02	0.70	840	1 800
2	GBN 35 AAC	0.30	0.32	870	725
3	Mineral wool	0.07	0.04	750	140
4	Rendering (cement)	0.03	0.93	840	1 700

Corrected thermal resistance is $R^t = 2.1\ m^2K/W$.

2. Terrace

Layer	Material	δ [m]	λ [W/kgK]	c [J/kgK]	p [kg/m³]
1	Rendering (lime-cement)	0.02	0.87	840	1 700
2	Reinforced concrete	0.14	1.74	840	2 500
3	Sloped mortar	0.10	0.93	840	1 800
4	GBN 35 AAC	0.20	0.32	870	725

5	Extruded polystyrene	0.15	0.04	1 430	20
6	Mortar slab	0.03	0.93	840	1 800
7	Sandstone	0.02	2.03	920	2 400

Corrected thermal resistance is R^t = 4.191 m^2K/W.

3. Slab over the service basement

Layer	Material	δ [m]	λ [W/kgK]	c [J/kgK]	p [kg/m^3]
1	Sandstone	0.02	2.03	920	2 400
2	Mortar slab	0.055	0.96	840	1 800
3	Concrete	0.15	1.74	840	2 500
4	Extruded polystyrene	0.09	0.04	1 420	20
5	Rendering (cement)	0.02	0.90	840	1 700

Corrected thermal resistance is R^t = 2.20 m^2K/W.

The wall toward the staircase is made of reinforced concrete with a thickness of 0.13 m, rendered on both sides. Corrected thermal resistance is R^t = 0.34 m^2K/W.

The exterior surface of opaque envelope elements is treated with light-colour finish, α = 0.30.

Glazed areas are thermo-insulating windows fitted with mobile exterior thermo-insulating shutters and interior shading blinds. The average window sunlight coefficient is 0.80 (where shading is not used during the summer season). The mobile exterior shutters can be oriented so as to ensure full shading of the windows. Window thermal resistance (glazing and opaque frame) is 0.77 m^2K/W.

The window optical factor has hourly values linked to the direct component of solar radiation and a fixed value linked to the diffuse component of solar radiation. The values change every month. The geometrical characteristics specific to the position of the Sun in the sky are measured for the middle of the month, taking into account the local latitude and the projection of the solar ecliptic.

The thermal capacity of interior building elements is 221 760 J/m^2K, with reference to the surface area of those elements.

The main area of the building has mechanical ventilation with a heat recovery unit placed at the air exhaust/intake. The fresh air ventilation rate is 0.72 ac/h, and the efficiency of the heat recovery unit is 75 % (average value). The ventilation system is based on the following strategies:

- during vacant hours, ventilation is done exclusively by air infiltrated through the mobile window joints;

- during occupied hours:
    - mechanical ventilation with constant air flow during the hours when outside temperature is below the admissible minimum inside temperature or above the admissible maximum inside temperature;
    - natural ventilation with variable air flow when outside temperature is between the inside temperature values admissible as thermal comfort temperature in the space used.

III.1.2 Operational parameters of an office building

The energy profile of the building changes with the month of the year, depending on the number of hours of natural light. The occupied hours are from 8:00 to 17:00, five days per week. The consumption of electricity (logistics) coincides with the occupied hours and is determined based on the specific power of 3 W/m^2. Artificial lighting (an element that influences the building's thermal balance) is economical, with a power of 15.028 kW. The thermal flow linked to human metabolism is 45.78 kW. The use of hot water (4 hours/day) determines a thermal flow of 6.17 kW.

The simulation of the building's thermal response covers four representative months of a typical climate year (winter, spring, summer, autumn). In addition, the values for heat and cooling requirements for each month of the year are also indicated. It is clear that high-performance systems and energy management have an impact on the building's energy performance. It should be noted that the average thermal resistance values of the envelope for the two buildings examines are 0.98 m^2K/W, for the C107 building, and 1.216 m^2K/W, respectively.

Therefore, it is **not** the solutions relating to the envelope that can lead to significant differences in the energy performance of the two buildings examined. Table III.1 presents the components of the energy performance of the two buildings in question, in the absence of renewable energy sources and energy supply systems. In the case of the solution used for the reference building, the values for each energy factor and overall represent the references that are the starting point when adding energy supply systems and renewable energy sources. The overall energy performance of office buildings is discussed in the context of the analysis of the economic efficiency of all building types examined. Therefore, table III.1 does not include energy supply efficiency or the impact of renewable sources of energy.

Table III.1

Energy factor	Reference building	C107 building
Heating requirements (kWh/m^2year)	16.64	53.72
Cooling requirements (kWh/m^2year)	4.39	10.47
Domestic hot water requirements (kWh/m^2year)	5.28	5.28
Lighting and equipment requirements (kWh/m^2year)	13.80	12.12
Energy requirements for mechanical ventilation (kWh/m^2year)	3.64	7.15
Total (kWh/m^2year)	43.75	87.72

Winter (January)

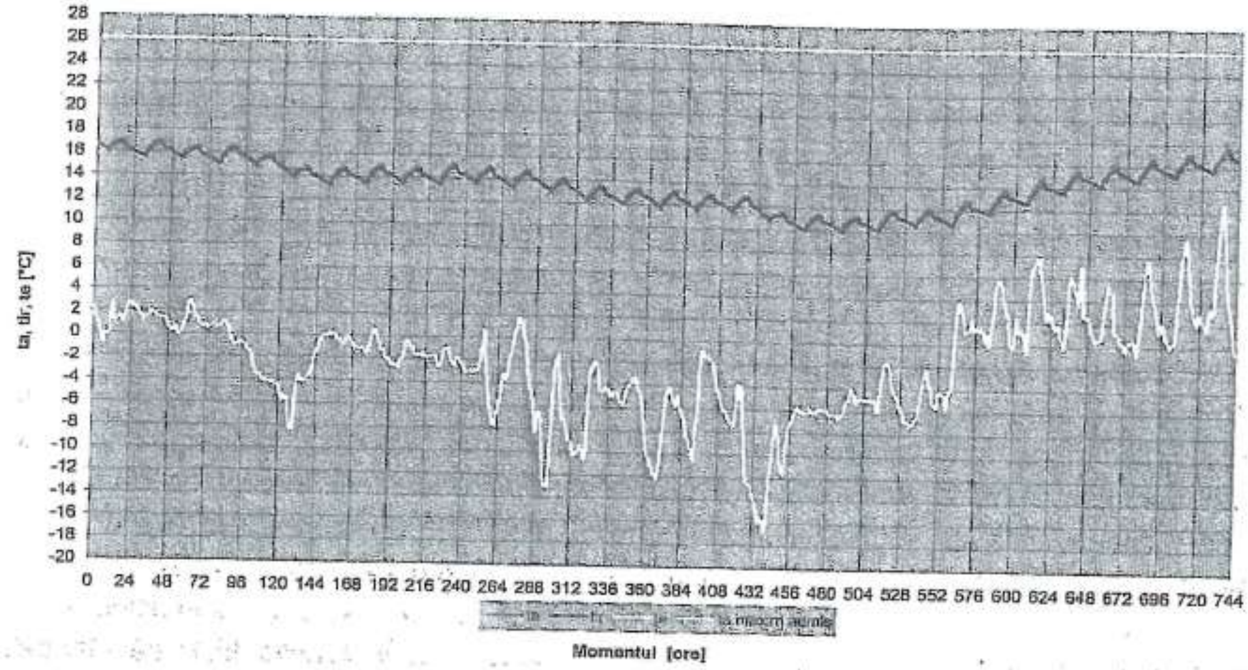

Figure III.1: Significant temperatures (hourly values - Q = 0) for a new office building, free-running temperatures, mechanical ventilation, Rg = 26.64 % - January, typical climate year - Bucharest
Key:
Bottom: Time (hours)

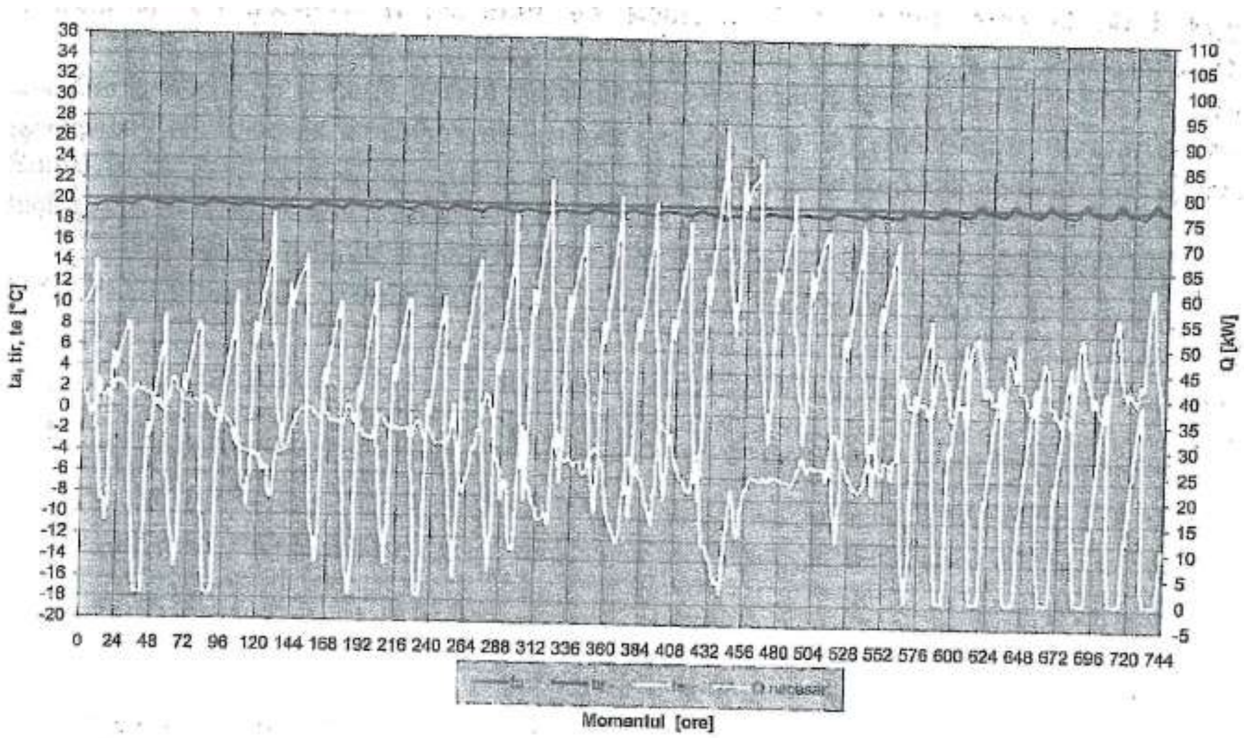

Figure III.2: Significant temperatures and thermal flow (hourly values) for a new office building, air conditioning, mechanical ventilation, Rg = 26.64 % - January, typical climate year - Bucharest
Key:
Bottom: Time (hours)

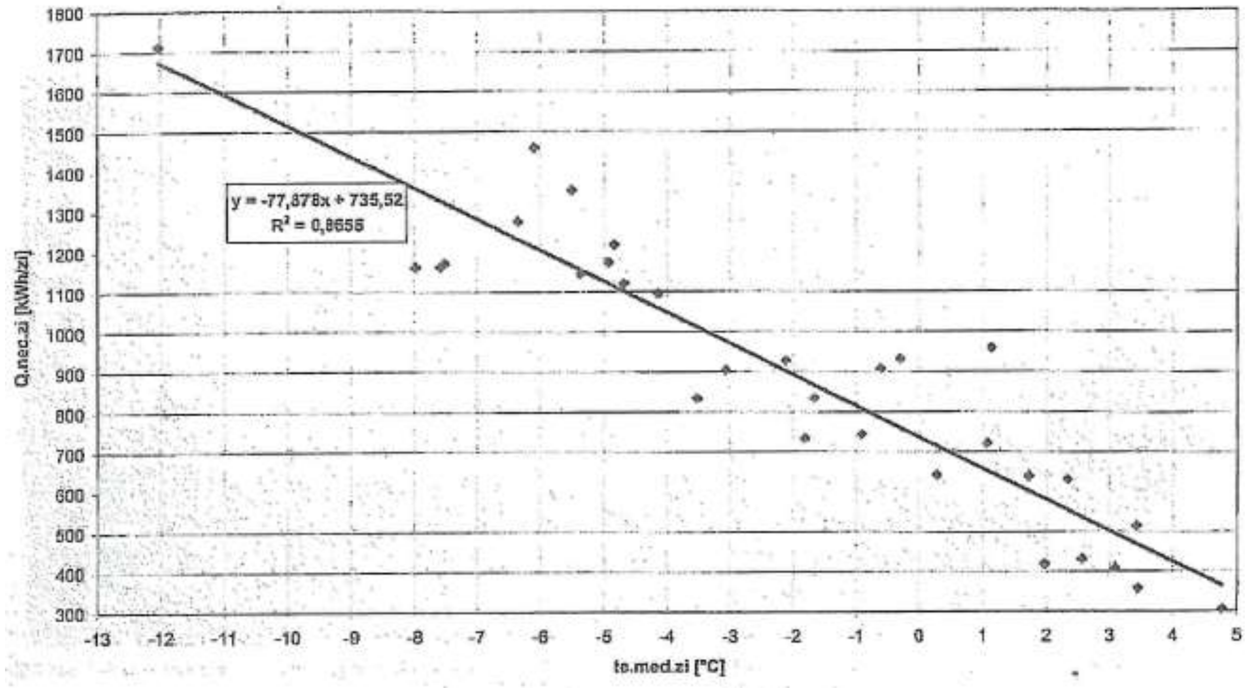

Figure III.3: Daily heating requirements correlated with the daily average outside temperature
Key:
Horizontal: daily average temperature (ºC)

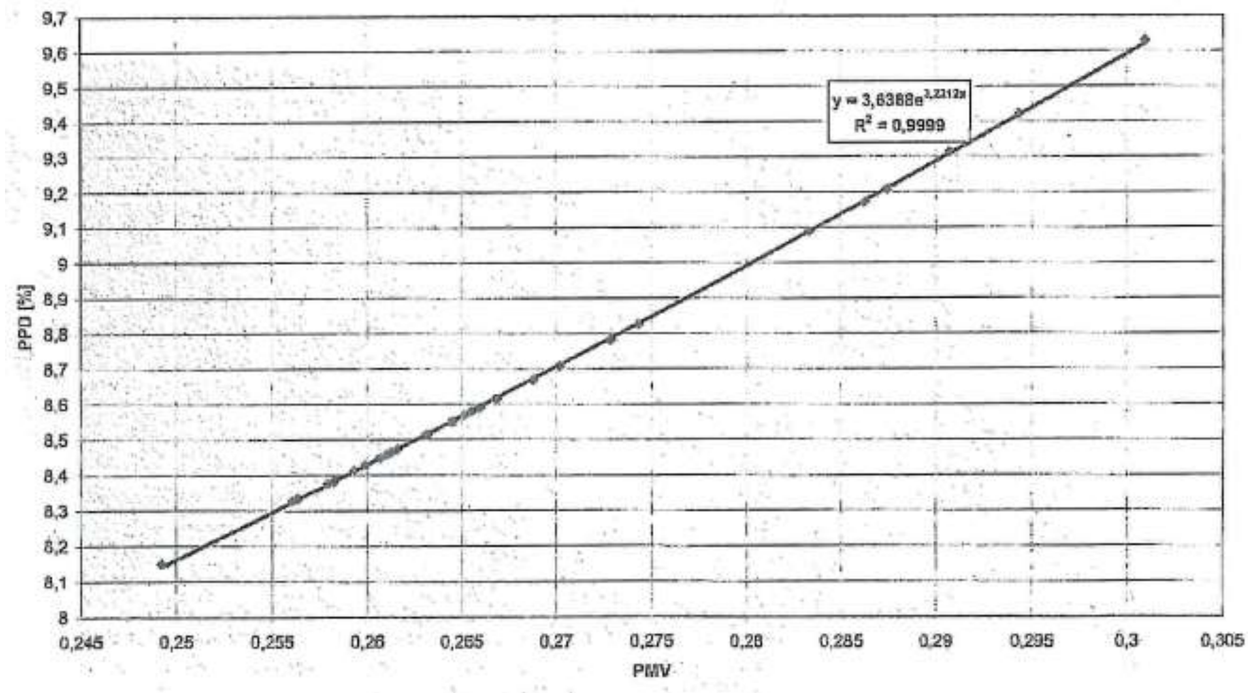

Figure III.4: Correlation of the daily average PPD values with the daily average PMV values

Spring (April)

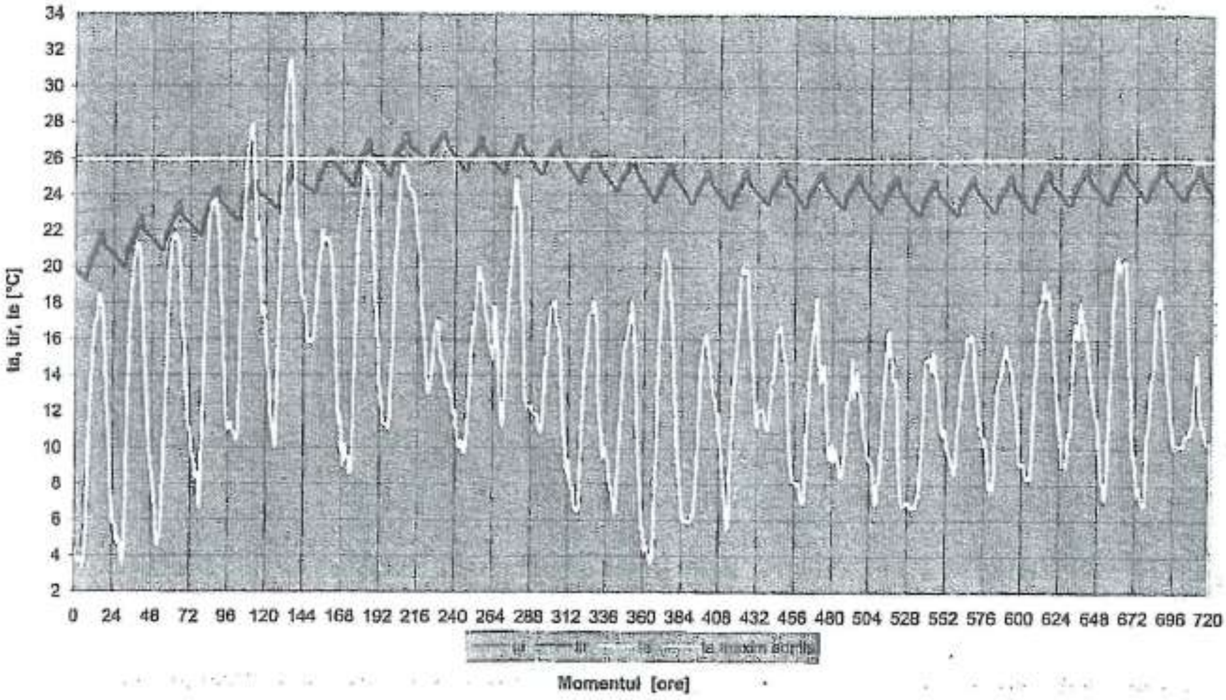

Figure III.5: Significant temperatures (hourly values - Q = 0) for a new office building, free-running temperatures, mechanical ventilation, Rg = 26.64 % - April, typical climate year - Bucharest
Key:
Bottom: Time (hours)

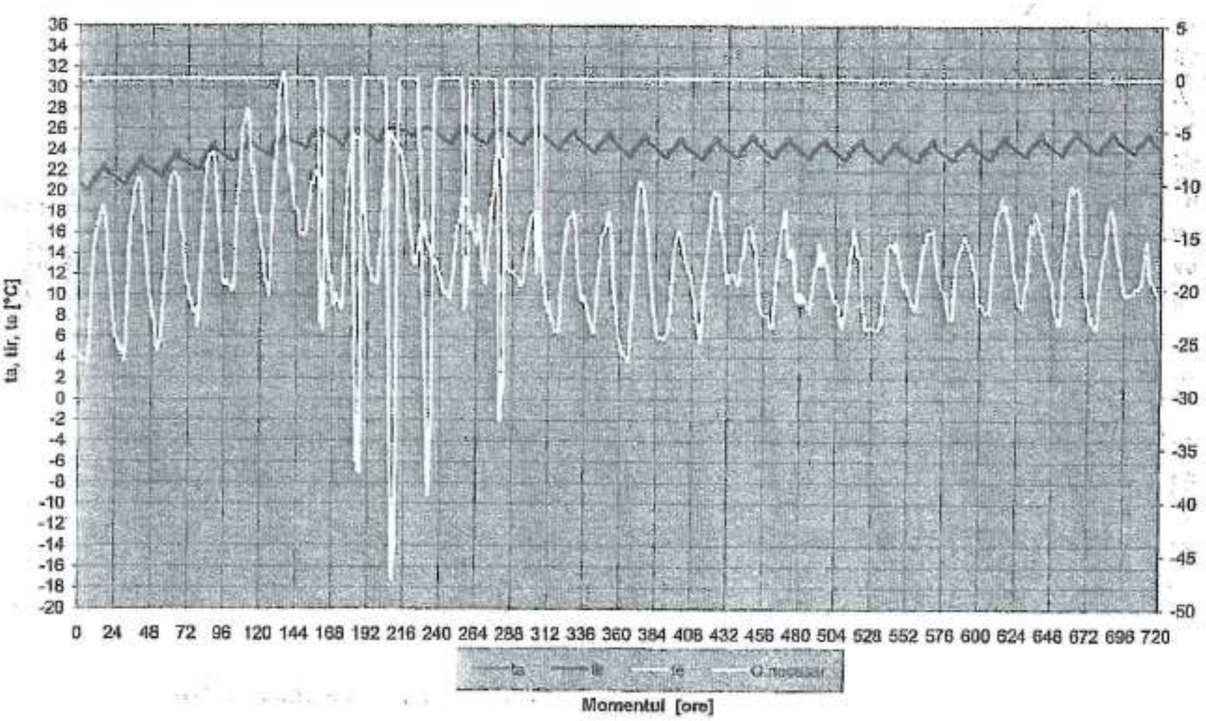

Figure III.6: Significant temperatures and thermal flow (hourly values) for a new office building, air conditioning, mechanical ventilation, Rg = 26.64 % - April, typical climate year - Bucharest
Key:
Bottom: Time (hours)

Summer (July)

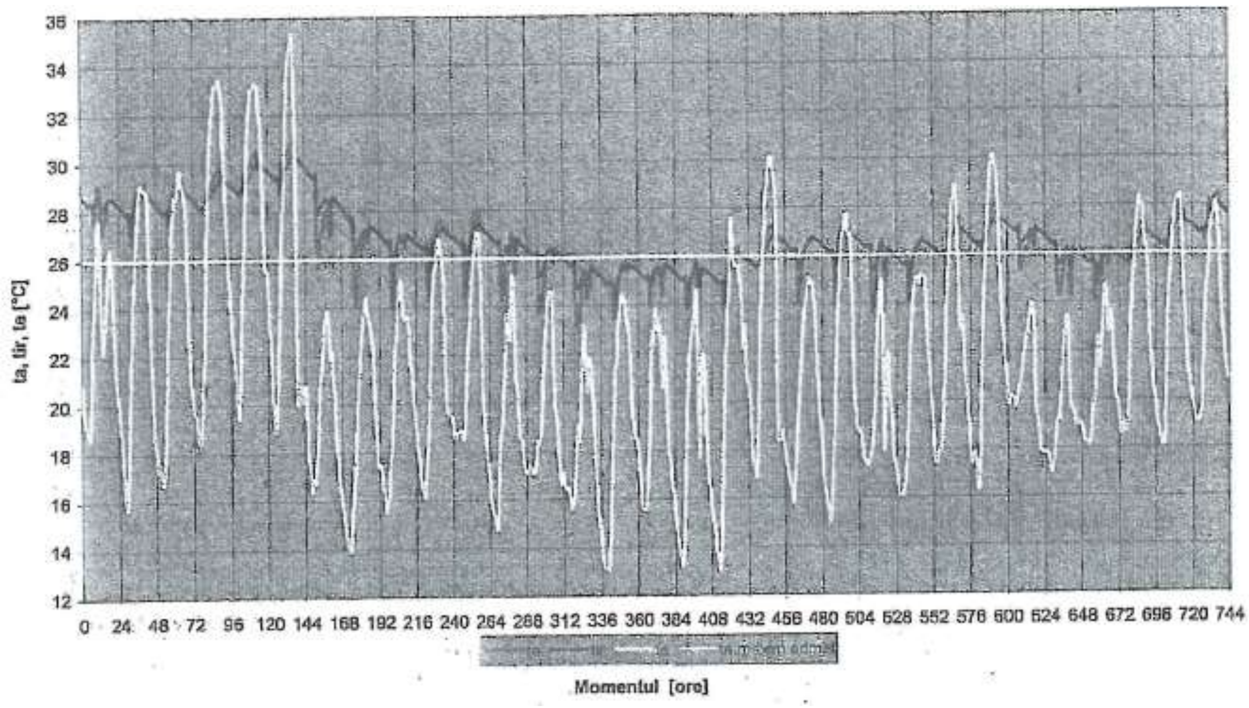

Figure III.7: Significant temperatures (hourly values - Q = 0) for a new office building, free-running temperatures, mechanical ventilation, Rg = 26.64 % - July, typical climate year - Bucharest
Key:
Bottom: Time (hours)

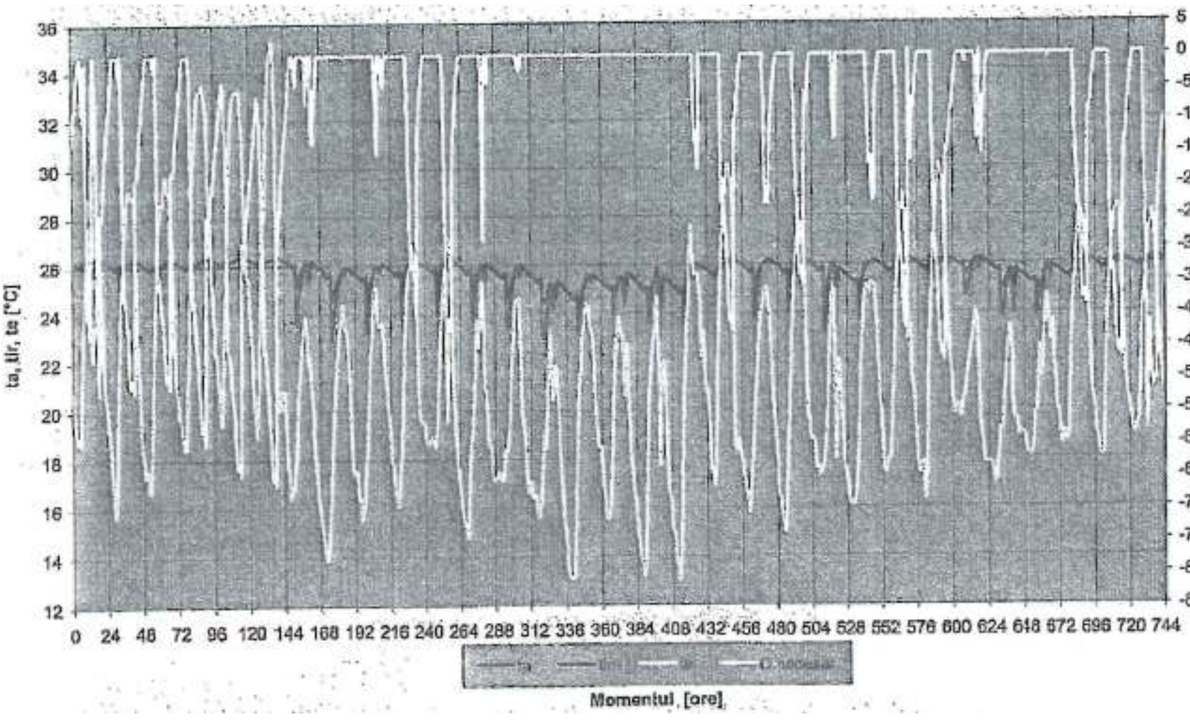

Figure III.8: Significant temperatures and thermal flow (hourly values) for a new office building, air conditioning, mechanical ventilation, Rg = 26.64 % - July, typical climate year - Bucharest
Key:
Bottom: Time (hours)

Autumn (October)

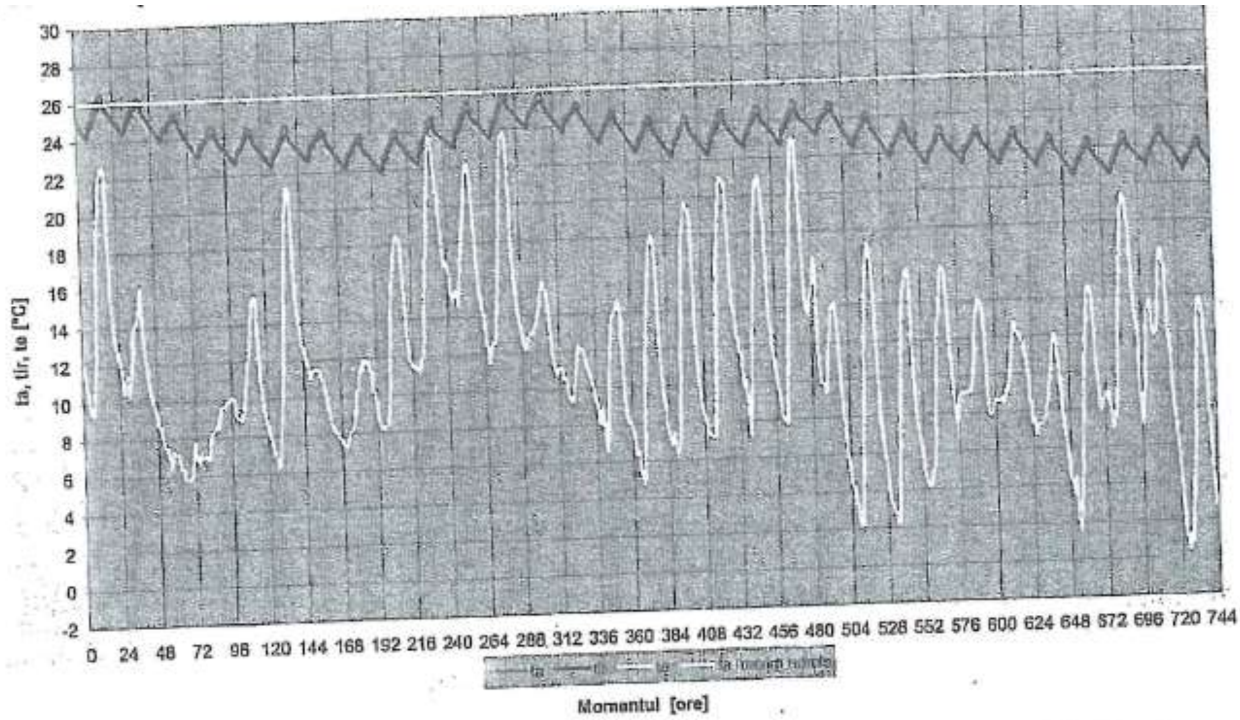

Figure III.9: Significant temperatures (hourly values - Q = 0) for a new office building, free-running temperatures, mechanical ventilation, Rg = 26.64 % - October, typical climate year - Bucharest
Key:
Bottom: Time (hours)

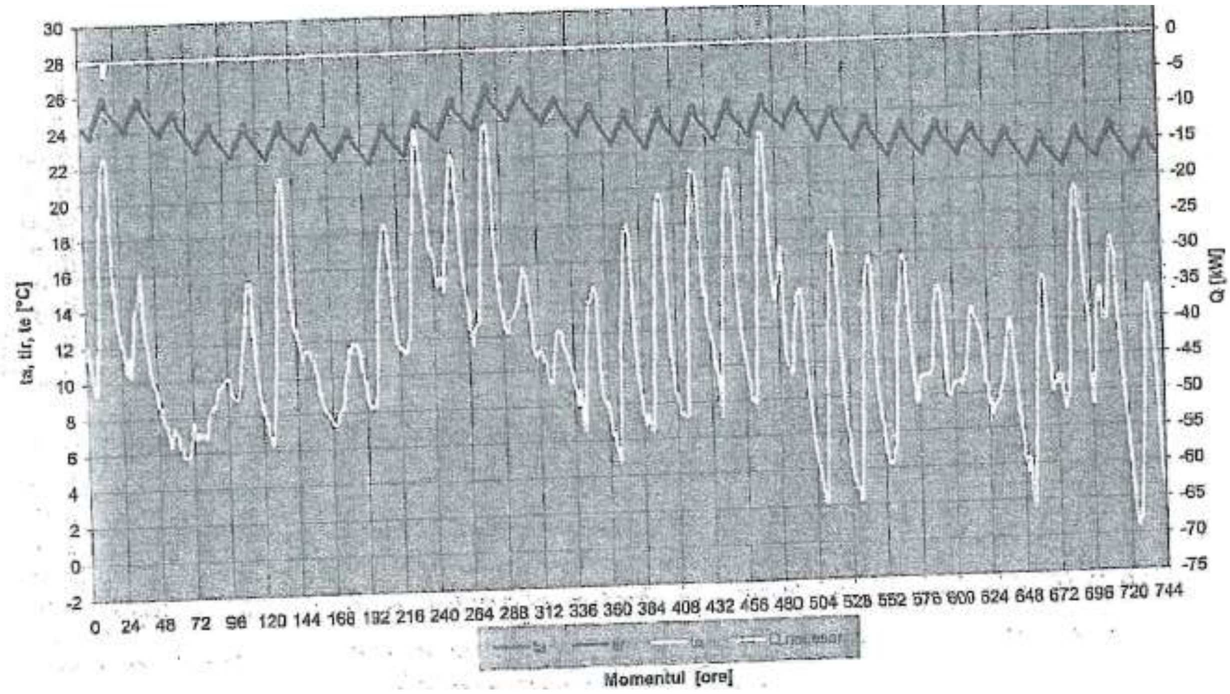

Figure III.10: Significant temperatures and thermal flow (hourly values) for a new office building, air conditioning, mechanical ventilation, Rg = 26.64 % - October, typical climate year - Bucharest
Key:
Bottom: Time (hours)

III.1.3 Determining the size of heating and cooling systems

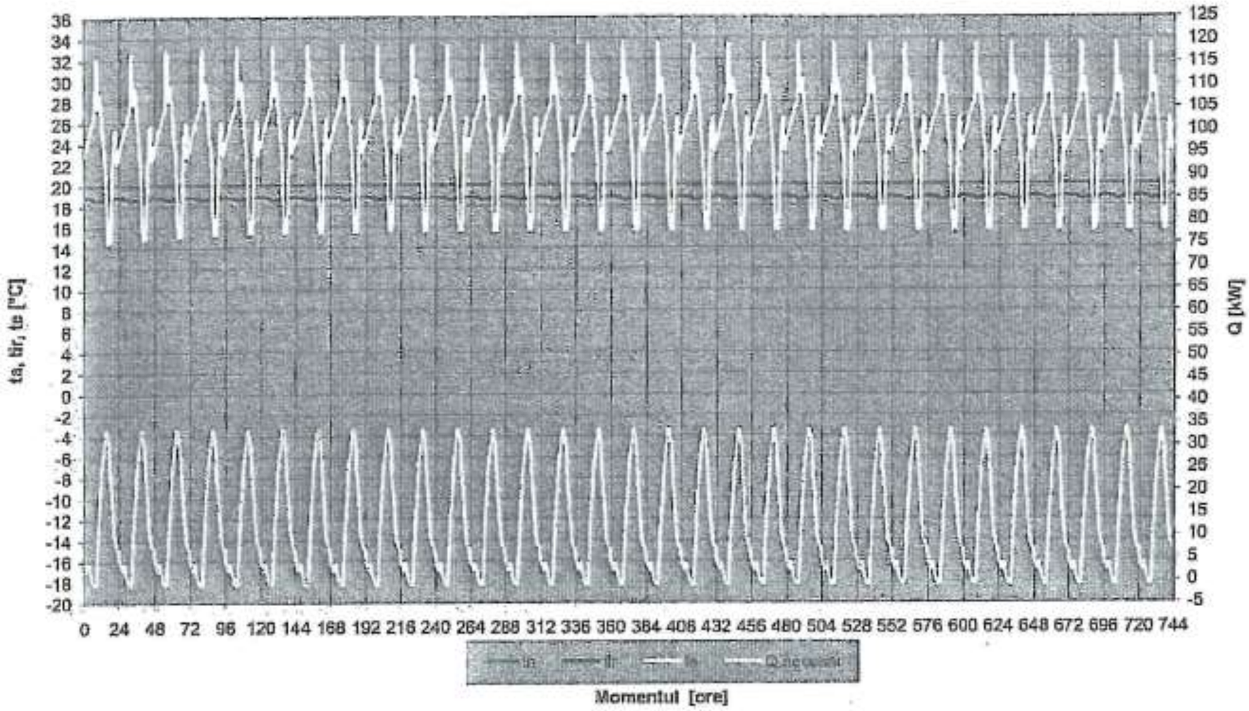

Figure III.11: Significant temperatures (hourly values - Q = 0) for a new office building, free-running temperatures, mechanical ventilation, Rg = 26.64 % - calculation winter - Bucharest
Key:
Bottom: Time (hours)

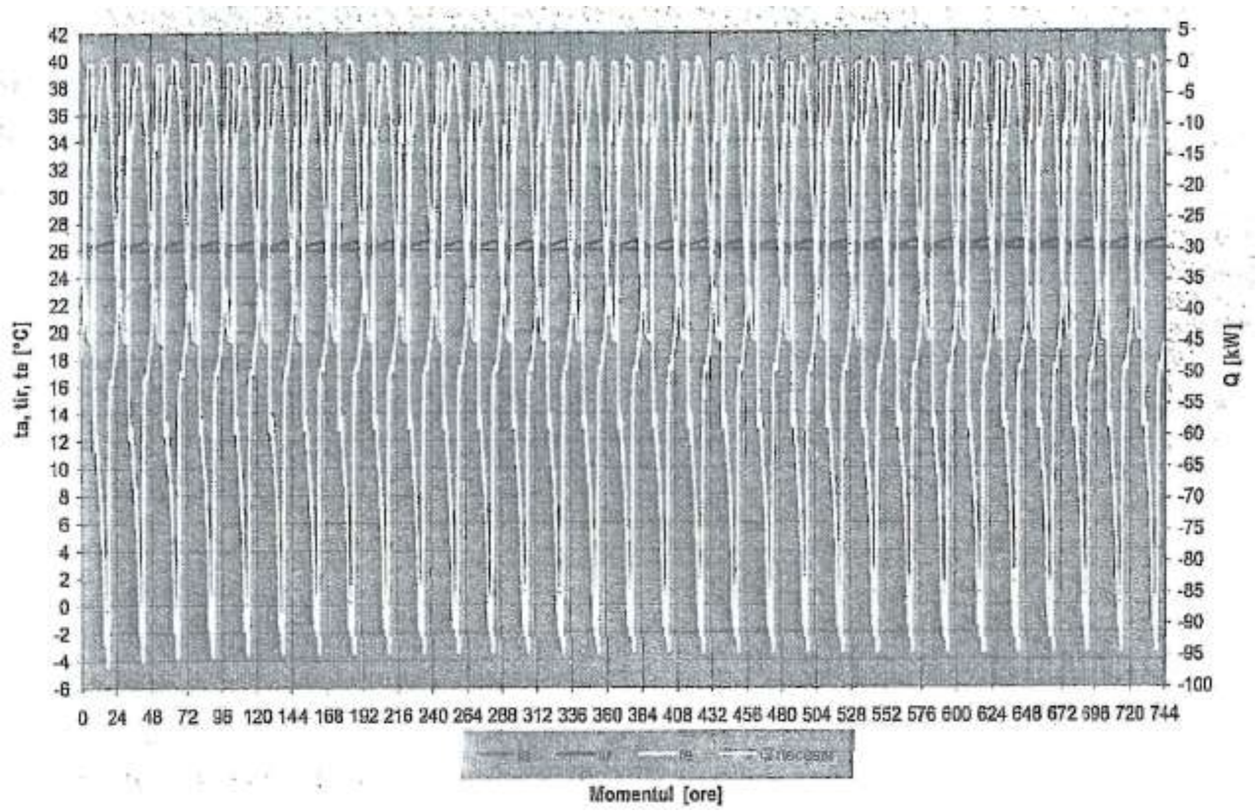

Figure III.12: Significant temperatures and thermal flow (hourly values) for a new office building, air conditioning, mechanical ventilation, Rg = 26.64 % - calculation summer - Bucharest
Key:
Bottom: Time (hours)

III.1.4 Temperature control strategy for the summer season

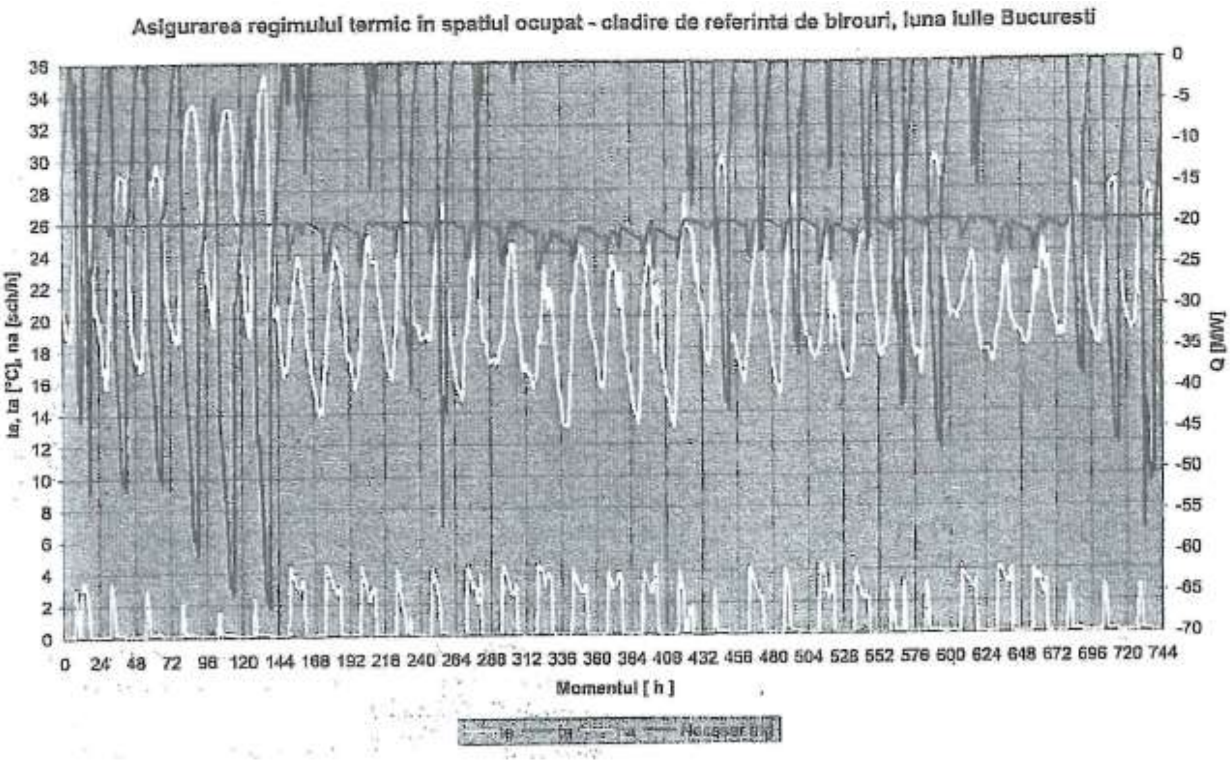

Figure III.13: Cooling through natural/mechanical ventilation and artificial cooling
Key:
Top: Achieving temperature conditions in the space used - reference office building - July, Bucharest
Bottom: Time (hours)

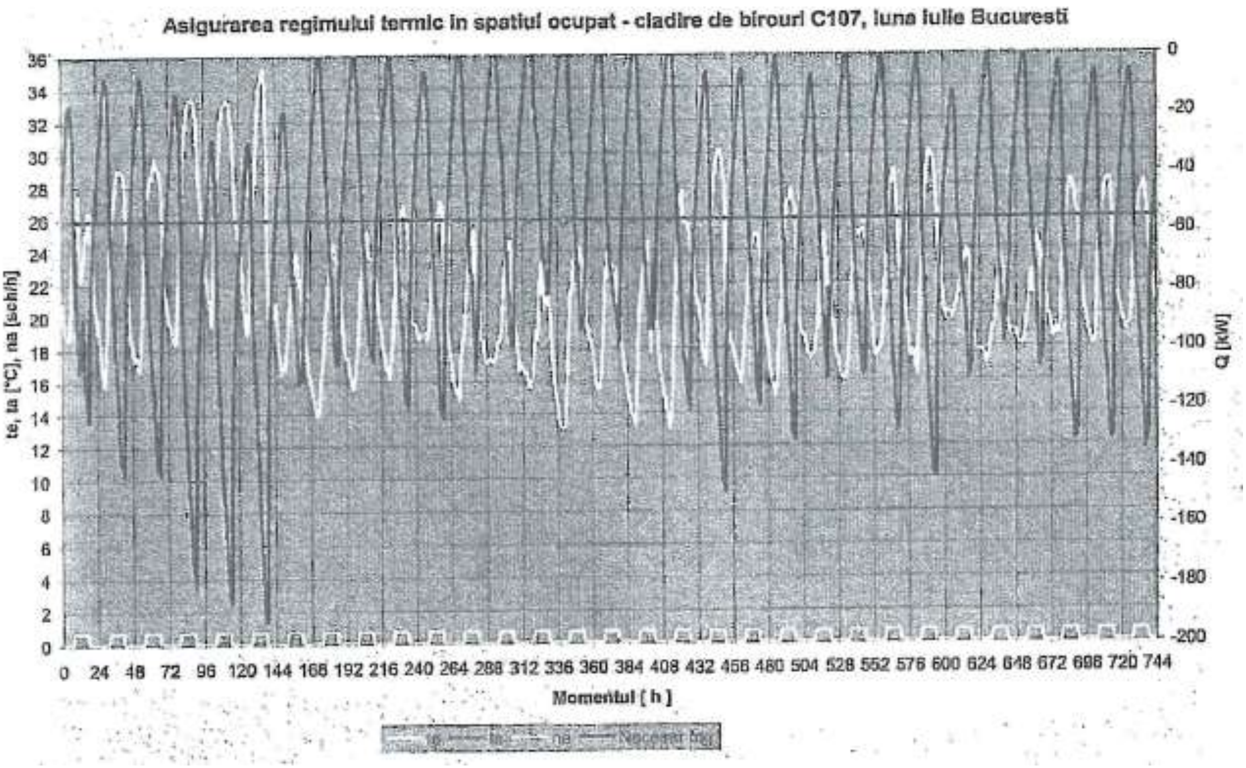

Figure III.14: Cooling through mechanical ventilation and artificial cooling
Key:
Top: Achieving temperature conditions in the space used - C107 building - July, Bucharest
Bottom: Time (hours)

III.1.5 Monthly values for heating requirements for the spaces used and cooling requirements

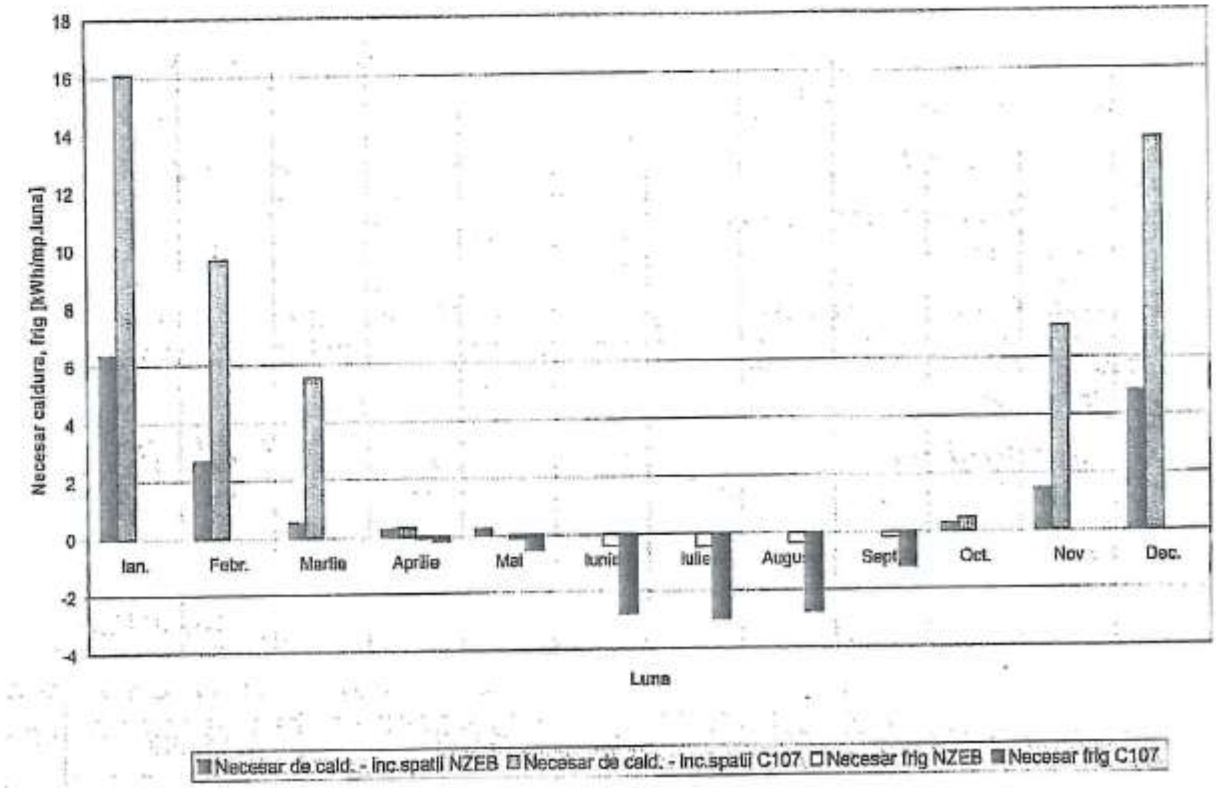

Figure III.15: Heating and cooling requirements for NZEBs and C107 buildings - office buildings, climate zone II
Key:
Horizontal: Month
Vertical: Heating and cooling requirements (kWh/m^{2}month)
Bottom: Heating requirements - NZEB, Heating requirements - C107, Cooling requirements - NZEB, Cooling requirements - C107

III.2 Input data and dynamic modelling strategies for the energy behaviour of apartment blocks (climate zones I, II, III, and IV)

Given the high presence in urban areas, and the energy implications in respect of the energy targets under the Europe 2020 strategy, as well as the issue of the sustainability of urban areas, the analysis is based on four climate zones.

The characteristics of the envelope (both the opaque and the transparent parts) are the same as those of the reference apartment blocks.

Ensuring the indoor microclimate involves mechanical ventilation, for each apartment, combined with heat recovery from the ventilated air being removed. An essential element in sensibly reducing energy consumption is the fitting of buildings with mobile thermo-insulating shutters and mobile blinds, used during the summer season.

The tables below present a summary of the heating requirements (heating and domestic hot water), cooling requirements and power requirements for the reference duplex C107 building, for climate zones I, II, III, and IV.

Climate zone I

Table III.2

Energy factor	Reference building	C107 building
Heating requirements (kWh/m^{2}year)	7.58	28.78
Cooling requirements (kWh/m^{2}year)	0.00	5.25
Domestic hot water requirements (kWh/m^{2}year)	61.25	61.21
Lighting and equipment requirements (kWh/m^{2}year)	28.36	28.36
Energy requirements for mechanical ventilation (kWh/m^{2}year)	4.56	-
Total (kWh/m^{2}year)	101.71	123.60

Climate zone II

Table III.3

Energy factor	Reference building	C107 building
Heating requirements (kWh/m^{2}year)	11.42	40.99
Cooling requirements (kWh/m^{2}year)	0.00	4.71
Domestic hot water requirements (kWh/m^{2}year)	61.21	61.21
Lighting and equipment requirements (kWh/m^{2}year)	28.36	28.36
Energy requirements for mechanical ventilation (kWh/m^{2}year)	4.56	-

Total (kWh/m^{2}year)	105.56	135.27

Climate zone III

Table III.4

Energy factor	Reference building	C107 building
Heating requirements (kWh/m^{2}year)	12.65	43.42
Cooling requirements (kWh/m^{2}year)	0.00	5.62
Domestic hot water requirements (kWh/m^{2}year)	61.21	61.21
Lighting and equipment requirements (kWh/m^{2}year)	28.36	28.36
Energy requirements for mechanical ventilation (kWh/m^{2}year)	4.56	-
Total (kWh/m^{2}year)	106.78	138.61

Climate zone IV

Table III.5

Energy factor	Reference building	C107 building
Heating requirements (kWh/m^{2}year)	18.67	57.13
Cooling requirements (kWh/m^{2}year)	0.00	0.73
Domestic hot water requirements (kWh/m^{2}year)	61.21	61.21
Lighting and equipment requirements (kWh/m^{2}year)	28.36	28.36
Energy requirements for mechanical ventilation (kWh/m^{2}year)	4.56	-

Total (kWh/m^{2}year)	112.8	147.43

The analysis of the four tables above shows the sensible effect of the heat recovery units, during the cold season, and of the passive measures used during the summer season. Furthermore, the difference of maximum 11.85 % between the maximum (climate zone IV) and the minimum (climate zone I) leads to the conclusion that the NZEB solution can be used anywhere in Romania.

Another conclusion is that the passive solution and the systems that include heat recovery units lead to a balancing of energy requirements between the thermal factor and electricity.

Table III.6

Energy factor	Reference building	C107 building
Thermal factor	21.92	58.00
Electricity	21.83	29.74

In the case of apartment blocks, the difference in favour of the thermal factor continues to be significant:

Table III.7

Energy factor	Reference building	C107 building
Thermal factor	72.63	106.9
Electricity	32.92	28.36

Therefore, the use of renewable energy sources (RES) for electricity has a major impact in the case of offices, and efficient high-performance cogeneration/tri-generation systems are recommended for residential areas made of apartment blocks.

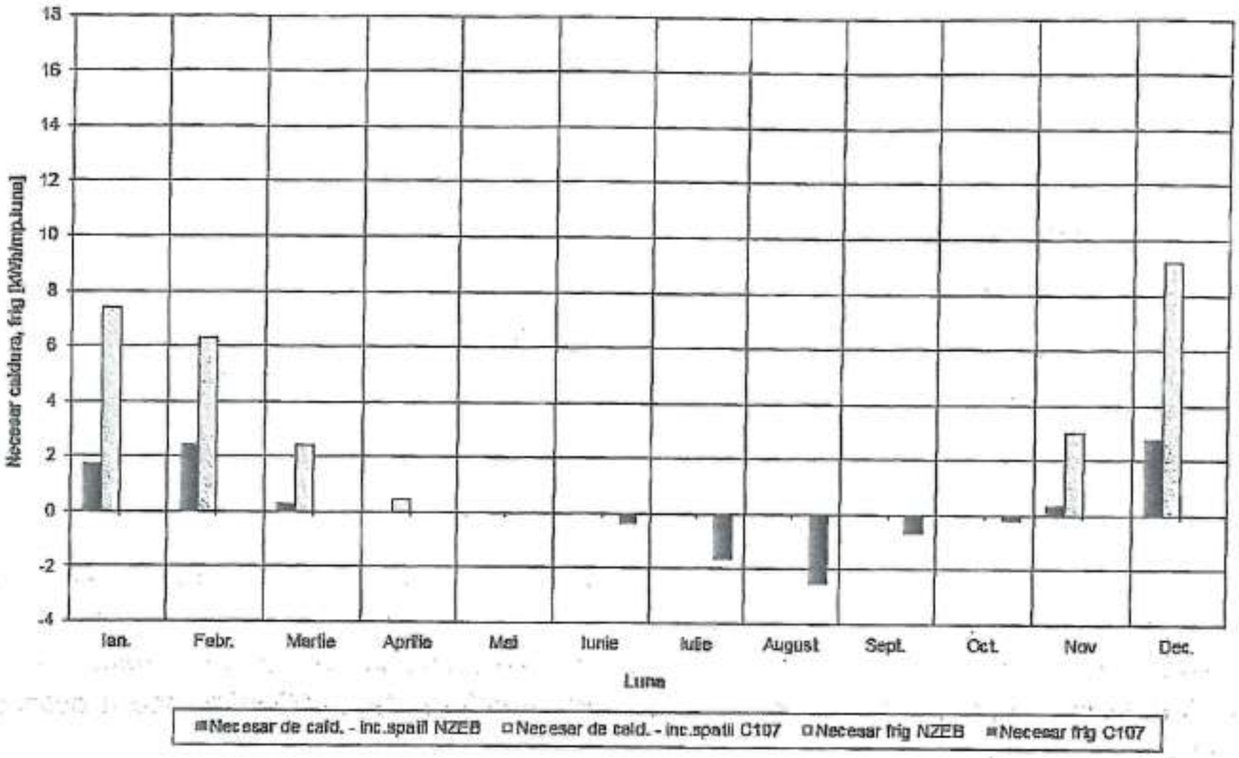

Figure III.16: Heating and cooling requirements for NZEBs and C107 buildings - apartment blocks, climate zone I
Key:
Horizontal: Month
Vertical: Heating and cooling requirements (kWh/m^2month)
Bottom: Heating requirements - NZEB, Heating requirements - C107, Cooling requirements - NZEB, Cooling requirements - C107

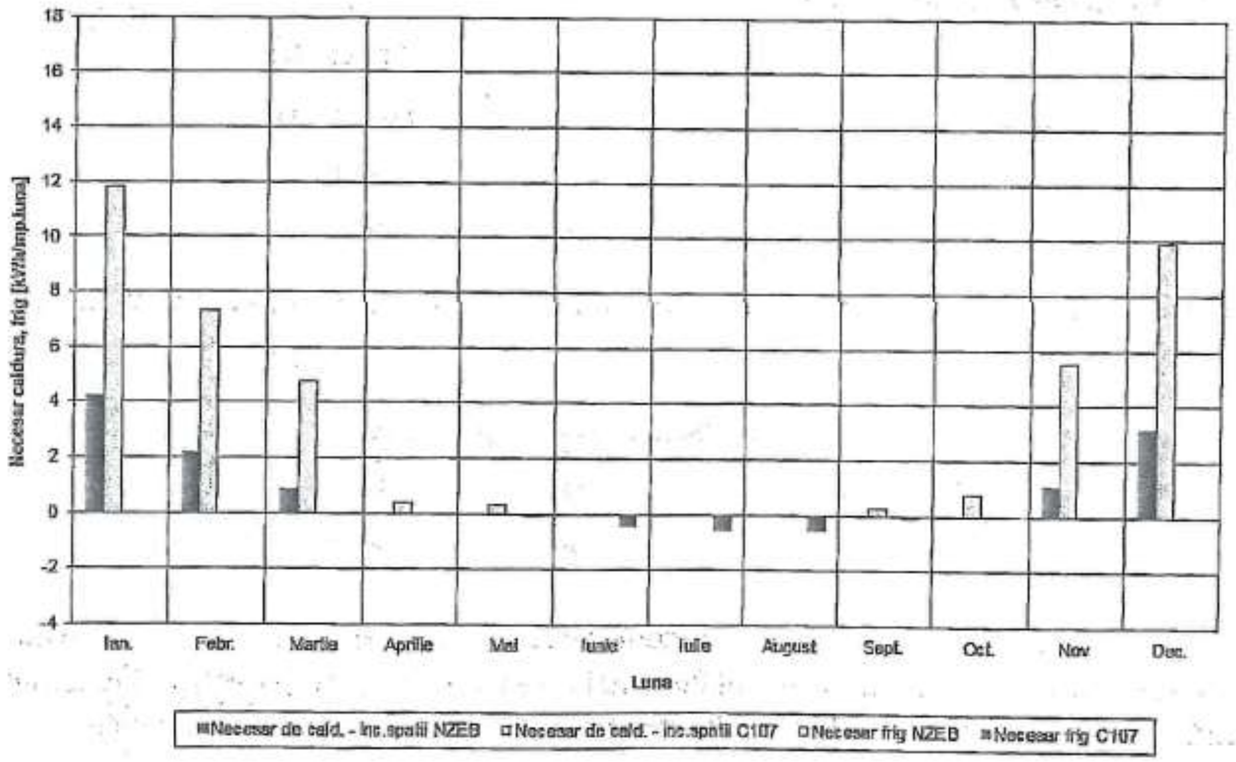

Figure III.17: Heating and cooling requirements for NZEBs and C107 buildings - apartment blocks, climate zone II
Key:
Horizontal: Month
Vertical: Heating and cooling requirements (kWh/m^2month)
Bottom: Heating requirements - NZEB, Heating requirements - C107, Cooling requirements - NZEB, Cooling requirements - C107

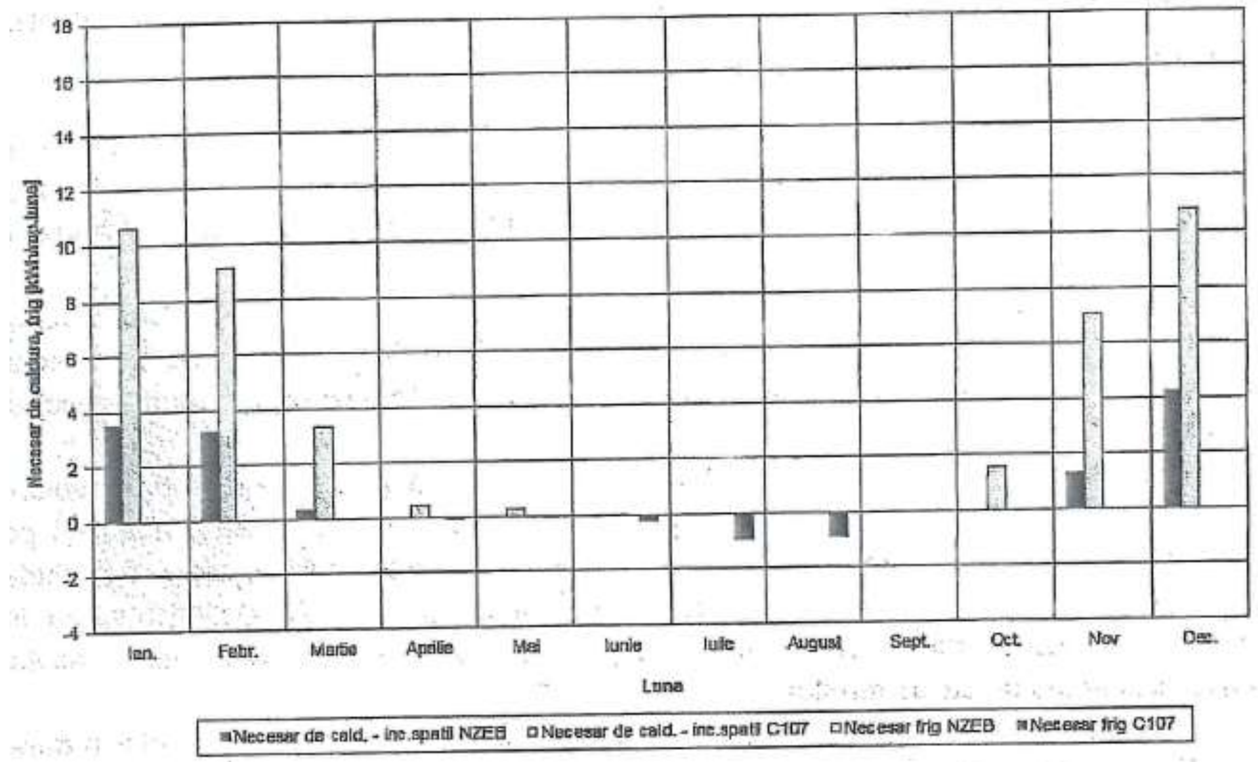

Figure III.18: Heating and cooling requirements for NZEBs and C107 buildings - apartment blocks, climate zone III
Key:
Horizontal: Month
Vertical: Heating and cooling requirements (kWh/m^2month)
Bottom: Heating requirements - NZEB, Heating requirements - C107, Cooling requirements - NZEB, Cooling requirements - C107

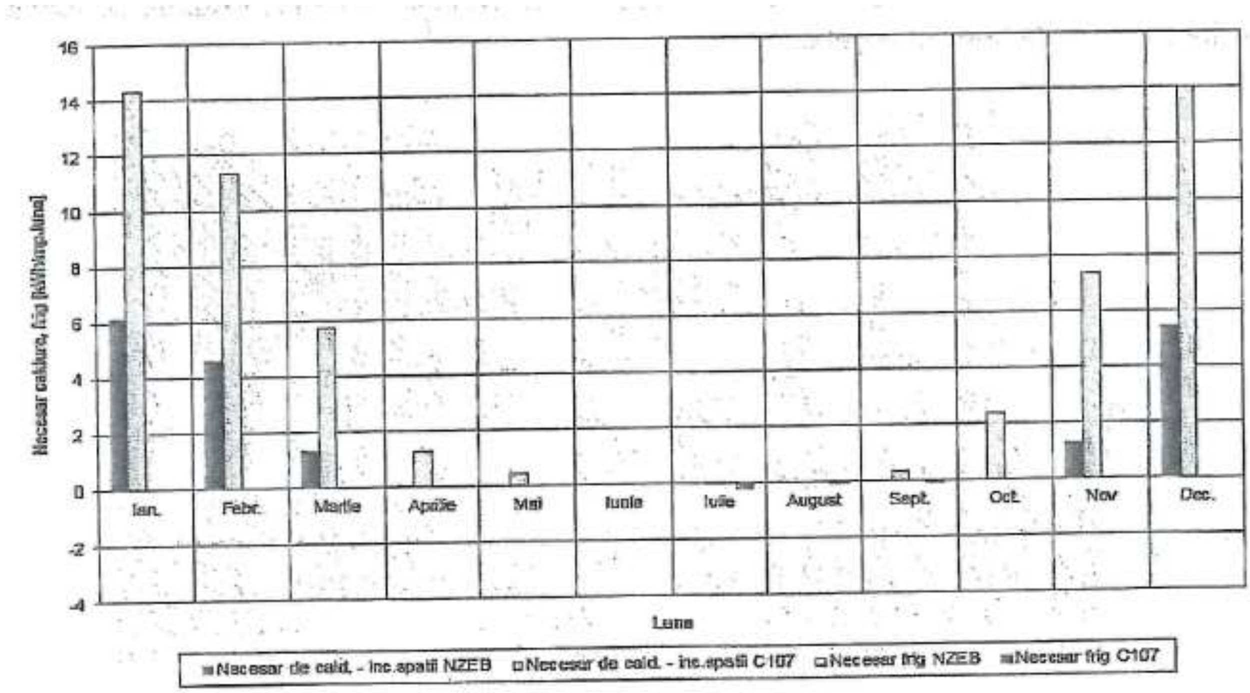

Figure III.19: Heating and cooling requirements for NZEBs and C107 buildings - apartment blocks, climate zone IV
Key:
Horizontal: Month
Vertical: Heating and cooling requirements (kWh/m^{2}month)
Bottom: Heating requirements - NZEB, Heating requirements - C107, Cooling requirements - NZEB, Cooling requirements - C107

III.3 Input data and dynamic modelling strategies for the energy behaviour of single-family buildings (climate zones I, II, III, and IV)

The reference building has a ventilated solar area that also includes the hot water installation based on solar energy. Annexes 1 and 2 to this study present the modelling of the thermal response of the solar area and the solar installation for hot water.

The ventilated solar area works as a heat recovery system. The summary chart presenting the heating requirements for the reference building and the C107 building demonstrates the extremely important impact that the solar area has on the energy requirements (thermal factor) of an individual building.

Figures III.22 and III.25 highlight the utility of the hot water solar installation placed inside the solar area. It should be noted that air temperature in the solar area is positive during the cold season, which makes it unnecessary to have a heat exchanger as a part of the solar installation (elimination of the source of entropy caused by an average temperature difference is greater than zero between the primary circuit and the heat storage unit).

The energy configuration of the reference building shows that the solar area significantly reduces heating requirements by comparison with the C107 building. The thermal resistance of the envelope is 3.67 m^{2}K/W, compared with 2.502 m^{2}K/W in the case of the C107 building. This is an additional argument in favour of the possibility of configuring individual residential buildings as NZEBs, which would have a major impact on the national energy balance.

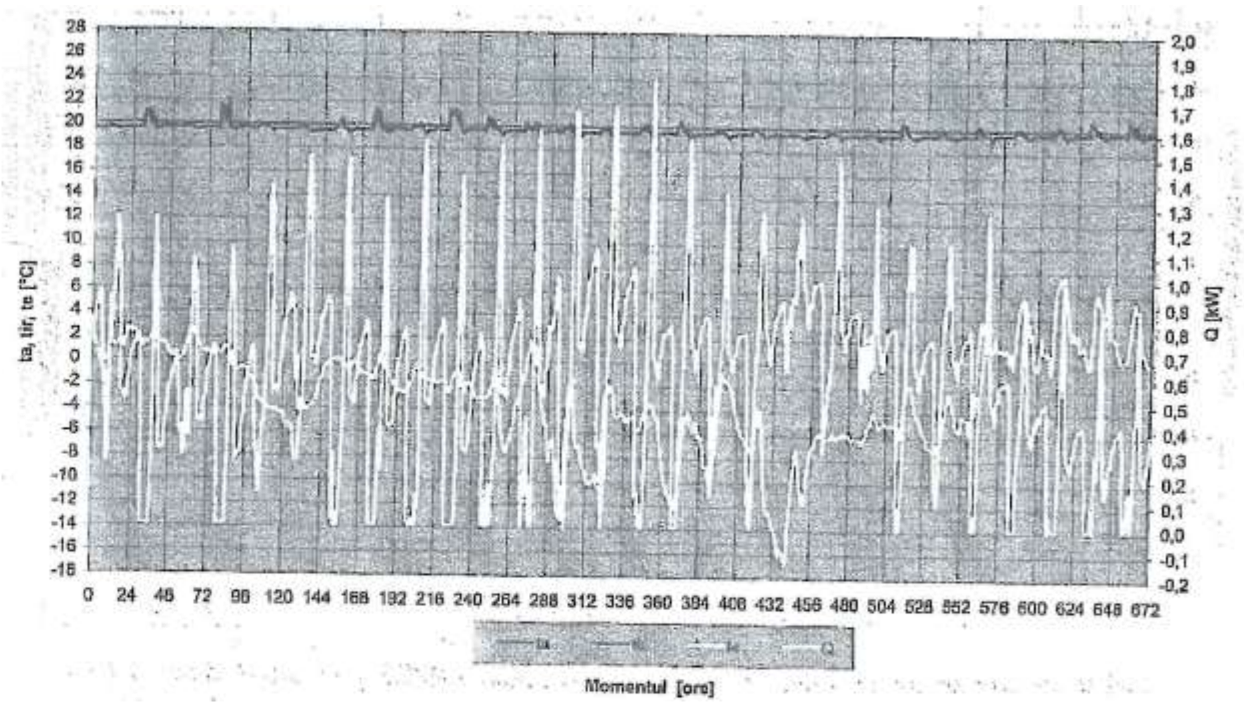

Figure III.20: Significant temperatures and thermal flow (hourly values) for the reference single-family building, air conditioning - January, climate zone II
Key:
Bottom: Time (hours)

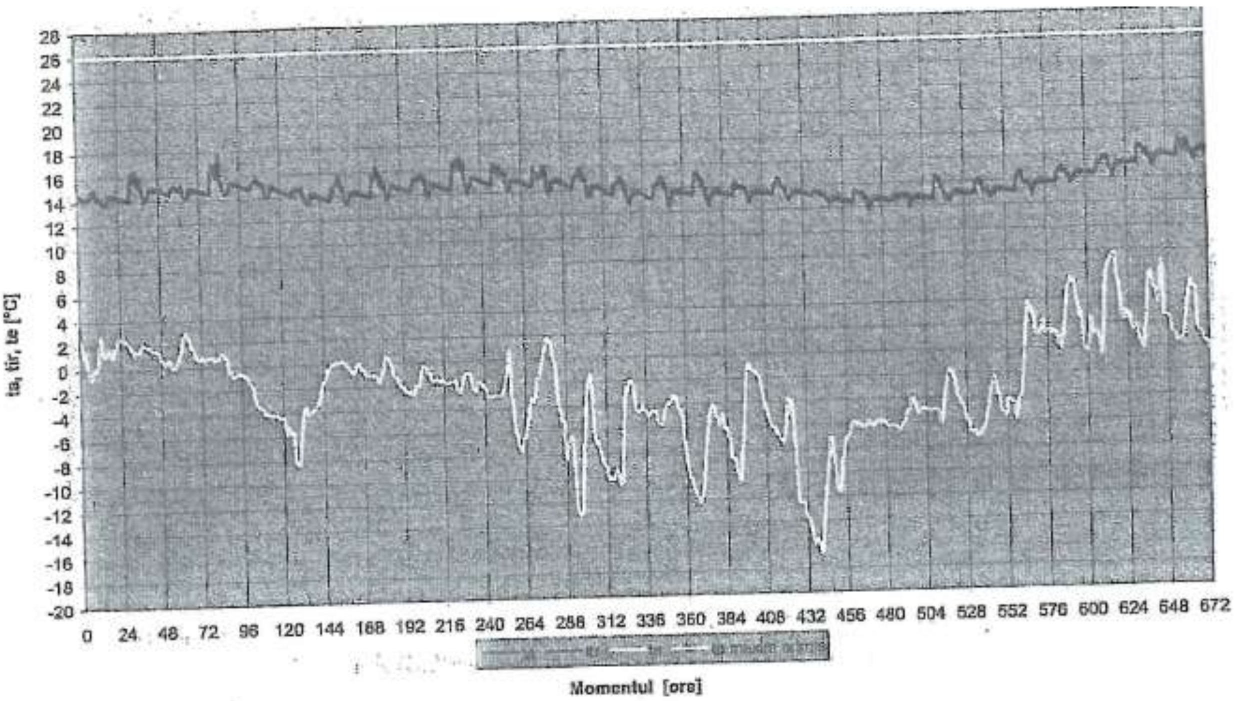

Figure III.21: Significant temperatures (hourly values - Q = 0) for the reference single-family building, free-running temperatures - January, climate zone II
Key:
Bottom: Time (hours)

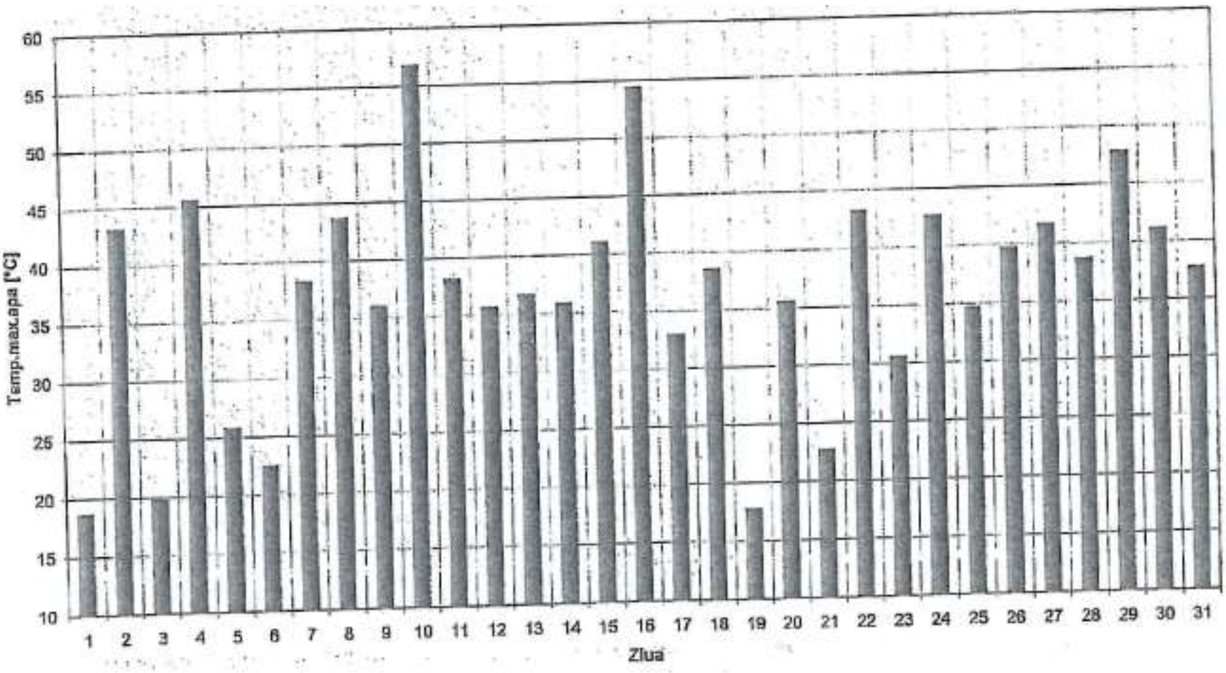

Figure III.22: Maximum daily temperature of the water in the heat storage unit - January, typical climate year - solar installation placed in the solar area, climate zone II
Key:
Horizontal: Day
Vertical: Maximum water temperature (ºC)

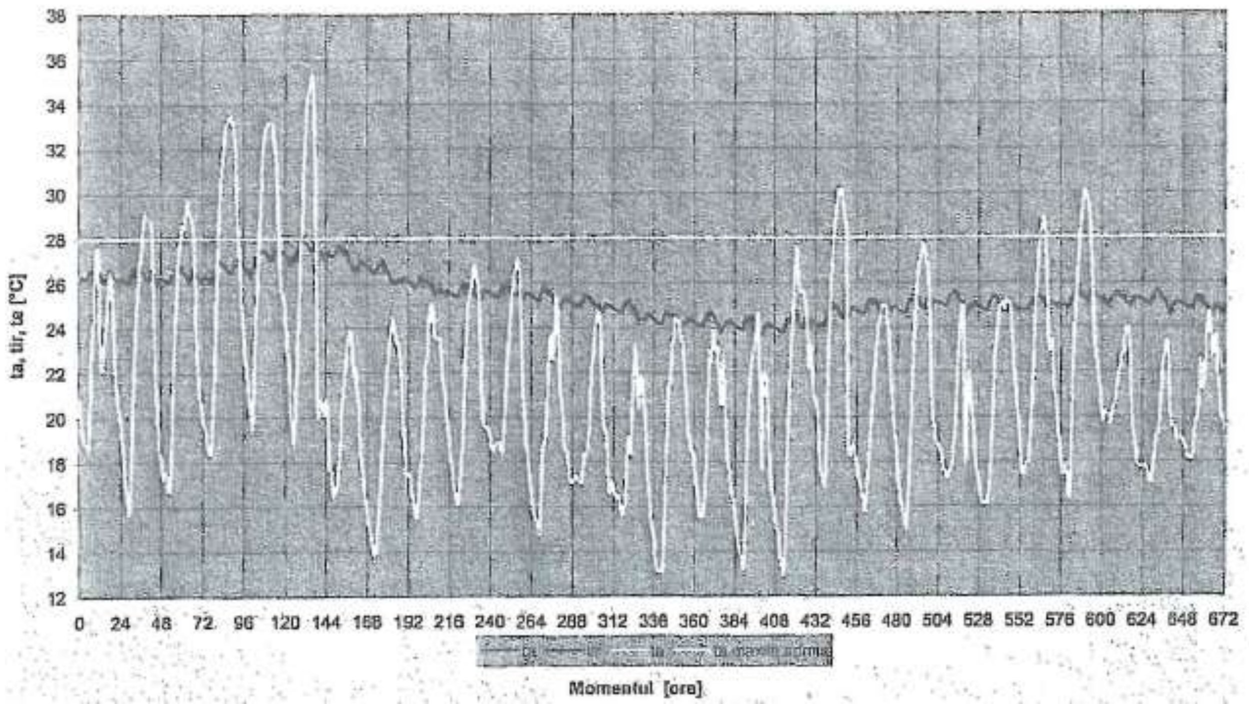

Figure III.23: Significant temperatures (hourly values - Q = 0) for the reference single-family building, free-running temperatures - July, climate zone II
Key:
Bottom: Time (hours)

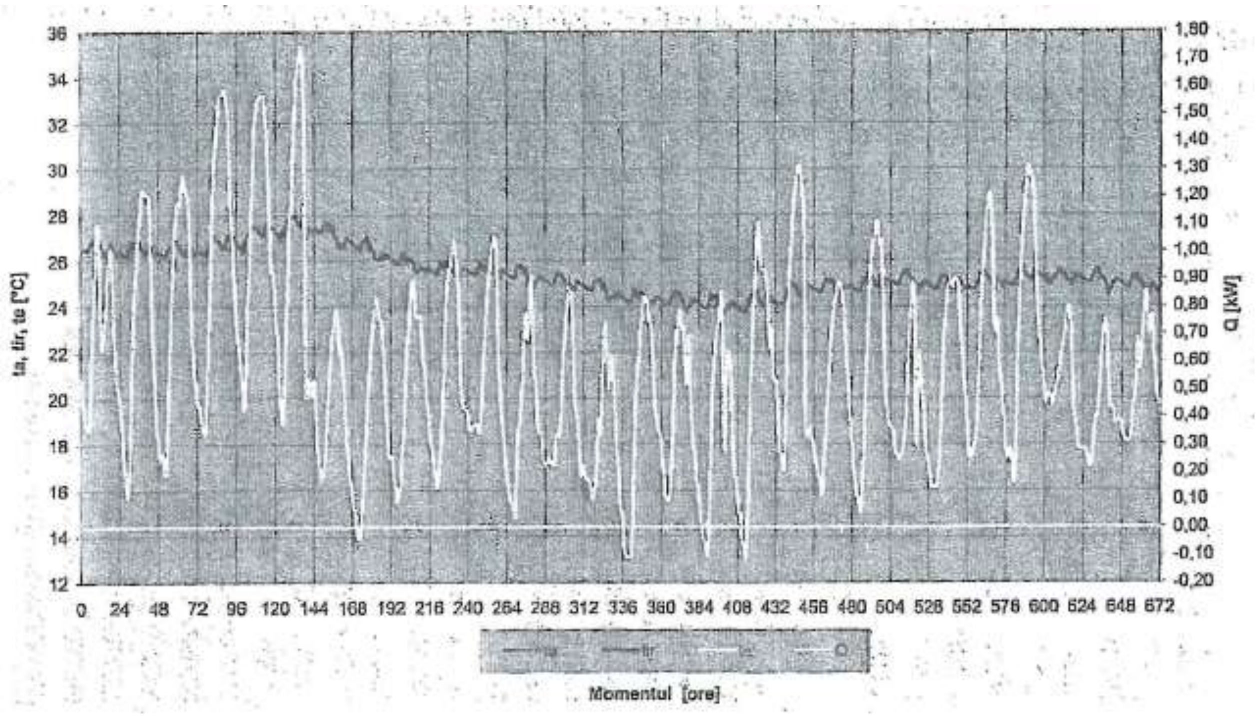

Figure III.24: Significant temperatures and thermal flow (hourly values) for the reference single-family building, air conditioning - July, climate zone II
Key:
Bottom: Time (hours)

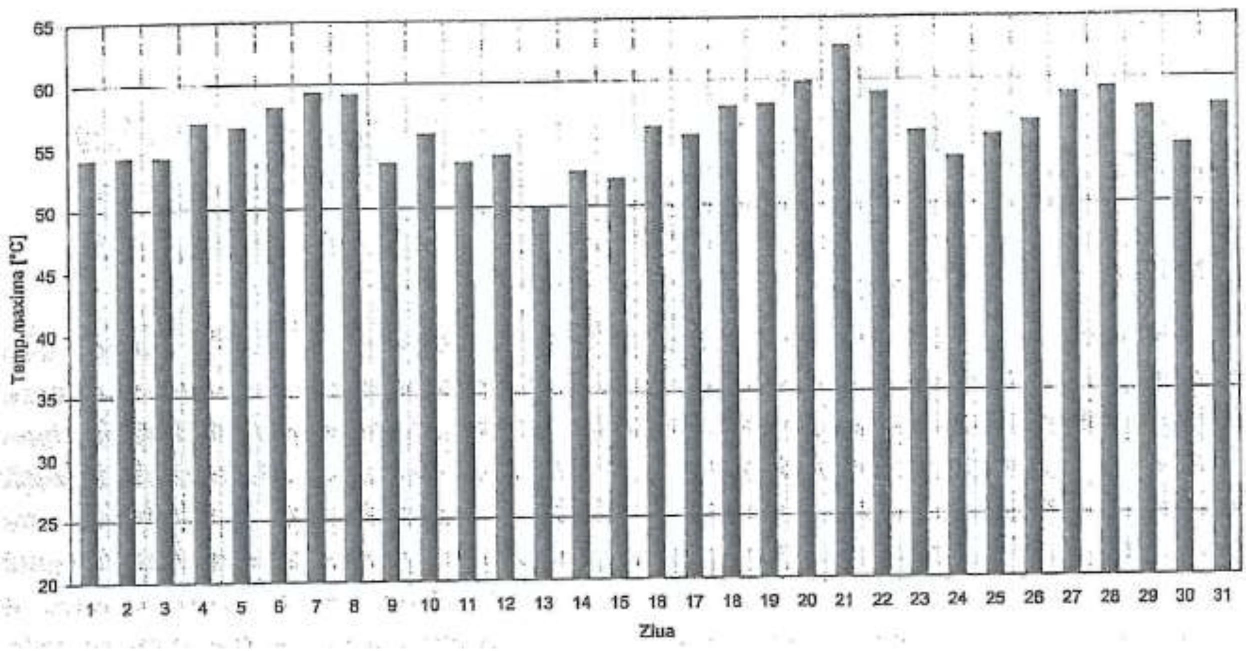

Figure III.25: Maximum day temperature - July, typical climate year, climate zone II - heat storage unit for solar hot water - individual residential building
Key:
Horizontal: Day
Vertical: Maximum temperature (ºC)

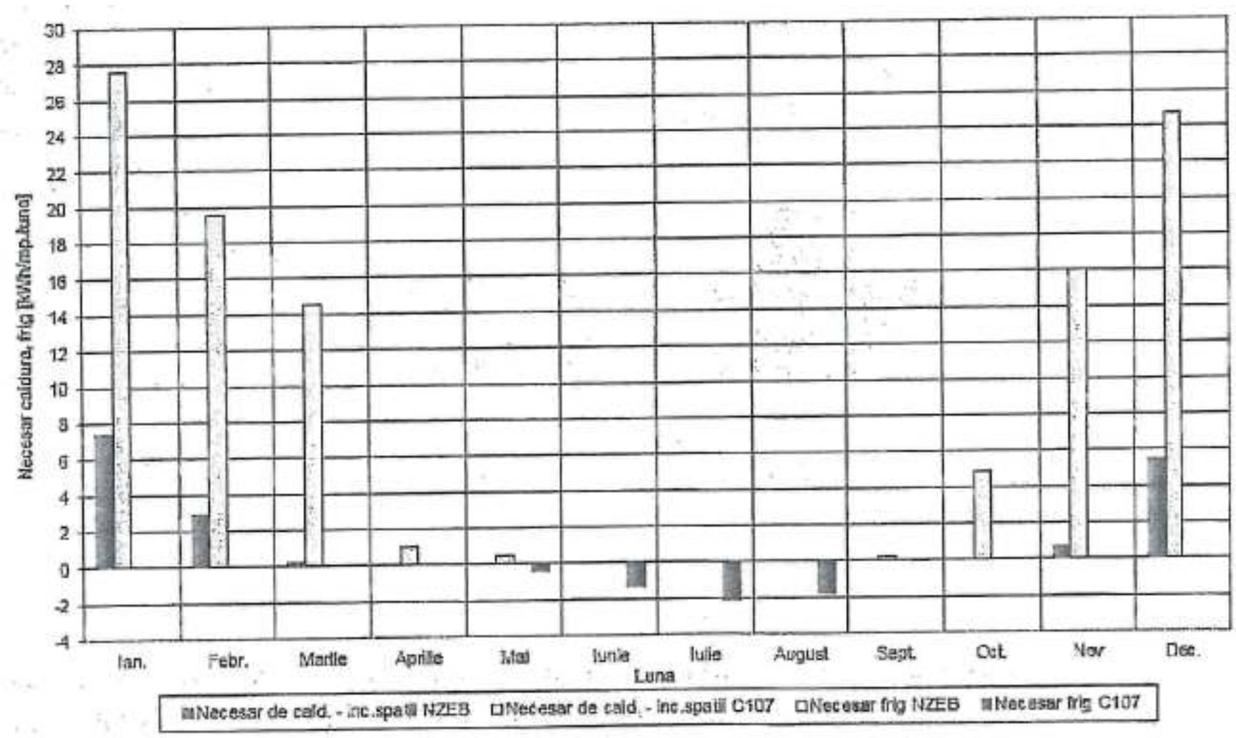

Figure III.26: Heating and cooling requirements for NZEBs and C107 buildings - single-family buildings, climate zone II
Key:
Horizontal: Month
Vertical: Heating and cooling requirements (kWh/m^{2}month)
Bottom: Heating requirements - NZEB, Heating requirements - C107, Cooling requirements - NZEB, Cooling requirements - C107

Chapter IV - Estimating primary energy for the operation of buildings

IV.1 Methodology

Directive 2010/31/EU imposes the construction of NZEBs (Article), but the definition of the general framework for energy efficiency calculations rests with each of the Member States of the EU. The characteristics of the calculation methods are covered in Article 3 of the aforementioned Directive. The general framework for energy efficiency calculations must be based on energy delivered and exported, in accordance with SR EN 15603: 2008. The chart in figure III.1 is a symbolic and simplified representation of the energy balance of a building (energy values resulting from the time-based integration of extensive thermodynamic parameters representing energy flows). Primary energy is calculated using primary energy factors f_i (in the simplified model the same factors are used for the factors of delivered and exported energy). The case studies in this document refer to conversion coefficients differentiated based on the efficiency of the generation, transmission and distribution systems.

$$E = \sum_i (E_{del,i} - E_{\exp,i}) \cdot f_i$$

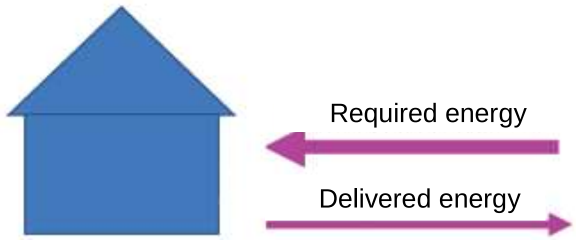

Figure III.1: Net energy and primary energy

IV.2. Energy-related requirements

To obtain a correct definition, the NZEB building identified via the primary energy indicator refers to the specific energy calculation framework, which includes the following elements:

• System boundaries for the net energy delivered (in accordance with SR EN 15603: 2008);

• Standard input data for energy calculation (in accordance with SR EN 15251: 2007);

• Reference to the typical climate year, used in energy calculations (in accordance with SR EN ISO 15927-4: 2005). In the case of Romania, there are typical climate years determined for nine localities with satisfactory national representativeness;

• Primary energy conversion coefficients (in accordance with SR EN 15603: 2008). The conversion coefficients are used in accordance with the European standard and the national data (electricity – ANRE 2012 annual report).

IV.3. Calculation methodology suitable for NZEBs

Article 2 of Directive 2010/31/EU (recast) defines energy performance as follows: "'nearly zero-energy building" means a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby'.

IV.4 Thermodynamic contour and processes

The summary chart in figure III.2 shows the correlation between the demand for utilities and the consumption of utilities on the basis of the structure of the property flows at the level of the thermodynamic contour of the building's areas, and of the efficiency of generating and supplying energy inside the building. The fundamental European standard used to draw also the local Calculation Methodology (Mc 001/2006) is SR EN ISO 13790: 2009 (2005 version). It contains simplified calculation methods (with seasonal, monthly and hourly time steps) recommended for determining the demand for thermal utilities. The proposed calculation methods are in admissible compliance with the local calculation methods (NP 048-2000, as amended in 2006) also for buildings that are medium-sized in terms of heating requirements, i.e. around 250 kWh/m^{2}year (with reference to buildings located in winter climate zone II, with maximum national representativeness for urban areas).

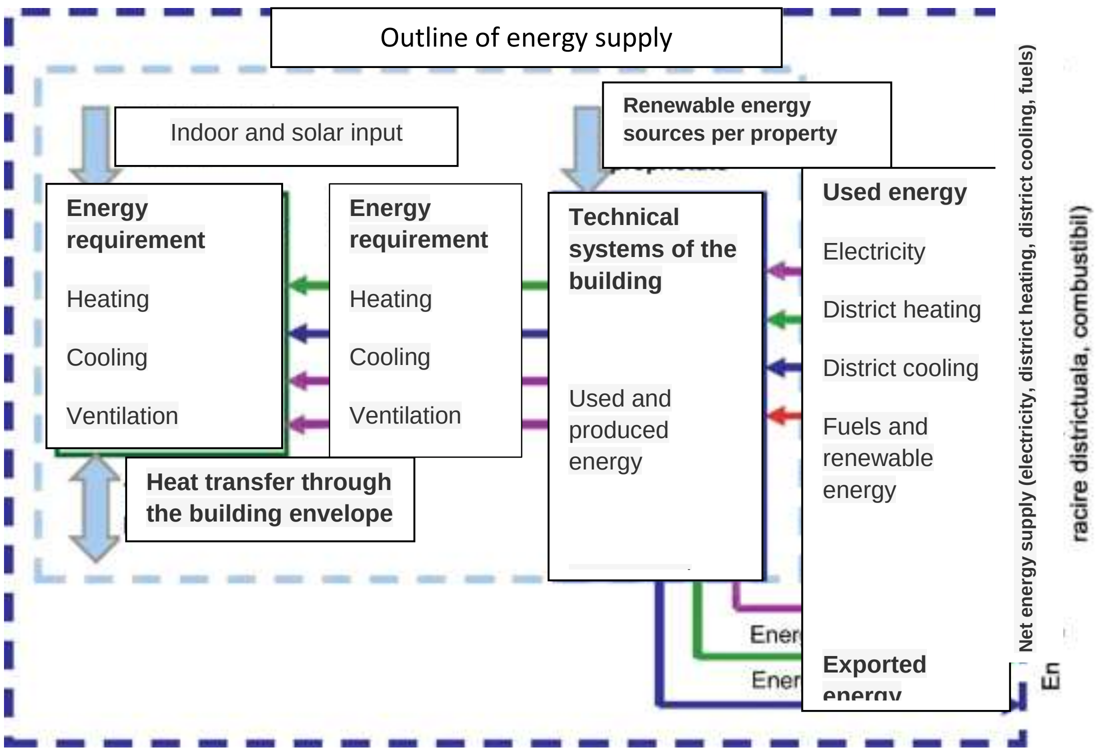

Figure III.2: Energy boundaries for the net energy supply

IV.5 Primary energy conversion coefficients

Energy conversion coefficients used for primary energy at the end consumer. They are values that complement the data in Chapter II.1.10 of the Calculation Methodology Mc 001-2/2006.

Type of energy/fuels	Conversion coefficient
Electricity	2.62
Natural gas	1.17
Heating (cogeneration)	0.92
High-efficiency cogeneration	0.30
Pellets	1.08

The significance of subunit values is derived from the method of defining the efficiency of cogeneration systems. The efficiency of cogeneration is defined as the sum of the partial efficiency of generating electricity and heat at system level:

$$\eta_{CG} = \eta_E + \eta_T$$

The cogeneration index is defined as follows:

$$y = \frac{\eta_E}{\eta_T}$$

$Q_{f\,E}$ is the quantity of electricity delivered by the cogeneration system, and $Q_{f\,T}$ is the heat delivered by the system. Both are measured at the 'fence' of the energy source. Based on the efficiencies given above, for the two forms of energy, cogeneration efficiency is defined as follows:

$$\eta_{CG} = \frac{Q_{fE} + Q_{fT}}{\frac{Q_{fE}}{\eta_E} + c_T \cdot Q_{fT}}$$

This can be rewritten as below.

$$\eta_{CG} = \frac{1+y}{\frac{y}{\eta_E} + c_T}$$

This in turn gives the primary energy conversion coefficient for thermal energy:

$$c_T = \frac{1+y}{\eta_{CG}} - \frac{y}{\eta_E}$$

The charts below present the variation of the conversion coefficient for thermal energy depending on the system's cogeneration efficiency. The cogeneration solutions (heating index y[1]) taken into account are the following:

[1] European Commission - low and high power cogeneration - ENERO, May 2002

Cogeneration solution	Heating index (y)
Internal combustion engine (Otto, Diesel)	0.60 - 0.93
Gas turbine	0.30 - 0.60
Steam turbine	0.21 (steam)

In the case of the thermal factor, the charts also take into account the thermal flow dissipated along the transmission and distribution lines for the primary and secondary heating agents, through the P values representing the equivalent of the dissipation of the integrated thermal flow in the course of the operation of the system, from the quantity of energy produced at the fence of the cogeneration system. In Romania, at present P is 0.20 - 0.25, which reflects the unsuitability of the district heating systems.

Taking the cogeneration efficiency of the local systems (approximately 75 %) as the reference value, it follows that in the system design case (y = 0.21) the conversion coefficient for thermal energy is 1.08. Relative to the data presented in the study, this gives a value of 1.12 for the system used in Bucharest (y = 0.1764).

Producing power and heat separately has an efficiency value for the use of primary energy that can be calculated as follows:

$$\eta_S = \frac{1+y}{\dfrac{y}{\eta_E} + \eta_T^{-1}}$$

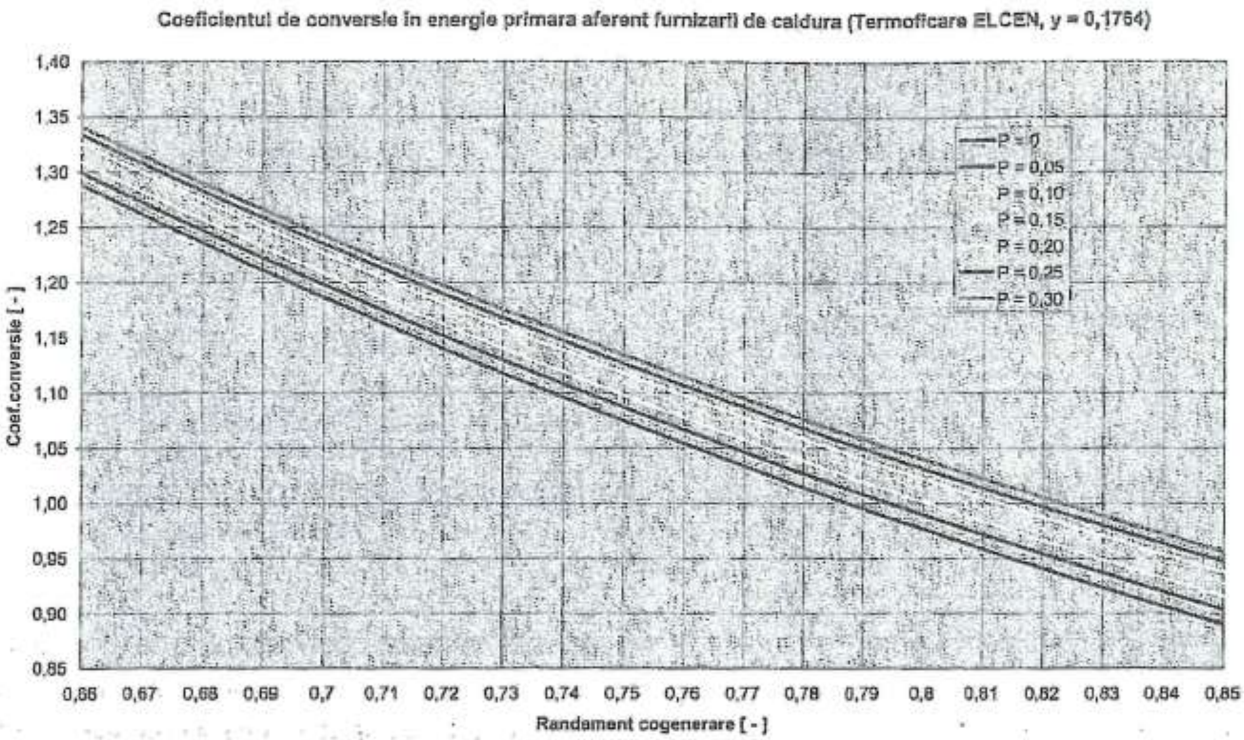

Figure IV.3: Conversion coefficient for the district heating system used in Bucharest[1]
Key:
Top: Primary energy conversion coefficient for the heat supply (ELCEN district heating, y = 0.1764)
Horizontal: Cogeneration efficiency
Vertical: Conversion coefficient

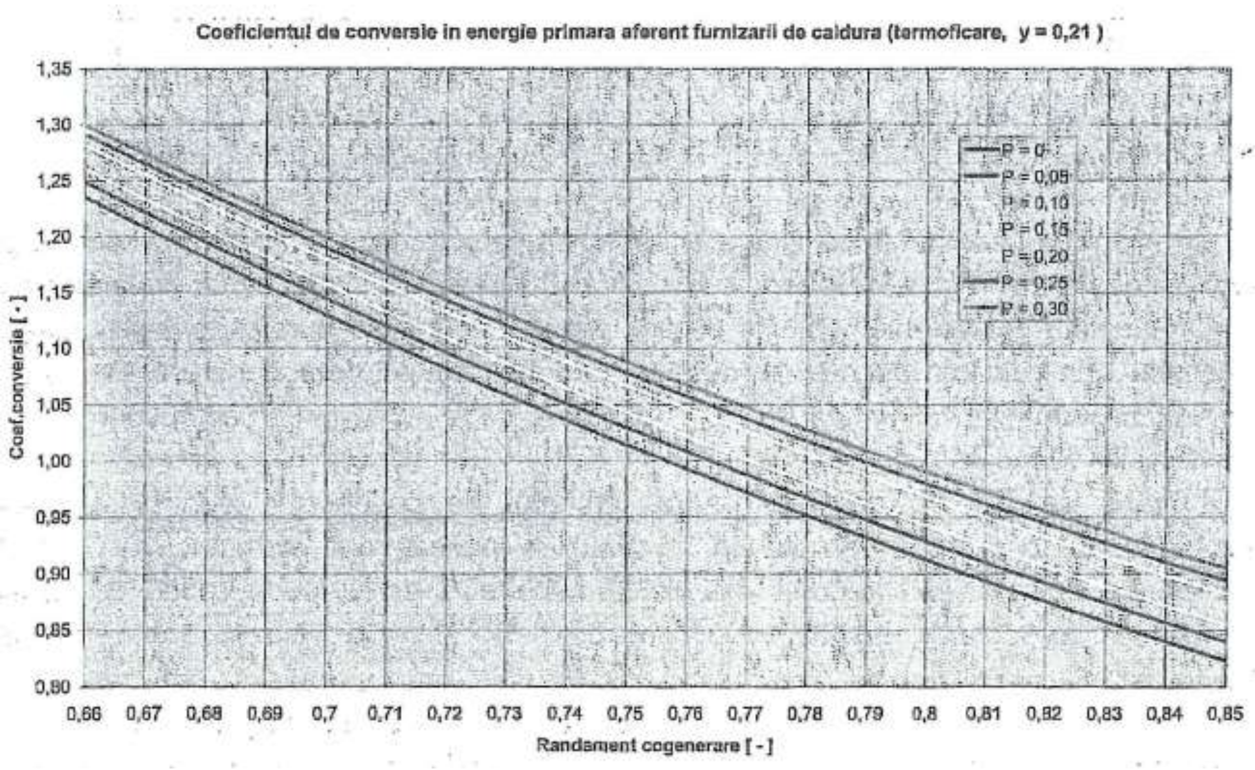

Figure IV.4: Conversion coefficient for the district heating system - local system
Key:
Top: Primary energy conversion coefficient for the heat supply (district heating, y = 0.21)
Horizontal: Cogeneration efficiency
Vertical: Conversion coefficient

[1] Cetacli, Dan S *Cogeneration and district heating, past and present*, FOREN, 2012, Neptun-Olimp, Romania

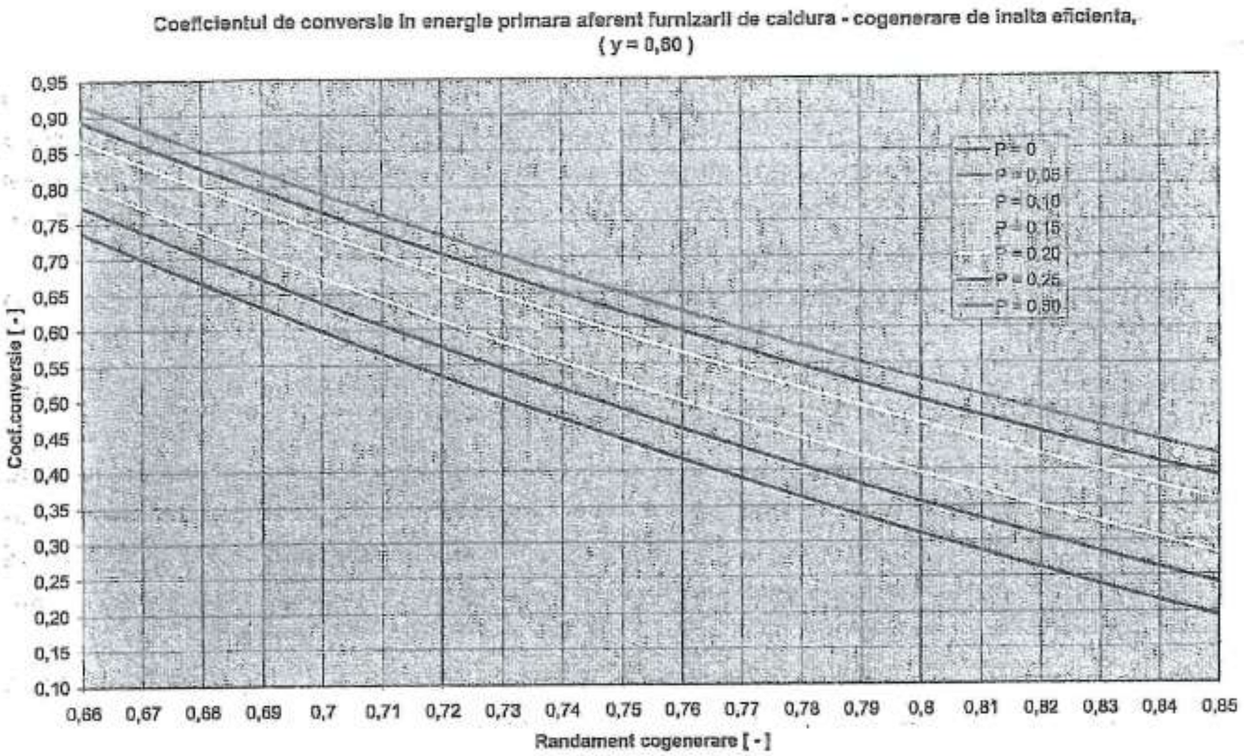

Figure IV.5: Conversion coefficient for high efficiency cogeneration
Key:
Top: Primary energy conversion coefficient for the heat supply - high efficiency cogeneration (y = 0.60)
Horizontal: Cogeneration efficiency
Vertical: Conversion coefficient

The value of y is similar to the heating index. The same symbol is used exclusive for comparing the performance of the two systems (cogeneration and separate production of power and heat). The usual values for high performance heat and power plants are the following:

$$\eta_E = 0{,}36, \qquad \eta_T = 0{,}90$$

This gives η_S = 0.733 for y = 0.1764, which is very close to the cogeneration efficiency value of 0.75. These values (partially) justify the campaign for disconnecting buildings from the district heating system. If energy-efficient buildings are built and the solutions identified by the optimal cost analysis are used for existing buildings undergoing an energy upgrade, the equivalent value of the y coefficient ranges from 0.25 to 0.35, which leads to η_s efficiency values between 0.69 and 0.64. These values require that heat and power utilities be supplied using a high-performance energy system matching the performance of the building. Therefore, a policy of upgrading buildings, both new and existing, in accordance with Directive 2010/31/EU without correlating it with the promotion of high efficiency cogeneration is an error illustrated by the negative trend in the energy efficiency of the buildings and the individual systems for supplying heat and power utilities. In the light of the definition of nearly zero energy buildings, it is not recommended to resolve this contradiction by developing renewable energy sources instead of a balanced use of high efficiency cogeneration systems, especially in urban areas. Unfortunately, the declarations describing the district heating system in Bucharest as a high efficiency system are a sign of a lack of implication in the real promotion of high efficiency cogeneration in Romania.

If such a project were implemented, for a cogeneration index of y = 0.60 (specific to high efficiency systems) the primary energy conversion coefficient would be reduced to 0.37, which would mean a significant reduction in the consumption of fossil energy resources to cover the demand from urban consumers, and implicitly a significant reduction in harmful emissions.

Given that the findings of this study target the period beyond 2020, the numerical analyses are based on a primary energy conversion coefficient (specific to the cogeneration systems) of 0.92 (heat and power plant upgrades that would lead to a cogeneration efficiency of 80 %).

The solution that can lead to significant savings in fossil fuels is a transition to low and medium-power high efficiency cogeneration systems, which would bring the conversion coefficient down to around 0.30. This solution involves constructing new buildings with low energy consumption and organising residential areas. In the case of existing buildings with high energy consumption (offices, hospitals), low power cogeneration/trigeneration systems are a suitable solution in large urban areas.

IV.6 On-site RES - estimating the energy potential of collecting and converting solar energy into electricity using photovoltaic solar collectors

All building types covered in this study are fitted with photovoltaic panels and the necessary equipment (inverter, accumulator, etc.) to use electricity for domestic purposes (220 V monophasic). The photovoltaic panels have a solar energy collection efficiency of 15% and are placed on the roofs of the buildings. In all the cases, the azimuth is south. The angle of the panels relative to the horizontal plane was determined to maximise the solar energy collected in the course of the year at the level of the freely exposed surface unit. The charts in figures IV.6, IV.7, IV.8 and IV.9 present the solar energy collected and the correction coefficient applied on overall solar radiation in order to determine the energy collected on the plane given by the optimal angle, for each climate zone in Romania. The values of the intensity of overall solar radiation are based on the hourly values specific to the typical climate year.

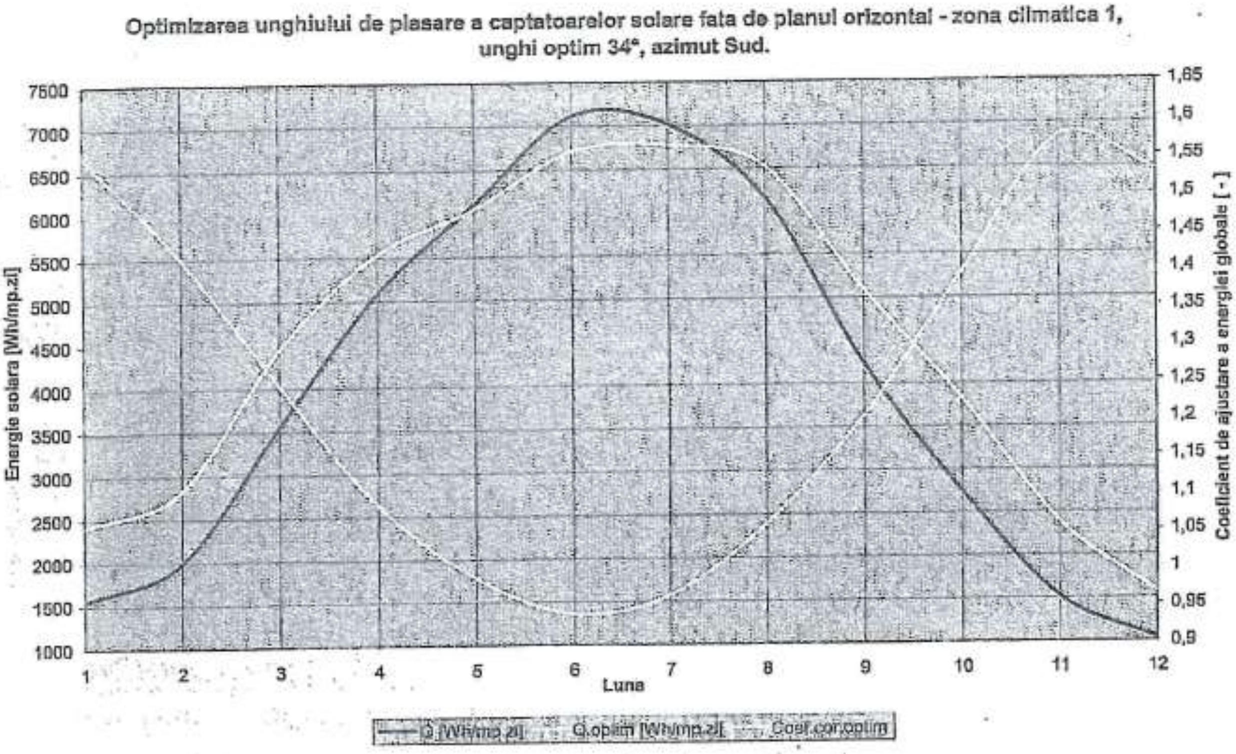

Figure IV.6: Energy collected on the optimal plane for the placement of solar panels (climate zone I)
Key:
Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone I, optimal angle 34º, azimuth south
Vertical left: Solar energy (Wh/m^{2}day)
Vertical right: Adjustment coefficient for overall energy
Bottom: Q (Wh/m^{2}day), Q optimal (Wh/m^{2}day), Optimal correction coefficient

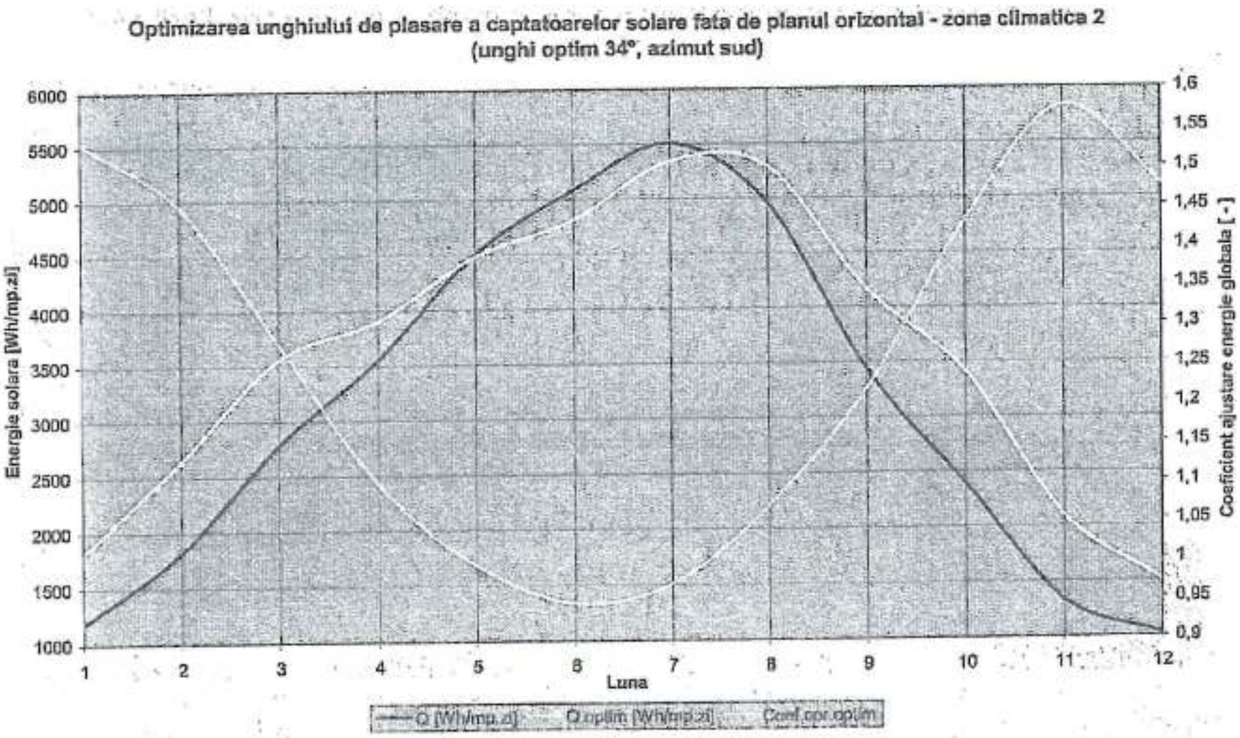

Figure IV.7: Energy collected on the optimal plane for the placement of solar panels (climate zone II)
Key:
Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone II, optimal angle 34º, azimuth south
Vertical left: Solar energy (Wh/m^{2}day)
Vertical right: Adjustment coefficient for overall energy
Bottom: Q (Wh/m^{2}day), Q optimal (Wh/m^{2}day), Optimal correction coefficient

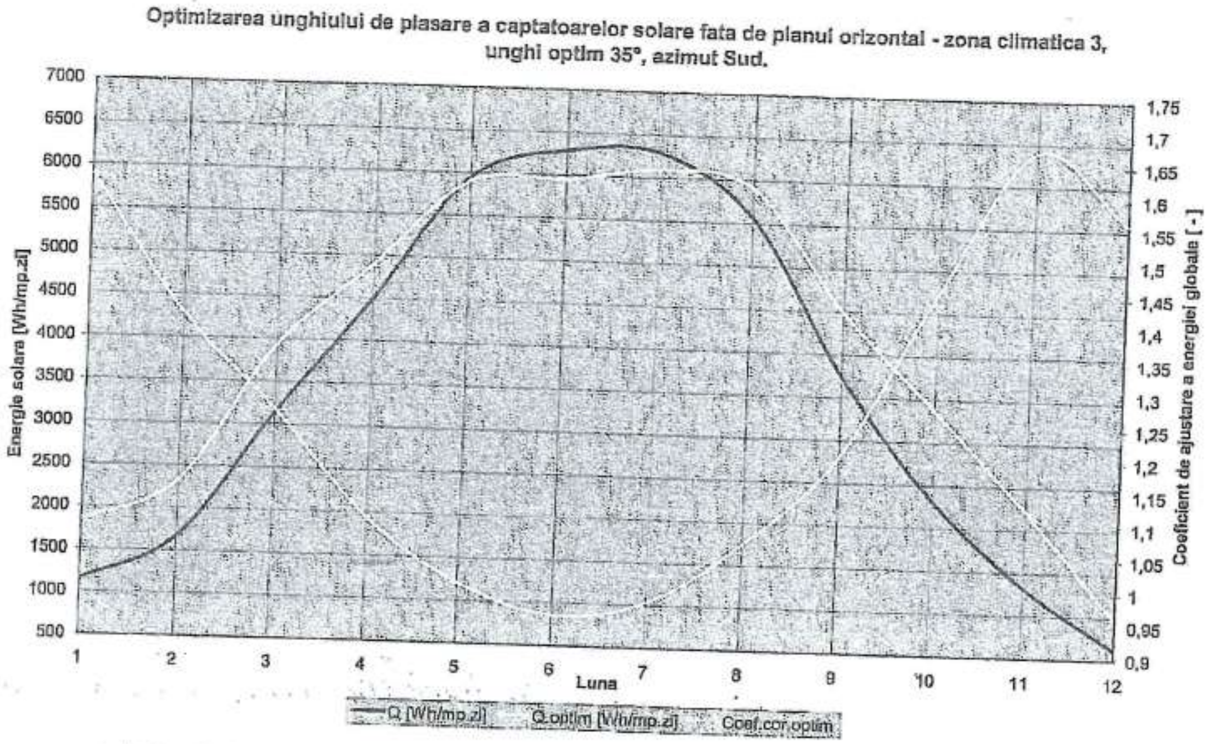

Figure IV.8: Energy collected on the optimal plane for the placement of solar panels (climate zone III)
Key:
Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone III, optimal angle 35º, azimuth south
Vertical left: Solar energy (Wh/m^{2}day)
Vertical right: Adjustment coefficient for overall energy
Bottom: Q (Wh/m^{2}day), Q optimal (Wh/m^{2}day), Optimal correction coefficient

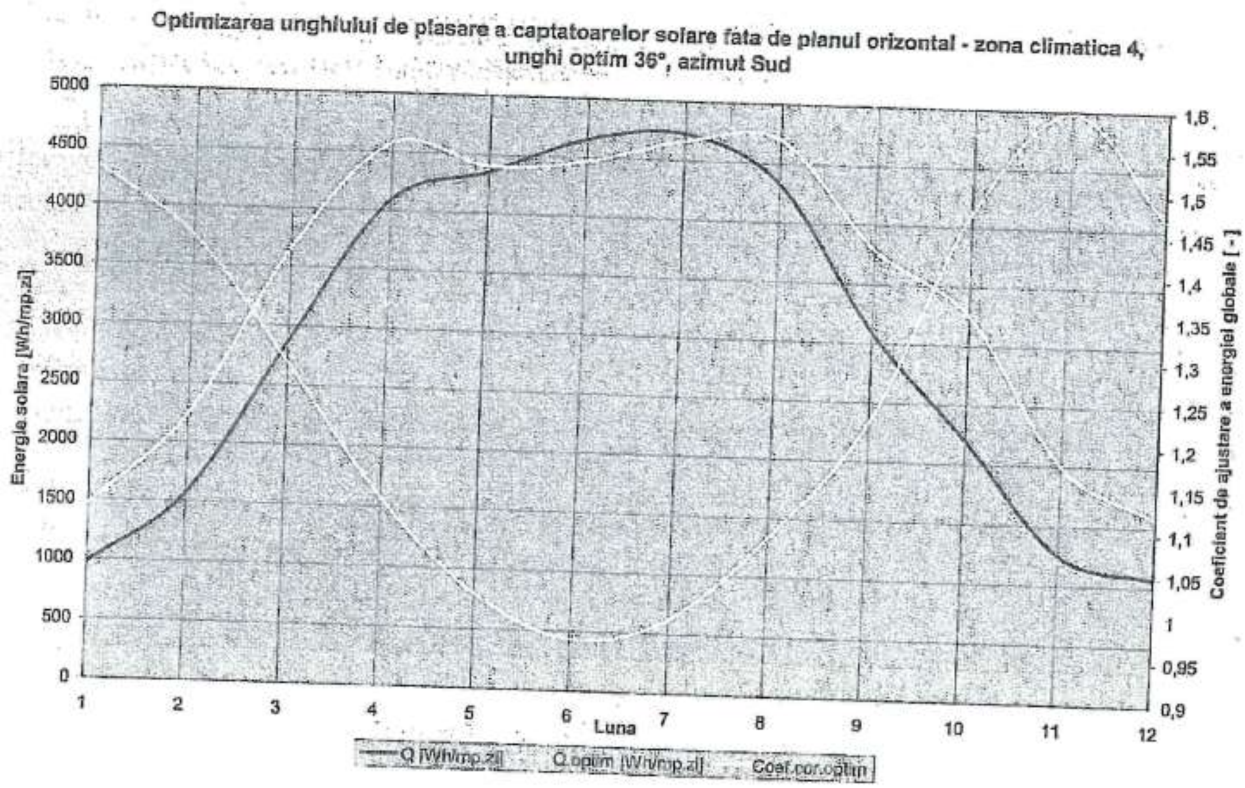

Figure IV.9: Energy collected on the optimal plane for the placement of solar panels (climate zone IV)
Key:
Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone II, optimal angle 36º, azimuth south
Vertical left: Solar energy (Wh/m^2day)
Vertical right: Adjustment coefficient for overall energy
Bottom: Q (Wh/m^2day), Q optimal (Wh/m^2day), Optimal correction coefficient

Chapter V - Economic efficiency of the technical solutions - Module for determining the investment payback period compared with a conventional building based on regulation C107/2010

V.1 Energy performance and payback period for the additional investment

V.1.1 Office building, climate zone I

Case 1: Surface area of the photovoltaic solar panels = 250 m^2

1.1 System using a water-water heat pump

- primary energy = 42.95 kWh/m^{2}year;
- primary energy C107 = 141.93 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 35.85 %;
- share of total energy consumption from solar energy = 35.85 %;
- payback period ≈ 10 years.

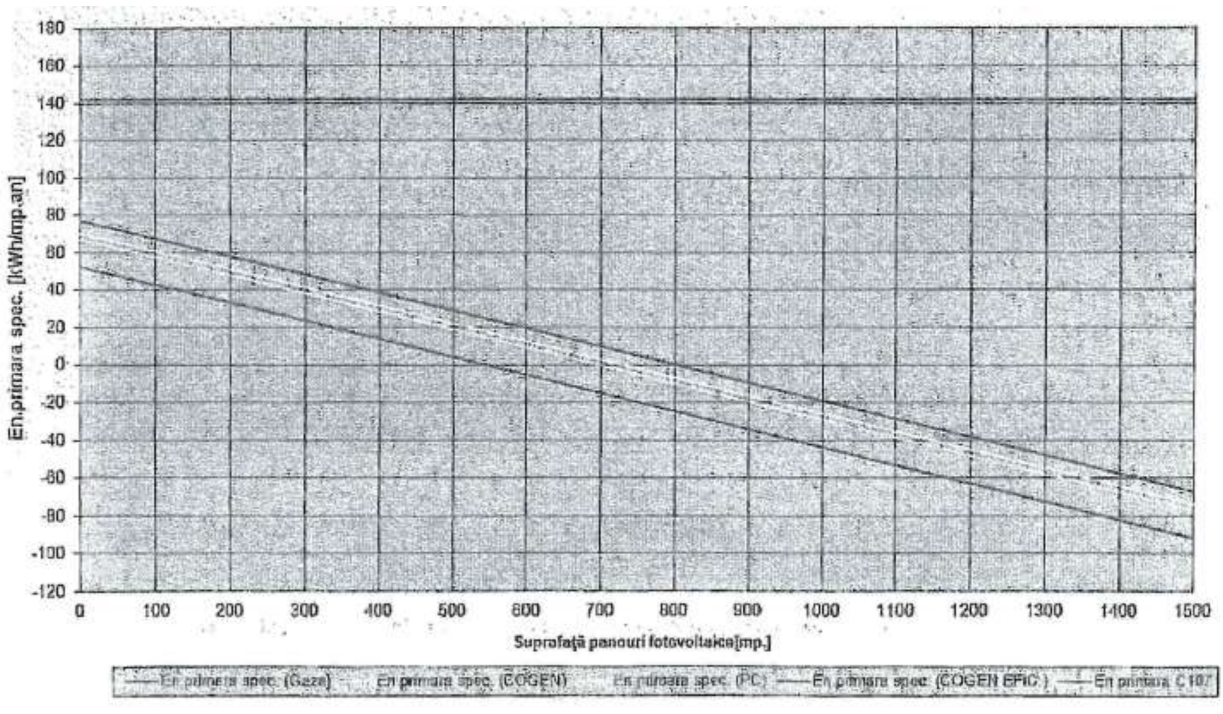

Figure V.1: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

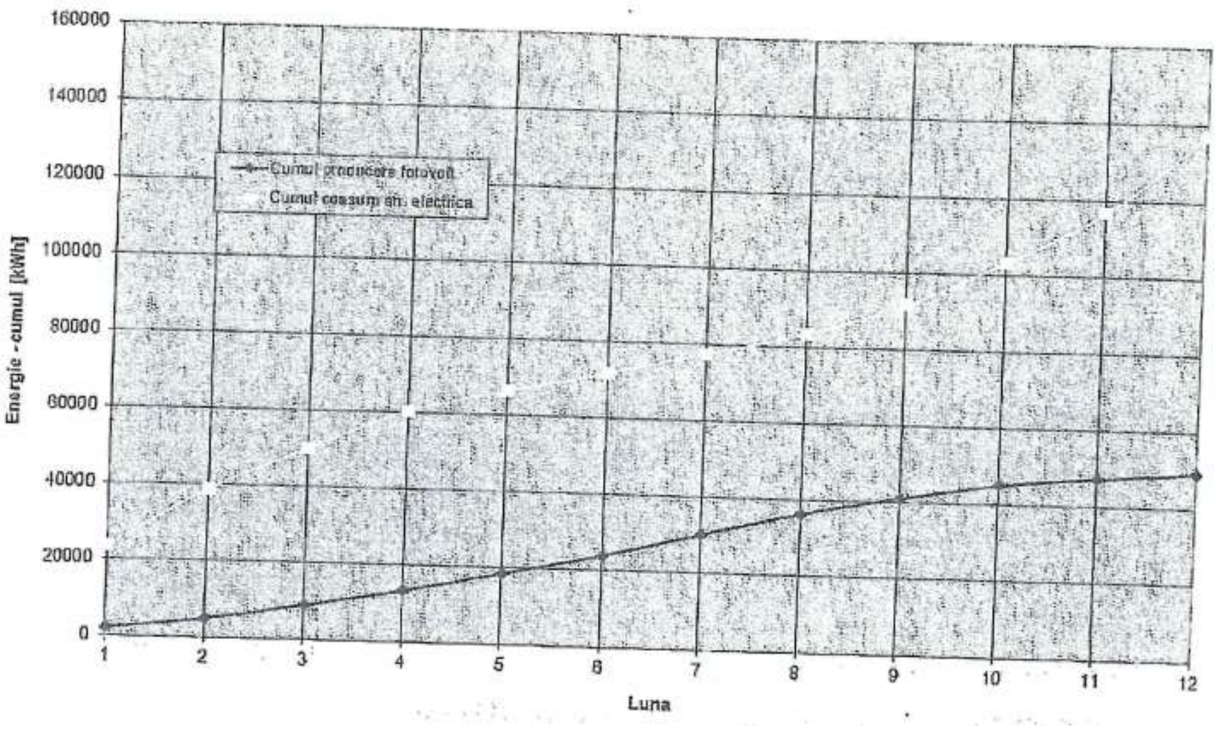

Figure V.2: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

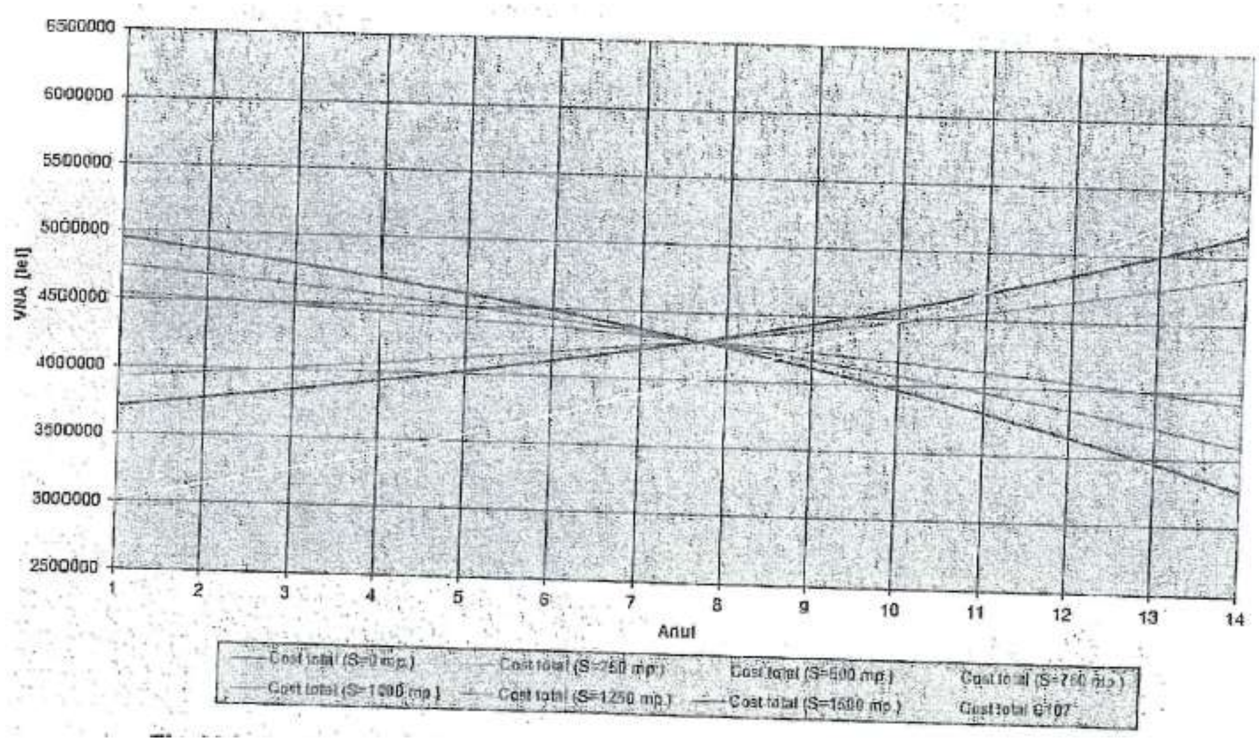

Figure V.3: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions

Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.2 System using a gas boiler

- primary energy = 52.96 kWh/m^{2}year;
- primary energy C107 = 141.93 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 52.54 %;
- share of total energy consumption from solar energy = 20.74 %;
- payback period ≈ 9.2 years.

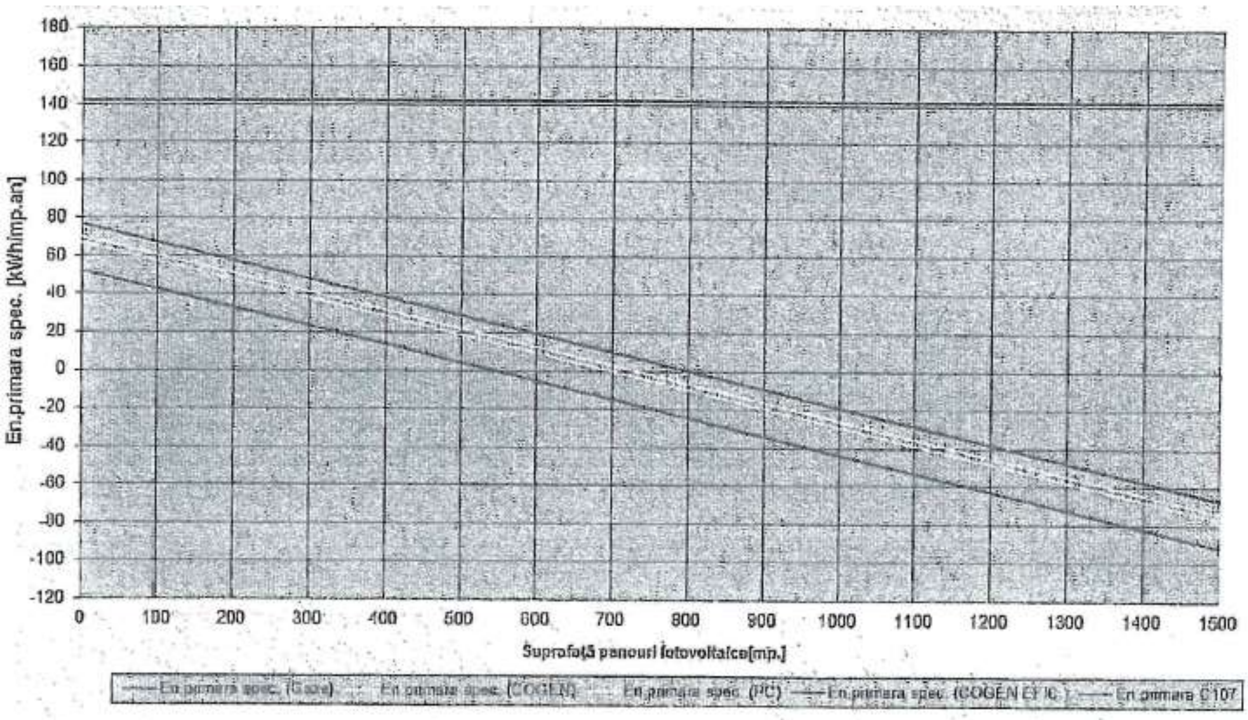

Figure V.4: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

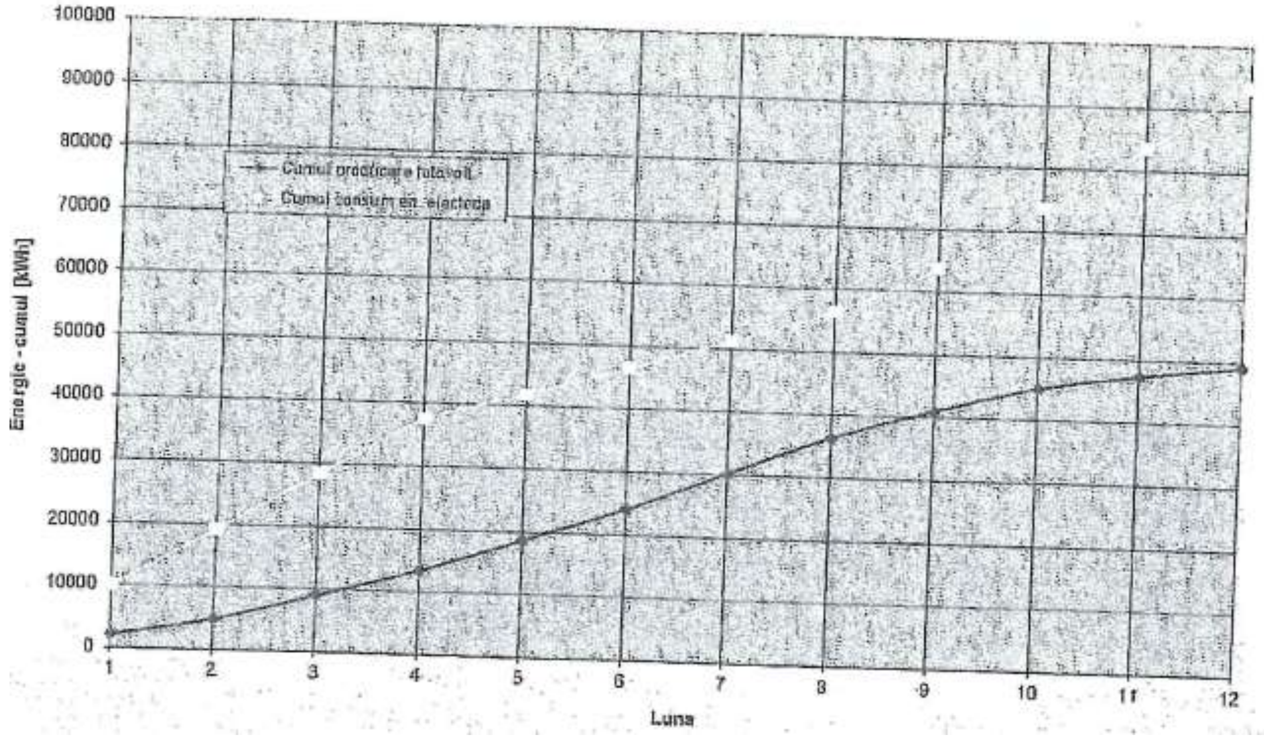

Figure V.5: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

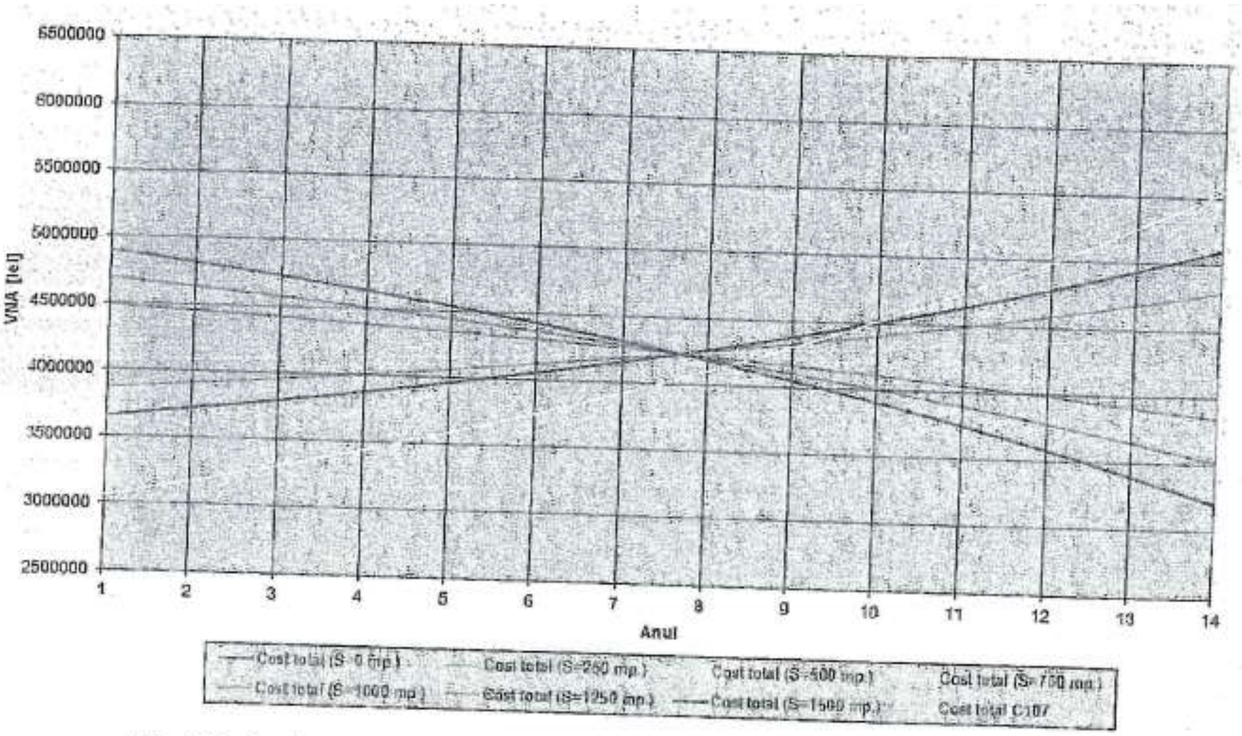

Figure V.6: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.3 System using current cogeneration

- primary energy = 46.23 kWh/m^2year;
- primary energy C107 = 124.14 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 52.54 %;
- share of total energy consumption from solar energy = 23.28 %;
- payback period ≈ 7.8 years.

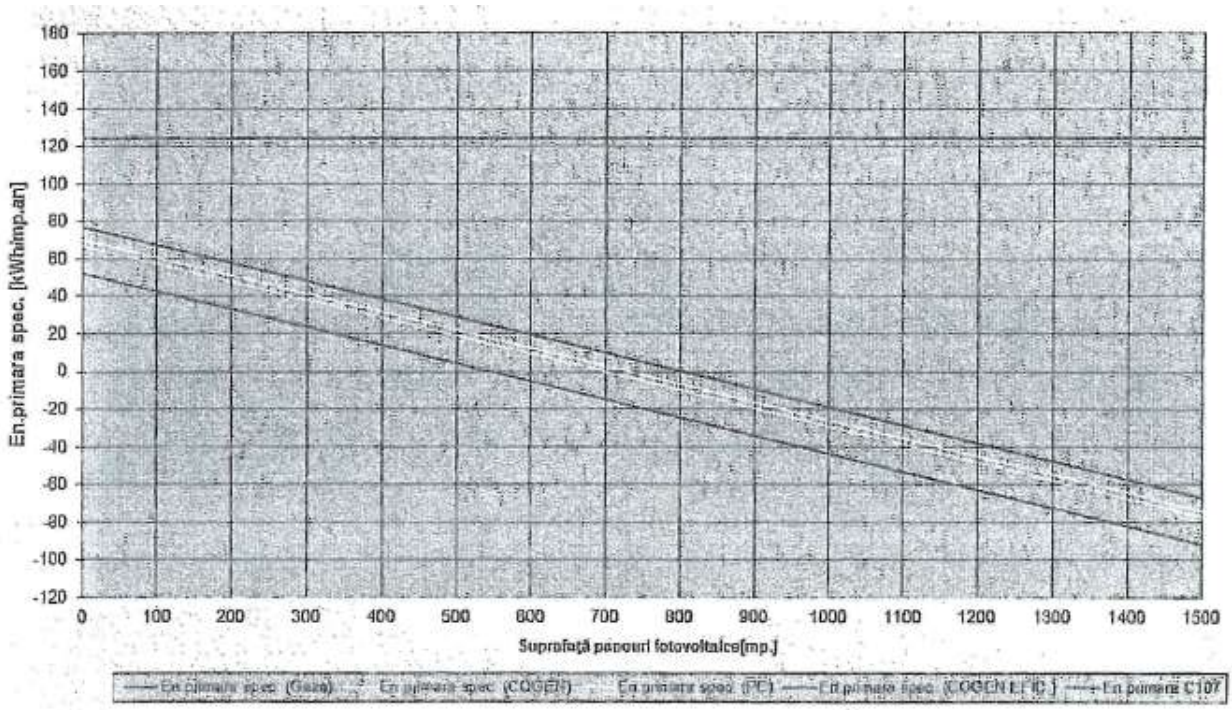

Figure V.7: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

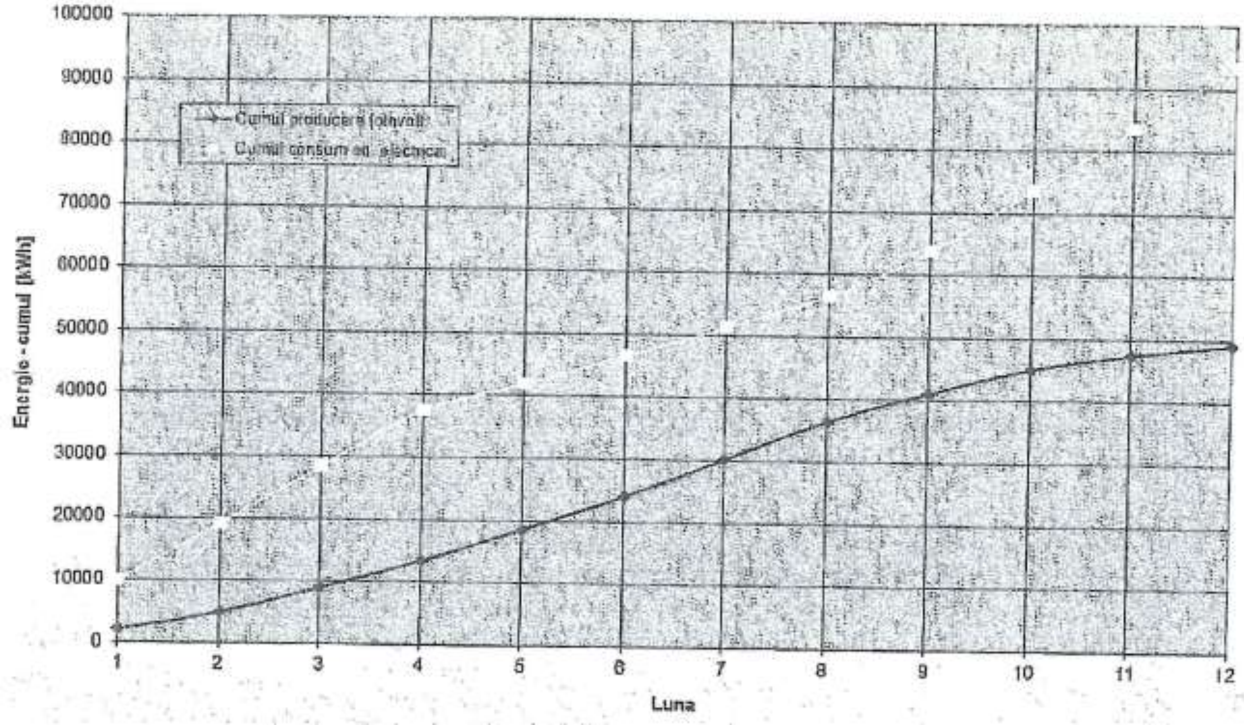

Figure V.8: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

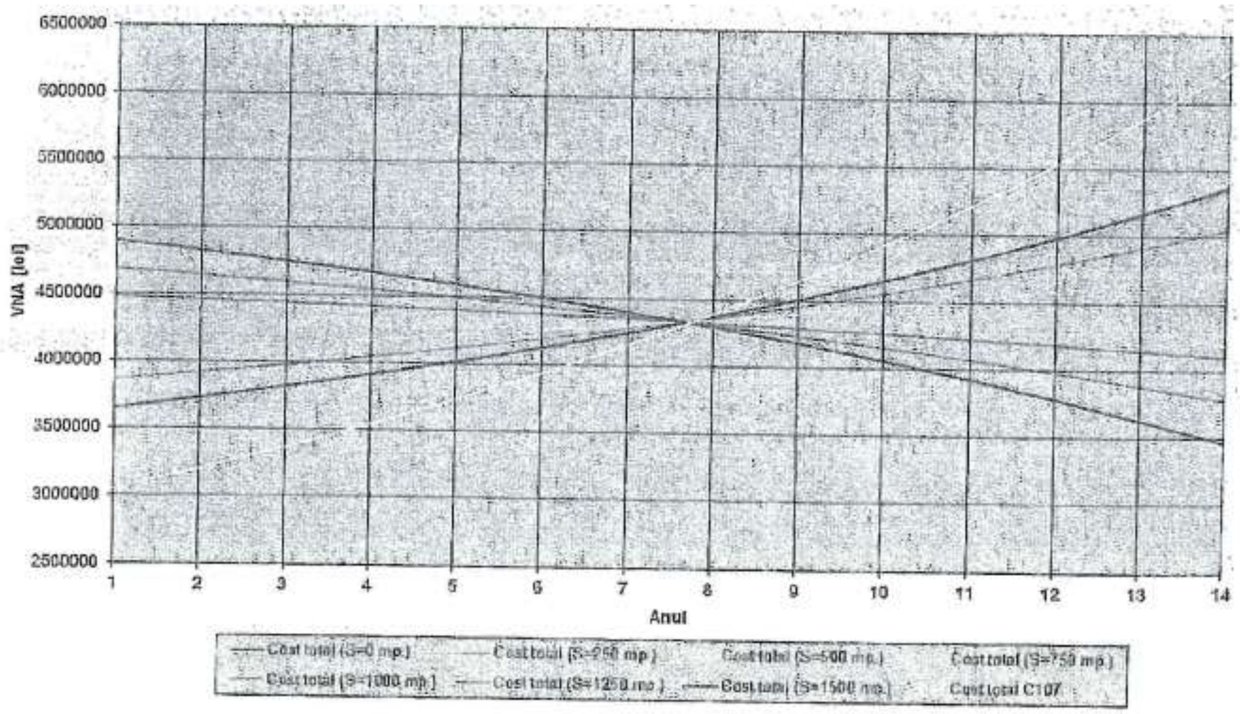

Figure V.9: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.4 System using high efficiency cogeneration

- primary energy = 28.26 kWh/m^{2}year;
- primary energy C107 = 124.14 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 52.54 %;
- share of total energy consumption from solar energy = 23.28 %;
- payback period ≈ 7.8 years.

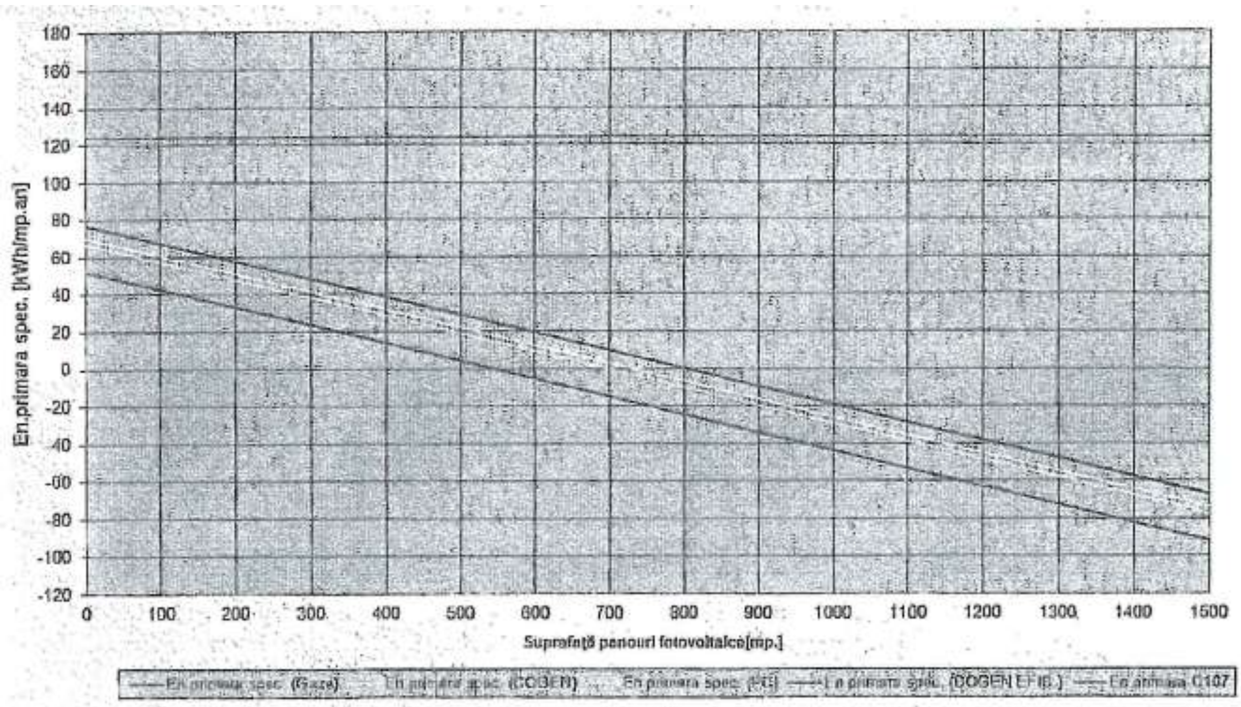

Figure V.10: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

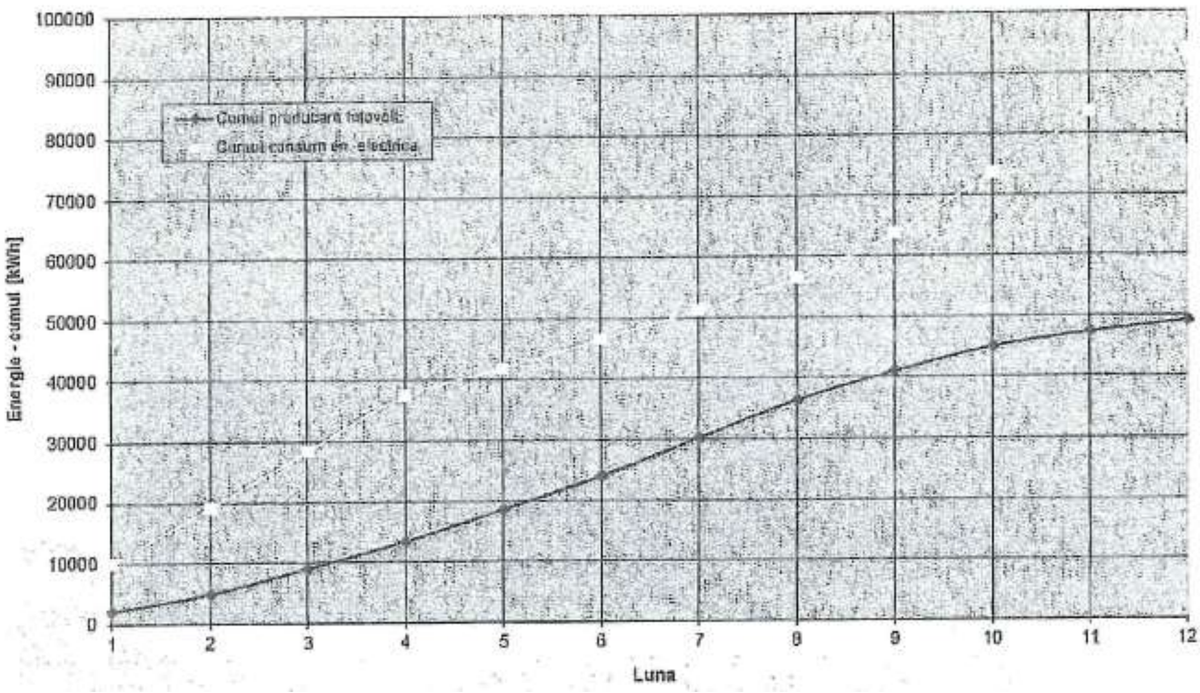

Figure V.11: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

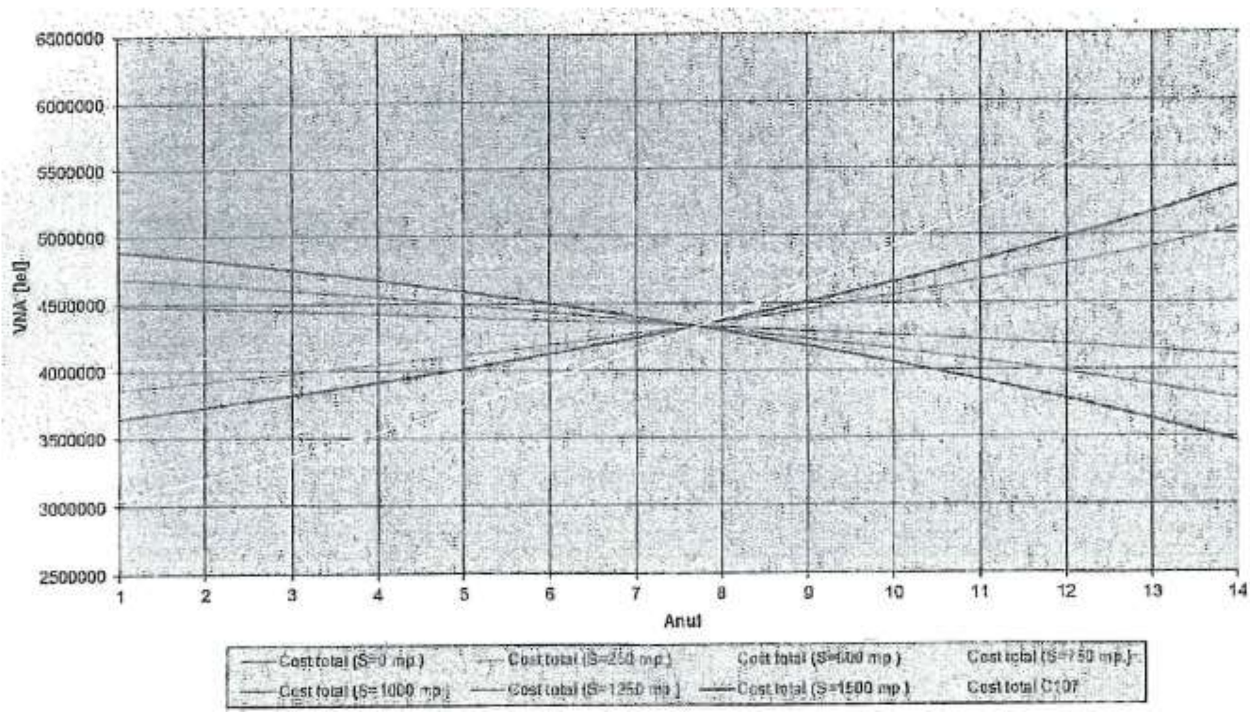

Figure V.12: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (mp = m^2)

PVP surface area = 250 m^2	Heat pump	Boiler	Current cogeneration	High efficiency cogeneration
primary energy (kWh/m^2year)	42.95	52.96	46.23	28.26
primary energy C107 (kWh/m^2year)	141.93	141.93	124.14	124.14
share of electricity consumption from PVP (%)	35.85	52.54	52.54	52.54
share of total energy consumption from solar energy (%)	35.85	20.74	23.28	23.28
payback period (years)	10.0	9.2	7.8	7.8

Case 2: Surface area of the photovoltaic solar panels = 1 500 m^2

2.1 System using a water-water heat pump

- primary energy = -77.05 kWh/m^2year;
- primary energy C107 = 141.93 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 215.08 %;
- share of total energy consumption from solar energy = 215.08 %;
- payback period ≈ 8.5 years.

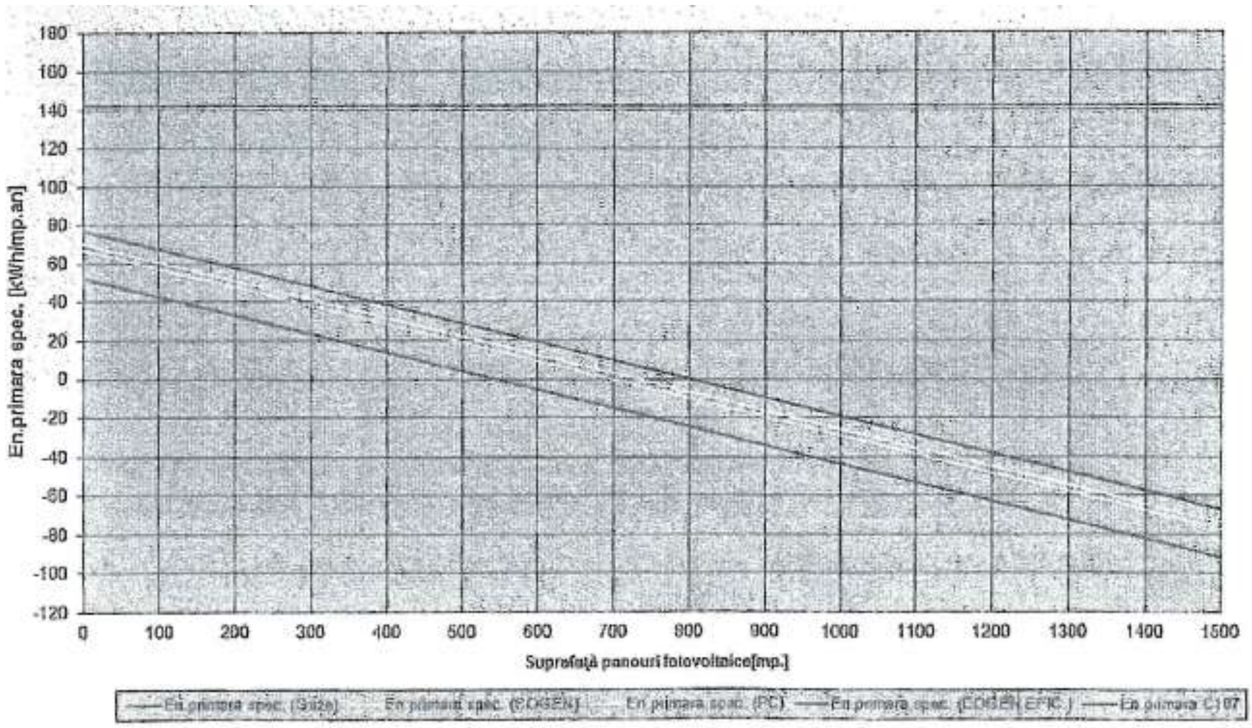

Figure V.13: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

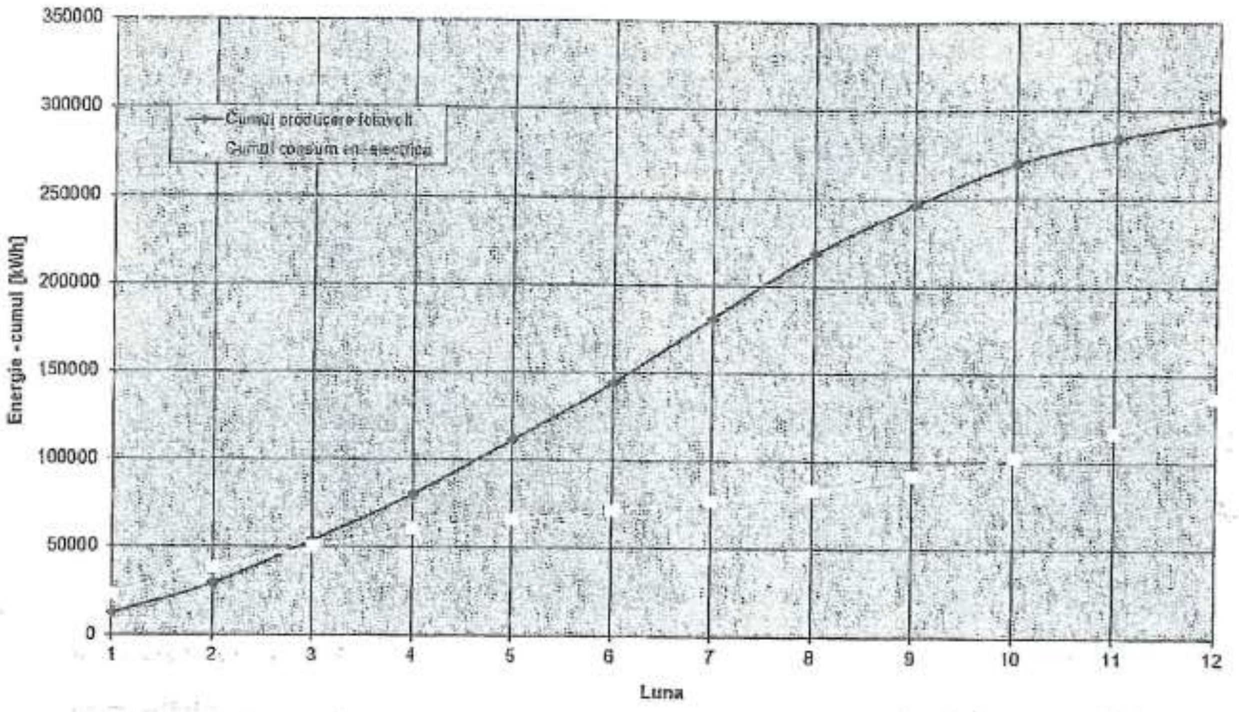

Figure V.14: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

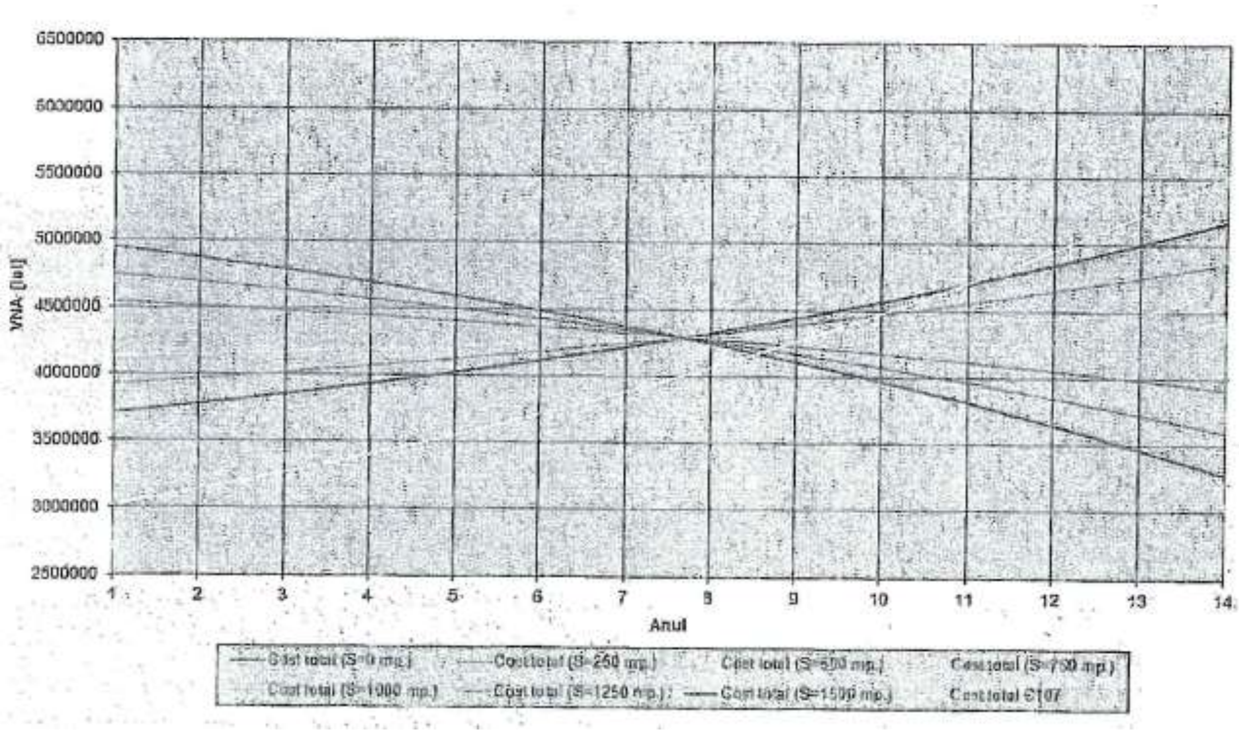

Figure V.15: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.2 System using a gas boiler

- primary energy = -67.04 kWh/m^{2}year;
- primary energy C107 = 141.93 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 315.23 %;
- share of total energy consumption from solar energy = 124.44 %;
- payback period ≈ 8.3 years.

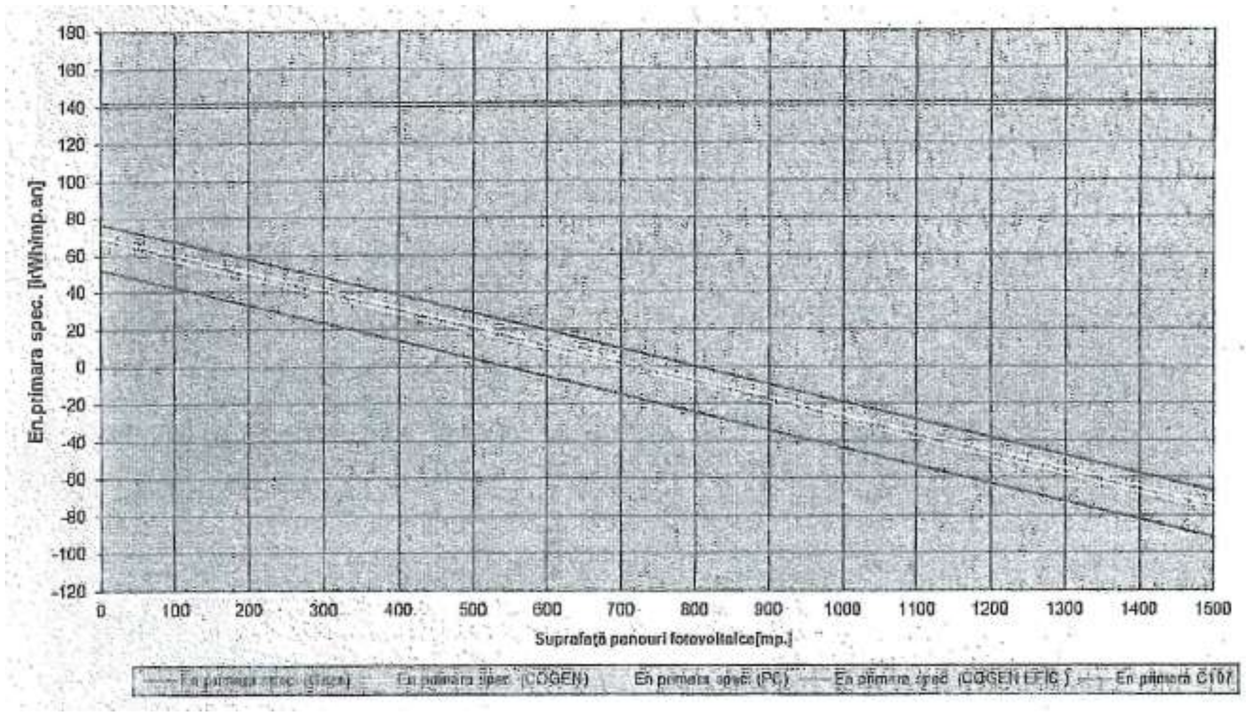

Figure V.16: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

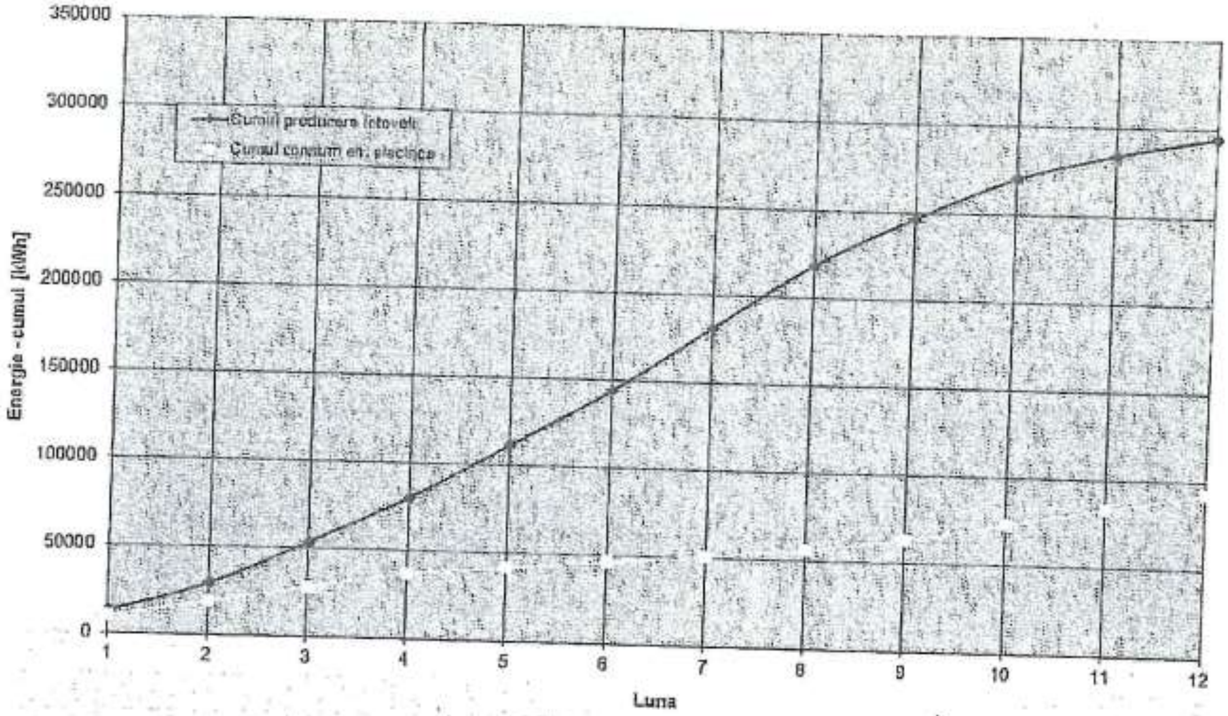

Figure V.17: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

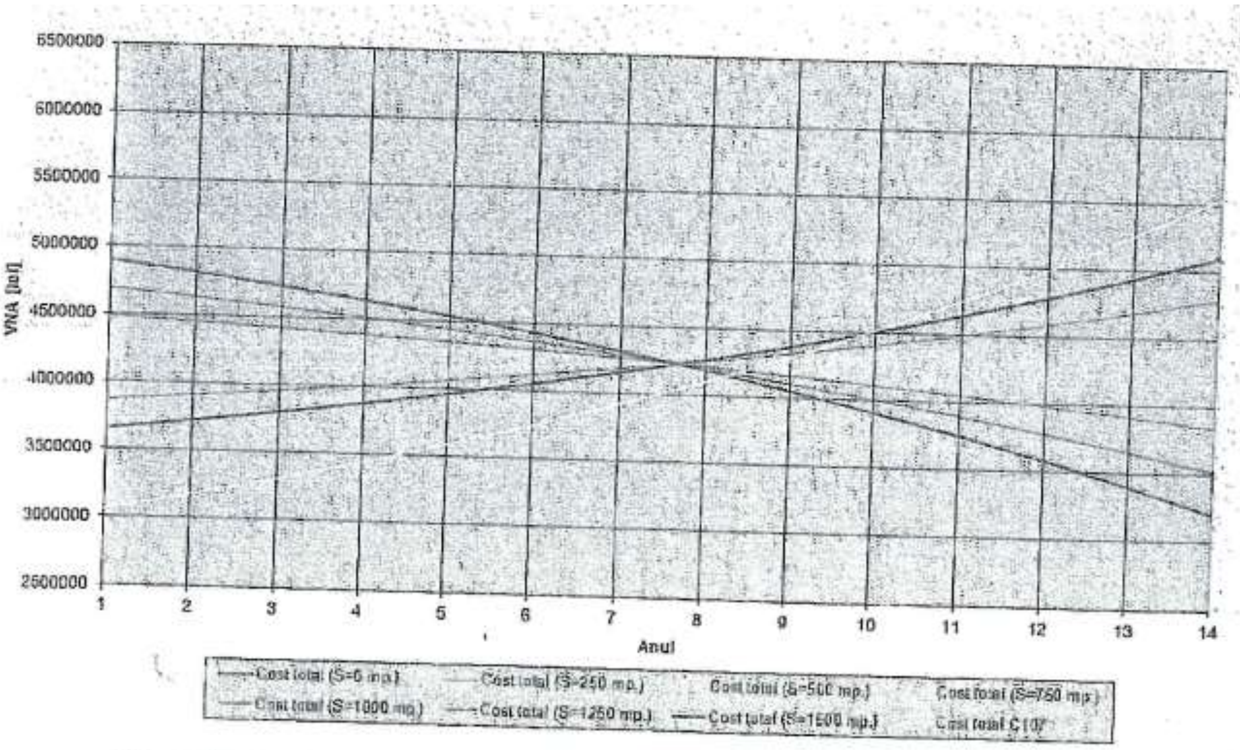

Figure V.18: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.3 System using current cogeneration

- primary energy = -73.77 kWh/m^{2}year;
- primary energy C107 = 124.14 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 315.23 %;
- share of total energy consumption from solar energy = 139.65 %;
- payback period ≈ 7.8 years.

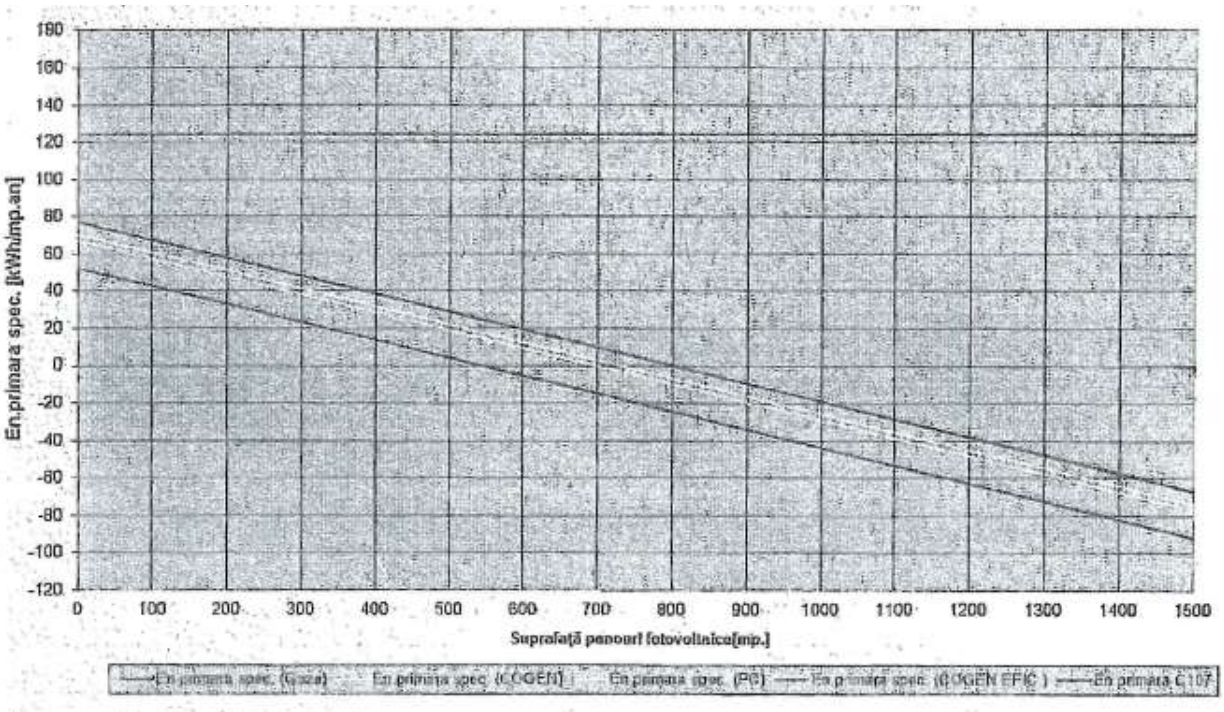

Figure V.19: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

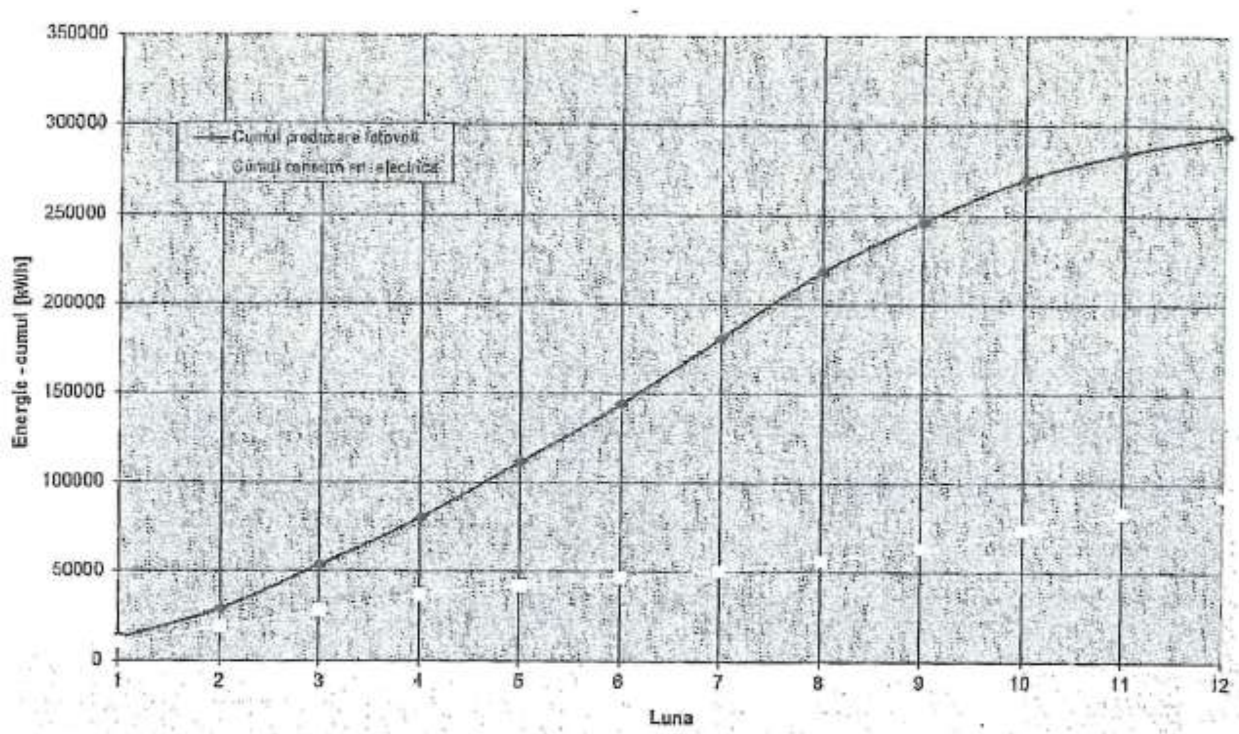

Figure V.20: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

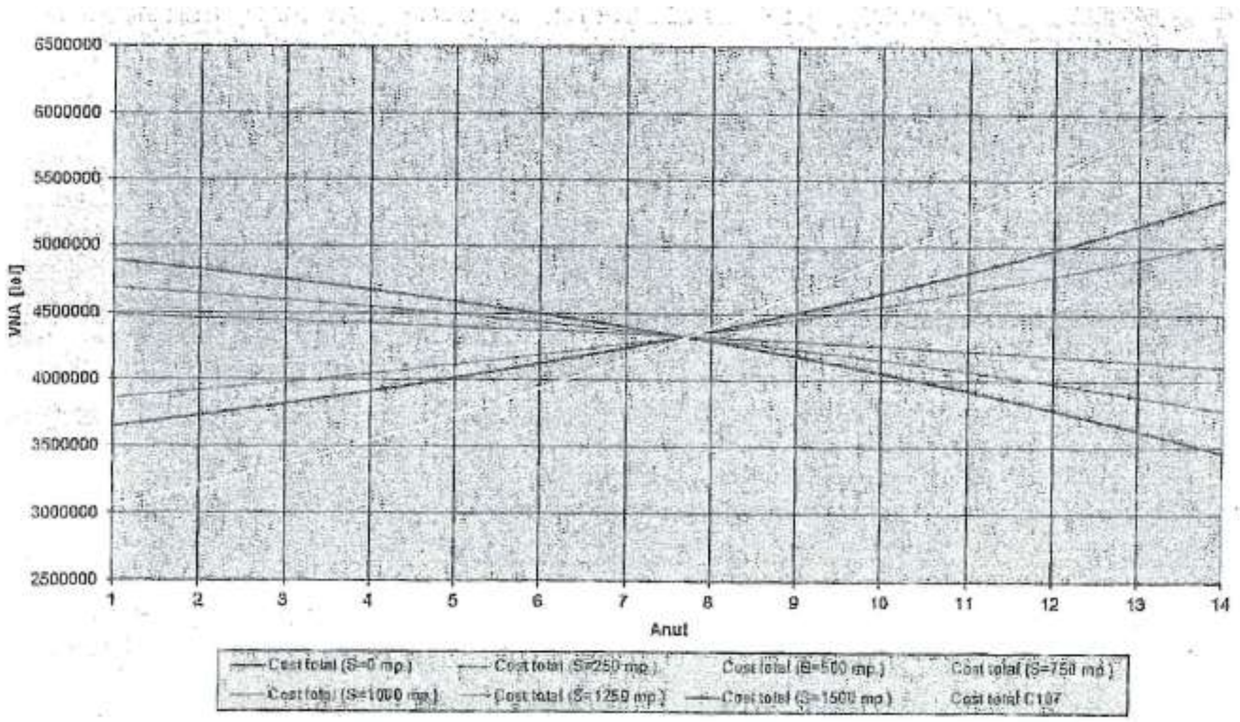

Figure V.21: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.4 System using high efficiency cogeneration

- primary energy = -91.74 kWh/m^2year;
- primary energy C107 = 124.14 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 315.23 %;
- share of total energy consumption from solar energy = 139.65 %;
- payback period ≈ 7.8 years.

PVP surface area = 1 500 m^2	Heat pump	Boiler	Current cogeneration	High efficiency cogeneration
primary energy (kWh/m^2year)	-77.05	-67.04	-73.77	-91.74
primary energy C107	141.93	141.93	124.14	124.14

(kWh/m²year)				
share of electricity consumption from PVP (%)	215.05	315.23	315.23	315.23
share of total energy consumption from solar energy (%)	215.08	124.44	139.65	139.65
payback period (years)	8.5	8.3	7.8	7.8

V.1.2 Apartment block

Apartment block, climate zone I

Case 1: Surface area of the photovoltaic solar panels = 50 m^2

1.1 System using a water-water heat pump

- primary energy = 135.55 kWh/m^{2}year;
- primary energy C107 = 216.46 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 11.41 %;
- share of total energy consumption from solar energy = 11.41 %;
- payback period ≈ 14.2 years.

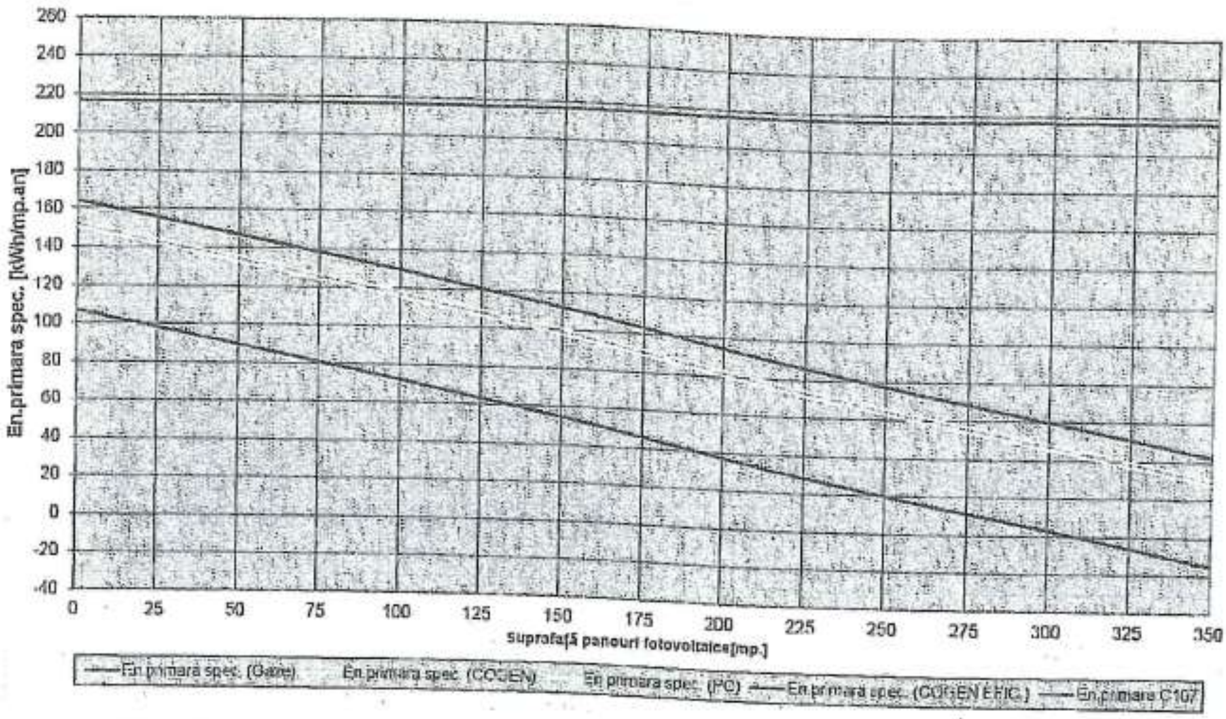

Figure V.22: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

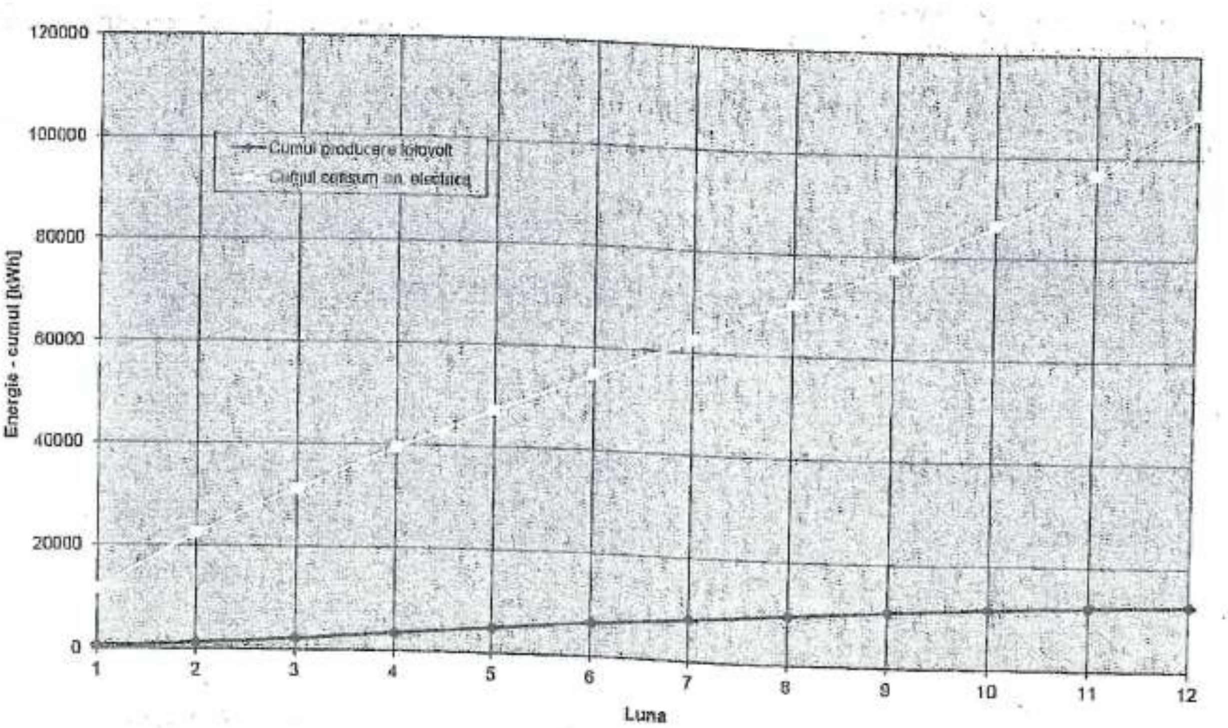

Figure V.23: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

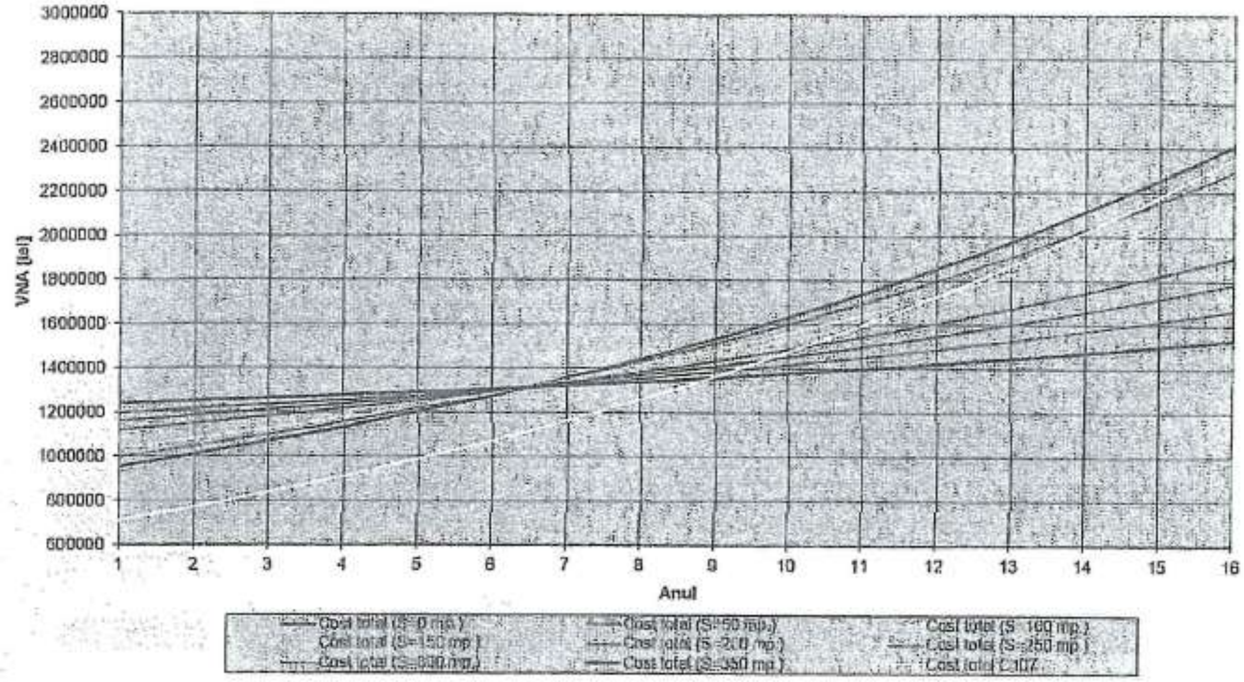

Figure V.24: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.2 System using a gas boiler

- primary energy = 146.82 kWh/m^2year;
- primary energy C107 = 216.46 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 20.23 %;
- share of total energy consumption from solar energy = 5.7 %;
- payback period ≈ 11.8 years.

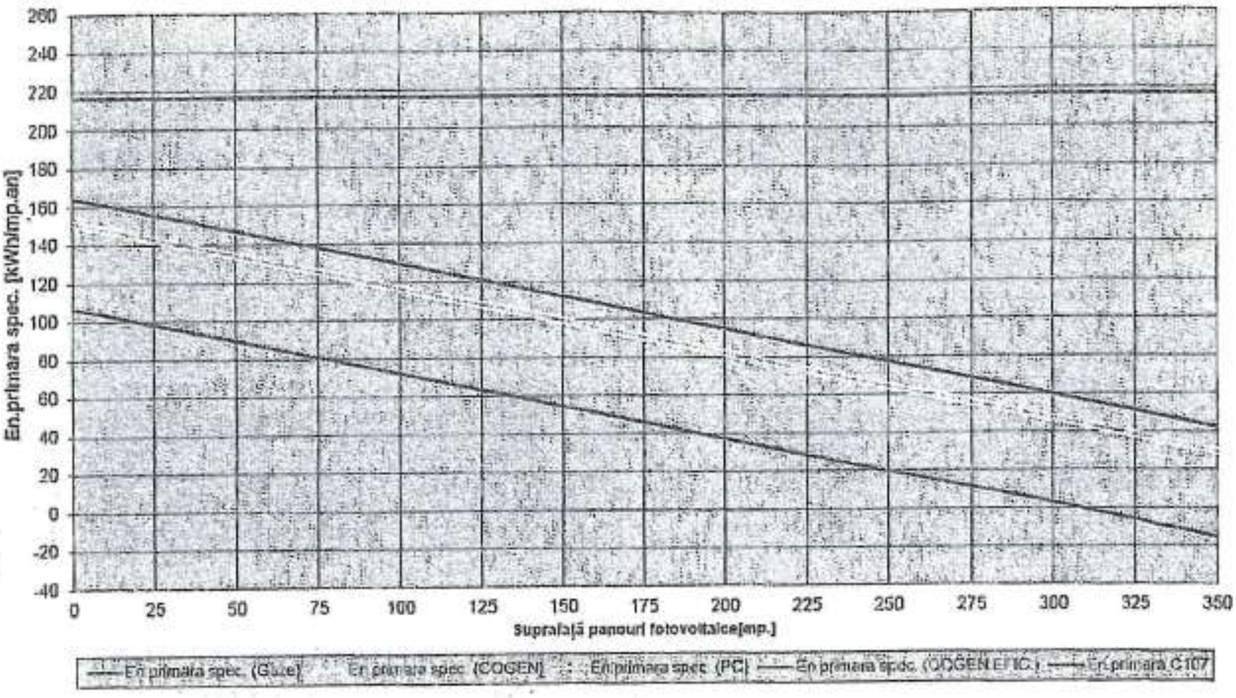

Figure V.25: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy ($kWh/m^2 year$)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

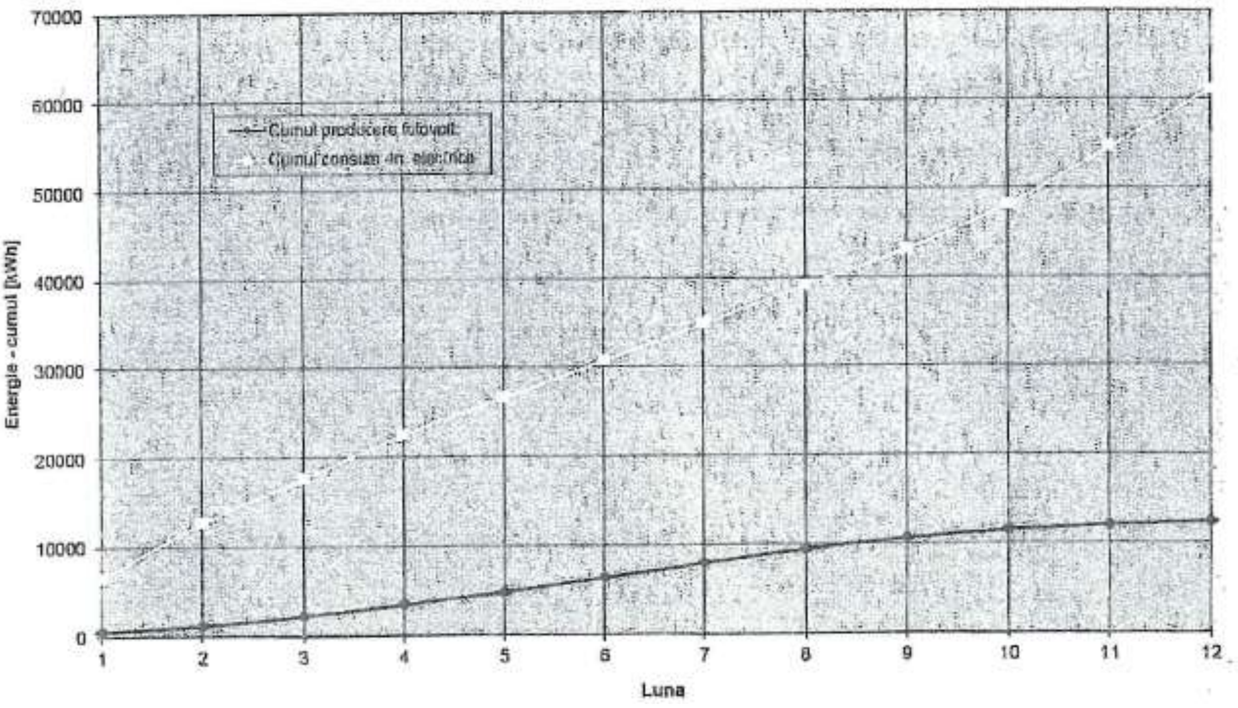

Figure V.26: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

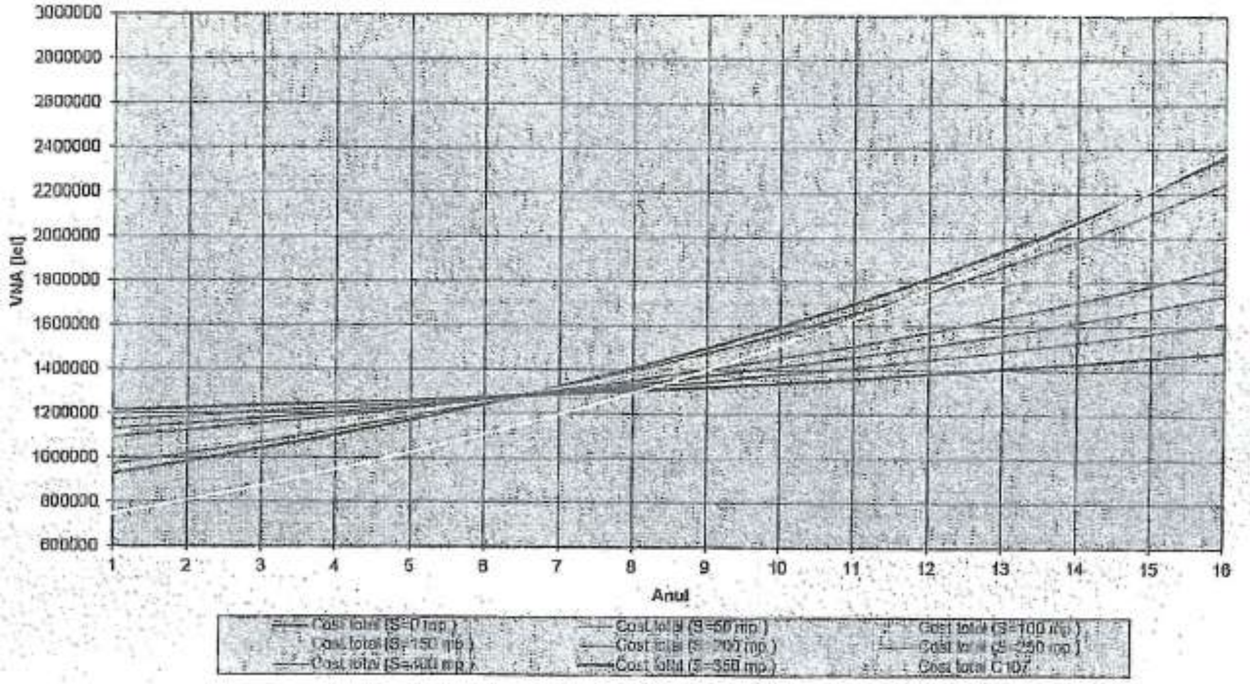

Figure V.27: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.3 System using current cogeneration

- primary energy = 132.78 kWh/m^2year;
- primary energy C107 = 188.85 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 20.23 %;
- share of total energy consumption from solar energy = 6.55 %;
- payback period ≈ 10.5 years.

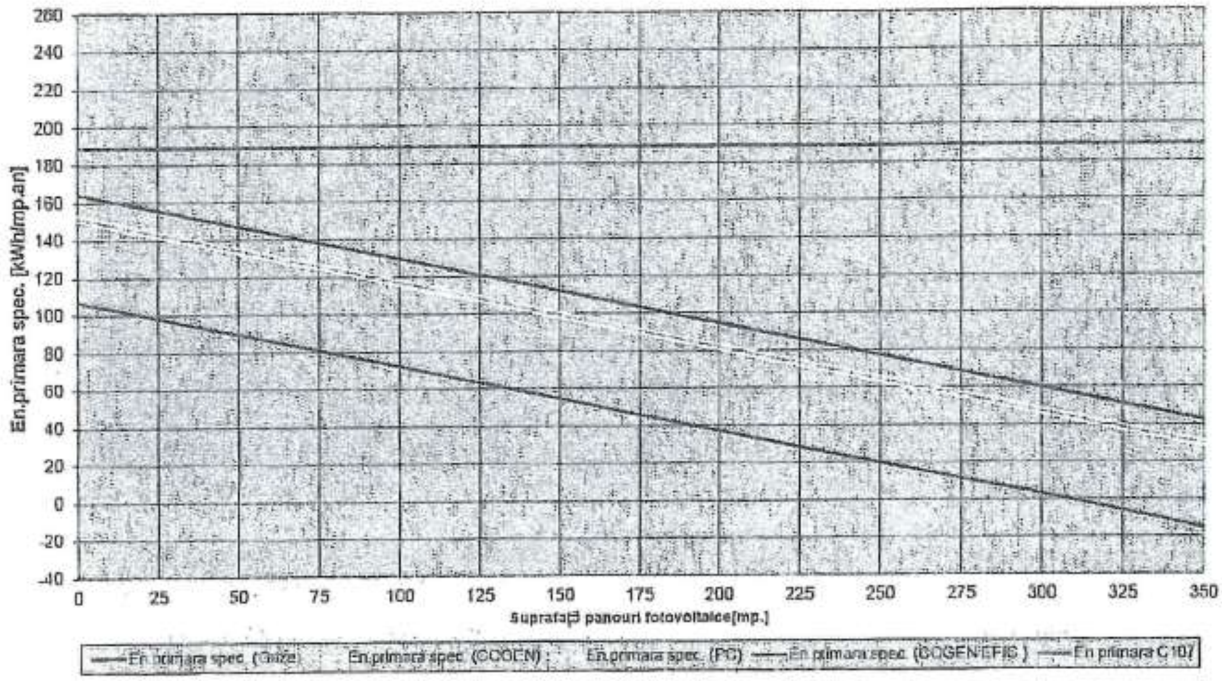

Figure V.28: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

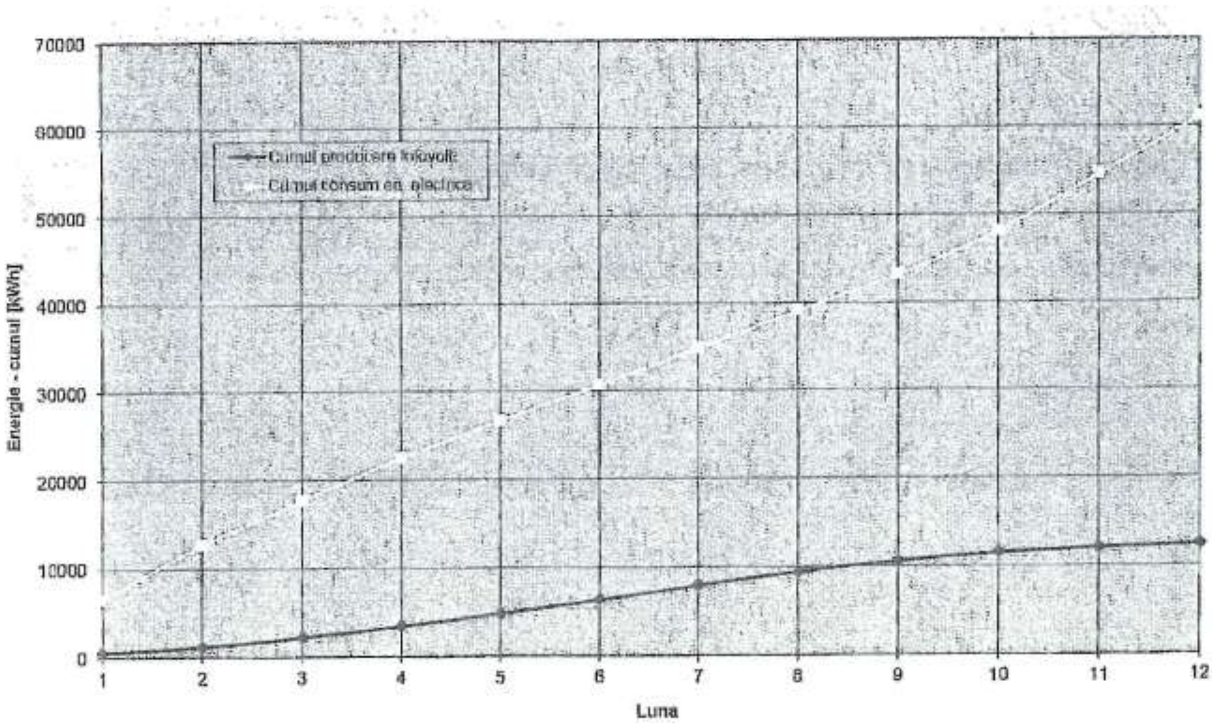

Figure V.29: Power generation and consumption
Key:

Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

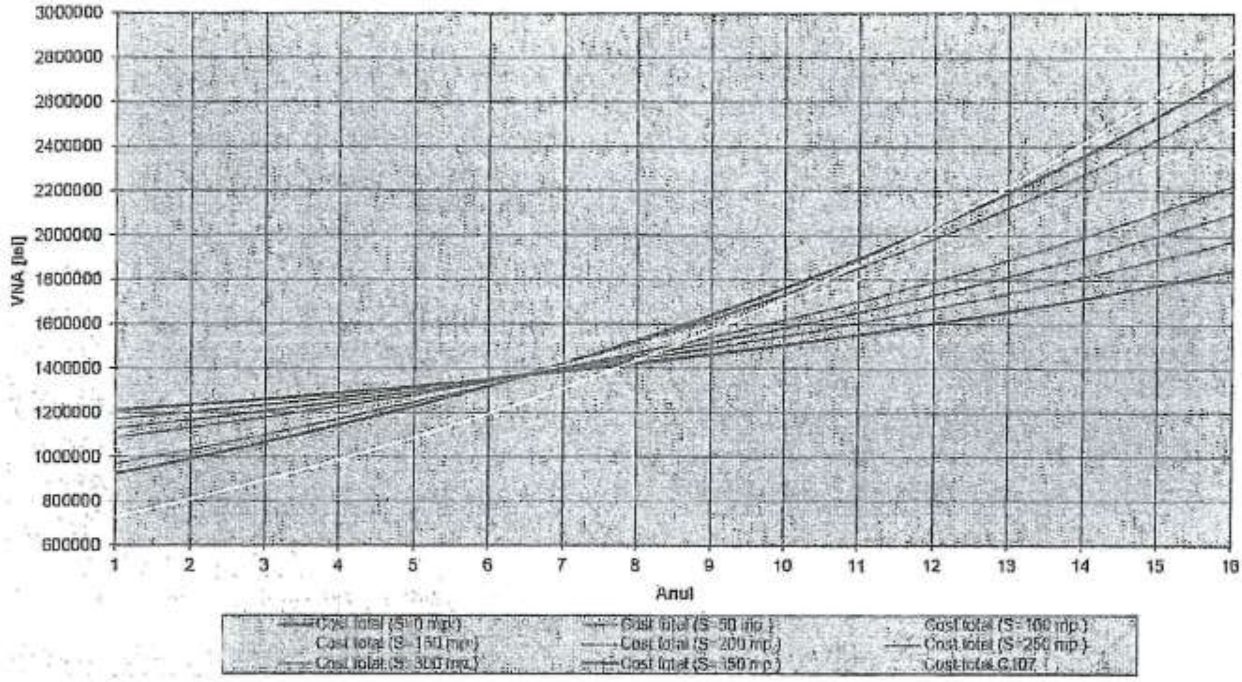

Figure V.30: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.4 System using high efficiency cogeneration

- primary energy = 89.44 kWh/m^2year;
- primary energy C107 = 188.85 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 20.23 %;
- share of total energy consumption from solar energy = 6.55 %;
- payback period ≈ 10.5 years.

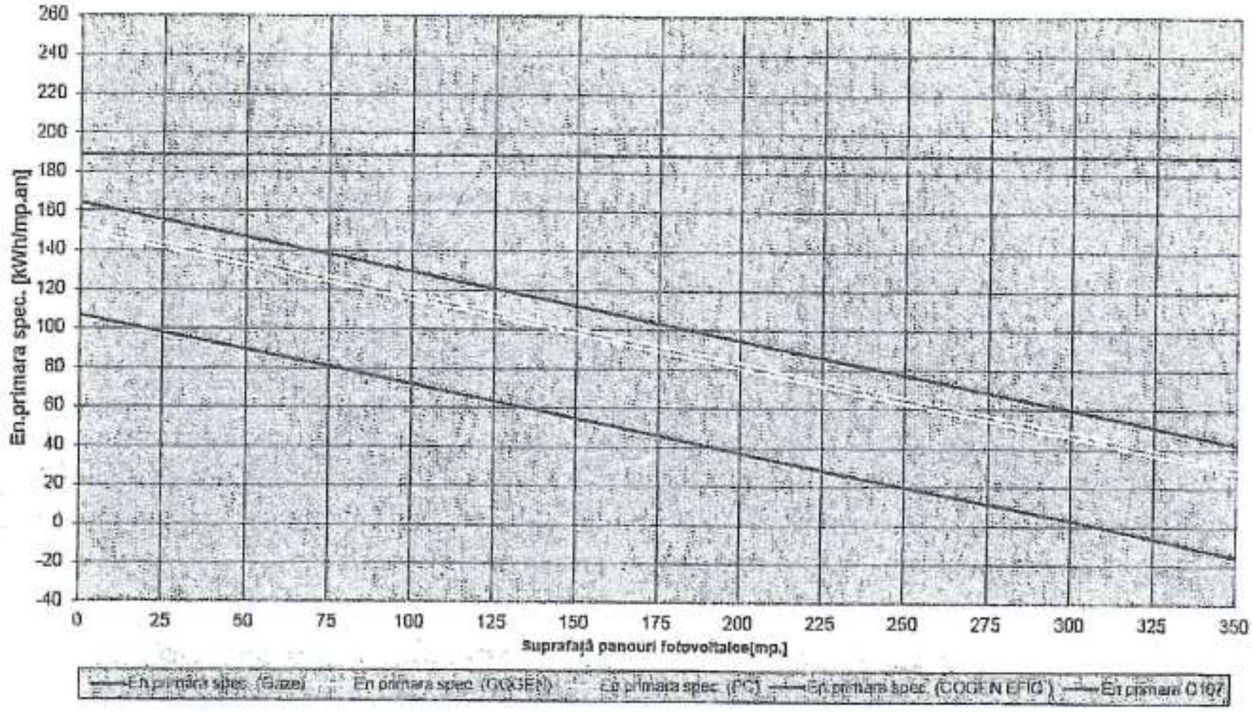

Figure V.31: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels

Key:

Horizontal: Photovoltaic panel surface area (m^2)

Vertical: Specific primary energy ($kWh/m^2 year$)

Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

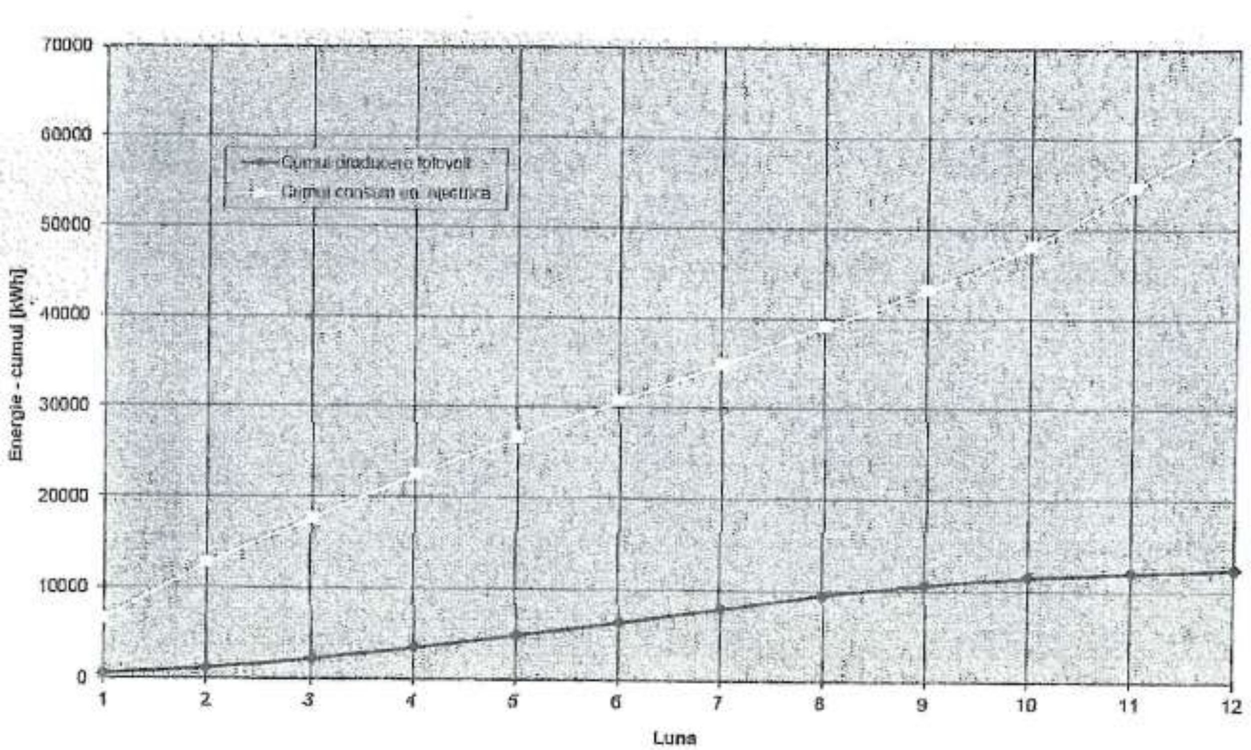

Figure V.32: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

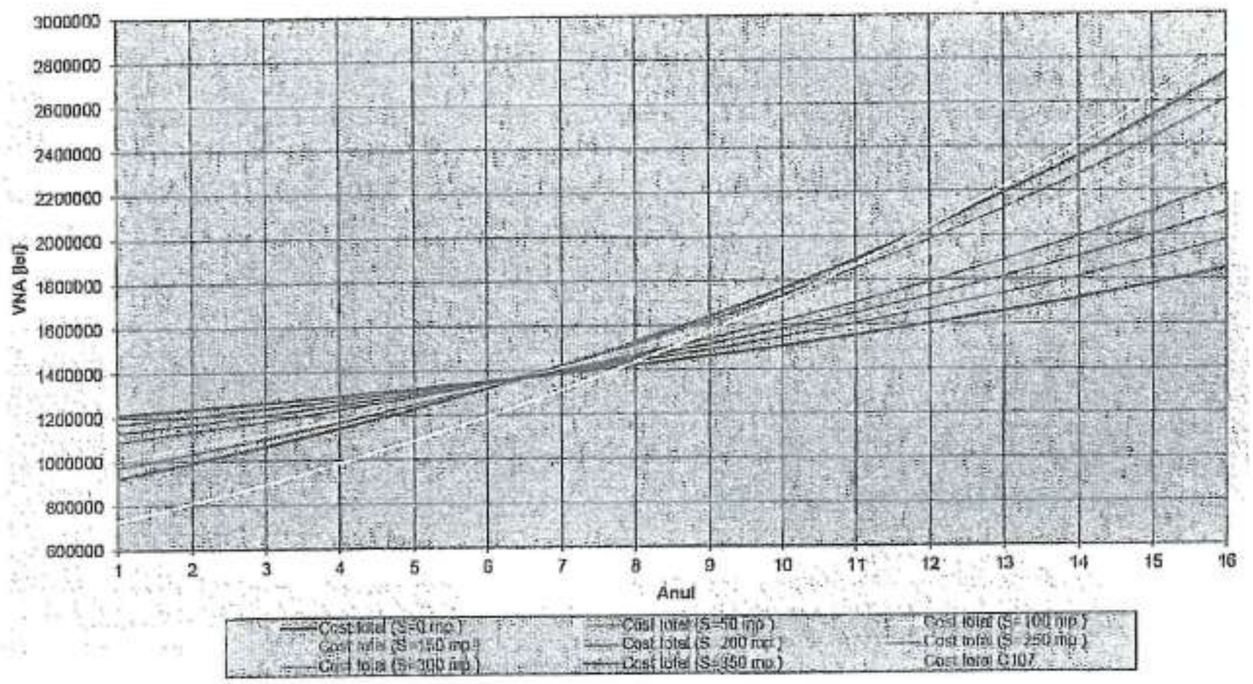

Figure V.33: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 50 m^2	**Heat pump**	**Boiler**	**Current cogeneration**	**High efficiency cogeneration**
primary energy (kWh/m^{2}year)	135.55	146.82	132.78	89.44
primary energy C107 (kWh/m^{2}year)	216.46	216.46	188.85	188.85
share of electricity consumption from PVP (%)	11.41	20.23	20.23	20.23
share of total energy consumption	11.41	5.70	6.55	6.55

from solar energy (%)				
payback period (years)	14.2	11.8	10.5	10.5

Case 2: Surface area of the photovoltaic solar panels = 300 m^2

2.1 System using a water-water heat pump

- primary energy = 48.30 kWh/m^{2}year;
- primary energy C107 = 216.46 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 68.43 %;
- share of total energy consumption from solar energy = 68.43 %;
- payback period ≈ 9.2 years.

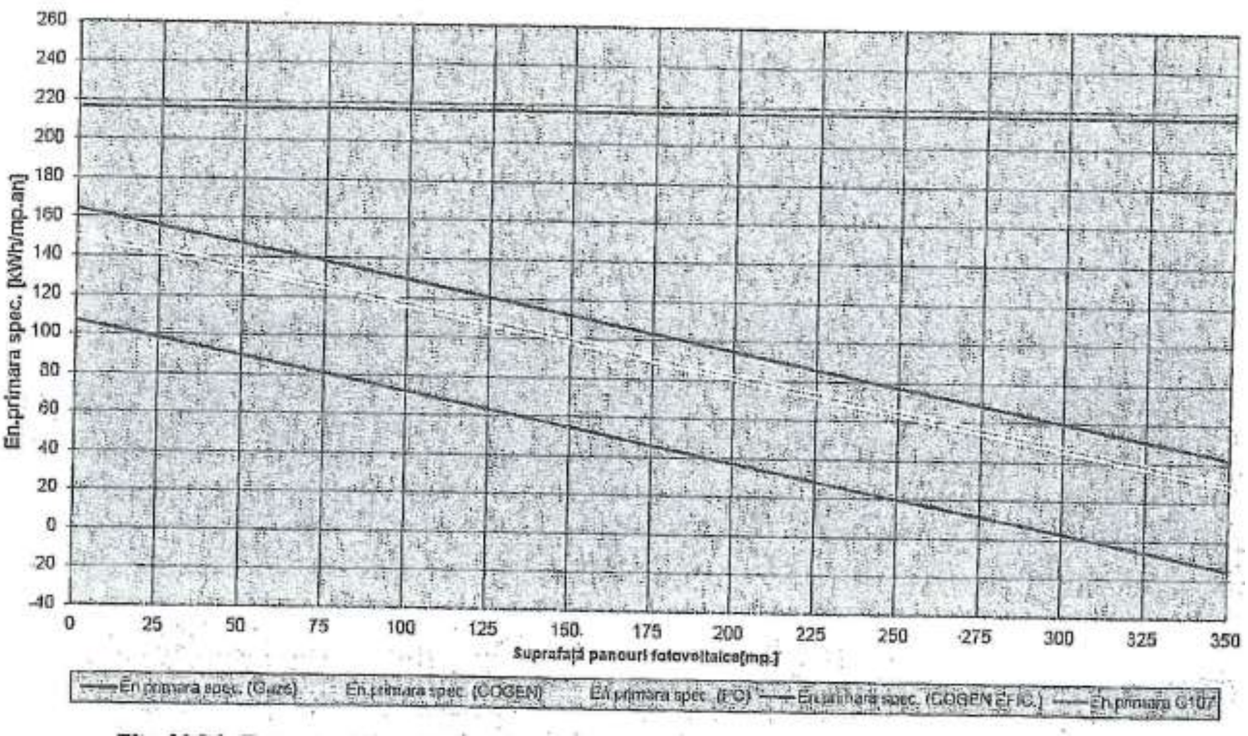

Figure V.34: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

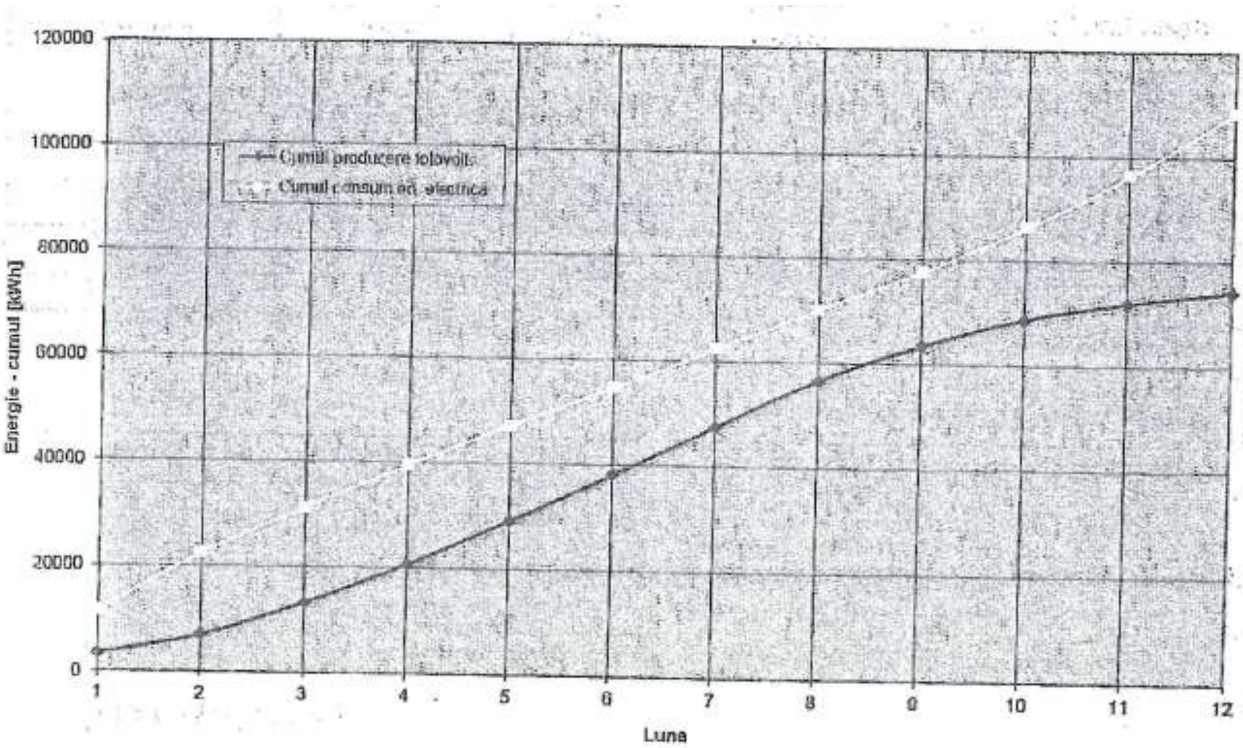

Figure V.35: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

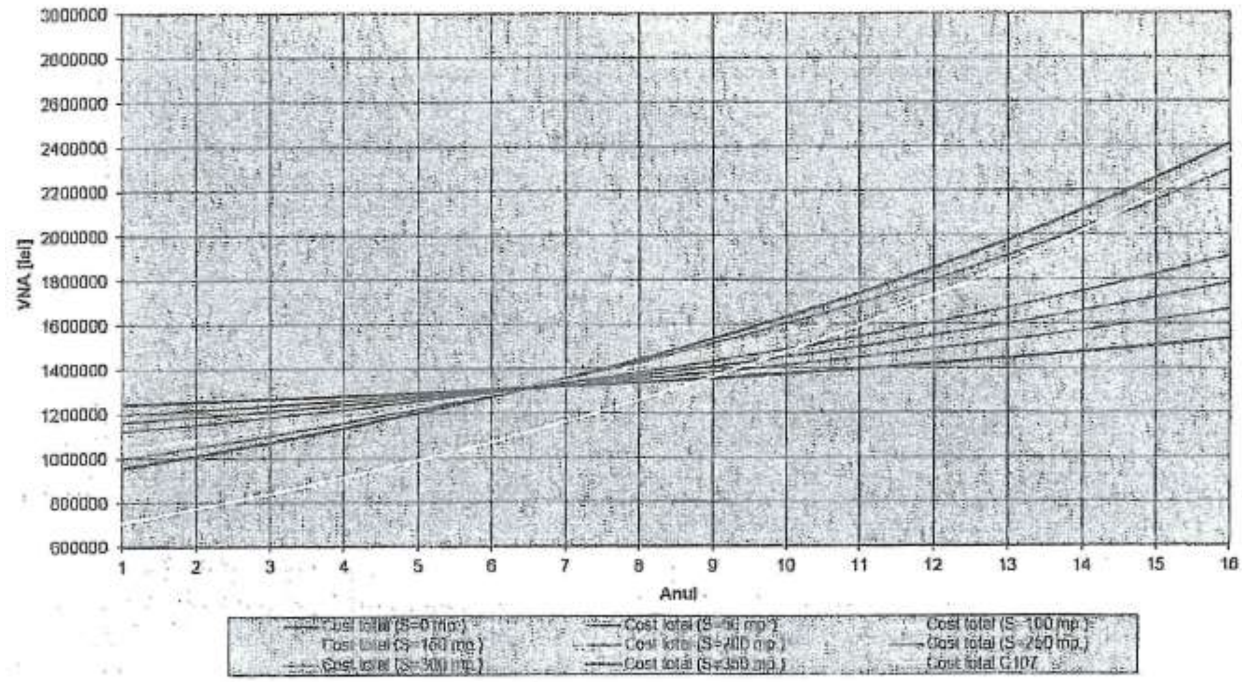

Figure V.36: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.2 System using a gas boiler

- primary energy = 59.57 kWh/m^{2}year;
- primary energy C107 = 216.46 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 121.39 %;
- share of total energy consumption from solar energy = 34.21 %;
- payback period ≈ 8.4 years.

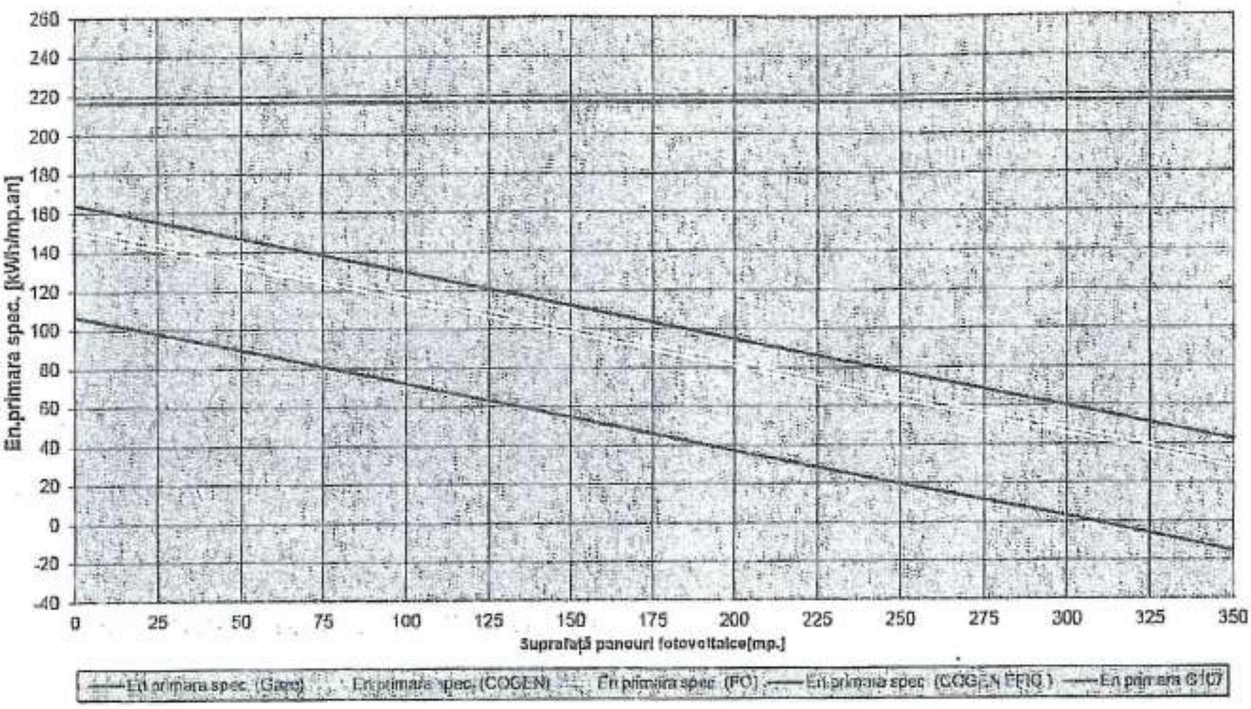

Figure V.37: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

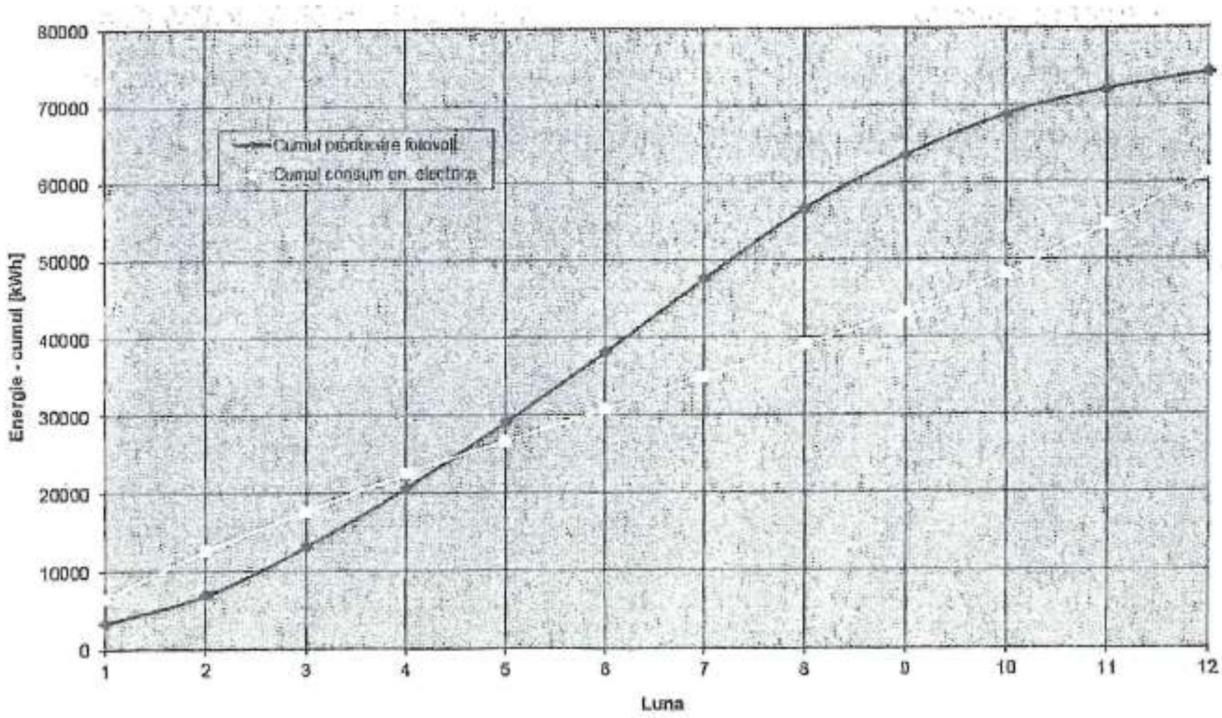

Figure V.38: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

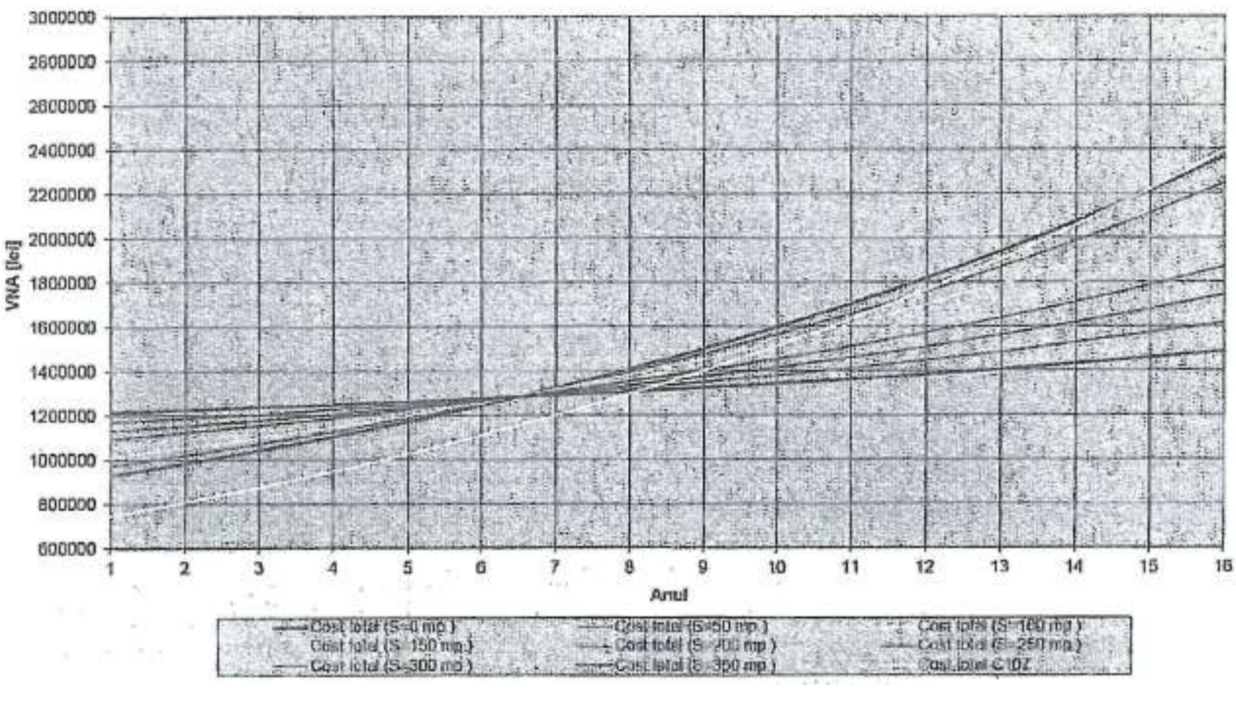

Figure V.39: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (mp = m^2)

2.3 System using current cogeneration

- primary energy = 45.52 kWh/m^{2}year;
- primary energy C107 = 188.85 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 121.39 %;
- share of total energy consumption from solar energy = 39.29 %;
- payback period ≈ 8.1 years.

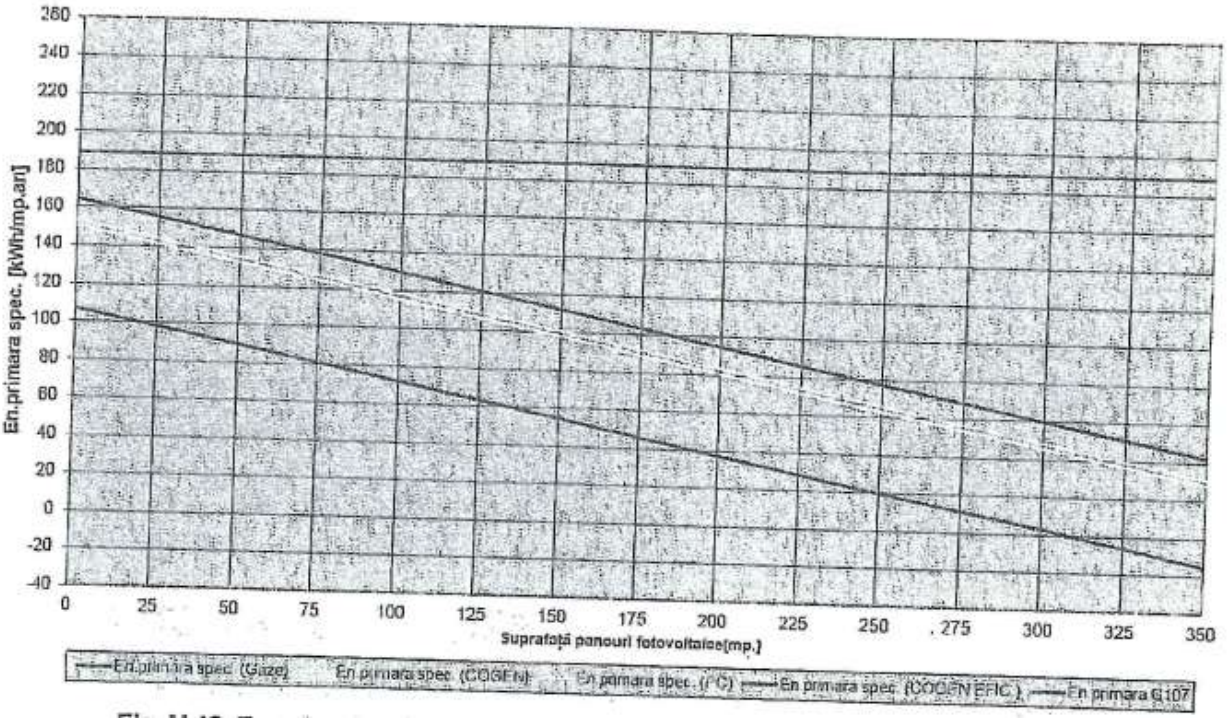

Figure V.40: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

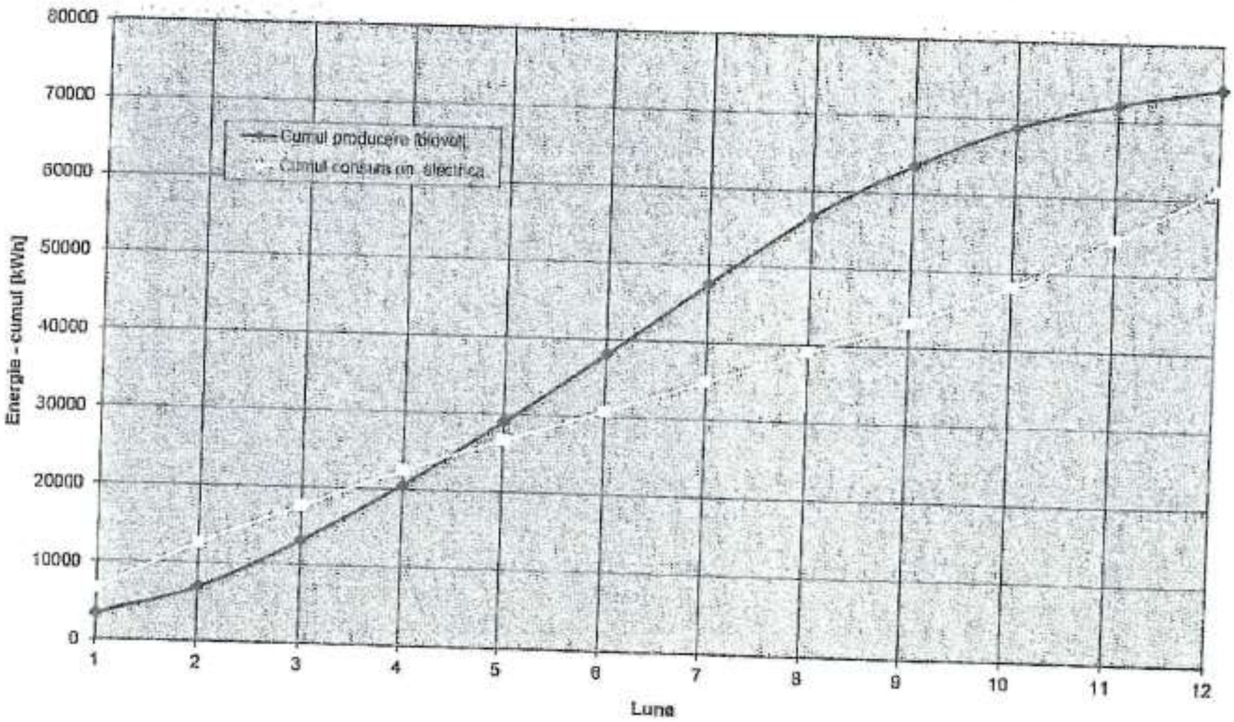

Figure V.41: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

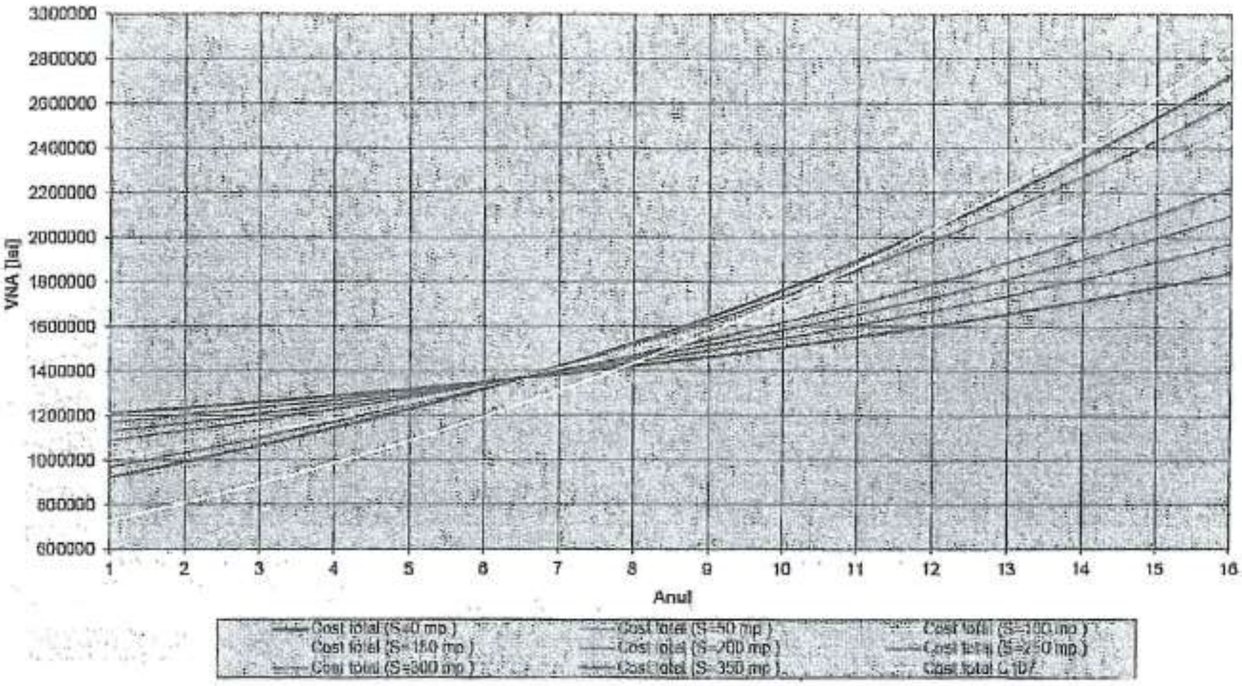

Figure V.42: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m²)

2.4 System using high efficiency cogeneration

- primary energy = 2.19 kWh/m²year;
- primary energy C107 = 188.85 kWh/m²year;
- share of electricity consumption from monocrystalline photovoltaic panels = 121.39 %;
- share of total energy consumption from solar energy = 39.29 %;
- payback period ≈ 8.1 years.

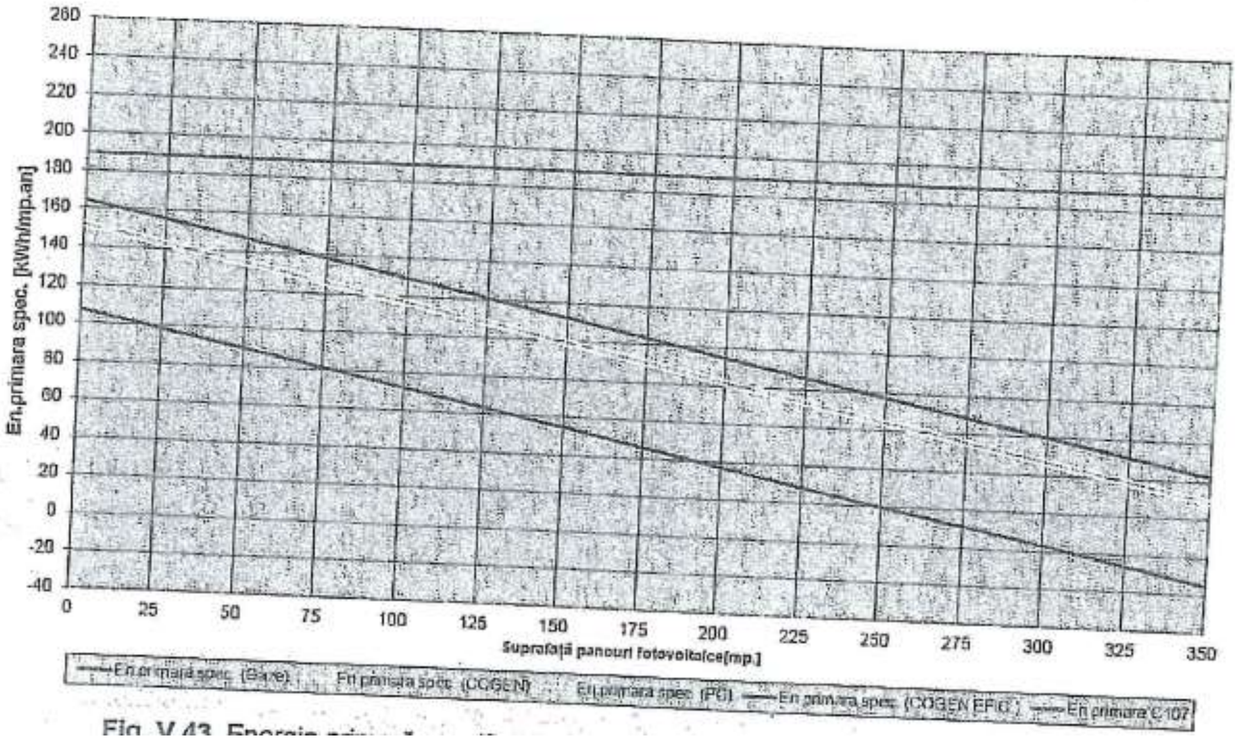

Figure V.43: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m²)
Vertical: Specific primary energy (kWh/m²year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

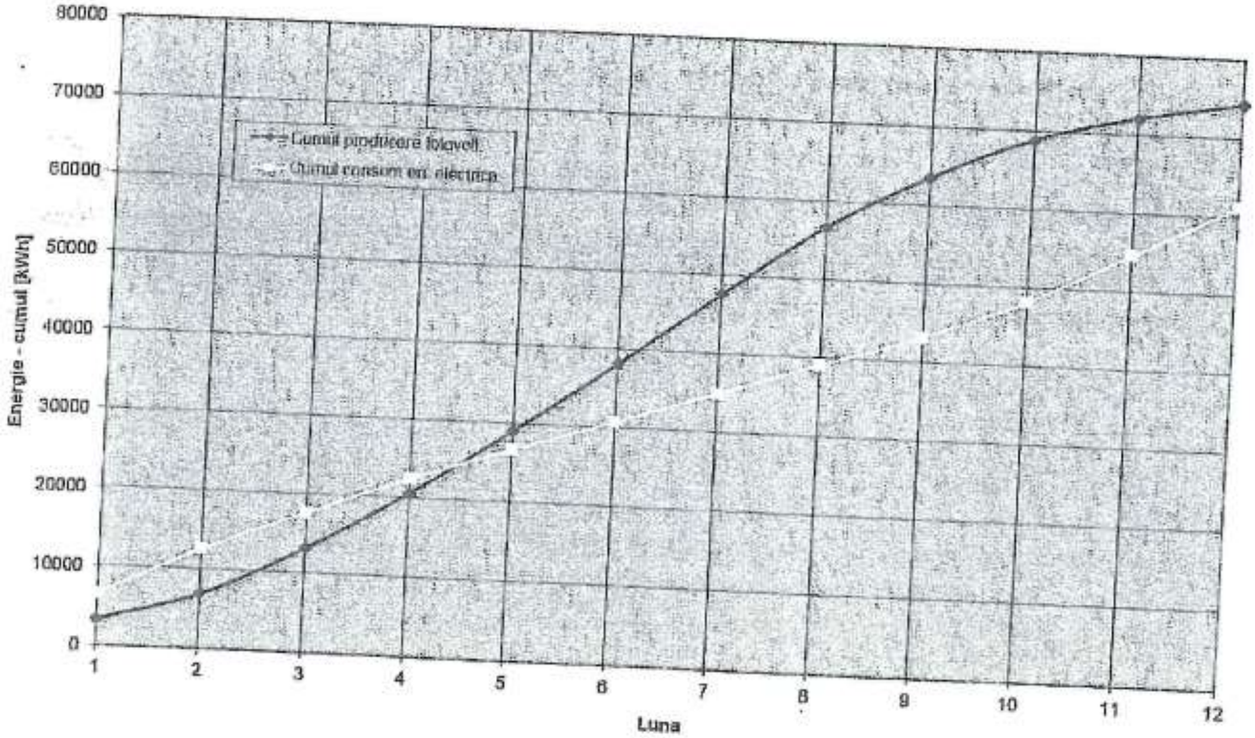

Figure V.44: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

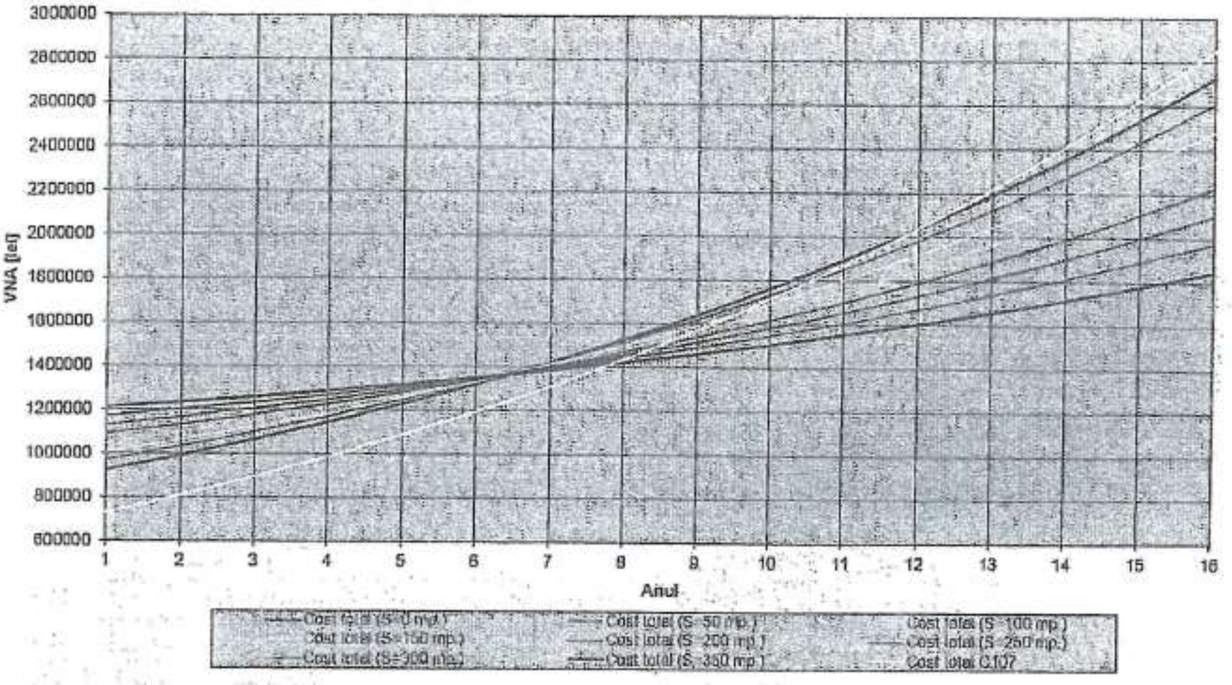

Figure V.45: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High efficiency cogeneration
primary energy (kWh/m^2year)	48.30	59.57	45.52	2.19
primary energy C107 (kWh/m^2year)	216.46	216.46	188.85	188.85
share of electricity consumption from PVP (%)	68.43	121.39	121.39	121.39
share of total energy consumption from solar energy (%)	68.43	34.21	39.29	39.29
payback period (years)	9.3	8.4	8.1	8.1

Apartment block, climate zone II

Case 1: Surface area of the photovoltaic solar panels = 50 m^2

1.1 System using a water-water heat pump

- primary energy = 142.86 kWh/m^2year;
- primary energy C107 = 224.70 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 8.85 %;
- share of total energy consumption from solar energy = 8.85 %;
- payback period ≈ 16 years.

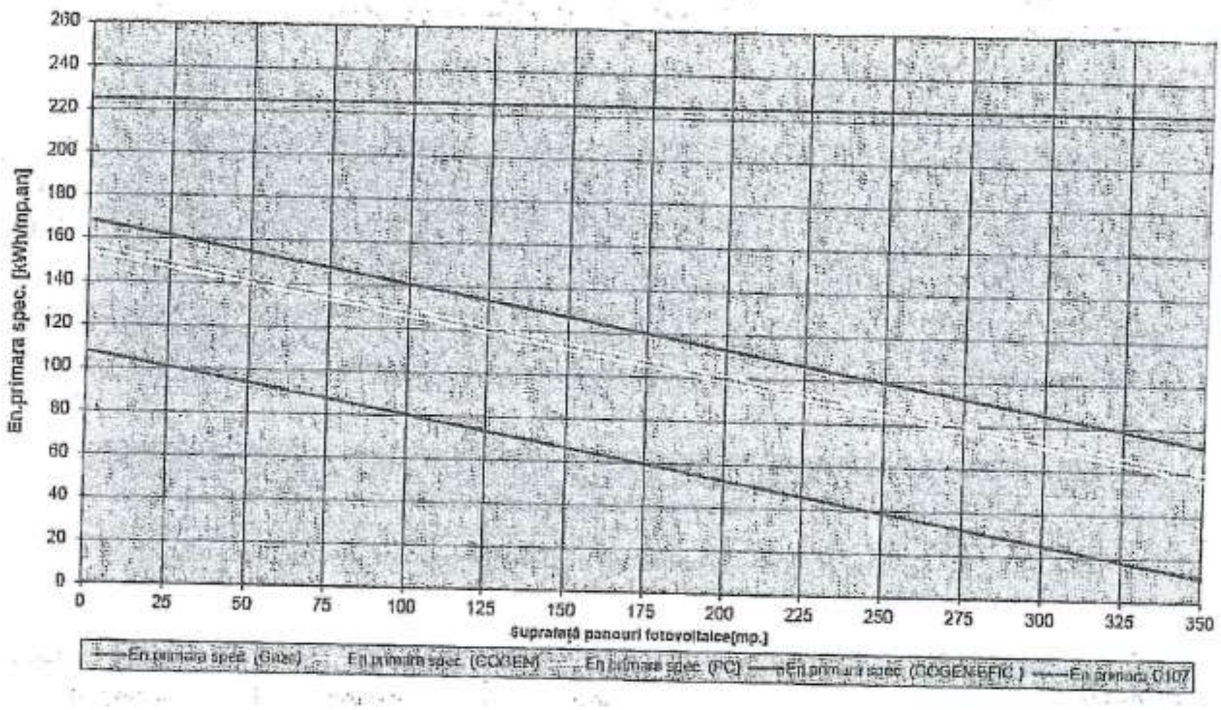

Figure V.46: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

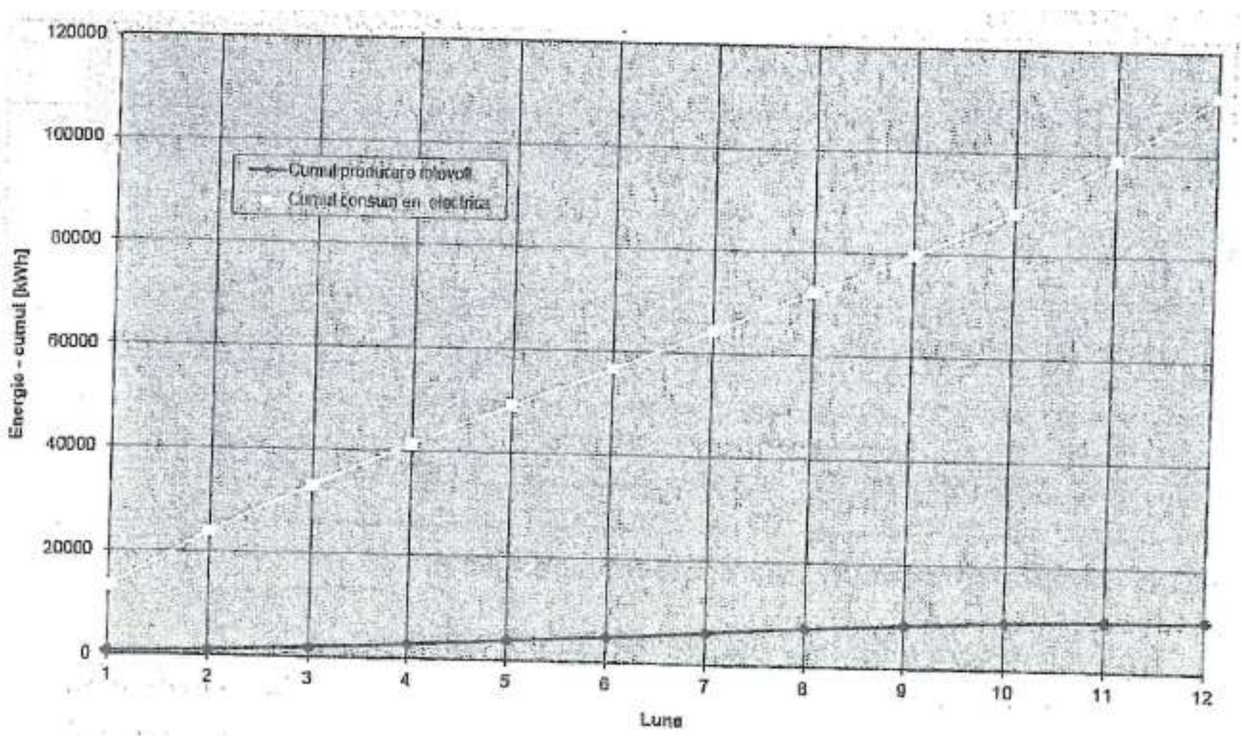

Figure V.47: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

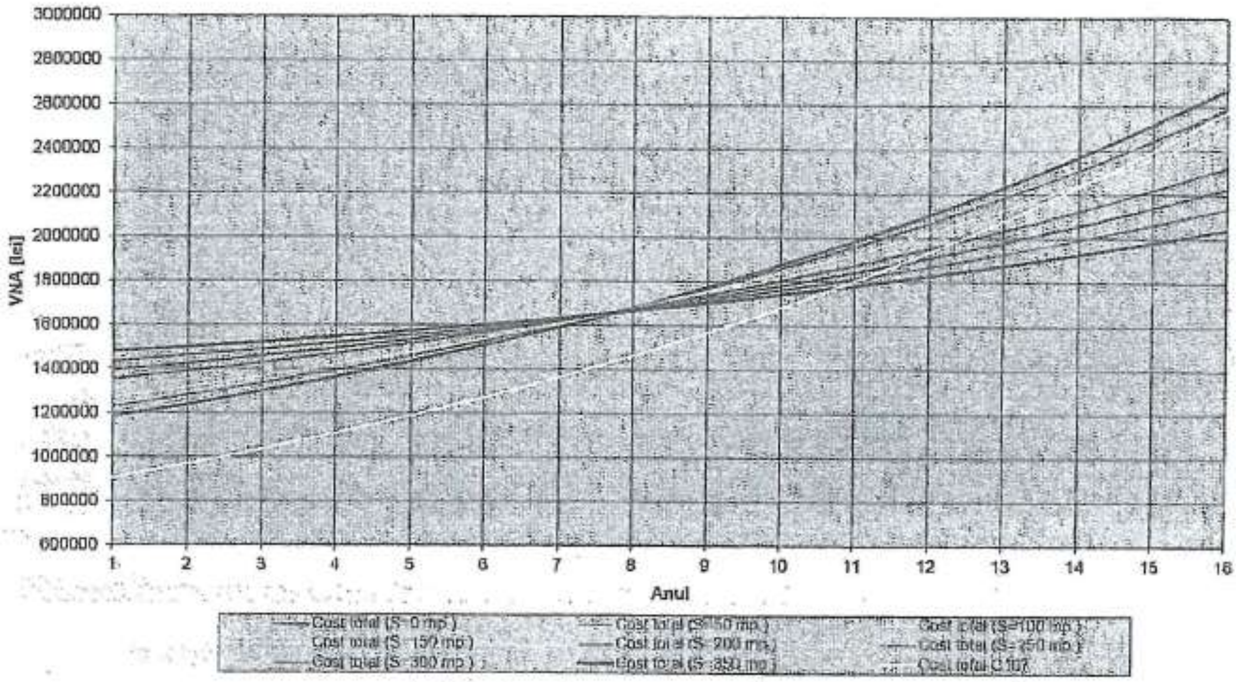

Figure V.48: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.2 System using a gas boiler

- primary energy = 154.76 kWh/m^2year;
- primary energy C107 = 224.70 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 16.08 %;
- share of total energy consumption from solar energy = 4.36 %;
- payback period ≈ 14 years.

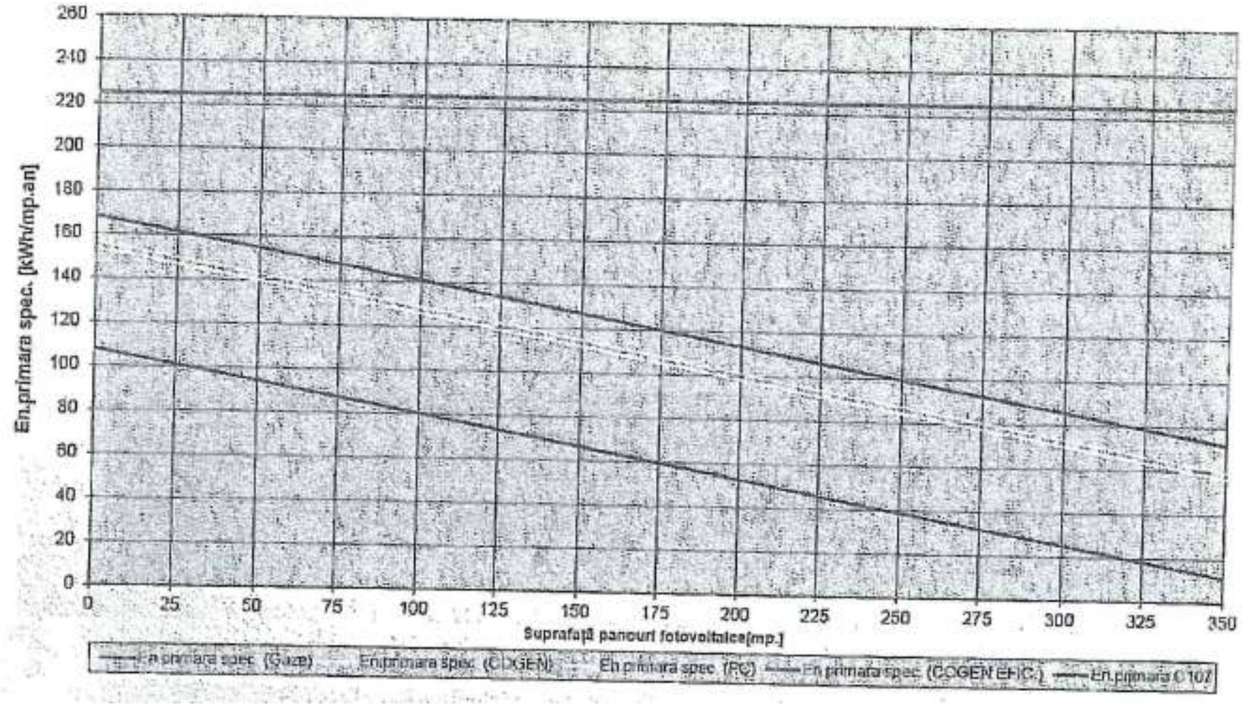

Figure V.49: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

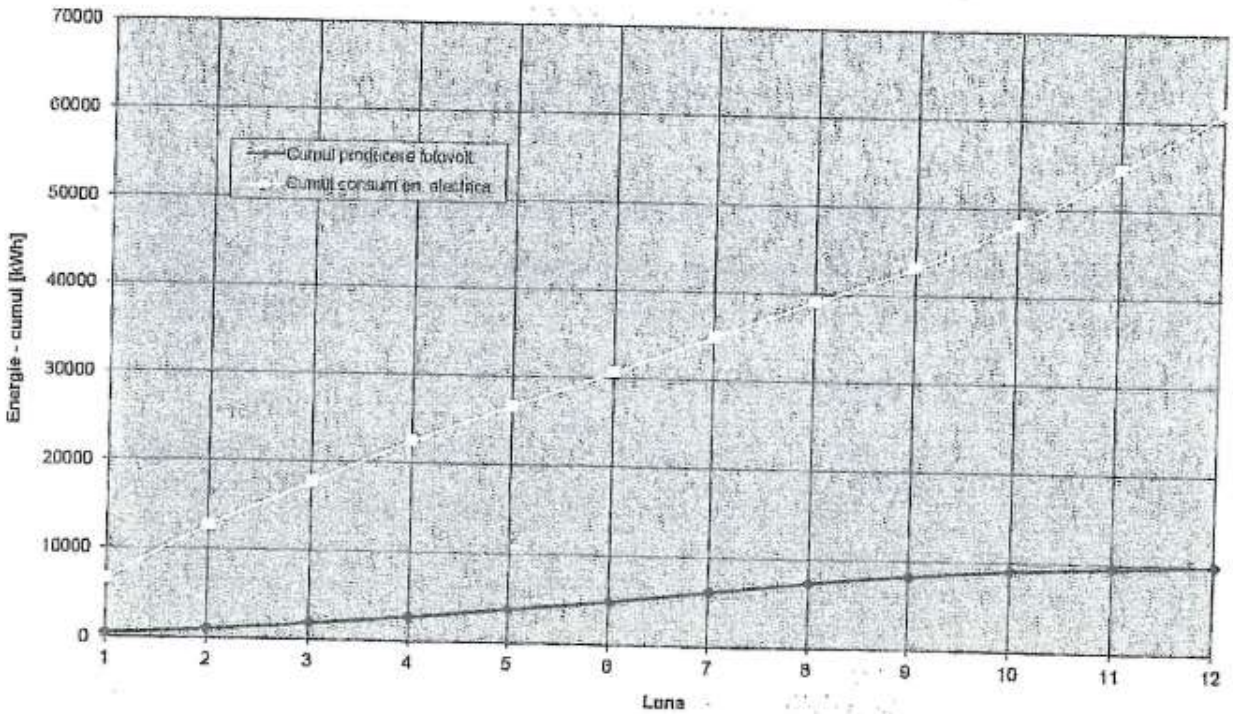

Figure V.50: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

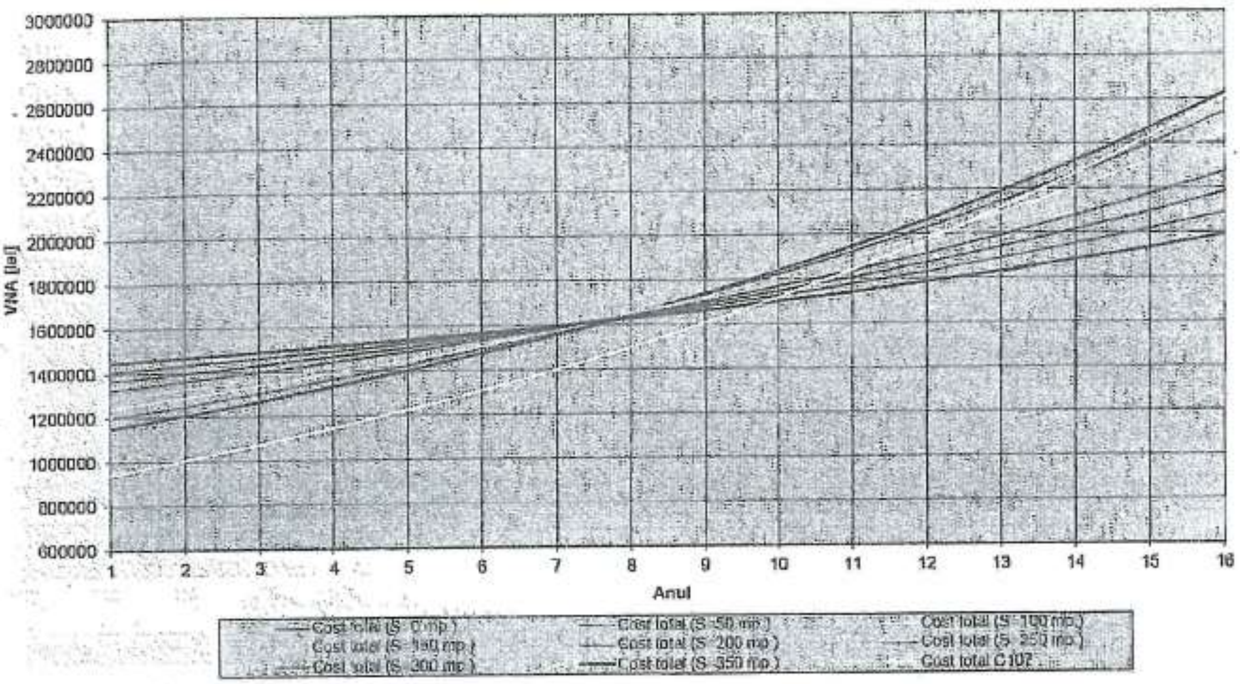

Figure V.51: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.3 System using current cogeneration

- primary energy = 139.93 kWh/m^{2}year;
- primary energy C107 = 193.34 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 16.08 %;
- share of total energy consumption from solar energy = 5.01 %;
- payback period ≈ 11.5 years.

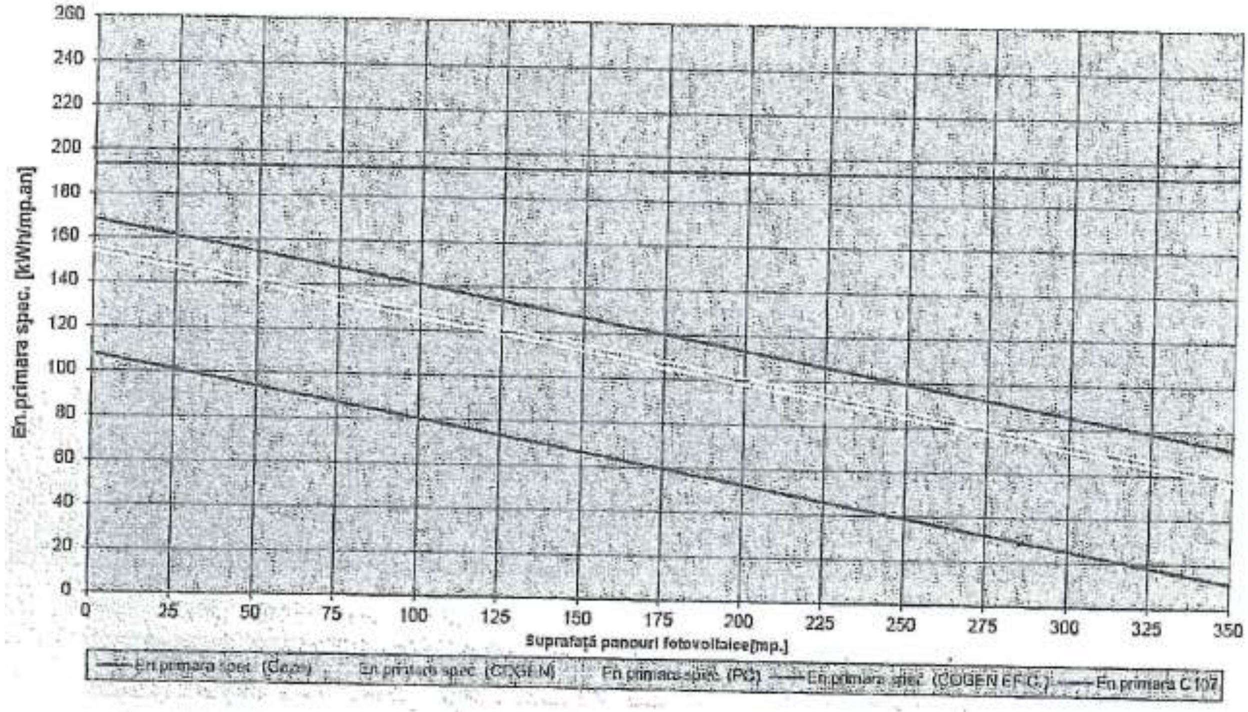

Figure V.52: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

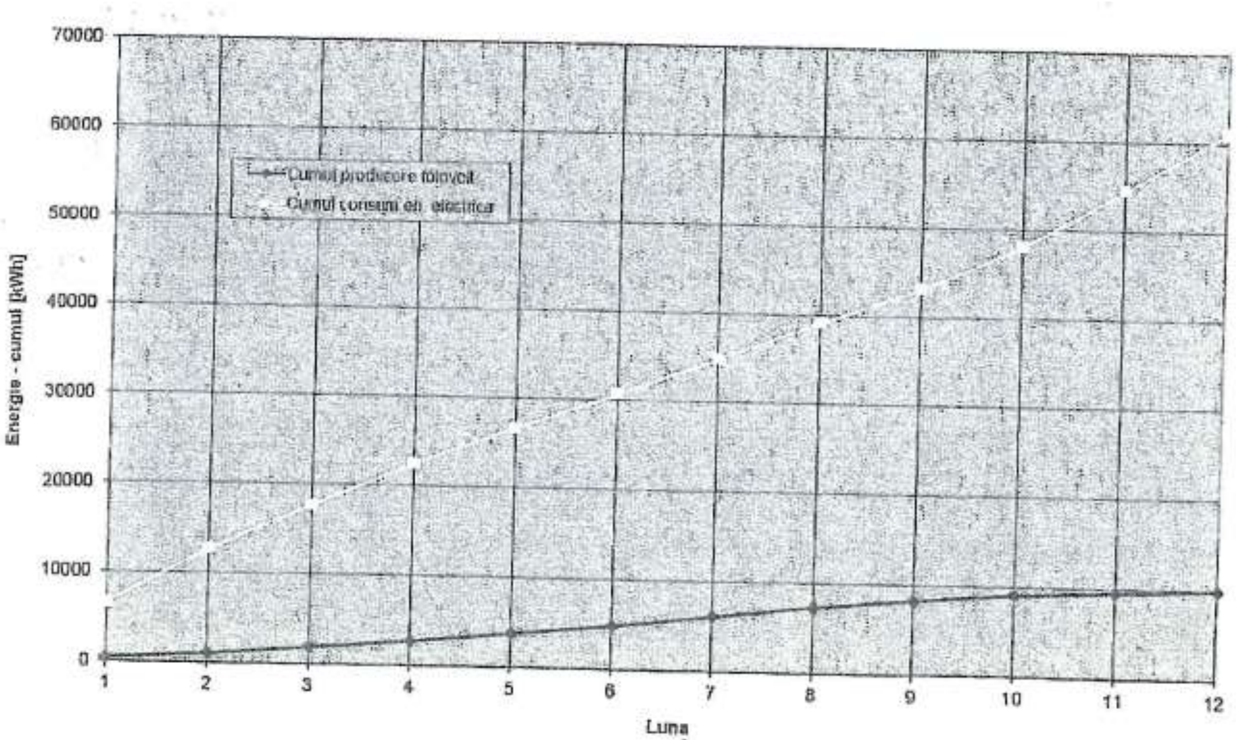

Figure V.53: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

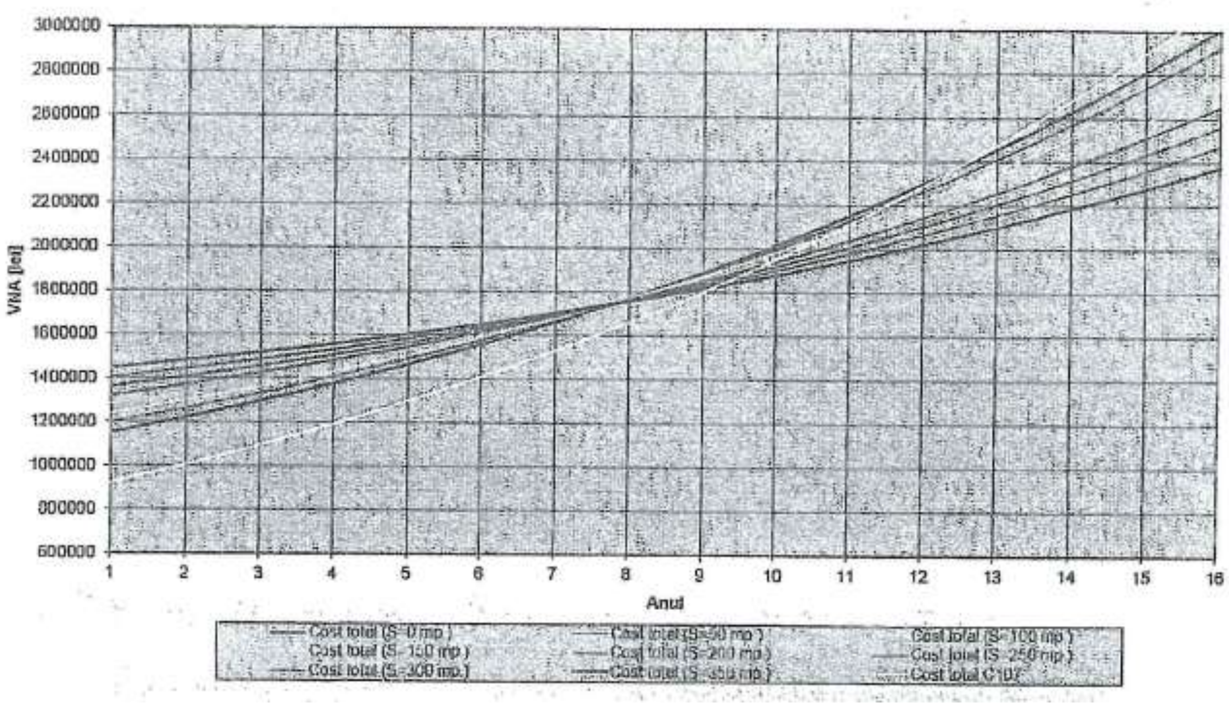

Figure V.54: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.4 System using high efficiency cogeneration

- primary energy = 94.18 kWh/m^2year;
- primary energy C107 = 193.34 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 16.08 %;
- share of total energy consumption from solar energy = 5.01 %;
- payback period ≈ 11.5 years.

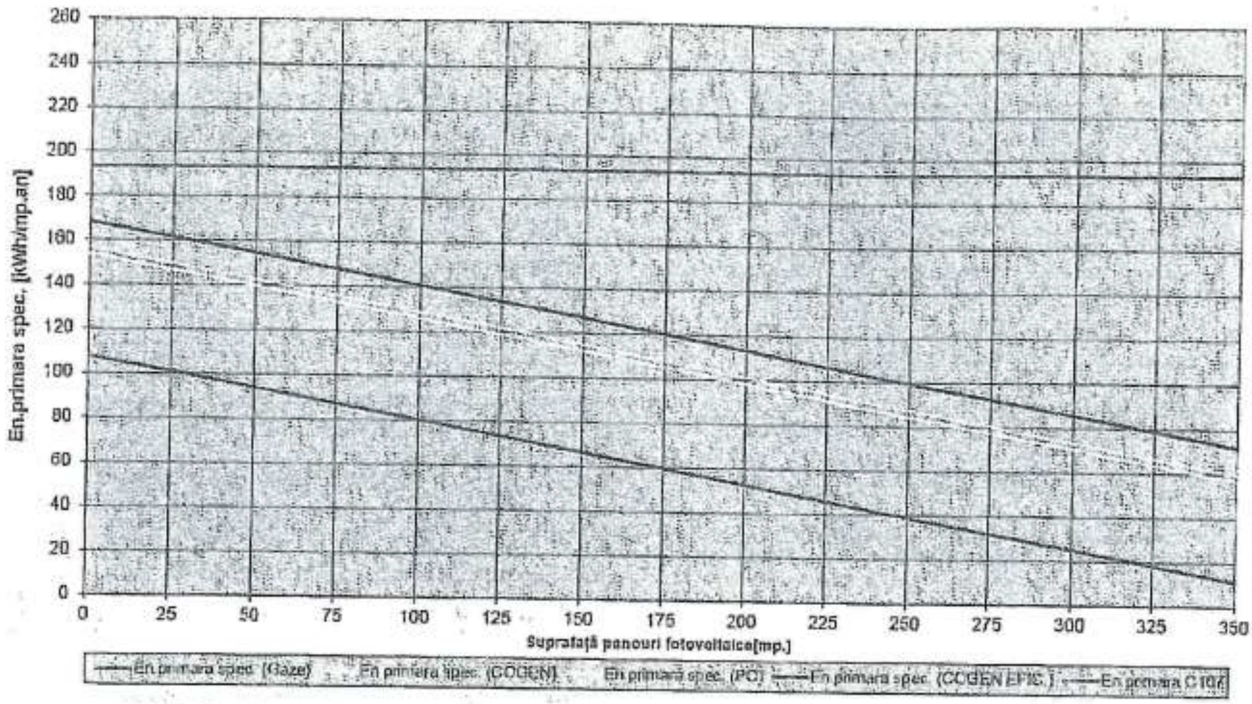

Figure V.55: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

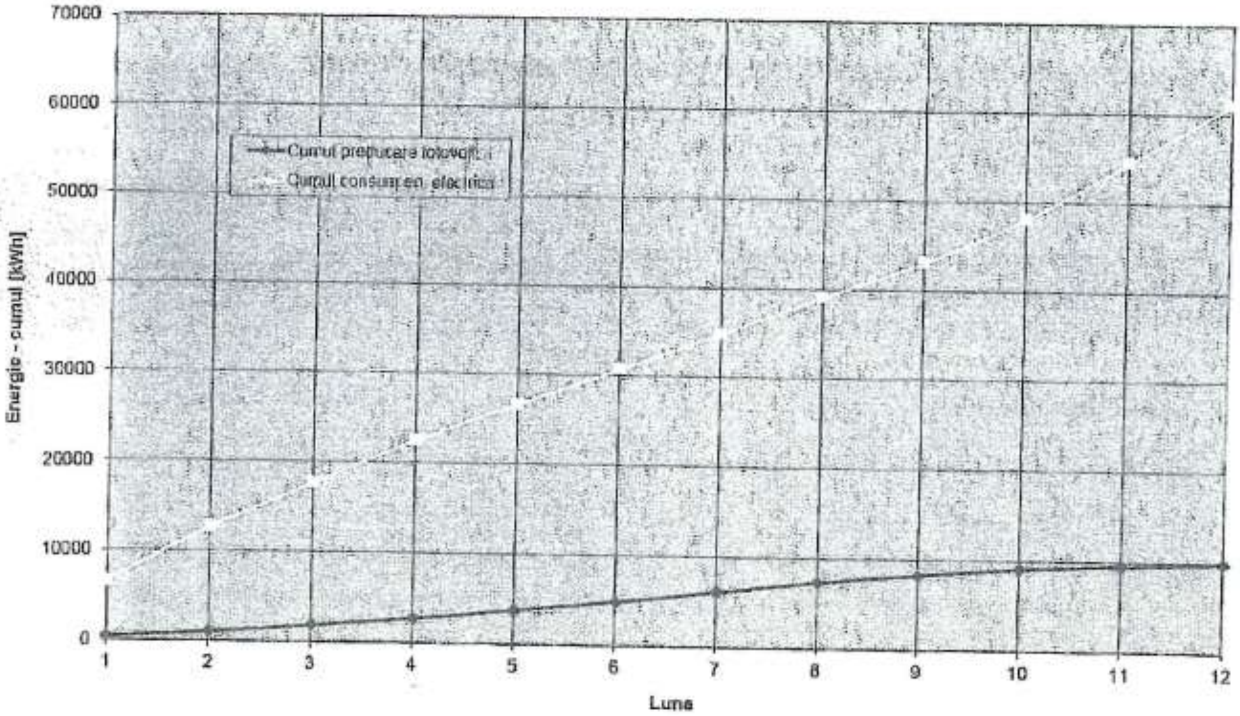

Figure V.56: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

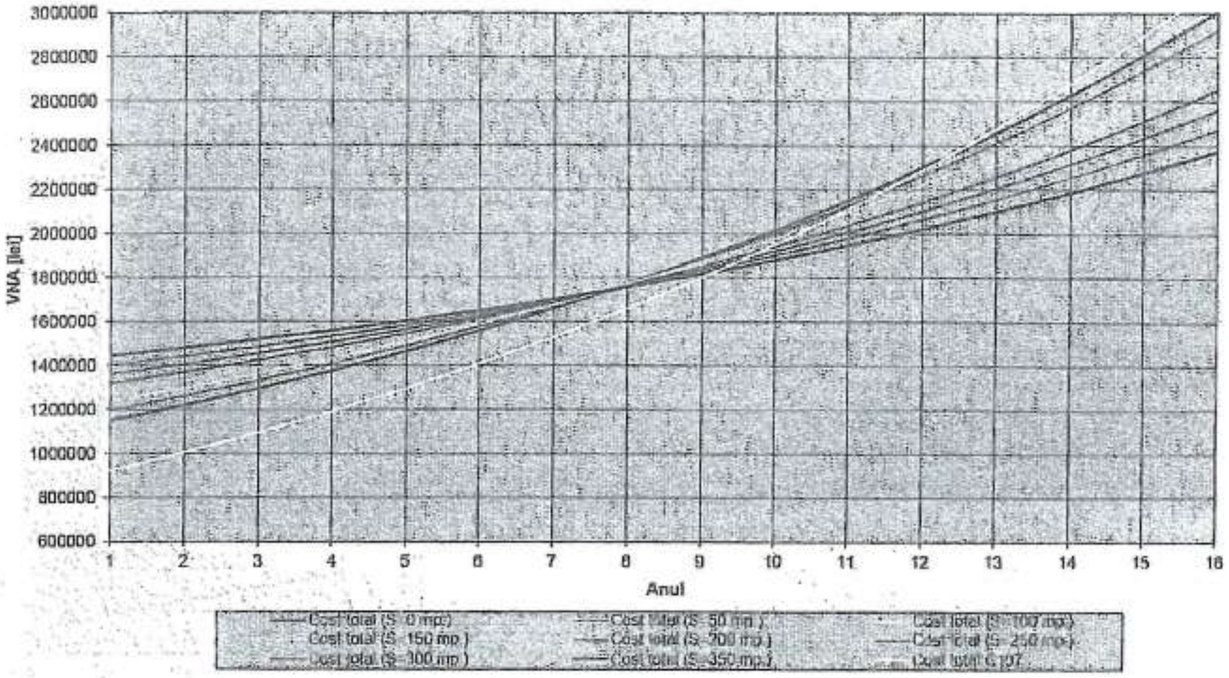

Figure V.57: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 50 m^2	**Heat pump**	**Boiler**	**Current cogeneration**	**High efficiency cogeneration**
primary energy (kWh/m^2year)	142.86	154.76	139.93	94.18
primary energy C107 (kWh/m^2year)	224.70	224.70	193.34	193.34
share of electricity consumption from PVP (%)	8.85	16.08	16.08	16.08
share of total energy consumption	8.85	4.36	5.01	5.01

from solar energy (%)				
payback period (years)	16.0	14.0	11.5	11.5

Case 2: Surface area of the photovoltaic solar panels = 300 m^2

2.1 System using a water-water heat pump

- primary energy = 73.54 kWh/m^{2}year;
- primary energy C107 = 224.70 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 53.08 %;
- share of total energy consumption from solar energy = 53.08 %;
- payback period ≈ 11.1 years.

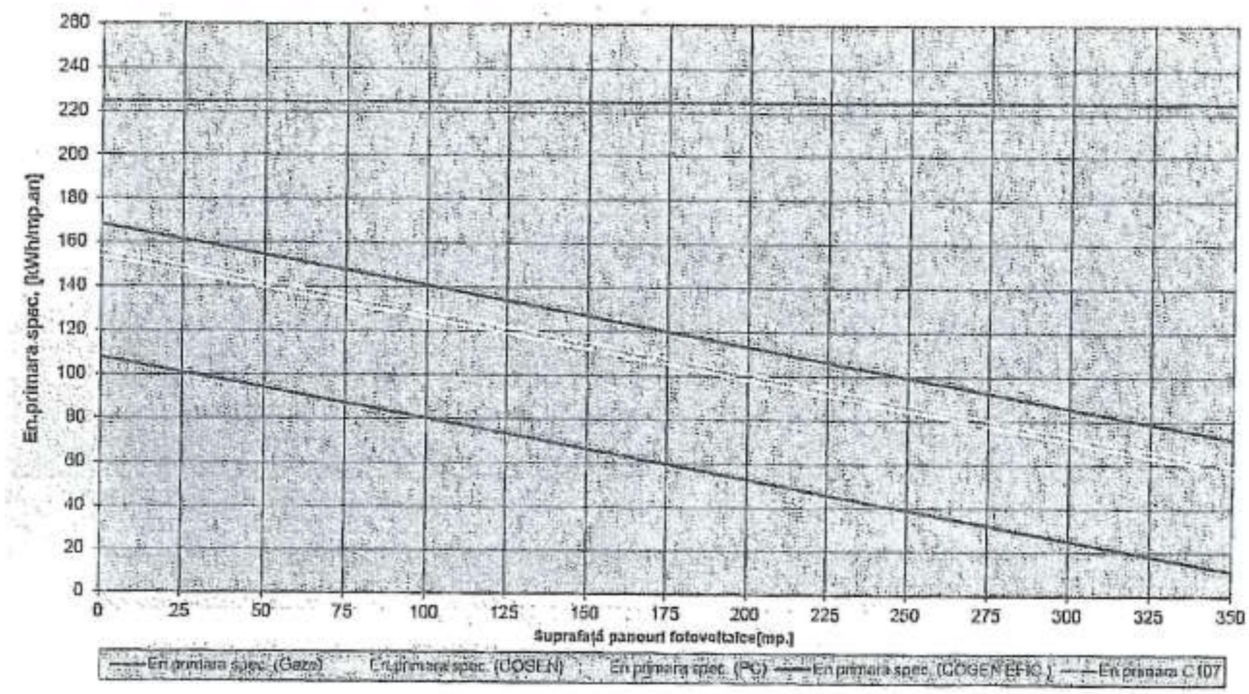

Figure V.58: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

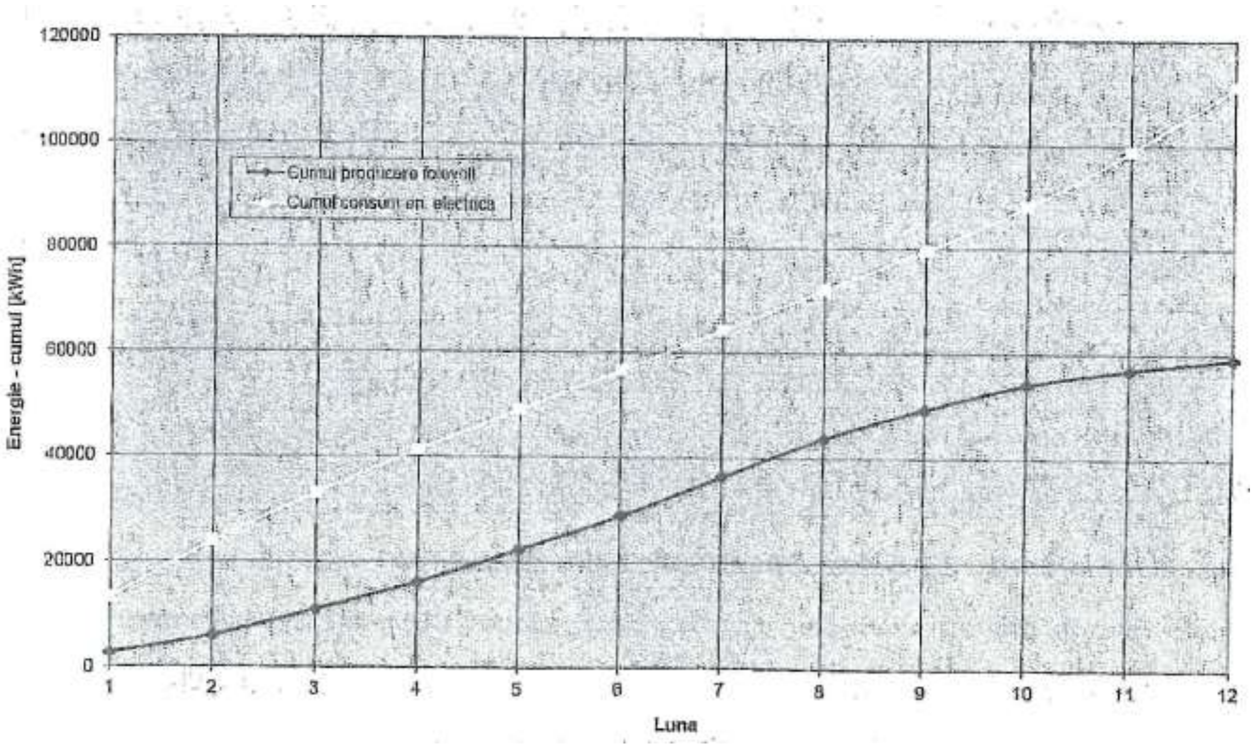

Figure V.59: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

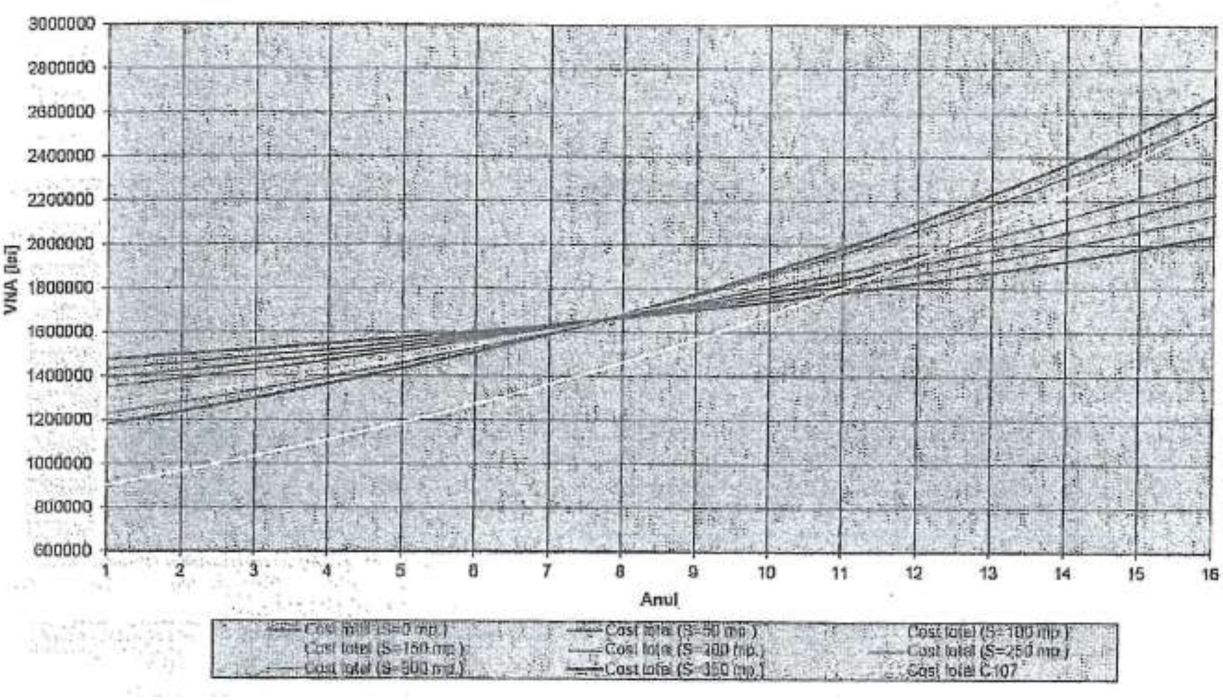

Figure V.60: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.2 System using a gas boiler

- primary energy = 85.43 kWh/m^{2}year;
- primary energy C107 = 224.70 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 96.45 %;
- share of total energy consumption from solar energy = 26.14 %;
- payback period ≈ 10.2 years.

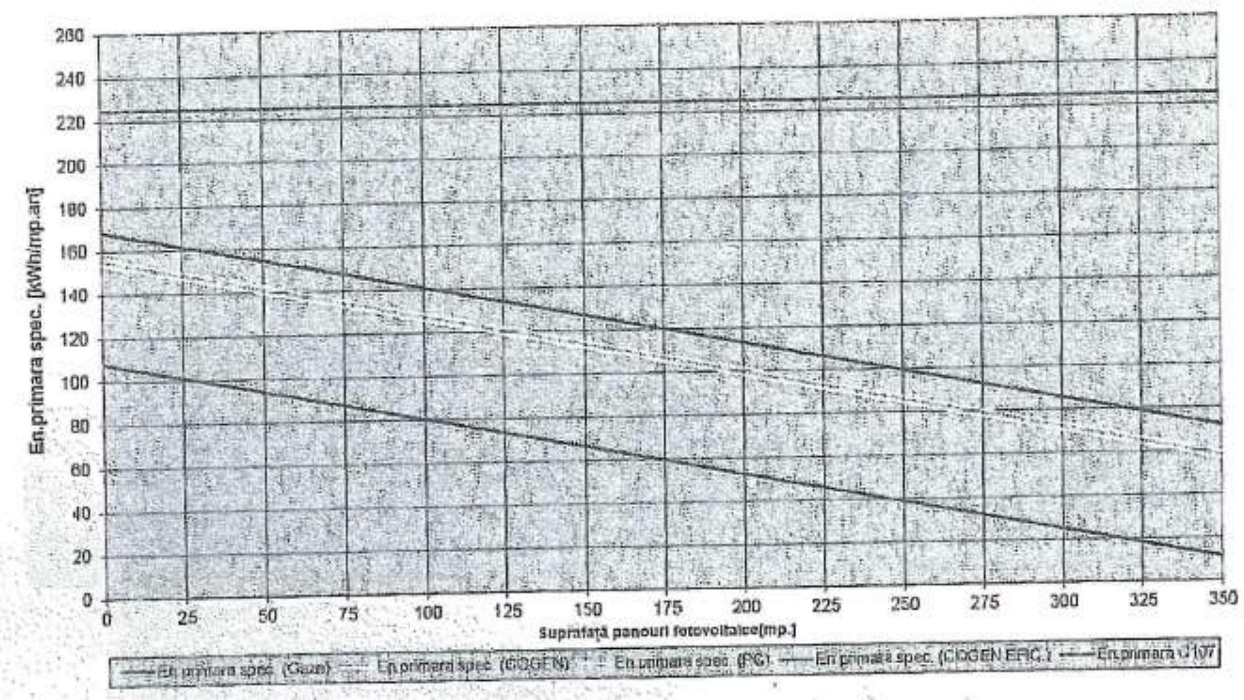

Figure V.61: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

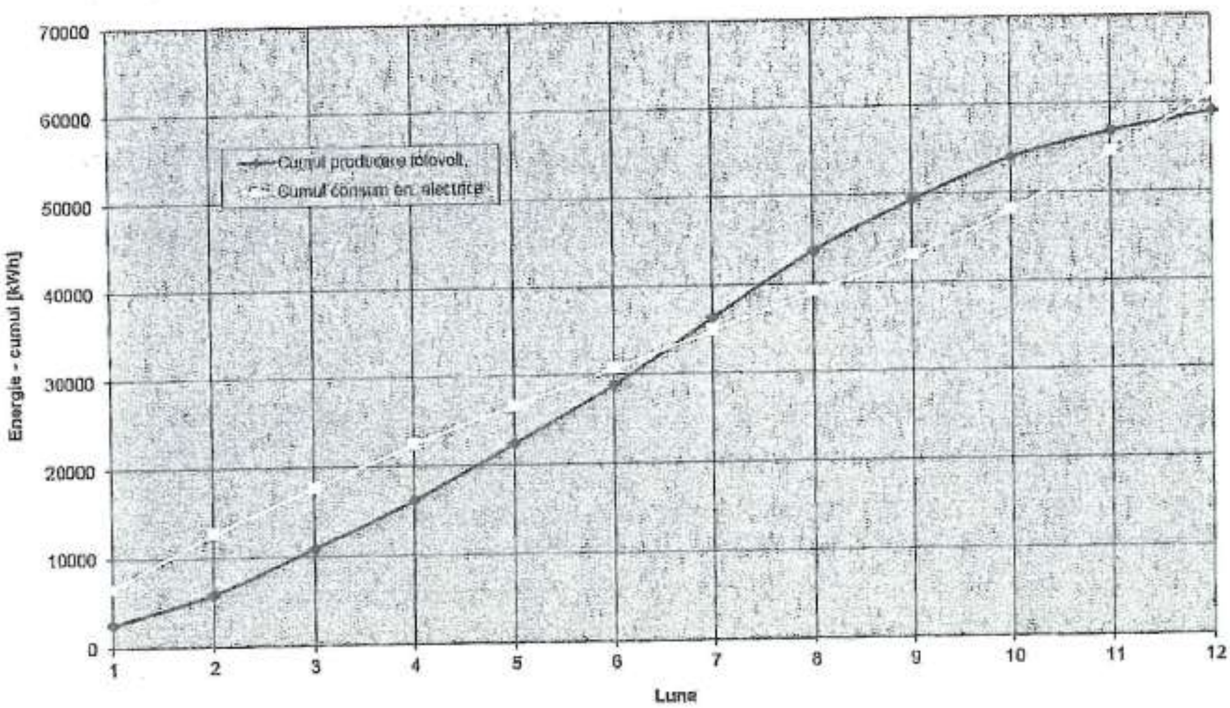

Figure V.62: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

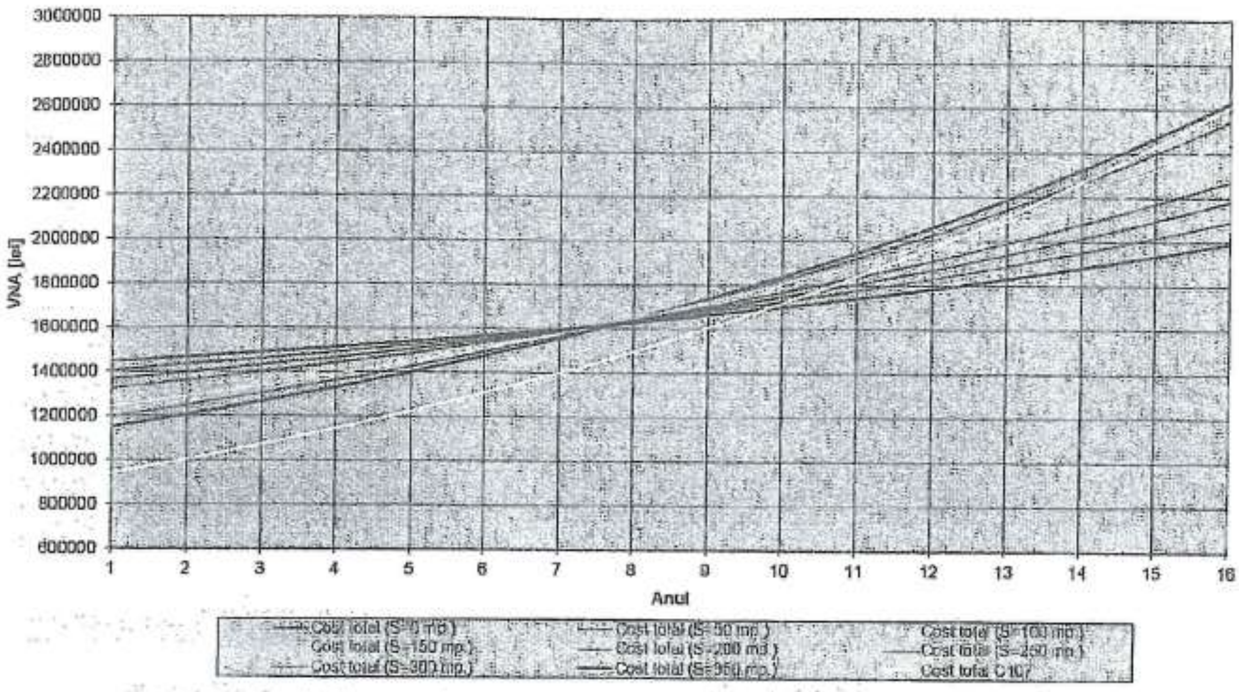

Figure V.63: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.3 System using current cogeneration

- primary energy = 70.61 kWh/m^{2}year;
- primary energy C107 = 193.34 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 96.45 %;
- share of total energy consumption from solar energy = 30.08 %;
- payback period ≈ 9.4 years.

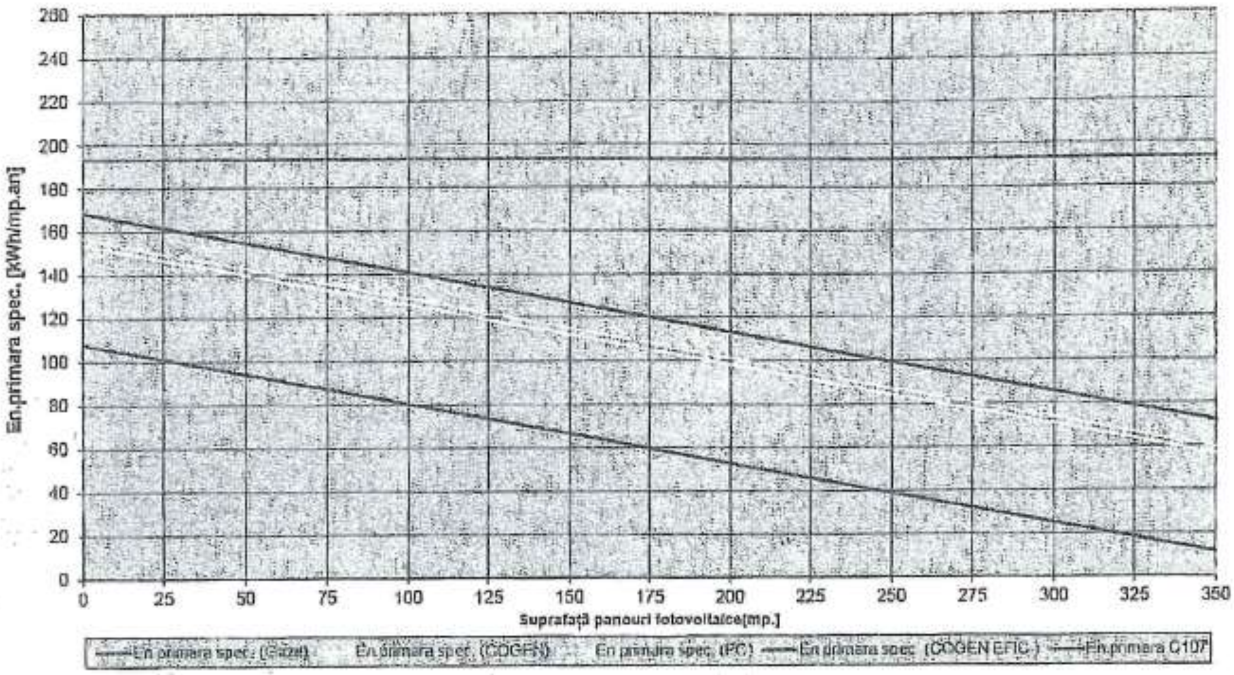

Figure V.64: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

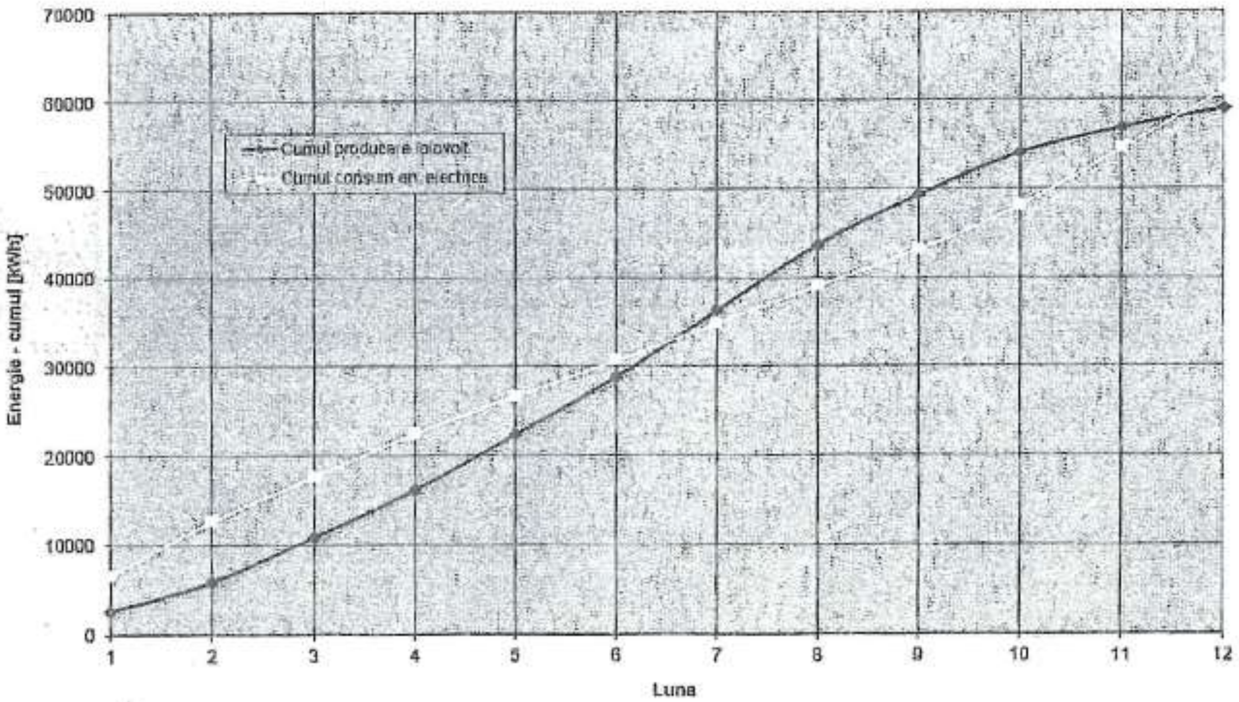

Figure V.65: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

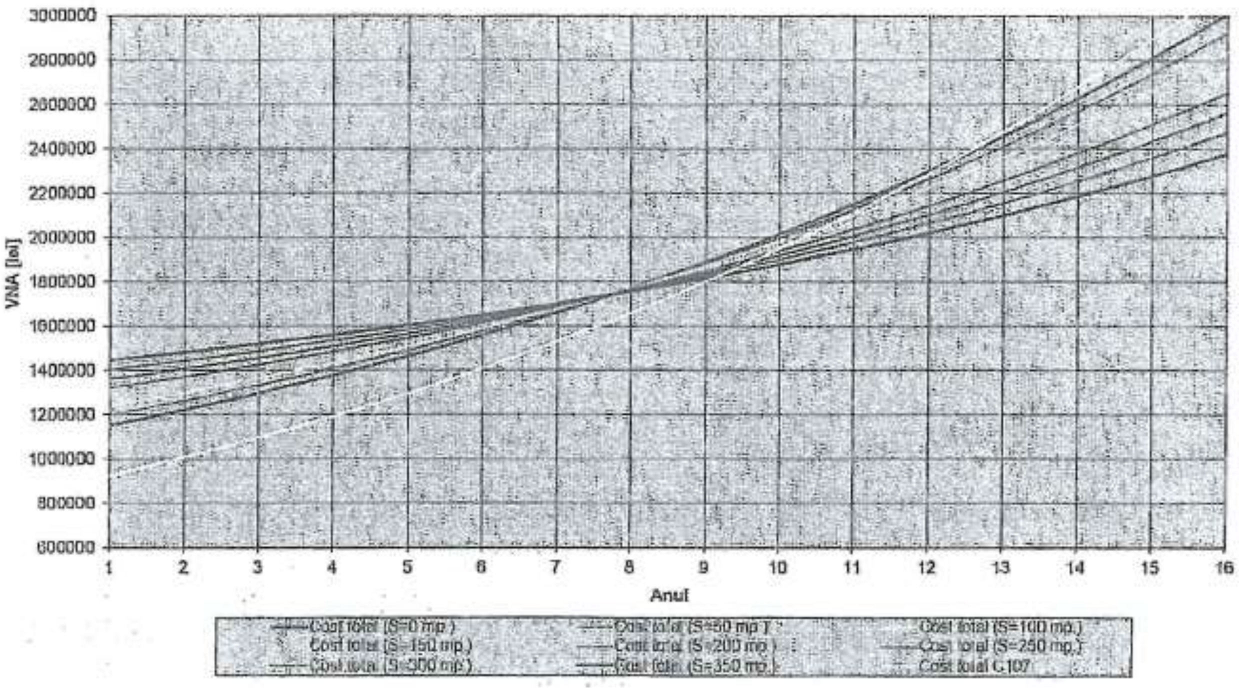

Figure V.66: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.4 System using high efficiency cogeneration

- primary energy = 24.85 kWh/m^{2}year;
- primary energy C107 = 193.34 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 96.45 %;
- share of total energy consumption from solar energy = 30.08 %;
- payback period ≈ 9.4 years.

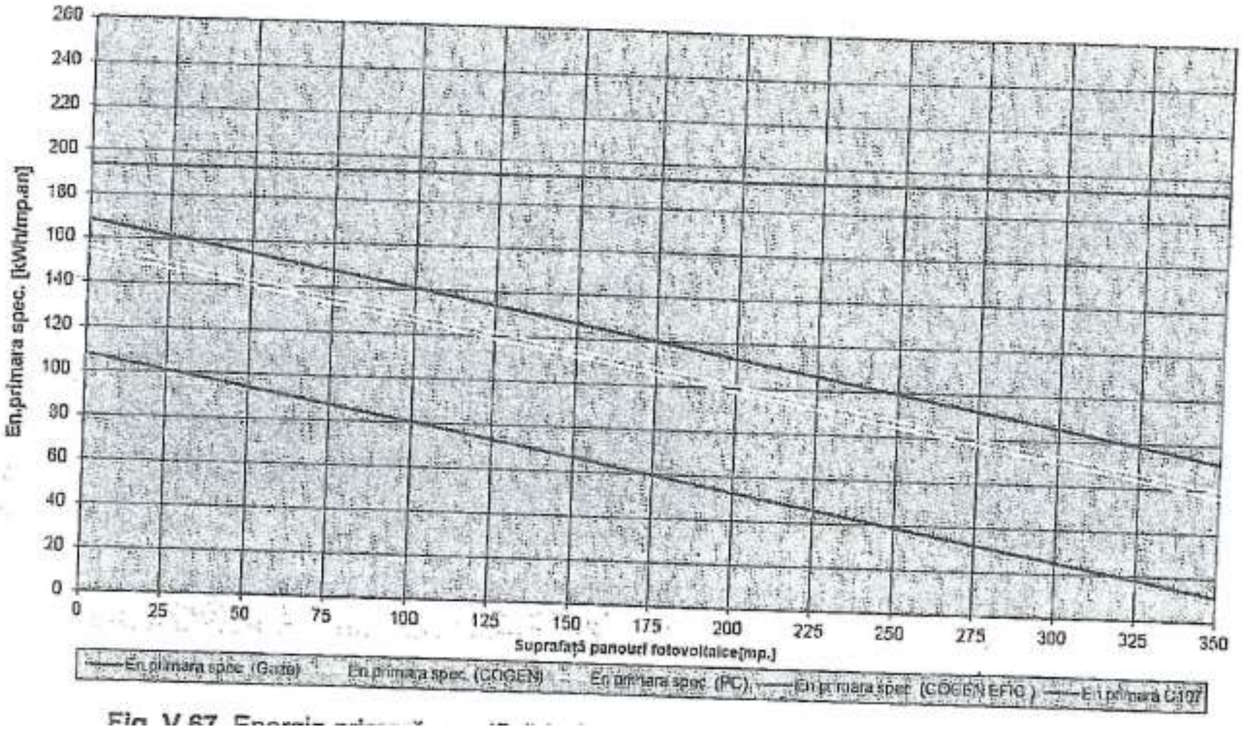

Figure V.67: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

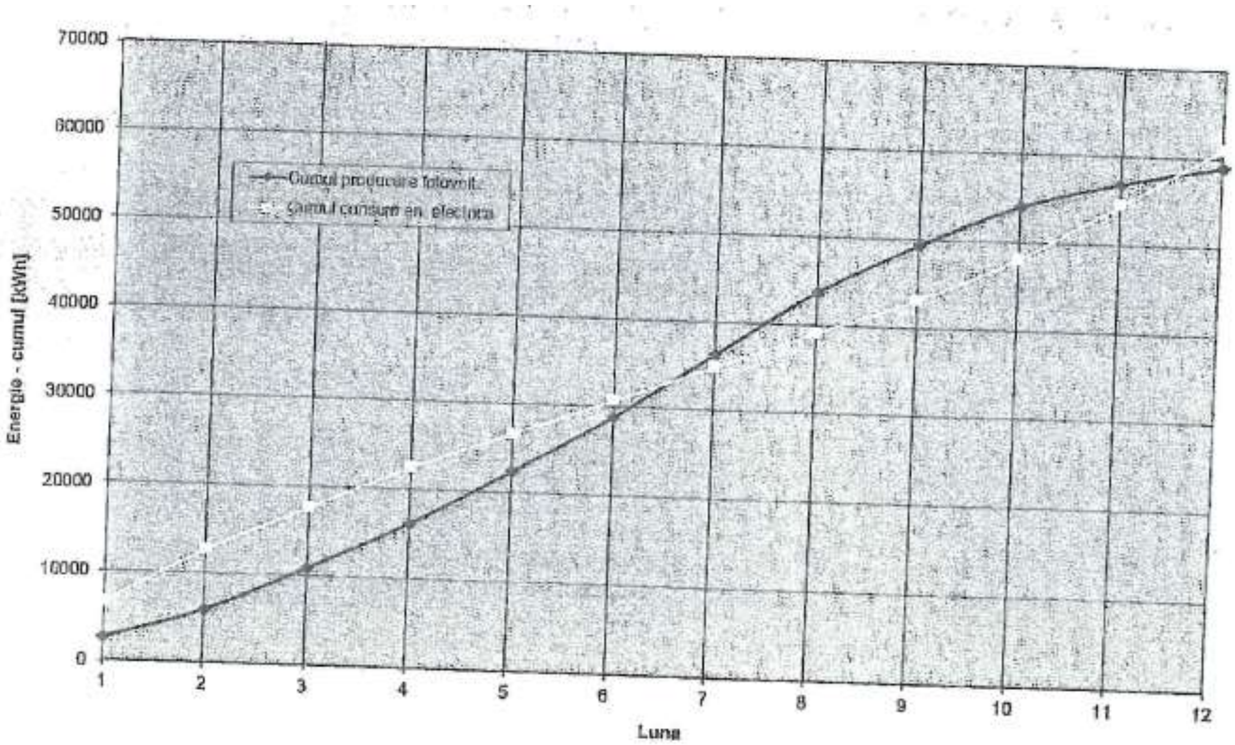

Figure V.68: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

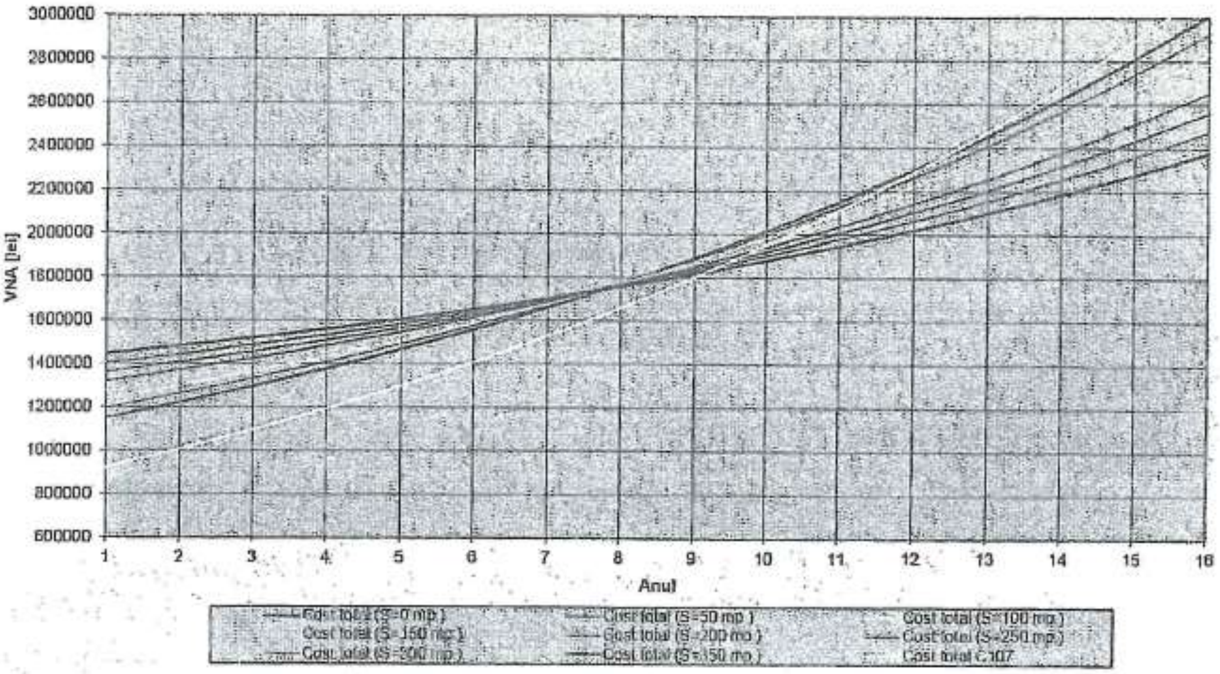

Figure V.69: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High efficiency cogeneration
primary energy (kWh/m^2year)	73.54	85.43	70.61	24.85
primary energy C107 (kWh/m^2year)	224.70	224.70	193.34	193.34
share of electricity consumption from PVP (%)	53.08	96.45	96.45	96.45
share of total energy consumption from solar energy (%)	53.08	26.14	30.08	30.08
payback period (years)	11.1	10.2	9.4	9.4

Apartment block, climate zone III

Case 1: Surface area of the photovoltaic solar panels = 50 m^2

1.1 System using a water-water heat pump

- primary energy = 142.48 kWh/m^2year;
- primary energy C107 = 229.04 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 9.78 %;
- share of total energy consumption from solar energy = 9.78 %;
- payback period ≈ 14.4 years.

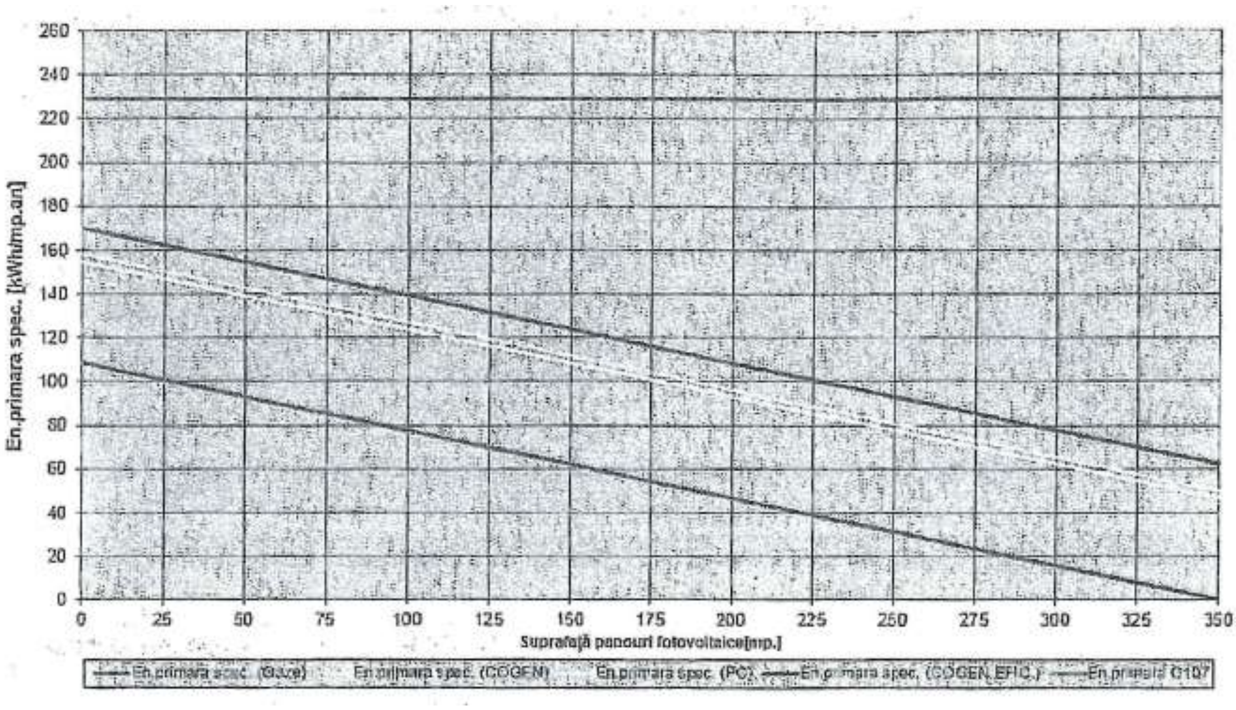

Figure V.70: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

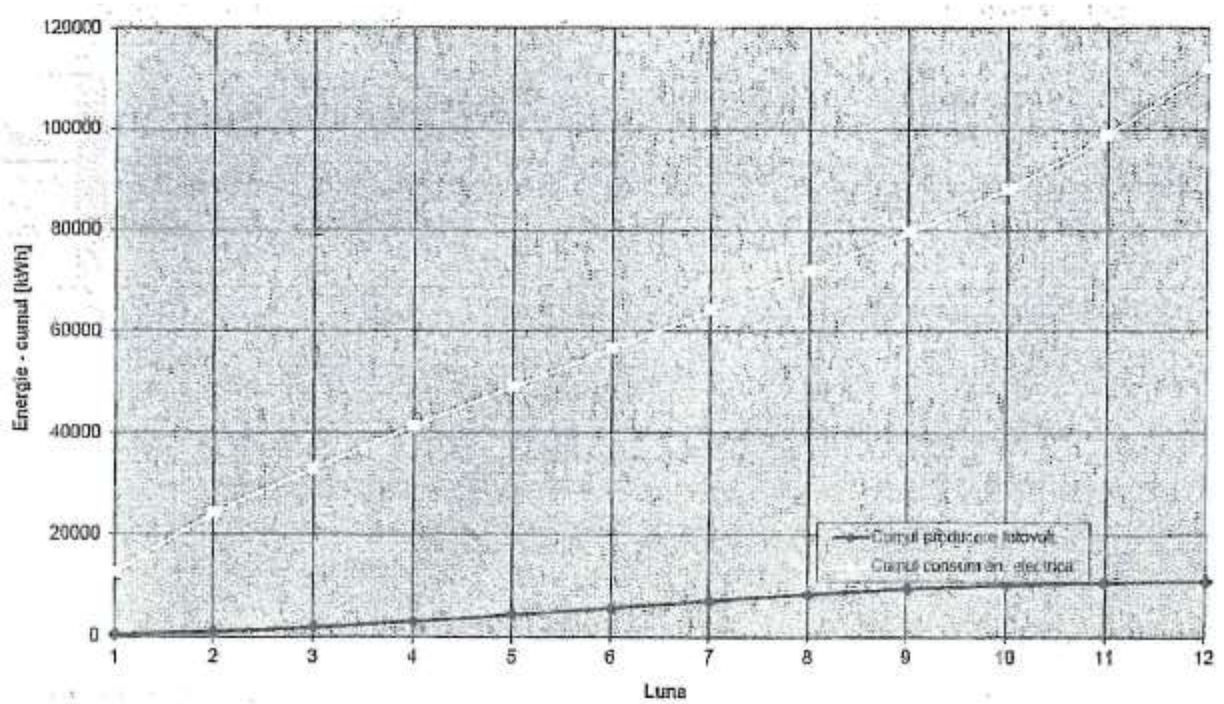

Figure V.71: Power generation and consumption
Key:

Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

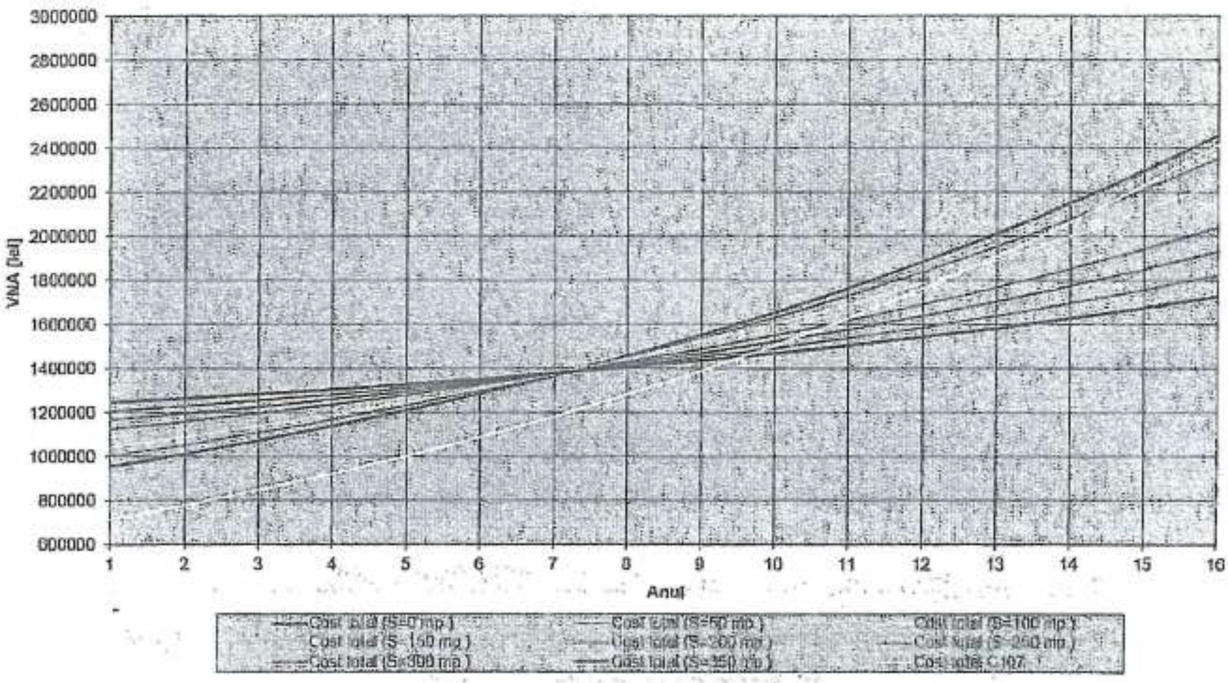

Figure V.72: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.2 System using a gas boiler

- primary energy = 154.57 kWh/m^2year;
- primary energy C107 = 229.04 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 17.91 %;
- share of total energy consumption from solar energy = 4.79 %;
- payback period ≈ 12.0 years.

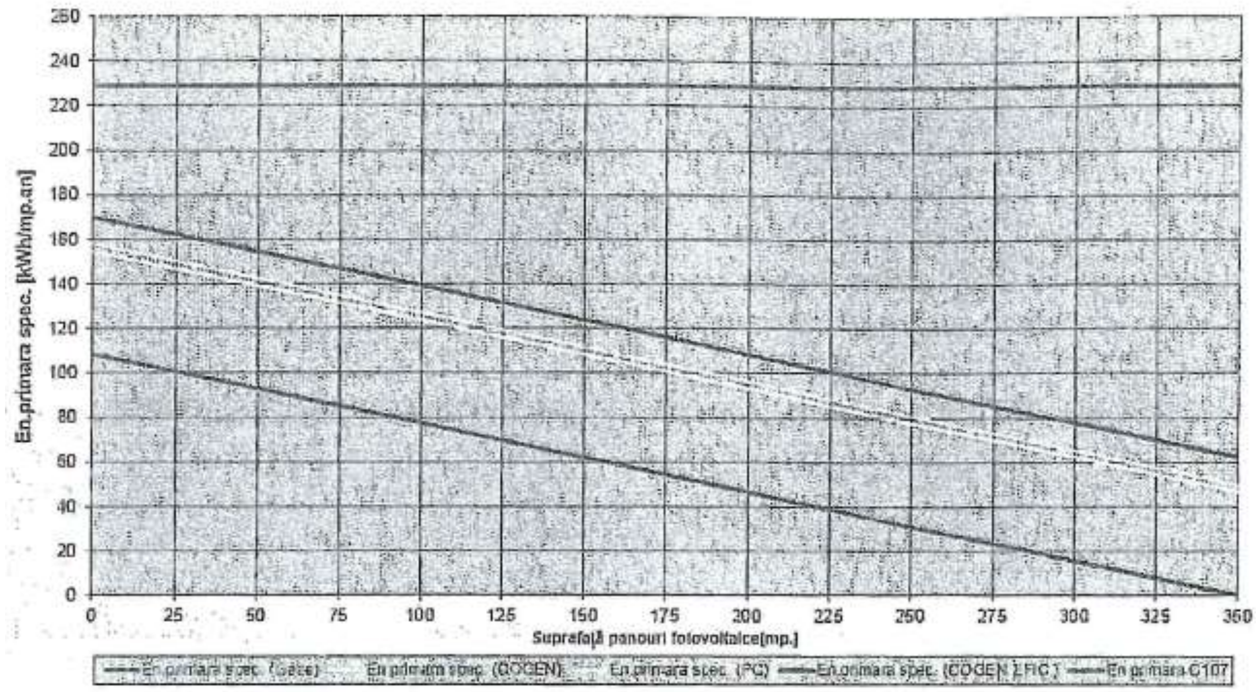

Figure V.73: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

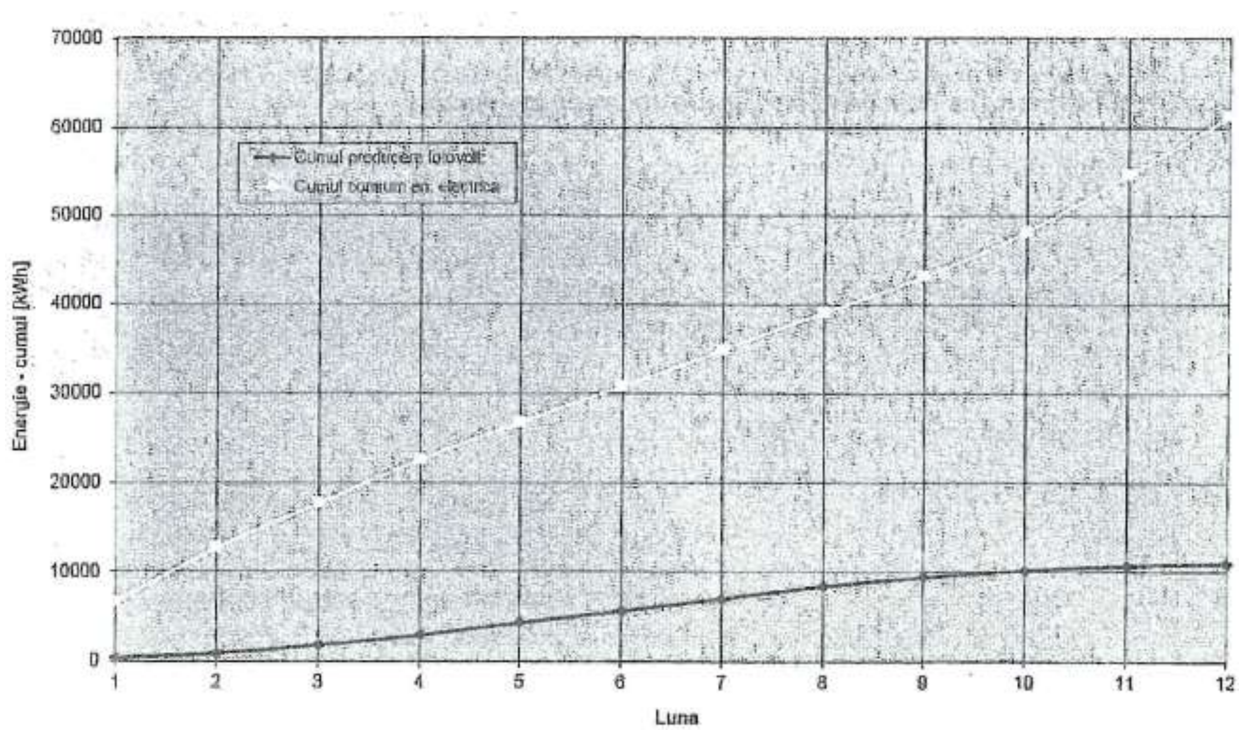

Figure V.74: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

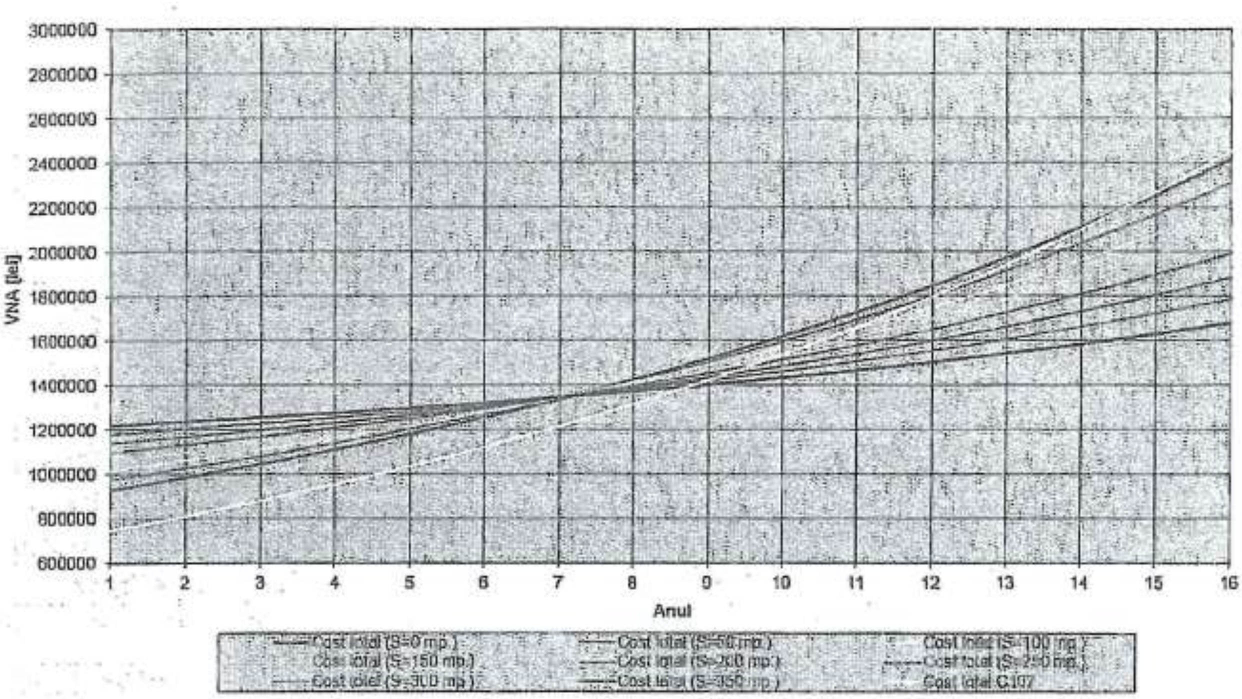

Figure V.75: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.3 System using current cogeneration

- primary energy = 139.49 kWh/m^2year;
- primary energy C107 = 196.94 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 17.91 %;
- share of total energy consumption from solar energy = 5.52 %;
- payback period ≈ 10.0 years.

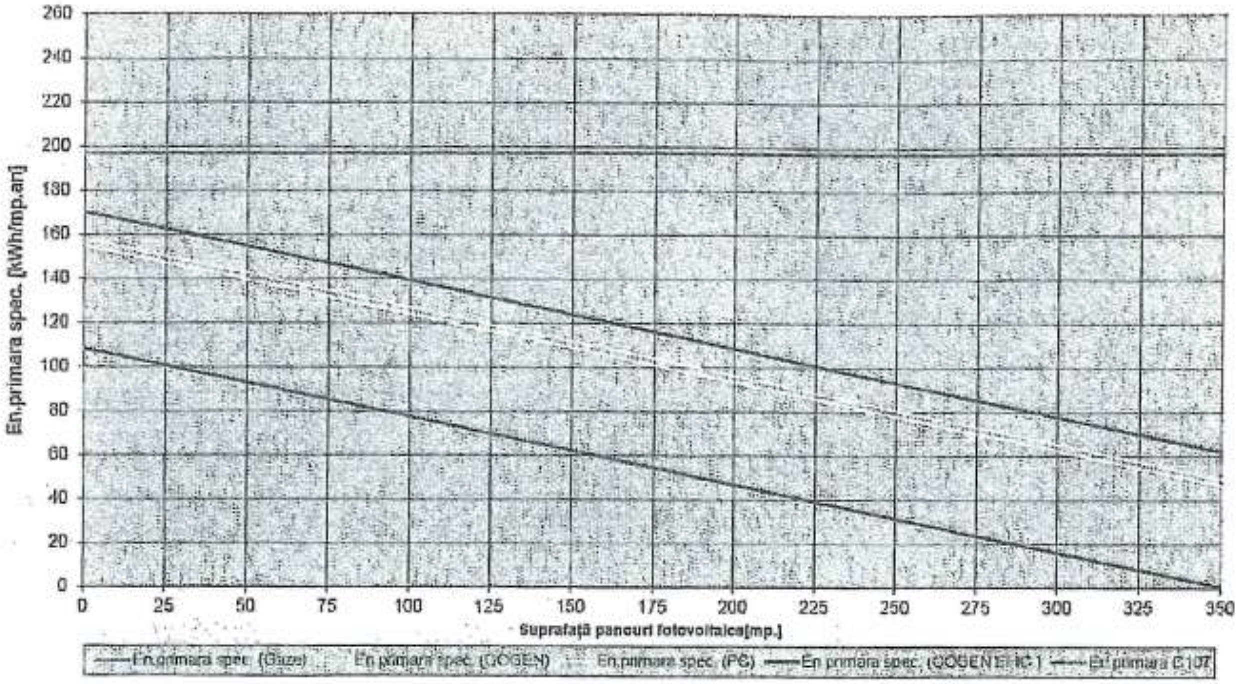

Figure V.76: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

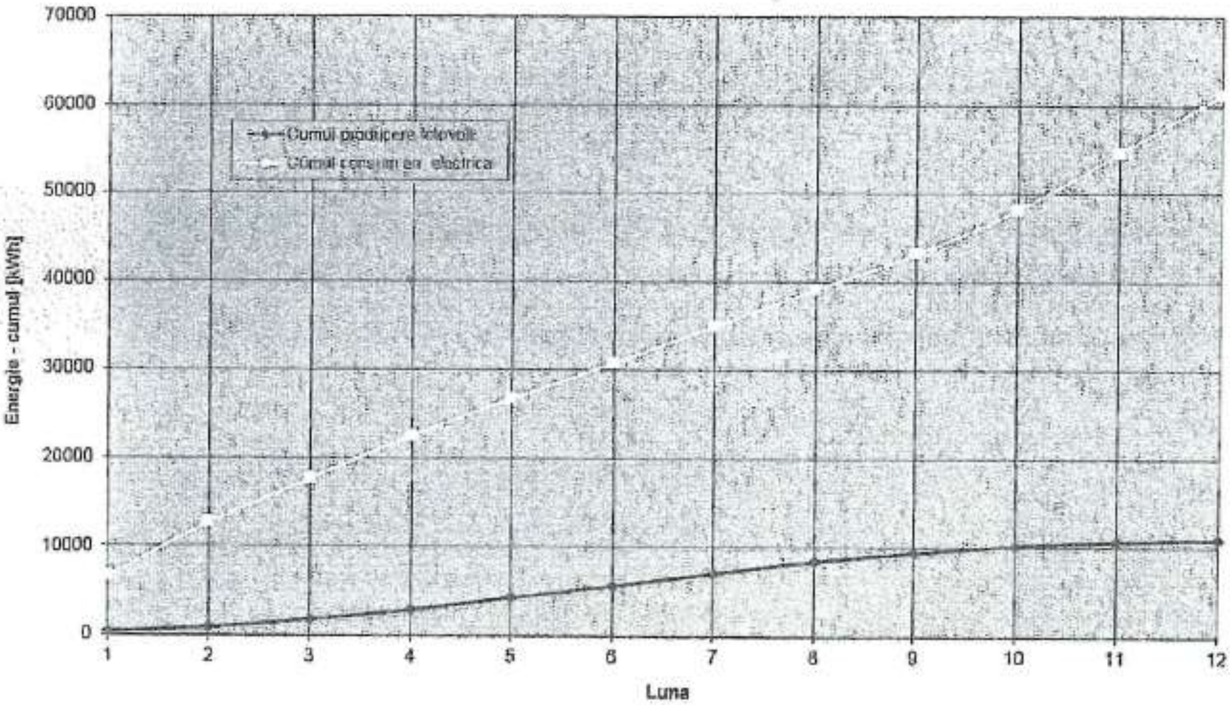

Figure V.77: Power generation and consumption
Key:

Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

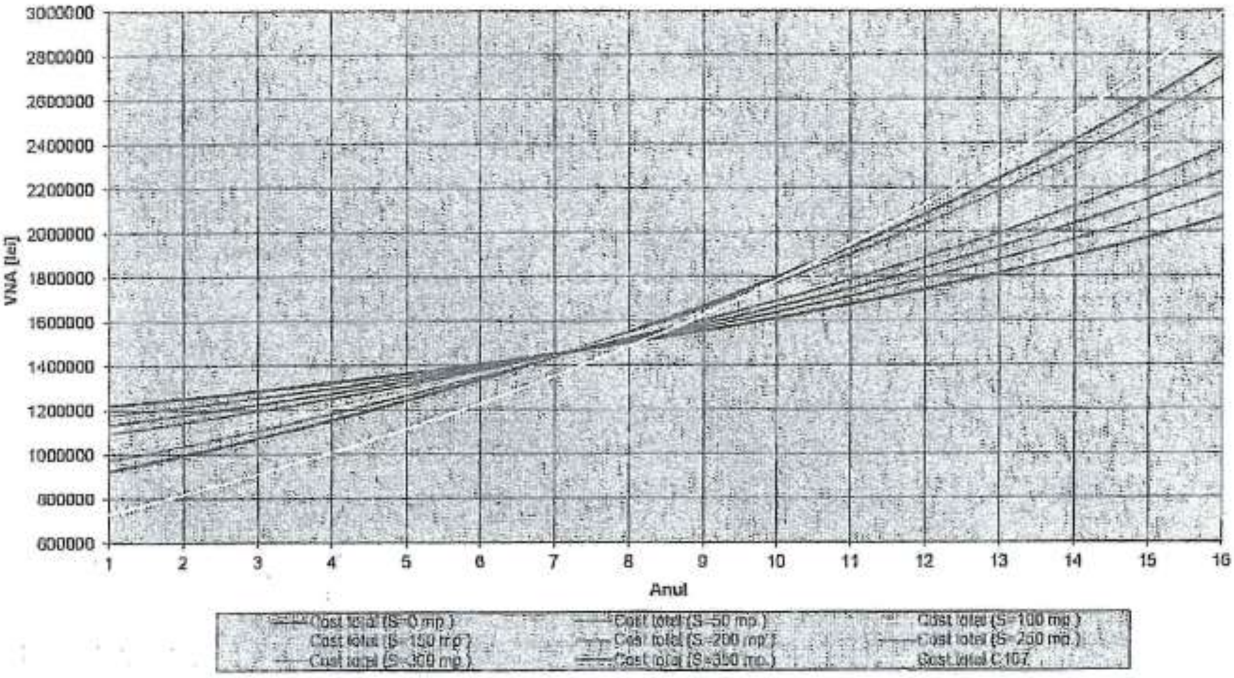

Figure V.78: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.4 System using high efficiency cogeneration

- primary energy = 92.96 kWh/m^2year;
- primary energy C107 = 196.94 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 17.91 %;
- share of total energy consumption from solar energy = 5.52 %;
- payback period ≈ 10.0 years.

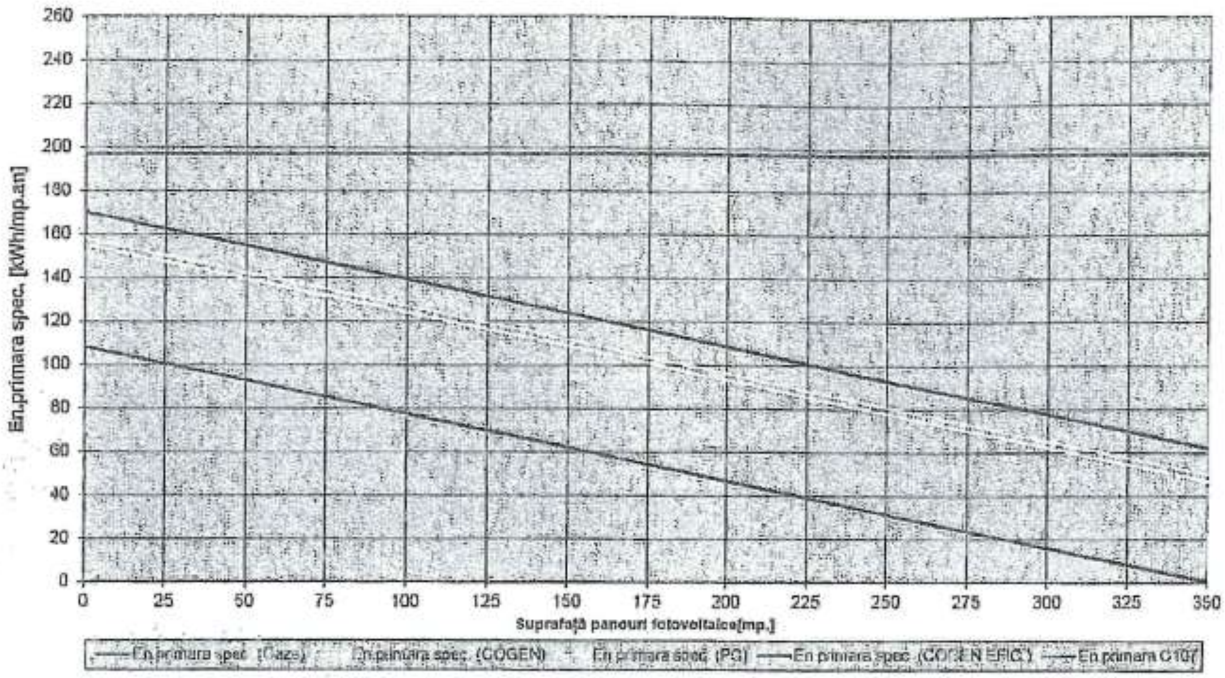

Figure V.79: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy ($kWh/m^2 year$)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

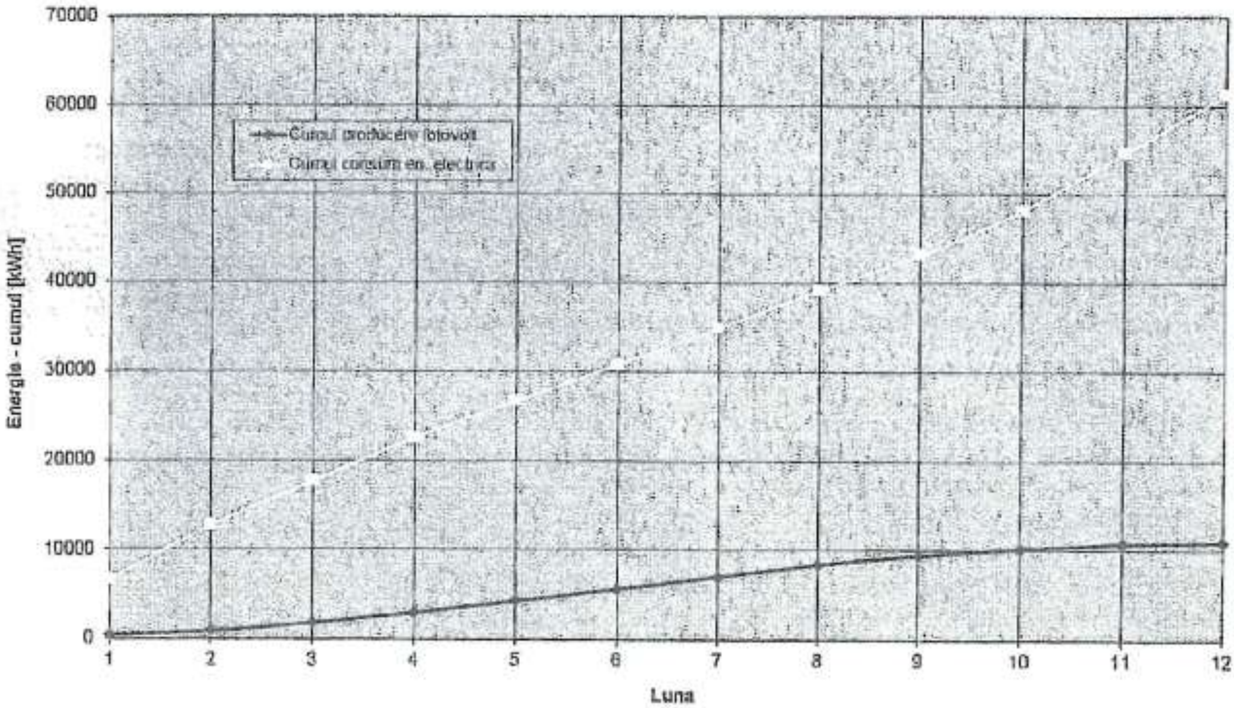

Figure V.80: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

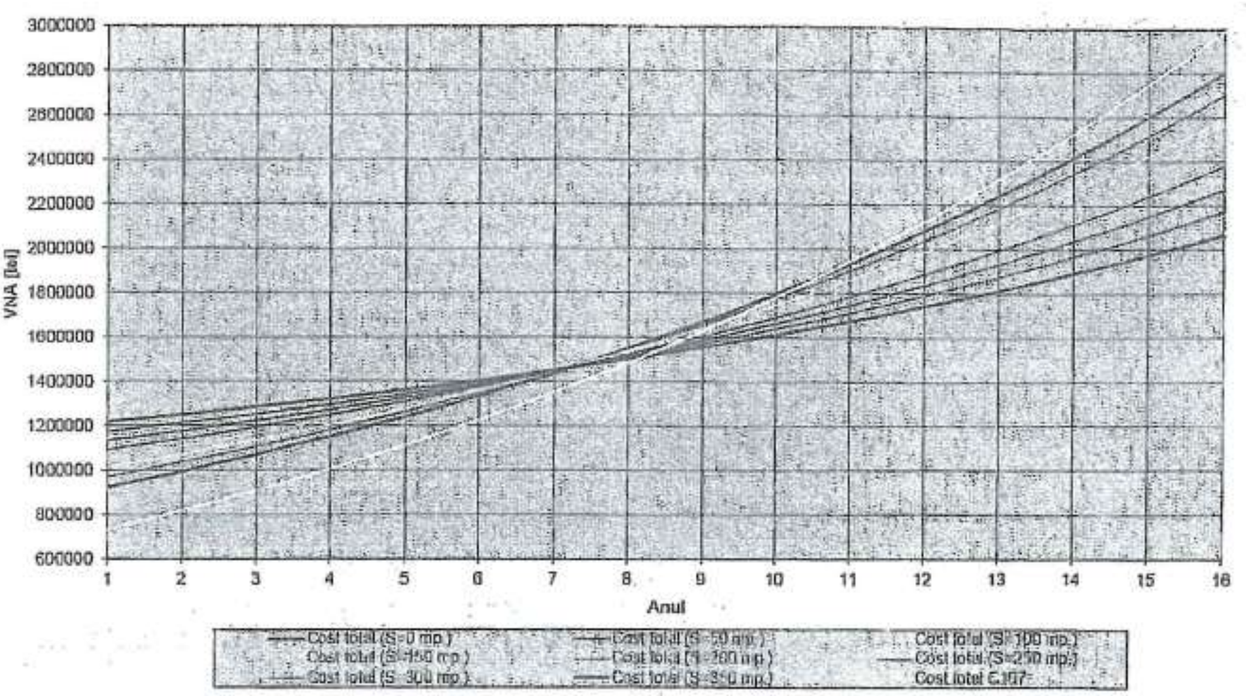

Figure V.81: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 50 m^2	**Heat pump**	**Boiler**	**Current cogeneration**	**High efficiency cogeneration**
primary energy (kWh/m^{2}year)	142.48	154.57	139.49	92.96
primary energy C107 (kWh/m^{2}year)	229.04	229.04	196.94	196.94
share of electricity consumption from PVP (%)	9.78	17.91	17.91	17.91
share of total energy consumption from solar energy	9.78	4.79	5.52	5.52

(%)				
payback period (years)	14.4	12.0	10.0	10.0

Case 2: Surface area of the photovoltaic solar panels = 300 m^2

2.1 System using a water-water heat pump

- primary energy = 65.24 kWh/m^{2}year;
- primary energy C107 = 229.04 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 58.69 %;
- share of total energy consumption from solar energy = 58.69 %;
- payback period ≈ 9.8 years.

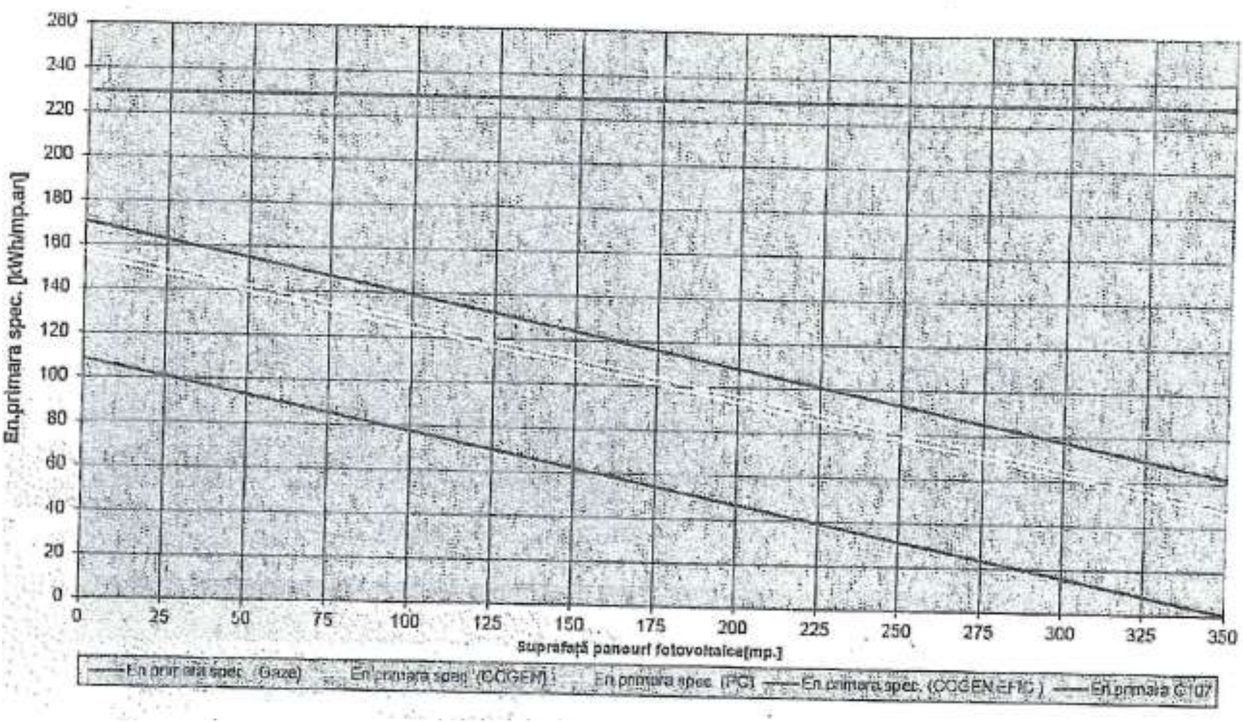

Figure V.82: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

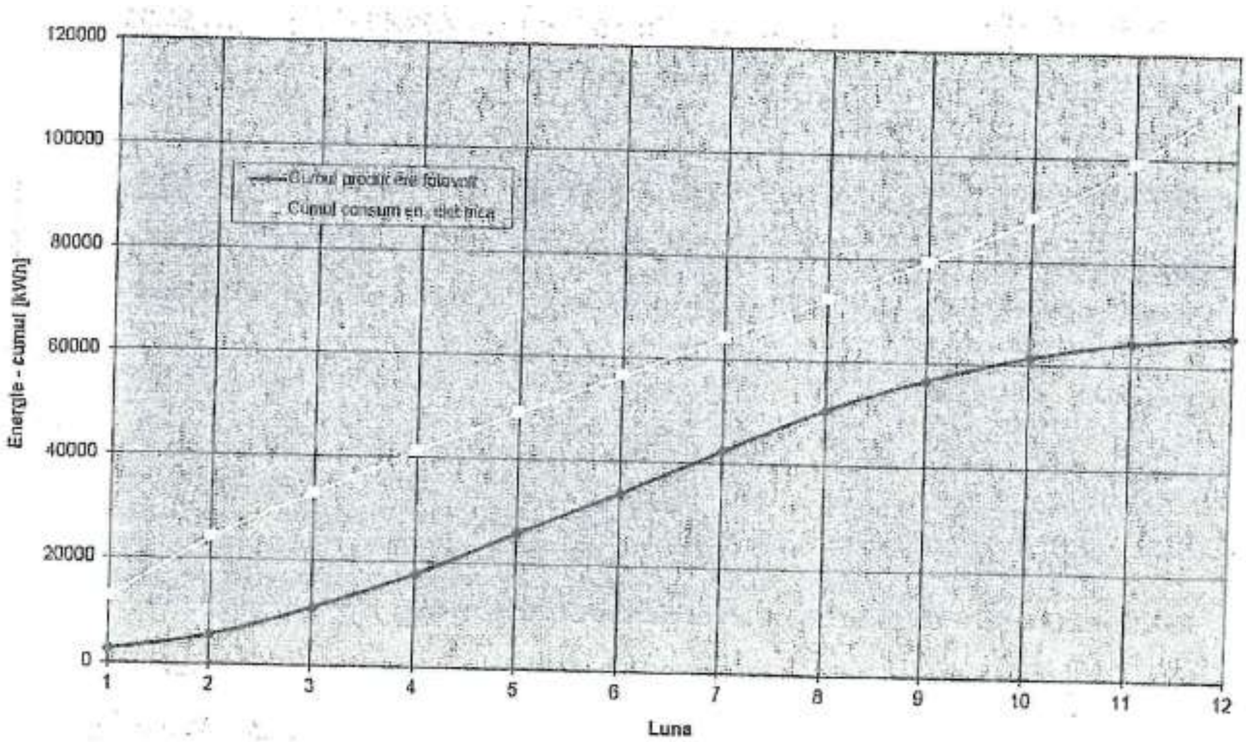

Figure V.83: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

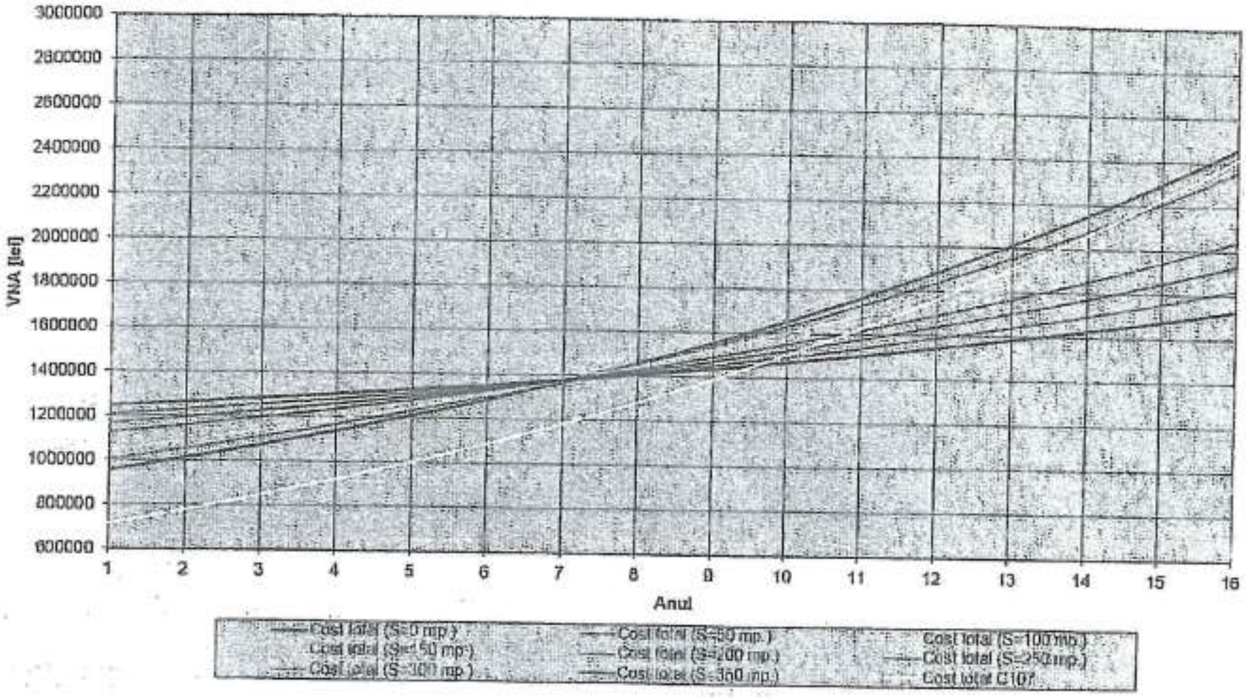

Figure V.84: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.2 System using a gas boiler

- primary energy = 77.34 kWh/m^{2}year;
- primary energy C107 = 229.04 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 107.45 %;
- share of total energy consumption from solar energy = 28.79 %;
- payback period ≈ 9.0 years.

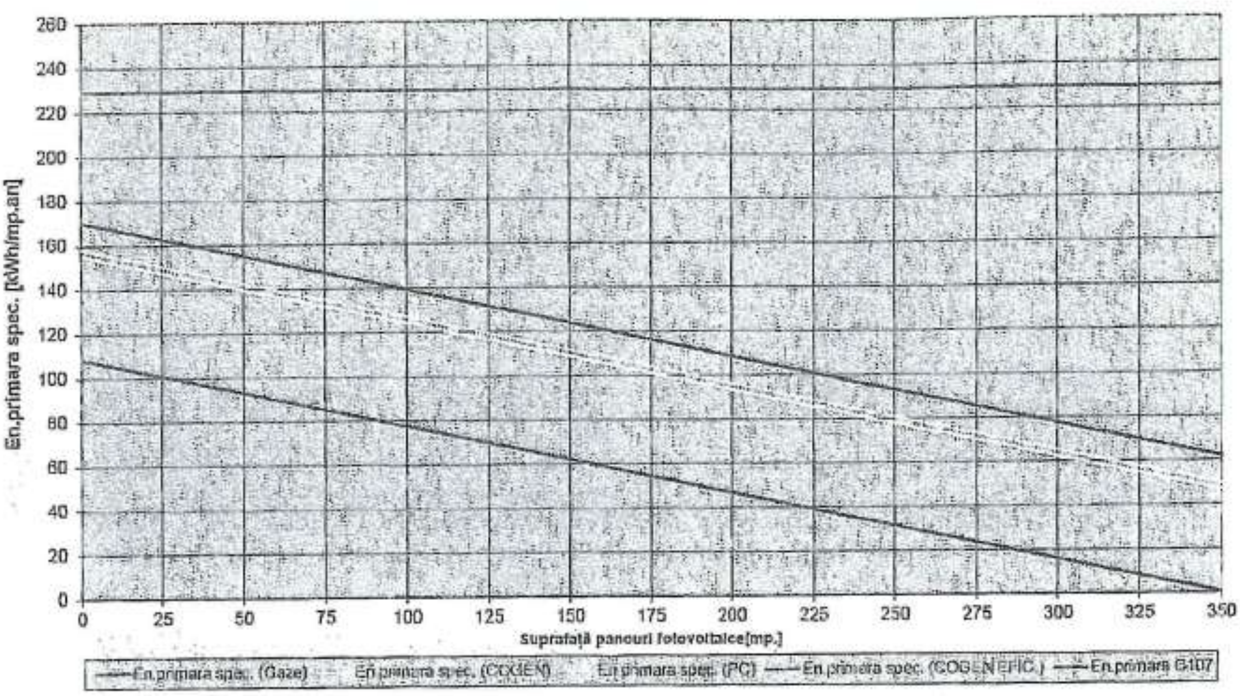

Figure V.85: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

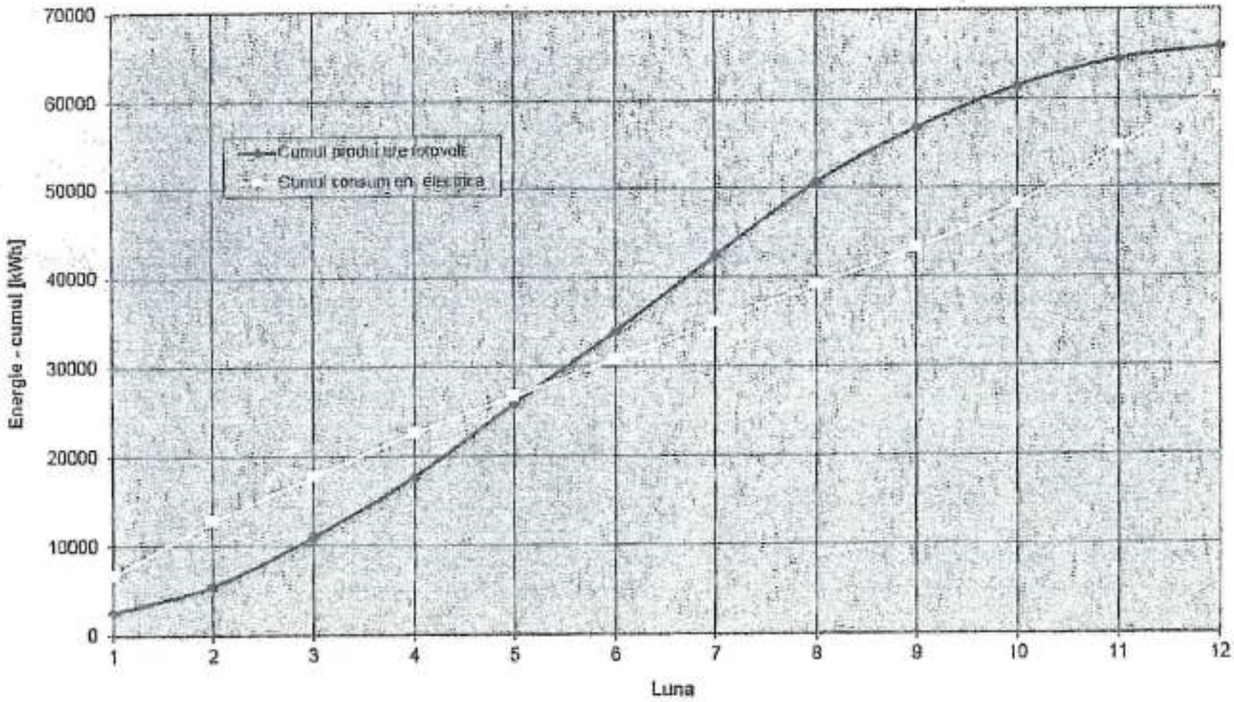

Figure V.86: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

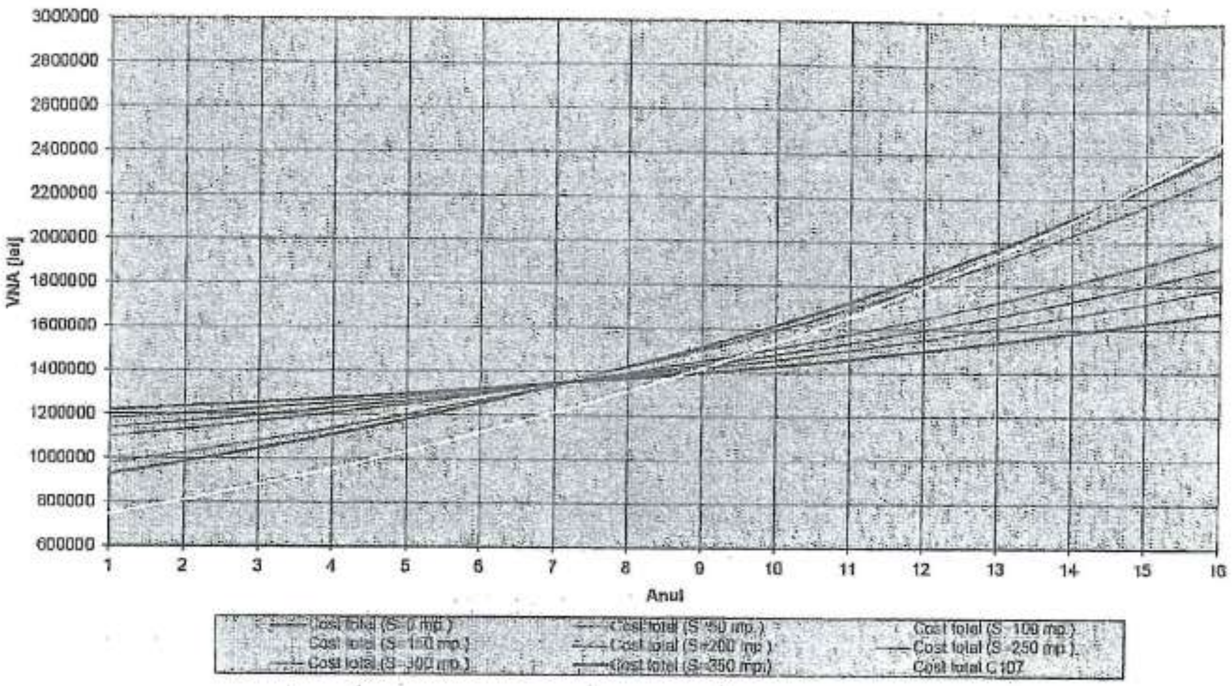

Figure V.87: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.3 System using current cogeneration

- primary energy = 62.26 kWh/m^{2}year;
- primary energy C107 = 196.94 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 107.45 %;
- share of total energy consumption from solar energy = 33.13 %;
- payback period ≈ 8.4 years.

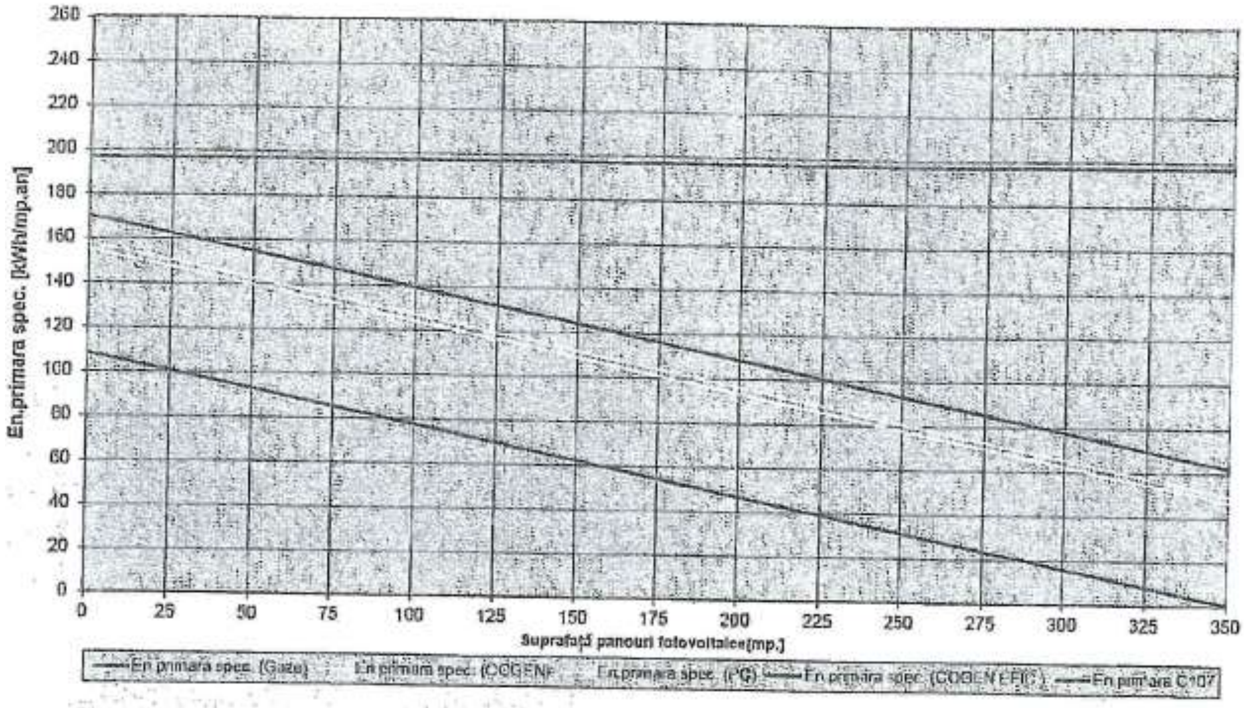

Figure V.88: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

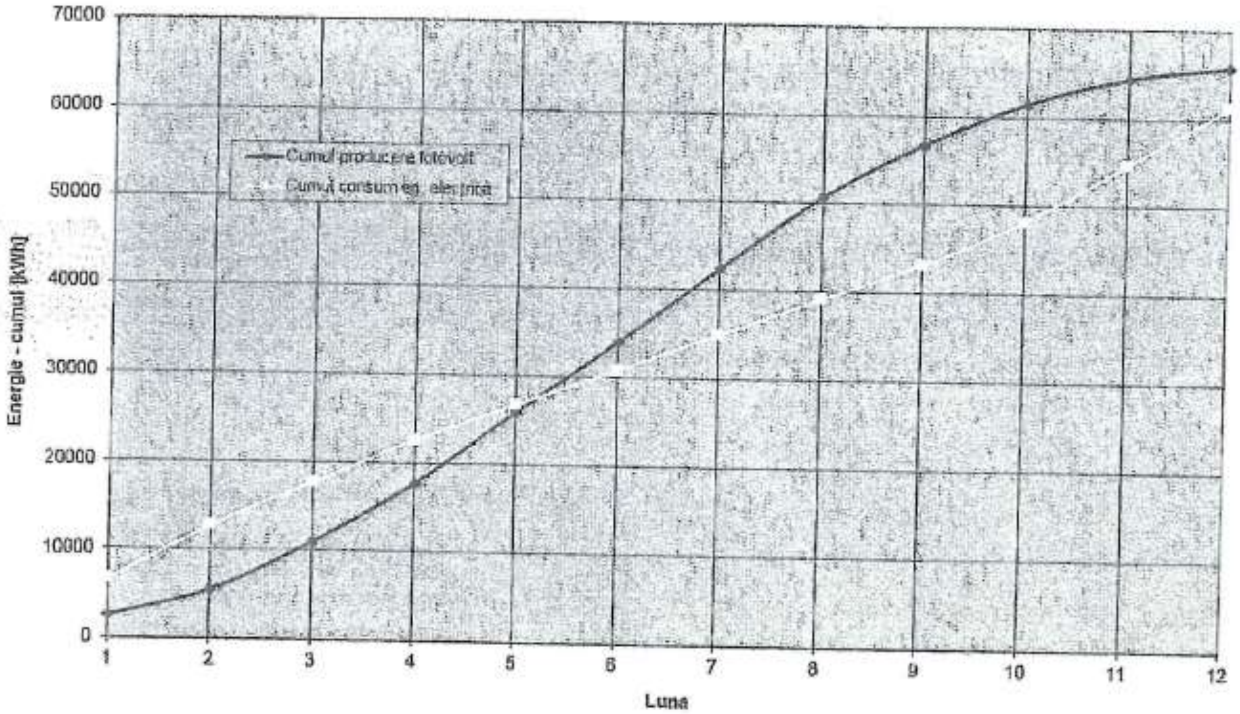

Figure V.89: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

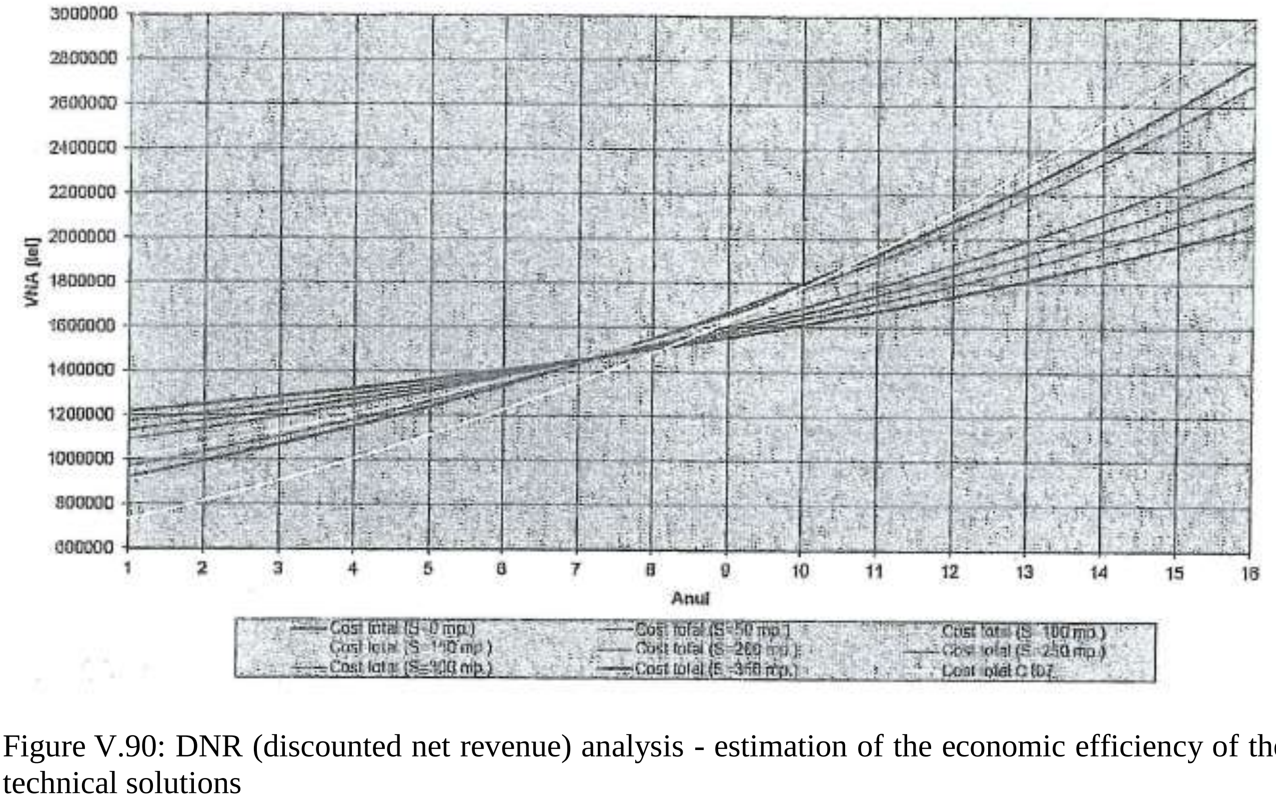

Figure V.90: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.4 System using high efficiency cogeneration

- primary energy = 15.73 kWh/m^{2}year;
- primary energy C107 = 196.94 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 107.45 %;
- share of total energy consumption from solar energy = 33.13 %;
- payback period ≈ 8.4 years.

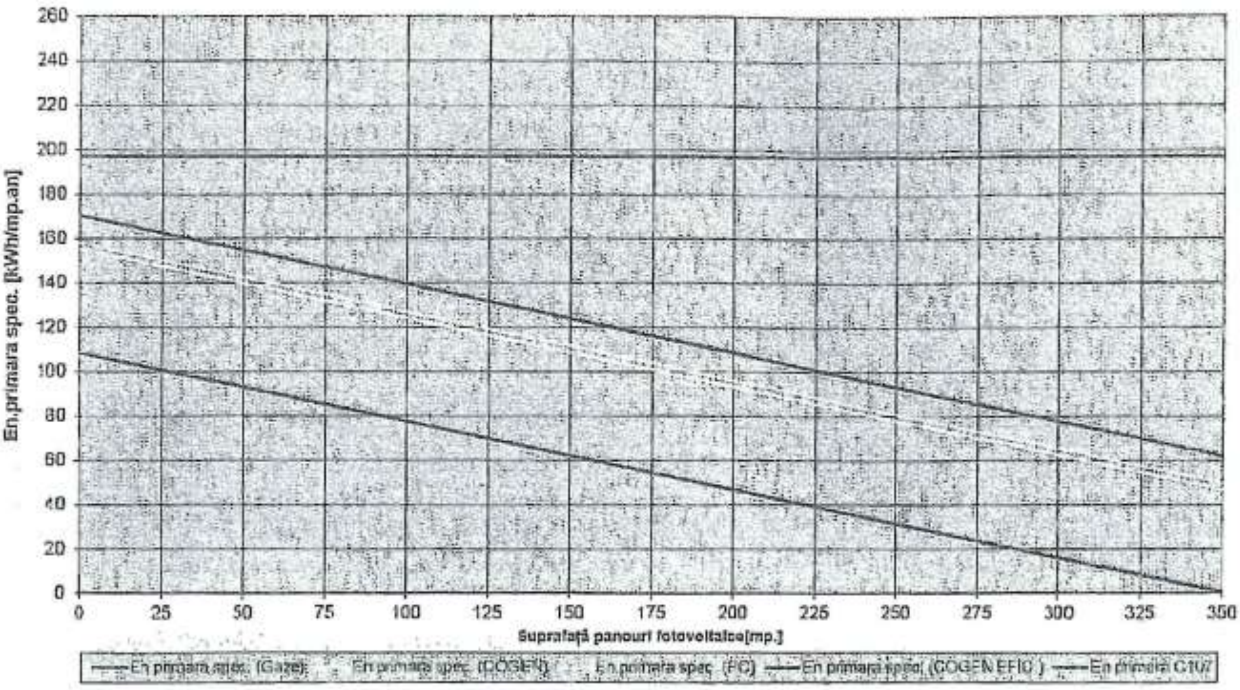

Figure V.91: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

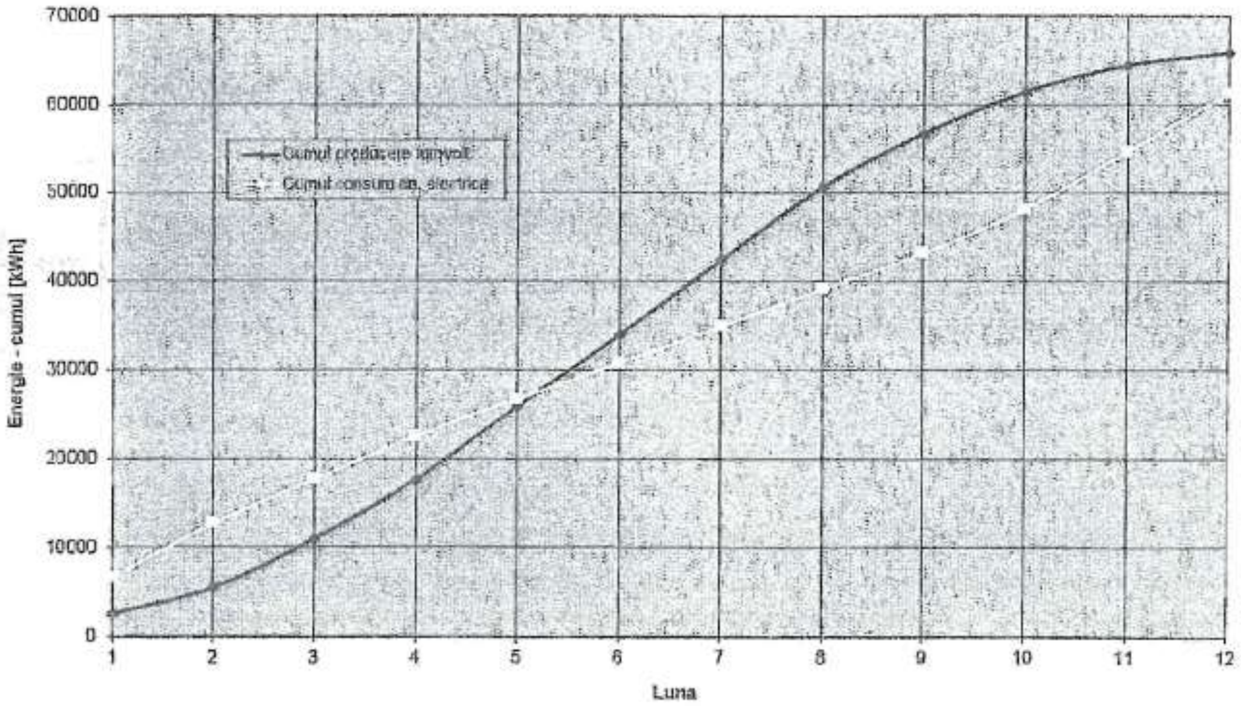

Figure V.92: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

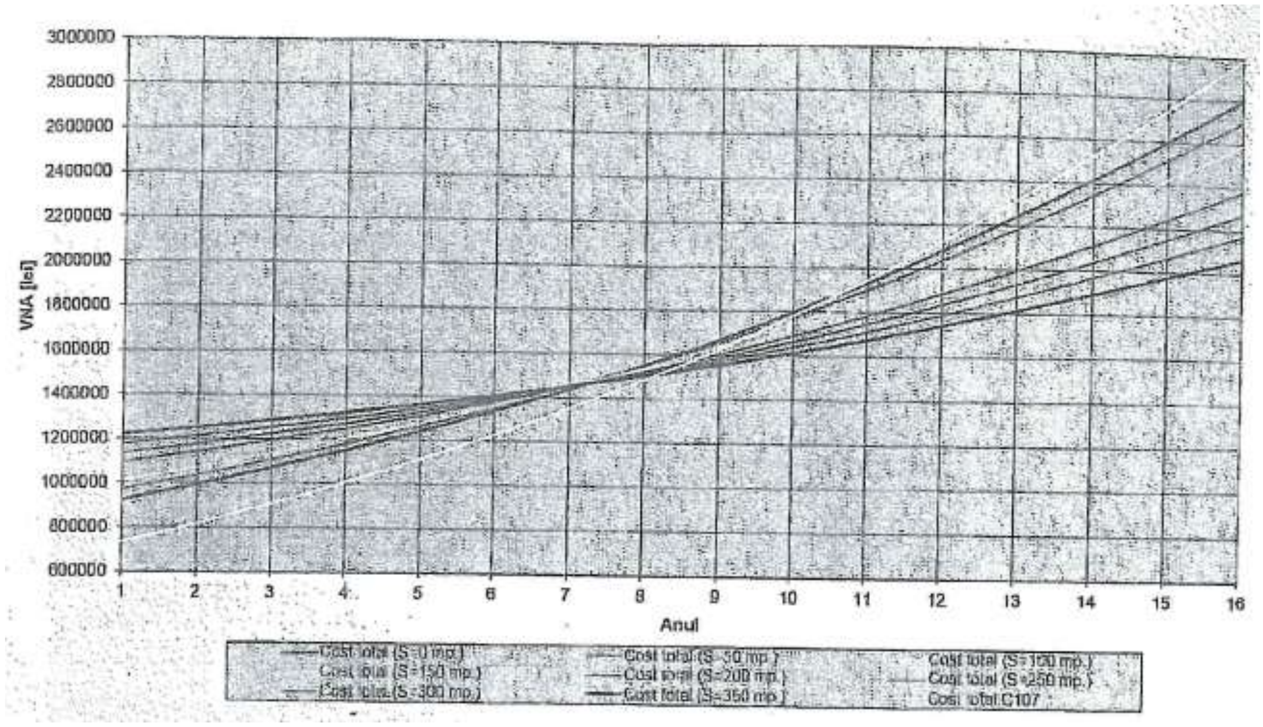

Figure V.93: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High efficiency cogeneration
primary energy (kWh/m^{2}year)	65.24	77.34	70.61	15.73
primary energy C107 (kWh/m^{2}year)	229.04	229.04	196.94	196.94
share of electricity consumption from PVP (%)	58.69	107.45	107.45	107.45
share of total energy consumption from solar energy (%)	58.69	28.79	33.13	33.13
payback period (years)	9.8	9.0	8.4	8.4

Apartment block, climate zone IV

Case 1: Surface area of the photovoltaic solar panels = 50 m^2

1.1 System using a water-water heat pump

- primary energy = 150.62 kWh/m^{2}year;
- primary energy C107 = 243.86 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 8.03 %;
- share of total energy consumption from solar energy = 8.03 %;
- payback period ≈ 14.9 years.

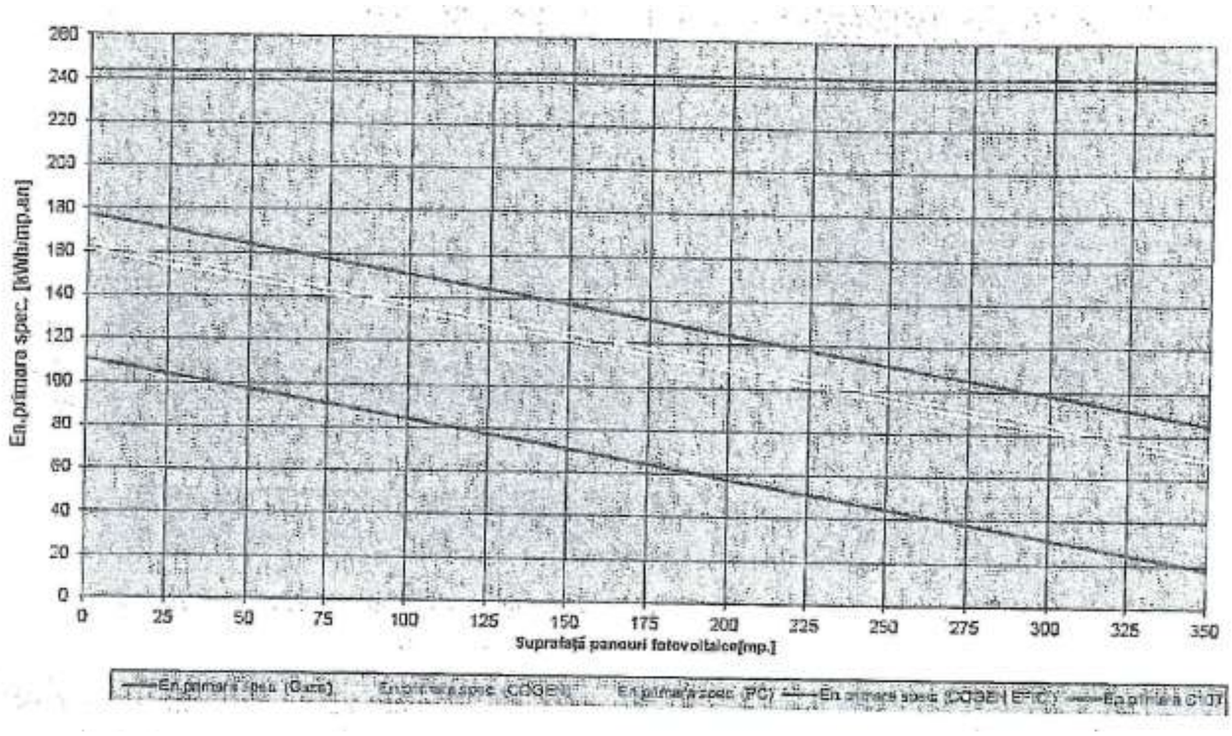

Figure V.94: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

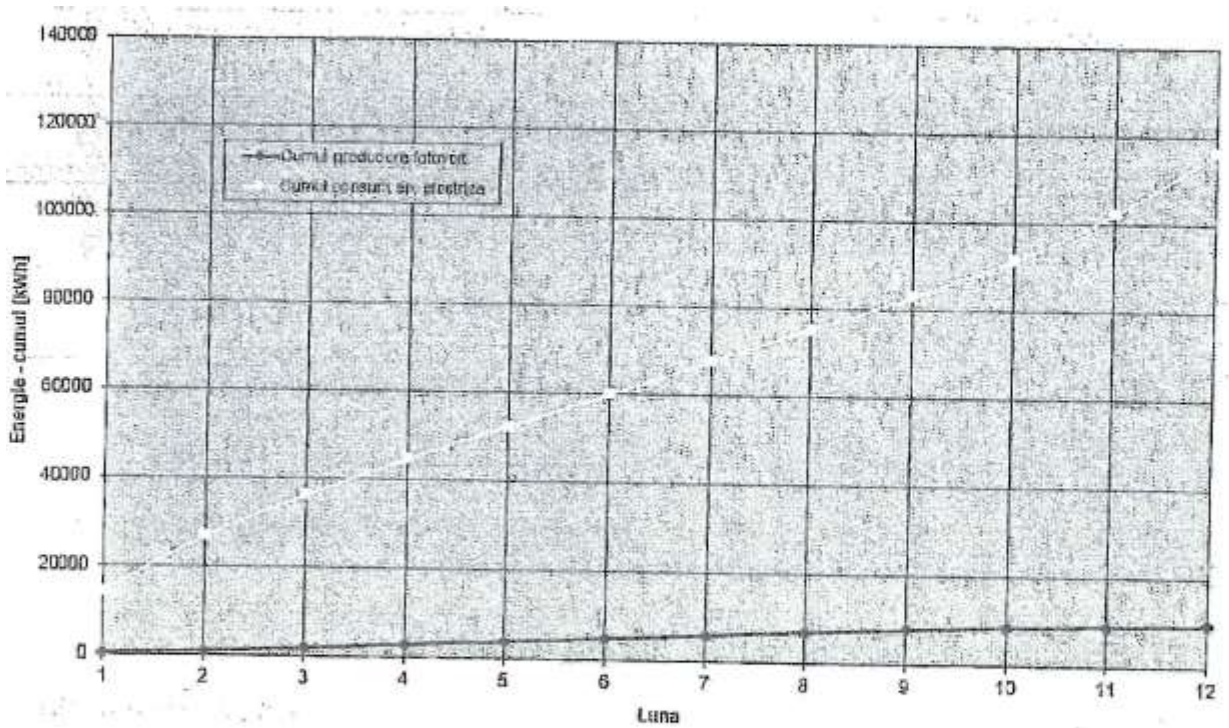

Figure V.95: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

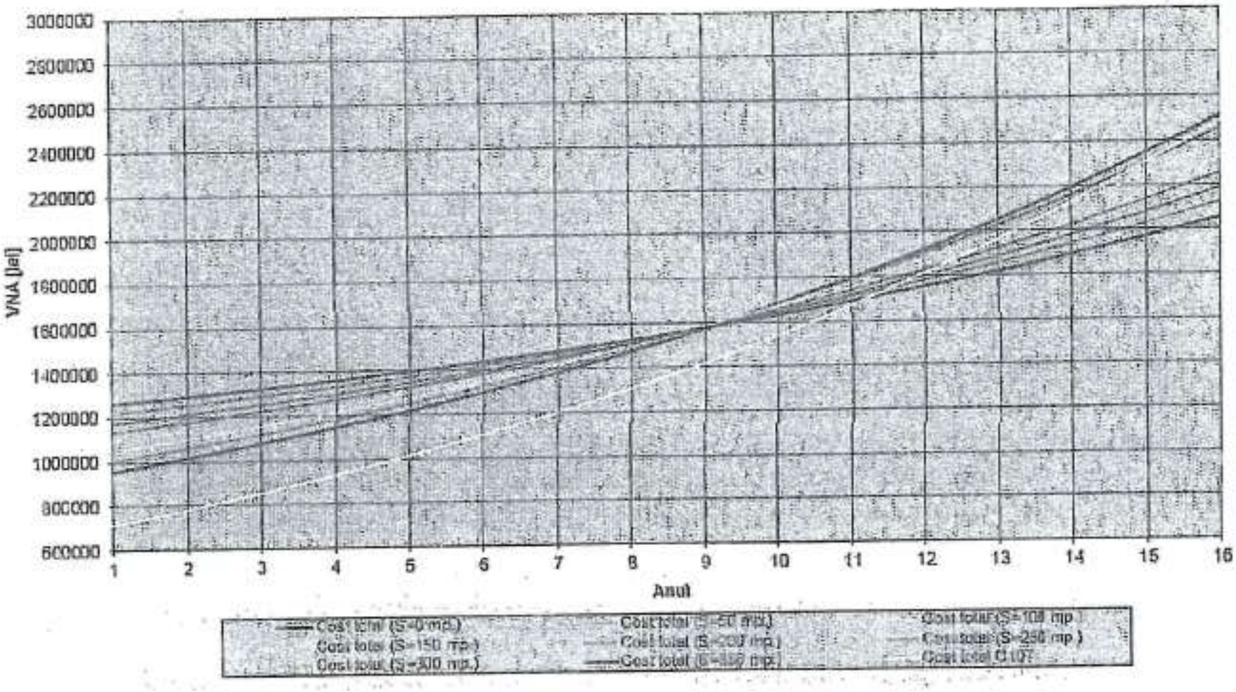

Figure V.96: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.2 System using a gas boiler

- primary energy = 163.70 kWh/m^{2}year;
- primary energy C107 = 243.86 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 15.24 %;
- share of total energy consumption from solar energy = 3.85 %;
- payback period ≈ 12 years.

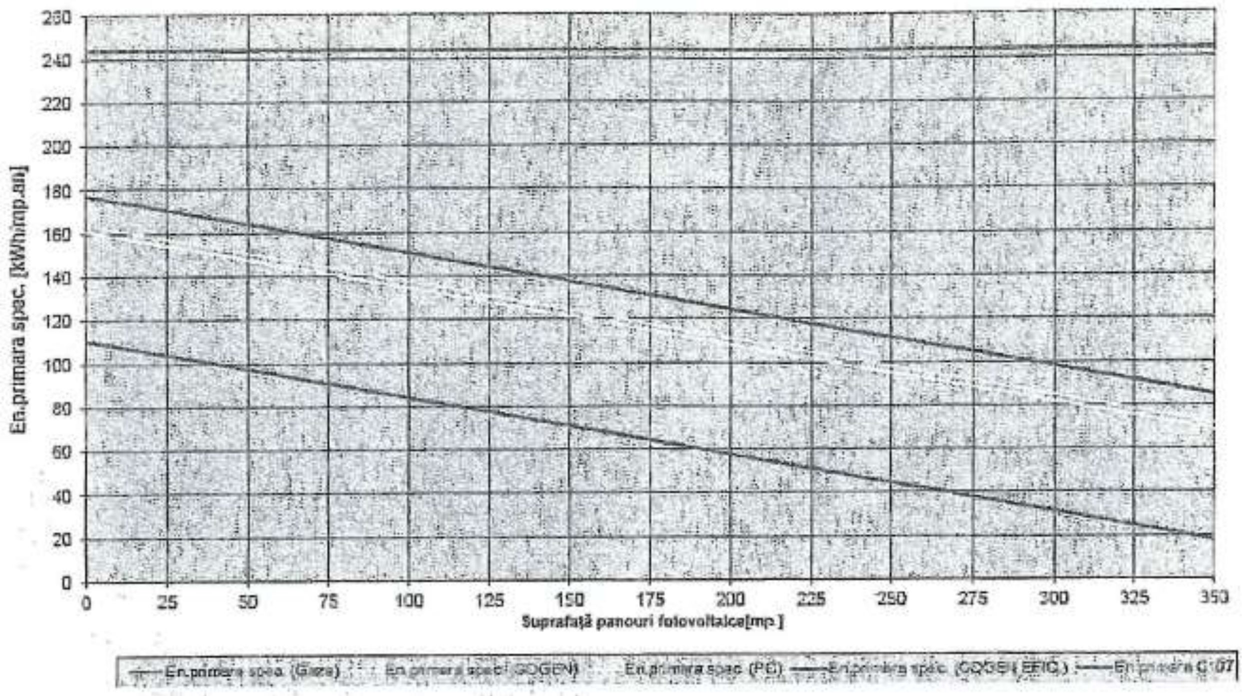

Figure V.97: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

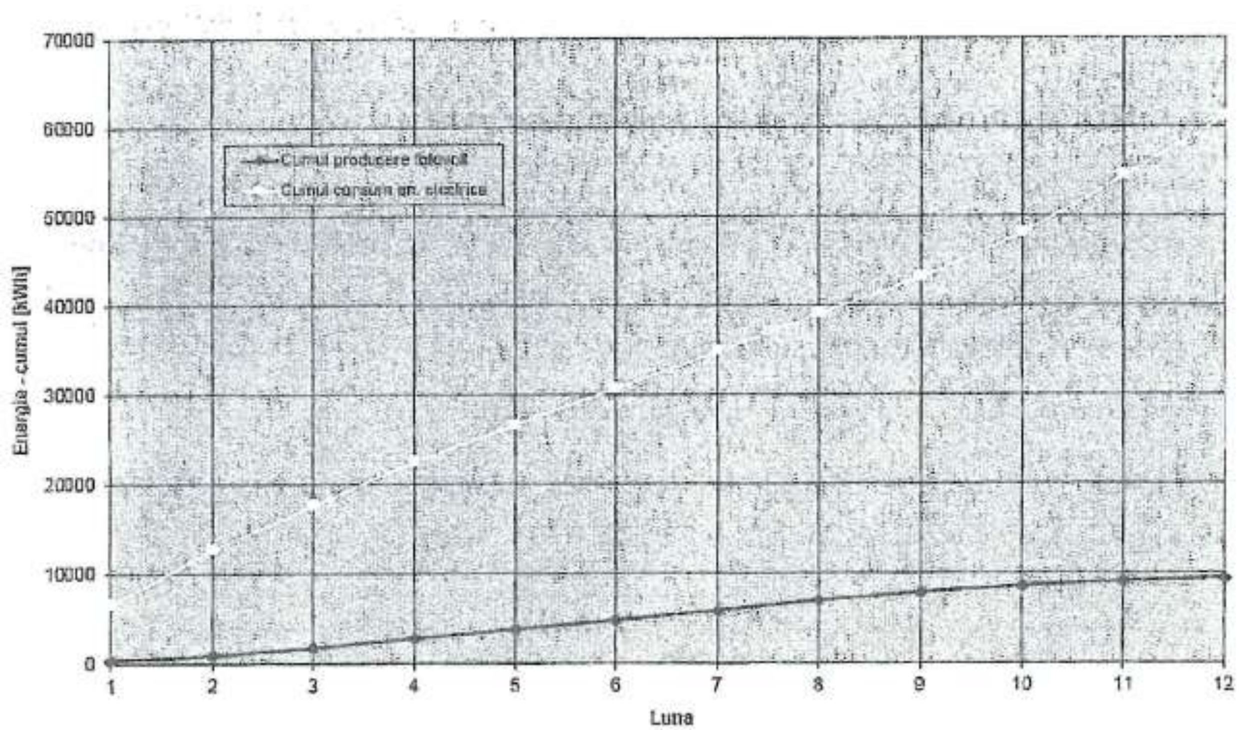

Figure V.98: Power generation and consumption
Key:

Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

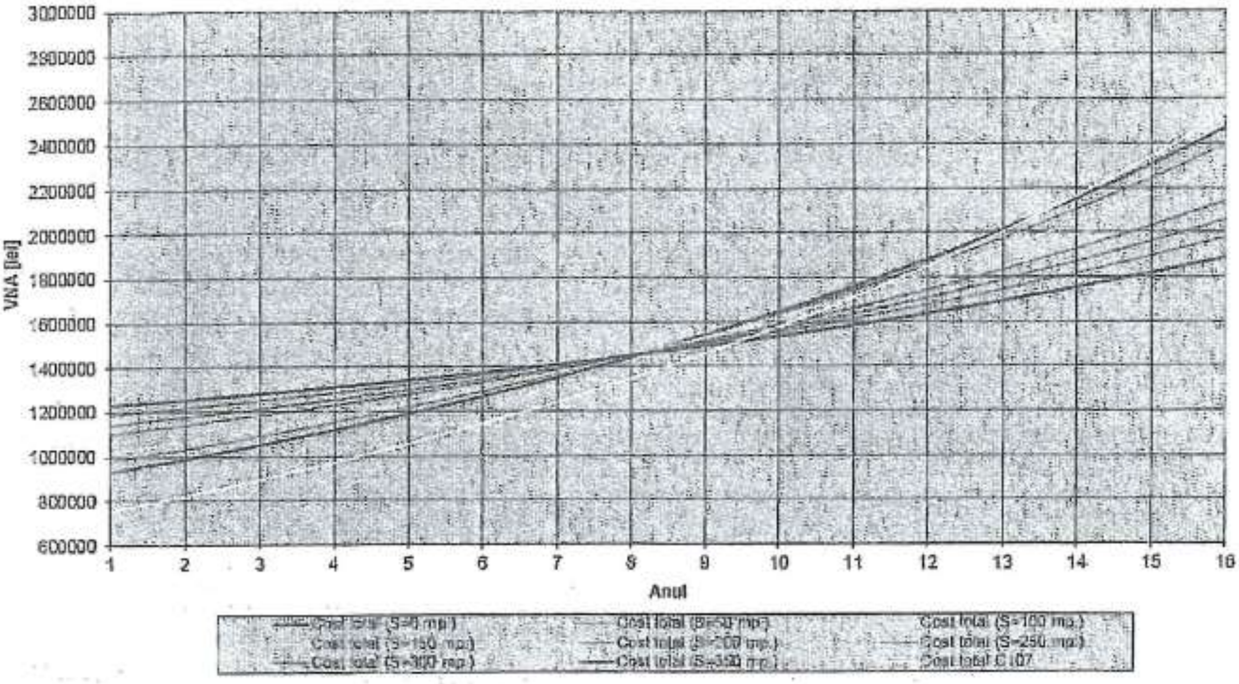

Figure V.99: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.3 System using current cogeneration

- primary energy = 147.40 kWh/m^2year;
- primary energy C107 = 207.55 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 15.24 %;
- share of total energy consumption from solar energy = 4.45 %;
- payback period ≈ 9.2 years.

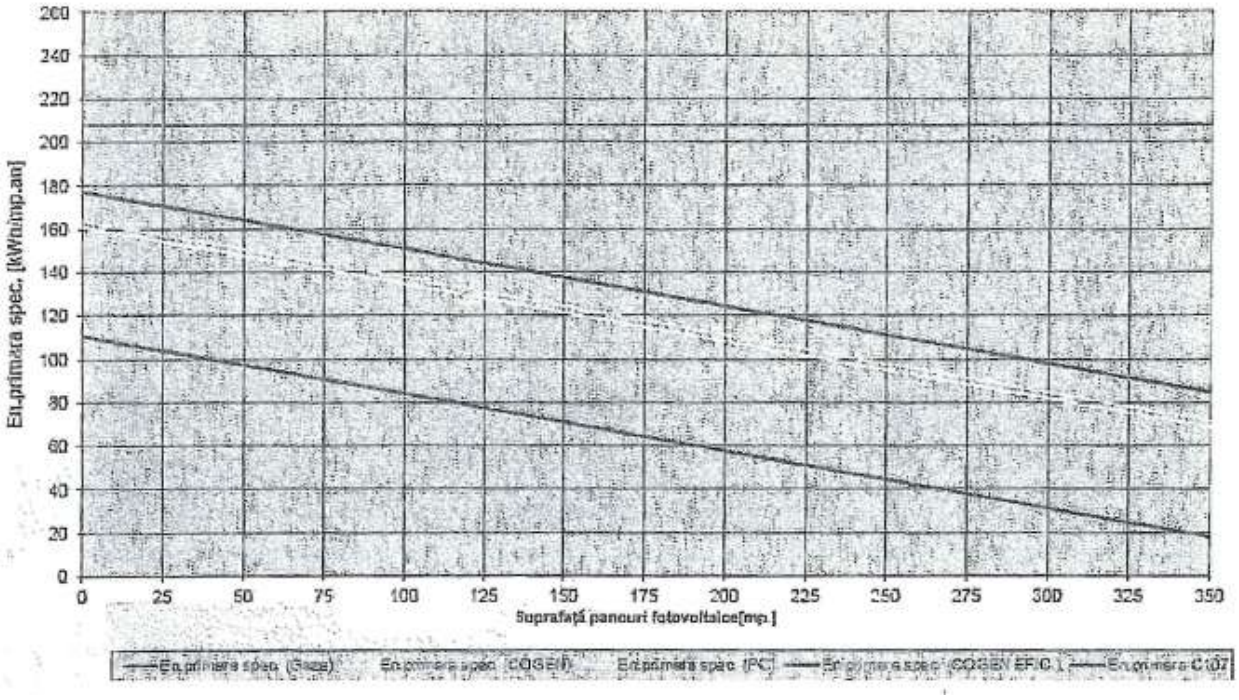

Figure V.100: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

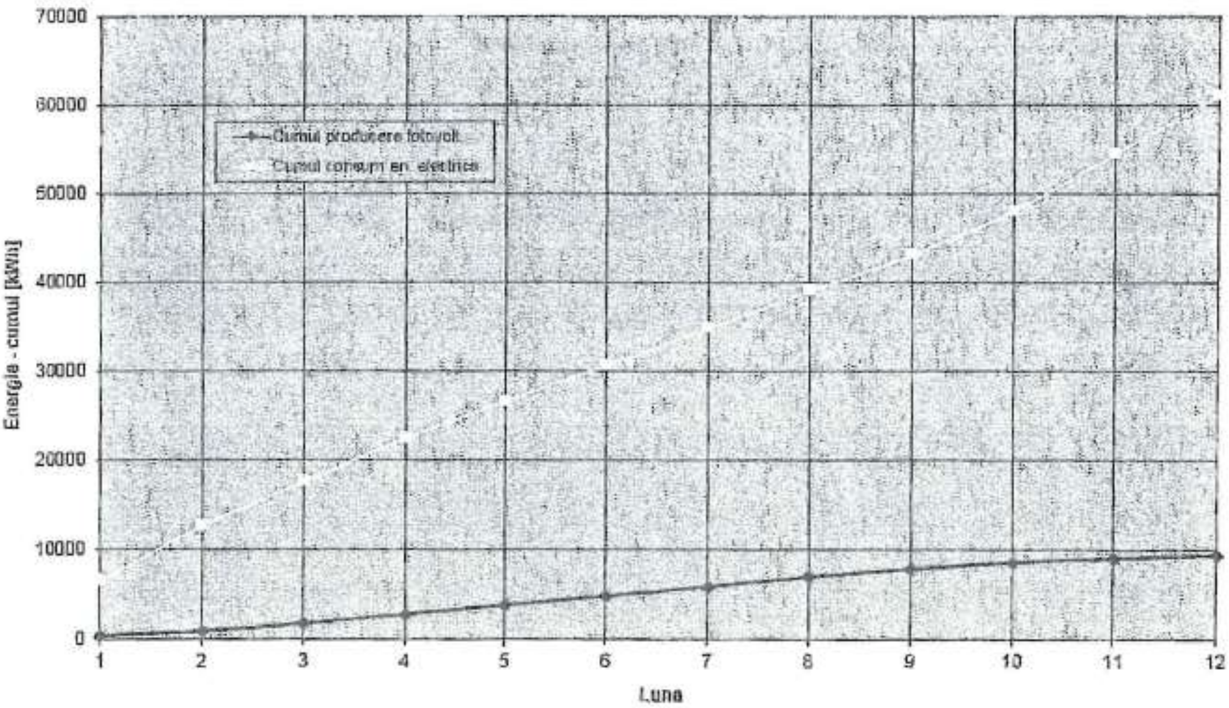

Figure V.101: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

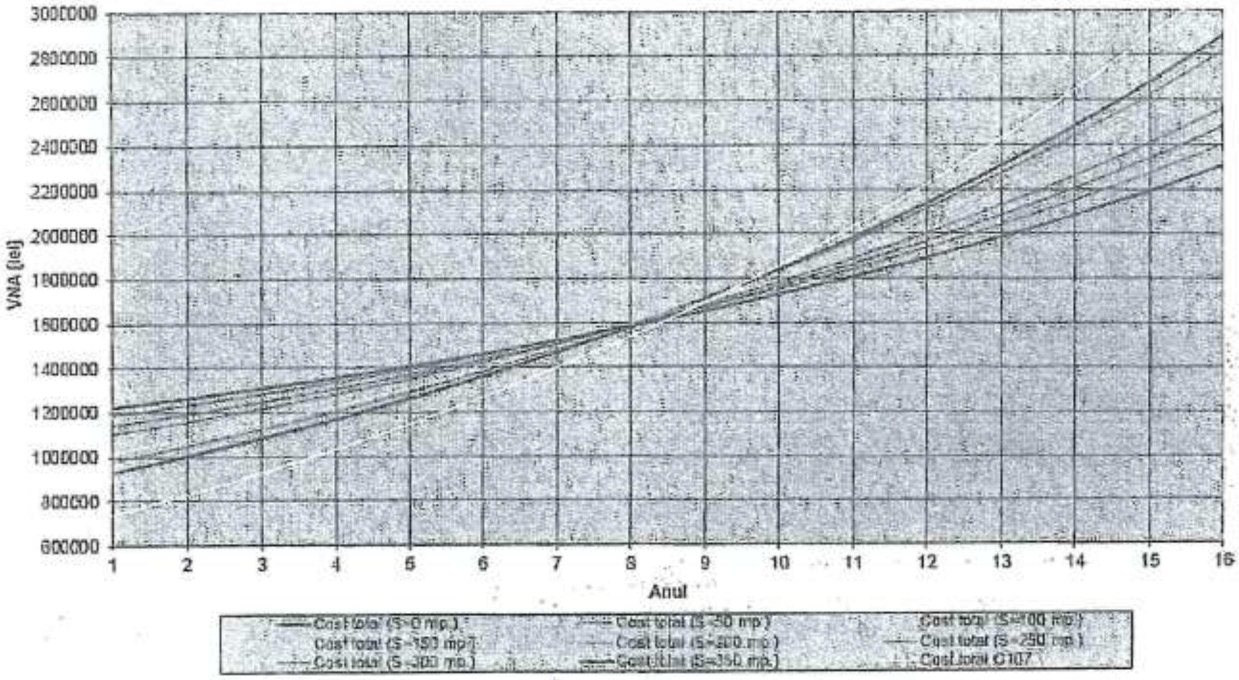

Figure V.102: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

1.4 System using high efficiency cogeneration

- primary energy = 97.07 kWh/m^2year;
- primary energy C107 = 207.55 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 15.24 %;
- share of total energy consumption from solar energy = 4.45 %;
- payback period ≈ 9.2 years.

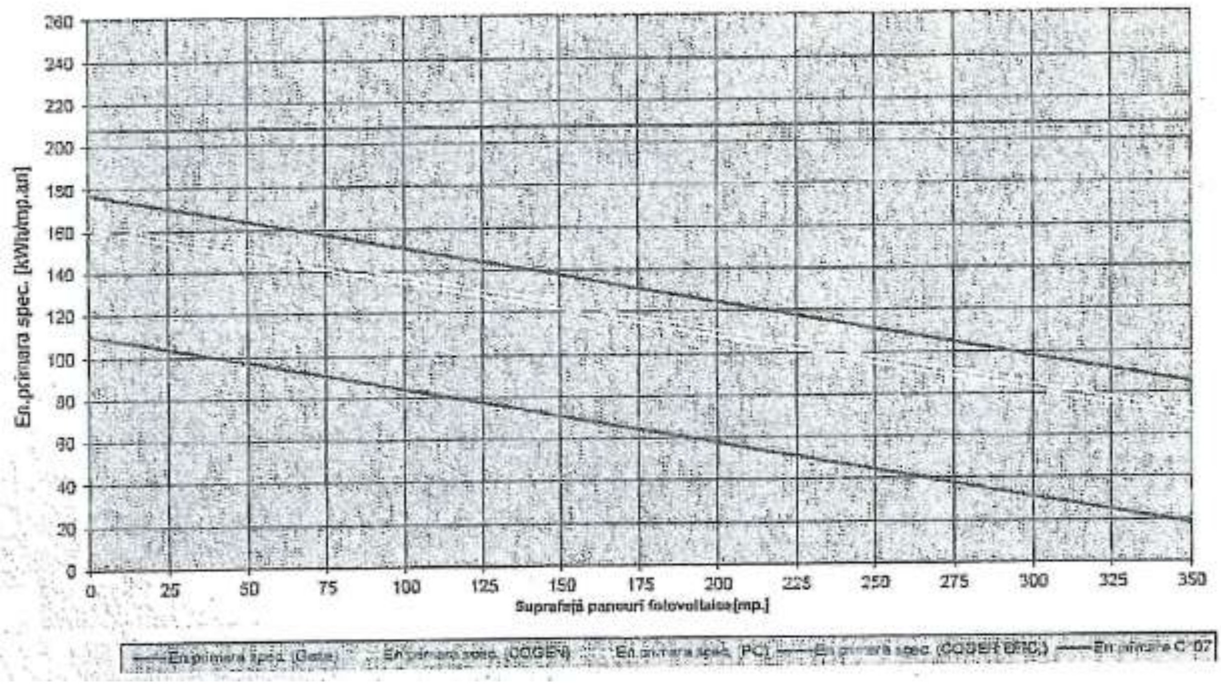

Figure V.103: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

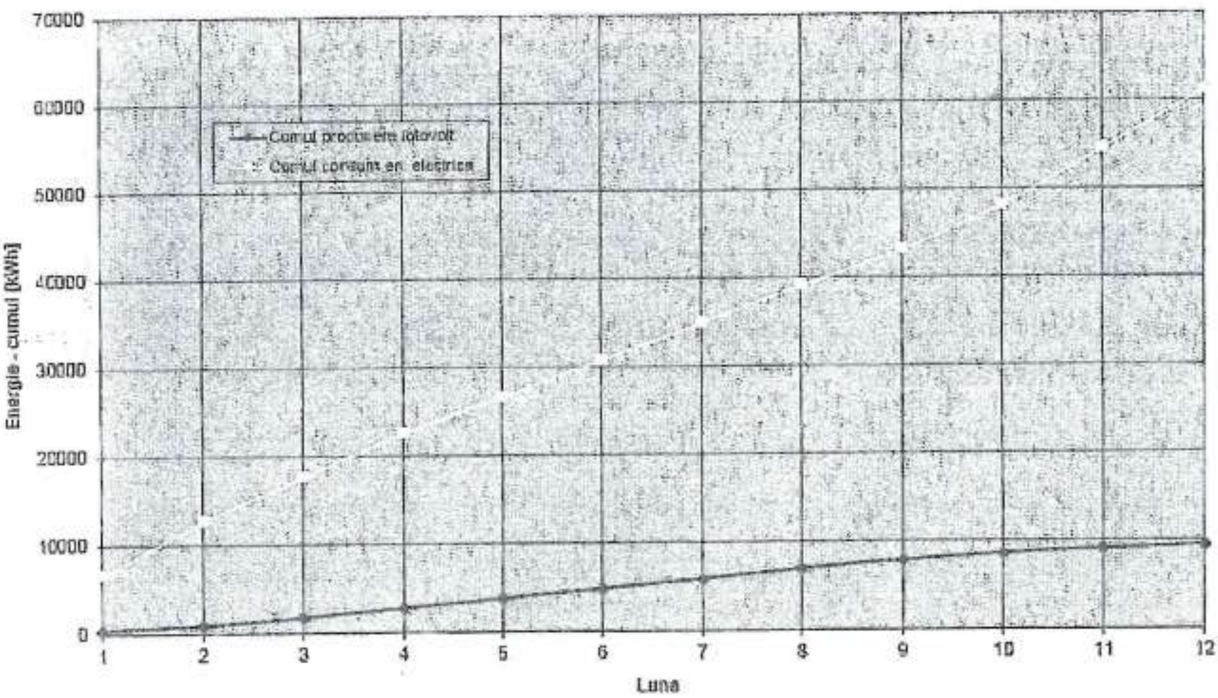

Figure V.104: Power generation and consumption
Key:

Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

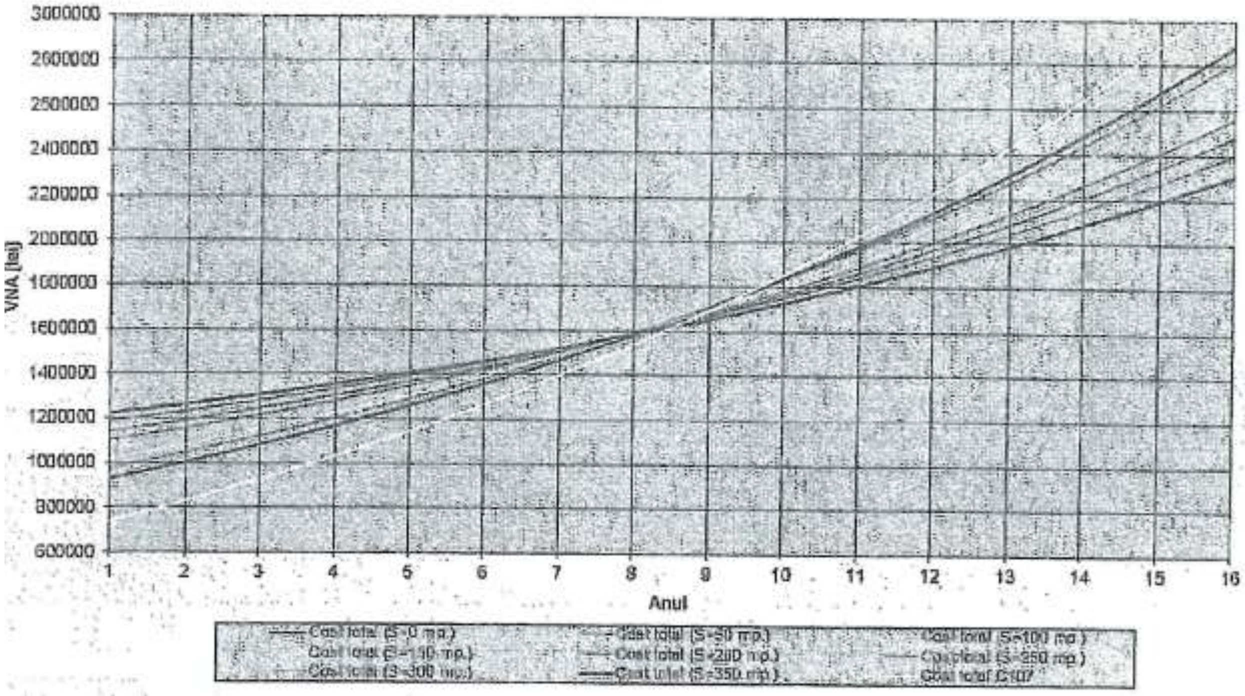

Figure V.105: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 50 m^2	**Heat pump**	**Boiler**	**Current cogeneration**	**High efficiency cogeneration**
primary energy (kWh/m^2year)	150.62	163.70	147.40	97.07
primary energy C107 (kWh/m^2year)	243.86	243.86	207.55	207.55
share of electricity consumption from PVP (%)	8.03	15.24	15.24	15.24
share of total energy consumption from solar energy	8.03	3.85	4.45	4.45

(%)				
payback period (years)	14.9	12.0	9.2	9.2

Case 2: Surface area of the photovoltaic solar panels = 300 m²

2.1 System using a water-water heat pump

- primary energy = 84.89 kWh/m²year;
- primary energy C107 = 243.86 kWh/m²year;
- share of electricity consumption from monocrystalline photovoltaic panels = 48.16 %;
- share of total energy consumption from solar energy = 48.16 %;
- payback period ≈ 11.4 years.

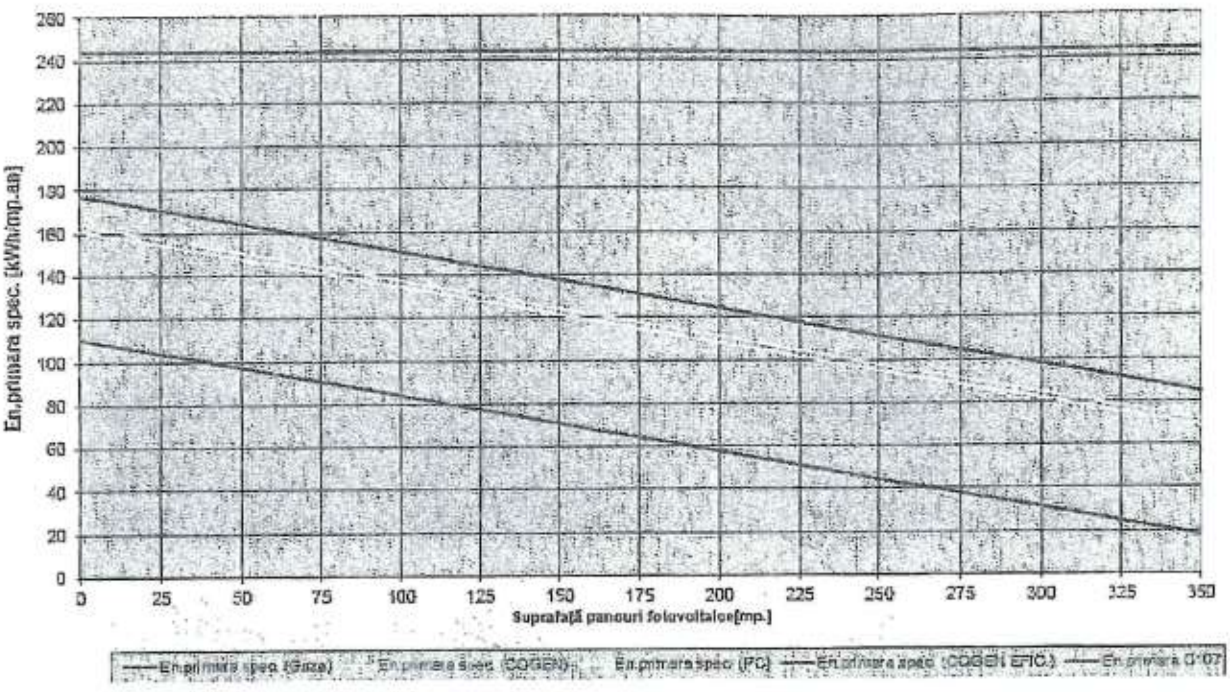

Figure V.106: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m²)
Vertical: Specific primary energy (kWh/m²year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

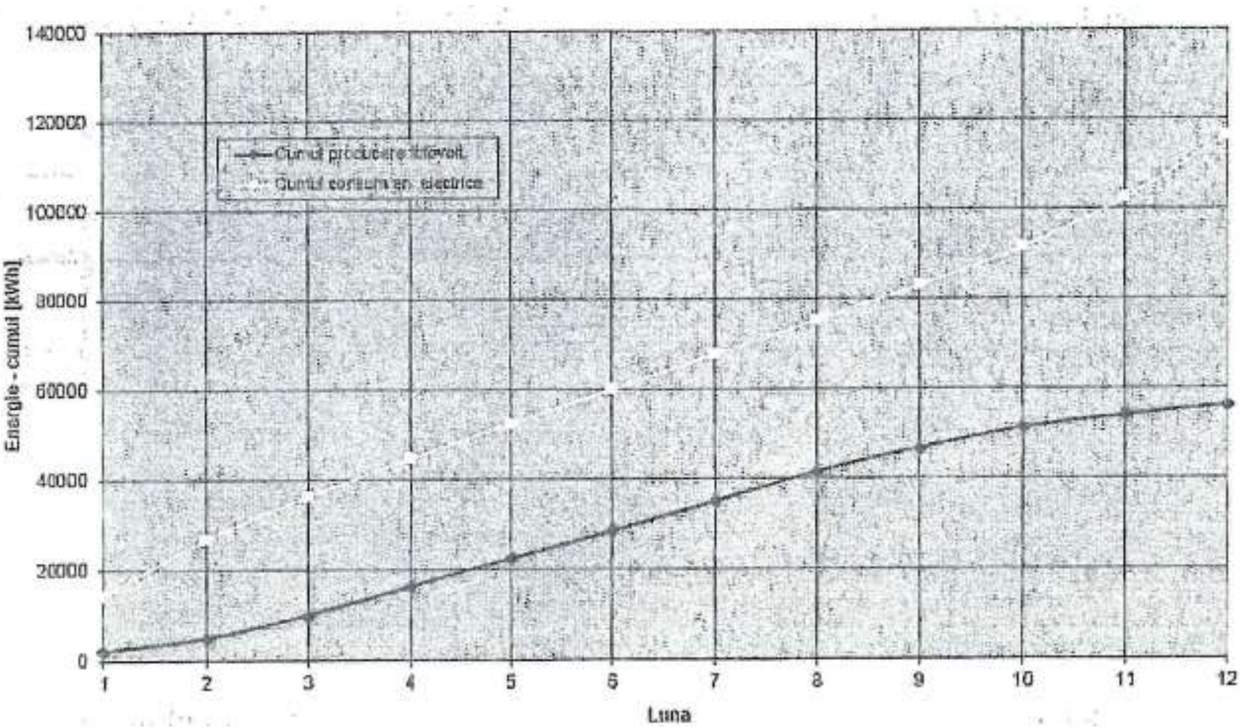

Figure V.107: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

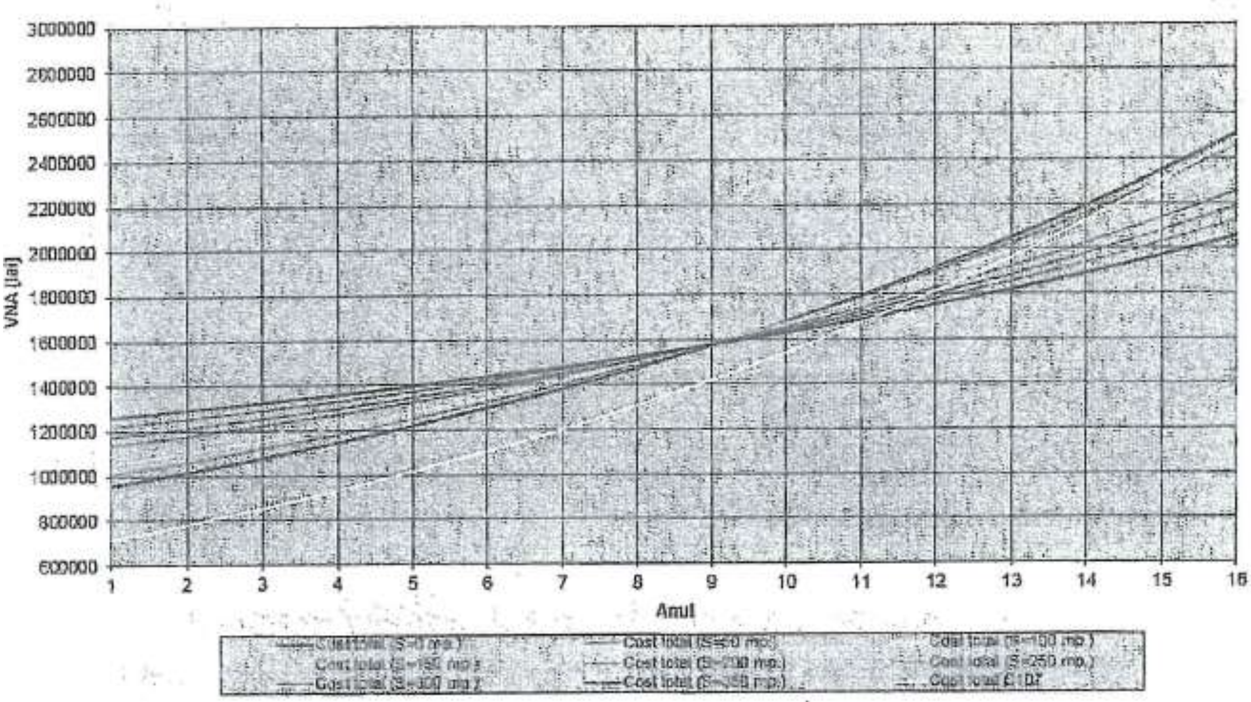

Figure V.108: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.2 System using a gas boiler

- primary energy = 97.98 kWh/m^{2}year;
- primary energy C107 = 243.86 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 91.44 %;
- share of total energy consumption from solar energy = 23.10 %;
- payback period ≈ 9.7 years.

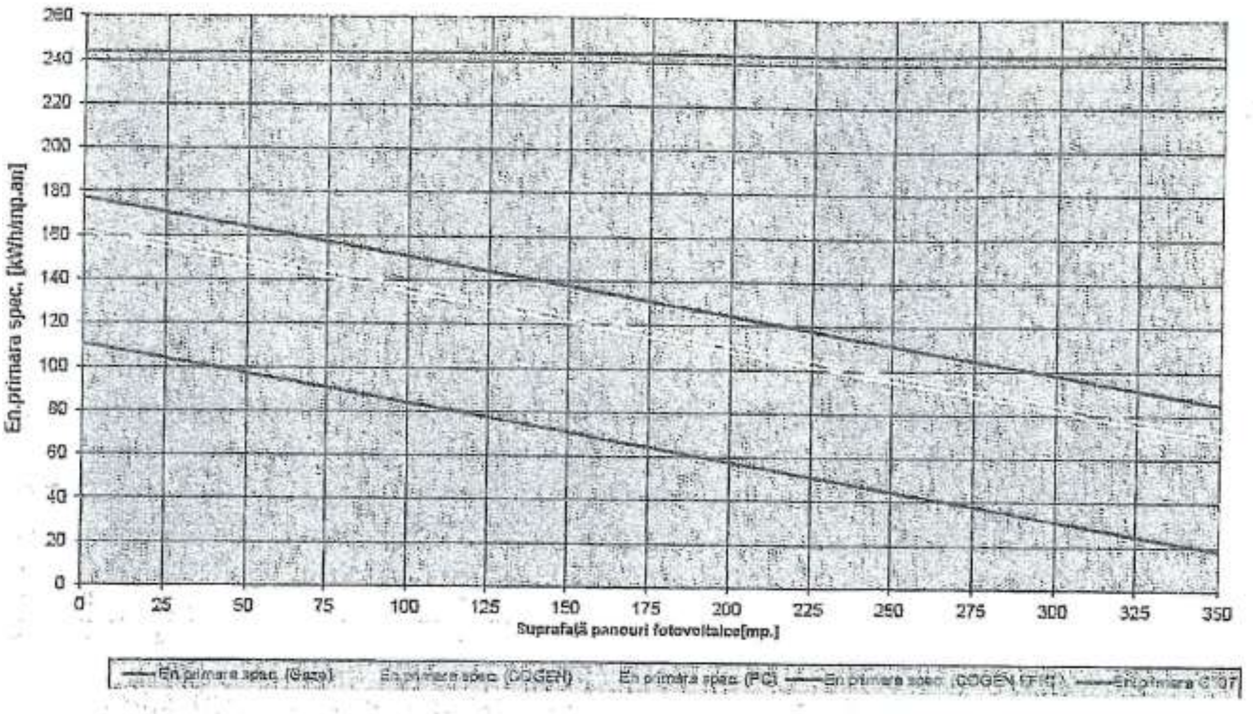

Figure V.109: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

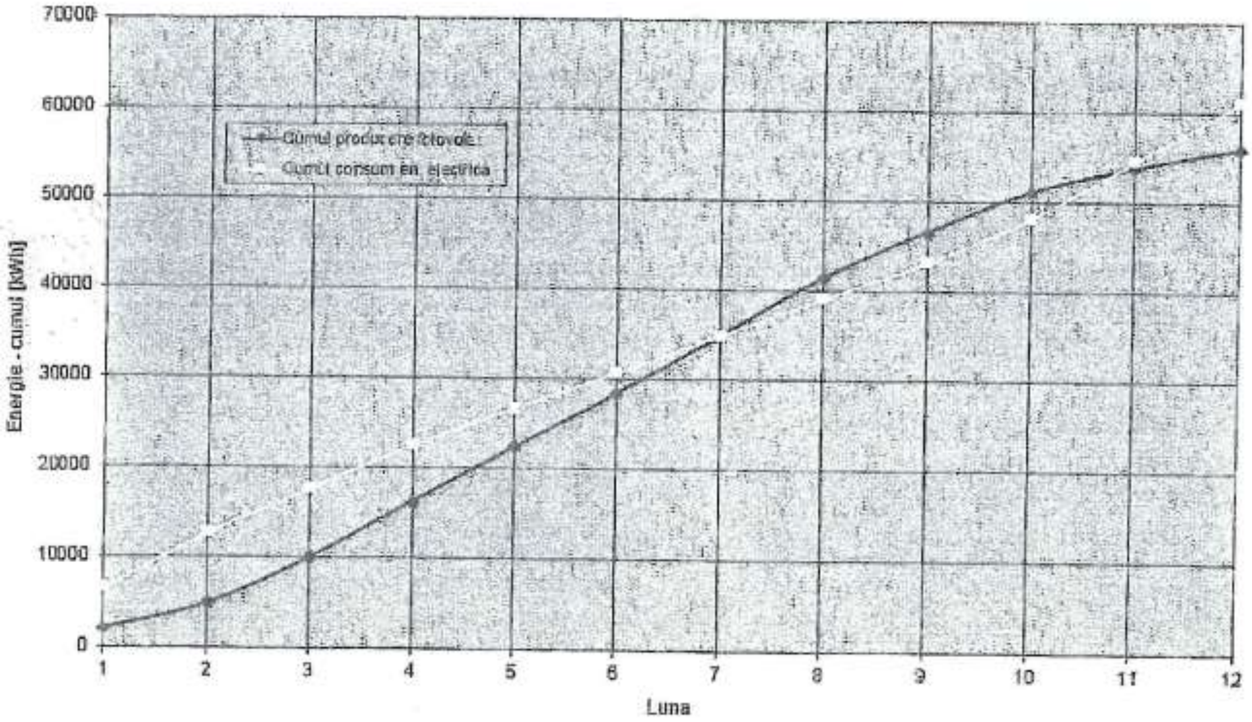

Figure V.110: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

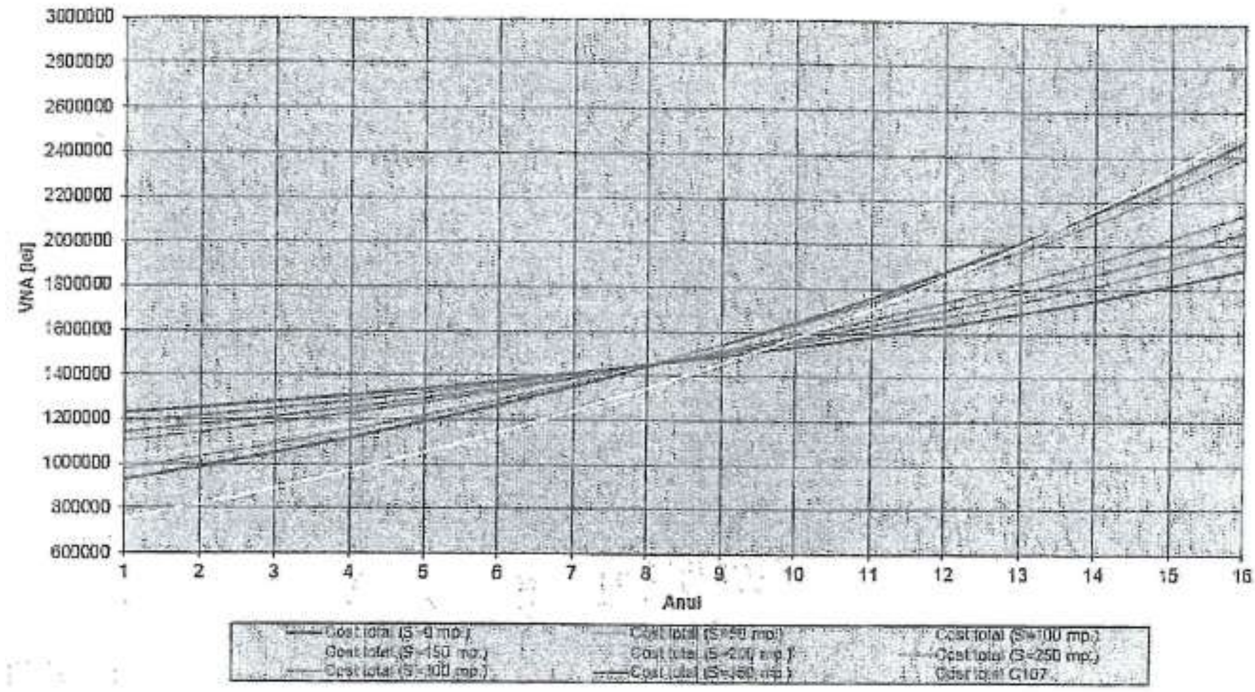

Figure V.111: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (mp = m^2)

2.3 System using current cogeneration

- primary energy = 81.67 kWh/m^2year;
- primary energy C107 = 207.55 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 91.44 %;
- share of total energy consumption from solar energy = 26.69 %;
- payback period ≈ 8.5 years.

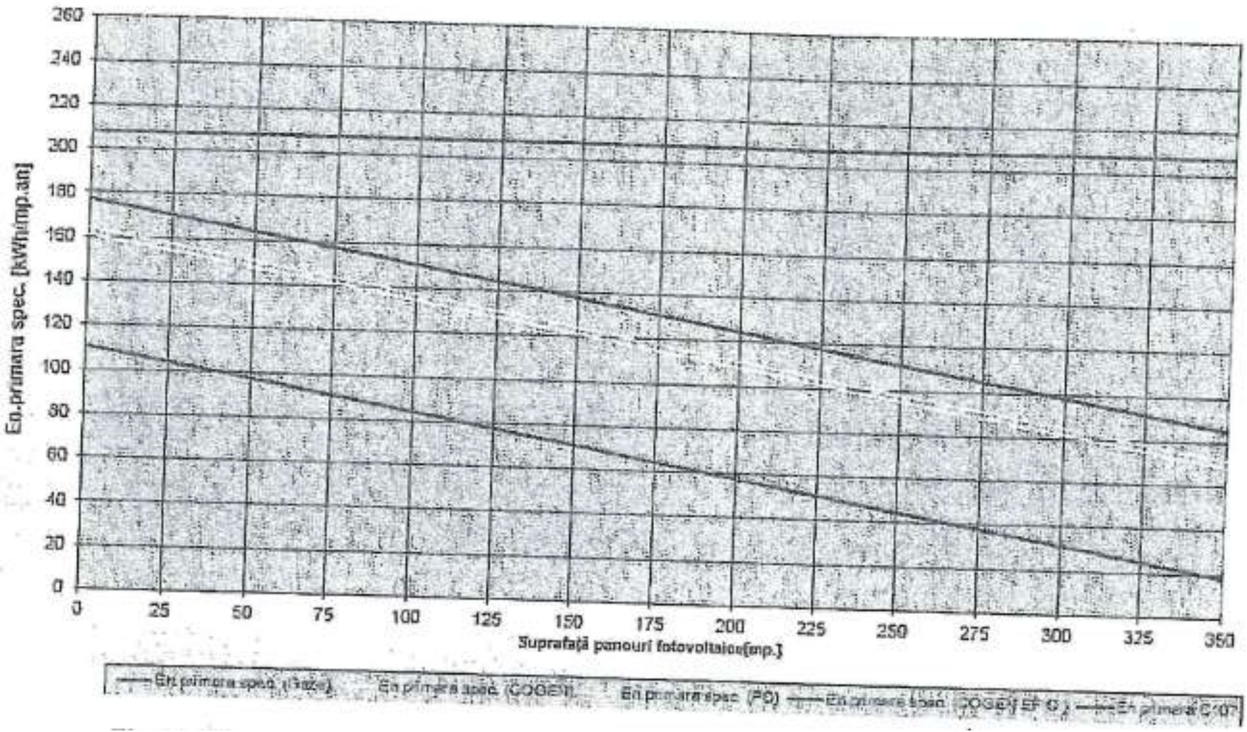

Figure V.112: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

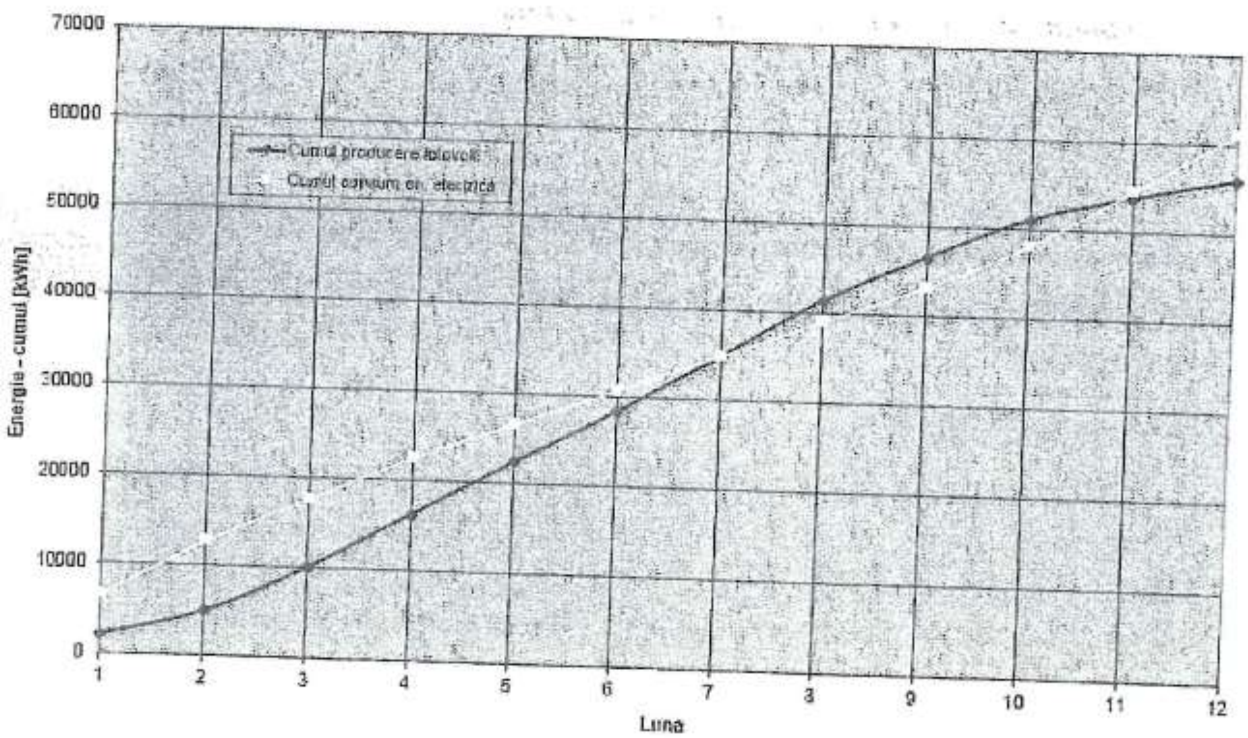

Figure V.113: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

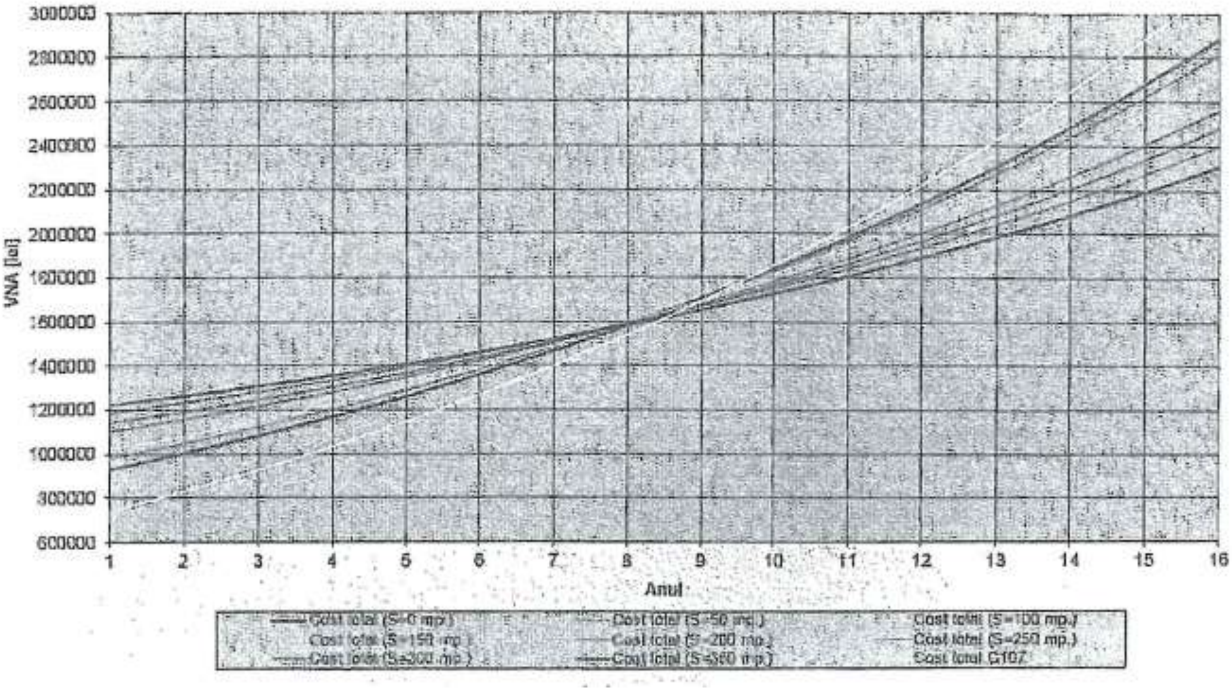

Figure V.114: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

2.4 System using high efficiency cogeneration

- primary energy = 31.34 kWh/m^2year;
- primary energy C107 = 207.55 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 91.44 %;
- share of total energy consumption from solar energy = 26.69 %;
- payback period ≈ 8.5 years.

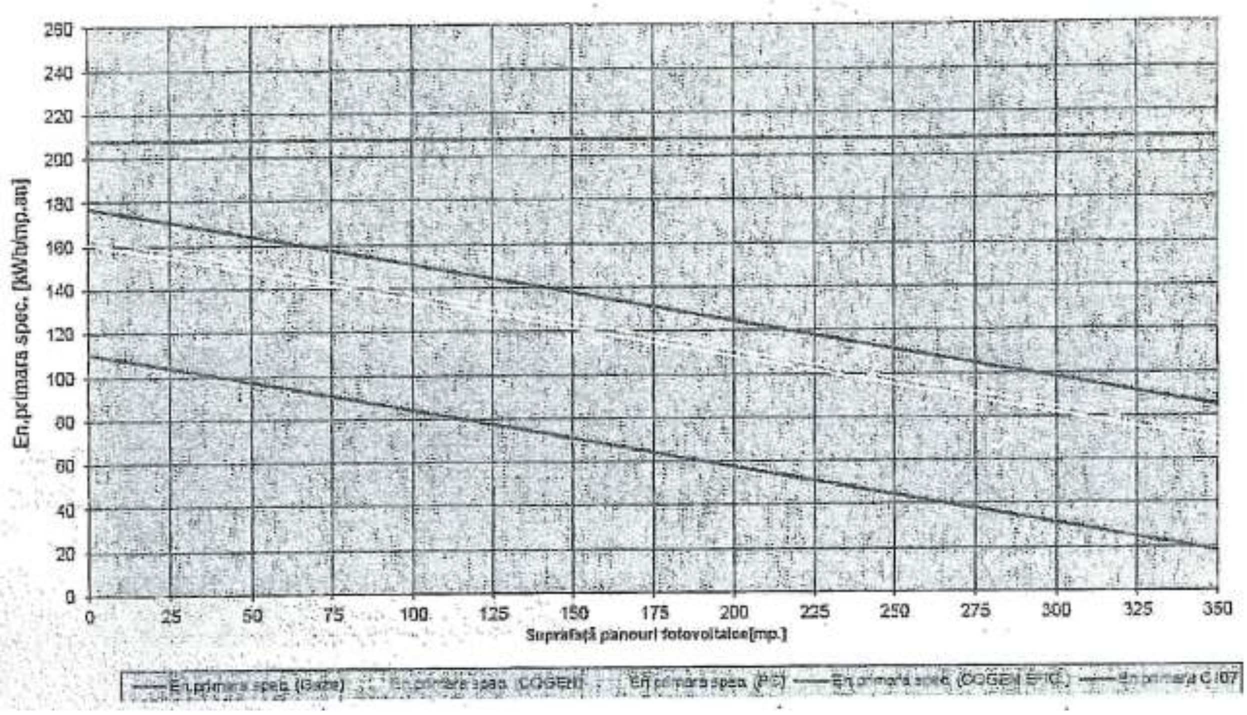

Figure V.115: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

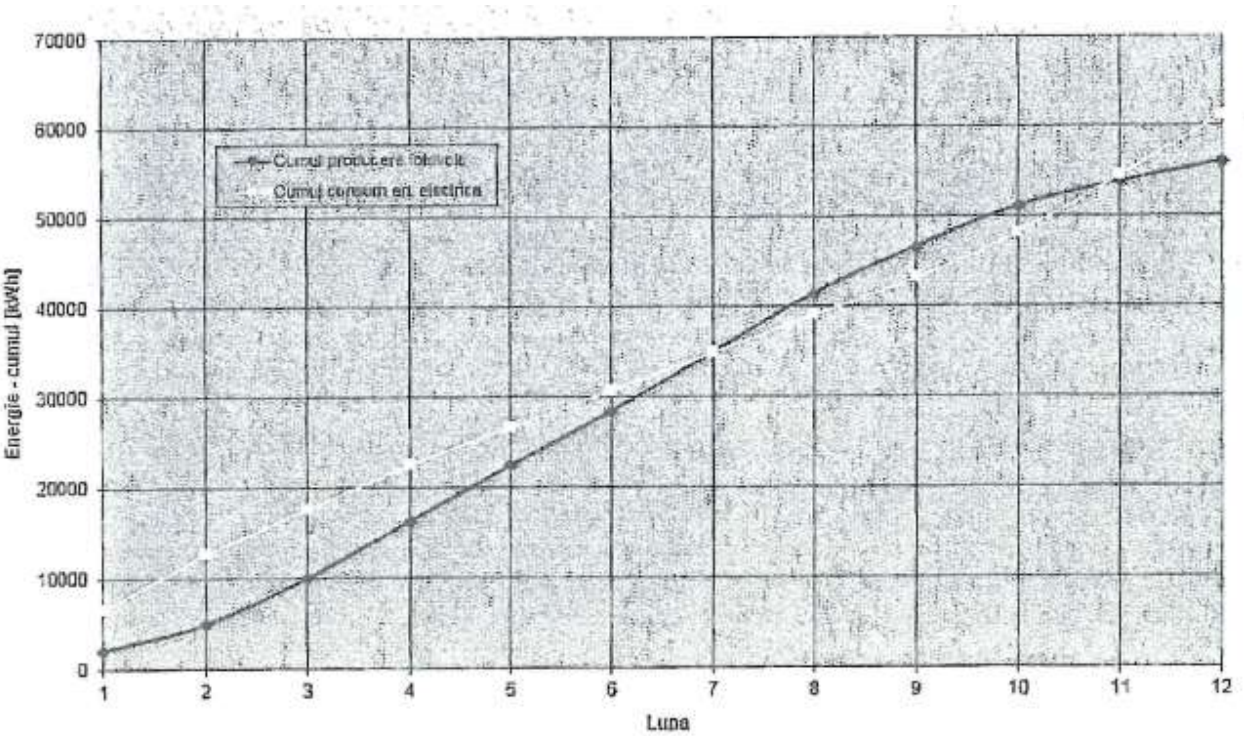

Figure V.116: Power generation and consumption
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

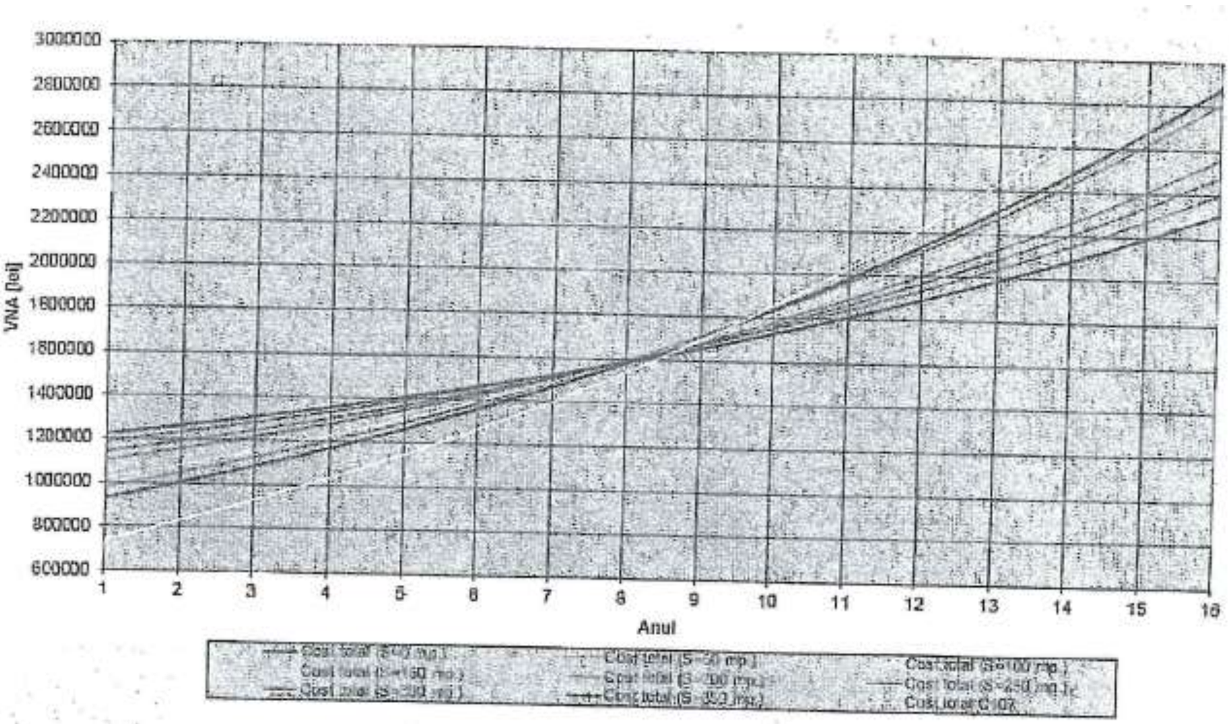

Figure V.117: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year

Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High efficiency cogeneration
primary energy (kWh/m^2year)	84.89	97.98	81.67	31.34
primary energy C107 (kWh/m^2year)	243.86	243.86	207.55	207.55
share of electricity consumption from PVP (%)	48.16	91.44	91.44	91.44
share of total energy consumption from solar energy (%)	48.16	23.10	26.69	26.69
payback period (years)	11.4	9.7	8.5	8.5

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V.1.3 Single-family building, climate zone II

System using a gas boiler

Case 1: Surface area of the photovoltaic solar panels = 3 m^2

- primary energy = 146.79 kWh/m^{2}year;
- primary energy C107 = 291.84 kWh/m^{2}year;
- share of electricity consumption from monocrystalline photovoltaic panels = 18.56 %;
- share of total energy consumption from solar energy = 45.26 %;
- payback period ≈ 11.7 years.

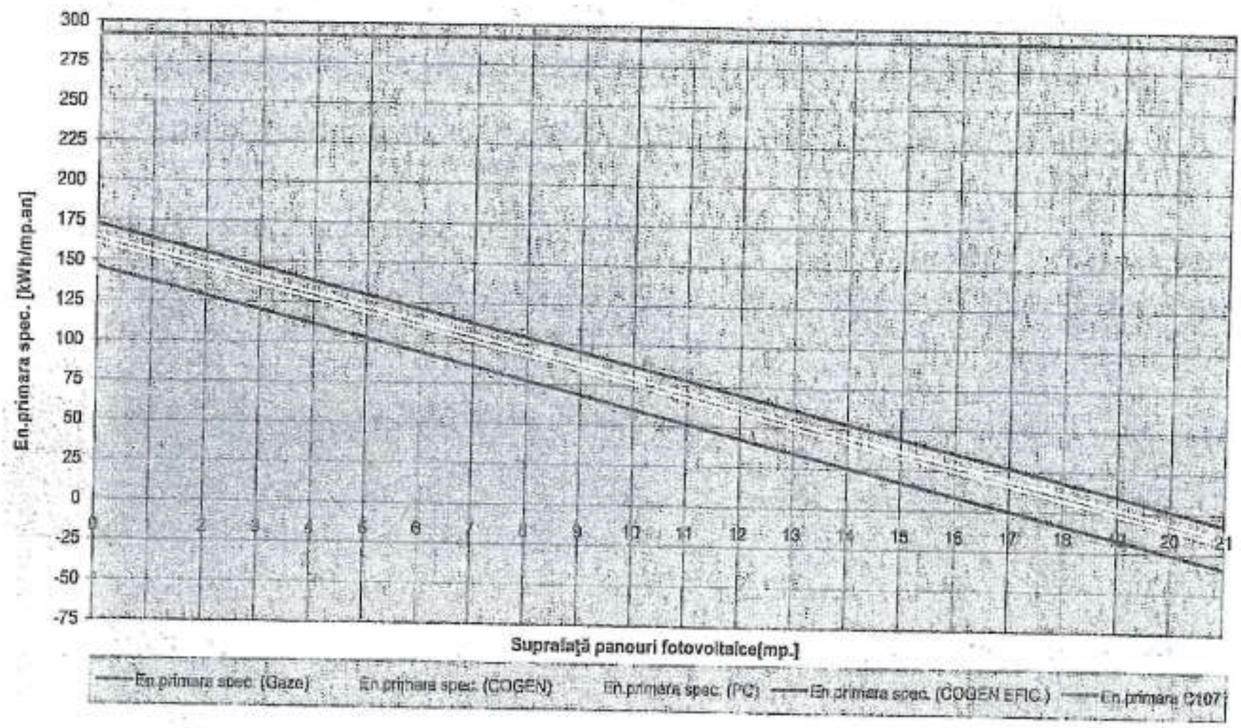

Figure V.118: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels - building fitted with solar hot water installation
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^{2}year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

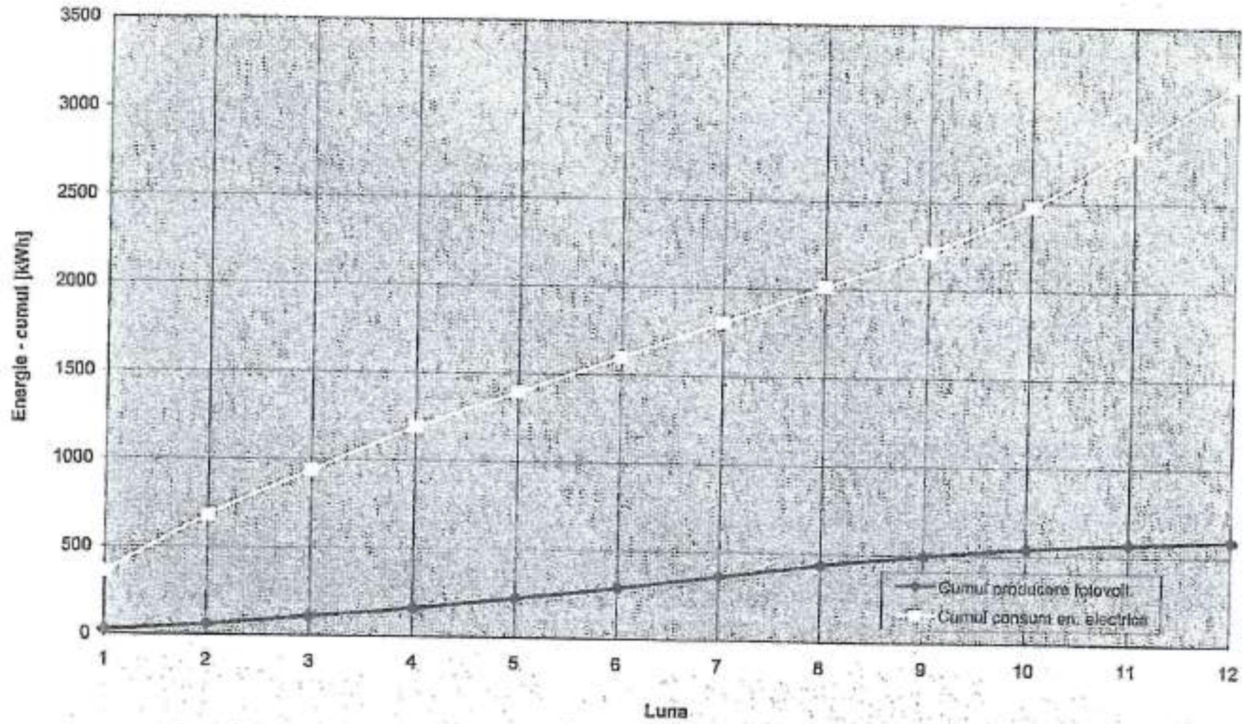

Figure V.119: Power generation and consumption - single-family building fitted with photovoltaic panels
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

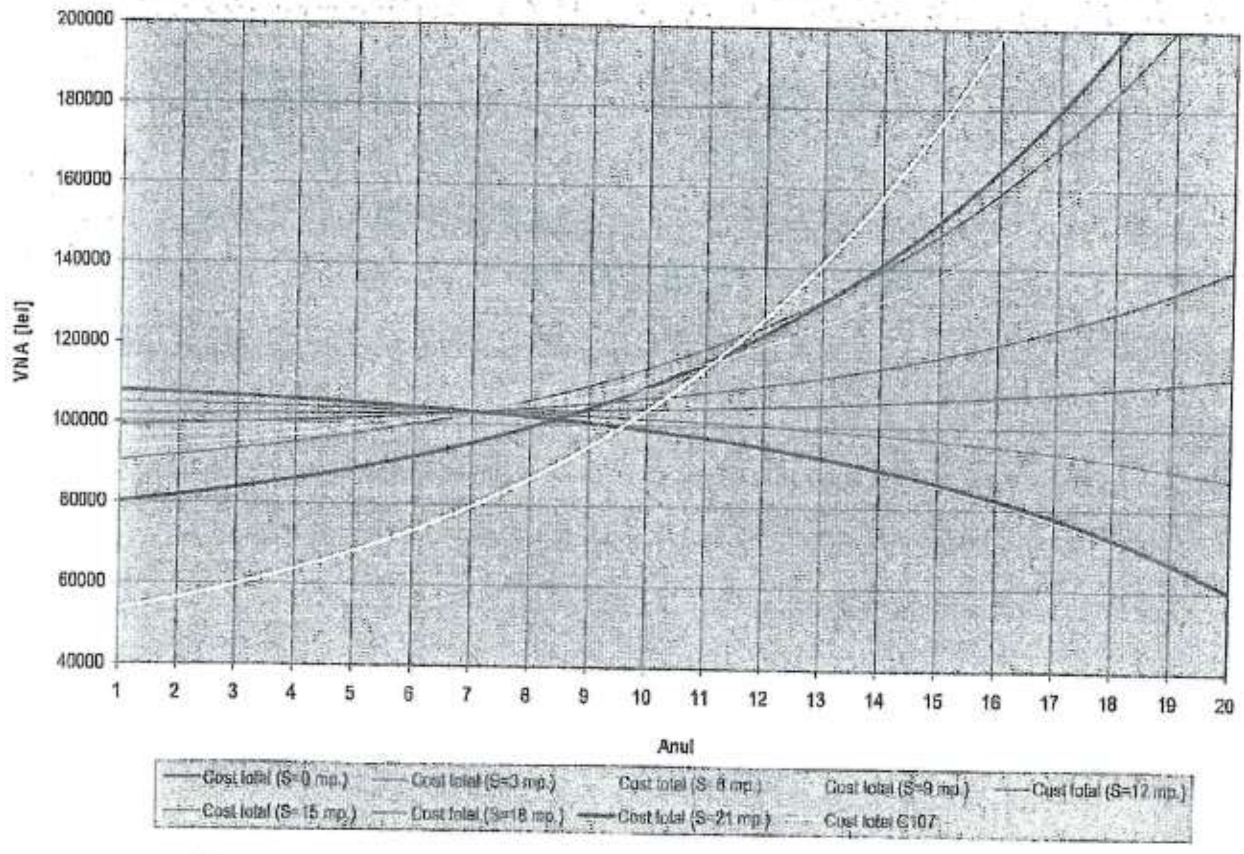

Figure V.120: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions
Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

Case 2: Surface area of the photovoltaic solar panels = 18 m^2

- primary energy = 18.37 kWh/m^2year;
- primary energy C107 = 291.84 kWh/m^2year;
- share of electricity consumption from monocrystalline photovoltaic panels = 111.37 %;
- share of total energy consumption from solar energy = 71.17 %;
- payback period ≈ 9.5 years.

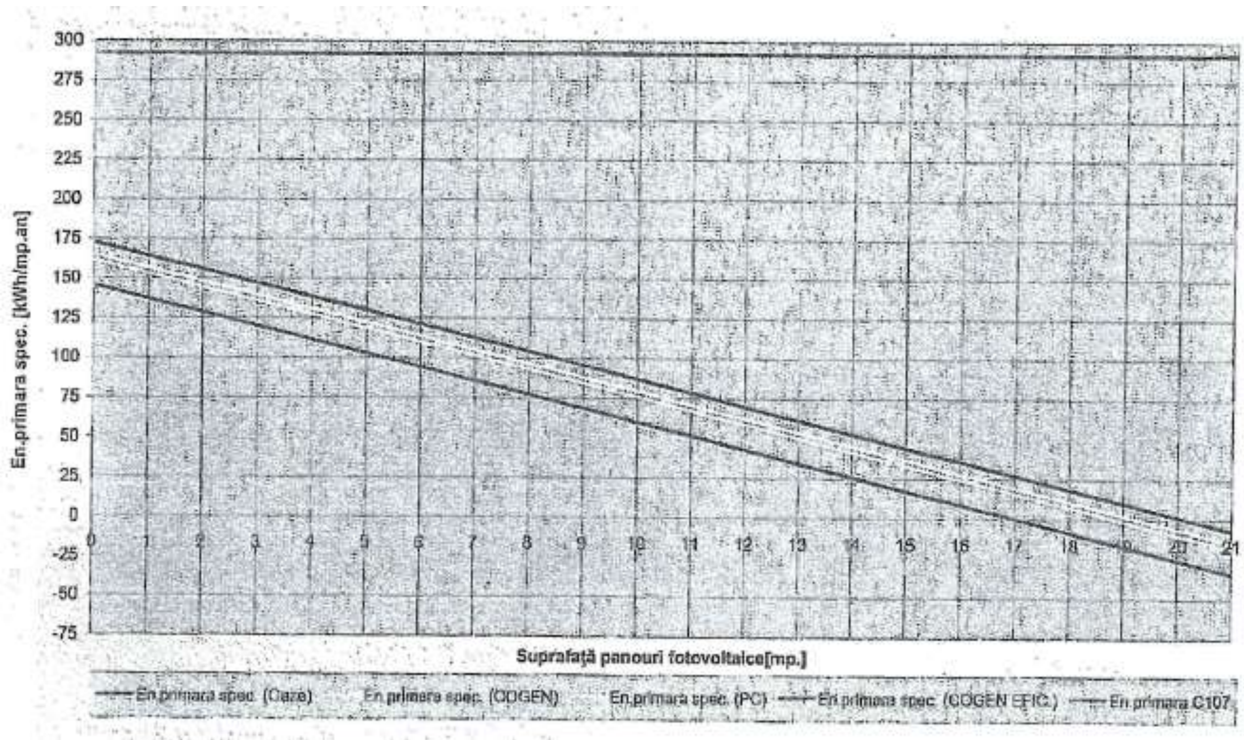

Figure V.121: Specific primary energy depending on the utility supply system and the surface area of the photovoltaic panels - building fitted with solar hot water installation
Key:
Horizontal: Photovoltaic panel surface area (m^2)
Vertical: Specific primary energy (kWh/m^2year)
Bottom: Specific primary energy (gas), Specific primary energy (cogeneration), Specific primary energy (PC), Specific primary energy (efficient cogeneration), Specific primary energy (C107)

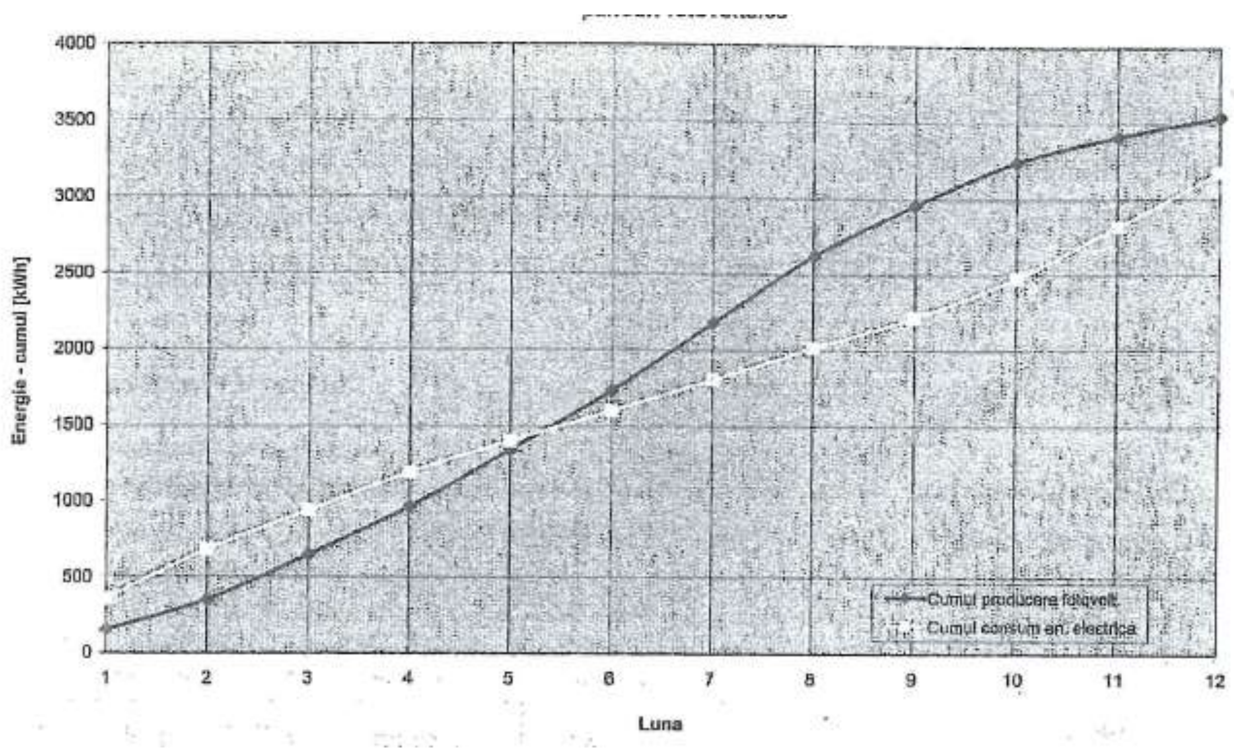

Figure V.122: Power generation and consumption - single-family building fitted with photovoltaic panels
Key:
Horizontal: Month
Vertical: Energy - aggregate (kWh)
Box: Aggregate photovoltaic generation, Aggregate power consumption

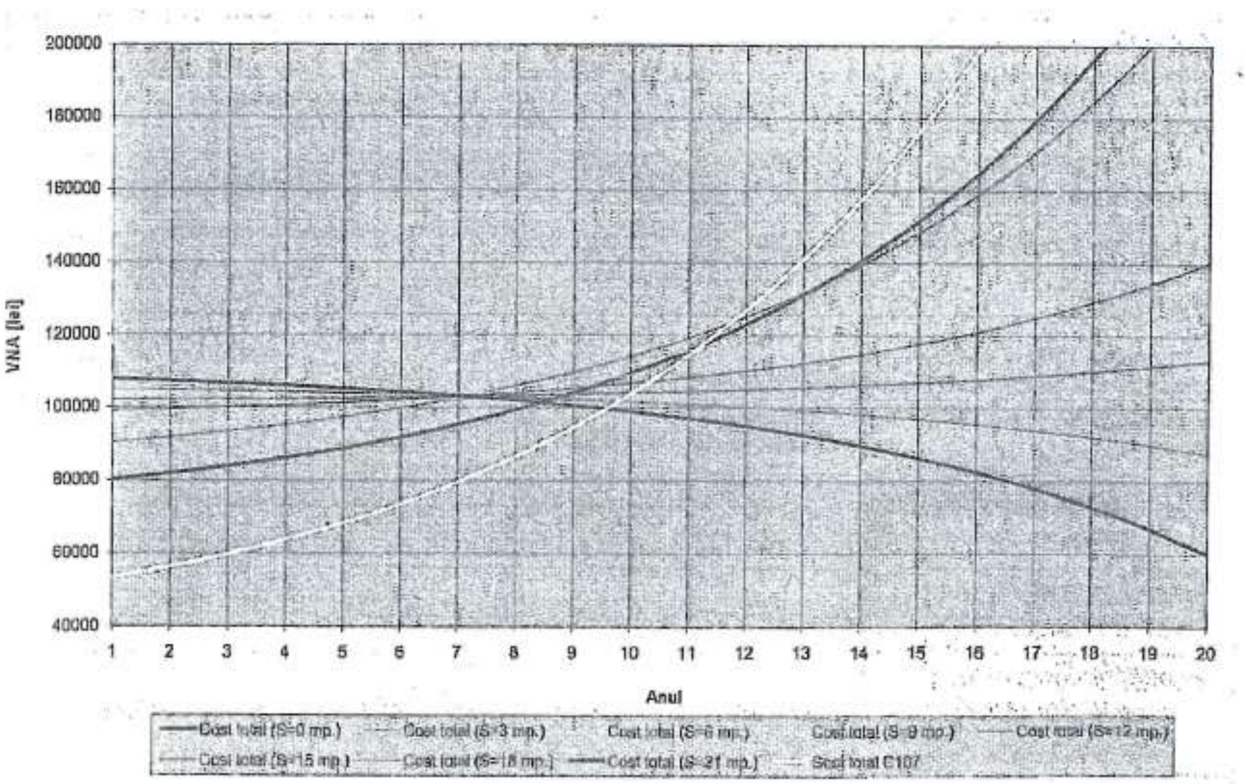

Figure V.123: DNR (discounted net revenue) analysis - estimation of the economic efficiency of the technical solutions

Key:
Horizontal: Year
Vertical: DNR (RON)
Bottom: Total cost (*mp* = m^2)

V.2 Results of the analysis of economic efficiency by type of building

NOTES:

1. The fields marked in grey do not meet the minimum conditions for being classified as NZEB;

2. The values highlighted in red are accepted if the permitted duration of the recovery of the additional investment exceeds the limit value of 10 years;

3. Values marked in bold refer to NZEB buildings.

V.2.1 Office buildings – climate zone II (maximum admissible specific primary energy for NZEB = 57 kWh/m^2year)

PVP surface area = 150 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^2year]	**42.95**	**52.96**	**46.23**	**28.26**
Primary energy C 107 [kWh/m^2year]	141.93	141.93	124.14	124.14
Share of power from PVP [%]	35.85	52.54	52.54	52.54
Share of total energy consumption from solar energy [%]	35.85	20.74	23.28	23.28
Payback period [years]	**10.0**	**9.2**	**7.8**	**7.8**

PVP surface area = 1 500 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^2year]	**– 77.05**	**– 67.04**	**– 73.77**	**– 91.74**
Primary energy C 107 [kWh/m^2year]	141.93	141.93	124.14	124.14
Share of power consumption from PVP [%]	215.05	315.23	315.23	315.23
Share of total energy consumption from solar energy[%]	215.08	124.44	139.65	139.65
Payback period [years]	**8.5**	**8.3**	**7.8**	**7.8**

V.2.2 Apartment blocks – climate zone I (maximum admissible specific primary energy for NZEB = 93 kWh/m^{2}year)

PVP surface area = 50 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	135.55	146.82	132.78	**89.44**
Primary energy C 107 [kWh/m^{2}year]	216.46	216.46	188.85	188.85
PVP surface area = 50 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Share of power consumption from PVP [%]	11.41	20.23	20.23	20.23
Share of total energy consumption from solar energy [%]	11.41	5.70	6.55	6.55
Payback period [years]	14.2	11.8	10.5	**10.5**

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	**48.30**	**59.57**	**45.52**	**2.19**
Primary energy C 107 [kWh/m^{2}year]	216.46	216.46	188.85	188.85
Share of power consumption from PVP [%]	68.43	121.39	121.39	121.39
Share of total energy consumption from solar energy [%]	68.43	34.21	39.29	39.29
Payback period [years]	**9.3**	**8.4**	**8.1**	**8.1**

V.2.3 Apartment blocks – climate zone II (maximum admissible primary energy for NZEB = 100 kWh/m^{2}year)

PVP surface area = 50 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	142.86	154.76	139.93	94.18
Primary energy C 107 [kWh/m^{2}year]	224.70	224.70	193.34	193.34
Share of power consumption from PVP [%]	8.85	16.08	16.08	16.08
Share of total energy consumption from solar energy [%]	8.85	4.36	5.01	5.01

Payback period [years]	16.0	14.0	11.5	11.5

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	**73.54**	**85.43**	**70.61**	**24.85**
PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy C 107 [kWh/m^{2}year]	224.70	224.70	193.34	193.34
Share of power consumption from PVP [%]	53.08	96.45	96.45	96.45
Share of total energy consumption from solar energy [%]	53.08	26.14	30.08	30.08
Payback period [years]	**11.1**	**10.2**	**9.4**	**9.4**

V.2.4 Apartment blocks – climate zone III (maximum admissible specific primary energy for NZEB = 111 kWh/m^{2}year)

PVP surface area = 50 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	142.48	154.57	139.49	**92.96**
Primary energy C 107 [kWh/m^{2}year]	229.04	229.04	196.94	196.94
Share of power consumption from PVP [%]	9.78	17.91	17.91	17.91
Share of total energy consumption from solar energy[%]	9.78	4.79	5.52	5.52
Payback period [years]	14.4	12.0	10.0	**10.0**

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	**65.24**	**77.34**	**70.61**	**15.73**
Primary energy C 107 [kWh/m^{2}year]	229.04	229.04	196.94	196.94
Share of power consumption from PVP [%]	58.69	107.45	107.45	107.45
Share of total energy consumption from solar energy [%]	58.69	2876	33.13	33.13

Payback period [years]	**9.8**	**9.0**	**8.4**	**8.4**

V.2.5 Apartment blocks – climate zone IV (maximum admissible specific primary energy for NZEB = 127 kWh/m^{2}a)

PVP surface area = 50 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	150.62	163.70	147.40	**97.07**
Primary energy C 107 [kWh/m^{2}year]	243.86	243.86	207.55	207.55
Share of power consumption from PVP [%]	8.03	15.24	15.24	15.24
Share of total energy consumption from solar energy [%]	8.03	3.85	4.45	4.45
Payback period [years]	14.9	12.0	9.2	**9.2**

PVP surface area = 300 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	84.89	**97.98**	**81.67**	**31.34**
Primary energy C 107 [kWh/m^{2}year]	243.86	243.86	207.55	207.55
Share of power consumption from PVP [%]	48.16	91.44	91.44	91.44
Share of total energy consumption from solar energy [%]	48.16	23.10	26.69	26.69
Payback period [years]	11.4	**9.7**	**8.5**	**8.5**

V.2.6 Single-family buildings – climate zone II (maximum admissible specific primary energy for NZEB = 111 kWh/m^{2}year) –building fitted with ventilated solar area and solar domestic hot water installation in the solar area

Gas boiler	**PVP surface area = 3 m^2**	**PVP surface area = 18 m^2**
Primary energy [kWh/m^{2}year]	146.79	**18.37**
Primary energy C 107 [kWh/m^{2}year]	291.84	291.84
Share of power consumption from PVP [%]	18.56	111.37
Gas boiler	**PVP surface area = 3 m^2**	**PVP surface area = 18 m^2**
Share of total energy consumption from solar energy	45.26	71.17

[%]		
Payback period [years]	11.7	**9.5**

V.3 Analysis of price sensitivity

The additional cost is determined by the price of building materials (including labour for the thermal protection of the building's envelope), the prices of the equipment used to achieve the building's microclimate and the prices of the systems for renewable energy sources. The additional investment payback period is determined using the following equation:

$$C_{INV}^{REF} + E_{el}^{REF}\cdot c_{e\,el}\cdot\sum_{\tau=1}^{T}\left(\frac{1+r_{e\,el}}{1+a}\right)^{\tau} + E_{t}^{REF} c_{e\,t}\cdot\sum_{\tau=1}^{T}\left(\frac{1+r_{e\,t}}{1+a}\right)^{\tau} + E_{comb}^{REF} c_{e\,comb}\cdot\sum_{\tau=1}^{T}\left(\frac{1+r_{e\,comb}}{1+a}\right)^{\tau} =$$

$$C_{INV}^{C107} + E_{el}^{C107}\cdot c_{e\,el}\cdot\sum_{\tau=1}^{T}\left(\frac{1+r_{e\,el}}{1+a}\right)^{\tau} + E_{t}^{C107} c_{e\,t}\cdot\sum_{\tau=1}^{T}\left(\frac{1+r_{e\,t}}{1+a}\right)^{\tau} + E_{comb}^{C107} c_{e\,comb}\cdot\sum_{\tau=1}^{T}\left(\frac{1+r_{e\,comb}}{1+a}\right)^{\tau} \quad (1)$$

The additional investment payback period D is, therefore, a function of the prices of the components representing the two investment costs C_{INV}^{REF} and C_{INV}^{C107}. In synthetic form, it is possible to define a function ('function (2)') with three variables:

$$D = f_1(p_1, p_2, p_3)$$

The calculated payback period is expressed based on the values $p_{1.0}$, $p_{2.0}$ and $p_{3.0}$ of the prices taken into consideration in this study. Give the absence in Romania of a database of the aforementioned prices, it is possible that the calculation data have some deviation.

The sensitivity analysis makes it possible to draw up national policies aimed at promoting NZEBs in line with the principle of economic efficiency, and to evaluate the error margin in respect of the numerical values used in the case studies in this document.

It is very difficult to determine function (2) as a function with three independent values (p_1, p_2, and p_3). Price variation (possible market prices) is expressed as follows:

$$\begin{cases} p_1 = p_{1.0}\cdot x_1 \\ p_2 = p_{2.0}\cdot x_2 \\ p_3 = p_{3.0}\cdot x_3 \end{cases} \quad (3)$$

The numerical coefficients X_j vary within a reasonable range:

$$x_j \in [0{,}7; 1{,}3] \quad (4)$$

Price variations are defined as:

$$dp_j = p_{j,0} dx_j \tag{5}$$

or:

$$\Delta p_j = p_{j,0} \Delta x_j \tag{6}$$

where:

$$\min\{\Delta x_j\} = -0{,}3; \quad \max\{\Delta x_j\} = 0{,}3 \tag{7}$$

The function for the additional investment payback period can be expressed in a modified form:

$$D = f_1(x_1, x_2, x_3) \tag{8}$$

Based on the method for estimating the value of D (graphed for the case studies in this document), it is possible to define three particular functions:

$$\begin{cases} D_1 = f_1\,(x_1, 1, 1) \\ D_2 = f_2\,(1, x_2, 1) \\ D_3 = f_3\,(1, 1, x_3) \end{cases} \tag{9}$$

and function D, through linear composition

$$D(x_1, x_2, x_3) = \alpha_1 \cdot f_1(x_1, 1, 1) + \alpha_2 \cdot f_2(1, x_2, 1) + \alpha_3 \cdot f_3(1, 1, x_3) \tag{10}$$

The variation of the additional cost recovery period D can be expressed like this:

costului suplimentar, D, se exprima sub forma:

$$dD(x_1, x_2, x_3) = \alpha_1 \cdot \left.\frac{\partial f_1(x_1, 1, 1)}{\partial x_1}\right|_{x_1=1} dx_1 + \alpha_2 \cdot \left.\frac{\partial f_2(1, x_2, 1)}{\partial x_2}\right|_{x_2=1} dx_2 + \alpha_3 \cdot \left.\frac{\partial f_3(1, 1, x_3)}{\partial x_3}\right|_{x_3=1} dx_3 \tag{11}$$

or like this:

$$\Delta D = \alpha_1 A_1 \Delta x_1 + \alpha_2 A_2 \Delta x_2 + \alpha_3 A_3 \Delta x_3 \tag{12}$$

which gives:

$$D \cong D_0 + \Delta D \qquad (13)$$

Within the range of variables x_1, x_2 and x_3 and of the calculation prices $p_{1.0}$, $p_{2.0}$ and $p_{3.0}$, with an error margin under 5.62%, variation ΔD can also be expressed in simplified form as:

$$D \cong A_1\Delta x_1 + A_2\Delta x_2 + A_3\Delta x_3 \qquad (14)$$

or:

$$\Delta D \cong \left.\frac{\partial f_1(x_1, 1, 1)}{\partial x_1}\right|_{x_1=1} \Delta x_1 + \left.\frac{\partial f_2(1, x_2, 1)}{\partial x_2}\right|_{x_2=1} \Delta x_2 + \left.\frac{\partial f_3(1, 1, x_3)}{\partial x_3}\right|_{x_3=1} \Delta x_3 \qquad (15)$$

The charts in figures V.124, V.125 and V.126, with reference to office buildings, apartment blocks and single-family buildings, present the functions $f_1(x_1, 1, 1)$, $f_2(1, x_2, 1)$ and $f_3(1, 1, x_3)$. The shapes produced by the aforementioned functions lead the following conclusions relating to payback period D_0 calculated in this study:

1. in the case of a building office fitted with photovoltaic panels, the impact that the price of the panels has on the investment payback period is determined relative to the variation in the other prices (building materials and equipment);

2. in the case of an apartment block, the conclusion under point 1 is maintained, noting that variations in the prices of building materials and equipment significantly amplify the effect of the variation in the price of the photovoltaic panels;

3. in the case of a single-family building, the comparable major role is played by the prices of the photovoltaic panels and of the equipment, while variation in the prices of building materials has negligible impact.

It follows that policies aimed at stimulating market absorption of photovoltaic panels and high performance equipment should be a strategic objective in promoting NZEBs in Romania effectively.

Another conclusion that supports the above is related to the fact that in all the cases examined fitting the buildings with the maximum possible surface areas for collecting solar radiation (photovoltaic panels) results in the shortest additional investment payback period, as shown in the table below.

Type of building	**S_{pp} = maximum**			**S_{pp} = 0**		
Office buildings	7.40	5.77	9.03	10.40	8.10	12.50
Apartment blocks	8.78	6.60	11.00	11.20	8.70	13.30
Single-family building	9.59	8.25	10.77	11.20	10.00	12.40

The summary table above shows that the investment is practically efficient in all the cases when fitting the maximum surface area of photovoltaic panels. In the absence thereof, the investment is efficient only if there is a reduction in current prices.

Moreover, the use of photovoltaic panels leads to a significant reduction in primary energy, in all the cases.

Drawing up a coherent and sustainable strategy is possible only if a database is set up, containing all the prices required in order to design NZEBs.

Based on the sensitivity analysis, all buildings under consideration can be included in the NZEB category, noting at the same time that they use a connection to energy networks and can deliver energy to the network.

The sensitivity analysis for **office buildings**, presented in the graph in figure V.124, was based on the following hypotheses:

- the office building is connected to a gas boiler;
- the surface area of the photovoltaic panels is 1 250 m^2;
- primary energy is -43.04 kWh/m^2year;
- primary energy for a C107 building is 141.93 kWh/m^2year;
- the share of power consumption from photovoltaic panels is 262.69 %.

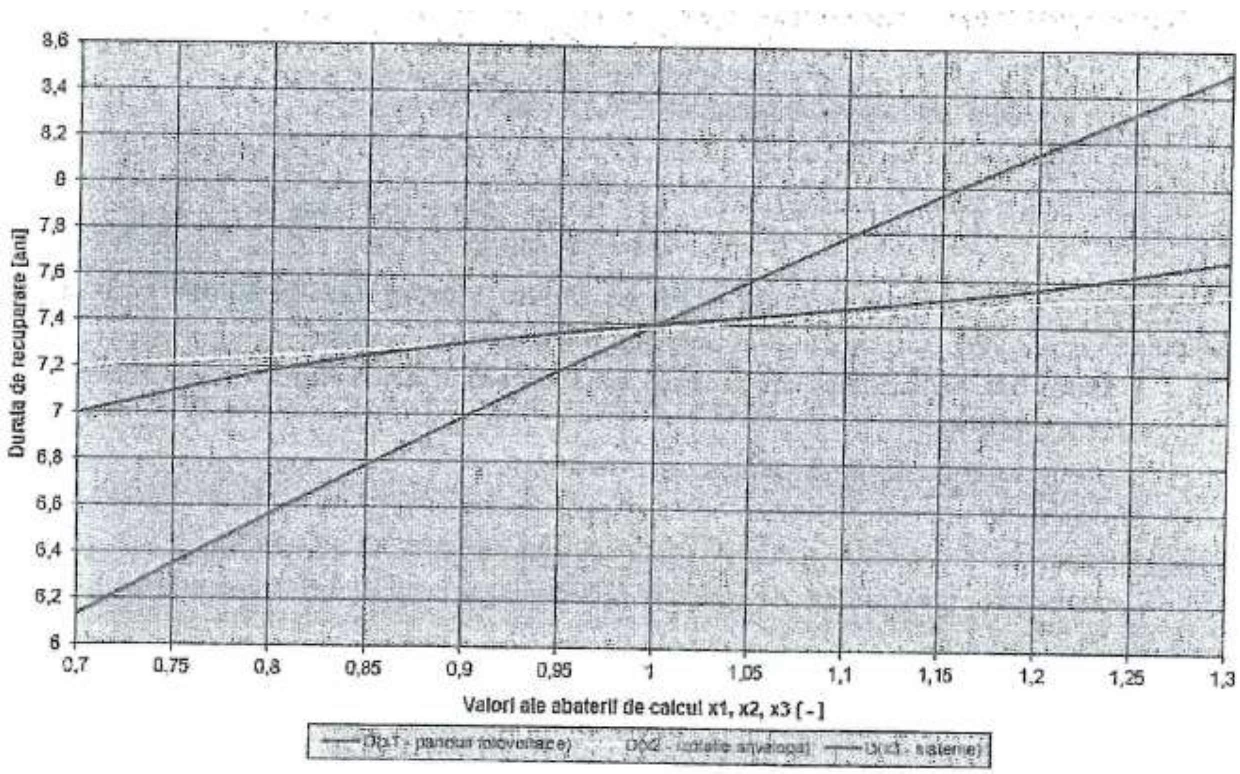

Figure V.124: Variation in the components of the deviation in the additional investment payback period relative to the variation in prices
Key:
Horizontal: Calculation deviation in x_1, x_2 and x_3
Vertical: Payback period (years)
Bottom: Photovoltaic panels, Envelope insulation, Systems

The sensitivity analysis for **apartment blocks**, presented in the graph in figure V.125, was based on the following hypotheses:

- the apartment block is connected to a high efficiency cogeneration network;
- the surface area of the photovoltaic panels is 250 m^2;
- primary energy is 38.71 kWh/m^2year;
- primary energy for a C107 building is 193.34 kWh/m^2year;
- the share of power consumption from photovoltaic panels is 80.38 %.

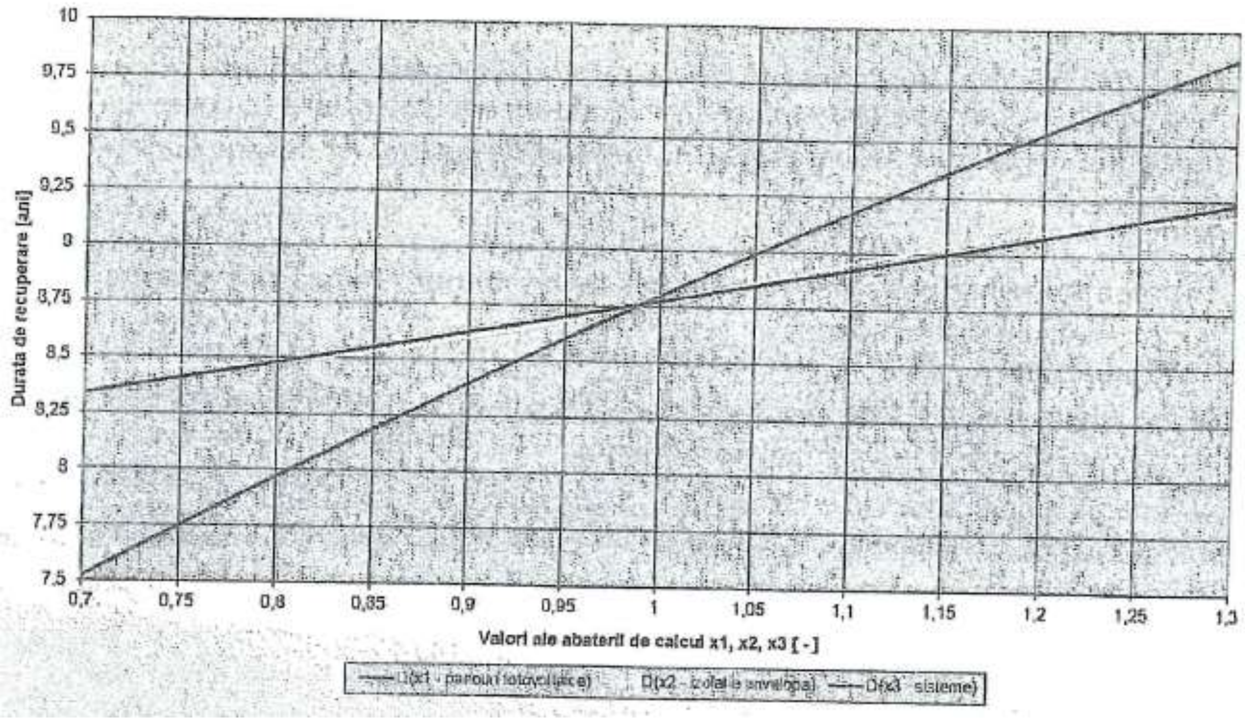

Figure V.125: Variation in the components of the deviation in the additional investment payback period relative to the variation in prices
Key:
Horizontal: Calculation deviation in x_1, x_2 and x_3
Vertical: Payback period (years)
Bottom: Photovoltaic panels, Envelope insulation, Systems

The sensitivity analysis for **single-family buildings**, presented in the graph in figure V.126, was based on the following hypotheses:
- the single-family building is connected to a high efficiency cogeneration network;
- the surface area of the photovoltaic panels is 18 m^2;
- primary energy is 18.37 kWh/m^2year;
- primary energy for a C107 building is 291.84 kWh/m^2year;
- the share of power consumption from photovoltaic panels is 111.37 %.

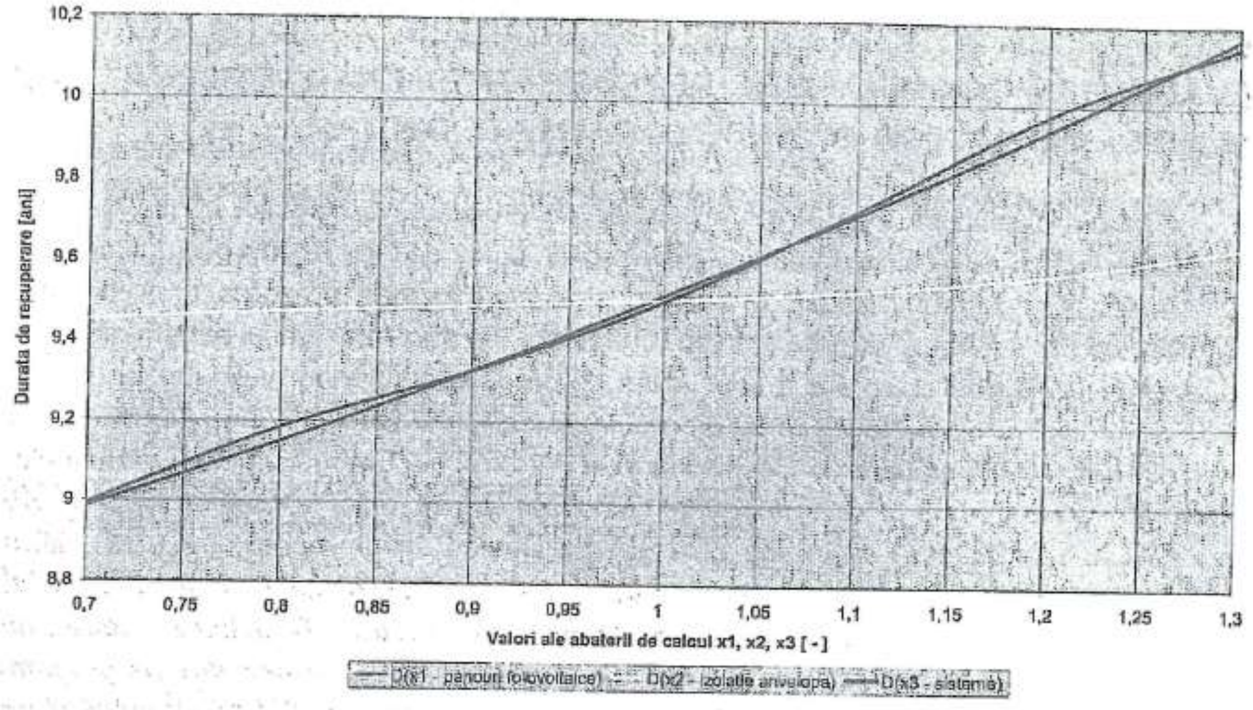

Figure V.126: Variation in the components of the deviation in the additional investment payback period relative to the variation in prices

Key:

Horizontal: Calculation deviation in x_1, x_2 and x_3

Vertical: Payback period (years)

Bottom: Photovoltaic panels, Envelope insulation, Systems

Chapter VI - Basis of the climate index method required for the preliminary evaluation of the energy performance of a building located in any locality in Romania

One of the major difficulties in designing NZEB buildings is staying within the limits that define them as such from an energy perspective. In particular, determining the annual heating and cooling needs requires the use of powerful software packages that are validated both empirically and numerically. Unfortunately, as a result of the very low level of interest shown by the decision-making actors in developing such (validated) products locally, the design process takes place using either unsuitable programs (that are certified strictly for drawing up energy performance certificates for existing apartments) or programs based on monthly or seasonal time steps at building level, resulting in incorrect values relative to those specific to dynamic simulation. In order to simplify decisions in the design stage, a simplified and approximate method was developed for assessing the annual heating requirements for the heating of spaces within NZEBs. The method is based on the processing of the detailed simulation made using a validated program based on an hourly time step and correlation of the cooling requirements values with the number of calculation degrees-days for localities in Romania. The annual heating requirements were calculated relative to the value specific to the building located in climate zone II. The results were a dimensional values in the form of the climate index (CI) correlated with the number of calculation degrees-days. The next section provides a brief overview of the theoretical basis and the calculated values. The analysis of the climate index will continue in the next (final) stage of this study, through diversification in respect of thermal comfort, degree of thermal protection and building operation strategies. Furthermore, the analysis will be extended to cover also the summer season (if the simulations require this).

VI.1 Defining the climate index (CI)

This study includes simulations based on an hourly time step for typical buildings and for C107 buildings, for all four climate zones included in the calculation, for the case of an apartment block. Therefore, the heating requirements for a typical climate year ('PEC') are known.

In the case of heating, the values for the reference building are PEC_{R1} ... PEC_{R4} (indexes 1, 2, 3 and 4 represent the climate zones). If climate zone II is taken as the national reference climate zone, the following ratios can be defined:

$$R_{R1}=\frac{PEC_{R1}}{PEC_{R2}}<1;\quad R_{R2}=\frac{PEC_{R2}}{PEC_{R2}}=1;\quad R_{R3}=\frac{PEC_{R3}}{PEC_{R2}}>1;\quad R_{R4}=\frac{PEC_{R4}}{PEC_{R2}}>1.$$

The same is also applied to the case of the C107 building:

$$R_{C1}=\frac{PEC_{C1}}{PEC_{C2}}<1;\quad R_{C2}=\frac{PEC_{C2}}{PEC_{C2}}=1;\quad R_{C3}=\frac{PEC_{C3}}{PEC_{C2}}<1;\quad R_{C4}=\frac{PEC_{C4}}{PEC_{C2}}>1.$$

The differences between R_{RK} and R_{CK} are analysed.

The R values are correlated with the number of degrees-days for the localities for which they were calculated (the degrees-days can be found in SR 4839-97) and are expressed in algebraic form as a function:

$$R_k = f\,(NGZ_k)$$

If a simulation is used to determine PEC_2 for a given building, in climate zone II (which is the arbitrary reference climate zone), it is possible to find PEC_k for any R_k using the function presented above. The number of degrees-days for the locality in question is known (from the standard), the R_k value can be calculated using the function, and that calculation can then be used to determine PEC_k on the basis of the following relationship:

$$PEC_k = PEC_2 \cdot R_k$$

In stage III, the procedure will be validated so as to use it with an acceptable error margin as a substitute for the dynamic modelling of NZEBs.

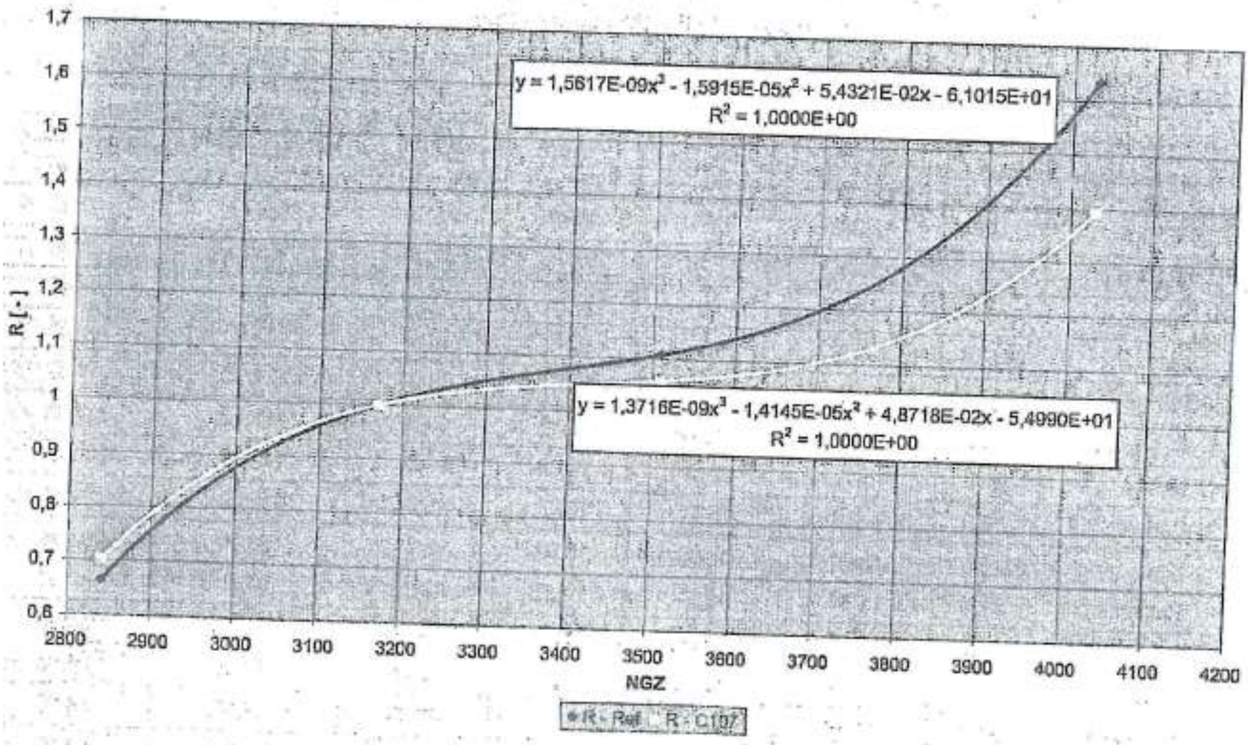

Figure VI.1: Climate index based on the number of calculation degrees-days and the technical solution specific to the apartment block

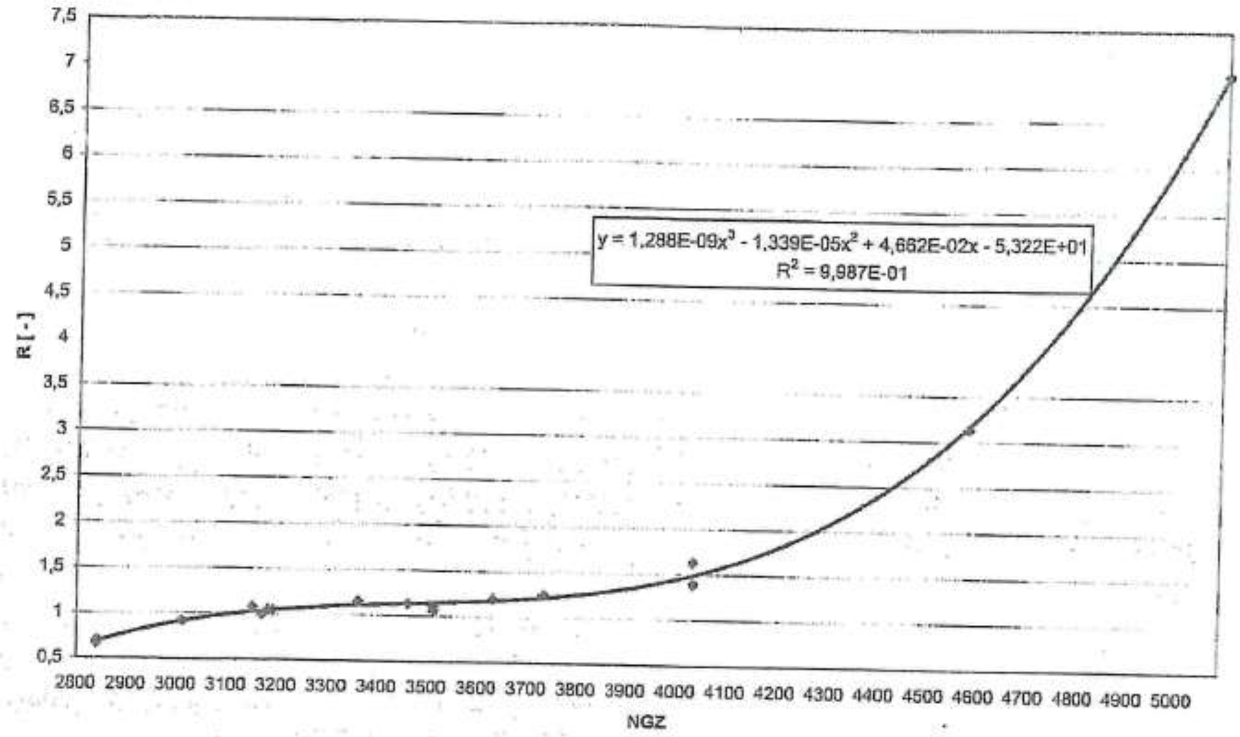

Figure VI.2: Variation of the climate index based on the number of calculation degrees-days - apartment block
Key:
Horizontal: Number of degrees-days

Ref. No	Locality	Number of degrees-days (*NGZ*)	Apartment block – *R*	Single-family building – *R*	Office building – *R*	Apartment block – C107	Single-family building – C107	Office building – C107
1	Alba Iulia	3460	12.98	18.91	18.97	46.59	123.77	59.93
2	Alexandria	3150	11.78	17.16	17.21	42.28	112.31	54.38
3	Adamclisi	3120	11.59	16.89	16.94	41.60	110.51	53.50
4	Arad	3020	10.75	15.67	15.71	38.59	102.52	49.64
5	Bacău	3630	13.39	19.51	19.57	48.06	127.68	61.82
6	Baia Mare	3350	12.56	18.30	18.36	45.08	119.75	57.98
7	Bistriţa	3850	15.11	22.02	22.09	54.24	144.10	69.77
8	Bârlad	3460	12.83	18.69	18.74	46.04	122.29	59.21
9	Blaj	3530	13.01	18.96	19.02	46.71	124.10	60.08
10	Botoşani	3630	13.39	19.51	19.57	48.06	127.68	61.82
11	Braşov	4030	18.04	26.28	26.36	64.74	171.98	83.27
12	Brăila	3170	11.89	17.33	17.38	42.68	113.39	54.90
13	Bucureşti	3170	11.89	17.33	17.38	42.68	113.39	54.90
14	Buzău	3150	11.78	17.16	17.21	42.28	112.31	54.38

15	Calafat	2980	10.31	15.03	15.07	37.01	98.33	47.61
16	Caracal	3100	11.45	16.68	16.73	41.10	109.17	52.86
17	Caransebeş	3180	11.94	17.40	17.46	42.87	113.89	55.14
18	Călăraşi	3010	10.65	15.52	15.56	38.22	101.53	49.16
19	Câmpina	3530	13.01	18.96	19.02	46.71	124.10	60.08
20	Câmpulung Moldovenesc	4270	25.13	36.62	36.73	90.21	239.64	116.02
21	Câmpulung Muşcel	3820	14.78	21.53	21.60	53.04	140.90	68.22
22	Cluj	3730	13.98	20.37	20.43	50.18	133.31	64.54
23	Constanţa	2840	8.18	11.92	11.96	29.36	78.01	37.77
24	Craiova	3170	11.89	17.33	17.38	42.68	113.39	54.90
25	Curtea de Argeş	3540	13.05	19.01	19.07	46.82	124.39	60.22
26	Deva	3300	12.42	18.10	18.15	44.58	118.43	57.34
27	Dorohoi	3850	15.11	22.02	22.09	54.24	144.10	69.77
28	Drăgăşani	3120	11.59	16.89	16.94	41.60	110.51	53.50
29	Făgăraş	3930	16.20	23.61	23.68	58.16	154.50	74.80
30	Focşani	3350	12.56	18.30	18.36	45.08	119.75	57.98
31	Galaţi	3190	11.99	17.48	17.53	43.05	114.37	55.37
32	Giurgiu	3030	10.85	15.81	15.86	38.95	103.48	50.10
33	Gura Honţ	3290	12.39	18.05	18.11	44.47	118.13	57.19
34	Griviţa	3190	11.99	17.48	17.53	43.05	114.37	55.37
35	Huşi	3420	12.73	18.55	18.60	45.69	121.38	58.77
36	Iaşi	3510	12.96	18.88	18.94	46.51	123.54	59.81
37	Lugoj	3100	11.45	16.68	16.73	41.10	109.17	52.86
38	Mangalia	2880	8.89	12.96	13.00	31.92	84.80	41.05
39	Medgidia	2960	10.07	14.67	14.71	36.13	95.98	46.47
40	Miercurea Ciuc	4250	24.37	35.51	35.62	87.48	232.39	112.51
41	Oradea	3150	11.78	17.16	17.21	42.28	112.31	54.38
42	Odorheiu Secuiesc	3940	16.36	23.84	23.91	58.73	156.01	75.54
43	Oraviţa	3000	10.54	15.36	15.40	37.83	100.51	48.66
44	Petroşani	3960	16.70	24.33	24.40	59.92	159.19	77.07
45	Piatra Neamţ	3560	13.11	19.10	19.16	47.06	125.01	60.53
46	Piteşti	3420	12.73	18.55	18.60	45.69	121.38	58.77
47	Ploieşti	3390	12.66	18.44	18.50	45.44	120.70	58.44
48	Râmnicu Sărat	3170	11.89	17.33	17.38	42.68	113.39	54.90
49	Râmnicu Vâlcea	3120	11.59	16.89	16.94	41.60	110.51	53.50
50	Reşiţa	3130	11.66	16.98	17.03	41.84	111.14	53.81
51	Roman	3700	13.78	20.07	20.13	49.44	131.35	63.59
52	Satu Mare	3370	12.61	18.37	18.43	45.26	120.24	58.21

53	Sibiu	3660	13.54	19.73	19.79	48.60	129.11	62.51
54	Sighişoara	3640	13.44	19.58	19.64	48.23	128.13	62.04
55	Slatina	3200	12.04	17.55	17.60	43.22	114.83	55.59
56	Slobozia	3150	11.78	17.16	17.21	42.28	112.31	54.38
57	Suceava	4080	19.18	27.94	28.03	68.83	182.86	88.53
58	Sulina	3000	10.54	15.36	15.40	37.83	100.51	48.66
59	Sebeş	3470	12.85	18.72	18.78	46.12	122.53	59.32
60	Timişoara	3180	11.94	17.40	17.46	42.87	113.89	55.14
61	Târgovişte	3390	12.66	18.44	18.50	45.44	120.70	58.44
62	Târgu Jiu	3540	13.05	19.01	19.07	46.82	124.39	60.22
63	Târgu Mureş	3540	13.05	19.01	19.07	46.82	124.39	60.22
64	Târgu Ocna	3410	12.71	18.51	18.57	45.61	121.15	58.66
65	Târgu Secuiesc	4370	29.46	42.93	43.06	105.75	280.92	136.01
66	Turnu Măgurele	3010	10.65	15.52	15.56	38.22	101.53	49.16
67	Turnu Severin	2810	7.59	11.05	11.09	27.23	72.34	35.02
68	Tecuci	3390	12.66	18.44	18.50	45.44	120.70	58.44
69	Tulcea	3070	11.21	16.34	16.39	40.25	106.93	51.77
70	Turda	3560	13.11	19.10	19.16	47.06	125.01	60.53
71	Urziceni	3170	11.89	17.33	17.38	42.68	113.39	54.90
72	Vaslui	3570	13.15	19.15	19.21	47.18	125.34	60.69
73	Vatra Dornei	4580	41.78	60.87	61.06	149.96	398.36	192.87
74	Zalău	3300	12.42	18.10	18.15	44.58	118.43	57.34

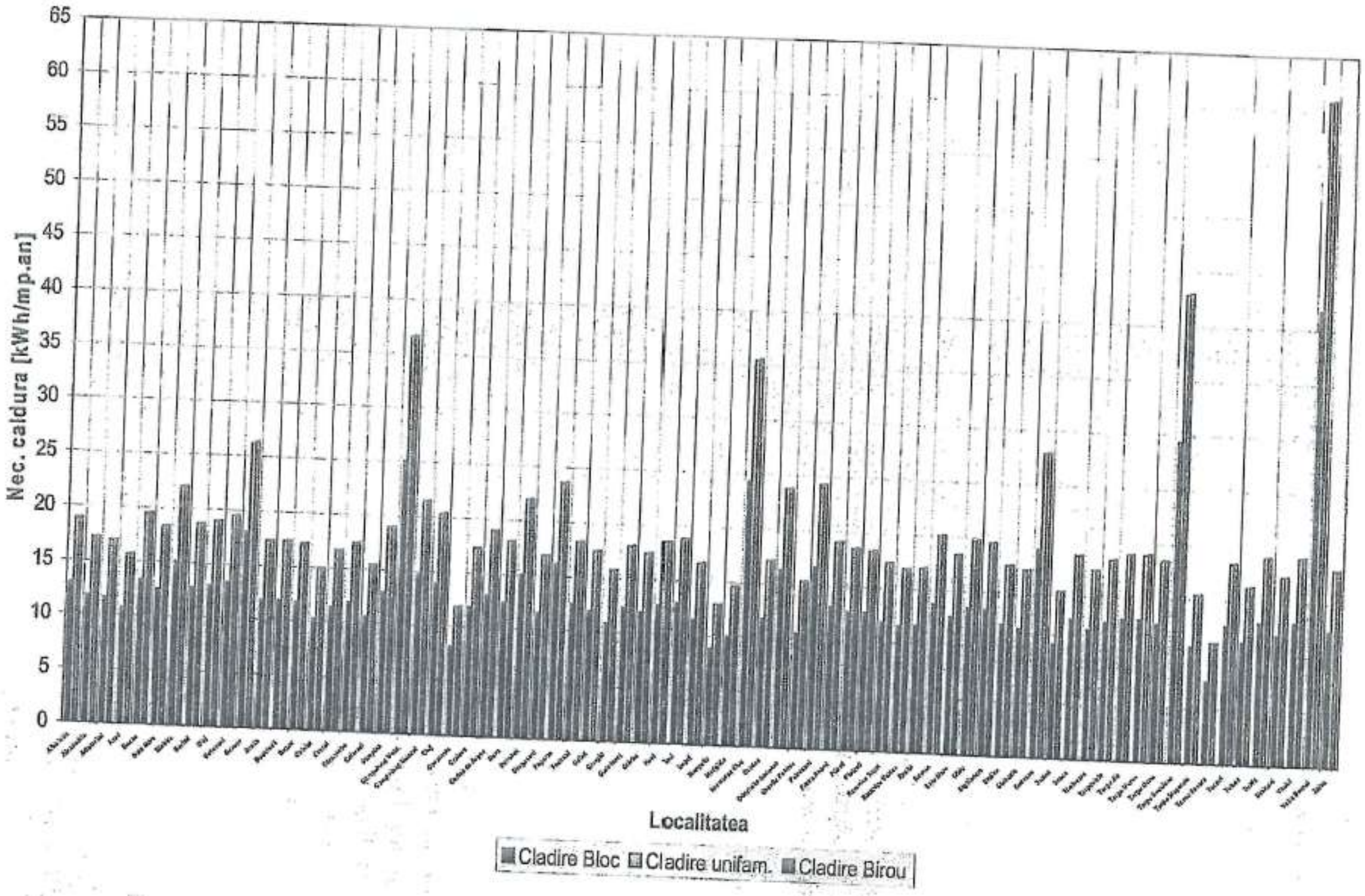

Figure VI.3: Annual heating requirements for the heating of the reference NZEBs in localities in Romania - climate index method
Key:
Horizontal: Locality
Vertical: Heating requirements (kWh/m^{2}year)
Bottom: Apartment block, Single-family building, Office building

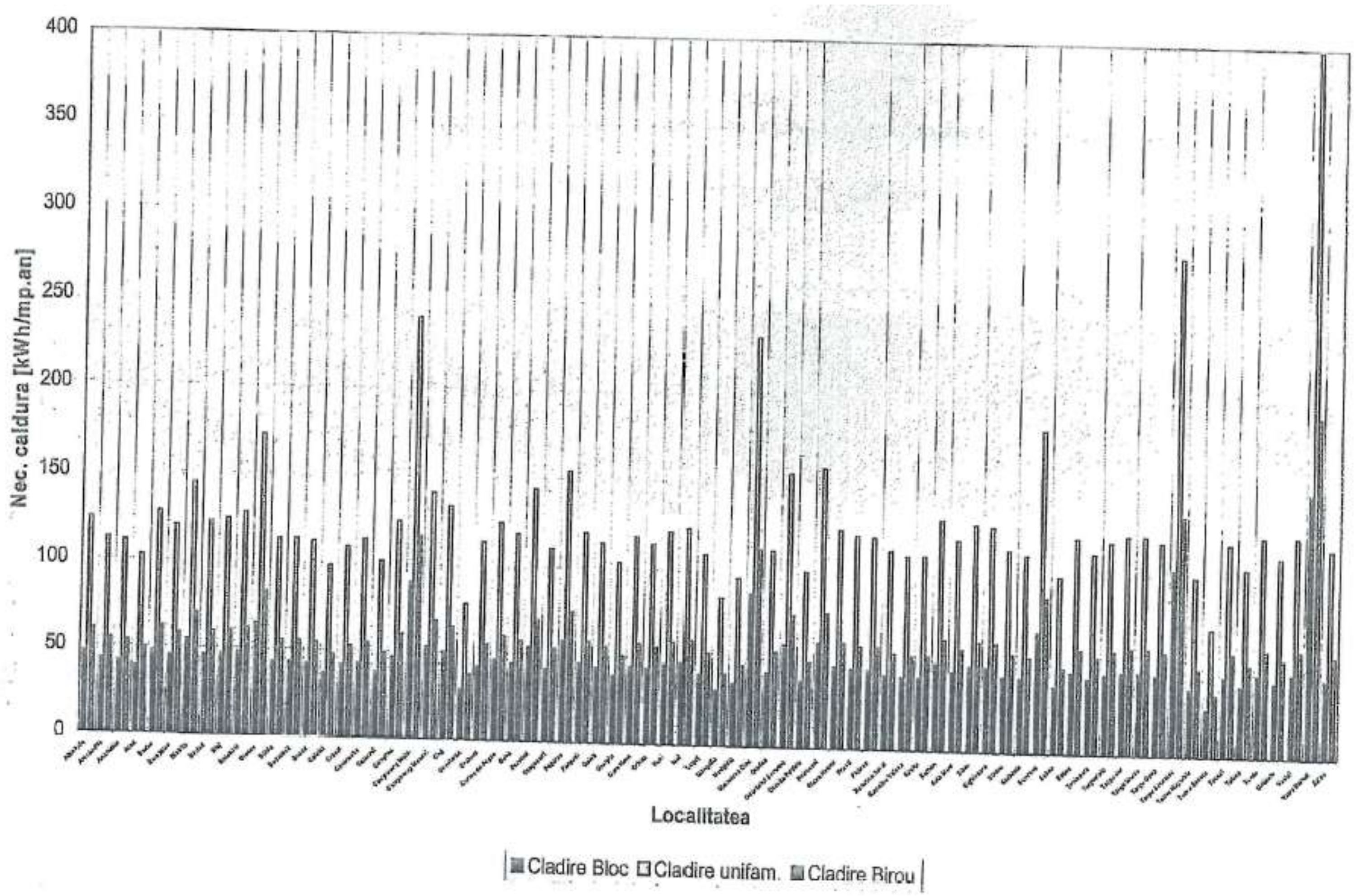

Figure VI.4: Annual heating requirements for the heating of C107 buildings in localities in Romania - climate index method
Key:
Horizontal: Locality
Vertical: Heating requirements (kWh/m^{2}year)
Bottom: Apartment block, Single-family building, Office building

Chapter VII - Definition of NZEB in Romania

A nearly zero energy building is characterised by **reduced consumption of energy from fossil sources** and uses **energy from** (non-fossil) **renewable sources**, in a proportion established by the procedure for defining the minimum requirements, in accordance with the provisions of Articles 4 and 5 of Directive 2010/31/EU.

Both in the case of new and in that of existing buildings included in national and local programmes of energy modernisation, the aim is that **the adopted technical solutions meet the minimum requirements related to costs**, determined in accordance with the provisions of Delegated Regulation (EU) No 244/2012.

The roadmap for the **requirements specific to nearly zero energy buildings** has to be a realistic decision based on a practical definition of the notion of a new nearly zero energy building, as an element of urban settlements, not on a one-off and purely demonstrative exercise. Therefore, the energy and environmental parameters adaptable to the new buildings are defined in relation to the current minimum requirements imposed on new buildings and to **local climate and technological restrictions**. 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 the principles of sustainable development,** in particular in respect of minimising the impact on the natural environment, including the local microclimate;

– **meeting energy needs, in particular from district urban/local networks, provided their energy efficiency is compatible with the energy performance of the new NZEBs.**

Fitting buildings with non-fossil sources of renewable energy (placed either on the building or on the land belonging to the building) is to be analysed very carefully in the stage of drawing up a local urban plan, in terms of impact on the natural environment and the **economic efficiency of the building**. The report on the solutions must contain a comparative analysis of fitting buildings with their own energy sources or connecting them to efficient district energy supply systems. This has to take into account the principles of sustainable development, which imply both freedom levels with regard to housing quality and minimisation of the impact on the natural environment;

The energy configuration of a new building in the NZEB category is performed by applying the method presented in the flowchart in figure II.17.

An NZEB building designed in Romania will be characterised by **the maximum intensity of the use of primary energy**, in accordance with Table VIII.1 in Chapter VIII − Conclusions. For information purposes, point **6 of Chapter VIII presents the energy performance and economic efficiency characteristics of NZEBs designed in Romania.**[58]

[58] During the last stage of this study, data tables will be added also for other types of building.

Chapter VIII - Partial conclusions and proposals for stage III (final)

VIII.1 Maximum admissible value for gross primary energy

Summary table VIII.1 (below) was drawn up based on the data included in the technical sheets of the buildings, relative to the **optimal cost**, and following the definition of the maximum admissible limits for **primary energy** for the processes of supplying thermal and electric utilities to NZEBs (climate zone II).

Table VIII.1

Type of building	Cost-optimal range [kWh/m^{2}year]	Maximum admissible value for NZEB [kWh/m^{2}year]
Public and office	62-100	57
Apartment blocks	56-112	100
Single-family buildings	155-230	111

The table provides three values for the maximum admissible energy intensity for classification as NZEB of the aforementioned types of building. The next stage of the study will add data for all types of building and for all climate zones in Romania, both as a result of validation based on dynamic modelling and by matching the analysis of economic efficiency.

Besides the above values, those of CO_2 emissions associated with the presented building types will also be determined.

The physical significance of the values in the summary table is that of an admissibility threshold, which must be verified during the process of designing an NZEB in Romania. Compliance with the above values is a preliminary condition for a building project to be classified as NZEB.

The prerequisite is determined by the energy requirements for the heating of spaces, at the end consumer, while the sufficient condition refers to complying with the maximum admissible investment payback period by reference to a building designed in line with regulation C107/2010, based on the savings achieved by applying NZEB solutions. The entire validation analysis is performed based on the climate data for a typical climate year for the zone of the locality in which the NZEB is to be designed.

Renewable energy sources are of two types, as follows:

- Sources that feed into the energy supply network of the locality (hydraulic, solar, high-efficiency cogeneration, geothermal, wind energy, etc.);
- Sources located on-site where the building is (solar thermal, solar electric, heat pumps, wind energy, fuel − pellets, agricultural waste, fuel cells, etc.).

VIII.2 Flowchart for the energy configuration of a NZEB

The numerical examples in this study are based on three of the most common (and therefore representative, from a social and energy perspective) building types, as follows:

– offices, administrative buildings;
– apartment blocks;
– single-family buildings.

The energy configuration method for an NZEB is presented in the form of a modular flowchart in figure VIII.1, and it applies to all building types, as specified in point 5 of Annex I to Directive 2010/31/EU.

VIII.3 Energy performance of office buildings, apartment blocks and single-family buildings

The performance values recorded in the tables represent the first stage in designing an NZEB, i.e. reducing energy consumption at the level of the end consumer. With reference to the flowchart, this stage is part of Module M1 - Dynamic simulation of reference building and C107. The impact of renewable energy sources is not taken into account.

For an office building (public building - administrative), in climated zone II, the values are presented in table VIII.2.

Energy factor	**Reference building**	**C 107 building**
Heating requirements [kWh / m^2 year]	16.64	53.72
Cooling requirements [kWh / m^2 year]	4.39	10.47
Energy requirements for domestic hot water [kWh / m^2 year]	5.28	5.28
Energy requirements for lighting, appliances [kWh / m^2 year]	13.80	12.12
Energy requirements for mechanical ventilation [kWh / m^2 year]	3.64	7.15
Total [kWh / m^2 year]	43.75	87.72

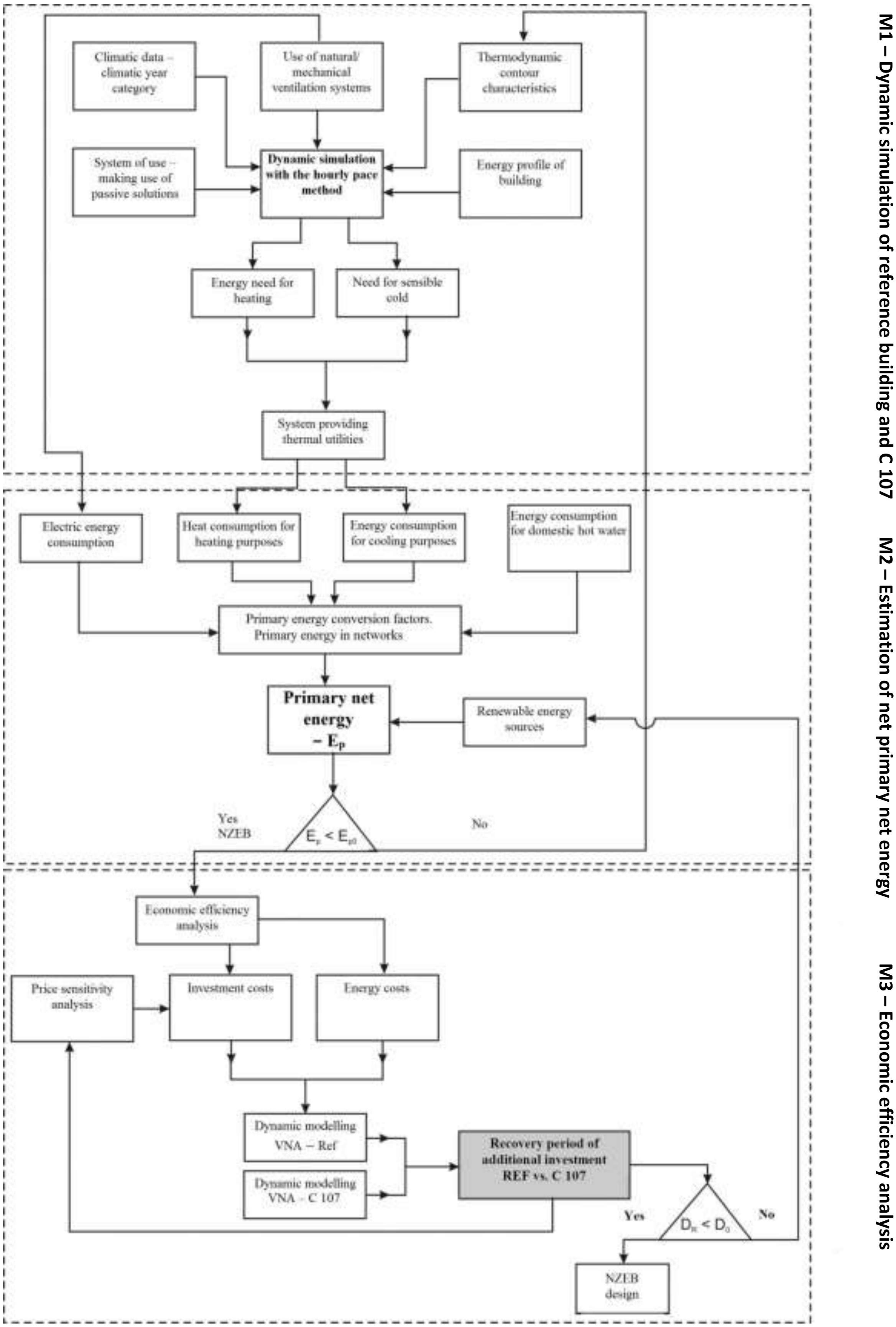

Figure VIII.1 - Modular flowchart

For apartment blocks in climate zones I, II, III, IV, the values are listed in the tables below.

Climate zone I

TableVIII.3.

Energy factor	Reference building	C 107 building
Heating requirements [kWh / m^2 year]	7.58	28.78
Cooling requirements [kWh / m^2 year]	0.00	5.25
Energy requirements for domestic hot water [kWh / m^2 year]	61.25	61.21
Energy requirements for lighting, appliances [kWh / m^2 year]	28.36	28.36
Energy requirements for mechanical ventilation [kWh / m^2 year]	4.56	–
Total [kWh / m^2 year]	101.71	123.60

Climate zone II

Table VIII.4

Energy factor	Reference building	C 107 building
Heating requirements [kWh / m^2 year]	11.42	40.99
Cooling requirements [kWh / m^2 year]	0.00	4.71
Energy requirements for domestic hot water [kWh / m^2 year]	61.21	61.21
Energy requirements for lighting, appliances [kWh / m^2 year]	28.36	–
Energy requirements for mechanical ventilation [kWh / m^2 year]	4.56	135.27
Total [kWh / m^2 year]	105.56	

Climate zone III

Table VIII.5

Energy factor	Reference building	C 107 building
Heating requirements [kWh / m^2 year]	12.65	43.42
Cooling requirements [kWh / m^2 year]	0.00	5.62
Energy requirements for domestic hot water [kWh / m^2 year]	61.21	61.21

Energy requirements for lighting, appliances [kWh / m^2 year]	28.36	28.36
Energy requirements for mechanical ventilation[kWh / m^2 year]	4.56	–
Total [kWh / m^2 year]	106.78	138.61

Climate zone IV

Table VIII.6

Energy factor	Reference building	C 107 building
Heating requirements [kWh / m^2 year]	18.67	57.13
Cooling requirements [kWh / m^2 year]	0.00	0.73
Energy requirements for domestic hot water [kWh / m^2 year]	61.21	61.21
Energy requirements for lighting, appliances [kWh / m^2 year]	28.36	28.36
Energy requirements for mechanical ventilation [kWh / m^2 year]	4.56	–
Total [kWh / m^2 year]	112.8	147.43

The information below presents the thermophysical characteristics of the thermo-insulating materials used for the thermal protection of the building envelope.

Vertical exterior walls

Table VIII.7

Layer	Material	δ [m]	λ [W/kgK]	c [J/kgK]	p [kg/m^3]
1	Rendering (lime-cement)	0.02	0.70	840	1 800
2	GBN 35 AAC	0.30	0.32	870	725
3	Mineral wool	0.07	0.04	750	140
4	Rendering (cement)	0.03	0.93	840	1 700

Corrected thermal resistance is R^t = 2.1 m^2K/W.

Terrace

Table VIII.8

Layer	Material	δ [m]	λ [W/kgK]	c [J/kgK]	p [kg/m^3]
1	Rendering (lime-cement)	0.02	0.87	840	1 700
2	Reinforced concrete	0.14	1.74	840	2 500
3	Sloped mortar	0.10	0.93	840	1 800
4	GBN 35 AAC	0.20	0.32	870	725

5	Extruded polystyrene	0.15	0.04	1 430	20
6	Mortar slab	0.03	0.93	840	1 800
7	Sandstone	0.02	2.03	920	2 400

Corrected thermal resistance is R^t = 4.191 m^2K/W.

Slab over the service basement

Table VIII.9

Layer	Material	δ [m]	λ [W/kgK]	c [J/kgK]	p [kg/m³]
1	Sandstone	0.02	2.03	920	2 400
2	Mortar slab	0.055	0.96	840	1 800
3	Concrete	0.15	1.74	840	2 500
4	Extruded polystyrene	0.09	0.04	1 420	20
5	Rendering (cement)	0.02	0.90	840	1 700

Corrected thermal resistance is R^t = 2.20 m^2K/W.

The wall toward the staircase is made of reinforced concrete with a thickness of 0.13 m, rendered on both sides. Corrected thermal resistance is R^t = 0.34 m^2K/W.

The exterior surface of opaque envelope elements is treated with light-colour finish, α = 0.30.

Glazed areas are thermo-insulating windows fitted with mobile exterior thermo-insulating shutters and interior shading blinds. The average window sunlight coefficient is 0.80 (where shading is not used during the summer season). The mobile exterior shutters can be oriented so as to ensure full shading of the windows. Window thermal resistance (glazing and opaque frame) is 0.77 m^2K/W.

The window optical factor has hourly values linked to the direct component of solar radiation and a fixed value linked to the diffuse component of solar radiation. The values change every month. The geometrical characteristics specific to the position of the Sun in the sky are measured for the middle of the month, taking into account the local latitude and the projection of the solar ecliptic.

The thermal capacity of interior building elements is 221 760 J/m^2K, with reference to the surface area of those elements.

The main area of the building has mechanical ventilation with a heat recovery unit placed at the air exhaust/intake. The fresh air ventilation rate is 0.72 ac/h, and the efficiency of the heat recovery unit is 75 % (average value). The ventilation system is based on the following strategies:

- during vacant hours, ventilation is done exclusively by air infiltrated through the mobile window joints;

- during occupied hours:
    - mechanical ventilation with constant air flow during the hours when outside

temperature is below the admissible minimum inside temperature or above the admissible maximum inside temperature;
- natural ventilation with variable air flow when outside temperature is between the inside temperature values admissible as thermal comfort temperature in the space used.

The main areas in **apartment blocks** have mechanical ventilation with heat recovery for each apartment (optional) or free-running natural ventilation.

The analysis of the summary tables highlights of the sensible effect of the heat recovery units and of the passive measures used during the summer season. Furthermore (in the case of apartment blocks), the difference of maximum 11.85 % between the maximum (climate zone IV) and the minimum (climate zone I) leads to the conclusion that the NZEB solution can be used anywhere in Romania.

It can also be seen that the use of passive solutions and heat recovery systems results in the balancing of energy requirements between the thermal and the electric factors in the case of office buildings.

Table VIII.10.

Energy factor	**Reference building**	**C 107 building**
Thermal factor	21.92	58.00
Electric factor	21.83	29.74

while in the case of apartment blocks, the difference in favour of the thermal factor remains significant:

Table VIII.11

Energy factor	**Reference building**	**C 107 building**
Thermal factor	72.63	106.9
Electric factor	32.92	28.36

As a result, the introduction of electric renewable energy sources (SER) has a major impact in the case of office buildings, while efficient systems such as high-efficiency cogeneration/trigeneration systems are recommended for residential areas with apartment blocks.

VIII.4 Coefficients of conversion into primary energy

The coefficients of conversion of the energy used at the end user into primary energy add to the data listed in Chapter II.1.10 of methodology Mc 001-2/2006. They are used in **Module M2** of Flowchart − Determination of Net Primary Energy.

Table V.12.

Type of energy / fuel	Conversion coefficient
Electricity	2.62
Natural gas	1.17
District heating (cogeneration)	0.92
High-efficiency cogeneration	0.30
Pellets	1.08

VIII.5 On-site RES – estimation of the energy potential of capturing and converting solar energy into electricity by using photovoltaic solar collectors

All building types covered in this study are fitted with photovoltaic panels and with the equipment necessary for using electricity (single phase 220 V) for domestic purposes (inverter and energy storage system, etc.). Photovoltaic panels have 15 % efficiency in capturing solar power and are located on the roof of the buildings. In all cases the azimuth is south. The angle of the panels relative to the horizontal plane was determined so as to maximise the solar energy captured throughout the year at the level of freely exposed surface unit.

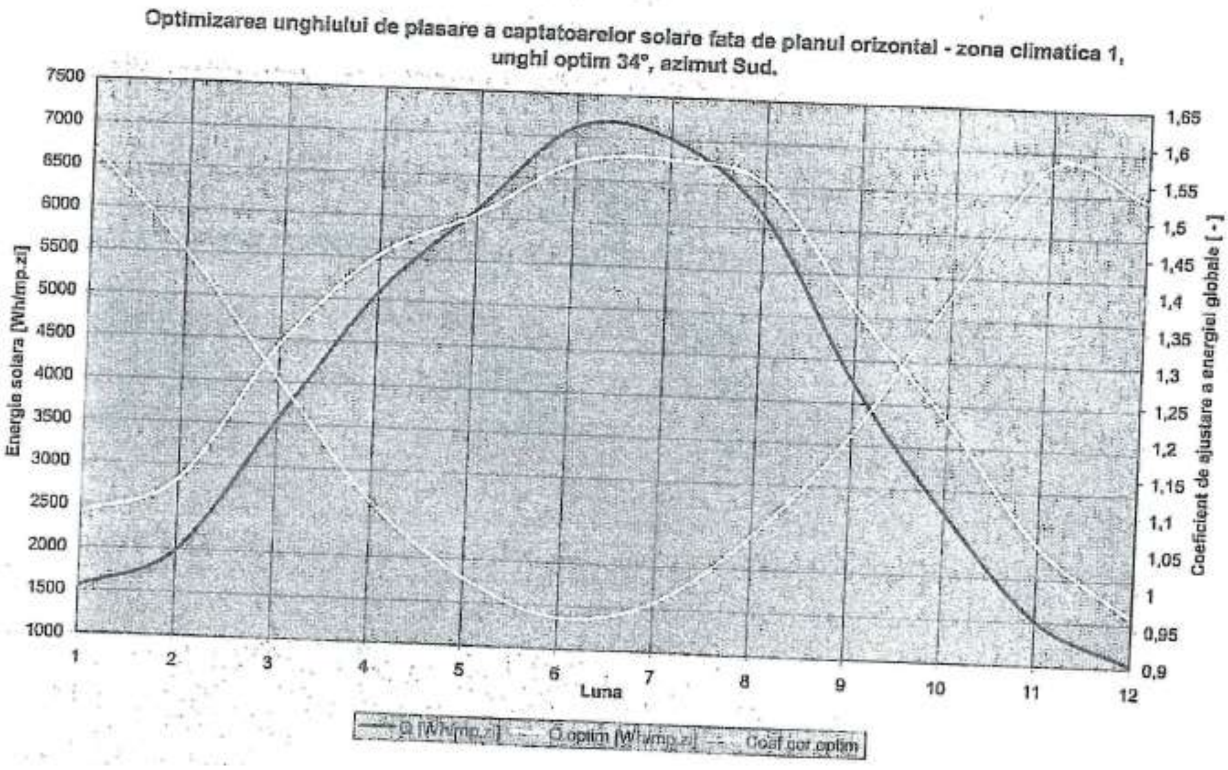

Figure VIII.2: Energy collected on the optimal plane for the placement of solar panels (climate zone I)
Key:
Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone I, optimal angle 34º, azimuth south
Vertical left: Solar energy (Wh/m^{2}day)
Vertical right: Adjustment coefficient for overall energy
Bottom: Q (Wh/m^{2}day), Q optimal (Wh/m^{2}day), Optimal correction coefficient

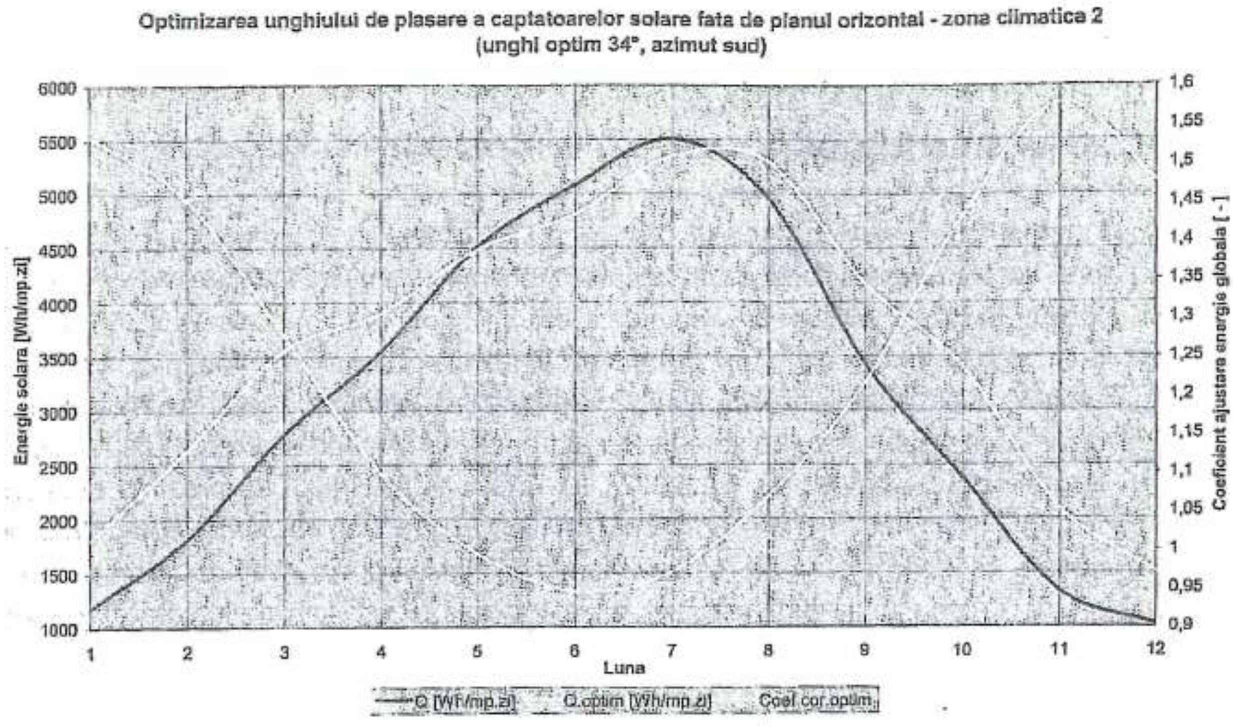

Figure VIII.3: Energy collected on the optimal plane for the placement of solar panels (climate zone II)
Key:
Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone II, optimal angle 34º, azimuth south
Vertical left: Solar energy (Wh/m^{2}day)
Vertical right: Adjustment coefficient for overall energy
Bottom: Q (Wh/m^{2}day), Q optimal (Wh/m^{2}day), Optimal correction coefficient

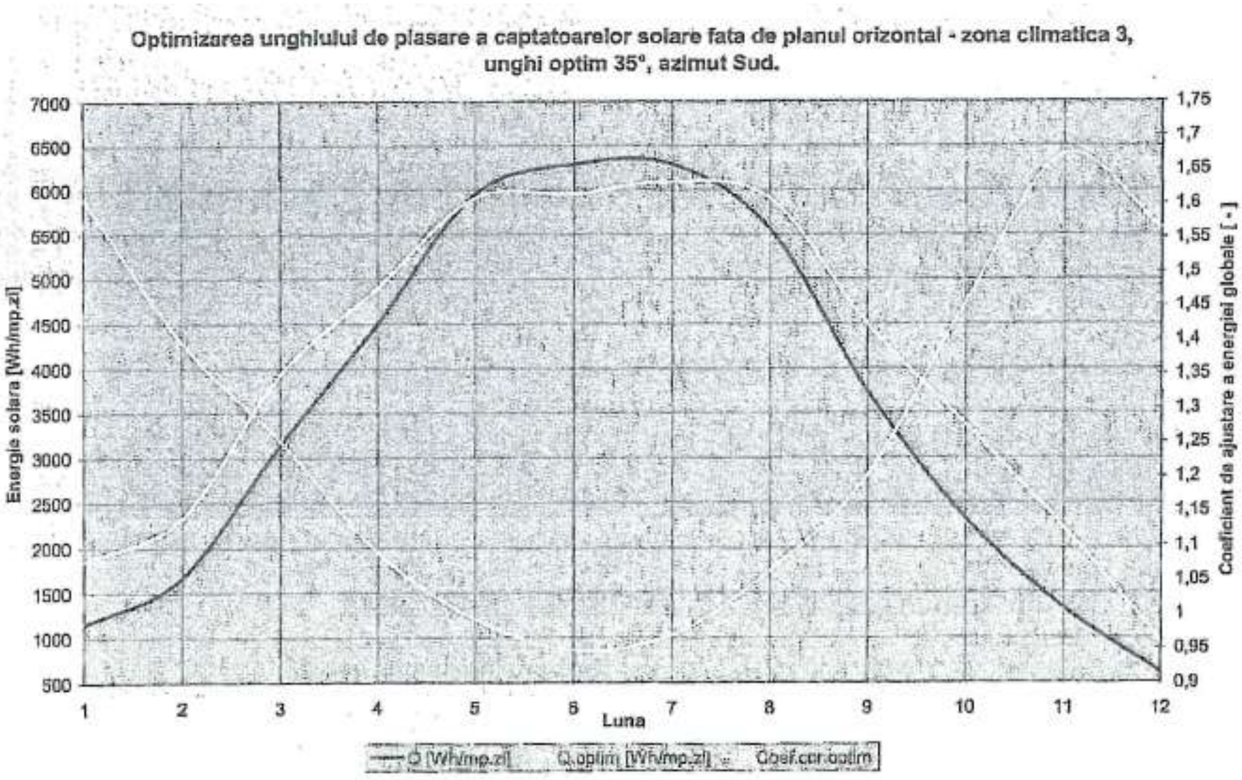

Figure VIII.4: Energy collected on the optimal plane for the placement of solar panels (climate zone III)

Key:

Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone III, optimal angle 35º, azimuth south

Vertical left: Solar energy (Wh/m^{2}day)

Vertical right: Adjustment coefficient for overall energy

Bottom: Q (Wh/m^{2}day), Q optimal (Wh/m^{2}day), Optimal correction coefficient

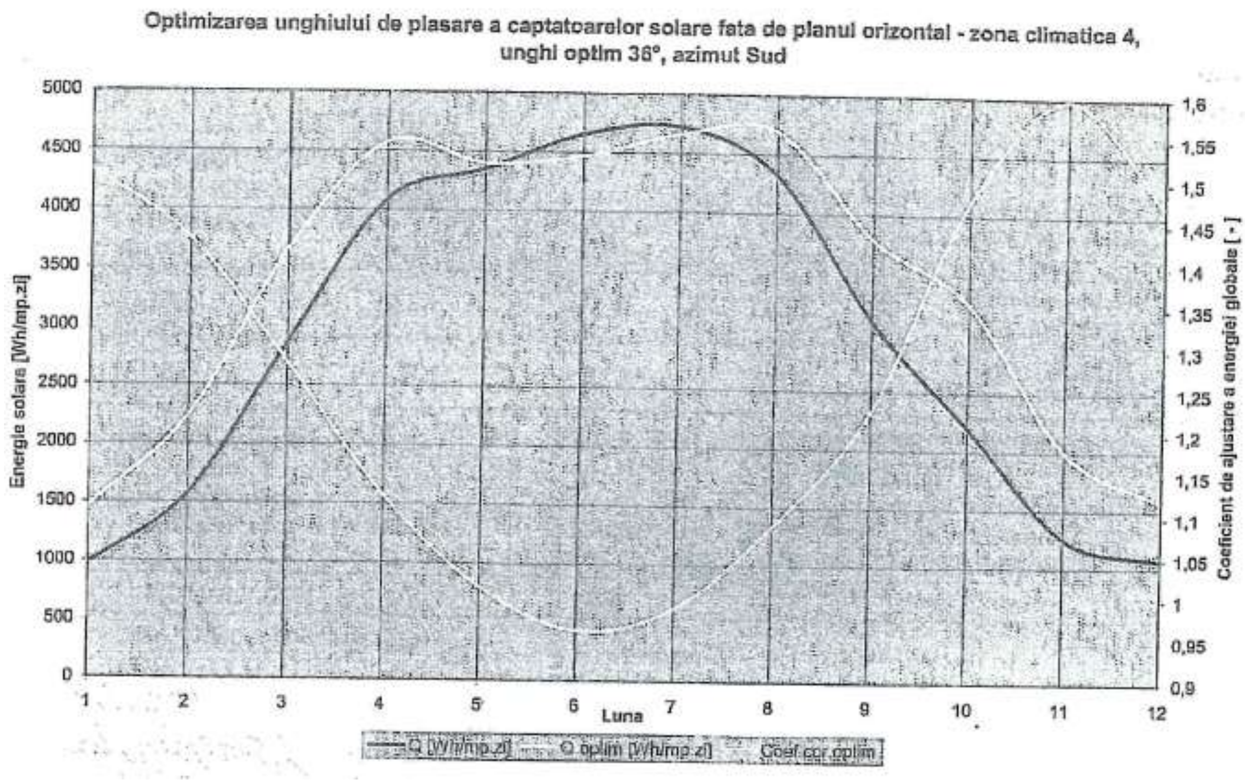

Figure VIII.5: Energy collected on the optimal plane for the placement of solar panels (climate zone IV)

Key:

Top: Optimising the placement angle for solar collectors relative to the horizontal plane - climate zone II, optimal angle 36º, azimuth south

Vertical left: Solar energy (Wh/m^{2}day)

Vertical right: Adjustment coefficient for overall energy

Bottom: Q (Wh/m^{2}day), Q optimal (Wh/m^{2}day), Optimal correction coefficient

VIII.6 Economic efficiency of technical solutions - Module M3

The economic efficiency of technical solutions is given by Module M3 for the determination of the investment payback period compared with conventional building constructed according to regulation C107/2010.

NOTE:

1. The fields marked in grey do not meet the minimum conditions for being classified as NZEB;
2. The values highlighted in red are accepted if the admissible additional investment payback period exceeds the limit value of 10 years;
3. Values marked in bold refer to NZEB buildings.

VIII.6.1 Office buildings – climate zone II (maximum admissible specific primary energy for NZEB = 57 kWh/m^{2}year)

Table VIII.13

PVP surface area = 150 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	**42.95**	**52.96**	**46.23**	**28.26**
Primary energy C 107 [kWh/m^{2}year]	141.93	141.93	124.14	124.14
Share of power consumption from PVP [%]	35.85	52.54	52.54	52.54
Share of total energy consumption from solar energy [%]	35.85	20.74	23.28	23.28
Payback period [years]	**10.0**	**9.2**	**7.8**	**7.8**

Table VII.14

PVP surface area = 1500 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	**– 77.05**	**– 67.04**	**– 73.77**	**– 91.74**
Primary energy C 107 [kWh/m^{2}year]	141.93	141.93	124.14	124.14
Share of power consumption from PVP [%]	215.05	315.23	315.23	315.23
Share of total energy consumption from solar energy [%]	215.08	124.44	139.65	139.65
Payback period [years]	**8.5**	**8.3**	**7.8**	**7.8**

VIII.6.2 Apartment blocks – climate zone I (maximum admissible specific primary energy for NZEB = 93 kWh/m^{2}year)

Table VIII.15

PVP surface area = 50 m^2	Heat pump	Boiler	Current cogeneration	High-efficiency cogeneration
Primary energy [kWh/m^{2}year]	135.55	146.82	132.78	**89.44**
Primary energy C 107 [kWh/m^{2}year]	216.46	216.46	188.85	188.85
Share of power consumption from PVP [%]	11.41	20.23	20.23	20.23
Share of total energy consumption from solar energy [%]	11.41	5.70	6.55	6.55
Payback period [years]	14.2	11.8	10.5	**10.5**

Table VIII.16

PVP surface area = 300 m^2	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy [kWh/m^2year]	**48.30**	**59.57**	**45.52**	**2.19**
Primary energy C 107 [kWh/m^2year]	216.46	216.46	188.85	188.85
Share of power consumption from PVP [%]	68.43	121.39	121.39	121.39
Share of total energy consumption from solar energy [%]	68.43	34.21	39.29	39.29
Payback period [years]	**9.3**	**8.4**	**8.1**	**8.1**

VIII.6.3 Apartment blocks – climate zone II (maximum admissible specific primary energy for NZEB = 100 kWh/m^2year)

Table VIII.17

PVP surface area = 50 m^2	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy [kWh/m^2year]	142.86	154.76	139.93	**94.18**
Primary energy C 107 [kWh/m^2year]	224.70	224.70	193.34	193.34
Share of power consumption from PVP [%]	8.85	16.08	16.08	16.08
Share of total energy consumption from solar energy [%]	8.85	4.36	5.01	5.01
Payback period [years]	16.0	14.0	11.5	**11.5**

Table VIII.18

PVP surface area = 300 m^2	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy [kWh/m^2year]	**73.54**	**85.43**	**70.61**	**24.85**
Primary energy C 107 [kWh/m^2year]	224.70	224.70	193.34	193.34
Share of power consumption from PVP [%]	53.08	96.45	96.45	96.45
Share of total energy consumption from solar energy [%]	53.08	26.14	30.08	30.08

Payback period [years]	11.1	10.2	**9.4**	**9.4**

VIII.6.4 Apartment blocks – climate zone III (Maximum admissible specific primary energy for NZEB = 111 kWh/m²year)

Table VIII.19

PVP surface area = 50 m²	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy [kWh/m²year]	142.48	154.57	139.49	**92.96**
Primary energy C 107 [kWh/m²year]	229.04	229.04	196.94	196.94
Share of power consumption from PVP [%]	9.78	17.91	17.91	17.91
PVP surface area = 50 m²	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Share of total energy consumption from solar energy [%]	9.78	4.79	5.52	5.52
Payback period [years]	14.4	12.0	10.0	**10.0**

Table VIII.20

PVP surface area = 300 m²	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy [kWh/m²year]	**65.24**	**77.34**	**70.61**	**15.73**
Primary energy C 107 [kWh/m²year]	229.04	229.04	196.94	196.94
Share of power consumption from PVP [%]	58.69	107.45	107.45	107.45
Share of total energy consumption from solar energy [%]	58.69	2876	33.13	33.13
Payback period [years]	**9.8**	**9.0**	**8.4**	**8.4**

VIII.6.5 Apartment blocks – climate zone IV (maximum admissible specific primary energy for NZEB = 127 kWh/m²year)

Table VIII.21

PVP surface area = 50 m²	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy [kWh/m²year]	150.62	163.70	147.40	**97.07**

Primary energy C 107 [kWh/m²year]	243.86	243.86	207.55	207.55
Share of power consumption from PVP [%]	8.03	15.24	15.24	15.24
Share of total energy consumption from solar energy [%]	8.03	3.85	4.45	4.45
Payback period [years]	14.9	12.0	9.2	**9.2**

Table VIII.22

PVP surface area = 300 m²	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy [kWh/m²year]	**84.89**	**97.98**	**81.67**	**31.34**
PVP surface area = 300 m²	**Heat pump**	**Boiler**	**Current cogeneration**	**High-efficiency cogeneration**
Primary energy C 107 [kWh/m²year]	243.86	243.86	207.55	207.55
Share of power consumption from PVP [%]	48.16	91.44	91.44	91.44
Share of total energy consumption from solar energy [%]	48.16	23.10	26.69	26.69
Payback period [years]	**11.4**	**9.7**	**8.5**	**8.5**

VIII.6.6 Single-family residential buildings – climate zone II (maximum admissible specific primary energy for NZEB = 111 kWh/m²year) – building fitted with ventilated solar area and solar domestic hot water installation in the solar area

Table VIII.23

Gas boiler	**PVP surface area = 3 m²**	**PVP surface area = 18 m²**
Primary energy [kWh/m²year]	146.79	**18.37**
Primary energy C 107 [kWh/m²year]	291.84	291.84
Share of power consumption from PVP [%]	18.56	111.37
Share of total energy consumption from solar energy [%]	45.26	71.17
Payback period [years]	11.7	**9.5**

VIII.7 Analysis of price sensitivity

The sensitivity analysis presented in the graph in the figure below was based on the following hypotheses:

- the **office building** is connected to a gas boiler;
- the surface area of the photovoltaic panels is 1 250 m^2;
- primary energy is -43.04 kWh/m^2year;
- primary energy for a C107 building is 141.93 kWh/m^2year;
- the share of power consumption from photovoltaic panels is 262.69 %.

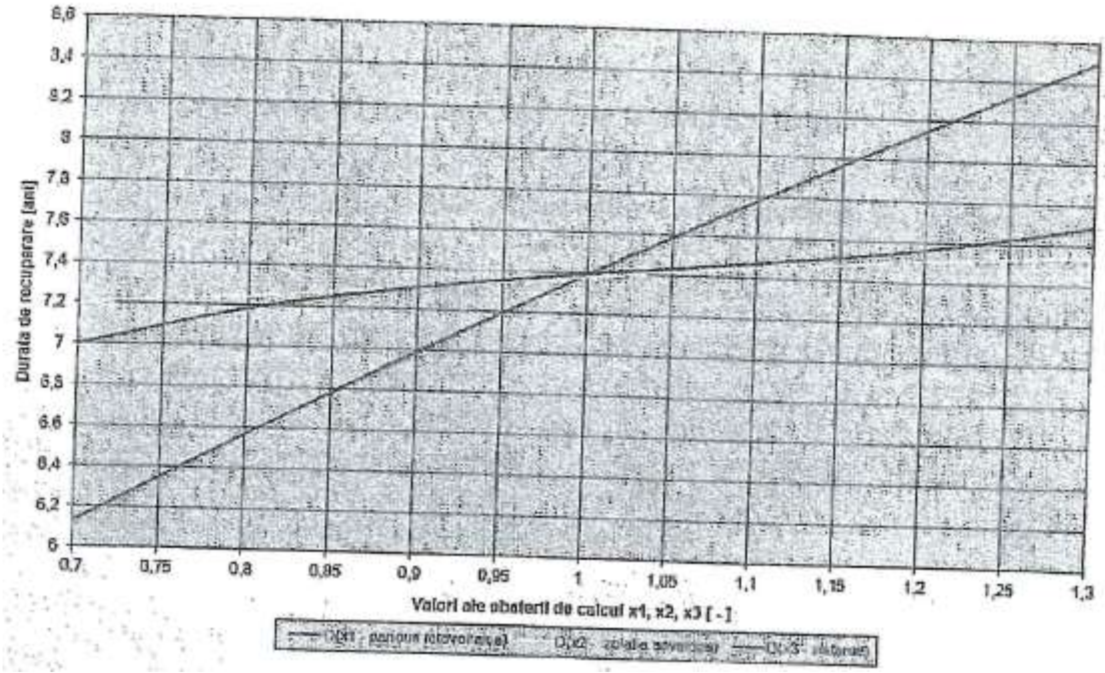

Figure VIII.6: Variation in the components of the deviation in the additional investment payback period relative to the variation in prices
Key:
Horizontal: Calculation deviation in x_1, x_2 and x_3
Vertical: Payback period (years)
Bottom: Photovoltaic panels, Envelope insulation, Systems

The sensitivity analysis presented in the graph in the figure below was based on the following hypotheses:

- the **apartment block** is connected to a high efficiency cogeneration network;
- the surface area of the photovoltaic panels is 250 m^2;
- primary energy is 38.71 kWh/m^2year;
- primary energy for a C107 building is 193.34 kWh/m^2year;
- the share of power consumption from photovoltaic panels is 80.38 %.

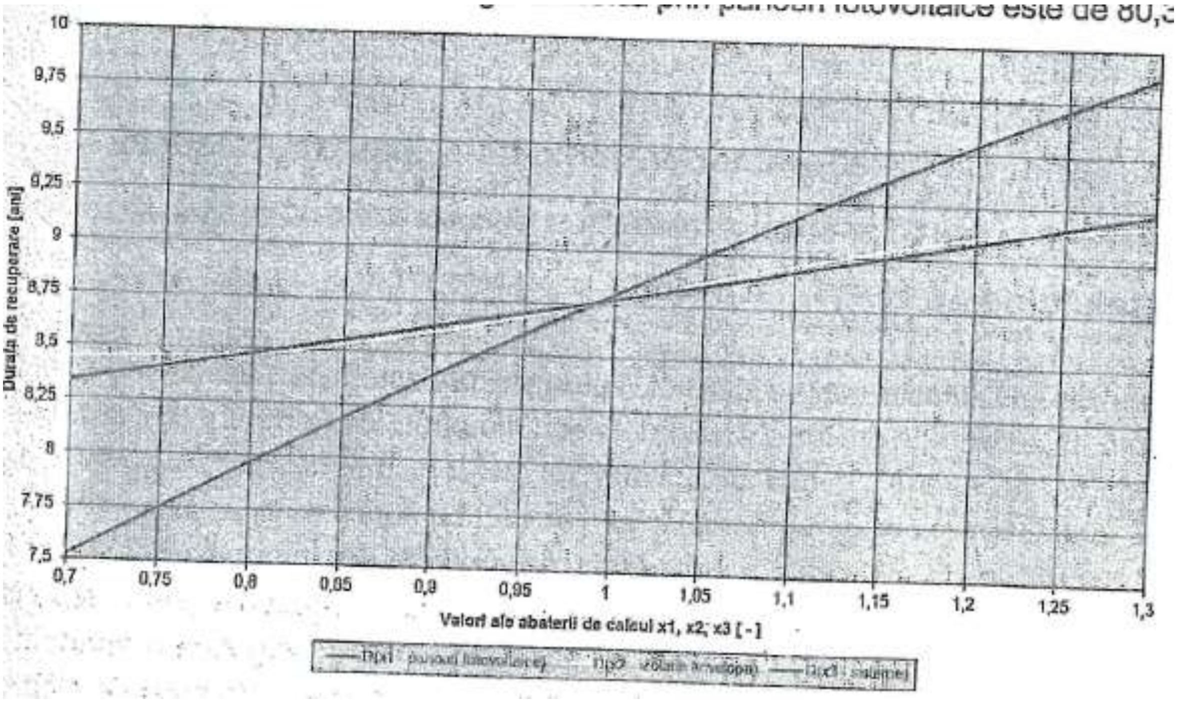

Figure VIII.7: Variation in the components of the deviation in the additional investment payback period relative to the variation in prices
Key:
Horizontal: Calculation deviation in x_1, x_2 and x_3
Vertical: Payback period (years)
Bottom: Photovoltaic panels, Envelope insulation, Systems

The sensitivity analysis presented in the graph in the figure below was based on the following hypotheses:
- the **single-family residential building** is connected to a high efficiency cogeneration network;
- the surface area of the photovoltaic panels is 18 m^2;
- primary energy is 18.37 kWh/m^2year;
- primary energy for a C107 building is 291.84 kWh/m^2year;
- the share of power consumption from photovoltaic panels is 111.37 %.

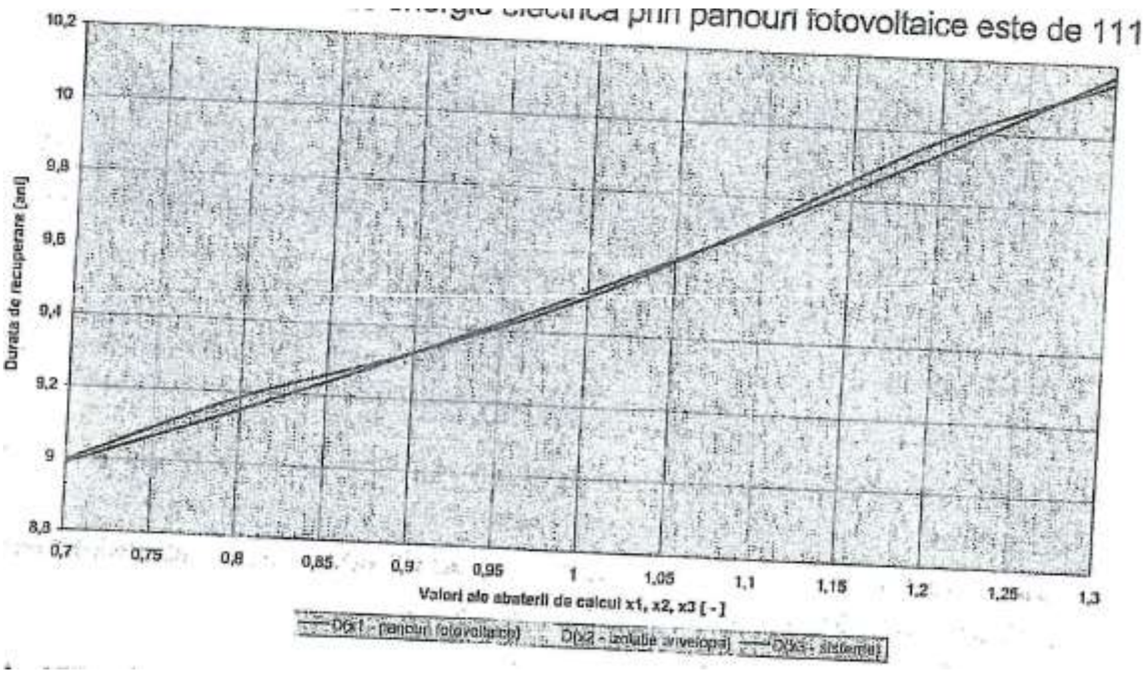

Figure VIII.8: Variation in the components of the deviation in the additional investment payback period relative to the variation in prices

Key:

Horizontal: Calculation deviation in x_1, x_2 and x_3

Vertical: Payback period (years)

Bottom: Photovoltaic panels, Envelope insulation, Systems

VIII.8 Basis of the climate index method required for the preliminary evaluation of the energy performance of a building located in any locality in Romania

One of the major difficulties in designing NZEB buildings is staying within the limits that define them as such from an energy perspective. In particular, determining the annual heating and cooling needs requires the use of powerful software packages that are validated both empirically and numerically. Unfortunately, as a result of the very low level of interest shown by the decision-making actors in developing such (validated) products locally, the design process takes place using either unsuitable programs (that are certified strictly for drawing up energy performance certificates for existing apartments) or programs based on monthly or seasonal time steps at building level, resulting in incorrect values relative to those specific to dynamic simulation. In order to simplify decisions in the design stage, a simplified and approximate method was developed for assessing the annual heating requirements for the heating of spaces within NZEBs. The method is based on the processing of the detailed simulation made using a validated program based on an hourly time step and correlation of the cooling requirements values with the number of calculation degrees-days for localities in Romania. The annual heating requirements were calculated relative to the value specific to the building located in climate zone II. The results were adimensional values in the form of the climate index (CI) correlated with the number of calculation degrees-days.

Table VIII.24

Ref. No	**Locality**	**Number of degrees-days (*NGZ*)**	**Apartment block – *R***	**Single-family building – *R***	**Office building – *R***	**Apartment block – C107**	**Single-family building – C107**	**Office building – C107**
1	Alba Iulia	3460	12.98	18.91	18.97	46.59	123.77	59.93
2	Alexandria	3150	11.78	17.16	17.21	42.28	112.31	54.38
3	Adamclisi	3120	11.59	16.89	16.94	41.60	110.51	53.50
4	Arad	3020	10.75	15.67	15.71	38.59	102.52	49.64
5	Bacău	3630	13.39	19.51	19.57	48.06	127.68	61.82
6	Baia Mare	3350	12.56	18.30	18.36	45.08	119.75	57.98
7	Bistriţa	3850	15.11	22.02	22.09	54.24	144.10	69.77
8	Bârlad	3460	12.83	18.69	18.74	46.04	122.29	59.21
9	Blaj	3530	13.01	18.96	19.02	46.71	124.10	60.08
10	Botoşani	3630	13.39	19.51	19.57	48.06	127.68	61.82
11	Braşov	4030	18.04	26.28	26.36	64.74	171.98	83.27
12	Brăila	3170	11.89	17.33	17.38	42.68	113.39	54.90
13	Bucureşti	3170	11.89	17.33	17.38	42.68	113.39	54.90
14	Buzău	3150	11.78	17.16	17.21	42.28	112.31	54.38
15	Calafat	2980	10.31	15.03	15.07	37.01	98.33	47.61
16	Caracal	3100	11.45	16.68	16.73	41.10	109.17	52.86

17	Caransebeş	3180	11.94	17.40	17.46	42.87	113.89	55.14
18	Călăraşi	3010	10.65	15.52	15.56	38.22	101.53	49.16
19	Câmpina	3530	13.01	18.96	19.02	46.71	124.10	60.08
20	Câmpulung Moldovenesc	4270	25.13	36.62	36.73	90.21	239.64	116.02
21	Câmpulung Muşcel	3820	14.78	21.53	21.60	53.04	140.90	68.22
22	Cluj	3730	13.98	20.37	20.43	50.18	133.31	64.54
23	Constanţa	2840	8.18	11.92	11.96	29.36	78.01	37.77
24	Craiova	3170	11.89	17.33	17.38	42.68	113.39	54.90
25	Curtea de Argeş	3540	13.05	19.01	19.07	46.82	124.39	60.22
26	Deva	3300	12.42	18.10	18.15	44.58	118.43	57.34
27	Dorohoi	3850	15.11	22.02	22.09	54.24	144.10	69.77
28	Drăgăşani	3120	11.59	16.89	16.94	41.60	110.51	53.50
29	Făgăraş	3930	16.20	23.61	23.68	58.16	154.50	74.80
30	Focşani	3350	12.56	18.30	18.36	45.08	119.75	57.98
31	Galaţi	3190	11.99	17.48	17.53	43.05	114.37	55.37
32	Giurgiu	3030	10.85	15.81	15.86	38.95	103.48	50.10
33	Gura Honţ	3290	12.39	18.05	18.11	44.47	118.13	57.19
34	Griviţa	3190	11.99	17.48	17.53	43.05	114.37	55.37
35	Huşi	3420	12.73	18.55	18.60	45.69	121.38	58.77
36	Iaşi	3510	12.96	18.88	18.94	46.51	123.54	59.81
37	Lugoj	3100	11.45	16.68	16.73	41.10	109.17	52.86
38	Mangalia	2880	8.89	12.96	13.00	31.92	84.80	41.05
39	Medgidia	2960	10.07	14.67	14.71	36.13	95.98	46.47
40	Miercurea Ciuc	4250	24.37	35.51	35.62	87.48	232.39	112.51
41	Oradea	3150	11.78	17.16	17.21	42.28	112.31	54.38
42	Odorheiu Secuiesc	3940	16.36	23.84	23.91	58.73	156.01	75.54
43	Oraviţa	3000	10.54	15.36	15.40	37.83	100.51	48.66
44	Petroşani	3960	16.70	24.33	24.40	59.92	159.19	77.07
45	Piatra Neamţ	3560	13.11	19.10	19.16	47.06	125.01	60.53
46	Piteşti	3420	12.73	18.55	18.60	45.69	121.38	58.77
47	Ploieşti	3390	12.66	18.44	18.50	45.44	120.70	58.44
48	Râmnicu Sărat	3170	11.89	17.33	17.38	42.68	113.39	54.90
49	Râmnicu Vâlcea	3120	11.59	16.89	16.94	41.60	110.51	53.50
50	Reşiţa	3130	11.66	16.98	17.03	41.84	111.14	53.81
51	Roman	3700	13.78	20.07	20.13	49.44	131.35	63.59
52	Satu Mare	3370	12.61	18.37	18.43	45.26	120.24	58.21
53	Sibiu	3660	13.54	19.73	19.79	48.60	129.11	62.51

54	Sighişoara	3640	13.44	19.58	19.64	48.23	128.13	62.04
55	Slatina	3200	12.04	17.55	17.60	43.22	114.83	55.59
56	Slobozia	3150	11.78	17.16	17.21	42.28	112.31	54.38
57	Suceava	4080	19.18	27.94	28.03	68.83	182.86	88.53
58	Sulina	3000	10.54	15.36	15.40	37.83	100.51	48.66
59	Sebeş	3470	12.85	18.72	18.78	46.12	122.53	59.32
60	Timişoara	3180	11.94	17.40	17.46	42.87	113.89	55.14
61	Târgovişte	3390	12.66	18.44	18.50	45.44	120.70	58.44
62	Târgu Jiu	3540	13.05	19.01	19.07	46.82	124.39	60.22
63	Târgu Mureş	3540	13.05	19.01	19.07	46.82	124.39	60.22
64	Târgu Ocna	3410	12.71	18.51	18.57	45.61	121.15	58.66
65	Târgu Secuiesc	4370	29.46	42.93	43.06	105.75	280.92	136.01
66	Turnu Măgurele	3010	10.65	15.52	15.56	38.22	101.53	49.16
67	Turnu Severin	2810	7.59	11.05	11.09	27.23	72.34	35.02
68	Tecuci	3390	12.66	18.44	18.50	45.44	120.70	58.44
69	Tulcea	3070	11.21	16.34	16.39	40.25	106.93	51.77
70	Turda	3560	13.11	19.10	19.16	47.06	125.01	60.53
71	Urziceni	3170	11.89	17.33	17.38	42.68	113.39	54.90
72	Vaslui	3570	13.15	19.15	19.21	47.18	125.34	60.69
73	Vatra Dornei	4580	41.78	60.87	61.06	149.96	398.36	192.87
74	Zalău	3300	12.42	18.10	18.15	44.58	118.43	57.34

Significant values for annual heating requirements for the heating of spaces in NZEBs and C107 buildings (based on the climate index method) (kWh/m^{2}year):

Table VIII.25

Type of building	Office - Administrative	Apartment block	Single-family building	C107
Medium value	13.47	19.63	19.69	48.36
Minimum value	7.59	11.05	11.09	27.23
Maximum value	41.78	60.87	61.06	149.96

Achieving the detailed values by locality ensures completion of the first stage of designing an NZEB located in Romania.

VIII.9 Additional conclusions and proposals in line with the research theme

• The medium values for annual heating requirements for the heating of spaces are very close to those specific to passive buildings (with reference to the similar climate type in Germany). The contribution of the system for providing thermal comfort is essential from the point of view of the heat consumption for heating at the end consumer. In cases that are connected to district cogeneration heating systems the efficiency of the technical system is approximately 92 %, but in the case of own sources the value decreases to approximately 78 %. Special care should be taken to maximise distribution efficiency (in the case of buildings fitted with a central source of heat or connected to the district heating network), which can vary between 95 % for new buildings and 70 % for existing buildings (as a result of the increased share of the heat flow dissipated in the service basement, relative to the heating requirements the main area of the building);

• The values presented above are characteristic of the reference building for each building type covered by the calculation. No differentiation has been made concerning the geometrical characteristics of the building (A / V compaction coefficient), albeit these differences do exist. Virtually, as indicated by the calculation method, if higher heating requirements values are obtained through dynamic simulation or using the values table of localities above, the thermal protection solution (fixed and mobile) is to be adapted so as to make the annual heat requirements less than or equal to the maximum value listed. The geometric configuration is to be determined taking into consideration the fact that the energy reconfiguration of a building results in certain costs that could lead to the removal of the building from the NZEB classification, with reference to decision module M3 (analysis of the economic efficiency analysis of the solution) in the flowchart;

• Given the importance of the energy configuration of building so as to classify it (at the design stage) as an NZEB, **the authors intend to draw up the basis for a roadmap outlining a future design guide for new NZEBs in Romania**;

• At the same time, a building that is designed and constructed in line with the NZEB requirements also has to pass the empirical test, which implies monitoring the thermodynamic and the functional parameters, and processing them so as to obtain the value for actual and virtual primary energy (relative to the typical climate year) that would confirm classification as an NZEB through empirical validation. To this end, the final stage of this study will include the **drawing up of a general outline of the procedure for empirically validating, monitoring and reporting the actual energy performance of NZEBs** (the procedure is also applicable in the case of other building types, with the difference that NZEBs requires high performance equipment with superior measurement precision);

• The success of the methods proposed in this study depends on the development of a database of technical and economic values that could be used in any study regarding solutions and/or strategies for implementing high energy performance buildings at throughout the country. That database should also include the thermophysical (thermodynamic and transmission) characteristics of building materials, data regarding the energy incorporated into materials and building technologies - demolition - post use, the characteristics of the equipment for the installations, lifetime, and prices. It is recommended that any correlation between price and characteristics be summarised in the form of empirical functions (based on the procedure used in this study - stage I). The database in question can be built by the professional associations, the design companies, an IT firm (which would develop the software component of the database), research institute with proven experience in the field, and the Ministry of Regional Development and Public Administration, by setting up a public-private partnership and using European funds under the Operational Programme for Competitivity for 2014-2020. The database should be public and updating it should be under the coordination of the Ministry of Regional Development and Public Administration.

ANNEX 1

Determining the mathematical model for estimating the energy efficiency of the ventilated solar area

The mathematical model is a calculation method necessary in order to use the global model for estimating the energy performance of low-energy buildings. We shall further present a simplified version of the detailed model based on the integration of Navier Stockes and Kirchhoff Fourier equations. The empiric validation of the model consists in processing the data measured using the INCERC experimental house as measurement basis between 2008 and 2009, in parallel with the results obtained by applying the new mathematical model. The detailed experiment is presented in published papers[59], [60]. The algorithm for using the calculation relations will be shown at the end.

1. Presentation of the experimental house equipped with ventilated solar area (CE)

The INCERC Bucharest experimental house is an individual residential building at the ground floor, with a hip roof, without basement, initially designed and built as experimental house for structure and closing elements made of autoclaved aerated concrete (AAC), and subsequently used as office building. The building currently consists of one apartment having one living room, two bedrooms, one kitchen, one bathroom, vestibule, corridor and porch.

The main façade, including the main entrance and the porch, faces west. The opposite façade, facing east, includes the secondary entrance to the building. It is moderately sheltered.

The INCERC experimental house has been subject to significant improvements of the initial energy performance, under research projects, consisting in thermal insulation of the opaque marginal constructive elements, in mounting thermally insulated windows and doors as well as an electric automated boiler, and in a solar area on the wall facing south. The inside

[59] *Mode of determination and calculation procedure for energy performance in buildings equipped with heating systems for the occupied spaces*, Contr. 337/2008 (project manager Dan Constantinescu).

[60] D. Constantinescu, *Assessment of the energy performance of the Solar area System attached to the CE – experimental house – experimental validation*, Revista CONSTRUCȚII, nr. 1/2010, pp. 53-71.

microclimate during the cold season is controlled by thermostatic taps mounted on the heating bodies.

The geometrical characteristics and the layout of the constructive elements of the experimental house are shown in figure 1.

The monitoring of the experimental house has been performed using a complex data collection system with a view to determining the thermodynamic parameters necessary to assess the energy performance in real operation conditions, through long term measurements (figure 2), as follows:

- Air temperature in the heated spaces of the experimental house;
- Temperature of the air forced from the collecting greenhouse;
- Temperatures of the go-and-return heating agent from the inside heating system at the level of the heat source;

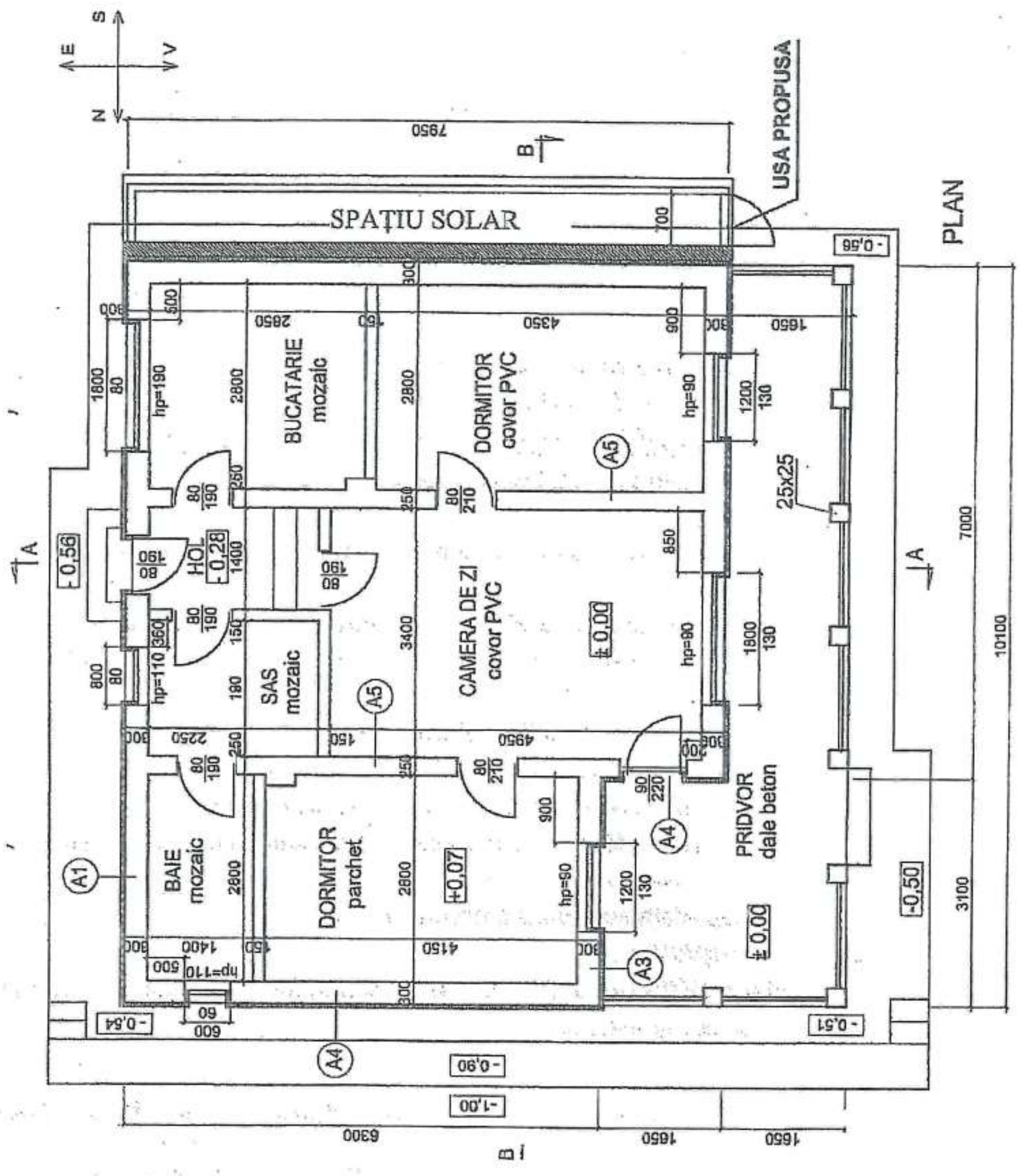

Fig. 1 Plan of the experimental house

RO	EN
Spaţiu solar	Solar area
Uşă propusă	Door proposed
Bucătărie mozaic	Kitchen mosaic
Dormitor covor PVC	Bedroom PVC carpet
Hol	Corridor
Sas mosaic	Vestibule mosaic
Camera de zi covor PVC	Living room PVC carpet
Baie mozaic	Bathroom mosaic

Dormitor parchet	Bedroom parquet
Pridvor dale beton	Porch concrete tiles

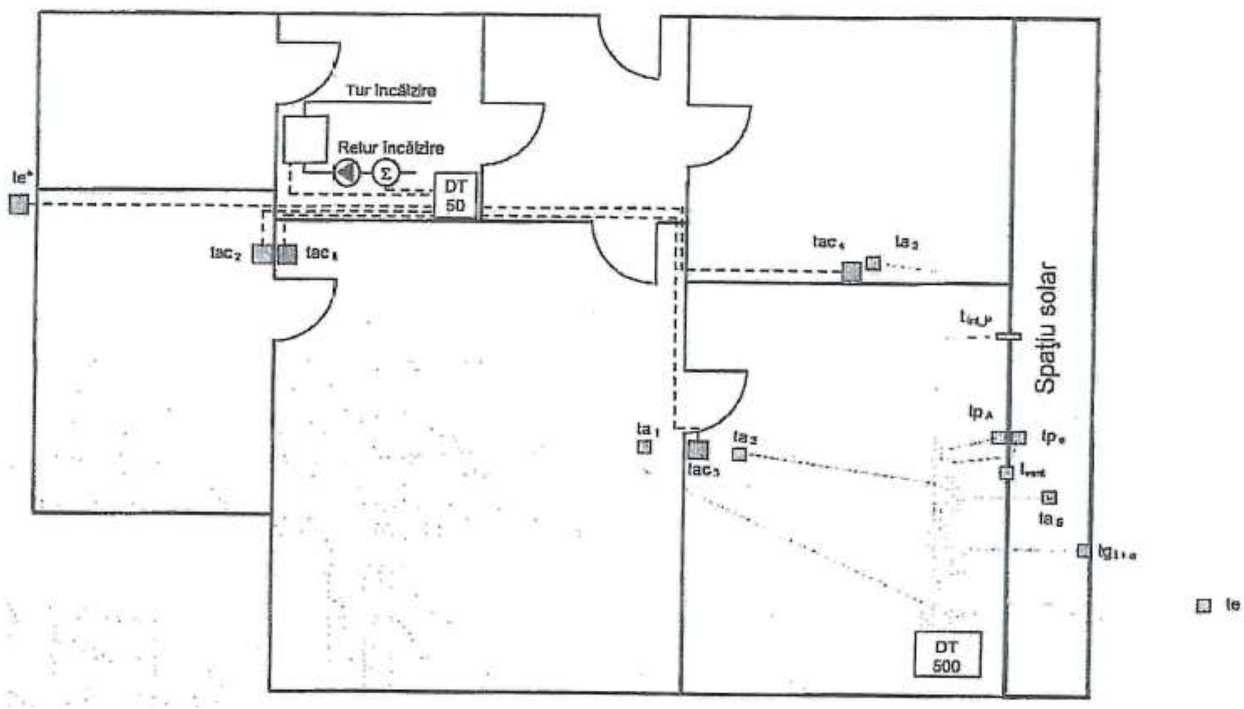

Fig. 2 Position of the measuring points

RO	EN
Tur încălzire	Heat go
Retur încălzire	Heat return
Spaţiu solar	Solar area

- Temperature of the solar radiation collecting unit (at surface and in thickness);
- Air thermal gradient in the collecting greenhouse (vertical and horizontal gradient);
- Glazing temperature;
- Outdoor temperature;
- Overall and diffuse intensity of the solar radiation in the horizontal plan;
- Volume flow of the air forced in the living space;
- Heat flow supplied by the heating system of the building;
- Thermal flow at the level of the SOUTH wall measured on the inside surface of the wall concerned;
- Temperature on the inside surface of the SOUTH wall;
- Infrared exploration:

Inside: exterior walls, heating bodies, air discharge aperture

Outside: exterior walls, greenhouse.

2. Assessment of the energy performance of the Solar area System attached to the experimental house (CE)

2.1. Hourly step mathematical model

The experimental house is equipped with ventilated solar area. The solar area function for obtaining heat comfort in the occupied space is reversible. Practically, during the hot season, air is extracted from the occupied space and it is evacuated outside, which allows natural ventilation of the premises by taking in air from the outside, and the function of fresh air insertion in the occupied space is fully replaced during the cold season by the forced insertion of preheated air in the occupied space. The preheating function is taken over by both the solar radiation collecting unit (0.20 m thick wall made of reinforced concrete) and the triple and selective glazing of the collecting greenhouse. Air circulation is ensured by two ventilators ensuring constant air flow rate as necessary to ensure the 0.6 exchange/h ventilation rate characteristic of the house, properly supplied with fresh air. The air entirely taken from the outside at temperature $t_e(\tau)$ flows along the collecting greenhouse space height and is flown into the living space at temperature $t_{ss}(\tau) > t_e(\tau)$. The solar area practically takes over part of the heat quantity that has to be supplied to the fresh air in order to let it reach the indoor air comfort temperature, $t_a(\tau)$, and, for many hours during the cold season, it also ensures partial or full heating of the space and thus replaces the conventional heating source. The long term experiment (since 2005) reveals the important function of the solar area in reducing the heat demand (by about 30%) correlated with the high rate of the building thermal protection. The solar area thus becomes an active-passive (mixed) component in the efficient use of solar radiation for the double purpose of ventilation and decrease in the building heat/cold consumption.

In order to quantify the thermal response of the solar area, it is important to know the temperature variation in the preheated/hot air flown into the occupied space, the thermal flow characteristic of the collector inside surface, as well as the decrease in energy consumption for long periods of time (week, month and season) in the cold season. These parameters allow correct and economically efficient dimensioning of the solar area system. The solar area has the function of envelope facing SOUTH. The hourly step modelling of the heat transfer processes implies preliminary modelling and validation of the ventilated solar area thermal response. The hourly step modelling of the space heating process is necessary in particular for buildings with very high glazing ratio with frequent successions of heating/natural mechanical ventilation/cooling processes even during the cold season. On the other hand, the presence of ventilated solar area equipment implies a simulation, at the building design stage, of the solar area thermal response during the cold season, which is only possible by hourly step modelling. The monthly step modelling proves to be a non-recommended procedure, similarly to the case of space cooling, because of the significant variation, during the day-night cycle of the virtual outdoor temperature characteristic of the outdoor environment adjoining the solar area.

The variation in the significant temperature field at the level of the solar area reveals the following functions:

- $t(x,\ y, \tau)$ – air temperature in the collecting greenhouse, where coordinates x and y mean the height and the depth of the greenhouse, respectively. The greenhouse span may be considered as not cause disturbances in the air temperature range as long as the outdoor air inlet in rather uniform and not punctual;

- $\vartheta(x,\tau)$ – temperature inside the collecting wall which may be considered one-dimensional because of the thermal conductivity of the material used for the collecting component, namely reinforced concrete, the value of which is λ = 1.74 W/mK.

The hypotheses above are the main simplifying hypotheses on which the mathematical model is based. Concerning the air temperature in the greenhouse, its variation by greenhouse depth is not significant as a result of the heat transfer concentration in the area of the boundary layer close to the two boundaries, namely the collecting wall and the glazing. Consequently, the adequate simulation model is the model corresponding to the control volume developed in the greenhouse depth, characterised by the average air temperature variable in relation with level y. The most adequate model in terms of thermally significant boundary, namely the solar radiation collecting wall, is the model of the uniform surface temperature in terms of temperature distribution on the height. We point out that this hypothesis is supported by the rather low intensity of the heat transfer from the solar radiation absorbing surface to the air and to the glazing.

Taking into account the elements above, the simulation model consists in the following thermal balance equations:

- Equation of the one-dimensional heat transfer through ducts through the collecting wall, with solution $\vartheta(x,\tau)$:
    - The equation shall be solved taking into account the uniqueness conditions, namely the initial condition $\vartheta(x,\tau=0)$, which shall be represented by a random value ϑ_0, due to the ergodicity characteristic of the heat parabolic equation and to the boundary conditions expressing the thermal flow continuity at the boundaries of the collecting component expressed by the 3rd rank boundary condition;

- Equation of the greenhouse air global thermal balance on the control volume determined by the greenhouse depth, height and span, with solution $t(\tau)$;
- Equation of the glazing thermal balance, with solution $\vartheta_v(\tau)$.

Figure 3 shows the calculation concept.

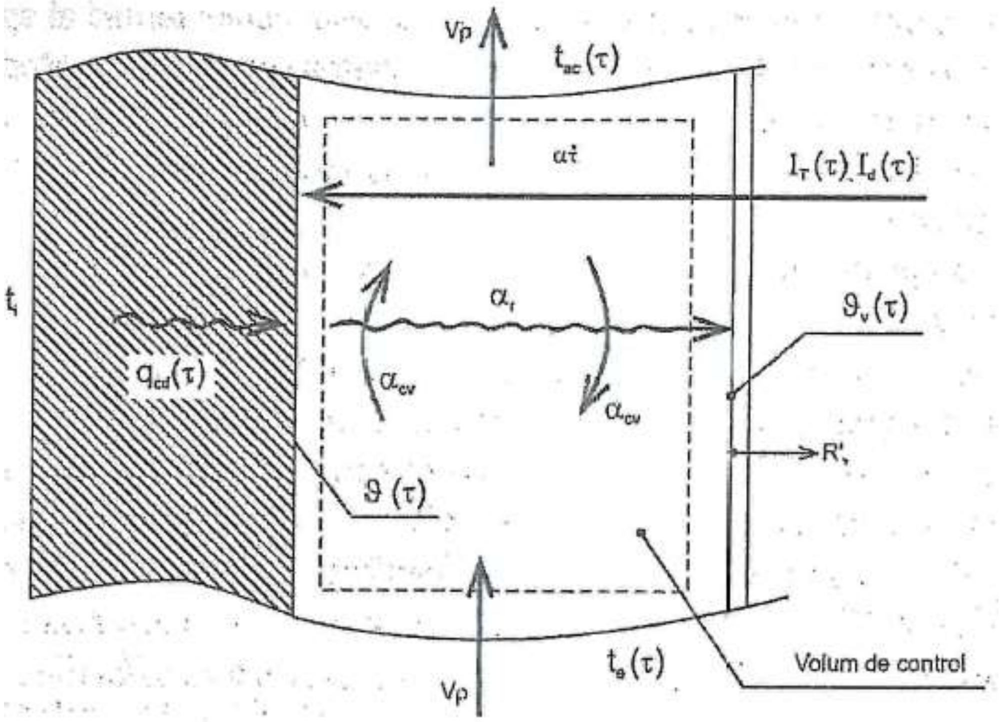

Fig. 3 Ventilated solar area calculation concept

RO	EN

Volum de control	Control volume

a. *Greenhouse air thermal balance equation:*

$$G_c t_e(\tau)+\alpha_{cv}S\cdot[\vartheta_p(x=\Delta,\tau)-t(\tau)]=G_c t(\tau)+\alpha_{cv}S\cdot[t(\tau)-t_v(\tau)] \quad (1)$$

Equation (1) is expressed supposing the simplifying hypothesis of air incompressibility.

b. *Glazing thermal balance equation:*

$$\alpha_r\cdot[\vartheta_p(x=\Delta,\tau)-t_v(\tau)]\cdot S_p+\alpha_{cv}\cdot[t(\tau)-t_v(\tau)]\cdot S_v=[t_v(\tau)-t_e(\tau)]\cdot R_v'^{-1}\cdot S_v \quad (2)$$

which provides the expression of air temperature $t(\tau)$ in relation with the temperatures of the thermodynamic outline of the control volume and with the outdoor temperature:

$$t(\tau)=A_1\vartheta_p(x=\Delta,\tau)+A_2 t_v(\tau)+A_3 t_e(\tau) \quad (3)$$

When introduced in balance equation (1), equation (3) determines the expression of the temperature for the greenhouse glazing:

$$t_v(\tau)=B_1\vartheta_p(x=\Delta,\tau)+B_2 t_e(\tau) \quad (4)$$

Processing of equations (3) and (4) leads to:

$$t(\tau)=C_1\vartheta_p(x=\Delta,\tau)+C_2 t_e(\tau) \quad (5)$$

c. *The 3rd rank boundary condition at level $x=\Delta$* leads to the following thermal balance equation:

$$-\lambda\cdot\left.\frac{\partial\vartheta(x,\tau)}{\partial x}\right|_{x=\Delta}\cdot S_p+(\alpha\tau)\cdot[C_s I_T(\tau)+(1-C_s)\cdot I_d(\tau)]\cdot S_v=\alpha_{cv}S_p\cdot[\vartheta_p(x=\Delta,\tau)-t(\tau)]+$$
$$+\alpha_r S_p\cdot[\vartheta_p(x=\Delta,\tau)-t_v(\tau)] \quad (6)$$

The following notation is made: $\frac{S_v}{S_p}=\beta$.

Processing of equation (6) shall lead to the following relation:

$$-\lambda\cdot\left.\frac{\partial\vartheta_p(x,\tau)}{\partial x}\right|_{x=\Delta}=[\alpha_{cv}\cdot(1-C_1)+\alpha_r\cdot(1-B_1)]\cdot[\vartheta_p(x=\Delta,\tau)-t_{Es}(\tau)] \quad (7)$$

where the equivalent outdoor temperature is expressed as follows:

$$t_{Es}(\tau)=\frac{\alpha_{cv}C_2+\alpha_r B_2}{\alpha_{cv}\cdot(1-C_1)+\alpha_r\cdot(1-B_1)}\cdot\left[\frac{\alpha\tau\beta}{\alpha_{cv}C_2+\alpha_r B_2}\cdot I(\tau)+t_e(\tau)\right] \quad (8)$$

where:

$$I(\tau)=C_s\, I_t(\tau)+(1-C_s)\cdot I_d(\tau)$$

Relation (7) refers to the 3rd rank boundary condition at level x=Δ.

d. *The 3rd rank boundary condition at level $x=0$* shall be expressed as follows:

$$-\lambda\cdot\frac{\partial\vartheta_p(x,\tau)}{\partial x}\bigg|_{x=0}=\alpha_i\cdot[t_i(\tau)-\vartheta_p(x=0,\tau)] \tag{9}$$

With the following notations:

$$\dot{\alpha}_e=\alpha_{cv}\cdot(1-C_1)+\alpha_r\cdot(1-B_1);\qquad \dot{\alpha}_i=\frac{1}{\alpha_i}+\sum_m\left(\frac{\delta}{\lambda}\right)_m \tag{10}$$

where m – index for the layers forming the solar radiation collecting unit other than the collecting wall made of reinforced concrete, with the two boundary conditions becomes:

$$\begin{cases}-\lambda\cdot\frac{\partial\vartheta_p(x,\tau)}{\partial x}\bigg|_{x=0}=\dot{\alpha}_i\cdot[t_i(\tau)-\vartheta_p(x=0,\tau)]\\ -\lambda\cdot\frac{\partial\vartheta_p(x,\tau)}{\partial x}\bigg|_{x=\Delta}=\dot{\alpha}_e\cdot[\vartheta_p(x=\Delta,\tau)-t_{Es}(\tau)]\end{cases} \tag{11}$$

and is combined with the heat parabolic equation referring to the structure of the collecting wall.

An acceptable solution for the issue of heat transfer through the solar radiation collecting unit may be obtained using the heat integral equation [3]. The intensity of the heat transfer at level $x=0$ (adjoining the occupied space) shall be determined using the following relation:

$$q_i(x=0,\tau)=q_i(\tau=0)\cdot\exp(M_1\tau)+\frac{N_1}{M_1}\cdot[\exp(M_1\tau)-1]+\frac{N_2}{M_2}\cdot[\exp(M_1\tau)-(1+M_1\tau)] \tag{12}$$

The expression for the collecting wall temperature at level $x=\Delta$, $\vartheta_p(x=\Delta,\tau)$ shall be determined by the following relation:

$$\vartheta_p(\dot{x}=1,\tau)=\frac{1+\mathrm{Bi}_e\cdot(1+\mathrm{Bi}_i^{-1})}{n+\mathrm{Bi}_e}\cdot Rq_i(\tau)-\frac{\mathrm{Bi}_e}{n+\mathrm{Bi}_e}\cdot[t_i(\tau)-t_{Es}(\tau)]-Rq_i(\tau)\cdot(1+\mathrm{Bi}_i^{-1}) \tag{13}$$

where $\dot{x}=\frac{x}{\Delta}$.

The following notations were used:

$$\begin{cases}M_1=\dfrac{\frac{a}{\Delta^2}\cdot\frac{n\cdot[1+\mathrm{Bi}_e(1+Bi_i^{-1})]}{n+\mathrm{Bi}_e}}{\mathrm{Num}};\ M_2=\dfrac{\frac{\mathrm{Bi}_e}{(1+n)(n+\mathrm{Bi}_e)}}{\mathrm{Num}}\\ M_3=\dfrac{\frac{a}{\Delta^2}\cdot\frac{n\cdot\mathrm{Bi}_e}{n+\mathrm{Bi}_e}}{\mathrm{Num}};\ \mathrm{Num}=\dfrac{1+\mathrm{Bi}_e\cdot(1+\mathrm{Bi}_i^{-1})}{(1+n)(n+\mathrm{Bi}_e)}-0{,}50-\mathrm{Bi}_i^{-1}\end{cases} \tag{14}$$

The collecting unit's thickness Δ and the thermal diffusivity a shall be determined by the procedure for generating the equivalent homogenous structure[61].

$$\begin{cases} N_1 = -\left[M_2 \cdot \frac{t_{E_j} - t_{E_{j-1}}}{\Delta\tau} + M_3 \cdot (t_{i_0} - t_{E_{j-1}}) \right] \\ N_2 = M_3 \cdot \frac{t_{E_j} - t_{E_{j-1}}}{\Delta\tau} \end{cases} \quad (15)$$

Relations (12) and (13) are applicable through the recurrence procedure in finite (hourly) time lags $\Delta\tau$. Identifier j defines the current calculation interval and $j-1$ defines the previous time lag shifted by $\Delta\tau$.
The average air temperature in the control volume shall be determined using relation (15) according to value $\vartheta_p(x = \Delta, \tau)$, determined by relation (13), and by the outdoor temperature $t_e(\tau)$. The air temperature variation along the control volume height (of the collecting greenhouse) may be expressed by the following relation:

$$t(\dot{y}, \tau) = t_e(\tau) \cdot \exp(-a\dot{y}) + [E_1 \cdot \vartheta_p(x = \Delta, \tau) + E_2 \cdot t_e(\tau)] \cdot [1 - \exp(-a\dot{y})] \quad (16)$$

This is used to determine the temperature value for the air exhausted in the occupied space at each time τ for $\dot{y} = 1$.

3. Experimental validation of the mathematical model based on the solar area – winter 2008-2009

The experiment was conducted during the 2008-2009 cold season, when the solar area operated and contributed to providing the fresh air rate to CE INCERC Bucharest.
The two ventilators supplying preheated fresh air in the solar area greenhouse are characterised by volume air flows of 44.49 m^3/h and 57.60 m^3/h, amounting in total to 102.09 m^3/h. In relation with the total volume of the building, i.e. 167.8 m^3, this flow rate represents 0.61 exchanges/h.
The following validation time frames were selected:

1) 1 October 2008 – 10 October 2008 – 15 days (232 hours)
2) 15 November 2008 – 25 December 2008 – 41 days (976 hours)
3) 13 January 2009 – 4 March 2009 – 51 days (1,217 hours)

with a total of 107 days (2,425 hours), which is a significant time frame for the purpose of validating the calculation method.

[61] D. Constantinescu, *Tratat de inginerie termică – Termotehnica în construcţii*, vol. 1, Editura AGIR, Bucureşti, 2008.

Beside the analysis of the hour differences between the exhausted air temperature measured, $t_{as-m}(\tau)$, and the exhausted air temperature determined by calculation $t_{as-t}(\tau)$, the validation indicators used include the differences during the time frames mentioned above between the solar area energy performance determined theoretically and the performance calculated based on the parameters measured:

$$Q_{vss}(\tau) = Gc_{pa} \cdot [t_{as}(\tau) - t_e(t)] \tag{17}$$

1. The specific values in terms of Energy Performance for the first experiment time frame are 3.66 kWh/m^2 (according to measurement), and 3.92 kWh/m^2 (according to the theoretical model), which leads to an overall deviation of 7.26%, which we consider acceptable. The graph in figure 4 shows the hour variations $t_{as-t}(\tau)$, $t_{as-m}(\tau)$ and $t_e(\tau)$ for the time frame considered. Averaging results in $\bar{t}_{as-t} = 28.1°C$, $t_{as-m} = 27.3°C$.

2. The specific values in terms of Energy Performance for the second experiment time frame are 9.53 kWh/m^2, and 9.83 kWh/m^2, which leads to an overall deviation of 3.16%, which certifies the validity of the calculation model. The graph in figure 5 shows the hour values $t_{as-t}(\tau)$ and $t_{as-m}(\tau)$ for the time frame considered. Averaging results in $\bar{t}_{as-t} = 11.7°C$, $\bar{t}_{as-m} = 11.5°C$.

3. The values in the third case are $\bar{q}_m = 15.26$ kWh/m^2, $\bar{q}_t = 15.84$ kWh/m^2, $\varepsilon = 3.63\%$, which represents clear validation. The values $\bar{t}_{as-t} = 12.5°C$ and $\bar{t}_{as-m} = 12.2°C$ also attest very good estimation via the theoretical model. The graph in figure 6 shows hour values $t_{as-t}(\tau)$, $t_{as-m}(\tau)$ and $t_e(\tau)$.

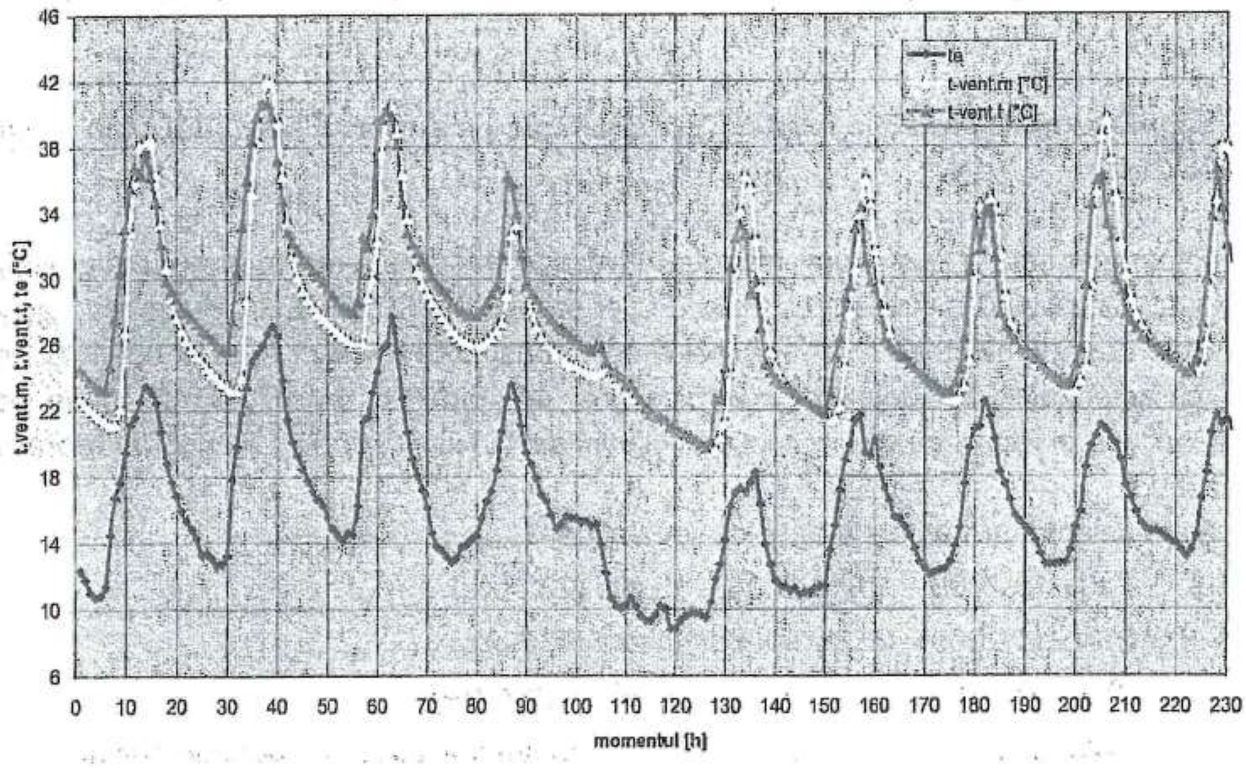

Fig. 4 Temperatures characteristic of the operation of the ventilated solar area
1 October 2008 – 10 October 2008 (232 hours) CE INCERC Bucharest

RO	EN
Time [h]	Time [h]

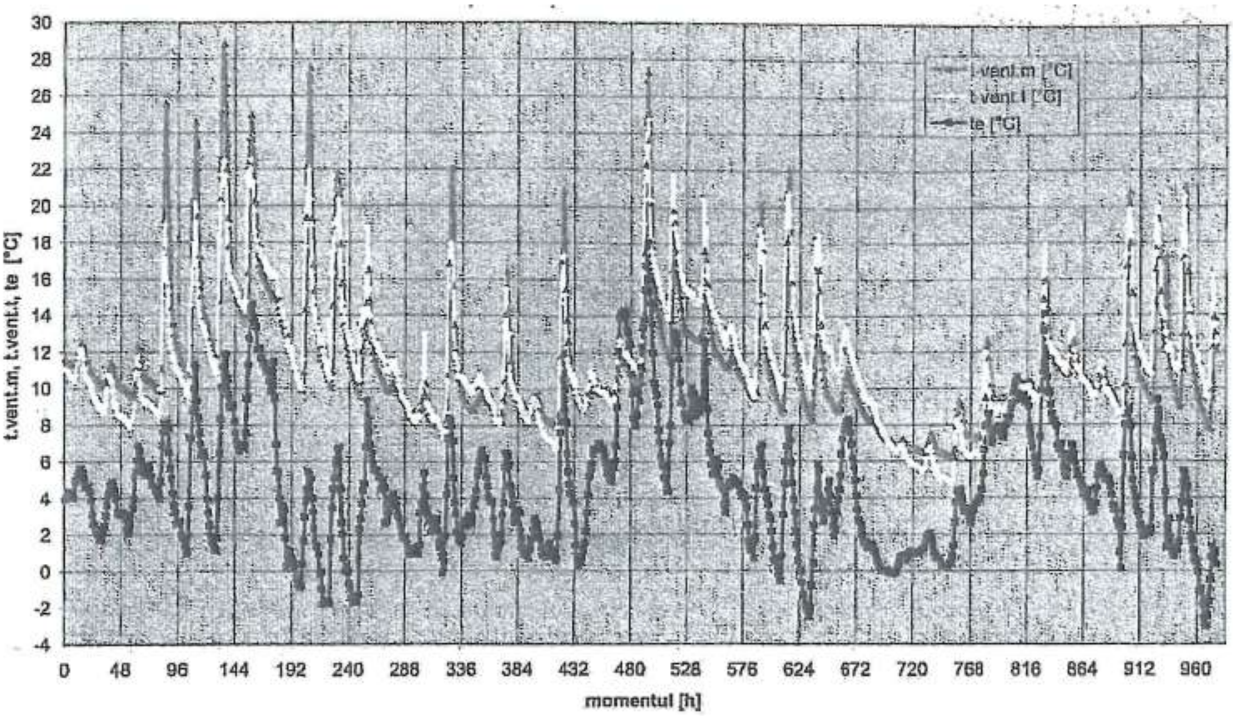

Fig. 5 Temperatures characteristic of the operation of the ventilated solar area
15 November 2008 – 25 December 2008 – (976 hours) CE INCERC Bucharest

RO	EN
Time [h]	Time [h]

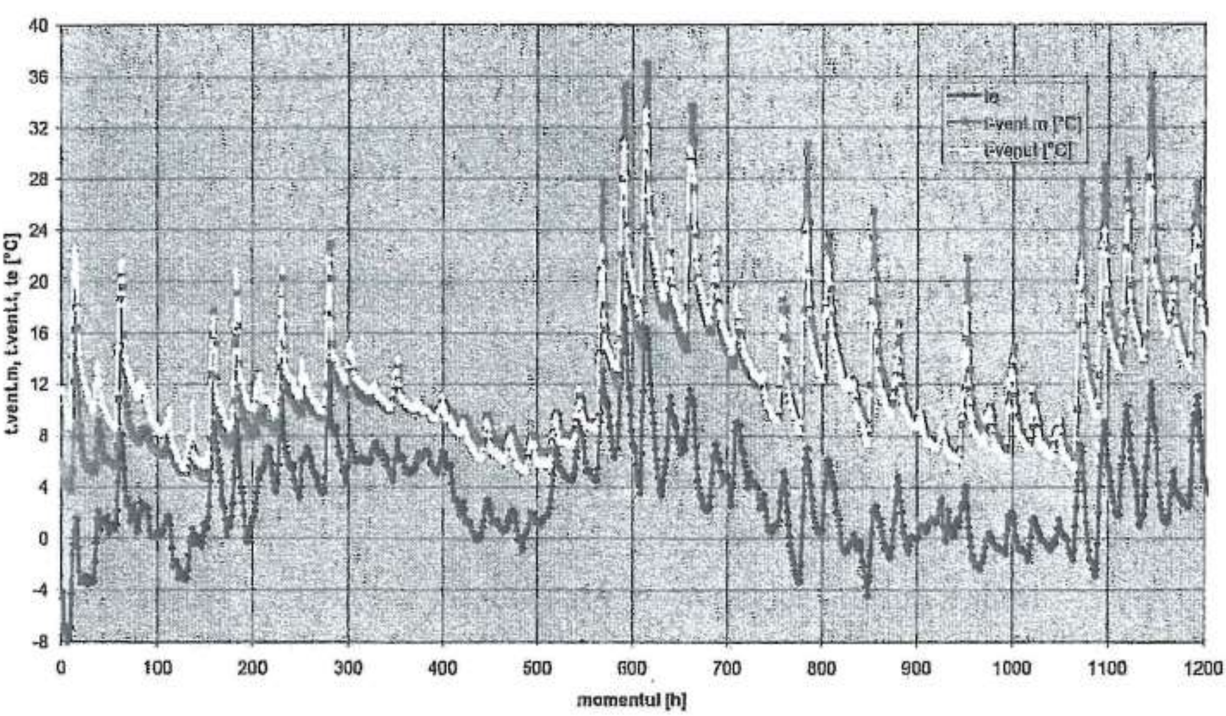

Fig. 6 Temperatures characteristic of the operation of the ventilated solar area

13 January 2009 – 4 March 2009 – (1 217 hours) CE INCERC Bucharest

RO	EN
Time [h]	Time [h]

4. Summary of the calculation equation

Determine the superficial heat transfer coefficient:

$$\dot{\alpha}_e = \alpha_{cv} \cdot (1 - C_1) + \alpha_r \cdot (1 - B_1)$$

Calculate the equivalent temperature pertaining to the solar area:

$$t_{E,SS}(\tau) = t_e(\tau) + \frac{(\alpha \cdot \dot{\tau})}{\dot{\alpha}_e} \cdot [c_s \cdot I_T(\tau) + (1 - c_s) \cdot I_{dif}(\tau)]$$

Determine the thermal flow density at level $x = 0$ of the opaque wall:

$$q_i(x = 0, \tau) = q_i(\tau = 0) \cdot \exp(M_1\tau) + \frac{N_1}{M_1} \cdot [\exp(M_1\tau) - 1] + \frac{N_2}{M_2} \cdot [\exp(M_1\tau) - (1 + M_1\tau)]$$

Determine the expression of the collecting wall temperature at level $x = \Delta$, $\vartheta_p(x = \Delta, \tau)$ using the following equation:

$$\vartheta_p(\dot{x} = 1, \tau) = \frac{1 + Bi_e \cdot (1 + Bi_i^{-1})}{n + Bi_e} \cdot Rq_i(\tau) - \frac{Bi_e}{n + Bi_e} \cdot [t_i(\tau) - t_{Es}(\tau)] - Rq_i(\tau) \cdot (1 + Bi_i^{-1})$$

The air temperature variation on the control volume height (of the collecting greenhouse) may be expressed using the following equation:

$$t(\dot{y}, \tau) = t_e(\tau) \cdot \exp(-a\dot{y}) + [E_1 \cdot \vartheta_p(x = \Delta, \tau) + E_2 \cdot t_e(\tau)] \cdot [1 - \exp(-a\dot{y})]$$

Calculation constants:

$$\beta = \frac{S_V}{S_P}, g = \frac{G}{S_P}$$

$$A_1 = -\frac{\alpha_r}{\alpha_{cv}} \cdot \beta^{-1}, \quad A_2 = \frac{\alpha_{cv} + \alpha_r \beta^{-1} + R_v'^{-1}}{\alpha_r}, \quad A_3 = -(\alpha_{cv} R_v')^{-1}$$

where:

$$A_1 + A_2 + A_3 = 1$$

$$B_1 = -\frac{g \cdot c_{p_a} \cdot A_1 + \alpha_{cv}[\beta A_1 - (1 - A_1)]}{\mathrm{Num}_1}$$

$$B_2 = -\frac{g \cdot c_{p_a}(A_3 - 1) + \alpha_{cv} A_3 (1 + \beta)}{\mathrm{Num}_1}$$

$$\mathrm{Num}_1 = g c_{p_a} A_2 + \alpha_{cv}[\beta_2 (A_2 - 1) + A_2]$$

$$C_1 = A_1 + A_2 B_1, \quad C_2 = A_3 + A_2 B_2$$

$$D_1 = \frac{\alpha_r}{\mathrm{Num}_2}, \quad D_2 = \frac{\alpha_{cv}}{\mathrm{Num}_2}, \quad D_3 = \frac{R_v'^{-1}}{\mathrm{Num}_2}, \quad \mathrm{Num}_2 = \alpha_{cv} + \alpha_r + R_v'^{-1}$$

$$a = \frac{\alpha_{cv}(2 - D_2)}{g c_{p_a}}$$

$$E_1 = \frac{1 + D_1}{2 - D_2}, \quad E_2 = \frac{D_3}{2 - D_2}$$

Notations:

S_p – collecting wall area [m^2];
S_v – glazing [m^2];
α_{cv} – air convection heat transfer coefficient [W/m^2K];
α_r – radiation heat transfer coefficient [W/m^2K];
g – air specific mass flow [kg/s];
c_{p_a} – specific heat at constant air thickness [J/kg];
H – distance on the vertical between the air circulation apertures [kg/s];
$t_e(\tau)$ – temperature of the outside air [°C];
$I_T(\tau)$ – overall intensity of the solar radiation on the vertical plan [W/m^2];
$I_{dif}(\tau)$ – diffuse component of the solar radiation on the vertical plan [W/m^2];
$\alpha_{\dot{\tau}}$ – optical factor of the greenhouse glazing [-].

Modelling of the operation of the solar domestic hot water system of the individual building

Note: **The solar system is placed in the solar area of the building**

- The expression of the temperature pertaining to the production of hot water is the following:

$$t_{E_{ss}}^{ac}(\tau) = \vartheta_a(\tau) + \frac{\alpha\dot{\tau}}{\alpha_i + R_{iz}^{-1}} \cdot I(\tau) \qquad (1)$$

- The value of the temperature of the water supplied by the solar system during sunny hours is given by the following expression:

$$t(x = L) = t_{E_{ss}}^{ac}(\tau) + [t(\tau) - t_{E_{ss}}^{ac}(\tau)] \cdot \exp\left(-\frac{\alpha_i + R_{iz}^{-1}}{\dot{g} \cdot c}\right) \qquad (2)$$

- The equation of the functional characteristic of the tubular solar collectors is the following:

$$\eta = F_R(\alpha\dot{\tau}) - F_R k_\Sigma \cdot \frac{t(\tau) - t_a(\tau)}{I(\tau)} \qquad (3)$$

where:

$$\begin{cases} F_R = -\dfrac{\dot{g} \cdot c}{\alpha_i + R_{iz}^{-1}} \cdot \left[1 - \exp\left(-\dfrac{\alpha_i + R_{iz}^{-1}}{\dot{g} \cdot c}\right)\right] \\ k_\Sigma = (\alpha_i + R_{iz}^{-1})^{-1} \end{cases} \qquad (4)$$

- The temperature variation in the Thermal Storage Unit (TSU) during the thermal load hours is determined using the following equation:

$$t(\tau_j) = t_{E_{ss}}^{ac}(\tau_j) + [t(\tau_j - \Delta\tau) - t_{E_{ss}}^{ac}(\tau_j - \Delta\tau)] \cdot \exp(-a \cdot \Delta\tau) \qquad (5)$$

where:

$$a = \frac{G_a}{V \cdot \rho_a} \cdot \left[1 - \exp\left(-\frac{\alpha_i + R_{iz}^{-1}}{g_a \cdot c}\right)\right] \qquad (6)$$

$$\Delta\tau = 3600 \text{ s}$$

- The hot water coverage level is determined using the following equation:

$$\varepsilon = \frac{t_{final} - t_0}{t_{C_0} - t_0} \qquad (7)$$

Notations:

$I(\tau)$ – overall intensity of the solar radiation [W/m^2];
$\vartheta_a(\tau)$ – average temperature of the solar area [°C];
$t(\tau)$ – average temperature of the water in the TSU [°C];
G_a – water mass flow ensured by the pump [kg/s];
V – TSU volume [m^{3}s];
α_i – superficial coefficient of the heat transfer between the solar radiation collecting unit and the outdoor environment [W/m^2];
R_{iz} – thermal resistance of the thermal insulation [m^2 K/W].

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28	INT	Marszal, Anna Joanna; Bourrelle', Julien S.; Nieminen, Jyri; Berggren, Björn; Gustavsen, Arild; Heiselberg, Per; Wall, Maria . (2010): North European Understanding of Zero Energy/Emission Buildings. Published during proceedings of Renewable Energy Conference 2010. Trondheim	Overview
29	INT	Marszal, Anna; Heiselberg, Per (2012): Zero Energy Building definition – a literature review. A technical report of subtask A of the IEA SHC Task40 / Annex 52 "Towards Net Zero Energy Solar Buildings", Aalborg University. Aalborg	Summary, Overview
30	INT	Voss, Karsten; Sartori, Igor; Napolitano, Assunta; Geier, Sonja; Goncalves, Helder; Hall, Monika et al. (2010): Load Matching and Grid Interaction of Net Zero Energy Buildings. Published by EuroSun Conference 2010, Graz	methodological Explanation
31	AT	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW): klima:aktiv Bauen und Sanieren (2011): Kriterienkatalog Bürogebäude Neubau, Wien	Exemplification to "klima:aktiv"
32	AT	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW): klima:aktiv Bauen und Sanieren (2011): Kriterienkatalog Bürogebäude Sanierung, Wien	Exemplification to "klima:aktiv"
33	AT	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW): klima:aktiv Bauen und Sanieren (2011): Kriterienkatalog Wohngebäude Sanierung, Wien	Exemplification to "klima:aktiv"
34	AT	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW): klima:aktiv Bauen und Sanieren (2012): Kriterienkatalog Bildungseinrichtungen Neubau, Wien	Exemplification to "klima:aktiv"
35	AT	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (BMLFUW): klima:aktiv Bauen und Sanieren (2012): Kriterienkatalog Wohngebäude Neubau, Wien	Exemplification to "klima:aktiv"

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36	AT	Bundesministerium für Verkehr, Innovation und Technologie (BMVIT): Forschungs- und Technologieprogramm „Haus der Zukunft", Wien. Online available under www.hausderzukunft.at, last reviewed 21.05.2012	Exemplification to "Haus der Zukunft"
37	AT	Klima- und Energiefonds (2012): Leitfaden Mustersanierung 2012, Wien	Exemplification to "Mustersanierung"
38	BE	Attia, Shady; Mlecnik, Erwin; van Loon, Stefan (2011): Principles for nearly zero-energy buildingsin Belgium. Louvain-la-Neuve	methodological Explanation
39	BE	Mlecnik, Erwin (2011): Defining nearly zero-energy housing in Belgium and the Netherlands. In: Energy Efficiency	methodological Explanation
40	BE	Mlecnik, Erwin; Attia, Shady; van Loon, Stefan (2011): Net zero energy building: A review of current definitions and definition development in Belgium. Published by Passiefhuis-Platform. Berchem	Overview
41	CA	Athienitis, Andreas (2007): Canadian Market, Regulations and Technologies applied to Low-Energy Buildings (houses): A State-of-the-Art. Published by Solar Buildings Research Network. Montreal	Exemplification to "EQuilibriumTM"
42	CA	Green, Thomas C. (2009): EQuilibriumTM. Demonstrating a Vision for Sustainable Housing in Canada, EQuilibriumTM Housing - Canada Mortgage and Housing Corporation. IEA Task 40 / Annex 52 Net Zero Energy Solar Buildings. Montreal, 06.05.2009	Exemplification to "R-2000 Standard"
43	CH	Leibundgut, Hansjürg (2011): LowEx building design. For a ZeroEmissionArchitecture, published by Vdf Hochschulverlag AG. Zürich	Exemplification to "LowEx building"
44	CH	MINERGIE® (2011): MINERGIE-A®/A-ECO®. Online available under http://www.minergie.ch/minergie-aa-eco.html, last reviewed 11.01.2012	Exemplification to "Minergie©-A"
45	CH	Zimmermann, Mark; Althaus, Hans-Jörg; Haas, Anne: Benchmarks for sustainable construction. A contribution to develop a standard. In: Energy and Buildings 37/2005, S. 1147–1157	Overview
46	CZ	Ministry of Industry and Trade; Czech Technical University Prague; Chamber of Commerce of Czech Republic; Czech Green building Council and Czech Passive house Centre (in the approval process): The Amendment of the Act on Energy Management 406/2000 Coll., Prague	Exemplification to "nearly zero-energy building"
47	DE	Bundesministerium für Verkehr, Bau und Stadtentwicklung (2012): Effizienzhaus Plus mit Elektromobilität. Technische Informationen und Details. Online available under www.bmvbs.de/DE/EffizienzhausPlus/Projekt/effizienzhaus-plus-projekt_node.html, last reviewed 18.04.2012.	Exemplification to "EffizienzhausPlus"
48	DE	Fraunhofer Institut für Bauphysik (2011): Wege zum Effizienzhaus-Plus. Published by Bundesministerium für Verkehr, Bau und Stadtentwicklung. Berlin	Exemplification to "EffizienzhausPlus"

		Publicaţie	Conţinut
49	DE	Heinze, Mira; Voss, Karsten (2009): Goal: Zero Eenergy Building - Exemplary Experience Based on the Solar Estate Solarsiedlung Freiburg am Schlierberg, Germany. In: Journal of Green Building 4 (4), S. 1-8.	Exemplification to "Plusenergiehaus ©"
50	DE	Schirmer, Stefan (2011): dena-Modellvorhaben „Auf dem Weg zum EffizienzhausPlus". Energetische Anforderungen des Modellvorhabens. Published by Deutsche Energieagentur dena. Berlin	Exemplification to "Effizienzhaus Plus"
51	DE	Sobek, Werner (2009): Triple Zero®. Published by Werner Sobek, Greentech. Stuttgart. Online available under www.wernersobek.com, last reviewed 21.05.2012.	Exemplification to "TripleZero©"
52	DE	solares bauen (2005): Das zeroHaus. Online available under http://www.zero-haus.de/zertifizierung.html, last reviewed 09.02.2005	Exemplification to "zeroHaus"
53	DE	Sonnenhaus-Institut e.V. (2008): Das Sonnenhaus. ...unabhängig und umweltbewusst: Wohnen mit der Sonne. Straubing	Exemplification to "Sonnenhaus"
54	DE	Stockinger, Volker; Grunewald, John; Jensch, Werner (2012): Plus-Energie. Begriffsdefinition, Umsetzung, Bilanzierung und Klassifizierung. In: HLH (3), page 20–32	methodological Explanation
55	DE	Voss, Karsten (2008): Was ist eigentlich ein Nullenergiehaus. Passivhaustagung 2008, Numberg	methodological Explanation
56	DE	Voss, Karsten; Musall, Eike (2011): Null- und Plusenergiegebäude: Allgemeine Bilanzierungsverfahren und Schnittstellen zur normativen Praxis in Deutschland. In: EnEVaktuell (IV), page 3–5.	methodological Explanation
57	DE	Voss, Karsten; Musall, Eike; Lichtmeß, Markus (2010): Vom Niedrigenergie- zum Nullenergiehaus: Standortbestimmung und Entwicklungsperspektiven. In: Bauphysik 32 (12), page 424–434.	methodological Explanation
58	DK	Lund, Henrik; Marszal, Anna Joann; Heiselberg, Per (2011): Zero energy buildings and mismatch compensation factors. In: Energy and Buildings 43 (7), page 1646–1654	methodological Explanation
59	DK	Marszal, Anna Joanna; Heiselberg, Per; Lund Jensen, Rasmus; Nørgaard, Jesper (2012): On-site or off-site renewable energy supply options? Life cycle cost analysis of a Net Zero Energy Building in Denmark. In: Renewable Energy 44, page 154–165	Overview
60	DK	Velux (2011): Velux Modelhome 2020. Published by Velux. Hørsholm. Online available under www.velux.de/privatkunden/wohnqualitaet_energieeffizienz_nachhaltigkeit/modelhome2020?cache=0, last reviewed 29.05.2012	methodological Explanation
61	GR	Santamouris; Sfakianaki (2011): Zero Energy Green Neighbourhood. Report Prepared by CRES on the zero energy project of Green Neighbourhood, CRES, Pikermi Athens, 2011	Exemplification to "Green Neighbourhood"

62	NL	Agentschap NL (2010): Energieneutraal Bouwen, hoe doe je dat?. Online available under www.agentschapnl.nl/sites/default/files/bijlagen/Infoblad_Energieneutraal_Bouwen.pdf, last reviewed 21.05.2012	methodological Explanation
63	NL	Platform energietransitie Gebouwde Omgeving (2009): Stevige ambities, Klare taal!, definiëring van doelstellingen en middelen bij energieneutrale, CO2-neutrale of Klimaatneutrale projecten de	methodological Explanation
64	NL	Agentschap NL (2010): Uitgerekend Nul, Taal, Rekenmethode en Waarde voor CO2 cq. energieneutrale utiliteitsgebouwen. Online available under http://www.agentschapnl.nl/sites/default/files/ bijlagen/Rapportage%20Uitgerekend%20Nul.pdf, last reviewed 30.05.2012	methodological Explanation
65	NL	W/E adviseurs (2009): Stevige ambities, Klare taal!, definiëring van doelstellingen en middelen bij energieneutrale, CO2-neutrale of Klimaatneutrale projecten in de gebouwde omgeving. Online available under www.agentschapnl.nl/sites/default/files/bijlagen/Rapport%20-%20Stevige%20ambities%20klare%20taal, %20definitiestudie%20-20november%202009.pdf, last reviewed 21.05.2012	Overview
66	NO	Norwegian University of Science and Technology NTU: The Research Centre on Zero Emission Building. Online available under www.sintef.no/Projectweb/ZEB/About-ZEB, last reviewed 21.05.2012	methodological Explanation
67	SE	Elmroth, Arne (2012): Energihushållning och värmeisolering – Byggvägledning 8 En handbook i anslutning till Boverkets byggregler (engl.: A guide to the energy requiremenst in the building regulations), Svensk Byggtjänst, Stockholm. Online available under www.byggtjanst.se, last reviewed 25.05.2012	methodological Explanation
68	SE	Sandberg, Eje (2012): Kravspecifikation för nollenergihus, passivhus och minienergihus. Published by Sveriges Centrum för Nollenergihus. Styrelsen	Exemplification to "nollenergihus"
69	SP	González Álvarez, Marcos (2011): Nearly zero-energy buildings, from research to real construction. International Conference within Construmat 2011 fair. Barcelona	Overview
70	UK	CIBSE (2010), Down to Zero, CIBSE Journal, February 2010, pp. 36-40.	Overview
71	UK	Department of Energy and Climate Change (DECC) (2012): 2012 consultation on changes to the Building Regulations in England Section two Part L (Conservation of fuel and power), in Communities and Local Government (CLG), London. Online available under http://www.communities.gov.uk/documents/planningandbuilding/pdf/2077834.pdf, last reviewed 30.05.2012	methodological Explanation
72	UK	Department of Finance and Personnel (Ireland): The Energy Performance of Buildings in Northern Ireland. Online available under http://www.dfpni.gov.uk/index/buildings-energy-efficiency-buildings/energy-performance-of-buildings.htm, last reviewed 30.05.2012	methodological Explanation

73	UK	Building Standards Division (BSD): Sustainability labelling in Scottish Building Standards. Online available under http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/about/bsdsustain, last reviewed 30.05.2012	methodological Explanation
74	UK	Building Standards Division (BSD): Introduction to Energy Performance. Online available under http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/profinfo/epcintro, last reviewed 30.05.2012	methodological Explanation
75	US	Crawley, Dru; Pless, Shanti; Torcellini, Paul: Getting to Net Zero. ASHRAE Journal 51, 2009, S. 18 –25	methodological Explanation
76	US	Griffith, Brend et al.: Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector. Technical Report NREL/TP-550-41957, 2007	Overview

Annex D

LIST OF POWER AND HEAT COGENERATION CAPACITIES WITH FINAL ACCREDITATION

Annex to Decision No 1279 of 28 May 2014 of the President of the National Regulatory Agency for Energy (ANRE)

Ref. No	Producer		Installed electric capacity (MW)	Main fuel	Technology (**)	Commercially operating capacities (yes/no)	Capacities with final accreditation (yes/no)	High efficiency electric capacity (MW)		Date of the approval of final accreditation	Declared date of the start of commercial operation
	Economic operator and location	Plant and location						Total	of which eligible for the aid scheme for cogeneration	(dd/mm/yyyy)	(ll/yyyy)
1	S.C. ELECTROCENTRALE GALAŢI SA.	CET Galaţi	375.00	natural gas	TA	yes	-	101.73	101.73	-	-
2	S.C. TERMICA S.A. SUCEAVA	CET Suceava	100.00	coal	TA	yes	-	40.73'	40.73	-	-
3	S.C.TERMO CALOR CONFORT S.A. Piteşti	CET Gavana - Piteşti	6.00	natural gas	TC	yes	-	2.29	2.29	-	-
4	S.C. DALKIA TERMO IAŞI S.A. (*)	CET lasi U	100.00	coal	TA, TC	yes	-	79.54	70.07	-	-
		CET Iaşi I	25.00	natural gas	TA	yes	-	0.00	0.00	-	-
5	S.C. DALKIA TERMO PRAHOVA S.R.L.	CET Brazi - Ploiesti	260.00	natural gas	TA, TC	yes	-	106.94	106.94	-	-
			28.04		CC	yes	yes			28.12.2010 28.05.2014	-
6	S.C. COMPLEXUL ENERGETIC	CTE Mintia - group 3	210.00	coal	TA	yes	-	57.01	57.01	-	-

	HUNEDOARA S.A.	CET Paroseni (*)	150.00	coal	TA	yes	-	42.61	42.60	-	-
7	Regia Autonoma pentru Activitati Nucleare / Drobeta-Tumu Severin (*)	ROMAG TERMO plant (CET Halanga)	222.00	coal	TA, TC	yes	-	134.06	100.52	-	-
8	S.C. CET ARAD S.A.	CET lignite / Arad	50.00	coal	TA	yes	-	50.00	50.00	-	-
9	S.C. Centrala Electrica de Termoficare BRAŞOV S.A.	CET Braşov	100.00	coal	TA	yes	-	0.00	0.00	-	-
10	S.C. Electrocentrale Bucharest S.A.	Bucharest branch - CET Bucharest Sud-groups 3 si 4	200.00	natural gas	TA	yes	-	187.20	187.20	-	-
		Bucharest branch - CET Bucuresti Vest - combined-cycle plant	186.25	natural gas	CC	yes	-	186.25	186.25	-	-
		Bucharest branch - CET Grozăveşti	100.00	natural gas	TA	yes	-	71.20	71.20	-	-
		Bucharest branch - CET Progresu	200.00	natural gas	TA, TC	yes	-	128.10	128.10	-	-
		Constanţa branch - CET Palas	100.00	natural gas	TA	yes	-	70.60	70.60	-	-

		Bucharest branch - CET Titan	8.00	natural gas	TC	yes	-	2.90	2.90	-	-
11	S.C. CET S.A. BACAU (*)	CET Bacau	50.00	natural gas	TA	yes	-	23.18	23.15	-	-
			14.00	natural gas	TG	yes	-	13.96	13.90	-	-
12	S.C. COMPLEXUL ENERGETIC OLTENIA S.A.	CET Craiova II	300.00	coal	TA	yes	-	106.36	106.36	-	-
13	S.C. ELECTROCENTRALE ORADEA S.A.	CET Oradea	195.00	coal	TA, TC	yes	-	78.18	78.18	-	-
14	S.C. CET GOVORA S.A.	CET Govora	200.00	coal	TA, TC	yes	-	58.59	58.59	-	-
15	S.C. ELECTRO ENERGY SUD S.R.L.	Giurgiu cogeneration plant	17.60	natural gas	MT	yes	yes	17.60	17.60	14.11.2012	11.2012
16	S.C. OMV PETROM S.A. (*)	CET Petrobrazi / Ploieşti	53.14	LCO	TG	yes	-	53.14	11.10	-	-
		CET Petrom City / Bucharest	4.54	natural gas	MT	yes	-	3.13	1.57	-	-
17	S.C. Compania Locală de Termoficare COLTERM S.A. / Timişoara	CET Timişoara Sud	19.70	coal	TC	yes	-	12.50	12.50	-	-
		CET Freidorf	1.00	natural gas	MT	yes	-	1.00	1.00	-	-

18	S.C. ENET S.A. FOCŞANI	CET / Focsani	8.00	natural gas	TC	yes	-	13.60	13.60	-	-
			13.60		MT	yes	yes			28.05.2014	-
19	S.C. CET GRIV1ŢA S.R.L. / Bucharest	CET Grivita / Bucharest	11.40	natural gas	TC	yes	-	4.64	4.64	-	-
20	R.A.G.C.L. PAŞCANI	CT 5 / Pascaai	0.69	natural gas	MT	yes	-	0.69	0.69	-	-
21	S.C. COLONIA CLUJ-NAPOCA ENERGIE S.R.L.	CT 3 Gheorgheni	0.58	natural gas	MT	yes	-	0.58	0.58	-	-
		CT 8 Gheorgheni	0.21	natural gas	MT	yes	-	0.21	0.21	-	-
		CTZ Someş Nord	4.65	natural gas	MT	yes	-	4.65	4.65	-	-
22	S.C. RULMENŢI S.A. Bârlad (*)	CET	11.99	natural gas	MT	yes	-	11.68	6.59	-	-
23	S.C. U.A.T.A.A. MOTRU S.A.	CET	5.50	coal	TC	yes	-	4.40	4.40	-	-
24	S.C. INTERAGRO S.RX. ZIMNICEA (*)	CET	2.01	natural gas	MT	yes	-	0.95	0.62	-	-
25	S.C. ENERGY COGENERATION GROUP S.R.L. / Zimnicea	CET	12.00	natural gas	TG	yes	-	9.33	9.33	-	-
		CET Nord / Braşov	20.17	natural gas	MT	yes	yes	20.17	20.17	28.12.2010	11.2010

26	**S**.C. BEPCO **S**.R.L.	CET Metrom / Braşov	6.71	natural gas	MT	yes	yes	6.71	6.71	28.12.2010	11.2010
		CET Noua / Braşov	2.68	natural gas	MT	yes	yes	2.68	2.68	28.12.2010	11.2010
		CET Nord 2 / Braşov	13.19	natural gas	MT	yes	yes	13.19	13.19	18.11.2011	01.2012
27	S.C. VEST-ENERGO S.A. / Bucharest	CET Militari / Bucharest	4.00	natural gas	TC	yes	-	14.16	14.16	-	-
			6.09		MT	yes	yes			28.12.2010	12.2010
			8.07		MT	yes	yes			24.06.2011	06.2011
28	S.C. SERVICH COMUNALE S.A. RĂDĂUŢI	CET	7.00	natural gas	TG	yes	-	7.00	7.00	-	-
29	S.C. ECOGEN ENERGY S.A. / Buzău	CET	6.09	natural gas	MT	yes	-	6.09	6.09	-	-
30	S.C. MODERN CALOR S.A. / Botoşani	CET Botoşani	4.00	natural gas	TG	yes	-	12.53	12.53	-	-
			8.80		MT	yes	yes			25.10.2012	10.2012
31	S.C. CONTOURGLOBAL SOLUTIONS S.R.L. / Ploieşti (*)	CET	6.08	natural gas	MT	yes	-	6.08	5.55	-	
32	S.C. COMPA S.A. SIBIU	CET	3.10	natural gas	MT	yes	-	3.10	3.10	-	-
33	R.A.M. Buzău	CET	0.68	natural gas	MT	yes	-	0.68	0.68	-	

34	S.C. ENERGOSIB S.R.L. / Sibiu	CET	0.95	natural gas	MT	yes	-	0.48	0.48	- ...	
35	S.C. ZAHĂRUL LUDUȘ S.A. (*)	CET	6.00	natural gas	TC	yes	-	3.17	0.55		- '
36	UNIVERSITATEA POLITEHNICA BUCURESTI (*)	CET	1.67	natural gas	MT	yes	-	1.67	0.62	-	
37	S.C. AQUALAND DEVA S.R.L. (*)	CET	0.90	natural gas	MT	yes	-	0.90	0.73	-	-
38	S.C. VIROMET S.A. / Victoria (*)	CET	12.00	natural gas	TC	yes	-	1.90	0.42	-	-
39	S.C. PROENERGY CONTRACT - INSTALLATIONS S.R.L.	CET / Buzias Hotel Centre	0.20	natural gas	MT	yes	yes	0.20	0.20	27.01.2012	02.2012
40	S.C. LUKOIL ENERGY AND GAS ROMANIA S.R.L.	CET LUKOIL / Ploieşti	66.00	petroleum coke	TC, TA	yes	-	16.83	16.83	-	-
41	S.C. PREFAB S.A. (*)	Calarasi site	5.40	natural gas	TG	yes	yes	5.40	4.47	14.11.2012	01.2013
42	S.C. PETROCART S.A. (*)	Petrocart cogeneration plant / Piatra Neamţ	1.8	natural gas	MT	yes	-	1.80	0.28	-	-
43	S.C. POLIGEN POWER ENERGY S.R.L.	CT Tudor III / Miercurea-Ciuc	4.0	natural gas	MT	yes	yes	4.00	4.00	17.04.2013	04.2013

44	S.C. DONAU CHEM S.R.L. Turnu Măgurele (*)	DONAU CHEM cogeneration plant / Tumu Măgurele	20.25	natural gas	TG	yes	yes	20.25	8.40	25.09.2013	-
45	S.C. AMURCO S.R.L. / Bacău (*)	ITGCR AMURCO / Bacău	13.50	natural gas	TG	yes	yes	13.50	3.14	27.11.2013	-
46	City of Bacău	CET Bacău / Bacău	10.95	natural gas	CC	no	yes	10.95	10.95	22.01.2014	01.2014

(*) Economic operators that own/operate cogeneration units and consume power generated by those units for their own consumption locations on the same site, for their own activities other than the production of power and heat - in such cases the electric capacity eligible for the aid scheme was reduced relative to the high efficiency electric capacity given by the self-evaluation calculation, in accordance with Article 18 of the procedure for approving new projects or upgrading cogeneration plants, as approved by Order No 115/2013 of the President of the National Regulatory Agency for Energy (ANRE)

(**) Type of cogeneration technology: CC - combined TG + TA cycle, TA - steam condensation turbine with heating connections, TC - steam turbine with counter-pressure, TG - gas turbine with heat recovery, MT - internal combustion