CONCERTED ACTION
ENERGY PERFORMANCE
OF BUILDINGS

Implementation of the EPBD in Croatia

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1. Introduction

The first requirements for the energy efficiency of buildings in Croatia were established by regulation in 1970. This regulation defined the requirements for the building envelope (maximum specific thermal losses and permitted thermal transmittance values). Improvements to the requirements continued until 1987. Certain transposition activities of the Energy Performance of Buildings Directive (EPBD) started in 2005 under the Ministry of Construction and Physical Planning (MCPP). The Technical regulation on energy economy and heat retention in buildings established the maximum permitted annual energy needs for heating (QH,nd)[1], as well as a new, higher restriction on thermal transmittance values (U-values) for building elements. In 2007, the Physical Planning and Building Act transposed the provisions of the EPBD related to the energy certification of buildings and requirements for the energy performance of buildings.

Official implementation of the EPBD within Croatian regulations started in 2008 under the MCPP, and involved improving the technical regulation and amending the Physical Planning and Building Act. As a result of the latter, certain parts of the transposition became the responsibility of the Ministry of Economy (Act of Energy End-use Efficiency), in particular energy certification, regular inspection of heating and air-conditioning (AC) systems in buildings, and establishment of an independent control system. In this way, the EPBD transposition and implementation was divided under the competence of two ministries. The Act on Energy End-use Efficiency (in part related to energy efficiency in buildings) and the Physical Planning and Building Act were overridden by the new Building Act published in 2013. With this new regulation, the transposition and implementation of the EPBD passed under the sole competence of the MCPP.

The Building Act (Official Gazette 153/2013) has set the legislative basis for applying minimum technical requirements for the energy performance of buildings and their components, as well as for setting requirements for existing buildings and their components that are undergoing renovation. It also requires the drafting of studies containing technical, environmental and economic analyses of alternative energy supply systems, to be developed prior to building permit issuance for all buildings with a total useful surface area exceeding 50 m², the issuance of Energy Performance Certificates (EPCs), as well as carrying out regular inspections of heating and AC systems in buildings, and the establishment of an independent control system.

From 2012 to November 2014, new subordinate regulations were adopted, or existing ones were amended. The most important one is the new Technical regulation on rational use of energy and heat retention in buildings (OG 97/2014 and 130/2014), in which calculations were carried out for cost-optimal levels of minimum energy performance requirements using the comparative methodology framework for all types of buildings. Furthermore, definitions were proposed for Nearly Zero-Energy Buildings (NZEBs) for all types of buildings.

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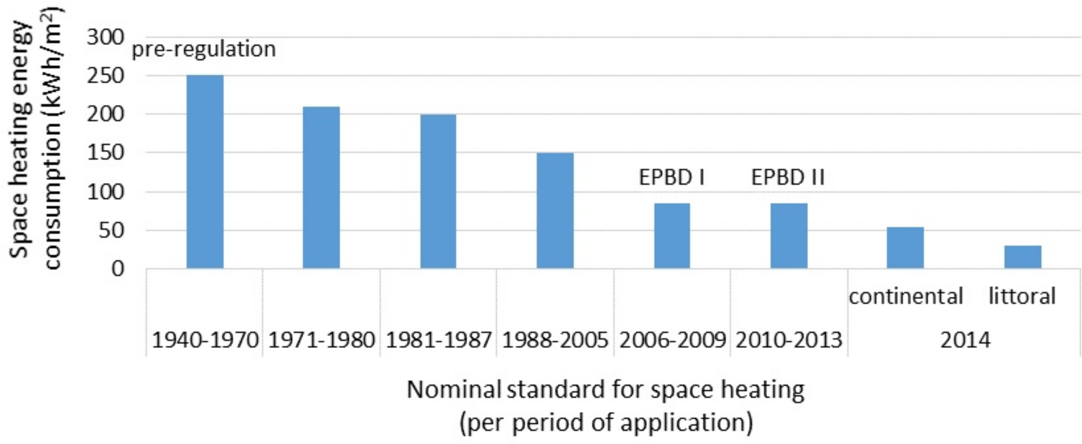
[1] *According to ISO 13790:2008 Energy performance of buildings - Calculation of energy use for space heating and cooling, and also according to EU Regulation 244/2012.*

Figure 1:
Energy consumption in Croatia for the heating of residential buildings per periods of application of the regulation[2] (expressed as $Q_{H,nd}$).



2. Current status of implementation of the EPBD

I. ENERGY PERFORMANCE REQUIREMENTS

I.i. Progress and current status

The requirements for energy consumption and heat retention in buildings that were set and have been implemented since 2005, related in particular to prescribing the maximum specific thermal energy needs for heating ($Q_{H,nd}$) for residential and non-residential buildings, and the maximum allowed heat transmission coefficients (U-values) for single parts of the building envelope. There are additional requirements related to energy savings in case of building reconstruction: the necessary minimum heat retention, maximum thermal losses, reduction of the effects of thermal bridges and prevention of water vapour condensation.

Based on the cost-optimal analyses that were carried out in 2013 and 2014, requirements were set on individual types of buildings regarding energy needs for heating ($Q_{H,nd}$). The requirement regarding the primary energy consumption (E_{prim}) is included in the Technical regulation on rational use of energy and heat retention in buildings (OG 97/2014 and 130/2014) and the remaining requirements for delivered (final) energy consumption (E_{del}) are specified in the new technical regulation, published in November 2015 (OG 128/15).

The technical regulation (OG 97/2014 and 130/2014) prescribes the requirements of the energy performance of new buildings and, in case of major refurbishment, of existing buildings. Requirements are prescribed for maximum primary energy consumptions, maximum annual energy needs for heating, maximum heat transmission coefficients, reduction of the effects of thermal bridges (for this purpose, a catalogue of good solutions has been developed), the efficiency of technical systems, the efficiency class of the building automation and control system, the airtightness of buildings, and the share of Renewable Energy Sources (RES). Provisions for indoor environmental quality (including air quality, thermal comfort, lighting and acoustics) are also ensured, for which the values recommended in HRN EN 15251:2008 are used.

Compliance with the requirements of airtightness is proven by testing the new or renovated existing building according to HRN EN 13829:2002[3], method A, before the technical inspection of the building. For a pressure difference between inside and outside of 50 Pa, measured airflow, reduced to a volume of indoor air, should not exceed n_{50} = 3.0 h^{-1} in buildings without mechanical ventilation devices, or n_{50} = 1.5 h^{-1} in a building with a mechanical ventilation device. For multi-family residential buildings, airtightness requirements must be fulfilled for each apartment. For non-residential buildings, airtightness requirements must be fulfilled by the

[2] *The first regulation was in 1970. Before that, construction was according to the prevailing common practices.*
[3] *Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurisation method.*

building envelope. The minimum airtightness of windows, balcony doors and roof windows is determined according to EN 12207: 2001[4], and must be class 2 for buildings of up to two floors, or class 3 for higher buildings.

Annual energy needs for heating, $Q_{H,nd}$ (kWh/year), is calculated according to the standard ISO 13790:2008 monthly method, including requirement for calculating the solar heat gains Q_{sol}, necessary to consider the opacity of movable shading in glazings.

Pursuant to the technical regulation, the reference climate is the climate observed at characteristic meteorological stations in continental and littoral Croatia. Continental Croatia includes all places where the mean monthly outdoor temperature of the coldest month is equal to or less than 3 °C as observed by the closest to the building's location meteorological station. Littoral Croatia includes all places where the mean monthly outdoor temperature of the coldest month is higher than 3 °C as observed by the closest to the building's location meteorological station.

The requirements for residential and non-residential buildings heated to a temperature of 18 °C or more, include prescribed maximum values of energy needs for heating (depending on the building shape and climate) and maximum primary energy consumption depending on the climate (see Tables 1 and 2).

With regard to RES, the building must meet one of the following three requirements:

1. at least 20% of the total energy needs for the operation of the systems in the building is covered by energy from RES;
2. a share of the total delivered energy supply for heating and cooling of the building, as well as for Domestic Hot Water (DHW), preparation is obtained in one of the following ways:
   > at least 25% from solar radiation;
   > at least 30% from gaseous biomass;
   > at least 50% from solid biomass;
   > at least 70% from geothermal energy;
   > at least 50% from heat from the environment;
   > at least 50% from cogeneration installations with a high efficiency, in compliance with a special regulation;
3. 50% of the energy needs of a building is covered from district heating that meets the requirements from item 2.

Table 1:
Maximum allowed annual thermal energy needs for heating ($Q_{H,nd}$) of residential and non-residential buildings heated to a temperature of 18 °C or more (past and present status).

Building type	**Climate**	**Shape factor f_0 (m^{-1}) = Area / Volume**		
		$f_0 \leq 0.20$	$0.20 < f_0 < 1.05$	$f_0 \geq 1.05$
Maximum $Q_{H,nd}$ Technical regulation 2008				
residential kWh/m².year	continental & littoral	51.31	41.03 + 51.41·f_0	95.01
non-residential kWh/m³.year	continental & littoral	16.42	13.13 + 16.45·f_0	30.40
Maximum $Q_{H,nd}$ Technical regulation 2014				
building* ≤ 80 m² kWh/m².year	continental & littoral	51.31	41.03 + 51.41·f_0	95.01
Single-family house kWh/m².year	continental	40.50	33.62 + 34.4·f_0	69.74
	littoral	21.60	17.73 + 19.33·f_0	38.03
other residential & non-residential kWh/m².year	continental	40.50	32.39 + 40.58·f_0	75.00
	littoral	21.60	17.27 + 21.65·f_0	40.00

*surface area of the gross floor area of a building equal or below 80 m² regardless of type (residential and non-residential)

Table 2:
Optimal value of primary energy consumption (E_{prim}) by building types according to cost-optimal analyses (Technical regulation 2014 current status).

	E_{prim} for new buildings [kWh/m².year]		**E_{prim} for renovated old buildings [kWh/m².year]**	
	Continental climate	Littoral climate	Continental climate	Littoral climate
Single-family house	100	60	135	70
Apartment blocks	120	90	180	130
Offices	65	65	65	65
Educational buildings	60	55	90	75
Hospitals	280	280	330	300
Hotels and restaurants	120	70	135	115
Sports facilities	400	170	400	215
Wholesale and retail trade services buildings	450	280	475	300

[4] *Windows and doors - Air permeability - Classification*

Table 3: Maximum allowed heat transmission coefficient, U [W/m².K], for elements of new buildings and after reconstruction of existing buildings heated to a temperature of 18 °C or more, and heated between 12 °C and 18 °C (previous and current status).

Building element	Maximum U-values [W/m².K]							
	Technical regulation 2008				Technical regulation 2014			
	heated ≥ 18°C		12°C < heated < 18°C		heated ≥ 18°C		12°C < heated < 18°C	
	Cont.	Littoral	Cont.	Littoral	Cont.	Littoral	Cont.	Littoral
External walls	0.45	0.60	0.75	0.75	0.30	0.45	0.50	0.60
Transparent facade elements (frame)	1.80	1.80	3.00	3.00	1.40	1.80	2.50	2.80
Glazing only	/	/	/	/	1.10	1.10	1.40	1.40
Roofs	0.30	0.40	0.40	0.50	0.25	0.30	0.40	0.50
Ceilings above external air	0.30	0.40	0.40	0.50	0.25	0.30	0.40	0.50
Walls and ceilings of non-heated rooms	0.50	0.65	2.00	2.00	0.40	0.60	0.90	1.20
Floor	0.50	0.50	0.65	0.80	0.30	0.50	0.65	0.80
External doors	2.90	2.90	2.90	2.90	2.00	2.40	2.90	2.90
Ceilings and floors between apartments	1.40	1.40	1.40	1.40	0.60	0.80	1.20	1.20

The maximum allowed heat transmission coefficient values for single parts of the building were tightened by approximately 20% as compared to those prescribed in 2008.

I.ii. Format of national transposition and implementation of existing regulations

The Building Act (Official Gazette 153/2013) has overridden two previous acts in which the transposition and implementation of the EPBD had been divided (the Act on Energy End-use Efficiency, in part related to energy efficiency in buildings, and the Physical Planning and Building Act). It has also amended subordinate regulations that were adopted earlier. Finally, the Building Act has provided a unique basis for full transposition of the EPBD. The subordinate regulations are:

> the Technical regulation on rational use of energy and heat retention in buildings (OG 97/2014 and 130/2014);

> the Ordinance on energy audits of buildings and energy certification (OG 48/2014);

> the Ordinance on requirements and criteria for persons performing energy audits of construction works and energy certification of buildings (OG 81/2012 and 64/2013);

> the Ordinance on the control of Energy Performance Certificates (EPCs) of buildings and of reports on energy audits of construction works (OG 81/2012 and 79/2013);

> the methodology for carrying out energy audits of construction works with the algorithm for calculating the energy performance of buildings (June 2014).

The national methodology includes the algorithm for calculating the energy performance of buildings. The algorithm is based on CEN standards, except in individual cases where CEN standards were not appropriate, in which case other solutions were used (e.g., the application of the roof standard, ventilation and AC). The algorithm includes five parts according to the following calculation fields:

> energy needs for space heating and cooling in buildings according to HRN EN ISO 13790;

> energy requirements and efficiency of thermal technical systems in buildings (systems for space heating and DHW);

> energy requirements and efficiency of thermal technical systems in buildings (cogeneration systems, district heating systems, photovoltaic systems);

> energy requirements and efficiency of lighting systems in buildings;

> energy requirements for the application of ventilation and AC systems for space heating and cooling in buildings.

For the purposes of primary energy calculation, a set of primary energy conversion factors were determined (Table 4). Their calculation used three-year average data from actual annual energy balances of Croatia in 2009-2011 (determined according to EUROSTAT's Methodology for Energy Balances).

Energy source	Primary energy factor				Emission t_{CO_2}/TJ (kg_{CO_2}/GJ)
	Total	Renewable component	Non-renewable component	Imported component	
Lignite	1.082	0.0001	1.081	0.0001	105.13
Fuelwood	1.111	1.0001	0.111	0.0001	8.08
Wood pellets	1.191	1.0364	0.123	0.0322	9.56
Wood chips	1.211	1.0303	0.154	0.0268	11.76
Solar energy	1.048	1.0130	0.024	0.0115	1.96
Geothermal energy	1.211	1.0933	0.080	0.0383	6.52
Natural gas	1.097	0.001	1.095	0.001	61.17
Fuel oil	1.132	0.001	1.130	0.001	86.20
Electric energy	1.614	0.433	0.798	0.383	65.22
District heating Croatia - average	1.523	0.022	1.494	0.008	100.69

Table 4: Primary energy factors.*

*Only the non-renewable component is used for calculating the energy performance of buildings. These factors are applied as of 1 October 2014.

I.iii. Cost-optimal procedure for setting energy performance requirements

A cost-optimal analysis was carried out for the following building types: single-family houses, apartment blocks, offices, educational buildings, hospitals, hotels and restaurants, sports facilities and wholesale and retail trade buildings. When carrying out cost-optimal analyses, the global cost has been calculated for every building type variant. The sensitivity analysis has been carried out with regard to changes of discount rate, inflation rate, market interest rate, cost of CO_2 emissions and growth rate of energy costs.

Data on the lifecycle of components and technical systems were determined pursuant to Standard EN 15459:2007, Energy performance of buildings - Economic evaluation procedure for energy systems in buildings. For those systems and components not covered by the standard, data from good engineering practices in Croatia were used. The microeconomic and macroeconomic cost-optimal analysis has been carried out pursuant to the EU Regulation 244/2012, fully pursuant to Standard EN 15459:2007.

The average performance of the building stock that constitutes the basis for the reference buildings is not applicable to NZEBs because the current average building cannot become NZEB according to the cost-optimal analysis, even with major refurbishments. Uniform input parameters for the selection of the necessary level of thermal insulation of the external envelope were achieved by optimising the building concept with regard to solar energy capture and protection from excessive solar gains. The differences in the investment cost for different thermal insulation levels are negligible in relation to the total cost and do not have a significant role in determining the optimal level. The relations between technological solutions of the system are mostly fixed, regardless of the thermal performance of the external envelope; as in all cases, this refers to a necessary small effect of the heating and cooling systems that operates during the peak load regimen during a very small share of time.

A comparison of the cost-optimal analysis in relation to the existing regulations cannot be given, since at the time of the studies, energy needs for heating had not been particularly regulated for each building type, and primary and final energy had not been regulated at all. The results of the cost-optimal study with regards to maximum energy consumption for each building type expressed as energy needs for heating ($Q_{H,nd}$), primary energy (E_{prim}) and final energy (E_{del}) are listed in Tables 5 and 6. Relevant requirements shall be set with the new technical regulation of 2015.

Table 5: Maximum allowed requirements for new buildings heated to a temperature of 18 °C or more.

New buildings Building type	$Q_{H,nd}$ [kWh/m².year]						E_{prim} [kWh/m².year]		E_{del} [kWh/m².year]	
	Continental			Littoral			Cont.	Litt.	Cont.	Litt.
	$f_0 \le 0.20$	$0.20 < f_0 < 1.05$	$f_0 \ge 1.05$	$f_0 \le 0.20$	$0.20 < f_0 < 1.05$	$f_0 \ge 1.05$				
Single-family houses	40.50	$32.39 + 40.58 \cdot f_0$	75.00	24.84	$17.16 + 38.42 \cdot f_0$	57.50	115	70	80	50
Apartment blocks	40.50	$32.39 + 40.58 \cdot f_0$	75.00	24.84	$19.86 + 24.89 \cdot f_0$	45.99	120	90	80	60
Offices	16.94	$8.82 + 40.58 \cdot f_0$	51.43	16.19	$11.21 + 24.89 \cdot f_0$	37.34	70	70	40	40
Educational buildings	11.98	$3.86 + 40.58 \cdot f_0$	46.48	9.95	$4.97 + 24.91 \cdot f_0$	31.13	65	60	60	60
Hospitals	18.72	$10.61 + 40.58 \cdot f_0$	53.21	46.44	$41.46 + 24.89 \cdot f_0$	67.60	300	300	220	220
Hotels and restaurants	35.48	$27.37 + 40.58 \cdot f_0$	69.98	11.50	$6.52 + 24.89 \cdot f_0$	32.65	130	80	90	50
Sports facilities	96.39	$88.28 + 40.58 \cdot f_0$	130.89	37.64	$32.66 + 24.91 \cdot f_0$	58.82	400	170	290	110
Wholesale and retail trade services buildings	48.91	$40.79 + 40.58 \cdot f_0$	83.40	13.90	$8.92 + 24.91 \cdot f_0$	35.08	450	280	290	170
Other non-residential	40.50	$32.39 + 40.58 \cdot f_0$	75.00	24.84	$19.86 + 24.89\, f_0$	45.99	150	100	/	/

Table 6: Maximum allowed requirements for major refurbishments of buildings heated to a temperature of 18 °C or more.

Major refurbishment Building type	$Q_{H,nd}$ [kWh/m².year]						E_{prim} [kWh/m².year]		E_{del} [kWh/m².year]	
	Continental			Littoral			Cont.	Litt.	Cont.	Litt.
	$f_0 \le 0.20$	$0.20 < f_0 < 1.05$	$f_0 \ge 1.05$	$f_0 \le 0.20$	$0.20 < f_0 < 1.05$	$f_0 \ge 1.05$				
Single-family houses	50.63	$40.49 + 50.73 \cdot f_0$	93.75	27.00	$19.24+38.82 \cdot f_0$	60.00	135	80	120	60
Apartment blocks	50.63	$40.49 + 50.73 \cdot f_0$	93.75	27.00	$21.59 + 27.06 \cdot f_0$	50.00	180	130	120	85
Offices	21.18	$11.03 + 50.73 \cdot f_0$	64.29	17.60	$12.19 + 27.06 \cdot f_0$	40.60	75	75	40	40
Educational buildings	14.98	$4.84 + 50.73 \cdot f_0$	58.10	10.81	$5.40 + 27.06 \cdot f_0$	33.83	90	75	60	60
Hospitals	23.40	$13.26 + 50.73 \cdot f_0$	66.51	50.48	$45.06 + 27.06 \cdot f_0$	73.48	340	330	250	230
Hotels and restaurants	44.35	$34.21 + 50.73 \cdot f_0$	87.48	12.50	$7.09 + 27.06 \cdot f_0$	35.50	145	115	90	80
Sports facilities	120.49	$110.35 + 50.73 \cdot f_0$	163.61	40.91	$35.50 + 27.06 \cdot f_0$	63.93	420	215	295	190
Wholesale and retail trade services buildings	61.14	$50.99 + 50.73 \cdot f_0$	104.25	15.11	$9.71 + 27.06 \cdot f_0$	38.13	475	300	290	185
Other non-residential	50.63	$40.49 + 50.73 \cdot f_0$	93.75	27.00	$21.59 + 27.06 \cdot f_0$	50.00	180	130	/	/

I.iv. Action plan for progression towards Nearly Zero-Energy Buildings (NZEBs)

Calculations were carried out for cost-optimal levels of minimum energy performance requirements for all types of buildings during 2013 and 2014. Furthermore, NZEB definitions were proposed and implemented in the technical regulations OG 97/2014 and 130/2014 for all types of buildings.

The primary energy needs for NZEBs (Table 7) have been established as the lowest primary energy value among the analysed systems, as long as they do not correspond to a high global cost. Thereby it is ensured that for NZEBs, technically feasible solutions are determined.

The least-cost measures have been determined by cost-optimal analysis; therefore the optimal level of energy consumption of buildings has been determined. In contrast, in determining the requirements for NZEBs, the solutions with the lowest primary energy have been chosen with no criteria for the global cost size.

At least 30% of the annual primary energy must be covered from RES generated on-site (i.e, at the building or in its vicinity).

All new buildings that are under construction must comply with the NZEB standard by 31 December 2020, and all new buildings owned or occupied by public authorities must have NZEB performance after 31 December 2018. Increasing the number of NZEBs is planned to be achieved by stimulating construction through programmes for the energy renovation of buildings (four programmes according to building type).

The number of low-energy and passive buildings increases in Croatia on a yearly basis and in particular for single-family houses (Table 8). By December 2014, there were a total of 22 buildings (of which 3 apartment blocks) with energy class A⁺, representing an energy consumption for heating ($Q_{H,nd}$) under 15 kWh/m².year. Although the detailed national application of the NZEB definition took place in November 2014 and no NZEB according to that regulation has been built yet, examples of existing buildings that already fulfil the envisaged NZEB requirements can be provided. The multi-family building "*Šparna hiža*" (in the local dialect, the name for a low-energy house) in the city of Koprivnica, was designed at the level of energy class A⁺ with a final energy consumption for heating being less than 15 kWh/m².year, with the total final energy consumption amounting to 33.66 kWh/m².year, and with a renewable solar energy source.

Table 7: Maximum primary energy for NZEBs by building type (Technical regulation 2014 current status).

NZEB Buildings categories	**E_{prim} [kWh/m².year]**	
	Continental climate	Littoral climate
Single-family houses	40	30
Apartment blocks	80	50
Offices	30	25
Educational buildings	55	50
Hospitals	200	190
Hotels and restaurants	80	65
Sports facilities	190	100
Wholesale and retail trade services buildings	170	140

Figure 2:
First Šparna hiža in Koprivnica.

Figure 3:
Third Šparna hiža in Koprivnica.

Table 8:
The planned annual increase in NZEBs according to the National Action Plan to increase the number of NZEBs by 2020 (published in 2014).

Building categories	**NZEBs annually target [m²]**	**Approximate number of NZEBs***	**Specific additional NZEBs cost in relation to the new buildings [€/m²]**	
			Continental climate	Littoral climate
Single-family houses	63,000	400	127	87
Apartment blocks	90,700	200	244	159
Offices	19,736	6	71	19
Educational buildings	3,612	2	118	205
Hospitals	4,723	2	66	118
Hotels and restaurants	14,630	2	7	50
Sports facilities	1,428	1	144	255
Trade services buildings	20,879	6	38	70

* The approximate number of buildings based on the estimated useful floor area for each type of building in the cost-optimal studies can therefore vary according to the real size of the constructed building.

I.v. Implementation of the Energy Efficiency Directive (EED) regarding building renovation and the exemplary role of public buildings

The long-term strategy for mobilising investment in renovating the national building stock in Croatia was published in the Official Gazette on June 2014. The strategy's main objective is to identify, on the basis of the established optimal economic and energy model for building renovation, effective measures for long-term mobilisation of cost-effective deep renovation of the building stock in the Republic of Croatia by 2050, including all buildings from the residential and non-residential sectors. The strategy deals with several topics: an overview of the national building stock of the Republic of Croatia, analysis of key elements of the building renovation programme, policies and measures to stimulate cost-effective deep renovations of buildings, a forward-looking perspective to guide individual investment decisions, the construction industry and financial institutions up to 2050, and an evidence-based estimate of expected energy savings and wider benefits based on calculations and model data, including wider economic benefits from energy savings, and improved housing and quality of work.

When selecting measures aimed at increasing energy efficiency, along with renovating the external building envelope pursuant to the technical regulations and overall building renovation pursuant to passive, as well as active building standards, the introduction of systems using RES were also concurrently considered to the highest possible extent, with as aim to meet the requirements from Article 9 of the EPBD, which prescribes the approximation of the building/renovation standards of NZEBs.

Achieving the objectives of energy renovation according to NZEB standards, requires significant funds for investment and operational costs, estimated at nearly 7 billion € up to 2050. With the proposed dynamic of energy renovation, the total reduction of CO_2 emissions by 2020 will be 87.22%. The sources of financing currently available are not sufficient to realise the set goals, so new, innovative financing mechanisms are proposed, which combine public and market instruments customised so that a wide range of investors are introduced. Structural and investment funds of the European Union will represent the primary source of funds for the removal of barriers in the financial sector, and will gradually allow more involvement of

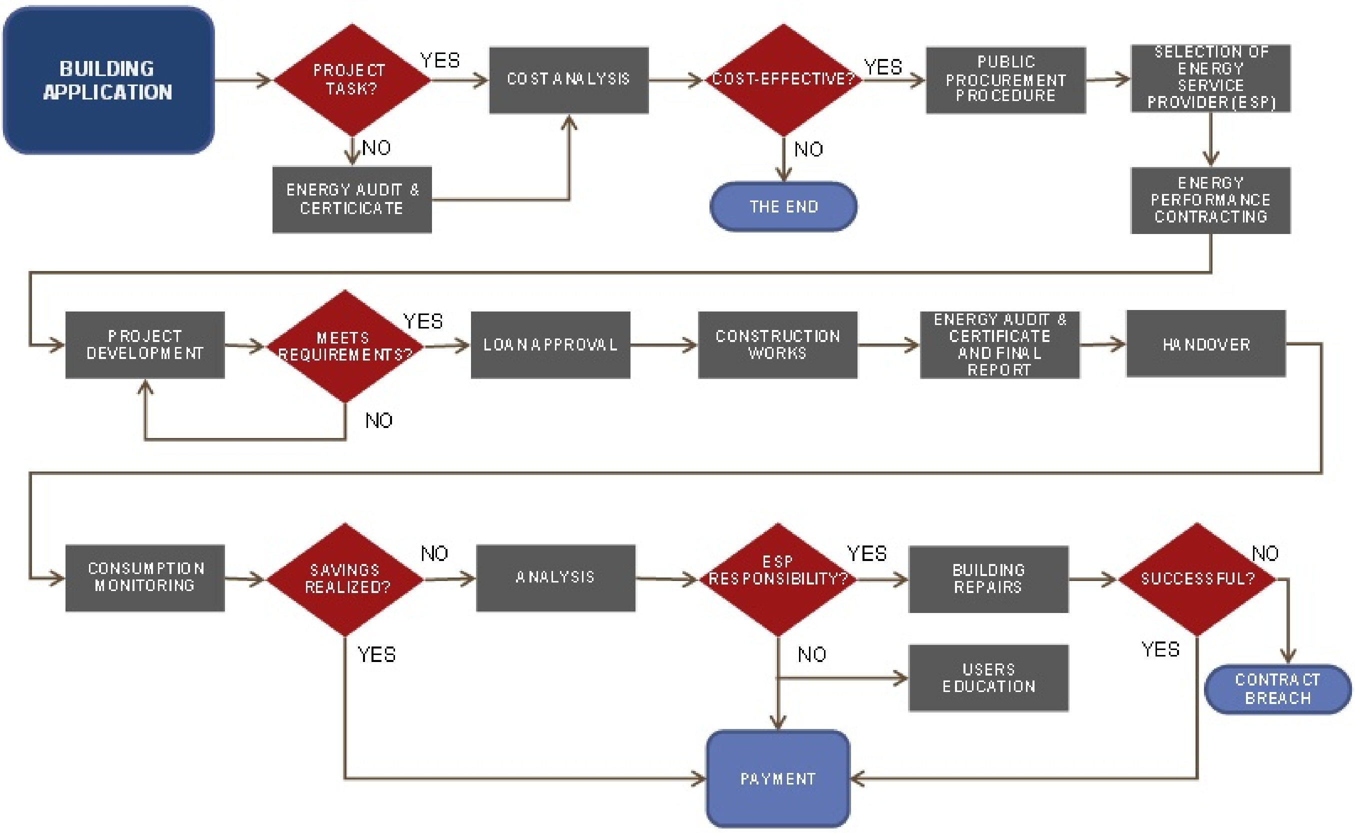


Figure 4: Energy renovation of public sector buildings flowchart according to the Programme for energy renovation of public sector buildings 2014-2015.

financial institutions and private investors in the energy services market. The required energy saving level in central government buildings (774 buildings with 1,325,000 m^2), pursuant to the EED, must be achieved through an alternative approach, in line with Article 5 of the EED. The annual savings (equivalent to renovating 3% of the buildings owned and occupied by the central government) have been calculated to reach 1,36 GWh (4,89 TJ) per year. This consumption corresponds to approximately 17 buildings being renovated annually, and represents 0.0045% of the total final consumption within all buildings in 2012 (ca 29,777.78 GWh).

The Programme for the energy renovation of public sector buildings promotes the complete reconstruction of the building, which therefore includes measures for the building envelope and for technical systems. For these measures, private capital investment is used, with no extra cost to the state budget. The programme envisages the energy renovation of existing buildings in which profitability is established, or for building a new building in which the provider of energy services can offer the energy savings provided by the project. All the costs, including the costs of maintenance, design, financing and other costs, must be appropriate to compensate for the fee paid by the client. To be included in the programme, the building must meet the following criteria:

1. the building has a large annual energy consumption (usually > 200 kWh/m^2);
2. the building is not part of a complex, and the energy consumption can be clearly separated from the neighbouring buildings;
3. the building has no non-compliances in terms of other essential requirements of building;
4. the building is not protected as cultural heritage, because that could raise the investment costs and the pay-back period over 14 years.

I.vi. Other relevant plans

Although financial institutions have developed market models with more favourable loan conditions for energy efficiency projects, in this sector the role of the government continues to be crucial for the success of the implementation. For this reason, the MCPP launched the development of energy renovation programmes for four identified building purposes (public, commercial, multi-residential and family houses). Four programmes for energy renovation of buildings were adopted:

> The Programme for energy renovation of public sector buildings 2014-2015, as described in connection to implementation of Article 5 of the EED.

  This programme regulates the procedure of carrying out energy services in the public sector in such a way that the private sector plays the role of energy services provider, and the cost-effectiveness of the investment is supported by grants of the Environmental Protection and Energy Efficiency Fund, privileged loans of the Croatian Reconstruction and Development Bank, and guarantees of the Croatian Agency for SMEs, Innovations and Investments Agency.

> The Programme for energy renovation of family houses 2014-2020 and the Programme for energy renovation of multi-residential buildings 2014-2020.

  These programmes provide co-financing for energy renovation of family houses and multi-residential buildings with funds from the Environmental Protection and Energy Efficiency Fund, EU structural instruments and budgets of local and regional self-government units.

> The Programme for energy renovation of commercial buildings 2014-2020.

  This programme provides co-financing of energy renovation of commercial purpose buildings with the following financial mechanisms foreseen:

  - establishment of revolving funds following the JESSICA model;
  - introduction of priority measures of energy efficiency renovation within the framework of operative programmes for the use of funds from EU structural instruments;
  - introduction of legal obligations to energy suppliers to achieve energy savings of their customers;
  - continuous implementation of programmes and projects of the Environmental Protection and Energy Efficiency Fund.

II. REQUIREMENTS FOR TECHNICAL BUILDING SYSTEMS(TBS)

II.i. Coverage of heating, domestic hot water, air-conditioning and large ventilation systems

Requirements for technical systems are prescribed in the Technical regulation on rational use of energy and heat retention in buildings. The designed and installed heating systems in new buildings must compensate for heat losses in order to maintain indoor thermal comfort. Amongst other requirements, a heating system must have thermally insulated pipework, low design temperature (e.g., ≤ 60 °C, recommended ≤ 40 °C) of the heating medium (e.g., water) and a balanced regulation of indoor temperature in the building. The energy efficiency of the system for DHW is met by the selection of heat generation equipment (through tanks or instantly), energy efficient distribution and balanced regulation of the systems in the building.

In case of the reconstruction of the technical system in existing buildings, such as replacements of heat generators, energy fuel, central ventilation units, lighting systems, etc., the requirements for the technical regulation relating to the new building are applied if the total cost of the reconstruction exceeds 25% of the technical system value. If reconstruction does not exceed 25% of the technical system value, the energy efficiency of the building must not be lowered, and the system must at least have the technical characteristics that it had before reconstruction (existing technical characteristics). The Technical regulation for heating and cooling systems in buildings determines the requirements for energy performance, design elements, installation, fitness for purpose, maintenance, etc. The Technical regulation on ventilation, partial air-conditioning and conditioning systems in buildings prescribes the technical performance of ventilation, partial AC and AC systems in buildings, as well as the requirements for their design, execution, fitness for use, maintenance, and other requirements for these systems.

II.ii. Regulation of system performance, distinct from product or whole building performance

The regulations indicate that new residential buildings comprising more than 3 residential units must be equipped with a centralised heat generation system. This is not required under the following circumstances:

> for buildings connected to a district heating system;
> for buildings with gas-fired heating systems;
> for buildings equipped with heating systems with air/air heat pumps, if the seasonal heating factor of individual heat pumps is SCOP ≥ 4.0;
> for buildings equipped with heating systems with air/water, water/water and soil/water heat pumps, if the seasonal heating factor of individual heat pumps is SPF ≥ 3.0. This seasonal factor includes the heat pump, regulation, auxiliary heating unit and other parts of the system, such as pumps and ventilators on the side of the heat storage tank;
> when the annual thermal energy needs for heating per surface area unit of the useful building floor area $Q''_{H,nd}$ (KWh/m^2.year) in which a controlled temperature is maintained does not exceed 15 kWh/m^2.year.

There are no specific requirements for heating systems in non-residential buildings. The technical regulation requires the use of a centralised heat generation system in residential buildings, because they generally have more than one owner (e.g., dwellings in apartment building), so this reduces private investment and additional costs for each owner in every building unit separately. This problem does not occur in non-residential buildings, because non-residential buildings typically have one owner who provides a centralised heat generation system for the entire building.

The air change rate of indoor air in buildings where persons stay or work shall be at least 0.5 h^{-1}. At the time when the building is unoccupied, an air change rate of at least 0.2 h^{-1} should be provided. The lowest air change rate shall be higher in individual parts of the building if necessary for the purpose of avoiding threats to hygiene and health conditions, and/or due to the use of open-flame heating and/or cooking devices. If it is not possible to ensure natural air ventilation that meets the requirements for the prescribed air quality, hybrid or mechanical ventilation should be designed. For multi-family residential buildings, airtightness requirements must be fulfilled for each apartment. For non-residential buildings, airtightness requirements must be fulfilled for the building envelope.

When installing a new forced ventilation or AC system, or in case of an extensive reconstruction of the existing one, the specific fan power must be at least class I according to HRN EN 13779:2008: SFP < 500 W/(m^3/s).

Heat recovery must be provided if the building (residential or non-residential) meets all the following requirements:

> it is ventilated by a mechanical device;

> the air exchange rate exceeds 0.7 h^{-1}, in line with the intended use of the building;

> the outdoor air flow rate exceeds a total of 2,500 m^3/h (694 l/s).

If heat recovery is installed, then it must comply with the following minimum efficiency (η) requirements:

> heat recovery circulation system: total η ≥ 0.55 (application only in case of separate installation of the pressure and extraction ventilation unit);

> other heat recovery systems: total η ≥ 0.70.

Building automation and control systems include products, software and technical services for automatic regulation, supervision and optimisation, human intervention and control. They are calculated pursuant to the HRN EN 15232:2012 standard. Four system efficiency classes are established: A, B, C and D, with class A relating to buildings with a highly efficient system, and class D referring to non-efficient systems. In new and existing buildings that are undergoing renovation, the designed automation and control system must be of A, B or C efficiency class (Table 9).

II.iii. Provisions for installation, dimensioning, adjustment and control

There are a series of technical measures for heat distribution elements in a building that must be fulfilled when designing a new system or during major refurbishment of existing systems. A heating element supplying heat to a room must have a heat regulator installed (e.g., a thermostatic radiator valve in the central heating system) if the usable surface area of the net floor area of a room exceeds 6 m^2.

New and refurbished systems providing heating and DHW must include pipework insulation. The minimum thermal insulation thickness must be:

> 2/3 of the pipe diameter, and not exceeding 100 mm for conduits or fittings in a non-temperature-controlled building area;

> 1/3 of the pipe diameter, and not exceeding 50 mm for conduits or fittings inside the walls and grooves of the intermediate structure, at the conduit intersection, near central heating medium distributors;

> 1/3 of the pipe diameter, and not exceeding 50 mm for conduits or fittings in a temperature-controlled building area;

> 6 mm if acoustic insulation in the intermediate structure for conduits and fittings in the surface layer of the floor.

Thermal insulation is also necessary for heat accumulation tanks (at least 50 mm). When designing the construction of a new system or renovating an existing one comprising a heat storage tank (e.g., for DHW), the tank must be provided with at least a 50 mm thick insulation, so as to minimise thermal losses of connection pipes and fittings.

Requirements for sizing the system are set in the main design. Sizing, adjustment and control is carried out by an authorised designer in line with professional standards. The functionality of the technical system is tested according to the requirements in the project documentation before commissioning. In addition, the supervising engineer carries out the control of the whole construction according to the main design.

II.iv. Encouragement of active energy-saving control (automation, control and monitoring)

As indicated above, there are energy factors to be applied if the building includes automation controls (depending on the class). This also serves as an encouragement measure, e.g., in the Programme of energy renovation of public sector buildings. One of the criteria in the public procurement procedure includes automation of fuel and/or water consumption metering.

BACS class	Efficiency factor for heating and cooling energy				
	Residential buildings	Offices	Schools	Hospitals	Hotels
A	0.92	0.70	0.80	0.86	0.68
B	0.93	0.80	0.88	0.91	0.85
C	1.00	1.00	1.00	1.00	1.00
D	1.08	1.51	1.20	1.31	1.31

Table 9: Energy efficiency of automation and control – residential and non-residential buildings – heating and cooling.

III. ENERGY PERFORMANCE CERTIFICATES (EPCs) REQUIREMENTS

The Ordinance on energy audits of buildings and energy certification (OG 48/2014) prescribes, amongst others, the method of energy certification, the content and form of the EPC of buildings, energy management in buildings, and the establishment of measures for improving energy efficiency in buildings.

III.i. Progress and current status on sale or rental of buildings

Overview and administration system

An EPC is mandatory as of July 2013 for the sale of a building or a building unit. Energy certification is preceded by the energy audit mandatory for new buildings prior to permit issuance, for existing buildings that are being sold, and for existing public buildings for which the display of EPCs is prescribed. Only those EPCs entered in the registry kept by the MCPP are valid. Currently there is no obligation to produce an EPC for renting out or leasing a building or a building unit. This obligation must apply from January 2016.

In order to produce an EPC, an energy audit of the building or building unit is required. The method of carrying out these energy audits is officially established in the Methodology for carrying out energy audits of buildings. Energy audits of independent building units (apartments or offices) must include the following actions:

> on-site inspection and data gathering on the energy performance of the building, its technical systems, the effective regimen and parameters of building use and the actual consumption of energy and water (over the last three years bills);
> analysis of the building energy performance and its technical systems;
> analysis of the existing energy management;
> energy calculation (demand, final, primary) according to algorithms and standardised regimen of use, for real and reference climatic data;
> development of an energy balance and models according to the actual use (control on the basis of gathered bills);
> proposal of economically justified measures for improving the energy performance of an independent building unit, and general recommendations for the building if energy generation is centralised - calculated on the basis of the actual manner of the use of the independent building unit.

Upon having performed the energy audit and the energy audit report, the EPC is prepared which includes a proposal for measures to improve the energy efficiency of these systems or the application of alternative solutions.

EPCs are valid for a period of 10 years. In case of reconstruction that affects the energy class, the new EPC can be issued before the expiration of 10 years. For buildings that are included in the energy renovation programmes (regardless of whether it is minor or major refurbishment), energy certification after renovation is mandatory, as well as the calculation of achieved energy savings in relation to pre-renovation.

How flats are certified in apartment buildings

For new multi-residential buildings, prior to the issuance of the use permit, a single EPC is prepared for the entire building. It is also possible to have an EPC additionally issued for an individual building unit, if requested by the investor. In such a case, for this individual building unit, the separately issued EPC is also valid. When individual building units are sold, then only the specific building unit on sale will require a certification. As indicated before, the obligation of obtaining an EPC when renting out or leasing a flat must also be applied as of 1 January 2016.

Format and content of the EPC

EPCs of residential and non-residential buildings contain 5 pages. The first page indicates the energy class that is highlighted and data on the authorised person who prepared the certificate. The energy class is expressed as energy needs for space heating $Q_{H,nd}$. The second page contains climatic data, data on technical systems, the thermal characteristics of the individual envelope elements, the energy needs of the building (annual demand for heating, DHW preparation, ventilation, lighting), the total annual delivered and primary energy, and carbon dioxide emissions.

The third page contains a proposal of measures for improving the energy performance of the building, including instructions to the occupant on where more detailed information on energy efficiency improvement measures is available. In case of new buildings, the third page also includes recommendations to the new building owner concerning the use of the building in order to achieve the designed energy consumption. The fourth and fifth pages contain explanations of technical terms and a list of applied regulations and standards.

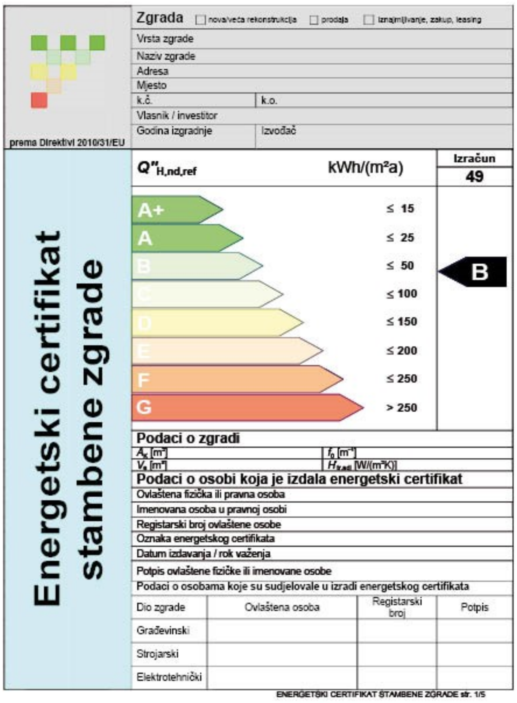
The energy class is expressed as specific thermal energy needs for heating ($Q_{H,nd}$) in the reference climate (continental or littoral).

The relative value of the annual thermal energy needs for heating for non-residential buildings, $Q_{H,nd,rel}$ [%], is the ratio of the specific annual energy needs for heating for reference climatic data, $Q'_{H,nd,ref}$ [kWh/m³.year] and the permitted specific annual energy needs for heating for reference climatic data, $Q'_{H,nd,dop}$ [kWh/m³.year], and is calculated according to the following expression:

$$Q_{H,nd,rel} = Q'_{H,nd,ref} \;/\; Q'_{H,nd,dop} \times 100\ [\%].$$

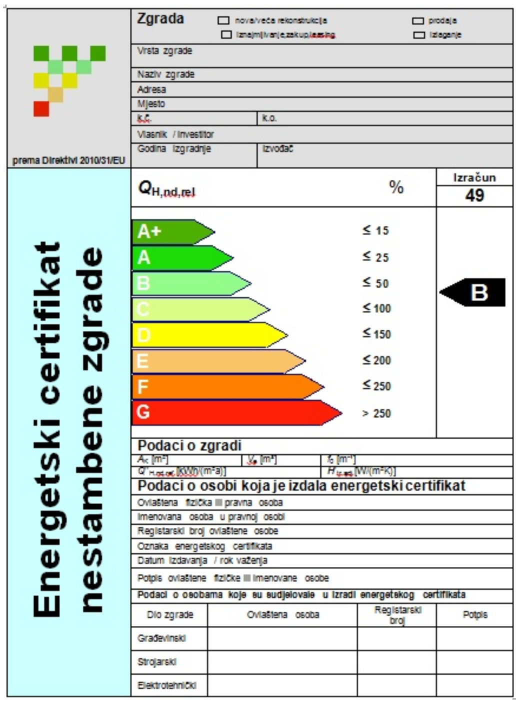
A special format of EPC is established for other non-residential buildings that are heated to a temperature between 12°C and 18°C and in which energy is used to achieve certain conditions. For these types of buildings, no energy class is stated, but a proposal of measures is also given to improve the energy performance (e.g., warehouses, production facilities, workshops, garages, etc.).

Figure 5:
EPC of a residential building – first page.



NOTE: Energy classes of residential buildings are expressed as $Q''_{H,nd,ref}$ – specific annual energy needs for heating for reference climatic data in kWh/m².year according to the following scale:

A+	≤ 15
A	≤ 25
B	≤ 50
C	≤ 100
D	≤ 150
E	≤ 200
F	≤ 250
G	> 250



NOTE: Energy classes of non-residential buildings are expressed as $Q_{H,nd,rel}$ – relative value of the annual thermal energy needs for heating expressed in % and according to the following scale:

A+	≤ 15
A	≤ 25
B	≤ 50
C	≤ 100
D	≤ 150
E	≤ 200
F	≤ 250
G	> 250

Figure 6:
EPC of a non-residential building – first page.

Figure 7:
EPC of other non-residential buildings – first page.

EPC activity levels

Since first issued in 2010, there has been an increasing growth in the number of EPCs, both for new and existing buildings, especially from July 2013 onwards. As of December 2014, there are a total of 64,560 EPCs for both new buildings (12,260) and existing buildings (52,300). This also includes EPCs for the purpose of display in public buildings.

Classes B and C are prevailing in new buildings, and C and D in existing ones. In addition, new buildings have less EPCs with a low energy class and more with a high energy class, whereas in existing buildings, there is a reversed situation.

Figure 8: Issued EPCs.

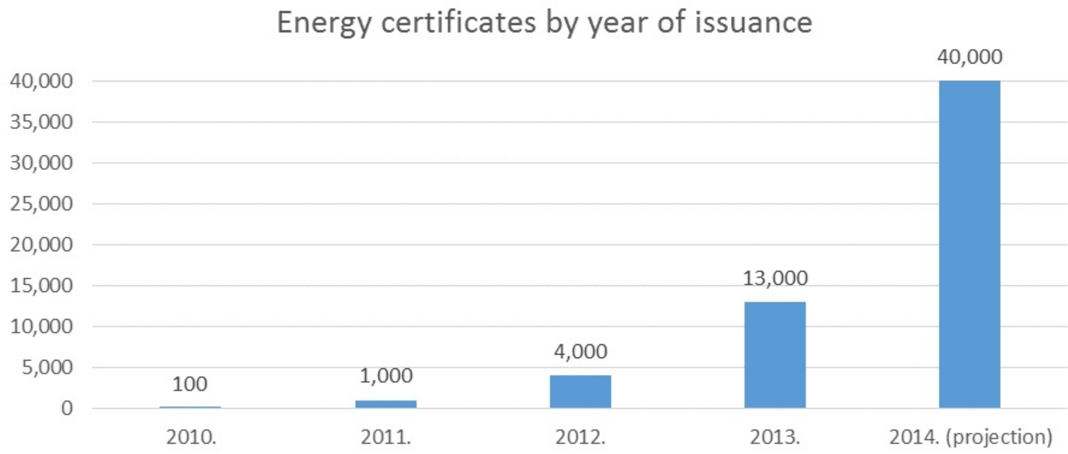


Figure 9: Issued EPCs comparative overview.

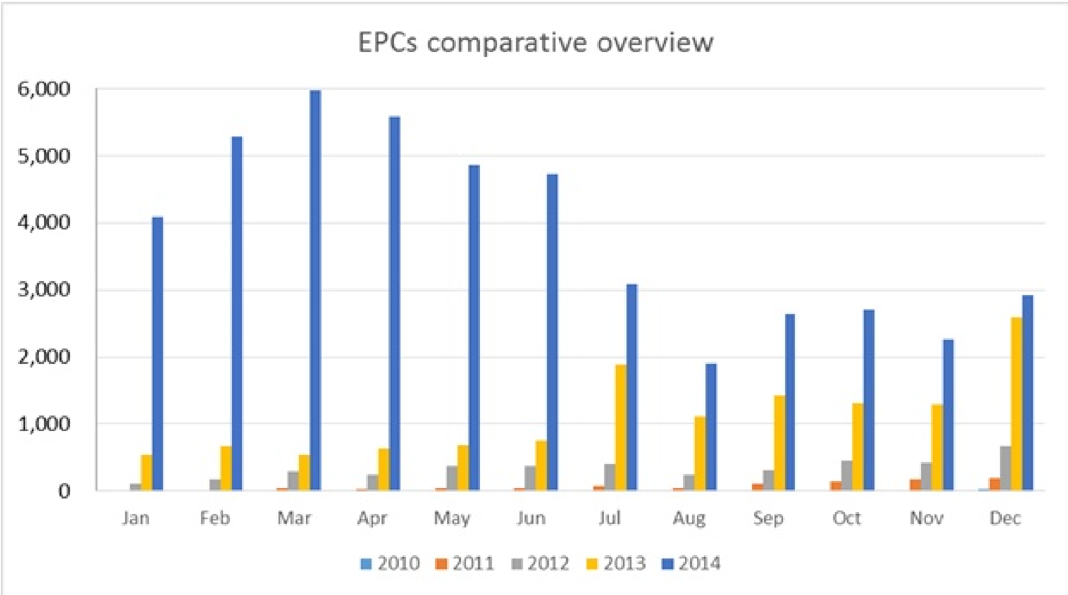


Figure 10: Issued EPCs by type of building: residential and non-residential.

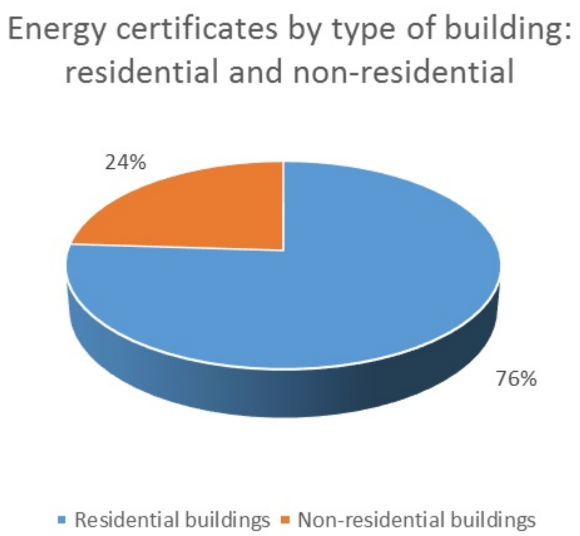
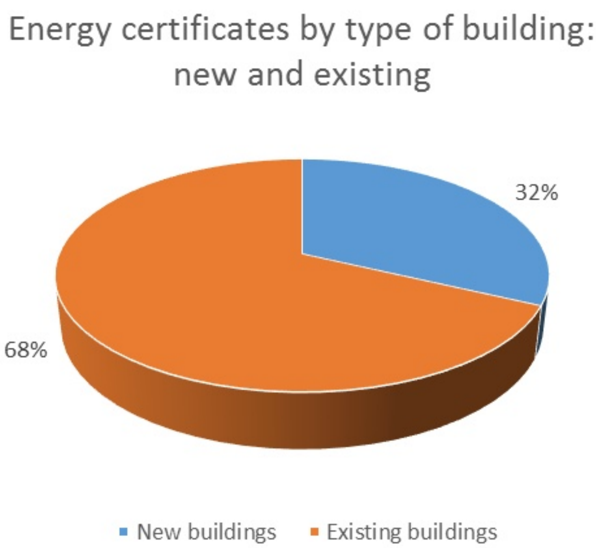


Figure 11: Issued EPCs by type of building: new and existing.



Considering all the certified buildings together, the common class is C, so this represents the average energy class for the building stock in Croatia. Nearly a quarter of the issued EPCs are in Zagreb. In addition, more developed counties have more issued EPCs, and vice versa.

Typical EPC costs

Initially, the maximum price for EPCs was prescribed for buildings and individual units in relation to their size. Since 2014, the Decision on maximum prices is no longer in force and price formation is market based.

The average market price of an EPC for an existing apartment in a building amounts to approximately 1,000 kuna (130 €). For entire buildings, the price depends on the complexity of technical systems, and the shape and size of the building. The price includes the costs of the energy audit, the preparation of the energy audit report and the preparation of the EPC, including the suggested measures for improving the energy performance of the building. The estimated average cost of an EPC for an average house (150 m^2) is approximately 2,000 kuna (270 €), and for an average apartment building (500 m^2) 5,000 kuna (670 €). For an average non-residential building (3,000 m^2), the cost varies very much depending on the building type (e.g., an office building is much cheaper than hospitals), but it can be estimated to cost, on average, about 15,000 kuna (2,000 €). The cost for EPCs experienced a decrease in 2013 due to an increasing number of authorised persons.

Assessor corps

The requirements for persons issuing EPCs and carrying out regular inspections of heating systems, and cooling or AC systems in buildings are prescribed by the Ordinance on requirements and criteria for persons performing energy audits of construction works and energy certification of buildings (OG 81/2012 and 64/2013).

Energy certification of buildings is performed by both authorised natural and legal persons. Authorisation is granted by the MCPP for:

> energy audits and certification of buildings with a simple technical system (natural and legal persons);

> energy audits of buildings with a complex technical system (natural and legal persons);

> energy certification of buildings with a complex technical system (legal persons).

Figure 12:
Issued EPCs by classes - existing buildings.

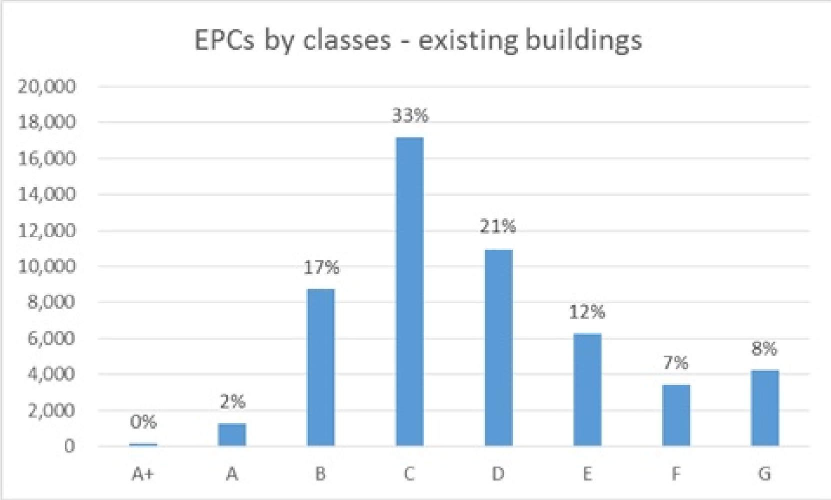


Figure 13:
Issued EPCs by classes - new buildings

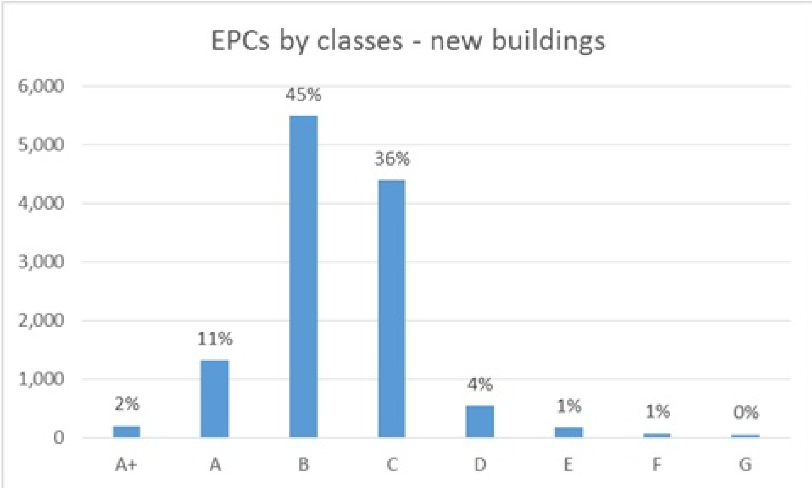
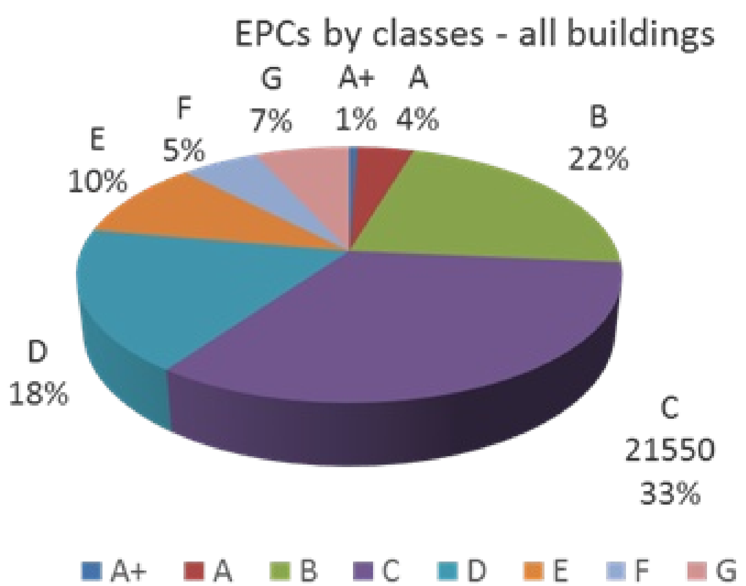


Figure 14:
Issued EPCs by classes - all buildings.



The authorisation to audit and certify complex systems also authorises the audit and certification of simpler systems.

The energy audits of buildings with a complex technical system (a requirement for EPCs), must be carried out by authorised persons:

> for the mechanical part of the building, a person qualified in the field of mechanical engineering;
> for the construction part of the building, a person qualified in the field of architecture or civil engineering;
> for the electrical engineering part of the technical system, a person qualified in the field of electrical engineering.

Figure 15: Authorised persons according to qualification.

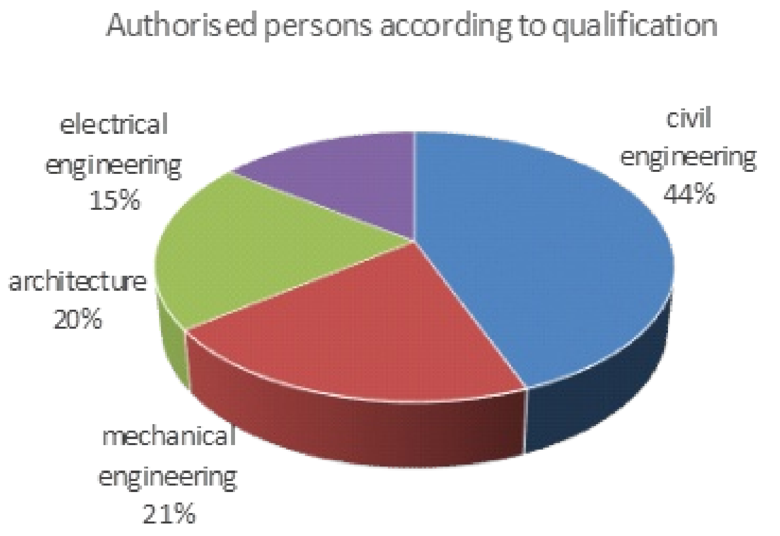
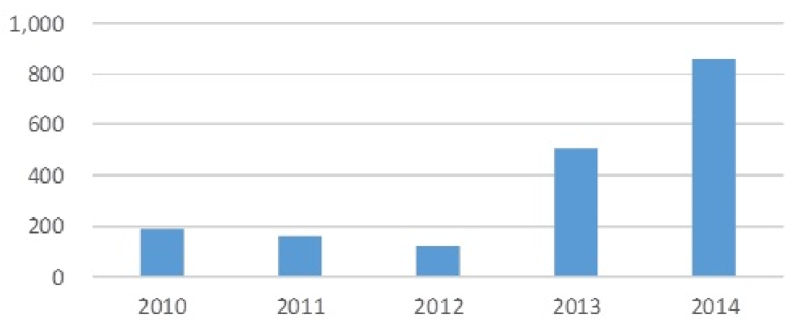


Table 10: Accreditations for simple and complex technical systems by the end of December 2014.

	Simple technical systems – Module 1	Complex technical systems – Module 2	Total
Natural persons	663	277	940
Legal persons	204	529	733
Total	867	806	1,673

Figure 16: Authorised persons according to first accreditation.



The EPC must be signed by the person authorised to issue EPCs and by all persons who participated in the energy audit.

The authorisation is granted for a period of 5 years, whereupon it can be extended for the same period. The requirements for authorisation include a completed graduate university study in the field of architecture, civil engineering, mechanical engineering or electrical engineering, and 5 years of professional working experience. The requirements also include the successful completion of the appropriate professional training programme carried out by authorised institutions (Module 1 and Module 2). The training programme consists of two modules, one following up the other, and a Continuous Development Programme (CPD). Module 1 enables authorisation for energy audits and certification of buildings with a simple technical system, and Module 2 enables authorisation for energy audits and certification of buildings with a complex technical system.

Module 1 has a duration of 40 hours and contains themes related to regulations (EU directives in the field of energy efficiency and national legislation transposing their provisions), themes from the field of building physics, on heating systems, electric lighting, on the methodology of carrying out energy audits and applying computer tools. Module 2 also has a duration of 40 hours. It builds on the themes of Module 1, but with additional themes, e.g., RES, alternative energy supply systems, cooling devices, regulation and automation systems in buildings, electric lighting in buildings, public lighting, etc. In Croatia, there are 13 regionally distributed institutions (faculties and professional organisations) that were granted authorisation for carrying out the training programme. By the end of December 2014, authorisation had been granted to 1,673 natural and legal persons (Table 10).

Compliance levels by sector

There are penalties prescribed by law for those owners who fail to provide an EPC at sale, if they fail to deliver it to buyers, or if they fail to indicate the energy class in sale advertisements published in the media. Penalties are also established for authorised real estate brokers if - acting on behalf of their clients to which they provide brokerage services - they fail to include the energy class in the media advertisements. The prescribed fines for owners and real estate brokers amount to 15,000 to 30,000 kuna (approximately 2,000 - 4,000 €), for a legal person, and to

5,000 to 10,000 kuna (approximately 700 - 1,300 €), for owners and real estate brokers who are natural persons. No fine has been issued yet. The supervision of the compliance with this obligation is under the competence of the Ministry of Economy - market inspectorate.

Authorised persons have the obligation to submit the EPCs, together with the reports on performed energy audits, to the registry within 15 days from being issued. The fines prescribed for legal persons range from 30,000 to 45,000 kuna (approximately 4,000 - 6,000 €), and from 15,000 to 30,000 kuna (approximately 2,000 – 4,000 €) for natural persons. No fine has been issued yet.

Quality Assurance (QA) of EPCs

All issued EPCs undergo administrative controls during their entry into the data base (registry). Administrative control includes checking whether the EPC is made by a person with the appropriate authorisation, whether all the required files are submitted, whether the EPC is properly marked, etc.

The method of carrying out the control of EPCs is prescribed by the Ordinance on the control of EPCs of buildings and of reports on energy audits of construction works (OG 81/2012 and 79/2013). Persons authorised for carrying out the control of EPCs are legal persons who comply with the requirements regarding experience in providing EPCs. On this basis, 5 legal persons have been authorised to carry out controls.

Detailed quality control of 105 EPCs (84 residential building EPCs, 21 non-residential building EPCs) was carried out during the period of December 2013 to September 2014. This represents 0.2% of all the EPCs that were issued. The control included control of input data, accuracy of energy class calculations and proposed measures for improved energy performance of buildings. An EPC is declared invalid if it contains calculation results, input data or proposed measures with significant deviations (more than 30%). If an EPC is declared invalid, the information is published on the ministry’s website, the responsible expert must draft a new EPC free of charge, and a fine is imposed. The fines prescribed for legal persons range from 30,000 to 45,000 kuna (approximately 4,000 - 6,000 €), and from 15,000 to 30,000 kuna (approximately 2,000 - 4,000 €) for natural persons. In case several EPCs from the same authorised person are declared invalid, their authorisation may be revoked.

The result of carried out control shows that almost 15% of controlled EPCs are declared invalid, and others contain certain irregularities that do not affect the energy class. These results can be explained due to the very small sample of the controlled EPCs, and the fact that a significant amount of EPCs were controlled due to complaints, and not by random selection. Authorised persons have to issue a new EPC to replace the one declared invalid. Also, the misdemeanour proceedings for the imposition of fines were started. A further approximately 200 detailed quality control of EPCs began at the end of 2014, bringing the total sample of quality controlled EPCs to 0.5% of the total issued EPCs.

III.ii. Progress and current status on public and large buildings visited by the public

Overview

Public buildings, for which an EPC must be displayed, include several types: buildings used by public authorities for performing their activities (e.g., ministry buildings), buildings used for community living (e.g., nursing homes, student dorms) and non-residential buildings in which a number of people are present, or a larger number of people are provided a service (e.g., retail shops, hotels). These definitions may apply to an individual building or a part of a building.

All public buildings with a total useful floor area over 500 m^2 must display the EPC. From July 2015, this requirement also applies to public buildings with a total useful floor area over 250 m^2. Municipal services officers verify whether these EPCs are adequately displayed, by visiting the buildings and making a report. In case of non-compliance with the regulation, they shall ask the owner to display the EPC.

EPCs for public buildings are of the same format as that of non-residential buildings, and follow the same procedures (audit followed by issue of EPC). The assessors of public buildings also follow the same requirements as those for non-residential buildings. Out of the total issued building EPCs, 19% refer to public buildings, approximately 12,000. Public buildings account for approximately 90% of the non-residential EPCs. The costs for a public building EPC is the same as previously described for non-residential buildings (approximately 15,000 kuna or 2,000 €). EPCs are also valid over a period of 10 years. If measures are carried out on a building, whereby an improvement of the building energy performance is achieved, the EPC must be re-issued.

Fines for public building owners who fail to display the EPC are established by law and amount to 15,000 to 30,000 kuna (approximately 2,000 - 4,000 €) for legal persons, and 5,000 to 10,000 kuna (approximately 700 - 1,300 €) for natural persons. No fines have yet been issued. This obligation is commonly followed.

III.iii. Implementation of mandatory advertising requirement

As of January 2014, there is an obligation to indicate the energy class in sale advertisements published in the media (papers and other press, radio and television programmes, electronic publications, teletext, etc.). Portals that have the sole purpose of advertising and do not contain edited programme contents published daily or periodically by an electronic publication provider for purposes of public information and education, namely real estate portals, are not considered media. This obligation is commonly followed.

Figure 17: Clip from an animated film promoting energy certification.

Figure 18: Clip from an animated film promoting energy certification.

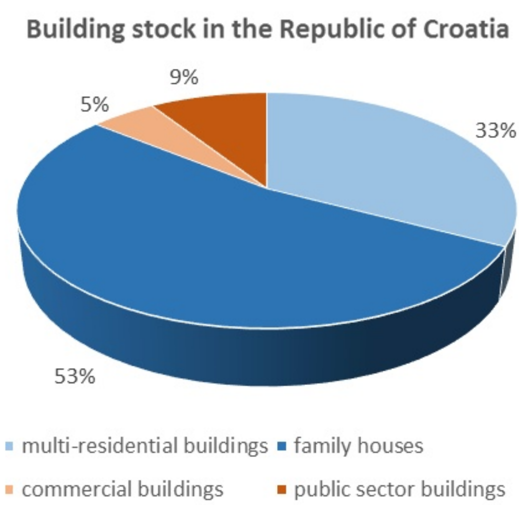


Figure 19: Building stock in Croatia.

III.iv. Information campaigns

In order to improve public information on the need and significance of the energy certification of buildings, a number of activities have been carried out. There are help desks providing information to citizens, and the ministry's official website provides additional information to citizens and authorised persons. For the purposes of promoting national programmes of energy renovation of buildings, workshops with interest groups were carried out, and additionally, an animated film covering the topic has been made and broadcast during 2013.

The Energy Efficiency and Environmental Protection Fund, within the scope of its activities, also supports energy efficiency programmes, including carrying out energy audits of buildings and preparing EPCs. In 2013, for the purposes of carrying out energy audits and presentation activities, 268,842.24 kuna (approximately 36,000 €), were spent, and in 2014, 5,082,547.27 kuna (approximately 678,000 €). For encouraging educational and information activities in the field of energy efficiency, 153,980 kuna (approximately 21,000 €) were spent in 2013 and 2,063,212.39 kuna (approximately 275,000 €) in 2014. In 2014, public tenders were carried out for co-financing of energy audits, production of EPCs, energy renovations, RES, or other energy efficiency projects in buildings (www.fzoeu.hr). These activities represent 34,029,783.01 kuna (approximately 4,537,000 €) in investments.

III.v. Coverage of the national building stock

According to several sources, the overall building stock in Croatia consists of 899,107 buildings (Table 11).

The residential building stock covers 86% of the national building stock and includes 294,317 (33%) multi-residential buildings and 477,594 family houses (53%). The majority of the non-residential buildings consists of public sector buildings and commercial purpose buildings. There are 45,541 (5%) commercial purpose buildings, including shops, hotels, restaurants, etc, and the number of public sector buildings amounts to 81,655 (9%).

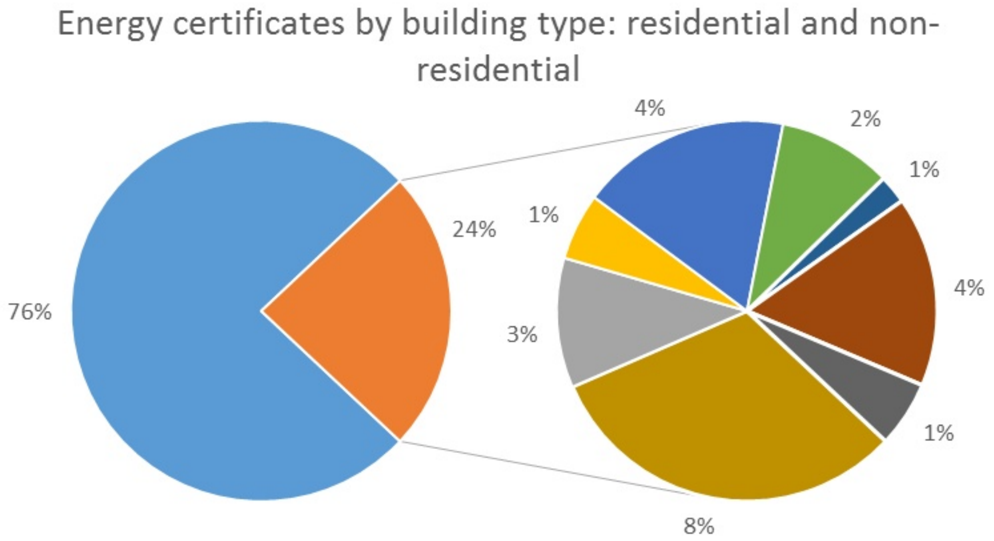


Figure 20: Issued EPCs by types of residential and non-residential buildings.

RB	Residential buildings (with one, two or more dwellings, and buildings for community housing)
NRB	Non-residential buildings
NRB1	Office, administrative and other commercial buildings of similar prevailing purpose
NRB2	School and faculty buildings, nursery schools and other educational institutions
NRB3	Hospitals and other buildings for health, social and rehabilitation purposes
NRB4	Hotels and restaurants and similar buildings for short-term dwelling (incl. apartments)
NRB5	Other non-residential buildings heated to a temperature of +18°C or more (e.g.: buildings for transport and communications, terminals, stations, buildings for transport, post offices, telecommunication buildings, buildings for culture and art and entertainment, museums and libraries, etc.)
NRB6	Construction works for sports
NRB7	Wholesale and retail buildings (shopping centres, buildings with stores)
NRB8	Other non-residential buildings in which energy is used to achieve certain conditions

IV. INSPECTION REQUIREMENTS – HEATING AND AIR-CONDITIONING (AC) SYSTEMS

Number of building units in the country (end of 2013)	899,107
Number of building units with EPC (end of 2014)	64,560
% of building units with/without EPC (end of 2014)	7.18% / 92.82%
EPCs issued in 2013 for new and existing buildings	13,446
EPCs issued in 2014 for new and existing buildings	46,009

Table 11: Percentage of the Croatian building stock with an EPC at the end of December 2014.

In response to Articles 14 and 15 of the EPBD, Croatia has opted for carrying out regular inspections of heating systems and cooling/AC systems in buildings. This obligation has been transposed first by the Act of Energy End-use Efficiency in 2012. Now, the Building Act is the legal basis for regular inspections, including the dynamics for carrying out regular inspections of these systems. Regular inspections include inspections of accessible parts of the heating system and AC system. The report to be drafted on the performed inspection must also include a proposal of measures for improving the energy performance. Development of the registry of reports is in progress and will be in function by the end of 2015.

i. Progress and current status on heating systems and AC systems

Overview, technical method and administration system

Regular inspection of the heating system and cooling or AC system in a building must be carried out concurrently with the energy audit of the building for purposes of EPC issuance because for now, these two obligations overlap.

When not concurrent with EPC issuance, heating systems with a boiler of an effective rated output of more than 20 kW are regularly inspected every 10 years. Those with a boiler of an effective rated output of more than 100 kW are inspected every 2 years, or 4 years in the case of a gas-fuelled boiler. Cooling or AC systems in buildings with effective rated output of more than 12 kW must be regularly inspected at least once every 10 years.

A regular inspection of the heating system and cooling or AC system in a building includes collection and inspection of documents, visual and functional inspection of the heating system and of heated areas, the necessary measurements, assessment of the size of the system relative to building needs, development of a proposal of measures for improving the energy efficiency of the system and/or application of alternative solutions and drafting of the final report. The report must contain information on all actions carried out within the framework of the regular inspection, measurement results, comparisons with technical specifications of the manufacturer, and a proposal of measures for improving the energy efficiency of the system. Reports are prepared by authorised persons. The report content is determined by the Ordinance and Methodology for carrying out energy audits of buildings.

Inspectors are the same persons who can perform energy audits of buildings with a complex technical system, but only a person who is also qualified in the field of mechanical engineering. By the end of 2014, a total of 213 authorised persons (natural and legal) are allowed to carry out regular inspections of heating and AC systems in buildings. Enforcement and penalties for regular inspections of heating and AC systems are the same as for the energy certification of buildings. However, as no separate heating and AC reports were issued in 2013 and 2014 (they are carried out as part of issuing EPCs), no fines have yet been issued. A new ordinance under preparation will better regulate this issue.

Promotional activities for regular inspections of heating and AC systems were carried out within the framework of promotional activities for the energy certification of buildings.

Quality control of inspection reports

The method of carrying out control of inspection reports is prescribed by the Ordinance OG 81/2012 and 79/2013. On this basis, to date, 4 legal persons have been authorised for carrying out controls (the same legal persons have been authorised for carrying out control of EPCs of buildings) and employ natural persons with completed university qualifications in the field of mechanical engineering. The content of the controls includes verification and control of the validity of input data, completeness of reports, and completeness of the measures proposed to improve energy efficiency. As no separate heating and AC reports were issued so far, no inspection reports were controlled in 2013 and 2014.

3. A success story in EPBD implementation

Dissemination and training on energy efficiency for professionals in the field of architecture, construction and building services (mechanical and electrical) started with implementing the first professional training programmes for persons who would perform energy audits and energy certification of buildings. These programmes have been implemented since 2009 and have been developed in such a way to be applicable to all the indicated professions. The objective of the programmes is to enhance knowledge in fields linked with energy consumption in buildings for the indicated engineering professions, and to acquire certain knowledge and skills from

Figure 21: Proposal of measures for improving the energy efficiency in the reports of regular inspections of heating and AC systems in a building.

16. Proposal of measures for improving the energy efficiency of the heating system									
No.	Title and description of the measure	Final energy savings [kWh/year]				Energy cost savings [kn/year]	Needed investments [kn]	Simple pay-back period [years]	CO_2 emission savings [tCO_2/year]
		Energy source 1	Energy source 2	Energy source 3	Energy source 4				
1.									
…									

9. Proposal of measures for improving the energy efficiency of the air-conditioning system									
Br.	Title and description of the measure	Final energy savings [kWh/year]				Energy cost savings [kn/year]	Needed investments [kn]	Simple pay-back period [years]	CO_2 emission savings [tCO_2/year]
		Energy source 1	Energy source 2	Energy source 3	Energy source 4				
1.									
…									

other professions in order to establish a pool of engineers that, with their competencies, are able to consider construction works and buildings as a whole in terms of energy.

The programmes are carried out by professional institutions - 7 faculties, 2 institutes and 4 professional organisations, with lecturers being recognised professionals. Since the beginning of programme implementation, more than 2,200 engineers have completed these training programmes, of which the majority are authorised to carry out energy audits, energy certification of buildings and regular inspections of heating and cooling or AC systems in buildings. By the end of 2014, 1,673 authorisations were issued to legal and natural persons. This Croatian model of creating professional and competent staff for carrying out energy audits and energy certifications of buildings has also been implemented by other countries in the Balkan region.

Furthermore, energy efficiency has also found its place in the curriculum of university institutions. Thus, as of the 2013/2014 academic year, the Faculty of Civil Engineering in Osijek has been carrying out, within the framework of the graduate university study, the elective course Energy-efficient construction works. In terms of content, the course comprises three units: (1) Legislative framework and technical regulations in the field of energy efficiency; (2) Methodology of thermal energy calculation and thermography, and Technology and construction works, aimed at energy efficiency increase; and (3) Economic aspects of energy efficiency. Upon successful completion of the course programme, students are able to calculate the heat transmission coefficient and the necessary energy for heating and cooling needs of residential buildings, to determine technological measures and to describe the works necessary for buildings in order to increase energy efficiency, and to evaluate different solutions on the basis of economic cost-benefit analyses.

In order to ensure adequate skills and abilities of construction workers and installers on the Croatian market, the MCPP launched the project CROSKILLS - Build Up Skills Croatia, in June 2012. This project focuses on improving the education system of construction workers and installers of technical systems in the field of energy efficiency. The project is part of the EU initiative for a workforce in the area of sustainable construction within energy efficiency and renewable energy, and it is jointly carried out in 30 European countries. The project Build up Skills Croatia (CROSKILLS) – Pillar I has been successfully implemented, defining the needs for educated workers on energy efficiency tasks. Furthermore, the project resulted in establishing a national platform of relevant stakeholders as an advisory body when carrying out the set targets for the project BUILD UP Skills: Strengthening energy efficiency skills and certification schemes for building workers (CROSKILLS II) - Pillar II. Through implementation of this project, a certification scheme is to be established for the lifelong training of workers on energy efficiency tasks. The project's duration is 3 years and ends in August 2017.

Presentations on the importance of energy efficiency in buildings held at the Faculty of Civil Engineering and the Faculty of Architecture in Zagreb were useful for students, enabling them to realise the importance of this field, especially for their profession, and in 2011 they established the students' association SUPEUS (www.supeus.hr) for energy efficiency promotion and consultation. SUPEUS assembles students of various faculties in Zagreb (civil engineering, architecture, mechanical engineering, electrical engineering, economy) and organises workshops for students and various competitions. At the initiative of SUPEUS members, a team from the University of Zagreb participated in the SOLAR DECATHLON 2014 international competition in Paris, where they built and presented the MEMBRAIN (www.membrain.com.hr).

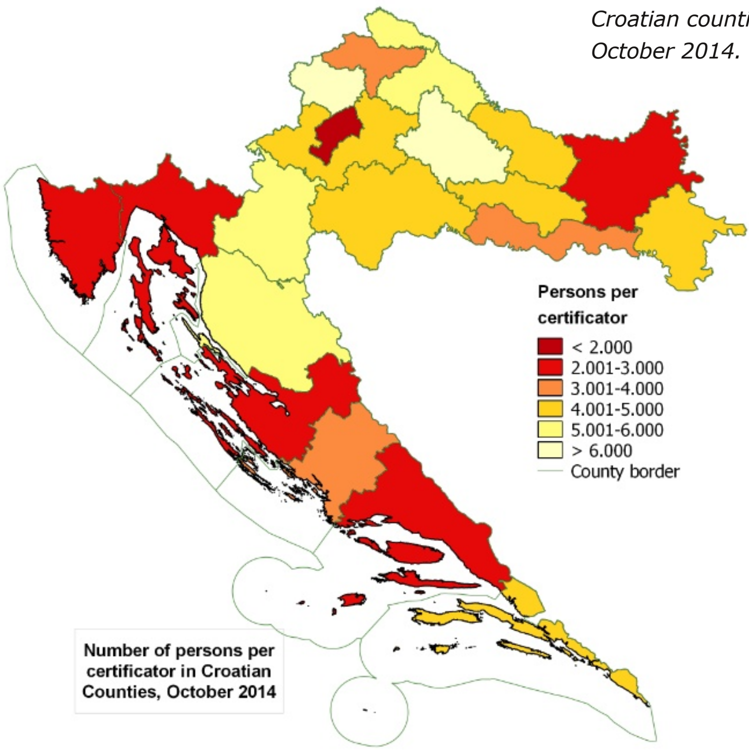


Figure 22: Number of inhabitants per qualified expert in Croatian counties, October 2014.

4. Conclusions, future plans

Following the calculations for defining reference buildings and setting requirements for new buildings as well as for the reconstruction of existing buildings within a cost-optimal framework, the implementation of the new technical regulation 2015 has become the standard to follow in practice. Several computer programmes have been developed in order to facilitate the calculations based on European standards. Some are commercial programmes, but the government envisages the development of a programme that would be available to all users free of charge. The national methodology for the energy performance of buildings (algorithms) that was adopted for this purpose is periodically corrected, in line with the experience acquired in implementing cost-optimal analyses.

For the purposes of promoting alternative systems in the designs of new buildings, a study on the applicability of alternative systems was prepared. This also included the development of type solutions for the application of alternative systems, and should be used when designing new buildings with a surface area of 50 - 1,000 m^2. A designer is required to develop an alternative system study prior to developing the main design, and deliver it to the investor. The study provides guidance to the designer on how to develop the project. Application of the study, i.e., type solutions for alternative systems, is mandatory as of 1 January 2015.

NZEBs are defined by primary energy consumption in continental and littoral climate zones. A public debate related to energy standards of NZEBs was carried out, and following this, a number of information workshops for stakeholders were held, in order to present them this standard and to enable the building industry to adequately prepare for meeting the new requirements for the construction of these buildings. The definitions for NZEBs for all types of buildings are implemented in the Technical regulation on rational use of energy and heat retention in buildings (OG 97/2014 and 130/2014).

Figure 23: The self-sustaining house MEMBRAIN concept at the Solar Decathlon competition in Paris, 2014.

As the building sector in Croatia accounts for 43% of final energy consumption, special attention must be paid to more intense implementation of national programmes of building renovation. Therefore, a continuation of promotional activities is planned. The establishment of an internet platform for information on available energy efficiency mechanisms and financial and legal frameworks and instruments is envisaged in order to better spread information to all relevant market participants. The establishment and administration of a system for monitoring, measurement and verification of energy savings is planned in order to appropriately monitor the implementation of measures for energy efficiency improvement.

Regulations to certify RES installers for smaller and biomass fuelled boilers, solar thermal systems, shallow geothermal systems and heat pumps were published in May 2015 (OG 56/15). For installers of photovoltaic systems, a regulation is in force and implemented, pursuant to which more than 80 installers obtained certification by October 2014.

A new Ordinance on the energy certification of buildings is under preparation. According to the new ordinance, the energy class will be expressed as delivered (final) energy instead of net energy needs at present. Reporting of delivered energy on EPCs will be mandatory, and it will include energy to be delivered to the technical building system in order to meet needs for heating, cooling, ventilation, and preparation of DHW, and for non-residential buildings, lighting. Continuation of quality controls of issued EPCs of buildings (including reports on completed regular inspections of heating and cooling/AC systems in buildings) is planned to reach the same minimum scope as in 2014, in order to carry out controls for every authorised person at least once during their period of authorisation. Data on completed controls, i.e., annulled EPCs, will also be made available to the public in order to contribute to increasing their quality and instilling confidence in the beneficiaries of the energy certification of buildings.

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