REPUBLIC OF CROATIA
Ministry of Physical Planning, Construction and State Assets

LONG-TERM STRATEGY FOR NATIONAL BUILDING STOCK RENOVATION BY 2050

December 2020

CONTENTS

LIST OF ABBREVIATIONS

ERDF	European Regional Development Fund
EIHP	Energy Institute Hrvoje Požar
EC	European Commission
ESI	European Structural and Investment Funds
EU	European Union
EUROSTAT	Statistical Office of the European Union
EPEEF	Environmental Protection and Energy Efficiency Fund
PPIS	Physical Planning Information System
MCPP	Ministry of Construction and Physical Planning
MPCA	Ministry of Physical Planning, Construction and State Assets
MRDEUF	Ministry of Regional Development and EU Funds
MENP	Ministry of Environment and Energy
MESD	Ministry of Economy and Sustainable Development
NEEA	national energy efficiency authority
NN	*Narodne Novine* (Official Gazette of the Republic of Croatia)
nZEB	nearly Zero Energy Building
nZEN	nearly Zero Energy Neighbourhood
OPCC	Operational programme Competitiveness and Cohesion 2014–2020
VAT	value added tax
IB	intermediate body
Croatia	Republic of Croatia
SO	specific objective
SMiV	System for monitoring, measuring and verifying energy savings
TREEHRB	Technical regulation on energy economy and heat retention in buildings
MAB	multi-apartment buildings
GMA	guaranteed minimum allowance
EDS	Energy development strategy of the Republic of Croatia until 2030 with an outlook to 2050
NECP	Integrated national energy and climate plan for the Republic of Croatia for 2021–2030
EOJN	*Elektronički oglasnik javne nabave* (Electronic Public Procurement Classifieds of the Republic of Croatia)

EXECUTIVE SUMMARY

In 2020, Croatia's national building stock covered a total useful floor area of 237 315 397 m², of which 178 592 460 m² in residential buildings and 58 722 937 m² in non-residential buildings. This floor area includes all existing buildings, irrespective of whether they are permanently occupied, temporarily unoccupied or abandoned.

The baseline value for monitoring the progress of the renovation was determined based on the overall stock of permanently occupied buildings in 2020. For residential buildings, the floor area of newly built buildings and those renovated between 2011 and 2020 was deducted from the floor area of residential buildings permanently occupied in 2020 (128 960 894 m²) to obtain the useful floor area of 110 143 965 m² to be renovated by 2050. It comprises 42 395 923 m² in multi-apartment buildings and 67 748 042 m² in family houses.

For non-residential buildings, the 2020 total useful floor area was 58 722 937 m², comprising 42 623 410 m² in commercial buildings and 16 099 527 m² in public buildings. That is the floor area size to be renovated by 2050. The 2020 heated useful floor area of non-residential buildings amounted to 41 944 955 m^2, of which 30 445 293 m² is accounted for by commercial buildings and 11 499 662 m^2 by public buildings.

By projecting trends until 2050, it was established that in that year the building stock would consist of 189 646 889 m² in residential buildings and 66 732 712 m² in non-residential buildings, that is, 158 039 074 m² of useful floor area in residential buildings and 49 431 639 m² of heated useful floor area in non-residential buildings. The trend of changes in building area shows an above average increase in coastal counties, with a stagnation or even decrease in mainland counties. There is an evident high rate of demolition, resulting from a part of the building stock coming out of use either through physical demolition, temporary abandonment or unregistered abandonment of buildings formally in operation, and through their removal or replacement by new buildings in the same or another location.

According to data collected in the Information system of energy certificates (IEC) database, the average energy performance of the building stock is evenly represented in terms of thermal energy needed for heating in residential and office buildings. When it comes to other purposes, there is a shift towards lower (hospitals and family houses) or higher (shops, hotels and restaurants) energy ratings, reflecting both the initial state of the building stock as well as the investment intensity. In terms of primary energy, the share of buildings with lower energy performance is somewhat higher because primary energy has been in use as a criterion for only a short while, and some adjustment time is needed to reflect this in the average results for the building stock. The energy performance of the external envelope of buildings corresponds to regulatory requirements, depending on the respective construction period, with heating systems also showing an increase in system energy efficiency through the indirect indicator of the ratio of energy delivered and necessary for heating.

The energy renovation rate of buildings between 2014 and 2020 equalled 0.7% of floor area, i.e. 1.35 mil. m² per year, while the target rate for 2021 and 2022 is 1%, 1.5% for 2023 and 2024, 2.0% for 2025 and 2026, 2.5% for 2027 and 2028, and 3% for 2029 and 2030, followed by 3.5% between 2031 and 2040, and 4% between 2041 and 2050.

The overall building stock also includes buildings having the status of 'immovable cultural property' and buildings owned and used by the Croatian Armed Forces. Buildings with the status of immovable cultural heritage are included in the Register of Cultural Property of the Republic of Croatia, according to which 102 615 buildings are located within cultural and historic units with the status of cultural property, of which 1 950 buildings have the status of individually protected cultural property. Similarly, buildings owned and used by the Croatian Armed Forces are included in the overall building stock according to their purpose and construction period. Under the Croatian armed forces long-term development plan, they are divided into three groups – high-potential properties built for military purposes and used by the Ministry of Defence, temporarily high-potential properties currently undergoing abandonment, and low-potential properties which are not used by the Ministry of Defence. The plans of use and improvement of Croatian army

locations cover high-potential properties, of which 12 are the primary priority for renovation to increase their energy efficiency, implement waste management and the use of biomass.

Current energy renovation programmes include all building purposes, private, public and commercial users, as well as buildings with worst performance located in assisted areas and areas of special state concern. Technical possibilities for energy renovation are primarily reliant on a reduction in energy needs through renovation of the building's external envelope, in accordance with applicable regulations. The requirements for nZEBs also include technical systems and a minimum share of renewable energy sources in buildings. The renovation of the external envelope is supplemented by centralisation and modernisation of heating, cooling and ventilation systems as well as domestic hot water (DHW) generation using renewable energy sources, where the possibility of a separate boiler system or district heating system needs to be considered for each building. Some centralised, district heating systems have advantages over individual systems because they provide for easier use of waste thermal energy, interpolation and connectivity with other systems. Thus, a centralised use of renewable energy sources (RES) is possible in the immediate vicinity of the building, increasing the share of RES in such locations where technical possibilities for the installation of RES-based systems in buildings are limited.

Sustainable building renovation models can be supported by linking investments in building renovation with district heating system renovation, which provides for a switch in the economic operation model from that based on high operating costs (energy) to a system based on high investment costs (energy renovation) thanks to a constant reduction in building needs. District heating systems may, but do not need to, coincide with larger spatial units – city or town districts, neighbourhoods or settlements – which may be considered nearly Zero Energy Neighbourhoods (nZENs). It is through nZENS that the burden of achieving energy savings targets and targets concerning the share of RES energy is distributed among a larger number of buildings in a wider area, thus fully exploiting the potential of quality locations (for the inclusion of RES or for energy savings) and ultimately sharing such goals with buildings which, due to location constraints, cannot individually comply with building requirements or may be exempt from the obligation of compliance (cultural heritage, religious buildings, etc.). The aggregation of projects along the same lines can be implemented on a spatial basis (city or town districts), or through investment platforms or groups, consortia of small and medium-sized enterprises and bundled solutions. The creation of a network of one-stop shops may consolidate the information on energy renovation and financing possibilities.

The existing measures for encouraging building renovation in Croatia include primarily the implementation of national energy renovation programmes for different typologies of buildings and national and international projects. There is a series of obstacles to energy renovation, but the most frequent one in Croatia is the financial barrier, accompanied by legal barriers and insufficient information. Croatia's national policy of comprehensive building renovation will achieve the set targets through strategic, legislative, technical, financial, communication, and research and development measures, while also using financial models and incentives, grant schemes, the subsidised housing-saving system, and special funding programmes which include the possibility of using grants from EU funds.

Policies focusing on the overall building stock are accompanied by policies and measures focusing on specific problem areas, specifically:

- buildings with the worst performance, whose share by building purpose ranges between 19% and 82%; and
- seismically endangered buildings.

Split incentives, as another specific problem area, is not so pronounced in Croatia. Disadvantages of the real estate market constitute a major problem, so the largest real estate turnover is recorded in the City of Zagreb and the Split-Dalmatia County due to depopulation pressure, while renovation costs are disproportionately high in rural and less developed areas compared to the market value of property. Energy poverty is recognised as a growing problem, which is to be addressed by the measures envisaged under this Strategy. Skills and technologies in the field of nearly Zero Energy Buildings (nZEBs) and energy renovation have been promoted continually. The policy for increasing electromobility, in connection with the construction and energy renovation of buildings, is also related to nZEBs.

Public sector buildings are a special area of interest which is subject to appropriate measures – Systematic energy management in the public sector, Green public procurement, Energy renovation programme for public buildings, and Energy renovation programme for buildings with cultural heritage status.

The long-term plan with measures, measurable progress indicators and indicators for milestones in 2030, 2040 and 2050 provides measurable progress indicators in terms of the number of renovated buildings and their floor area, which is to increase from the current 0.7% annually (1 350 000 m²) to 3% in 2030, to stand at 3.5% between 2031 and 2040 and 4% between 2041 and 2050. Expressed in the floor area of renovated buildings, the target is 30.84 mil. m² of renovated buildings by 2030, 41.06 mil. m² between 2030 and 2040, and 32.10 mil. m² between 2040 and 2050. Additional progress indicators to be monitored through the register of issued building energy certificates are the increase in the quality of external envelope, the number of nZEBs and the total floor area of renovated nZEBs. In addition to these indicators, the reduction in energy consumption in public and residential buildings, the average thermal energy needed for heating/cooling of renovated public buildings, contribution to reduced energy consumption, and contribution to economic development by increasing the number of employees during the renovation process are all closely monitored.

In terms of meeting seismic resistance requirements, the building stock built up to 1963 (accounting for about 30% of the overall building stock) was not designed to transfer horizontal loads. Since 1964, Croatia has imposed considerably stricter requirements for building construction, and the European regulation increasing the safety of buildings in the event of earthquakes has been in effect since 2008. A number of technical measures aimed at decreasing fire risks and risks related to intense seismic activity may be implemented along with the energy renovation of buildings. These measures can increase the renovation cost by an average of HRK 1 500/m².

Deep and comprehensive building renovation will be encouraged over the next period. National energy renovation programmes, in relation to buildings undergoing major renovation, will encourage the use of highly efficient alternative systems, in so far as this is technically, functionally and economically feasible, and particular attention will be given to healthy indoor climate conditions, fire safety and risks related to intense seismic activity.

The required investment in the energy renovation and comprehensive renovation of the building stock is estimated at HRK 243.23 billion until 2050. The role of the State is in creating and improving conditions to create a favourable investment climate among investors for investments which are necessary. Favourable conditions include macroeconomic stability, efficient state administration, a competitive level of the tax burden, legal certainty, protection of competition, and existence of appropriate financial incentives to invest. The long-term model of financing renovation relies on energy service contracting under the energy service company (ESCO) model; the establishment of financial instruments – an urban renovation fund for energy renovation projects [implemented] through European Structural and Investment Funds and development banks – to offer long-term and sustainable financing mechanisms (loans, guarantees, equity) for public and private sector beneficiaries; further implementation of national energy renovation programmes for buildings; the establishment of a special support scheme to co-finance the energy renovation of buildings with the status of cultural property; the establishment of a special instrument to co-finance the technical preparation of projects; an energy efficiency obligation scheme for energy suppliers, and the establishment of a system of tax allowances for investing in energy renovation.

In addition to existing ownership relationships and the economic structure of co-owners, energy renovation grants are the main trigger point of the energy renovation of buildings in Croatia. Investing in energy renovation generates not only energy savings, which accumulate over the service life of buildings, but also a number of wider benefits through higher disposable income, which is channelled into consumption and in turn affects economic growth; increased real estate value and less quantifiable aesthetic external effects; decreased health risks; reduced poverty rate; and increased security of energy supply. Energy renovation, which also brings about structural renovation, fire safety and increased accessibility of buildings, extends the service life of buildings and that of existing infrastructure.

1 INTRODUCTION

The European Union has set a long-term target of reducing CO_2 emissions from the building sector by 80–95% by 2050. Furthermore, Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast) (OJ L 153, 19.5.2010, p. 13) requires EU Members States to encourage the installation of highly efficient alternative systems in so far as this is technically, functionally and economically feasible, while Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance) (OJ L 140, 5.6.2009, p. 16) (hereinafter: Directive 2009/28/EC) requires all EU Member States to introduce measures for increasing the share of energy from renewable sources.

In accordance with Article 47.a of the Building Act (*Narodne Novine* (Official Gazette of the Republic of Croatia) NN Nos 153/13, 20/17, 39/19, 125/19) and the commitments under Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency (Text with EEA relevance) (OJ L 156, 19.6.2018, p. 75) (hereinafter: Directive 2018/844/EU), transposed into national law, Croatia is required to submit to the European Commission the Long-term strategy for national building stock renovation by 2050 (hereinafter: the Long-Term Strategy), which encompasses the following areas:

- an overview of the national building stock;
- the identification of cost-effective approaches to renovation relevant to the building type and climate zone, considering potential relevant trigger points, where applicable, in the life-cycle of the building;
- policies and actions to stimulate cost-effective deep renovation of buildings, including staged deep renovation, and to support targeted cost-effective measures;
- an overview of the policies and actions to target the worst-performing segments of the national building stock, split-incentive dilemmas and market failures, and an outline of relevant national actions contributing to the alleviation of energy poverty;
- policies and actions focusing on all public buildings;
- an overview of national initiatives to promote smart technologies and well-connected buildings and communities, as well as skills and education in the construction and energy efficiency sectors;
- an evidence-based estimate of expected energy savings and wider benefits, such as those related to health, safety and air quality;
- an estimate of expected energy savings and wider benefits of systematic investment into integral energy renovation of the national building stock (new job creation, reduction of energy poverty, increase in property value, etc.).

In its methodology part, the Long-Term Strategy has been harmonised with Croatia's Integrated national energy and climate plan for 2021–2030 (1), and its Energy development strategy until 2030 with an outlook to 2050 (2).

The following sources of data on the current status of the building stock were used:

- National plan to increase the number of nearly zero-energy buildings by 2020,
- National energy efficiency programme for 2008–2016,
- Second national energy efficiency action plan for the period up to the end of 2013,
- Third national energy efficiency action plan for 2014–2016,
- Fourth national energy efficiency action plan for the period up to the end 2019,
- Energy renovation programme for family houses for 2014–2020 with a detailed plan for 2014–2016,
- Energy renovation programme for multi-apartment buildings for 2014–2020 with a detailed plan for 2014–2016,
- Energy renovation programme for commercial non-residential buildings 2014–2020 with a detailed plan of energy renovation of commercial non-residential buildings for 2014–2016,

- Energy renovation programme for public buildings for 2014–2015,
- Energy renovation programme for public buildings for 2016–2020.

In accordance with European Commission recommendations, the Long-Term Strategy was based on the following guidelines:

- set very high long-term goals for the national building stock renovation – minimum 80% reduction in greenhouse gas emissions by 2050;
- provide an overview of the national building stock to include all buildings in Croatia;
- propose clear and practicable financial models of the national building stock renovation by 2050;
- estimate the impact of proposed policies and measures on the national economic development;
- estimate expected energy savings in the national building stock for the purpose of better planning and monitoring of results achieved in the Strategy implementation phase;
- propose new long-term financing mechanisms, as well as the plans and perspectives to ensure a stable investment climate for all market participants.

2 OVERVIEW OF THE NATIONAL BUILDING STOCK

The structure of Croatia's building stock is changing continually. This overview of the building stock is based on existing data from available strategic documents, plans and programmes, new data collected during the preparation of this Long-Term Strategy, and assumptions about future building stock trends based on economic and demographic input.

The latest comprehensive data research carried out in the Long-term strategy for mobilising investment in the renovation of Croatia's national building stock (3) is based on data in the Long-term strategy for mobilising investment in the renovation of Croatia's national building stock of June 2014 (4), the National Plan for increasing the number of nearly zero-energy buildings (5), the National energy efficiency programme for the 2008–2016 period (6), the Energy renovation programme for family houses for 2014–2020 with a detailed plan for 2014–2016 (7), the Energy renovation programme for multi-apartment buildings for 2014–2020 with a detailed plan for 2014–2016 (8), the Energy renovation programme for commercial non-residential buildings for 2014–2020 with a detailed plan of energy renovation of commercial non-residential buildings for 2014–2016 (9), the Energy renovation programme for public buildings for 2016–2020 (10), and statistics on the census of households and population. Additional inputs and assumptions have been harmonised with data contained in the Integrated national energy and climate plan for the Republic of Croatia for 2021–2030 (1) and Croatia's Energy development strategy until 2030 with an outlook to 2050 (2).

Available data indicate that Croatia's building stock covered a total gross floor area of 198 133 193 m² in 2011. Annual changes in the building stock between 2011 and 2018 were determined from building stock trends, derived from data on issued building permits, as well as completed and demolished buildings.

CROATIAN	ENGLISH
	Trends in total floor area of buildings, 2011–2018
	mil. m^2
	204 418 233
	203 399 520
	202 371 546
	201 344 178
	200 604 890
	199 950 266
	199 148 397
	198 133 193

Figure 2.1: Trends in total floor area of buildings, 2011–2018

In 2020, the national building stock of Croatia covered a total useful floor area of 237 315 397 m², of which 178 592 460 m² in residential buildings and 58 722 937 m² in non-residential buildings. The floor area of permanently occupied residential buildings in 2020 was determined based on the 2011 census data, increased according to statistics on buildings completed and demolished between 2011 and 2018, and modelled for 2019 and 2020 data.

Croatia's useful floor area in 2020, consisting of the total stock of buildings to be renovated by 2050 according to their purpose is provided in Table 2-1.

Table 2-1: Total 2020 useful floor area of buildings for renovation

permanently occupied residential buildings	128 960 894 m²
RESIDENTIAL BUILDINGS FOR RENOVATION	**110 143 965 m²**

family houses for renovation	67 748 042 m²
multi-apartment buildings for renovation	42 395 923 m²
NON-RESIDENTIAL BUILDINGS FOR RENOVATION	**58 722 937 m²**
commercial non-residential buildings	42 623 410 m²
public non-residential buildings	16 099 527 m²
TOTAL BUILDINGS FOR RENOVATION	**168 866 902** m²

2.1 NATIONAL BUILDING STOCK CATEGORIES BY PURPOSE

For the purpose of this Long-Term Strategy, Croatia's national building stock is categorised by purpose as follows:

- multi-apartment buildings
- family houses
- public buildings
- commercial buildings.

The categorisation was based on the building types defined by national programmes of energy renovation of family houses, multi-apartment buildings, public buildings, and commercial non-residential buildings. In the context of the Long-Term Strategy, public buildings are buildings predominantly owned by public sector entities in which socially-oriented activities (education, training, science, culture, sport, healthcare and social welfare) and the activities of national and state administration, as well as those of local and regional self-government bodies and organisations and legal persons with public authority are performed; community housing buildings, including barracks, penitentiaries, prisons, correctional centres and other buildings intended for the use by armed forces, police or fire departments; buildings of citizens' associations and those of religious communities. A family house is any building in which more than 50% of the gross floor area is intended for housing, and which meets one of the following two conditions: it has a maximum of three residential units and/or a gross construction area of less than or equal to 600 m^2. Multi-apartment buildings are all buildings in which the entire gross floor area or more than 50% of the gross floor area is intended for housing, which have three or more residential units and are managed by a building manager, who is either a legal or a natural person, in accordance with the Ownership and Other Real Rights Act (NN Nos 91/96, 68/98, 137/99, 22/00, 73/00, 129/00, 114/01, 79/06, 141/06, 146/08, 38/09, 153/09, 143/12, 152/14). Commercial buildings are all predominantly privately-owned buildings in which more than 50% of the gross floor area is intended for commercial and/or service activities.

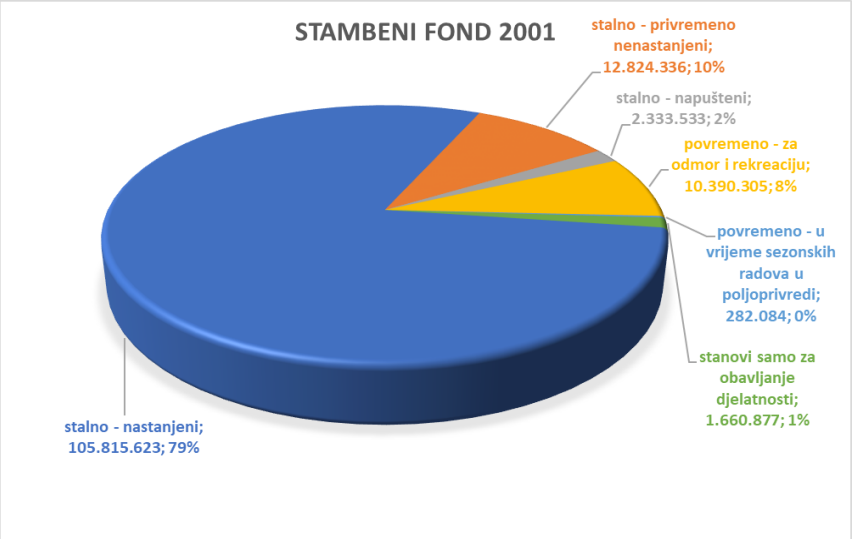
Buildings with the status of cultural property may be found in all four building categories. The Ministry of Culture and Media is also working on defining the part of the national building stock with the status of cultural property in order to analyse and monitor its status at national level. Moreover, buildings used by the Croatian army may be found in all building categories above, and the development of this segment of the building stock is defined in the Croatian armed forces' long-term development plan for 2015–2024 (11).

Table 2-2: Total gross floor area of buildings in Croatia by purpose in m² per year

	2011	2012	2013	2014	2015	2016	2017	2018
residential	**146 561 449**	**146 638 808**	**146 694 496**	**146 740 186**	**146 782 378**	**146 821 550**	**146 875 125**	**146 924 679**
multi-apartment	56 566 680	56 596 537	56 618 031	56 635 665	56 651 950	56 667 068	56 687 746	56 553 324
family	89 994 769	90 042 271	90 076 466	90 104 521	90 130 429	90 154 482	90 187 379	90 371 355
non-residential	**51 571 744**	**52 342 025**	**53 004 401**	**53 542 879**	**54 244 761**	**55 414 108**	**56 440 826**	**57 493 554**
office	8 641 609	8 690 577	8 700 234	8 786 495	8 841 865	8 871 938	8 992 494	9 310 763
education	5 614 153	5 682 727	5 720 018	5 751 638	5 793 588	5 827 083	5 888 671	5 912 968
hotels and restaurants	3 318 095	3 357 532	3 414 540	3 472 120	3 548 686	3 689 688	3 890 329	4 083 148
hospitals	2 952 511	2 988 574	3 008 186	3 024 815	3 046 877	3 064 492	3 096 881	3 109 659
sports halls	416 633	421 722	424 489	426 836	429 949	432 435	437 005	438 808
trade services	11 397 783	11 582 614	11 731 774	11 857 714	11 949 236	12 010 125	12 089 527	12 167 833
other	19 230 960	19 618 277	20 005 159	20 223 261	20 634 561	21 518 348	22 045 919	22 470 375

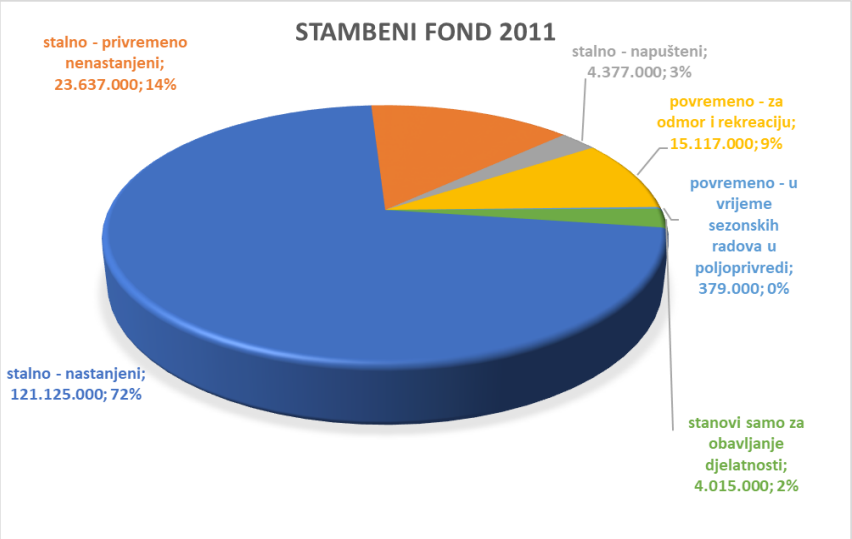
2.2 PROJECTION OF TRENDS IN THE BUILDING STOCK UNTIL 2050

The comparison of the structure of the building stock and the 2001 and 2011 population census shows a relative decrease in the floor area of permanently occupied apartments and a duplication of the floor area of temporarily and permanently abandoned apartments, which is directly linked to the population decline in the same period. The temporarily and permanently abandoned residential stock is a burden for the overall stock as it hinders the planning of measures to increase energy efficiency, while not contributing to the energy balance of the total building stock through energy consumption and reducing both the energy intensity of the residential sector and the potential for savings. Calculation models are therefore based on the useful floor area of the occupied residential building stock so that the energy intensity can reflect the actual state of the stock.



CROATIAN	ENGLISH
	2001 BUILDING STOCK
	permanently – temporarily unoccupied; 12 824 336; 10%
	permanently – abandoned; 2 333 533; 2%
	temporarily – for rest and recreation; 10 390 305; 8%
	temporarily – during seasonal work in agriculture; 282 084; 0%
	apartments in use for a business activity only; 1 660 877; 1%
	permanently – occupied; 105 815 623; 79%

Figure 2.2: Building stock structure by use in 2001 in m^2 and %



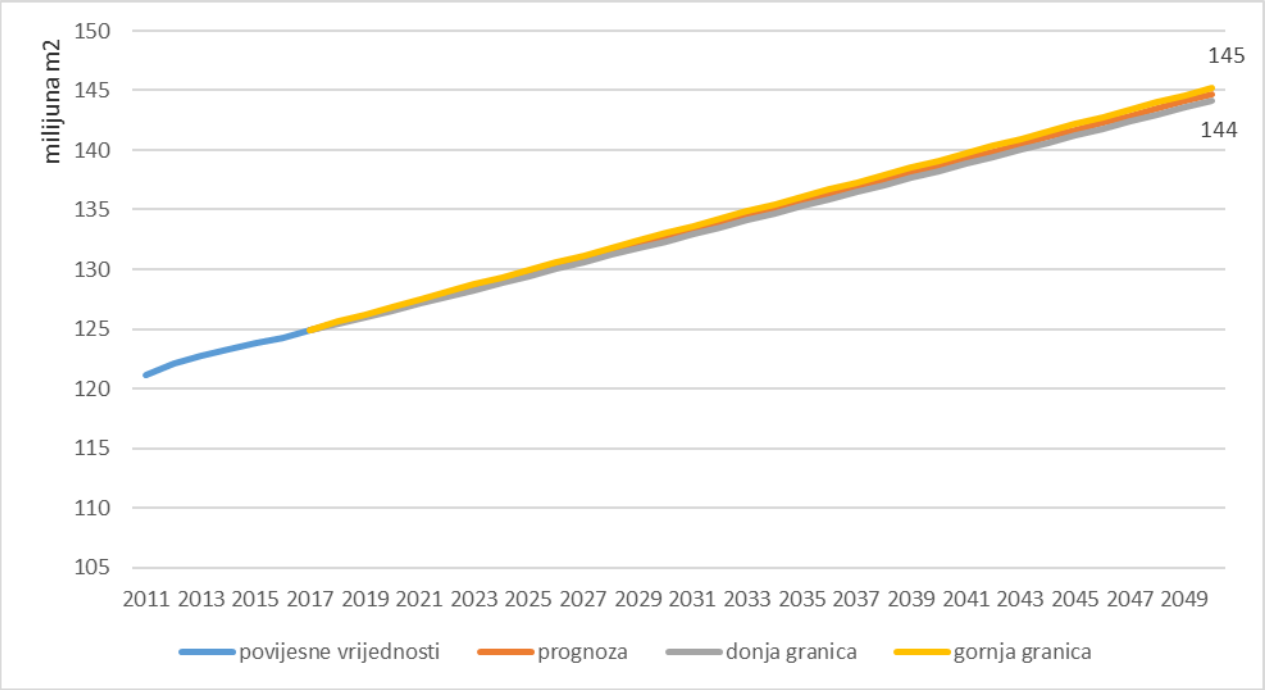
CROATIAN	ENGLISH
	2011 BUILDING STOCK
	permanently – temporarily unoccupied; 23 637 000; 14%
	permanently – abandoned; 4 377 000; 3%
	temporarily – for rest and recreation; 15 117 000; 9%
	temporarily – during seasonal work in agriculture; 379 000; 0%
	apartments in use for a business activity only; 4 015 000; 2%
	permanently – occupied; 121 125 000; 72%

Figure 2.3: Building stock structure by use in 2011, in m² and %

Available inputs were used to model the potential condition of the residential building stock in the period until 2050. Three sets of inputs were used for the modelling:

- trends in the total stock of permanently occupied residential buildings in Croatia between 2011 and 2017,
- trends in the stock of permanently occupied residential buildings between 2011 and 2017 by county,
- trends in the total stock of permanently occupied residential buildings between 1996 and 2017.

Linear regression was applied for the forecast, with a 95% probability of results falling between its upper and lower limit.

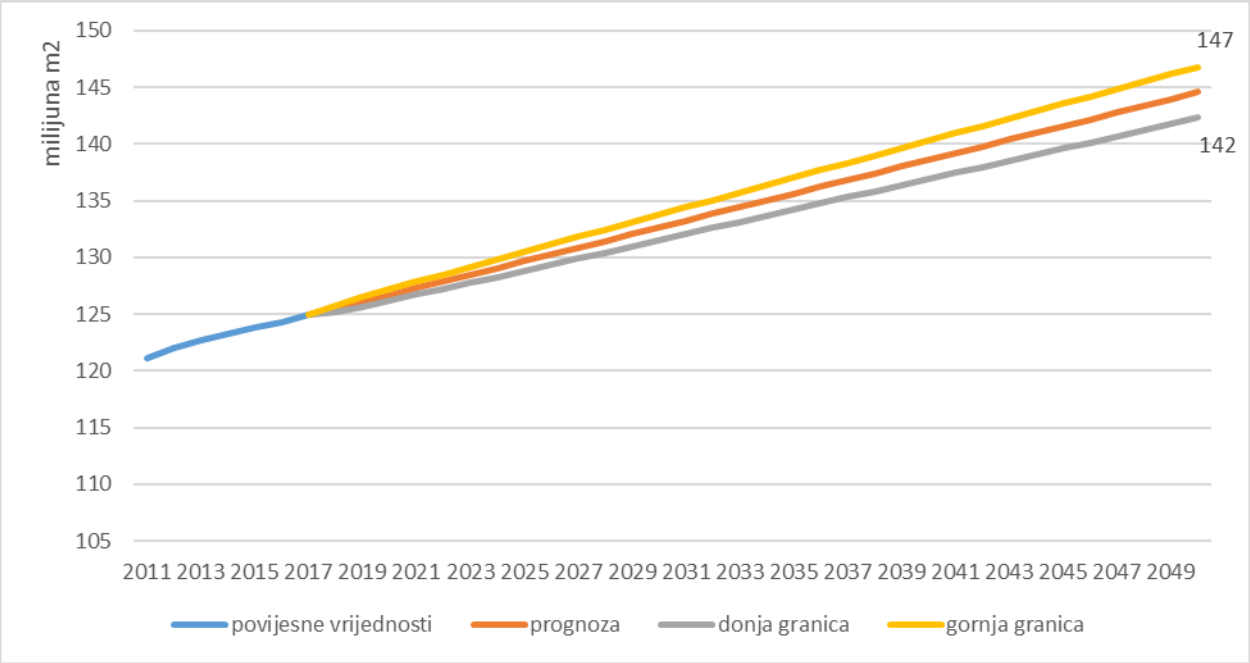


CROATIAN	ENGLISH
	mil. m^2
	historical data
	forecast
	lower limit
	upper limit

Figure 2.4: Forecast of trends in the floor area of residential buildings in Croatia until 2050, based on the 2011–2017 data series

In the first case, modelled on aggregated data on trends in the stock of permanently occupied residential buildings in Croatia between 2011 and 2017 (Figure 2.4:), with a 95% probability of results falling between the upper and the lower limit, the floor area of permanently occupied residential buildings will increase from the current 124 901 114 m² to 144 683 933 m² in 2050 (lower limit 144 159 938 m²; upper limit 145 207 928 m²).

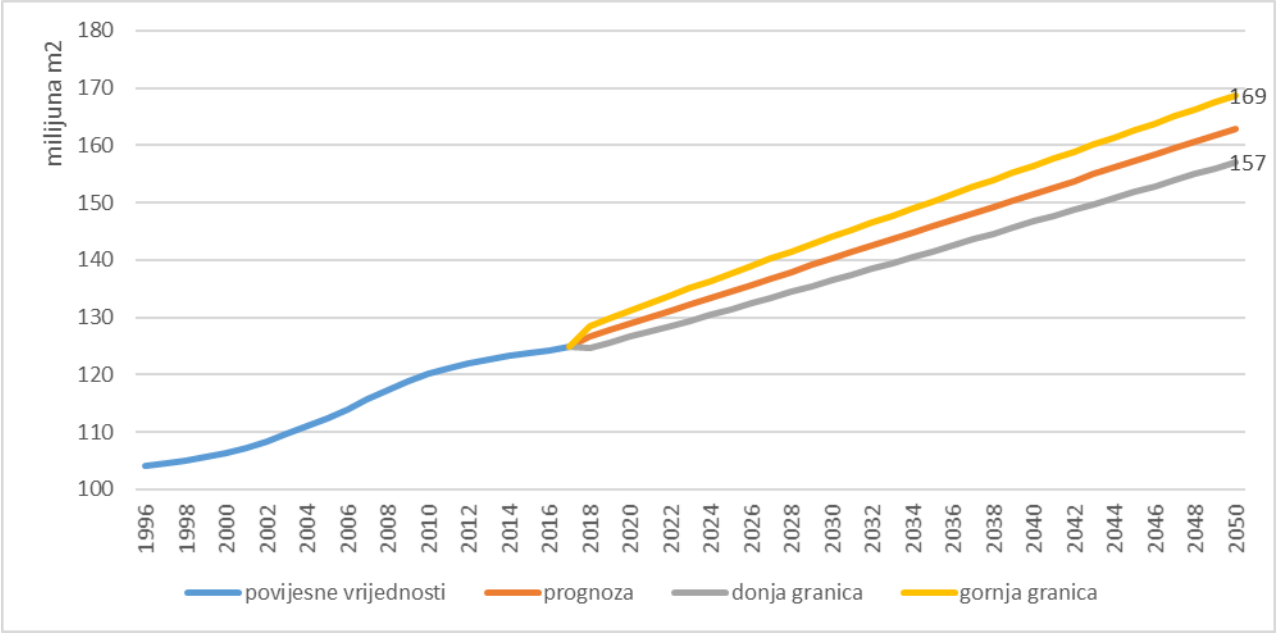
In the second case, due to different levels of development by county, the same input over the same period by county (2011–2017) and the same forecasting method used produces an almost identical potential floor area of the building stock of 144 567 276 m² by 2050 but with a slightly wider limit range (between 142 309 690 and 146 824 862 m² – Figure 2.5:).



CROATIAN	ENGLISH
	mil. m^2
	historical data
	forecast
	lower limit
	upper limit

Figure 2.5: Forecast of trends in the floor area of residential buildings in Croatia to 2050, based on the 2011–2017 data series by county

In the third case, the forecast was based on data on the floor area of permanently occupied apartments between 1996 and 2017. That approach was applied because the trends of the past six year are not a sufficiently reliable basis for forecasting an increase in the floor area of buildings in the upcoming 30 plus years. The 20-year range of inputs also includes periods of slower economic growth, return to the previous level of activity, credit expansion, recession and subsequent gradual recovery, changes in the ownership structure of the building stock (tenant purchase), as well as constant population outflows, thus providing a more realistic picture of long-term of developments in the floor area of the building stock. The results of the analysis indicate the potential floor area of buildings 162 891 454 m² in 2050, ranging between 157 101 752 m² and 168 681 156 m² with a 95% probability (Figure 2.6:).



CROATIAN	ENGLISH
	mil. m^2
	historical data
	forecast
	lower limit
	upper limit

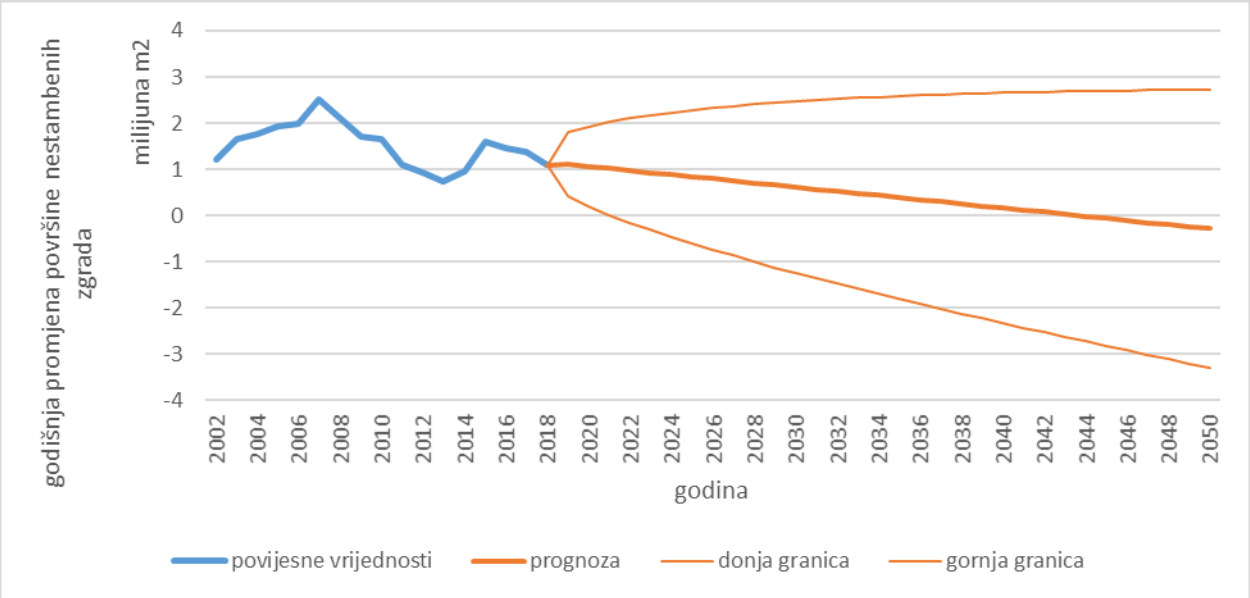
Figure 2.6: Forecast of trends in the floor area of Croatia's residential building stock based on the 1996–2017 data series

A demography-based model forecasting a decrease in the population of Croatia to 3.27 mil. in 2050 was used to plan future energy needs of the residential sector as part of the country's Energy development strategy until 2030 with an outlook to 2050 (2). In addition to the population decline, the number of members of an average household is expected to drop to 2.0 (from the current 2.78), while the residential unit floor area and the useful apartment floor area per person are expected to increase from 82.98 m² to 95.91 m² and from 30 m² to 48 m², respectively. Based on these inputs, the final residential building stock in 2050 would cover 158 039 074 m².

There is a relatively good overlap between the results of the model based on long-term statistics of building stock trends and the model based on long-term demographic projections; the analysis uses the model of building stock development that has been harmonised with Croatia's Energy development strategy until 2030 with an outlook to 2050 and its Integrated national energy and climate plan for 2021–2030, according to which the stock of permanently occupied apartments in 2050 will be 158 039 074 m², increasing by 33 137 960 m² in total or 1.0 mil. m² per year, which is lower than the average growth rate between 1996 and 2017, but higher than the 2011–2017 average. At the same time, the building stock is also burdened by temporarily abandoned apartments and will total 189 646 889 m² in residential buildings in 2050 if their floor area is included.

Changes in the non-residential building stock are partially consistent with the trends in the residential sector, primarily due to increased economic activity; however, they are not directly comparable. Modelling non-residential building stock is based on the assessment of the state of the non-residential building stock in 2011 that is provided in the Long-term strategy for mobilising investment in the renovation of Croatia's national building stock (Croatian Government, 2019), according to which Croatia had 80 196 public non-residential buildings with a total floor area of 13 801 902 m² and 44 728 non-residential commercial buildings with a total floor area of 36 540 459 m² in 2011. The building permits issued for non-residential buildings between 2002 and 2018 indicate a declining trend in the floor area of new non-residential buildings. The negative result of linear regression for 2050 is not realistic because, given the maintenance of the non-residential building stock and the replacement of dilapidated buildings and the 20-year service life of non-residential buildings, the required construction rate of approx. 1.5 mil, m² per year or 3% of the

non-residential building stock per year corresponds to the average floor area of non-residential buildings constructed between 2002 and 2018. The slower increase in the floor area of new non-residential buildings cannot be viewed as a long-term trend since energy renovation of buildings is conditional on increased economic activity, which is in turn driven by an increase and adaptation of space to new economic activities. Non-residential buildings are characterised by major investments which, if viewed individually, may distort the picture of trends in building floor area developments. Therefore, future developments in non-residential building stock were based on the specific floor area of non-residential buildings per employee provided in Croatia's Energy development strategy of until 2030 with an outlook to 2050 (12), according to which non-residential building area will equal 15 m² the per capita in 2050, representing a decrease in floor area compared to the current figures, and the structure of non-residential buildings will change considerably.



CROATIAN	ENGLISH
	annual change in floor area of non-residential buildings
	year
	mil. m^2
	historical data
	forecast
	lower limit
	upper limit

Figure 2.7: Annual change in floor area of non-residential buildings based on building permits issued in 2002–2018, with a forecast until 2050

The total floor area of non-residential buildings is expected to be 15 m² per capita in 2050, i.e. 66 732 712 m², with a ratio of the total area to the net heated area of 1.35:1, or 49 431 639 m² of heated building floor area.

Table 2-3: Projected total floor area of residential buildings in 2030, 2040 and 2050

	2030 m²	**2040 m²**	**2050 m²**
multi-apartment	64 160 346	68 605 285	73 180 074
family	103 288 933	110 444 645	117 809 397
residential total	**166 272 175**	**177 791 278**	**189 646 889**

Table 2-4: Projected total floor area of non-residential buildings in 2030, 2040 and 2050

	2030 **m²**	**2040** **m²**	**2050** **m²**
office	10 309 712	10 831 614	11 082 926
education	6 236 465	6 552 169	6 704 190
hotels and restaurants	4 650 511	4 885 930	4 999 292
hospitals	3 280 271	3 446 326	3 526 286
sports halls	462 823	486 252	497 534
trade services	12 833 465	13 483 125	13 795 956
other	24 303 780	25 534 093	26 126 528
non-residential total	**62 077 026**	**65 219 509**	**66 732 712**

The future structure of the building stock depends mostly on the distribution of investments over the future period – the continuity of new construction will remain stable due to a constant demand for new residential and business space, with possible periodic changes in its intensity. The previous period shows that a minimum pace of new construction remains stable even in extraordinary economic and financial circumstances. Moreover, it shows that a credit expansion not accompanied by appropriate policies to guide investment may cause an investment 'bubble' and its later burst.

Without policies to channel investment into renovation and preservation of the existing building stock, the pace of building renovation is generally slow. With the initial reason for construction being to meet the immediate and expected needs for space, investment is directed at the construction of new buildings. Only by actively channelling investment into increasing the rate of building renovation is it possible to affect the intensity of building renovation and the ratio of new construction to building renovation. Building renovation formally encompasses buildings being rebuilt and/or undergoing energy renovation, as well as those being built at the site of existing buildings, which are therefore removed (replacement construction). When monitoring the renovation rate, replacement buildings are difficult to identify because, as a rule, their purpose and size change and they are formally not linked to energy renovation.

The overall building stock also includes some buildings which have not been formally abandoned, but which do not contribute to energy consumption in buildings in practice. The treatment of such buildings, which are excluded from direct energy consumption by being temporarily abandoned, is important in terms of the total extent of building reconstruction. Given that they do not contribute to energy consumption, no savings are achieved by their energy renovation, so they are not included in the modelling of stock trends until 2050. Temporary abandonment of buildings creates a significant burden on infrastructure, either by reducing the intensity of its use or by complete abandonment of infrastructure; however, it is a spatial fact. Therefore, in addition to monitoring changes in stock in terms of an increase in building floor area through new builds, as well as the floor area of renovated buildings, it is also necessary to introduce a model to monitor spatial changes – not only construction and occupation of new space, but also abandonment.

For the purpose of analysing the structure of the building stock, the term 'stock demolition (abandonment)' has been introduced to mean its percentage coming out of use either by [physical] demolition, temporary abandonment or unregistered abandonment of buildings which are formally still in operation. According to construction statistics, the demolition rate is higher than the rate of registered [physical] demolition and conversion because it indicates the share of actually demolished, temporarily abandoned and abandoned buildings compared to the size of the new-build stock over the same period. Due to the type of data on the manner of use, demolition is difficult to monitor using traditional methods. Physical demolition (building demolition) is monitored through the statistics on demolished buildings, while data on functional demolition of buildings by abandonment are available at the population census level. The establishment of a building register would provide for an overlay of data on population trends, use of buildings and their spatial status. Until such register is established, which will not be possible until cadastral and land register data have been digitised and connected with spatial status being monitored through the Physical Planning Information

System (PPIS) and the Information system of energy certificates (IEC), demolition will have to be determined based on model and survey data.

The expected demolition rate (share of actually demolished, temporarily abandoned and abandoned buildings compared to the size of the new-build stock) in Croatia is exceptionally high, which means that a significant portion of new builds going forward will form a stock becoming abandoned, temporarily abandoned and demolished buildings. The demolition rate of the residential stock taken into account in the model for forecasting future building stock is 25% by 2050. Since buildings covered by the demolition rate are included in new-build rather than renovation statistics on, they do not contribute to the registered renovation rate although, as buildings meeting nZEB requirements for new builds, they help improve the building stock.

Table 2-5: Total expected floor area of buildings to be renovated by 2050, by decades

	2021–2030	**2031–2040**	**2041–2050**
renovation of residential buildings	20.17 mil. m²	26.97 mil. m²	21.12 mil. m²
construction of replacement residential buildings (demolition stock)	2.40 mil. m²[1]	2.16 mil. m²	2.54 mil. m²
renovation of non-residential buildings	10.67 mil. m²	14.10 mil. m²	10.98 mil. m²

2.3 OVERVIEW OF THE NATIONAL BUILDING STOCK BY CONSTRUCTION PERIOD

Different data sources were used to determine the age of buildings as accurately as possible. The starting point for the analysis was the 2011 population census, in which data on all apartments and occupied apartments in the following periods: prior to 1919, 1919–1945, 1946–1960, 1961–1970, 1971–1980, 1981–1990, 1991–2000, 2001–2005, 2006 and later (13), were processed; then they were supplemented with data on building permits issued and apartments and buildings demolished between 2011 and 2018, and finally adjusted for the demolition level included in the model. In 2018, the total building stock was 204 418 233 m², of which 146 924 679 m² in residential and 57 493 554 m² in non-residential buildings.

Table 2-6: Croatia's residential building stock by construction year (all buildings)

	multi-apartment		family	
	No of buildings	floor area	No of buildings	floor area
	–	m²	–	m²
prior to 1941	37 201	5 773 897	64 391	10 155 639
1941–1970	85 959	13 341 431	151 507	23 895 416
1971–1980	59 882	10 296 314	93 109	16 268 543
1981–1987	44 434	9 309 485	68 348	14 551 505
1988–2005	38 358	8 097 343	75 615	16 220 608
2006–2009	18 256	6 138 560	13 762	4 702 172
2010–2011	6 600	1 938 285	4 976	1 484 737
2012–2018	5 646	1 658 009	10 365	3 092 734
Total in 2018	**290 690**	**56 553 324**	**471 708**	**90 371 355**

[1] *(1) a total of 10 930 698 m² new buildings in 2021–2030, 14 721 602 m² in 2031–2040*

The non-residential building stock increased by 7 151 193 m² between 2011 and 2018; however, given that no data is available on the public/commercial status of those buildings, in the model they were included in public and commercial sectors according to their current ratio.

Table 2-7: Non-residential stock of Croatia by construction year

	commercial		public	
	No of buildings	floor area	No of buildings	floor area
	–	m²	–	m²
prior to 1941	2 338	1 498 159	12 365	1 545 813
1941–1970	12 587	8 064 602	22 525	2 815 845
1971–1980	6 733	5 251 934	19 021	1 882 000
1981–1987	4 323	5 108 279	10 158	2 152 000
1988–2005	10 596	8 107 287	11 059	2 722 497
2006–2009	6 199	6 352 000	3 673	2 073 747
2010–2011	1 952	2 158 198	1 395	610 000
2012–2018	6 354	5 190 616	11 392	1 960 577
Total in 2018	**51 082**	**41 731 075**	**91 588**	**15 762 479**

2.4 OVERVIEW OF THE NATIONAL BUILDING STOCK BY CLIMATE ZONE

In order to identify changes in the national building stock by climate zone, the trend in the number of buildings by county was determined based on statistical yearbooks of the Croatian Bureau of Statistics, the Energy renovation programme for commercial non-residential buildings for 2014–2020 with a detailed plan of energy renovation of commercial non-residential buildings for 2014–2016, and the Register of public central government buildings, and the calculation of targets under Directive 2012/27/EU. Based on average monthly temperatures at relevant weather stations according to the Rules on energy audits and energy certification of buildings (NN Nos 88/17, 90/20), counties were categorised into continental Croatia – cities and towns with an average monthly external air temperature of ≤3 °C in the coldest month at the building location, and coastal Croatia – cities and towns with an average monthly external air temperature of >3 °C in the coldest month at the building location.

The following tables provide an overview of the trends in the national residential and non-residential building stock by climate zone between 2011 and 2018.

Table 2-8: Croatia's residential building stock by climate zone

	2011	2012	2013	2014	2015	2016	2017	2018
	floor area m²							
multi-apartment								
continental	36 374 037	36 393 236	36 407 057	36 418 396	36 428 868	36 438 589	36 451 886	36 365 448
coastal	20 192 643	20 203 301	20 210 974	20 217 269	20 223 082	20 228 479	20 235 860	20 187 875
family								
continental	57 869 278	57 899 822	57 921 811	57 939 851	57 956 511	57 971 978	57 993 131	58 111 434
coastal	32 125 491	32 142 448	32 154 655	32 164 670	32 173 918	32 182 504	32 194 247	32 259 922

Table 2-9: Non-residential buildings by climate zone

	2011	2012	2013	2014	2015	2016	2017	2018
	floor area m²							
commercial								
continental	25 674 366	25 682 392	26 077 293	26 371 146	26 771 283	27 495 554	28 067 994	28 630 759
coastal	12 616 872	12 620 598	12 814 671	12 959 081	13 155 731	13 511 689	13 793 046	14 069 628
public								
continental	7 350 042	7 676 996	7 732 974	7 780 032	7 842 244	7 902 611	7 993 881	8 041 261
coastal	2 518 296	3 087 721	3 109 577	3 127 993	3 152 363	3 174 865	3 210 625	3 227 970

2.5 OVERVIEW OF THE NATIONAL BUILDING STOCK BY OWNERSHIP

The ownership structure of the building stock (public/private), in accordance with the Programme to encourage the construction of new and renovation of existing buildings to near zero energy standards (14), is stated separately by purpose, ownership and climate zone, and includes stock changes between 2011 and 2018.

Table 2-10: Private residential and non-residential commercial buildings by purpose and climate zone

building type / year	2011	2012	2013	2014	2015	2016	2017	2018
				floor area m²				
residential	142 176 678	142 251 723	142 305 745	142 350 068	142 390 997	142 428 997	142 480 970	142 529 041
multi-apartment	55 438 063	54 903 303	54 924 153	54 941 260	54 957 058	54 971 724	54 991 783	54 932 175
continental	35 648 303	36 973 127	36 934 763	36 902 157	36 866 144	36 831 205	36 796 295	36 756 411
coastal	19 789 760	17 930 176	17 989 391	18 039 103	18 090 913	18 140 519	18 195 488	18 175 765
family	86 738 615	90 042 271	90 076 465	90 104 521	90 130 429	90 154 482	90 187 379	90 596 623
continental	55 775 475	60 636 503	60 573 585	60 520 111	60 461 050	60 403 748	60 346 496	60 620 331
coastal	30 963 140	29 405 767	29 502 881	29 584 410	29 669 379	29 750 734	29 840 883	29 976 292
office	3 172 512	4 187 138	4 191 791	4 233 351	4 260 028	4 274 518	4 332 602	4 485 944
continental	2 127 585	2 808 025	2 811 145	2 839 017	2 856 907	2 866 624	2 905 577	3 008 414
coastal	1 044 927	1 379 113	1 380 646	1 394 334	1 403 121	1 407 893	1 427 024	1 477 531
hotels and restaurants	3 477 076	3 357 532	3 414 540	3 472 120	3 548 686	3 689 688	3 890 329	4 083 148
continental	2 330 627	2 250 498	2 288 710	2 327 304	2 378 625	2 473 137	2 607 623	2 736 866
coastal	1 146 450	1 107 034	1 125 831	1 144 815	1 170 061	1 216 551	1 282 706	1 346 282
trade services	11 943 890	11 582 615	11 731 774	11 857 714	11 949 236	12 010 125	12 089 527	12 167 833
continental	8 008 705	7 766 460	7 866 475	7 950 921	8 012 289	8 053 117	8 106 358	8 158 865
coastal	3 935 185	3 816 155	3 865 299	3 906 793	3 936 947	3 957 008	3 983 169	4 008 968
other	19 697 761	19 175 706	19 553 860	19 767 042	20 169 063	21 032 913	21 548 582	21 963 462
continental	13 207 450	12 857 410	13 110 964	13 253 904	13 523 461	14 102 676	14 448 435	14 726 615
coastal	6 490 310	6 318 296	6 442 896	6 513 138	6 645 602	6 930 236	7 100 146	7 236 847

Table 2-11: Public residential and non-residential buildings by purpose and climate zone

building type / year	2011	2012	2013	2014	2015	2016	2017	2018
	floor area m²							
residential	4 384 771	4 387 085	4 388 751	4 390 118	4 391 381	4 392 553	4 394 155	4 395 638
multi-apartment	1 128 617	1 693 234	1 693 877	1 694 405	1 694 892	1 695 344	1 695 963	1 762 118
continental	803 981	1 140 262	1 139 079	1 138 073	1 136 963	1 135 885	1 134 809	1 179 075
coastal	324 636	552 972	554 798	556 331	557 929	559 459	561 154	583 043
office	3 412 167	4 503 439	4 508 444	4 553 144	4 581 836	4 597 420	4 659 892	4 824 819
continental	2 640 399	3 484 846	3 488 718	3 523 308	3 545 511	3 557 570	3 605 912	3 008 414
coastal	771 768	1 018 594	1 019 726	1 029 836	1 036 325	1 039 850	1 053 980	1 477 531
education	5 883 146	5 682 727	5 720 018	5 751 638	5 793 588	5 827 083	5 888 671	5 912 968
continental	4 389 549	4 240 012	4 267 835	4 291 428	4 322 727	4 347 719	4 393 671	4 411 799
coastal	1 493 597	1 933 617	1 946 306	1 957 065	1 971 339	1 982 736	2 003 692	2 011 959
hospitals	3 093 976	2 988 574	3 008 186	3 024 815	3 046 877	3 064 492	3 096 881	3 109 659
continental	2 314 366	2 235 523	2 250 193	2 262 632	2 279 135	2 292 311	2 316 539	2 326 097
coastal	779 610	753 051	757 993	762 183	767 742	772 181	780 342	783 562
sports halls	436 595	421 722	424 489	426 836	429 949	432 435	437 005	438 808
continental	292 226	282 271	284 124	285 694	287 778	289 442	292 501	293 708
coastal	144 369	139 451	140 366	141 142	142 171	142 993	144 505	145 101
other	454 620	1 180 791	1 195 734	1 207 882	1 223 715	1 250 095	1 273 257	1 297 005
continental	353 900	919 189	930 822	940 278	952 604	973 139	991 169	1 009 657
coastal	100 720	261 602	264 912	267 604	271 112	276 956	282 087	287 349

2.6 OVERVIEW OF THE NATIONAL BUILDING STOCK BY AREA (URBAN/RURAL, COUNTY/CITY/MUNICIPALITY)

The national residential building stock has been analysed at county level, covering the pace of increase in the total floor area of residential buildings between 2011 and 2017 by county.

The Table shows the rate of increase in the floor area compared to the previous year (2012 vs. 2011, 2013 vs. 2012, etc.) for residential buildings by county which indicates, except for a slight deviation in the City of Zagreb and the Međimurje County, an above-average increase in the floor area of residential buildings in coastal counties and a below-average increase in continental counties. Tables 2-13 and Table 2-14 show the distribution of Croatia's residential and non-residential building stock in urban and rural areas.

Table 2-12: Annual rate of increase in the residential building floor area by county, 2011–2017

	2012/ 2011	2013/ 2012	2014/ 2013	2015/ 2014	2016/ 2015	2017/ 2016
Vukovar-Syrmia County	1.008	1.003	1.002	0.999	1.000	1.002
Koprivnica-Križevci County	1.004	1.002	1.002	1.002	1.002	1.003
Krapina-Zagorje County	1.004	1.004	1.002	1.002	1.002	1.002
Osijek-Baranja County	1.004	1.005	1.002	1.002	1.001	1.002
Sisak-Moslavina County	1.004	1.003	1.005	1.001	1.001	1.001
Bjelovar-Bilogora County	1.005	1.003	1.003	1.002	1.002	1.002
Karlovac County	1.003	1.003	1.004	1.003	1.002	1.002
Virovitica-Podravina County	1.007	1.003	1.002	1.002	1.002	1.002
Požega-Slavonia County	1.006	1.003	1.003	1.003	1.003	1.002
Varaždin County	1.007	1.003	1.003	1.004	1.004	1.004
Slavonski Brod-Posavina County	1.007	1.005	1.003	1.004	1.003	1.004
Zagreb County	1.008	1.005	1.003	1.003	1.003	1.003
City of Zagreb	1.008	1.005	1.004	1.004	1.003	1.007
Split-Dalmatia County	1.008	1.005	1.006	1.006	1.005	1.006
Međimurje County	1.007	1.005	1.006	1.005	1.006	1.008
Šibenik-Knin County	1.008	1.007	1.006	1.005	1.005	1.007
Lika-Senj County	1.008	1.007	1.006	1.010	1.008	1.007
Primorje-Gorski Kotar County	1.012	1.009	1.007	1.006	1.007	1.007
Dubrovnik-Neretva County	1.011	1.011	1.008	1.006	1.008	1.008
Istria County	1.014	1.010	1.009	1.007	1.007	1.010
Zadar County	1.013	1.010	1.008	1.009	1.008	1.012

Table 2-13: Croatia's residential stock by area – urban/rural, 2018

	multi-apartment		**family**	
	No of buildings	floor area	number of buildings	floor area
	m²	–	m²	–
urban	165 609	28 806 061	269 410	46 031 650
rural	130 727	27 747 263	212 663	44 339 705
total	**296 336**	**56 553 324**	**482 073**	**90 371 355**

Table 2-14: Croatia's non-residential stock by area – urban/rural, 2018

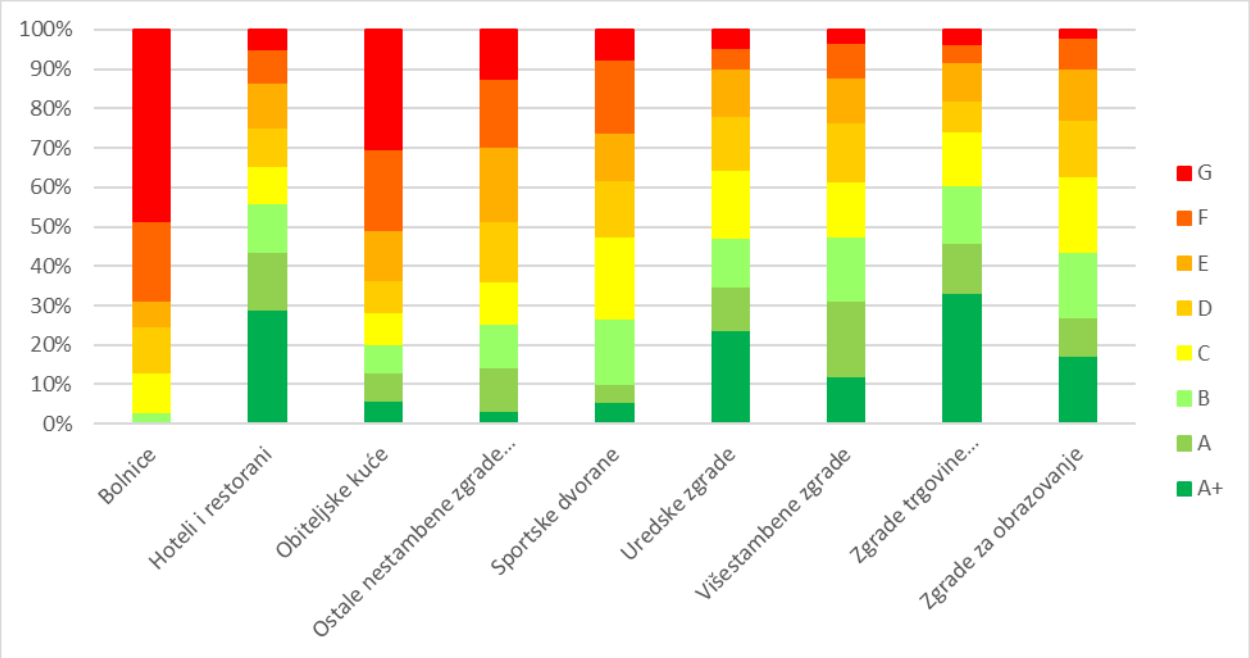
	commercial		**public**	
	No of buildings	floor area	number of buildings	floor area
	–	m²	–	m²
urban	35 956	29 374 539	64 469	11 095 223
rural	15 125	12 356 536	27 119	4 667 257
total	**51 082**	**41 731 075**	**91 588**	**15 762 480**

2.7 ENERGY PERFORMANCE AND BUILDING CHARACTERISTICS

2.7.1 Building energy ratings

The energy performance of buildings is determined using data available in the Information system of energy certificates (IEC), according to energy performance certificates collected and entered in the database between 30 September 2017 and 19 October 2019.

Energy ratings established according to the energy required for heating ($Q_{H,nd}$) by building type, based on the share in the total floor area of buildings (Figure 2.8:), are evenly distributed in multi-apartment buildings and somewhat evenly distributed in office buildings (residential and office buildings are the most common building types), while all other building types show a shift towards lower (hospitals, family houses) and higher (shops, hotels and restaurants) energy ratings.

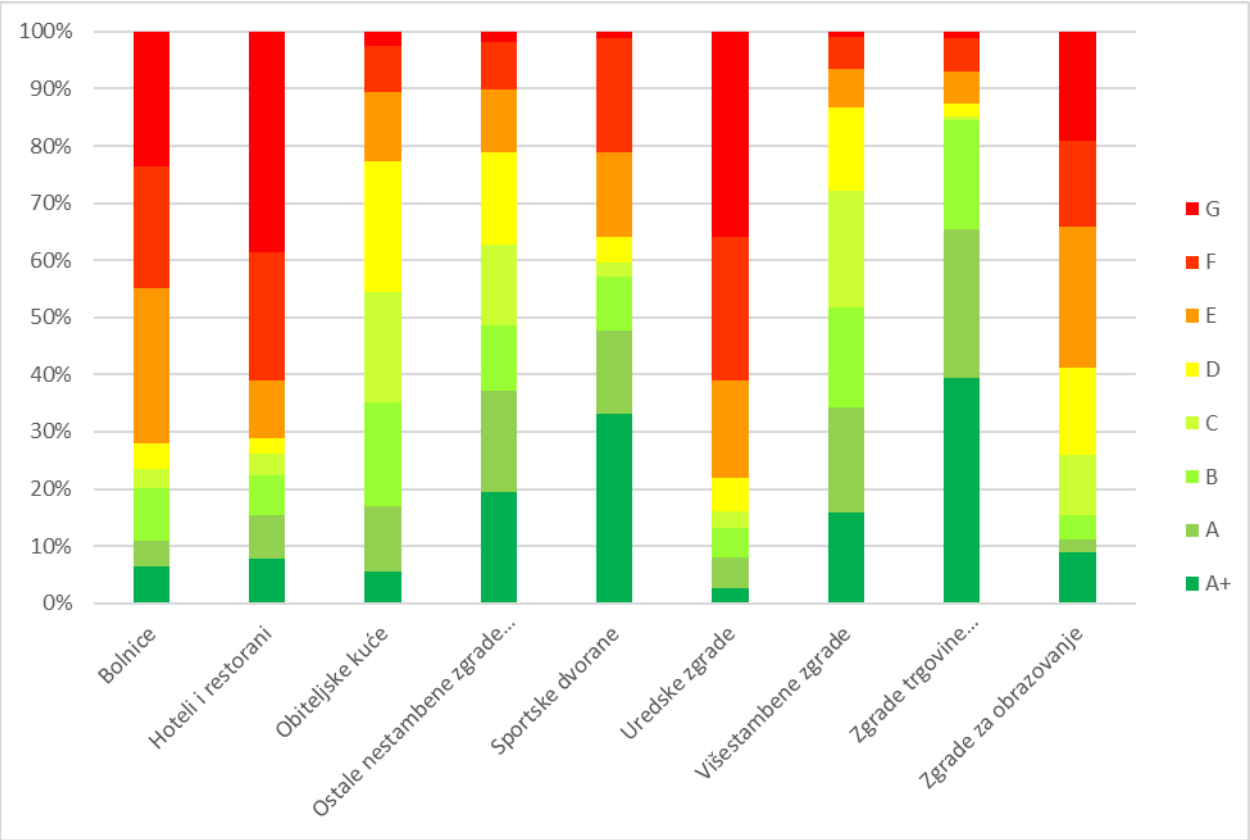


CROATIAN	ENGLISH
	Hospitals
	Hotels and restaurants
	Family houses
	Other non-residential buildings…
	Sports halls
	Office buildings
	Multi-apartment buildings
	Trade services buildings…
	Educational buildings

Figure 2.8: Distribution of energy ratings by $Q_{H,nd}$ by building type

An overview of energy ratings by primary energy (Figure 2.9:) shows a greater share of energy performance certificates with lower energy ratings, probably as a consequence of the relatively recent introduction of primary energy as the main indicator of building energy performance. There is a significant discrepancy in the energy class of hotels and restaurants as well as office buildings by thermal energy required for heating and their primary energy rating. The main reason for this lies in the inclusion in primary energy of the energy required for cooling and lighting, which has a major share [in the energy consumption] in these types of buildings. The rating of energy performance certificates is determined based on the minimum requirements for new buildings and the average characteristics of existing buildings. The bounds of primary energy ratings for existing buildings are such that, based on the calculations made in accordance with the Methodology of energy audits of buildings (15) and their purpose, the buildings which do not use quality

technical solutions (which have to be taken into account when assessing their energy ratings) are penalised for the systems they do not have installed and promptly downgraded to a lower energy class.

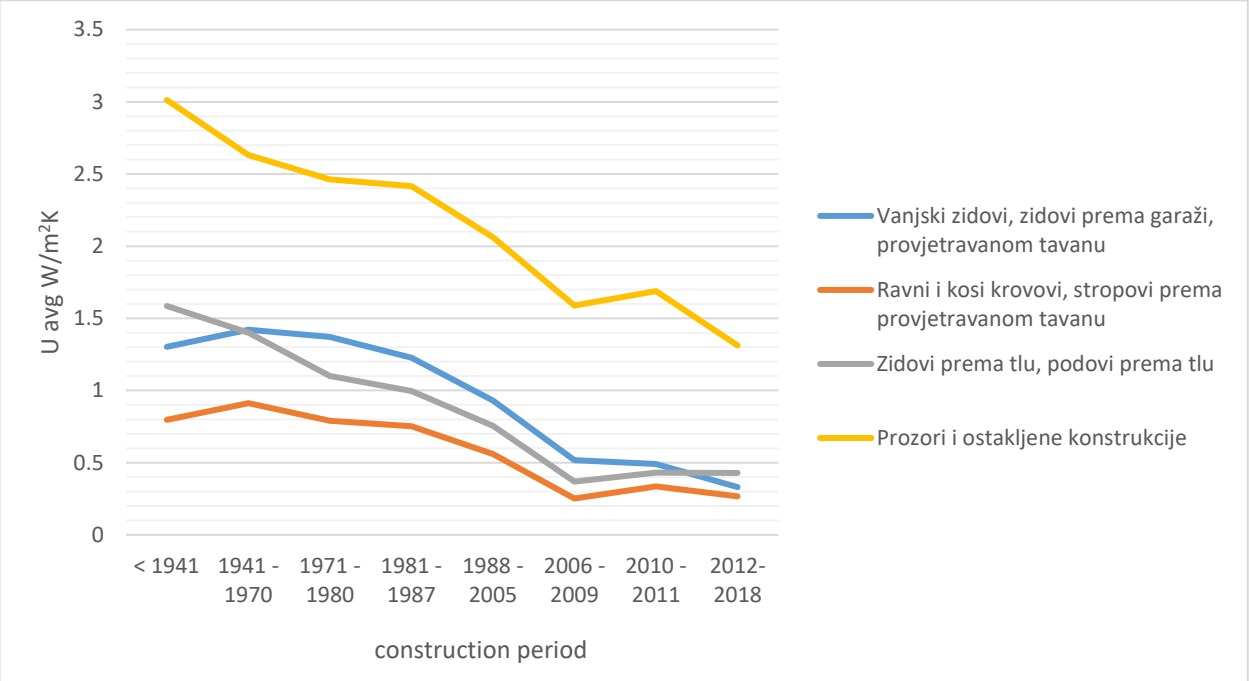


CROATIAN	ENGLISH
	Hospitals
	Hotels and restaurants
	Family houses
	Other non-residential buildings…
	Sports halls
	Office buildings
	Multi-apartment buildings
	Trade services buildings…
	Educational buildings

Figure 2.9: Distribution of energy ratings according to E_{prim} by building type

2.7.2 Thermal transmittance coefficients of structural parts and elements

The thermal transmittance coefficients of typical external envelope structures fall progressively as the construction year of the building is further in the past (Figure 2.10:). The thermal transmittance coefficient decreases most noticeably in glazed structures, where the average U_w equals 1.3 W/m²K. Having deteriorated in the 1970s, the thermal transmittance coefficient of the external wall structures, as well as flat and slanted roofs, subsequently reached 0.30 W/m²K and 0.25 W/m²K, respectively, while averaging 0.45 W/m²K for ground walls and floors on ground level.



CROATIAN	ENGLISH
	U avg W/m^{2}K
	construction period
	External walls, wall bordering garage or ventilated attic
	Flat and slanted roofs, ceilings bordering ventilated attic
	Ground walls, floors on ground level
	Windows and glazed structures

Figure 2.10: Change in typical thermal transmittance coefficients by construction period

The average thermal transmittance coefficients of all buildings, indicating the average condition of the building stock, equal 1.02 W/m²K for external walls, walls bordering garage or ventilated attic, 0.63 W/m²K for flat and slanted roofs and ceilings bordering unheated attic, 0.97 W/m²K for grounds walls, and 2.21 W/m²K for windows and glazed structures. Changes in the average thermal transmittance coefficients of structures may be used as a direct indicator of increased energy efficiency of the building stock.

2.7.3 Heating, cooling, DHW generation and lighting systems

Characteristics of heating, cooling, DHW generation and lighting systems may be monitored indirectly, using the ratio of energy required and delivered for heating, cooling and DHW generation. The average ratio of delivered and required energy is 1.27 kWh/kWh. This indicator shows the average increase of efficiency in heating, cooling, DHW generation and lighting systems of buildings by construction period. Depending on the year of construction, the ratio of delivered to required energy of all buildings decreases (with the exception of hotels, which recorded an increase between 2005 and 2009, possibly because the sample was too small). The continued improvement of the ratio of delivered to required energy of the overall stock is a positive trend. The ratio of delivered to required energy for heating and cooling is expected to decrease, i.e. the energy delivered per unit of energy required for heating and cooling is expected to decrease.

Table 2-15: Total energy delivered and required for heating and cooling

Building purpose	**Ratio of total energy delivered and required for heating and cooling**
Hospitals	1.54
Hotels and restaurants	1.19
Family houses	1.12
Other non-residential buildings heated to a temperature of +18 °C or higher	1.21
Sports halls	1.58
Office buildings	1.14
Multi-apartment buildings	1.36
Wholesale and retail trade services buildings	1.51
Educational buildings	1.05
Total	**1.27**

The overview by construction period shows that newer buildings perform better in terms of the ratio of energy delivered and required for heating. Based on the changes observed, this indicator is expected to improve in all buildings and all construction periods thanks to improved characteristics of heating and cooling systems and an increased share of renewable energy sources.

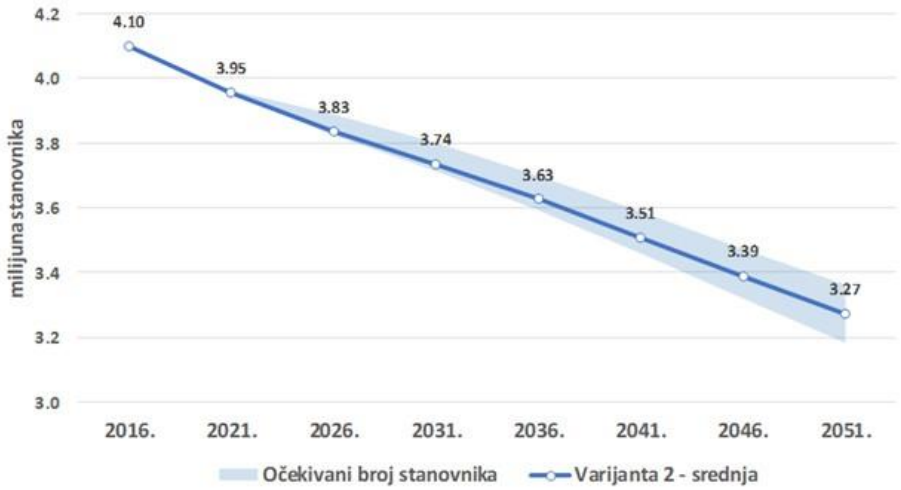
Table 2-16: Ratio of total energy delivered and required for heating and cooling by building type and construction period

Building purpose / period	**<1941**	**1941–1970**	**1971–1980**	**1981–1987**	**1988–2005**	**2005–2009**	**2012–2018**
Hospitals	1.57	1.68	1.52	1.38	1.62		1.33
Hotels and restaurants	1.30	1.24	0.96	1.42	1.32	0.98	1.15
Family houses	1.15	1.21	1.21	1.20	1.19	1.19	0.91
Other non-residential buildings heated to a temperature of +18 °C or higher	1.10	1.36	1.21	1.21	1.28	1.13	1.11
Sports halls	1.58	1.65	1.45	1.77	1.61	1.55	1.52
Office buildings	1.19	1.26	1.17	1.23	1.16	1.12	0.94
Multi-apartment buildings	1.30	1.20	1.17	1.23	1.24	1.29	0.92
Wholesale and retail trade services buildings	1.58	1.42	1.41	1.45	1.53	1.45	1.41
Educational buildings	1.06	1.06	1.13	1.01	1.02	1.36	0.87
total	1.29	1.22	1.19	1.22	1.24	1.27	0.96

Based on changes in the indicator observed in the tables above, it is possible to track changes in average system characteristics, thus obtaining information on which policy adjustments are necessary to bring about an increase in the energy efficiency of systems.

2.8 EXPECTED SHARE OF RENOVATED BUILDINGS IN 2050

The share of renovated buildings in 2050 depends on the approach applied to building renovation and the overall size of the building stock – not renovated, renovated and new. Even if an expected increase in space standard from the current 30 m² of living area per person to 48 m² in 2050 is taken into account, population changes (Figure 2.11:) indicate that Croatia's permanently occupied residential floor area will be 158 mil. m² in 2050.



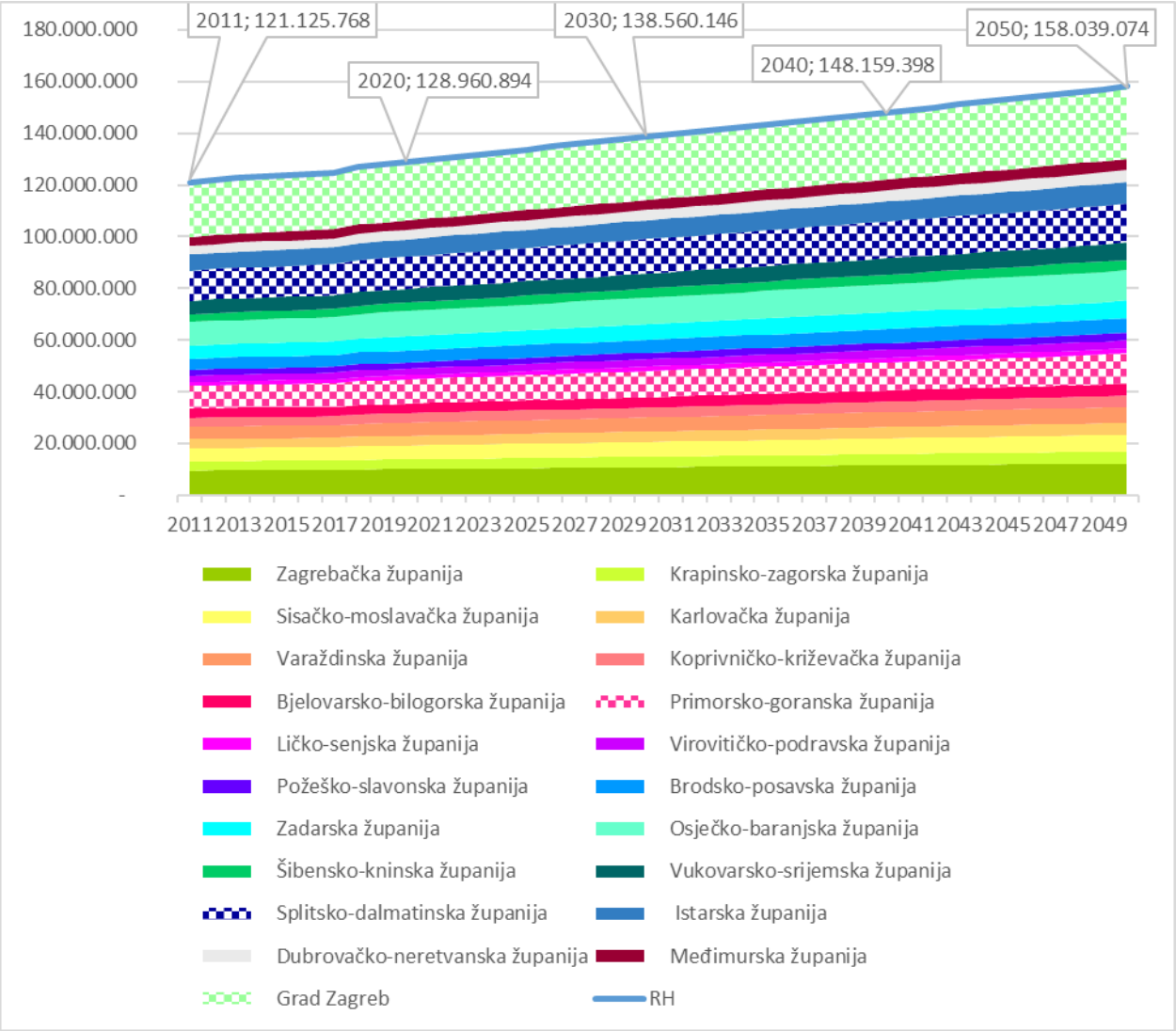
CROATIAN	ENGLISH
	million inhabitants
	expected population size
	Variant 2 – median

Figure 2.11: Population changes in Croatia's p.e. – median projection of demographic development

In the period up to 2050, there will be no major territorial redistribution of the building stock at county level, primarily due to the small share of new builds compared to the size of the existing building stock; however, renovation will change the buildings' energy performance.

The registered energy renovation rate of Croatia's building stock was 0.7% of the building stock, or 1.35 mil. m² per year, between 2014 and 2020.

Any further increase in the renovation rate between 2021 and 2050 depends largely on two critical factors – the first being the financial capacity of building owners and society as a whole to support a high rate of investment in buildings at a time of limited economic growth and depopulation, as well as the capacity of the construction sector to perform the appropriate scope of works. Statistics put the current production capacity of the construction sector's building construction at approx. 3.0 mil. m² per year (2.948 mil. m² in 2017), with the maximum (5.5 mil. m²) reached in 2007. In view of the population decline, it is assumed that such sector size will be difficult to achieve, so it will reach a maximum of approx. 5 mil. m² per year in 2050 assuming linear growth (Figure 2.12:).



CROATIAN	ENGLISH
	Zagreb County
	Sisak-Moslavina County
	Varaždin County
	Bjelovar-Bilogora County
	Lika-Senj County
	Požega-Slavonia County
	Zadar County
	Šibenik-Knin County
	Split-Dalmatia County
	Dubrovnik-Neretva County
	City of Zagreb
	Krapina-Zagorje County
	Karlovac County
	Koprivnica-Križevci County
	Primorje-Gorski Kotar County
	Virovitica-Podravina County
	Slavonski Brod-Posavina County
	Osijek-Baranja County
	Vukovar-Syrmia County
	Istria County

	Međimurje County
	Croatia
	180 000 000
	160 000 000
	140 000 000
	120 000 000
	100 000 000
	80 000 000
	60 000 000
	40 000 000
	20 000 000
	2011; 121 125 768
	2030; 138 560 146
	2020; 128 960 894
	2040; 148 159 398
	2050; 158 039 074

Figure 2.12: Planned development of Croatia's residential stock until 2050 by county

The baseline value for monitoring the progress of renovation was determined based on the total building stock in 2020. For residential buildings, the floor area of newly built buildings and those renovated between 2011 and 2020 was deducted from the floor area of residential buildings permanently occupied in 2020 (128 960 894 m²) to obtain the useful floor area of 110 143 965 m² to be renovated in residential buildings by 2050, of which 42 395 923 m² in multi-apartment buildings and 67 748 042 m² in family houses.

For non-residential buildings, the 2020 total useful floor area was 58 722 937 m², comprising 42 623 410 m² in commercial buildings and 16 099 527 m² in public buildings. The 2020 heated useful floor area of non-residential buildings amounted to 41 944 955 m^2, of which 30 445 293 m² is accounted for by commercial buildings and 11 499 662 m^2 by public buildings. That is the floor area size to be renovated by 2050.

2.9 SHARE/NUMBER OF NZEBS

According to data collected by the Ministry of Physical Planning, Construction and State Assets from administrative departments in charge of physical planning and construction, a total of 145 nZEBs with a total floor area of 176 981m² were built between 1 April 2014 and 31 December 2019. In the database of energy performance certificates of buildings (for the certificates entered into the IEC up to 29 October 2019), there were entries for a total of 616 buildings meeting nZEB requirements; however, as compliance with those requirements was not obligatory when energy performance certificates were issued, the fact of compliance was not recorded. Therefore, 1.6% of buildings with an energy performance certificate issued in 2018 and 2019 are nearly Zero Energy Buildings.

Table 2-17: No of nZEBs based on reports of administrative departments in charge of physical planning and construction

total nZEBs for the period	total gross floor area (m^2)	total net floor area (m^2)	period
22	47 790	42 879	1 January 2014–30 June 2017
18	14 220	8 171	1 July 2017 – 31 December 2017
17	9 007	8 360	01/01/2018 – 30/06/2018
38	73 931	59 632	1 July 2018 – 31 December 2018
49	31 668	28 494	01/01/2019 – 30/06/2019
1	365	307	1 July 2019 – 31 December 2019
145	**176 981**	**147 843**	

2.10 BUILDINGS WITH THE STATUS OF IMMOVABLE CULTURAL PROPERTY

The Register of Cultural Property of the Republic of Croatia is a public record of cultural heritage kept by the Ministry of Culture and Media. The Register containing a record of every cultural property was used to extract a list of buildings with the status of individual cultural property, in accordance with the draft Energy renovation programme for buildings with cultural heritage status for 2021–2030. A certain number of buildings located within cultural and historic units having the status of cultural property is also included in the Register. But the only data available on such buildings is their number and location (town, conservation department and county). In Croatia, 102 615 buildings are located within cultural and historic units having the status of cultural property, of which 44 889 in continental Croatia and 57 726 in coastal Croatia. That number also includes 1 950 buildings with the status of individual cultural property. Buildings located within cultural and historic units which do not have the status of individual cultural property were not classified by purpose and construction period within the category of cultural heritage buildings, but rather together with all buildings of Croatia's building stock. Moreover, Croatia has another 467 individually protected buildings outside the protected units which can be included in the energy renovation programme for buildings.

The Ministry of Culture and Media does not keep a record of the floor area of buildings with the status of cultural property (either individually or for those which are part of cultural and historic units) in the Register of Cultural Property or in any other databases or sources. An analysis of the building stock and the database of the Energy Management Information System (EMIS) as part of the proposal for the Energy renovation programme for buildings with the status of cultural property for 2021–2030 established that individually protected buildings covered by the programme, with a total area of 2 304 157 m², may be classified by purpose as shown in Table 2-17.

Table 2-18: Buildings with the status of immovable cultural property by purpose

Purpose	Coastal Croatia	Continental Croatia	Total
	floor area A_k (m^2)	floor area A_k (m^2)	floor area A_k (m^2)
Hospitals	125 946.89	340 688.40	466 635.29
Education	111 350.08	616 178.78	727 528.86
Sports	9 153.88	8 394.16	17 548.04
Office	181 951.52	615 912.99	797 864.51
Community residential buildings	39 310.19	110 260.93	149 571.13
Others	45 272.13	97 737.46	143 009.59
Total	512 984.69	1 789 172.73	2 302 157.42

According to an estimate of buildings for other purposes not covered by the EMIS, multi-apartment buildings accounted for 9 247 086 m² and family houses for 14 468 001 m².

2.11 BUILDINGS OWNED AND USED BY THE CROATIAN ARMY

The Croatian armed forces long-term development plan for 2015–2024 provides for a two-phase relocation of the Armed Forces troops to envisaged locations and the accompanying abandonment of low-potential properties over a 10 year period – the first phase by the end of 2019 and the second phase from 2020 to 2024.

Properties for defence purposes are owned by the Republic of Croatia and have been entrusted to the Ministry of Defence for use and management. They are categorised as follows:

- high-potential properties (properties built for military purposes used by the
- [Ministry] of Defence);
- temporarily high-potential properties (properties built for military purposes which are used by the Ministry of Defence but are undergoing abandonment);
- low-potential properties (properties built for military purposes not used by the Ministry of Defence).

Rationalising the use of military properties, the Ministry of Defence will only use high-potential properties, while the management of all low-potential and temporarily high-potential properties (after relocation) will be handed over for management to the Ministry of Physical Planning, Construction and State Assets.

In a bid to increase efficiency, accommodation, training and logistics facilities will be consolidated at high-potential locations, primarily training areas and barracks. The total number of properties will be rationalised and the abandonment and handover of low-potential properties will be expedited to reduce costs of their insurance and maintenance. The plan states the intention to continually raise labour, accommodation and training standards at high-potential locations and adapt the condition of facilities to meet the requirements of specific regulations in the fields of physical planning, construction, fire safety, safety and health at work, environmental protection and technical security.

The plan is to explore and develop a concept for the construction of prefabricated and modular buildings for accommodation, logistics and other purposes, as well as a rapid construction system, applying the processes aimed at achieving energy efficiency and waste management processes. Biomass energy installations will be designed and built at army training areas and in other military locations with resources and possibilities for biomass preparation.

Twelve locations have top priority, with plans to reconstruct existing facilities and increase their energy efficiency while also building teaching, administrative, accommodation and technical facilities. Another 15 locations have second priority, with plans to reconstruct, expand existing and build new facilities to include the application of renewable energy sources.

3 ANALYSIS OF KEY ELEMENTS OF THE BUILDING RENOVATION PROGRAMME

Energy renovation programmes to date have included all purposes of buildings, private, public and commercial users, as well as buildings with the worst performance in assisted areas and areas of special state concern. All renovation programmes are based on the provision of financial aid to building owners either through grants or other financing models, such as the energy performance contracting model.

The key elements of all building renovation programmes are as follows:

– eligibility criteria for applicants,

– list of eligible activities,

– total amount of grants available for award,

– the minimum and maximum amount of available grants,

– amount of the applicant's own share,

– eligible project location,

– main eligibility criteria and project proposal selection criteria,

– list of supporting documents required of the applicants, and

– list of ineligible costs/expenses.

So far, the Ministry of Physical Planning, Construction and State Assets, as Interim Body Level 1 (IB1), has published four calls for energy renovation co-financing, requiring heating energy savings of at least 20% in one and 50% in the other three calls:

– pilot project 'Energy renovation of buildings and use of renewable energy sources in public institutions performing educational activities', Ref. No KK.04.2.1.02 – minimum 20% savings

– call for project proposals 'Energy renovation of multi-apartment buildings', Ref. No KK.04.2.2.01 – minimum 50% savings

– call for project proposals 'Energy renovation of buildings and use of renewable energy sources in public institutions performing educational activities', Ref. No KK.04.2.1.03 – minimum 50% savings

– call for project proposals 'Energy renovation and renewable energy sources use in public buildings', Ref. No KK.04.2.1.04 – minimum 50% savings.

The preparation, adoption and implementation of such programmes proved efficient in encouraging energy renovation in Croatia between 2014 and 2020, so the adoption of further programmes for the period between 2021 and 2030 too is provided for in the Construction Act, as well as the Integrated national energy and climate plan.

3.1 TECHNICAL OPTIONS FOR THE ENERGY RENOVATION (RETROFIT) BY IMPLEMENTING ENERGY EFFICIENCY MEASURES AND DEPLOYING RES IN EACH BUILDING CATEGORY/TYPE

The priority energy efficiency measure during energy renovation is the renovation of the external envelope of heated space. While no major modification of a building's architectural design is possible in the energy renovation, the following design options regarding the architectural details of the building need to be taken into account separately for each building when renovating it: mobile shading elements; opening large glass surfaces on southern (south-eastern, south-western) parts of the façade; thermal protection of unprotected overhangs and penetrations to eliminate thermal bridges, etc. In addition to all the activities listed above,

this measure also needs to comply with the maximum permitted thermal transmittance coefficients of the building's structural parts.

In Croatia, the nZEB construction standard is defined in full by the Technical regulation on energy economy and heat retention in buildings (NN Nos 128/15, 70/18, 73/18, 86/18, 102/20). The transitional provision of Article 43(1) of the Act amending the Construction Act specifies that all new buildings must be nearly Zero Energy Buildings as of 31 December 2020. Moreover, the Technical Regulation provides for the main design of a building, enclosed with the application for a building permit, to be prepared in accordance with the provisions for nZEBs laid down in that regulation. These obligations do not apply to buildings for which the application for planning permission or building permit was submitted before 31 December 2019 or to buildings used by public authorities as building owners if the application for a planning permission or building permit was submitted before 31 December 2017. In Croatia, compliance with the nZEB standard is checked at the time the application for a building permit is submitted, that is, in the design stage of the building, rather than after obtaining the certificate of occupancy when it has already been built.

The performance of nZEBs is determined based on the characteristics of the building stock used to define reference buildings, including the optimisation of the building geometry in order to achieve the lowest possible level of energy required to meet buildings' energy needs. In Croatia, the nZEB definition applies to the following new buildings by purpose:

- family buildings,
- multi-apartment building,
- office building,
- educational building,
- (wholesale and retail) trade services buildings,
- hotel and restaurant buildings,
- hospital buildings, and
- sports hall buildings.

An nZEB is defined by the amount of primary energy consumed for heating, cooling, ventilation, DHW generation and lighting, as well as by a minimum 30% share of RES in the delivered energy required to meet buildings' energy needs. The Technical Regulation lays down limitations to the annual amount of thermal energy needed for heating per unit of the useful floor area of a building $Q''_{H,nd}$ [kWh/(m^2·a)], and of primary energy E_{prim}, which includes energy for heating, cooling, ventilation, DHW generation and, in the case of non-residential buildings, lighting for each building type by purpose.

3.1.1 Measure of heating, cooling and ventilation system and DHW generation system centralisation and modernisation by applying RES

Heating systems can be centralised and existing boiler rooms modernised by switching to renewable energy sources, as a potential solution for the integration of RES in buildings with limited technical possibilities. If the building's total energy requirements are small, and the system is suitable for low-temperature heating operation with pronounced cooling requirements, the use of a heat pump is recommended for heating, cooling and DHW generation.

For the purpose of defining the most appropriate heating system, the following options need to be considered for each building separately:

- separate (independent) boiler system,
- district heating system using RES.

In the case of separate boiler systems, the boiler room is situated within the building at the current location. In the case of district heating systems, the boiler room does not need to be situated within the building but may be part of other facilities connected to the pipeline system. In the latter case, it is necessary to provide a substation for thermal energy transmission from the district heating to the building. This measure involves the heating system regulation and balancing (thermostat sets, differential pressure controllers,

frequently operated pumps, etc.), as well as performing a thorough cleaning of the pipeline radiator system and all exchangers. In the case of separate boiler systems, the need for chimney renovation should also be considered for each building separately.

The limited applicability of RES in urban areas switches the focus in buildings from their use to larger district systems. By centralising and modernising heating systems, the structure of energy sources supplied to the building may be changed and compliance with the minimum share of RES in buildings may be ensured through the certification of the RES itself.

3.1.2 Technical possibilities for district heating systems (DHS)

Centralised or district heating systems (DHS) exist in a considerable number of cities and larger towns in Croatia, namely: Zagreb, Osijek, Sisak, Velika Gorica, Karlovac, Zaprešić, Samobor, Slavonski Brod, Split, Varaždin, Rijeka, Virovitica, Vinkovci, Vukovar and Požega. Technical possibilities and requirements for connecting a building to the DHS are described in detail in the Network rules of thermal energy distribution, but there is no difference in the technical possibilities and requirements depending on the building categories considered within the scope of this Long-term strategy.

Systems using centralised thermal energy supply have certain advantages over separate heat generation systems, including:

- the exploitation of waste heat from cogeneration plants (which significantly increases the overall efficiency of such plants compared to the cases in which no waste heat is used);
- possible interpolation to other systems (waste disposal, exploitation of waste heat from industry, etc.);
- centralised RES use to integrate renewable energy sources in buildings with limited technical possibilities at the current location of the building.

In the event that renewable energy sources are used in the DHS, when setting the optimum plant variant in terms of thermal energy generation only (heating plant) or thermal energy and electricity cogeneration, it is necessary to consider limitations related to energy efficiency laid down in the Tariff system for electricity generation from renewable energy sources and cogeneration.

In the strict sense, energy renovation hampers sustainable operation of district heating systems by increasing investment and maintenance costs of district systems to reduce energy needs, while at the same time users continue to press for lower energy prices. Problems related to DHS, including investment needs which are difficult to justify when energy consumption decreases through energy renovation of buildings, can be mitigated by changing the structure of energy sources and using appropriate primary energy factors – renewable and non-renewable components.

Existing regulations do not provide for the possibility of integrating renewable energy sources that are physically or organisationally separate from a building because only the non-renewable component of primary energy factors is used to determine the energy performance of a building. Given the technical limitations of buildings in urban centres and the level of investment in maintenance and operation of existing systems, future measures should be aimed at elaborating such a model that would increase the share of district systems by enabling buildings to use renewable energy sources or they would not be able to meet legal requirements. The first step would be to determine both specific primary energy factors for existing district heating systems and a long-term plan for changing primary energy factors of all energy sources, whereby equal treatment of all primary energy sources would gradually be ensured by applying the same approach to factor calculation.

3.2 POSSIBLE SUSTAINABLE BUILDING RENOVATION MODELS

Possible sustainable building renovation models cannot rely solely on subsidisation of building renovation and construction. Linking building energy renovation to district heating and cooling systems is a significant step that shows that energy systems are switching from operation based on high operating costs to operation based on high investment costs, much in the same manner that improved thermal quality of the external envelope significantly increased buildings' investments costs.

Over the next period, several levels of renovation will be implemented:

- **implementation of individual energy renovation measures** with the aim of achieving staged deep renovation,
- **integral energy renovation**, which includes a combination of several energy renovation measures, with building envelope measures being obligatory,
- **deep renovation**, comprising energy efficiency measures for the envelope and technical systems and reducing the annual consumption of heating ($Q_{H,nd}$) and primary energy (E_{prim}) [kWh/(m^2·a)] by at least 50% compared to pre-renovation energy consumption,
- **comprehensive renovation**, comprising optimal measures for improving the existing conditions of buildings, as well as building energy renovation measures and other measures, e.g. for increasing safety in the case of fire, ensuring healthy indoor climate conditions, improving mechanical resistance and stability of buildings, in particular to reduce risks related to earthquake loads. Comprehensive renovation of a building may also include other measures to improve the basic requirements for buildings.

In Croatia, requirements for nZEBs were determined for the first time in the Technical regulation on energy economy and heat retention in buildings (NN No 128/15), based on cost-optimal analyses of reference buildings. The national methodology laid down in the Technical Regulation is applied to analyse compliance with requirements. Their implementation is not restricted by enhanced requirements, introduced as part of a repeat cycle for determining cost-optimal requirements, which will also set new limits for nZEBs. Identified shortcomings of the methodology can be overcome in practice by applying accepted standards and rules of the profession.

At the national level, specific additional requirements should be developed for building reconstruction to meet nZEB standards because of limitations observed during reconstructions, so requirements concerning the characteristics of the external envelope and the building's technical systems, and RES integration should be constantly monitored.

In order to develop sustainable, inclusive, safe and resilient cities and towns, the Ministry is drafting the Programme for development of circular management of space and buildings for 2021–2030. Circular management of space and buildings contributes to sustainable development by preserving existing resources through the planning and revitalisation of space and the reuse of buildings to create long-term added value and enable efficient resource management. The Programme's objectives include the development of circular management of space and buildings, circular renovation of unused spaces and buildings, and a high level of knowledge and awareness of circular management of space and buildings.

3.3 ENERGY EFFICIENCY OF LARGER SPATIAL UNITS – CITY OR TOWN DISTRICTS, NEIGHBOURHOODS OR SETTLEMENTS

Due to their micro-location and other limitations transferred to the location from higher-level plans, individual buildings might face considerable technical discrepancies from optimal requirements for buildings. Relationships between buildings and possible ways of exchanging energy can be analysed at the level of city or town districts or neighbourhoods to enable a greater number of buildings to meet nZEB requirements, thus increasing their owners' motivation to undertake energy renovation. As energy efficiency requirements are extended to a wider area, problems related to the energy efficiency of construction areas or nearly Zero Energy Neighbourhoods – nZENs (larger spatial units with zero-energy consumption) also touches on other areas, such as smart technologies, smart networks, user involvement, additional ownership conditions and requirements.

Green infrastructure, such as tree lines, promenades, sports and recreational areas, children's playgrounds, grassy areas, blocks' inner courtyards, green roofs and green façades, etc., contributes to a reduction in energy needs of buildings and spaces, including districts and neighbourhoods, as well as to energy savings in heating and cooling. The interpolation of green and blue areas into the built urban fabric reduces space temperature and urban heat islands.

In addition to clear objectives and indicators for nZENs, what also needs to be defined are requirements in spatial plans, district-level administrative capacities, mechanisms for local consensus, and clear market rules.

The Programme of green infrastructure development for 2021–2030 promotes the inclusion of green infrastructure into spatial planning, focusing on the development and improvement of new and existing green and blue areas and their interconnection and inclusion in green infrastructure, as well as their better integration into the spatial planning of building areas in Croatian cities, towns and settlements.

3.4 PROJECT AGGREGATION

Aggregation of energy renovation projects is important because of access to financial instruments and other forms of financing for energy renovation. The fixed costs of project implementation, as well as the risks of failing to meet the set [targets], increase exponentially in proportion to a decrease in project size. Project aggregation reduces the costs and risks for financial institutions, also reducing the cost of project financing. The Irish Deep Retrofit 2019 pilot programme, implemented by the Sustainable Energy Authority of Ireland – SEAI (16), offers a simple model of project aggregation and risk mitigation, provided that, in addition to meeting other requirements for deep renovation of buildings, the project application covers at least five single-family houses. In this way, the applicant – who can be an energy service provider or another project developer – mitigates the risks to achieving any savings targets which may arise from objective circumstances of the specific project and simultaneously applies for a larger grant amount, reducing the administrative burden on financial institutions.

Projects may be aggregated through:

- **project aggregation platforms**

  Project aggregation platforms generally take the form of open databases of available projects for increasing energy efficiency, enabling the assessment of projects' benefits and financial risks. Project aggregation can be aggregated based on various criteria, the main purpose being to reduce risks for applicants. The issue with project aggregation is the creation of the database and how to motivate owners to access such platforms. Croatia has a well-developed national energy management information system (EMIS), which currently includes only public buildings, i.e. buildings owned or used by public sector entities. Based on EMIS data, energy and water consumption in buildings can be analysed before and after investing in the increase in energy efficiency. The voluntary extension of EMIS to other buildings and linking it with the Information system of energy certificates (IEC) may provide access to the most reliable information on buildings and potential investments in energy efficiency measures. For data protection reasons, the optimal approach is to design a stand-alone IT platform which would simultaneously allow building owners to put forward measures identified in energy renovation projects or energy efficiency certificates to be included in aggregated projects, while providing investors and financial bodies with access to aggregated project information. Alternatively, existing open-access platforms, such as De-risking energy Efficiency Platform (DEEP) owned by DG Energy, could be used or EMIS could be involved as a project information provider.

- **investment groups**

  Stakeholder investment groups can be formed on both the supply side and the demand side in projects to increase energy efficiency. It is impossible to systematically identify what motivates investors to invest in energy efficiency, but all investments increase energy efficiency in final energy consumption irrespective of the motivation. The primary market consists of investors seeking to reduce energy consumption – ESCOs and building owners. The secondary market involves investments in specialised technologies and products for increasing energy efficiency, such as LED lights, EMS systems or nZEBs, where the investor does not necessarily need to be motivated by energy savings but rather by legal obligations. The third segment consists of incremental investments implemented by upgrading to more energy efficient equipment and products. Finally, systematic investments to increase productivity, such as in district heating, or to improve public transport or optimise the supply chain form the fourth stakeholder group. In the context of crowd investing, particular attention going forward will be given to creating conditions for active

participation of customers/consumers in energy transition and to strengthening the framework for forming energy communities and renewable energy communities which will be involved in local energy production and production of energy for their own use, in accordance with the provisions of the Directive on the promotion of the use of energy from renewable sources, the Electricity Directive [(No 2009/72/EC)] and the Regulation on the internal market for electricity.

- **consortia of SMEs**

  Project aggregation requires an appropriate organisational response within the construction supply chain. The average investment in a single energy renovation project is approx. HRK 3 million, constituting a minor investment, but a number of projects significantly exceeds that amount. The upper limit to the aid for energy renovation of multi-apartment buildings of HRK 20 million corresponds to a major investment for which small enterprises are not very well able to compete. Consortia may be formed based on the business model of collaboration in construction or around specific issues, such as raising awareness and enhancing implementation capacities, which is the primary role of the Cluster for energy efficiency and sustainability in buildings – nZEB.hr.

- **bundled solutions**

  Solution bundling is a simple model for service users. In most cases, building owners are not aware of their obligation to maintain buildings or of the possibilities of implementation of the measures to increase energy efficiency. Calls for the award of aid for energy renovation of buildings generally provide funding for a large scope of measures, although measures primarily aimed at reducing energy needs are the most prevalent in projects, while complementary measures are rarely included. By bundling measures, various elements can be grouped together, for example energy audit and design, design and implementation of energy renovation projects, project aggregation and financing, etc. Bundled solutions can be adapted to local specificities, where the key elements of the bundle depend on dominant systems, energy sources used or structural characteristics. Bundles can also be created for various types of buildings to cater to their specific needs.

  Solutions can be combined into a vast number of bundles, some of them comprising:

  - biogas cogeneration on farms and thermal isolation of buildings;
  - energy renovation measures and measures related to renewable energy sources to meet requirements for nZEBs;
  - nZEB construction; and
  - renovation of district heating and cooling systems and energy renovation of buildings.

3.5 ONE-STOP-SHOP

One-stop-shops (OSSs) provide a simple access to information on energy renovation and financing possibilities, as well as promotion of energy efficiency among all user groups. Based on consultations in all stages of the renovation process, OSSs are funded from the budgets of local self-government units. One-stop-shop organisational models may be flexible and adaptable and would best be organised through the EPEEF, regional and local energy agencies offering this type of service to their users as part of their activities. It is crucial to collect in a single place information on saving potential, necessary steps and possible sources of financing and other forms of aid for energy efficiency projects.

OSS development models aimed at increasing energy efficiency have been tested in a series of EU-funded projects and national initiatives for various OSS types and target groups.

OSS types

One stop shops can be categorised into the following types:

- industrial – organised by producers or installers with the aim of expanding the market or improving customer service;
- consultancy – original user-oriented service created by expanding the existing range of services in order to expand customer reach;
- ESCO – relying on a complex offering of ESCO services in reorganised form, highlighting specific user benefits;

- local self-government – primarily motivated by the need to achieve climate objectives, but sometimes also social objectives; and
- cooperative – primarily aimed at achieving social benefits rather than energy and financial savings only.

Target user groups

In most cases, OSSs' target user groups are residential buildings, typically single-family residential buildings, given that residential buildings have the highest saving potential to be harnessed. They are followed by multi-apartment buildings and local government authorities. The offer of one stop shops is adapted to the user structure – e.g. an OSS targeting local self-government focuses on major projects and public buildings or investments into renewable energy sources, while OSSs supporting private users predominantly offer predefined renovation bundles, typically shaped by the industry, and examine the individual needs of each client to help them choose the appropriate bundle and adjust it to their needs. This is the way to both aggregate projects and reduce project management costs.

OSS benefits

OSS benefits are multi-faceted. Benefits to private users depend on personal characteristics – whether someone is a lay user or a well-informed user, and include:

- generally more information available on energy efficiency;
- information on the possible high potential for improvements in one's own home, personal advice;
- single point of contact and payment without the need to communicate with a large number of services providers;
- trust in a single service provider;
- individual steps in personal project management replaced by a complex approach;
- assessment of alternatives;
- quality control and quality guarantee for technical partners;
- faster project completion; and
- help in providing financing.

Local market stakeholders – installers, engineers, contractors – benefit from OSSs through services such as:

- training courses;
- tools for budgeting, implementation, supervision;
- new business contacts; and/or
- quality improvements through accreditation and quality control.

At the same time, one stop shops themselves also benefit from:

- increased resilience to legislative pressure – they adapt more easily to deregulation, liberalisation or privatisation;
- resilience to economic pressure thanks to increased workload;
- integration of a longer added-value chain by developing customer relationships;
- more stable relationships and better prices;
- better customer service; and
- higher sales with ancillary services.

One-stop-shops may operate as public authorities with the aim of achieving public objectives (energy savings).

Financing support

An addition service to be offered by an OSS to a greater or lesser extent is support in access to financing for the projects under its management. Support for private clients may take the form of:

- technical support to organisations primarily offering financial products (banks and credit lines);
- preparation of financial plans for clients, as well as support in making quality informed decisions and choices;
- own financing or raising loans or other forms of financing;
- steering towards aid or sources of credit; and
- preparation of project documentation, guarantees or financial plans to enable fast evaluation of loan applications by banks.

One-stop-shops are efficient because they are locally based, speeding up the process of energy renovation by informing and motivating users, as well as the provision of support to building owners, facilitating access to financing, and may also increase energy savings through energy renovation because they go through the entire process of renovation.

3.6 IDENTIFICATION OF A COST-EFFECTIVE APPROACH TO RENOVATION, DEPENDING ON BUILDING CATEGORY AND CLIMATE ZONE

In terms of the minimum requirement for buildings, renovation today should aim for a nearly Zero Energy Building, irrespective of its purpose. The cost-optimal building requirement and the definition of nZEB requirements were established in 2014 but are being redefined due to the passage of time and major changes in the market (40% increase in construction prices over five years between 2014 and 2019).

In selecting a cost-optimal level of energy renovation, the values referred to in the Technical regulation on energy economy and heat retention in buildings were compared with calculation results, while applying input parameters for building selection:

– all buildings (all variants) were categorised under purpose and climate, irrespective of the construction period;

– buildings built after 2005 were excluded from the comparison;

– buildings outside the cost-effective range were excluded from the comparison.

Based on data concerning reference buildings, the level of building energy renovation was optimised in terms of delivered and primary energy to a cost-optimal level, as well as to the nZEB level. The values provided for new-builds in the Technical regulation on energy economy and heat retention in buildings are used as reference requirements for building renovation in developing an energy model by 2050, with the expectation of an accelerated technological development to bridge the gap between current requirements and possibilities.

The implementation of nZEB requirements in practice has shown the need to establish specific requirements for renovated buildings which cannot meet requirements for new buildings due to external limitations. Until specific requirements for building renovation are adopted, the requirements set out in the Technical regulation on energy economy and heat retention in buildings are to be applied.

3.7 TRIGGER POINTS FOR ENERGY RENOVATION

Due to low purchasing power in Croatia, which is also reflected in a very low rate of energy renovation, the biggest trigger point for energy renovation are grants with a high percentage of co-financing of energy renovation works. The key trigger points in the life cycle of a building are related to the size of the investment and the durability of structural elements and system components. The average durability of building structures in Croatia exceeds the economic service life of buildings of approx. 50 years. Most external envelope structures have a service life of around 30 years. Boilers and ventilation devices as the most expensive elements of thermotechnical systems have a service life of up to 15 years. There is no overview of the average durability by components for Croatia, but a comprehensive overview by system elements is provided in the standard HRN EN 15459-1:2017 Energy performance of buildings – Economic evaluation procedure for energy systems in buildings (17). An analysis of the costs of energy renovation measures of buildings by purpose found that important investment points occur in 15-year cycles.

The median age of apartments in purchase and sale transactions, according to (18), was 36 years in 2017, when a quarter of apartments were up to 10 years old and a quarter were older than 50 years. Therefore, even 'new' apartments on the market are already close to the point at which considerable intervention on heating and cooling systems will be necessary, while the median group shows a need for considerable investment in the external envelope, which is the first trigger for energy renovation.

An increase in the median age in transactions may also indicate that energy renovation was triggered by the sale of an apartment by increasing its market value, so older apartments are becoming interesting to buyers, but this is not evident from data.

Apart from an obligation in the Building Act to maintain the building in usable condition, there is no legal basis for reconstruction or energy renovation of buildings. Article 17 of the Rules on maintenance of built structures (NN Nos 122/14, 98/19) introduces the obligation to improve compliance with the mandatory requirements for built structures, as well as energy performance of buildings and free access to and movement within the building if it is laid down in a special regulation adopted in accordance with provisions of the Building Act or in a special act.

The most probable times in which the energy renovation of buildings is initiated are related to a change of ownership (through purchase and sale, inheritance, generational change) of the major part of the building or a deterioration of its heating system.

Catastrophic events, such as earthquake, fire or flood, do not normally result in energy renovation, but in building replacement by new-builds or a facsimile renovation of buildings. However, more than 24 000 buildings were damaged in the earthquake which hit Zagreb and its surrounding area on 22 March 2020, so their reconstruction to repair the earthquake damage will definitely serve as a trigger point of energy renovation of buildings in Zagreb, the Krapina-Zagorje County and the Zagreb County.

3.8 DESCRIPTION OF THE METHOD USED IN COST-EFFECTIVENESS ANALYSIS

The cost optimum method is based on determining the global cost for any parts of the building which affect energy consumption in the building, any maintenance, operation and energy costs, as well as recycling costs and possibly the cost of CO_2 emissions. The method is described in detail in the standard HRN EN 15459/2008: Energy performance of buildings – Economic evaluation procedure for energy systems in buildings, and can be used to:

- assess the economic feasibility of energy efficiency options in buildings;
- compare various solutions to increase energy efficiency in buildings;
- evaluate economic performance of an overall building design and the building system (e.g. compared to its energy needs);
- determine the impact of energy efficiency measures on the existing system through the economic calculation of the cost of energy use and without that cost, based on the calculation of the net present value of global cost (excluding revenue which may be generated) – investment value, replacement of parts of the building related to energy consumption, and energy sources, maintenance and operation costs of the building.

Table 3-1: Input parameters of the cost-optimal calculation

	Code	Unit	Value
Building depreciation period		years	50
Calculation period	τ	years	30
Inflation rate	R_i	%	0.30
Market interest rate	R	%	6.60
real interest rate	R_R	%	5.91

discount rate[2]		%	7.00
value added tax		%	25
cost of CO_2 emissions		HRK/t	150

Table 3-2 shows the primary energy factors for the energy sources actually used in the packages of measures for cost-optimal calculation.

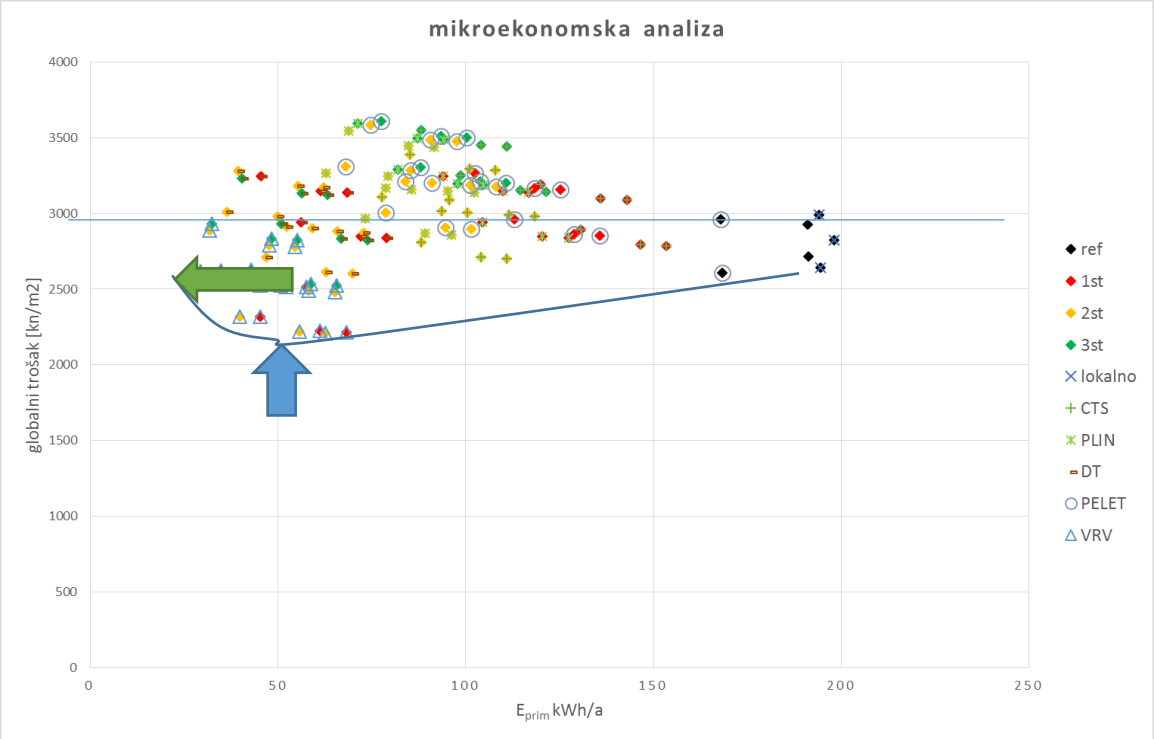
Table 3-2: Primary energy factors

Energy source	**Primary energy factor**	**tCO_2/TJ ($kgCO_2/GJ$) emissions**
	Total	
Firewood	**1.111**	8.08
Wood pellets	**1.191**	9.56
Wood chips	**1.211**	11.76
Natural gas	**1.097**	61.17
LPG	**1.162**	72.47
Extra light fuel oil	**1.140**	83.21
Electricity	**1.614**	65.22
District heating	**1.523**	100.69

In the selection of a cost-optimal level of energy renovation, values referred to in the Technical regulation on energy economy and heat retention in buildings were compared to the results of the calculation, while applying input parameters for the building selection:

- all buildings (all variants) were categorised by purpose and climate, irrespective of the construction period;
- buildings built after 2005 were excluded from the comparison;
- buildings outside the cost-effective range (above the global cost level of the reference building) were excluded from the comparison.

[2] *Decision on the Croatian National Bank discount rate, NN No 66/2011*



CROATIAN	ENGLISH
	Microeconomic analysis
	global cost [HRK/m2]
	E_{prim} kWh/a
	ref
	st. 1
	st. 2
	st. 3
	Local
	DHS
	GAS
	DT
	PELLET
	VRV

Figure 3.1: Method of determining the zone of cost-effective measures, cost-optimal levels and nZEB

Detailed information on investment costs for each combination of measures is the result of the cost specification for each building.

Data on the lifetime of building components and technical systems have been set according to EN 15459:2007 Energy performance of buildings – Economic evaluation procedure for energy systems in buildings, Annexes A and E and good engineering practice in Croatia for any systems and components not included in the standard.

The cost-optimal analysis for the microeconomic and macroeconomic aspect was conducted in accordance with points 4.3(2) and 4.4(2) of Annex I to Delegated regulation 244/2012, entirely in conformity with EN 15459:2007 Energy performance of buildings – Economic evaluation procedure for energy systems in buildings.

4 POLICIES AND MEASURES TO STIMULATE COST-EFFECTIVE INTEGRAL BUILDING RENOVATION

4.1 OVERVIEW OF EXISTING MEASURES TO STIMULATE BUILDING RENOVATION IN CROATIA

An overview of existing measures to stimulate building renovation in Croatia will include the following:

- national and international building renovation projects and programmes; and
- implementation of Croatia's operational programmes for various types of buildings.

Programmes of financial institutions aimed at integral energy renovation of buildings are described in detail in Chapter 11.2.

4.1.1 Overview of national and international building renovation projects and programmes

A large number of building renovation projects in Croatia have been implemented within the scope of the following programmes and initiatives:

- Operational Programme Competitiveness and Cohesion 2014–2020[3] for the use of the European Regional Development Fund and the Cohesion Fund;
- cross-border cooperation under the Instrument for Pre-Accession Assistance – IPA[4];
- European Commission's CONCERTO initiative within the European Research Framework Programme (FP7)[5];
- Competitiveness and Innovation Framework Programme – CIP[6];
- Horizon 2020, EU Research and Innovation programme in the period 2014–2020[7];
- programmes and projects of the Environmental Protection and Energy Efficiency Fund (EPEEF)[8];
- Loan programme for environmental protection, energy efficiency and renewable energy projects and the Loan programme for environmental protection projects of the Croatian Bank for Reconstruction and Development[9];
- technical assistance programme of the European Bank for Reconstruction and Development (EBRD)[10];

[3]Ministry of Economy, Labour and Entrepreneurship (2014), available at: https://strukturnifondovi.hr/wp-content/uploads/2019/02/OPKK_070219.pdf, [2017].

[4]Ministry of Regional Development and EU Funds (2017), available at: http://www.strukturnifondovi.hr/UserDocsImages/Publikacije/Instrument_pretpristupne_pomoci_IPA.pdf, [30 April 2017].

[5]European Commission (2014), available at: http://www.concertoplus.eu/, [30 April 2017].

[6]European Commission (2014), available at: http://ec.europa.eu/cip/, [30 April 2017].

[7]Agency for Mobility and EU Programmes (2017), available at: http://www.obzor2020.hr/, [2017].

[8]Environmental Protection and Energy Efficiency Fund (2017), available at: http://www.fzoeu.hr/en/energy_efficiency/energy_efficiency_in_the_building_sector/, [2017].

[9]Croatian Bank for Reconstruction and Development (2017), available at: https://www.hbor.hr/wp-content/uploads/2017/05/Za%C5%A1tita-okoli%C5%A1a-Pk-projekata-za%C5%A1tite-okoli%C5%A1a-energetske-u%C4%8Dinkovitosti_-1612-1704.pdf, [2017].

[10]European Bank for Reconstruction and Development (2017), available at: http://www.wb-reep.org/, [2017].

- UNDP project: Increasing Energy Efficiency in the Republic of Croatia[11];
- Technology Research and Development Promotion Programme – TEST[12];
- Ministry of the Economy's 2013–2015 Strategy Plan[13];
- Science and Research Investment Action Plan of the Ministry of Science and Education[14];
- Entrepreneurial Impulse[15] of the Ministry of Entrepreneurship and Crafts.

The Ministry responsible for construction continually stimulates and supports research and development of new energy and environmentally friendly construction materials and technologies through a number of national and international research and development projects, of which the following are worth mentioning: CIP-EIP-Eco-Innovation 2011 project: Energy Efficient, Recycled Concrete Sandwich Facade Panel – ECO-SANDWICH[16]. The ECO-SANDWICH project is aimed at stimulating the recycling and reuse of construction and demolition waste, promoting the substitution of conventional thermal insulation materials, promoting the application of prefabricated energy efficient products, and reducing energy consumption in production, greenhouse gas emissions and production waste by-products and product use. Horizon 2020[17] project BUILD UPON[18], as the world's largest cooperation project in the field of energy renovation of buildings, has connected more than 1 000 organizations from 13 countries at 80 events held during 2016 and 2017. It was aimed at starting a renovation revolution across Europe, helping countries to deliver strategies for the energy renovation existing buildings by 30 April 2017. These strategies are critical to reducing energy consumption in Europe, reducing the impact on climate change and creating buildings which ensure a high quality of life. A number of building renovation projects are expected to be implemented under the EU programme HORIZON 2020 in the period up to 2020[19]. One of the important HORIZON 2020 programme objectives is the acquisition of necessary knowledge and skills by all stakeholders (building owners, designers, contractors and end-users) in the process of energy-efficient building renovation.

4.1.2 Implementation of Croatia's operational programmes for various types of buildings

Since its launch on 1 January 2004, the Environmental Protection and Energy Efficiency Fund (EPEEF) has continually and systematically stimulated the energy renovation of buildings through numerous co-financing programmes in the field of sustainable construction. Table 4-1 shows the cumulative savings of alternative policy measures achieved between 2014 and 2016, i.e. in the period after the issuing and adoption of the 2014 Long-term strategy for mobilising investment in the renovation of Croatia's national building stock, through EPEEF tenders. The data collected on all measures which have been implemented are available in the System for monitoring, measuring and verifying energy savings (SMIV), which includes a record of the savings calculated using a bottom-up method.

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[11]UNDP project Increasing Energy Efficiency in the Republic of Croatia (2012), available at: https://www.fzoeu.hr/en/, [2012].

[12]Business Innovation Croatian Agency (2013), available at: http://www.hamagbicro.hr/inovacije/javni-sektor/test/, [31 December 2013].

[13]Ministry of Economy, Labour and Entrepreneurship (2012), available at: http://www.mingo.hr/userdocsimages/STRATE%C5%A0KI%20PLAN%20MINGO%202013-2015%20kona%C4%8Dno.doc, [30 April 2017].

[14]*Ministry of Science and Education (2008), available at: http://novebojeznanja.hr/UserDocsImages/Dokumenti%20i%20publikacije/Dokumenti%20i%20publikacije%20referirani%20u%20SOZTu%20(popis%201)/146%20Akcijski%20plan%20za%20poticanje%20ulaganja%20u%20znanost%20i%20istra%C5%BEivanje.pdf, [30 April 2008].*

[15]Ministry of Economy, Labour and Entrepreneurship (2016), available at: http://www.strukturnifondovi.hr/natjecaji/1276, [30 September 2016].

[16]*University of Zagreb, Faculty of Civil Engineering (2015), available at: http://www.eco-sandwich.hr/.*

[17]European Union, available at: https://ec.europa.eu/info/funding-tenders_en, [30 April 2017].

[18]*EU project – BUILD UPON, available at: http://buildupon.eu/hr/.*

[19]European Union, available at: http://ec.europa.eu/programmes/horizon2020/, [30 April 2017].

Table 4-1 : Cumulative savings of alternative policy measures achieved 2014–2016

Title of the measure	Savings [PJ]	Savings [tCO_2]	Total investment amount [HRK]	Total funds paid from the EPEEF [HRK]
RESIDENTIAL BUILDINGS				
Energy renovation programme for family homes (2014–2016)	1.10438	53 709.00	778 492 028.45	487 329 822.20
Energy renovation programme for multi-apartment buildings	0.25131	19 825.03	154 535 990.29	61 997 642.77
Introduction of individual thermal energy consumption metering	0.51337	42 331.63	116 930 071.23	46 313 643.72
PUBLIC SECTOR BUILDINGS				
Energy renovation programme for public buildings (2014–2015)	0.30125	22 388.49	344 258 164.79	155 309 742.45
COMMERCIAL NON-RESIDENTIAL BUILDINGS				
Energy renovation programme for commercial non-residential buildings	0.07073	5 388.05	49 781 776.24	20 279 641.08
PUBLIC LIGHTING				
'Energy Efficient Public Lighting' programme	0.19776	19 783.05	160 986 313.89	84 028 721.96
TRANSPORT				
Financial incentives for energy-efficient vehicles	0.083556	7 706.02	207 250 726.57	39 996 341.06
Promoting environmentally-friendly driving	0.09159	6 784.91	2 986 214.63	977 649.24
Introduction of a special motor vehicle tax based on CO_2 emissions	0	0.00	0.00	0
TOTAL	2.61395	177 916.18	1 815 221 286.09	896 233 204.48

Source: Annual report on progress achieved towards national energy efficiency target under Article 24(1), in accordance with Part 1 of Annex XIV to Directive 2012/27/EU, CEI.

After 2016, the European Structural and Investment (ESI) Funds, in particular the European Regional Development Fund (ERDF) will be intensively used for energy renovation of buildings under the Operational Programme Competitiveness and Cohesion (OPCC) for 2014–2020. An overview of the OPCC measures with a brief description of the achievements is provided in the Table 4-2.

Table 4-2: Overview of measures for energy renovation of buildings using ESI funds

Title of the measure	Short description of the measure
Households	
Promotion of integral renovation of apartment buildings	Late in 2016, the Ministry of Physical Planning, Construction and State Assets issued a call for energy renovation of multi-apartment buildings, receiving a total of 649 project proposals, of which 584 energy renovation projects were contracted, using the total allocation of funds available under the OPCC. More than 16 000 households are participating in the promotion of energy efficiency and renewable energy sources in multi-apartment buildings throughout Croatia, with the most common transitions being from energy class E to B, while the average annual energy savings for heating/cooling equal 66.71%. The average age of multi-apartment buildings is 49 years.
Public sector	
Energy renovation programme for public buildings (2016–2020)	The Ministry of Physical Planning, Construction and State Assets issued four calls for the energy renovation of public sector buildings under the OPCC: • Pilot project 4c1.1 'Preparation of project documentation for energy renovation of buildings and use of renewable energy sources in public institutions performing educational activities';

	• Pilot project 4c1.2 'Energy renovation of buildings and use of renewable energy sources in public institutions performing educational activities'; • Call 4c1.3 'Energy renovation of buildings and use of renewable energy sources in public institutions performing educational activities'; • Call 4c1.4 'Energy renovation and renewable energy sources use in public buildings'. A total of 871 grant contracts were signed for the energy renovation of buildings and preparation of project documentation, using the total allocation of funds available under the OPCC. Public sector buildings, with an average age of 52 years, achieve annual energy savings of 65% on average after energy renovation.
Commercial service sector	
Increasing energy efficiency and RES use in the commercial service sector (tourism and trade)	Available funds from the ERDF under the OPCC amount to HRK 300 million (EUR 40 million) – these funds are envisaged to be sued by the end of 2023; the implementation of the measure began with a public call of the Ministry of Environment and Energy in 2018.

The table below shows the preliminary results of implementation of all energy renovation programmes for buildings in Croatia between 2014 and 2019. It is evident that approximately 5.7 mil. m^2 of floor area of existing buildings has been renovated, using substantial financial resources but failing to meet the building renovation target. Given that 3.5% of the building stock floor area or 6.7 mil. m^2 was planned to be renewed each year between 2014 and 2019 under the 2014 and 2019 Long-term strategy for mobilising investment in the renovation of Croatia's national building stock, it is clear that the ambitious one-year target has not been achieved in the five year period. The cited data shows that energy renovation is a big challenge and that, even with strong financial incentives, its implementation is slower than desired as a result of numerous barriers in Croatia, which are explained in more detail in Chapter 4.3.

Table 4-3: Preliminary results of energy renovation programmes for buildings in Croatia, 2014–2019[20]

Programme	Implementation period	Renovated area [m^2]
Renovation of public buildings under the ESCO model	2014–2015	250 000
Renovation of public buildings with ERDF funds	2016–2019	1 350 000
Renovation of multi-apartment buildings with national funds	2014–2016	700 000
Renovation of multi-apartment buildings with ERDF funds	2016–2019	900 000
Renovation of family houses with national funds	2014–2016	2 500 000
TOTAL RENOVATED AREA		**5 700 000**

4.2 Analysis of measures to stimulate integral building renovation in European Union Member States

Article 5 of Directive 2012/27/EU defines the obligation to renovate public sector buildings owned by the central government in each Member State. To this end, national plans and policies have been developed as a framework for the implementation of renovation programmes. The approach taken by individual Member States differs according to implementation and financial mechanisms employed. The implementation of Article 5 of Directive 2012/27/EU is possible with what is known as the standard approach, i.e. the renovation of 3% of the total floor area of heated and/or cooled buildings owned and occupied by the central government each year, or an alternative approach to implement other cost-effective measures in eligible buildings owned and occupied by the central government aimed at achieving at least equal savings to the ones achieved under the standard approach. Under alternative approaches, each Member State defines various energy efficiency measures to achieve the required savings. Among the key prerequisites for the success of the renovation programme are the financing methods or financial instruments. In summary, the following can be observed at EU level:

[20] *Source: https://MPGI.gov.hr/UserDocsImages/dokumenti/EnergetskaUcinkovitost/1_Otvoreni_dijalog_5_IKS.pdf*

- almost all Member States have programmes to stimulate the renovation of buildings using standard or innovative financing models, or external financing;
- most financial instruments focus on existing buildings;
- the most commonly used methods of financing are subsidies, or grant co-financing, and to a lesser extent financial instruments (guarantees, loans at low interest rates, green bonds, etc.) or fiscal instruments (various forms of tax liabilities or allowances);
- there is no systematic method of monitoring or use of standardised indicators or reporting on the final goals achieved by individual programmes;
- a small portion of financial instruments focuses on the integral energy renovation of buildings;
- more active involvement of private funding has not been addressed in many Member States.

Energy renovation activities for buildings implemented in most EU Member States are regional or local initiatives, that is, sustainable development projects with the possibility of using co-financing from development funds. Available data on implemented energy renovation programmes are related to the use of EU operational programmes (ERDF), development programmes (Jessica and Elena), and a partial share of the national budget funding, subsidies or financing by building occupants. Numerous programmes focus on a specific group of buildings or a territorial unit compared to comprehensive national programmes. Some of the programmes listed below are aimed at illustrating the diversity of approaches to solving the problem of stimulating the renovation and construction of the building stock on nZEB sustainable construction principles.

- Portugal – The Energy Efficiency Programme in Public Administration (ECO.AP) was launched in 2011 with the aim of increasing energy efficiency by 30% by 2020 in public services and public administration authorities (all institutions under the jurisdiction of the central government). The Energy Efficiency Fund has funded programme activities, but a more detailed overview is not available.
- City of Berlin – The Berlin Energy Agency manages a project (Berlin Energy Saving Partnership) in which the City of Berlin and several ESCOs are partners. The service is procured through a public tender. Funding is provided under ESCOs that guarantee savings. The period of return for the measures is 8 to 12 years, 80% of the savings is accounted for by compensation for ESCOs, the other 20% is the direct profit of the City of Berlin. During the term of the energy saving contract, the ESCO maintains technical systems and the City of Berlin maintains the building itself.
- Province of Milan – centrally coordinated and group project preparation for energy renovation of 30-40 school buildings in several municipalities. Standardised energy performance contracts were prepared and the projects implemented as an ESCO service, with a 20% savings guarantee and payment through savings achieved on energy costs. The project was implemented through local banks and financed from an EIB loan of EUR 65 million (EIB-ELENA instrument).
- City of Prague – energy renovation of 15 schools through participation of three stakeholders: in accordance with the energy performance contract, modernisation/replacement of technical systems was carried out, with the external envelope financed by a subsidy under the EU Cohesion operational programme 2007-2013 and funds of building owners (approximately 28%).
- Poland – TM (Thermo-Modemization) programme offers a subsidy of 20% for commercial loans. Subsidies are provided from the state budget and are managed by the National Economy Bank (BGK). The programme is intended for all sectors, but 90% of the implemented projects are residential sector projects. Commercial loans are issued through 16 banks to which the client submits an energy audit showing the project profitability and a single application for a loan and subsidy.
- Graz, Austria – integral energy contracting included the application of three ESCO service mechanisms: an energy saving contract for the replacement of a boiler with a cogeneration plant; energy performance contract for a mechanical ventilation system with heat recovery and equipment; energy saving contract based on renewable energy sources for the solar thermal system. Altogether 75% of co-financing is provided through ESCO services. The model was applied to a public building protected as architectural heritage. Savings of 15% in delivered energy and 35% in CO_2 emissions were achieved.

Most Member States are trying to include private sources of funding in the energy renovation of public buildings. Experience to date shows a slow return on investment in integral building renovation projects, especially if investment in the building's external envelope is included, which discourages potential private investors. In very rare cases is it possible to carry out an integral building renovation project using only one source of funding, namely the energy service provider. Due to the possibility of expanding the market to energy service providers, additional financing methods, such as co-financing and subsidies have been introduced to ensure project profitability. The ESCO model is among the most commonly implemented instruments at local or regional level, but its introduction as the dominant model is being considered. For that reason, as well as on account of non-profitability, examples of integral renovation programmes are smaller in scope and number. The following can be concluded from the examples of practice in EU Member States:

- The ESCO model is used for partial building renovation. It is left to the owners, regional or local self-government units to develop or select. That model is not considered to be borrowing when the contract is well developed and essential risks are transferred to service providers. The vast majority of these projects are individually implemented in a number of Member States (Germany, Poland, the Czech Republic, Slovenia, Slovakia, etc.). Experiences with the ESCO model in developed markets, such as Italy, show considerable penetration of energy services in public buildings under partial renovations (thermotechnical systems, replacement of energy sources).
- No-subsidy funding sources, such as the ESCO model, standard borrowing or revolving funds, are implemented relatively successfully in the integral energy renovation of residential buildings. Primarily on account of high energy consumption, integral energy renovation of residential buildings has shown market profitability, so private capital may be involved. Models have been observed in countries with extremely high energy consumption for heating, especially due to climatic specifics (e.g. Latvia).
- In the case of integral energy renovation of public non-residential buildings, financing in rare cases is closed under the ESCO model without co-financing. This depends primarily on the prices of energy sources, the energy sources used, the way a building is used and the existing technology (including the external envelope). The examples of individual buildings show no ability of model replication onto a larger sample. In order for the model to be used more expansively, subsidies were introduced to ensure profitability for private investors. Problems with the ESCO model also include investing in the initial stages of energy efficiency investment focusing on easily achievable results with short periods of return (low-hanging fruit), e.g. replacement of energy sources and heating systems, where existing investment and interests of ESCO partners prevent the building from investing in integral renovation (e.g. Italy).

Energy savings for heating and cooling in Croatia's residential building is of great importance for the following reasons:

- reducing the emission of carbon dioxide (CO_2) into the atmosphere;
- security of supply – reducing the country's dependence on imported fuels;
- savings made on fuel purchases by suppliers (state, companies);
- prevention of energy poverty – reduction of energy costs for users/consumers (households, population).

This has also been recognised in the EU, which already has considerable experience with the energy renovation of residential buildings. Table 4-4 shows the energy renovation measures for multi-apartment buildings in the EU region, including the Czech Republic, Hungary, Slovakia and Slovenia. That region is the most similar to Croatia in terms of climate, while also showing considerable climatic differences from Croatia's Adriatic region. In these countries, there are approx. 3 mil. apartments in multi-apartment buildings, or around 27% of apartments in the region, theoretically accounting for approx. 50 000 buildings. The possibility of thermal energy savings through construction measures was determined to be around 64%, or around 75% if the effect of the installation of thermostatic radiator valves on heating elements is included. The simple period of return on investment is 8.6 years. The total potential for energy savings in multi-apartment buildings equals around 39%, representing 2.5% of the end-use energy demand in the region, or 4 Mt of CO_2. This region of the EU is special because it has the greatest potential for energy

savings compared to other regions. The buildings in question are predominantly made of large-sized prefabricated concrete walls, they have flat concrete roofs and floors, and double-glazed windows in wooden frames. The buildings are mostly connected to the district heating network, with the possibility of installing thermostatic radiator valves and balancing.

Table 4-4: Energy renovation of multi-apartment buildings, International Energy Agency – IEA/AIE – Table No 10 in the 'High rise refurbishment' publication

Values / Elemen	U – value before renovation (W/m^2K)	U – value after renovation (W/m^2K)	Annual energy savings (kWh/m^2)		Annual investment cost (EUR/m^2)	The price of saved energy (EURcent/kWh)	Simple period of return (years)
Walls	1.20	030	50.1	33.1%	0.92	1.5	8.7
Roof	2.17	0.24	21.7	12.0%	0.15	0.7	3.8
Floor	1.10	0.45	7.3	4.0%	0.13	1.7	9.9
Windo	2.90	1.70	26.7	14.7%	0.71	2.7	15.2
Unit	1.63	0.59	115.8	63.8%	1.91	1.6	9.3
Thermostatic radiator valves			54.5	30.0%	0.19	0.3	1.6
Combination of all the above measures			135.5	74.4%	2.10	1.5	8.6

Source: Renovation programme for multi-apartment buildings

At EU level, where residential buildings represent 75% of the total building stock, several scenarios for the structure and intensity in implementing energy renovation of the total residential and other building stock have been developed. In the case of deep energy renovation[21], the 2020 end-use energy annual savings are estimated at 527 TWh, or 13% compared to the end-use energy consumption in 2011. According to this plan, financial investments in the energy renovation of buildings would amount to EUR 477 billion, and monetary savings to EUR 487 billion. The annual reduction in CO_2 emissions in 2020 would be 161 Mt. The implementation of the energy renovation programme for buildings under the deep renovation scenario would create 1.2 mil. jobs per year at EU level. With the launch of the Programme for multi-apartment building and family home renovation, buildings will be categorised into two groups – renovated and unrenovated. Renovated buildings will have a higher market price, which translates into an increase in real estate prices. However, even though the renovation programme means an initial increase in real estate prices, in accordance with the microeconomic theory, as the supply of renovated properties increases, their price will decrease; in any case, it will always be higher than the price of unrenovated properties. Experiences from EU Member States such as Ireland show that the difference in the price of energy class A/B and F/G is 16% on average[22]. This is an additional effect of the renovation programme, as it is an incentive for building owners to invest in renovation, based on which they will be able to get a better price when selling/letting. Reduced energy consumption is a part of the benefits, the other part being an increase in market prices due to irregular and neglected regular maintenance of buildings, which is why most older buildings on the market only reach an acceptable level of maintenance through energy renovation.

[21] *Under the Building Act (NN Nos 153/13, 20/17, 39/19, 125/19), deep renovation in Croatia is defined as the energy renovation of a building which includes energy efficiency measures for the envelope and technical systems and results in a min. 50% reduction of heating ($Q_{H,nd}$) and primary energy (E_{prim}) consumption on an annual basis [kWh/(m²·a)] compared to the energy consumption before renovation.*

[22] The study was conducted in Ireland in 2012 on a sample of 20 000 properties, source: Martin Vaché, Institut Wohnen und Umwelt, Darmstadt.

4.3 ANALYSIS OF EXISTING BARRIERS TO INTEGRAL ENERGY RENOVATION OF BUILDINGS

Existing barriers to an integral energy renovation of buildings are numerous and may generally be divided into four main categories, shown in the following figure (Figure 4.1).

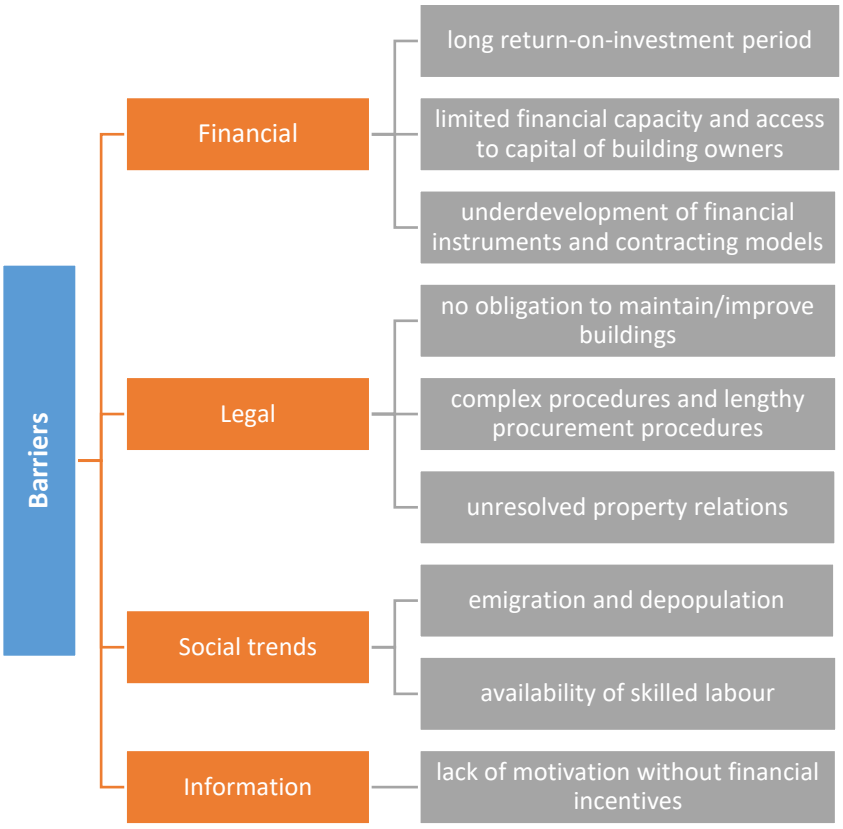


Figure 4.1: Main categories of existing barriers to integral energy renovation of Croatia's national building stock

Directive 2012/27/EU, as well as Directive (EU) 2018/2002 amending Directive 2012/27/EU, dictate support for development of the energy services market, development of new financial mechanisms and incentives and of institutional, financial and legal frameworks to eliminate existing market barriers and shortcomings preventing efficient end-use energy consumption. Consequently, this chapter identifies legal, financial and organizational barriers to a wider implementation of measures to increase energy efficiency in buildings.

The existing Croatian legislation is satisfactory insofar as it relates to the technical guidelines and requirements for the energy renovation of buildings, so it is not a barrier in the technical sense; however, what is missing is regulation introducing an obligation of energy renovation of existing buildings with the mandatory use of an optimal renewable energy sources for heating and cooling, where technically feasible and economically viable. At this point, only the obligation to perform energy audits and prepare and present energy performance certificates, which includes possible and acceptable measures to increase energy efficiency, is regulated. In addition, the absence of regular maintenance practices for buildings is also a barrier to their energy renovation.

The most significant barriers to energy renovation of Croatia's building stock are of a financial nature. Namely, Croatia is one of the poorest members of the EU, with the purchasing power of citizens significantly below the EU average. In addition, the indebtedness of local self-government units is high. This prevents the so-call closing of the financing structure for energy renovation projects for buildings in both the residential and the public sector, even where a grant co-financing programme exists. The situation is further exacerbated by the relatively low price of energy, the large share of cheap firewood in meeting the thermal energy needs for heating, especially in the residential sector, as well as heating habits (in much of Croatia, especially its coastal parts, space is heated only partially and not in its entirety, in accordance with projected

needs). All this leads to a rather long period of return on investment into renovation, which makes such investment projects unattractive without an incentive programme. Financial barriers become even more acute in the absence of continuous incentive programmes. Croatia strongly stimulates energy renovation, but on account of limited availability of funds, public calls for co-financing are conducted periodically, leading to market instability.

The next barrier, which is only partially taken into account, is the level of information, education and participation of the public in taking important decisions on building renovation. Lack of information on positive effects for each individual and society as a whole, which will certainly stem from the integral energy renovation of the entire national building stock, results in insufficient motivation and frequently in unfounded increase in the risks blocking potential investors further. Furthermore, ownership relations in buildings are sometimes extremely complex, and mixed ownership buildings are problematic in terms of renovation. In multi-apartment buildings, the decision to invest in renovation, depending on the amount of investment, requires the consent of more than a half of the building's co-owners, as calculated from the number of co-owners of the property and their co-ownership shares. Even though considerable progress has been made towards raising public awareness of the benefits of energy renovation through the implementation of incentive programmes, there is still a strong barrier of insufficient motivation for renovation while incentives in the form of grants are absent. In that sense, the introduction of a system of obligations for energy suppliers could have a positive impact on the implementation of energy renovation projects for buildings, as energy savings could be sold to obligated parties.

Solid development of the market in construction and energy services, as well as a sufficient number of experienced companies specialising in the implementation of integral energy renovation projects including mechanical, energy and construction elements of buildings, is a prerequisite of successful initiation and implementation of the integral energy renovation of the national building stock and requires an interdisciplinary approach. The crisis affecting Croatia's construction and energy sectors and resulting in the closure or bankruptcy of a large number of companies has exacerbated the existing barrier involving insufficient capacity, knowledge, competences and skills to a successful accomplishment of the complex task of integral building renovation. The outflow of construction workers to other EU Member States, where they can earn higher incomes, also contributes considerably to this problem, especially amid major labour shortages in the construction sector in recent years.

Demographic and migration trends,, as well as changes in the housing culture and lifestyle, also constitute an important barrier to a successful implementation of integral energy renovation of buildings. Specifically, there is a strong trend of emigration in certain parts of Croatia, increasing the number of unoccupied buildings whose energy renovation is not possible. In addition, there is also a strong inequality in Croatia in terms of development, which is reflected in real estate prices. While the price of energy renovation is the same in all parts of Croatia, real estate prices vary greatly, especially between coastal and continental Croatia. A real estate price determined primarily by location is in no way stimulating for energy renovation because no major difference in the sales price of a renovated property can be achieved if its location is less favourable. The integral energy building renovation is a complex process with a large number of participants interconnected by various interests and goals, representing merely another in a series of barriers to its successful implementation. Unresolved property relations and property ownership status are the next barrier to decision-making on energy renovation.

A typical barrier, slowing down the process of energy renovation of public sector buildings, is the public procurement procedure as it is always time-consuming and produces unsatisfactory results in a considerable number of cases. Procurement procedures conducted so far, which were based on the financially most favourable criteria for the selection of contractors, have simply failed to provide good results. Such contractual relationships do not guarantee quality, compliance with construction deadlines or a long-term guarantee for the work performed. When contracting public sector works in the coming years, in addition to applying the model of the most economically advantageous tender, it will be necessary to also apply criteria such as Design and Build[23] or ESCO or Public and Private Partnership implementation

[23] The Design and Build (D&B) contract requires the most economically advantageous tender, which will also guarantee that the building is functional and that the project will reduce the overall living cost. It is a turnkey model. The public partner publishes a

models[24], with mandatory criteria for the selection of tenderers, such as the lowest whole life cycle cost, achieving guaranteed savings and guarantees for work performed. Significant progress has been made in this area by implementing energy renovation projects under the energy service model (ESCO) through the Agency for Transactions and Mediation in Immovable Properties (Cr. abbr. APN) and with EPEEF co-financing, this model certainly needs to be improved and applied more widely in the next period[25]. The ESCO model has been harmonised with Eurostat guidelines on the treatment of such projects with regard to public debt. However, it should be made clear that deep renovation under the ESCO model can only be achieved with incentives in the form of grants, otherwise deep renovation projects are not attractive to energy service providers due to long return on investment periods.

One of the main barriers to the implementation of energy renovation of public sector buildings is the lack of financial resources and creditworthiness. That problem is especially pronounced when the building is not suitable for renovation under the ESCO model. Specifically, despite the share of grants in energy renovation projects for public sector buildings, some local and regional self-government units (LRSGUs) are incapable of providing the remaining part of the required investment. In practice, there are cases of LRSGUs which cannot provide even a minimum own share of 5% in energy renovation projects. Potential energy service providers are construction sector companies, which are already burdened by debts and insufficient income due to adverse economic market developments in recent years. Both factors limit their creditworthiness, especially that required for the purpose of repeatedly taking out long-term loans. On the other hand, their low income level provides for only a limited amount of own funding. Banks in Croatia do not show sufficient interest in financing projects on the principle of energy performance contracting. There are several reasons for such an attitude:

- large number of potential energy service providers without adequate creditworthiness,
- insufficient amount of guarantees,
- high cost of capital in Croatia.

The cost of capital is indeed high in Croatia. In addition, banks assess the level of risk separately for an energy service provider as a client. They are not prepared to provide long-term financing to a client who assumes all the risk of a project. Therefore, banks seek additional guarantees, such as a lien on the property. Interest rates are high, on account of both the country risk and the client risk. The Croatian market lacks financial instruments sufficient for the energy renovation of the entire public sector building potential.

In addition, the cost of building renovation increases through the need for structural renovation of buildings, which has become an absolute necessity following the earthquake which hit Zagreb and the surrounding area in March 2020. The cost of such renovation can in no way be justified by reduced energy costs, but they are an absolute must from a safety point of view.

Buildings entered in the Ministry of Culture and Media's Register of Cultural Property constitute a category of buildings requiring an even more complex process of energy renovation. There are 6 207 such individual immovable cultural properties and a group cultural properties under permanent or preventive protection in Croatia, entered in the Register of Cultural Property. Assuming an average area of 1 000 m^2, there is currently approximately 6.2 mil. m^2 of protected building area in Croatia, accounting for nearly 3% of the total national building stock area. According to the Energy renovation programme for buildings with the

tender but does not pay the private partner until the project is completed. The cost risk and the quality risk of construction is transferred to the private partner, while its financing and financing costs are borne by the public partner.

[24] In the case of an energy performance contract, the public partner publishes a tender, the private partner applies for it and wins a contract (as under the D&B model) if it guarantees the most economically advantageous terms with regard to a reduction in the overall living costs based on planned energy savings. However, the private partner under this model receives the first payment only after the reconstruction project is completed, on a monthly basis for the next 10 years (depending on the contract term) and only if the project shows that planned energy savings have been achieved, i.e. if the delivered energy services and other standards comply with the agreed terms. In the event that this does not happen, the private partner bears the risk and receives less compensation than agreed for evident failure to do the job as well as it has undertaken under the contract.

[25] For more information, see: http://apn.hr/energetska-obnova-zgrada-javnog-sektora/program-2016-2020/opcenito, (accessed: 7 November 2019)

status of cultural property for 2021–2030, of that area, 2 302 157 m² is accounted for public buildings registered in the EMIS.

The impact of various barriers to the process of deep renovation of Croatia's national building stock is not the same; in order to determine potential risks and depending on their impact, individual barriers which have been identified may be divided into the barriers of major, medium or minor impact.

Barriers with a major impact on the process of integral energy building renovation are the following:

- low standard of living, high unemployment rate and a large number of low-income retirees; all of which negatively affect the ability of citizens to use their financial capacity to invest in energy renovation, even with high rates of grant co-financing;
- weak financial capacities of local self-government units;
- lack of strong and continuous financial incentives for the energy renovation of buildings;
- lack of developed and tested financial models for investing in the energy renovation of buildings;
- insufficient preparedness of financial institutions to lend (e.g. by virtue of project financing) in order to stimulate the ESCO market;
- lack of regulation imposing an obligation to implement selection criteria based on the lowest whole life cycle cost, achieving guaranteed savings by implementing renovation measures and guarantees for the work performed and agreed standards.

The following barriers have a medium impact on the process of integral energy renovation of buildings:

- insufficient development of the energy services market, primarily on account of an insufficient number of companies specialising in the provision of services of integral building renovation and their lack of financial resources;
- labour shortage in the construction sector, caused by strong emigration;
- insufficient information, education and participation of the public in making important decisions on building renovation;
- low fuel prices, partial space heating (i.e. habits of the use and heating of rooms which are not in line with the projected conditions) and a large share of firewood in meeting the heating needs in households.

The following barriers have a minor but by no means negligible impact on the process of integral energy renovation of buildings:

- complexity of the process initiation and implementation;
- necessity of taking an individual and multidisciplinary approach to each individual building;
- unresolved property relations;
- additional complexity of the process of energy renovation of buildings entered in the Ministry of Culture and Media's Register of Cultural Property.

Integral energy renovation of buildings with the status of cultural property, including buildings within protected cultural and historical units, is part of the long-term strategy of the Ministry of Culture and Media. In this respect, the Ministry of Culture and Media has launched a series of activities to remove barriers to the implementation of energy efficiency in cultural properties, based on an appropriate approach given the specifics of that portion of the national building stock.

In existing multi-apartment buildings and family houses, the existing calls focus exclusively on the thermal needs of buildings for heating, i.e. energy efficiency measures aimed at reducing energy consumption for heating and domestic hot water preparation. With regard to other energy needs, especially in terms of household appliances and internal lighting, further development of EU standards and regulation in this area (e.g. ban on the sale of incandescent light sources, stricter criteria for energy efficiency classes, etc.) is already yielding visible results on the market and generally, they require lower investment costs than building renovation measures proposed by the programmes, which are a prerequisite of integral energy renovation. By changing the energy performance certification model, which now includes primary energy for all energy needs of buildings and not just the energy required for heating, and including the need for

cooling as the basic need for sufficient comfort in all buildings, the approach to the building and energy renovation exclusively through thermal energy required for heating will also change.

In addition, energy renovation will need to expand into comprehensive renovation to ensure long-term seismic resistance of buildings, requiring substantial resources to be provided and the return of which cannot be ensured through energy savings.

4.4 PROPOSED SOLUTIONS AND NEW MEASURES TO OVERCOME EXISTING BARRIERS

Croatia's national policy of integral energy renovation of the national building stock aimed at achieving the targets set in accordance with the provisions of EU directives needs to include six categories of measures[26]:

- strategic,
- legislative,
- technical,
- financial,
- communication and capacity-enhancing measures,
- research and development measures.

Strategic measures of integral energy renovation of the national building stock include:

- establishing support for the entire Croatian political spectrum for a comprehensive renovation of the national building stock;
- establishing a wide network of stakeholders as a basis for successful implementation of the building renovation plan – this measure is already being implemented through the Open partner dialogue, established by the Ministry of Physical Planning, Construction and State Assets;
- setting a target to reduce energy poverty of Croatia's population by improving the energy efficiency measures in the residential sector;
- setting integration objectives for various sectors; sustainable urban planning, sustainable construction, local energy resources, etc.

Legislative measures for successful renovation of the national building stock are the following:

- identify the most effective legislative mechanism applied to result in improved energy efficiency of buildings (energy certification, boiler room inspections, stricter technical standards, etc.);
- stimulate energy renovation of buildings within the legislative framework in the field of housing and building maintenance.

Technical measures need to include the following:

- continually harmonise technical norms and standards with new technological solutions available in the market;
- analyse and apply district heating system for building heating and cooling to the greatest extent possible;
- build gas-fired district heating systems in rural areas;
- ensure appropriate control of compliance with construction regulations and enforcement of minor offence provisions in the event of non-compliance;
- develop typical solutions for easy implementation in same-purpose buildings;
- stimulate voluntary quality certification of installation services and products.

Financial measures for the implementation of integral building renovation include the following:

- provision of grants for the renovation of residential and public buildings;
- development of financial instruments, especially for energy service providers.

[26]A guide to developing strategies for building energy renovation, BPIE, February 2013.

In order for financial institutions to be able to monitor energy service providers, financial instruments need to be developed in accordance with the rules for ESI funds use, for the specific purpose of use by energy service providers. The development of financial instruments in the context of this Long-term strategy should also create conditions for the development of the energy services market, including through the PPP model, that is, market development among private entities wishing to operate on the principles of energy services provision. In the case of financial instruments, it is possible to offer products that will primarily facilitate access to financing for all entities implementing projects under the energy service model, and in turn stimulate market development by removing specific barriers arising from the energy service model itself and reducing the problem of undercapitalisation (which is a systemic problem of the economy as a whole, especially pronounced among ESCOs due to capital intensity and the specific problem of the model as such which has already been mentioned). Three basic instruments are imposed here:

a) guarantee,
b) equity instrument,
c) credit facility.

The co-financing model should be adjusted so that the aid is granted directly to the service provider, without intermediation of, for example, the Agency for Transactions and Mediation in Immovable Properties; in that way, the risk of obtaining the aid would be shifted to the energy service provider without affecting the obligations under the energy performance contract.

Communication and capacity-enhancing measures include the following:

- establish publicly available databases with examples of good practices and all requisite data to initiate and implement building energy renovation projects;
- establish a system for monitoring energy renovation through the PPIS – denoting energy renovated buildings in a special PPIS layer, primarily those whose renovation was co-financed (to be implemented by the Ministry of Physical Planning, Construction and State Assets and EPEEF);
- initiate and continually implement training programmes for all categories of workers in the building segment;
- establish good communication channels for exchanging expertise and experiences among various levels of administration (national, regional, county, local);
- continually implement promotional and educational activities for various target groups with an emphasis on positive effects of the energy renovation of buildings;
- strongly and continually inform the general public about the implementation of this Long-term strategy.

Research and development measures are based on support of research and development of new technologies, techniques, materials and elements of a cost-optimal integral building renovation.

Specific examples of possible measures are described in more detail below.

Financial models and incentives

Financial models and incentives should mobilise investors on the demand side, and the construction industry on the supply side. The design of optimal incentives goes beyond the scope of this document, which briefly describes the principles and possible instruments for designing an incentive model. The sources of funding for the model include ESI funds (whose allocation in the next period between 2021 and 2027, based on good 2014–2020 experiences, would strongly contribute to meeting the objectives of the Long-term strategy), the expected benefits for the general government budget, justifying the use of publicly funded incentives, and new financial instruments. Specific incentive models must be pre-tested on microeconomic models in order to achieve the maximum ratio of effects produced in the form of new investment to the reallocation of resources to construction.

Grant scheme

Grant scheme makes it possible (and necessary) to achieve the following objectives:

- stimulate end recipients to develop technical documents necessary for the implementation of energy renovation projects with the aim of developing a range of energy renovation projects ready for implementation;
- stimulate investment in energy efficiency technologies which have not yet been proven on the domestic market, with the aim of making early use of the many innovations that exist on the market;
- stimulate the market to invest in energy efficiency measures achieving a technical standard higher than the minimum required;
- subsidise ESCO projects by co-financing the compensation for the duration of the contractual relationship.

Taking into account these objectives, as well as the practical needs and barriers set out in this Long-term strategy, grant schemes should be designed to foster:

a) motivation to use market funds;
b) investment in technical documentation;
c) investment in innovative technologies;
d) investment in the projects which are below the commercially acceptable cost-effective level but may achieve high economic and environmental benefits for the community;
e) investment in the measures achieving higher levels of technical standards.

Grant schemes under (a) would stimulate the financing of commercially viable projects in order to further motivate beneficiaries to carry out these projects. Relying on the market to finance commercially viable projects (those offering a return on equity to the investor under accessible financing conditions) is not necessarily sufficient because it is based on the assumption that all such investors will be motivated to use market funds. Experience shows that a certain part of a grants motivates beneficiaries to decide to implement the project in the first place.

Grant schemes under (b) would finance the preparation of technical-economic documentation, showing the profitability of investment in a potential energy renovation project. Given that the implementation of energy renovation projects depends on the findings and conclusions made in the documentation, a high share of co-financing is recommended to stimulate end recipients to assume the risk and invest their own share of co-financing funds. For projects in the private sector, this may take the form of co-financing of an investment study, main and detailed construction design, detailed energy audits, PPP cost comparisons, cost-benefit analyses, etc.

Grants under the schemes under (c) would be awarded for the use of equipment representing state-of-the-art, innovative technologies, whose market share is not yet high. This would motivate end recipients to assume the risk of investing in equipment which is not widely used on the market, thus indirectly stimulating technical innovation in the field of energy efficiency.

Grant schemes under (d) would be approved for measures or projects aimed at raising the level of technical standard. In view of a number of external factors, investing above a certain level of technical standard has no economic justification, but actually pays the price of achieving some non-economic goal (e.g. development of energy services market, employment, reduction of CO_2emissions). Such a grant scheme would stimulate the end recipients who are willing to pay that price.

Finally, the grant scheme under (e) would stimulate investment in projects which are not commercially viable. In the context of this Long-term strategy, projects which are not commercially viable are those providing the investor with a return on equity (ROE) below the level which may be earned in the market. The logic is that, if there is an insufficient return on equity in an energy efficiency project, a rational entity will invest its own equity elsewhere, so such investment should be stimulated by allocating aid to the projects which are below the acceptable ROE level under this grant scheme to compensate for the required difference.

Tax allowances

Tax allowances for investment are usually introduced under the income tax system. However, the system of income taxation in a debt-ridden country such as Croatia should be as clear and simple as possible,

preferably omitting allowances or making them an exception or, if any, the allowances should be associated with more important social goals. Therefore, in the period of implementing this strategy, once the grants potential is exhausted and in accordance with the fiscal framework and fiscal policy possibilities, the introduction of tax allowances should be considered for property owners who invest in renovation and achieve targeted construction and energy standards. Such allowances could multiply back through demonstrable reciprocal effects of induced economic activities on public revenues. Due to the aging population, the energy poverty of the elderly and their inability to provide necessary investment, there is a danger of a further long-term decline in the value of poorly maintained real estate. Therefore, it is necessary to define regulatory measures (through housing and real estate management legislation) to ensure regular maintenance of real estate, which will include energy renovation.

Subsidised housing-saving system

Housing-saving subsidies are maintained, with adjustments to economic conditions and budgetary constraints. Housing savings banks are looking for modalities to survive in a demanding market. Housing savings depositors believe in the purpose of housing savings, as evidenced by approximately 500 000 open housing-saving accounts. The fact that almost half of all loans granted by housing savings banks have been for remodelling and rebuilding[27] is also important, testifying to a dire need for renovation of apartments and buildings financing among citizen. The subsidised housing saving scheme an extremely flexible financial instrument, suitable for conducting sectoral policy in construction. The introduction of differentiated incentives may stimulate a preferred saving purpose and borrowing, which in this case refers to certain types of sustainable renovation of housing units. As long as such savings are government-subsidised, housing savings banks are the only credit institutions able to offer long-term loans at a favourable interest rate, which remains fixed through the entire loan repayment period. This largely contributes to achieving the indirect goal of financial stability and stress-free loan repayment. It is necessary to consider purpose-differentiated housing-saving subsidies, linked to the financing of sustainable building renovation. Purpose-differentiated subsidies should be accompanied by a regulatory reform to enable collective subsidised housing savings of the owners in multi-apartment buildings.

Special financing programmes that include the possibility of grants from EU funds

These incentives are unlikely to be sufficient to initiate sustainable building renovation of the scope and dynamics required by the current situation, and planned under this Long-term Strategy. Therefore, it is necessary to arrange for special loan-warranty financial schemes involving a distribution of risks and subsidies for some of the costs of [project] preparation, design, supervision and implementation, which cannot be done without engaging resources from EU funds and budgetary resources.

[27] *Institute of Public Finance (2013): Analiza sustava poticanja stambene štednje u Republici Hrvatskoj (Analysis of the subsidised housing-saving scheme in Croatia). Zagreb: Institute of Public Finance, available at: http://www.ijf.hr/upload/files/file/projekti/Analiza_sustava_poticanja_stambene_stednje_u_Republici_Hrvatskoj.pdf, [10 May 2017].*

5 OVERVIEW OF POLICIES AND MEASURES FOCUSED ON SPECIFIC PROBLEM AREAS

5.1 WORST-PERFORMING NATIONAL BUILDING STOCK

Worst-performing buildings do not generally meet the minimum requirements in terms of mechanical resistance and stability, fire safety or health protection. The energy renovation potential of these buildings is limited by the low quality of housing and the high costs associated with non-energy aspects of building renovation. At the same time, privately-owned buildings which may be categorised as worst-performing buildings maintain a high potential for energy renovation and savings to be achieved.

From an energy renovation perspective, the worst-performing buildings are all buildings with a D energy rating or worse (according to $Q_{H,nd}$) in continental Croatia, or with a C rating or worse (according to $Q_{H,nd}$) in coastal Croatia. Therefore, all policies and measures focus precisely on the building stock with the highest energy consumption. Generally speaking, based on data in the energy performance certificate database by purpose and climate area, more than 30% of buildings fall into the category of the worst-performing buildings. In addition, these buildings often have poor structural properties, so they require comprehensive renovation, requiring considerably higher investment costs.

Table 5-1: Share of the worst-performing buildings in the total building stock

Energy rating	**A+**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Total worst-performing buildings**
Hospitals	**0.07%**	**0.42%**	**9.99%**	**31.35%**	**24.07%**	**6.80%**	**9.71%**	**17.59%**	
Continental	0.00%	0.00%	6.49%	32.02%	12.52%	9.77%	12.28%	26.93%	**61%**
Coastal	0.19%	1.21%	16.52%	30.11%	45.58%	1.26%	4.92%	0.21%	**82%**
Hotels and restaurants	**14.02%**	**19.42%**	**26.75%**	**17.59%**	**11.68%**	**7.10%**	**2.38%**	**1.07%**	
Continental	0.00%	8.39%	28.44%	27.39%	8.61%	17.59%	5.84%	3.74%	**36%**
Coastal	19.26%	23.55%	26.11%	13.92%	12.82%	3.18%	1.08%	0.07%	**31%**
Family houses	**4.00%**	**13.00%**	**20.96%**	**20.65%**	**13.78%**	**10.61%**	**8.05%**	**8.95%**	
Continental	0.25%	1.72%	18.11%	22.53%	15.64%	14.98%	12.56%	14.22%	**57%**
Coastal	10.06%	31.20%	25.57%	17.63%	10.78%	3.55%	0.79%	0.43%	**33%**
Other non-residential buildings heated to a temperature of +18 °C or higher	**1.66%**	**14.79%**	**24.01%**	**20.66%**	**19.27%**	**11.91%**	**4.95%**	**2.76%**	
Continental	0.48%	8.76%	26.11%	21.25%	20.50%	13.61%	6.01%	3.28%	**43%**
Coastal	6.87%	41.47%	14.74%	18.02%	13.80%	4.38%	0.24%	0.46%	**37%**
Sports halls	**2.42%**	**5.25%**	**30.58%**	**33.96%**	**15.30%**	**6.49%**	**4.61%**	**1.40%**	
Continental	1.84%	4.25%	33.60%	27.38%	15.42%	9.10%	6.46%	1.96%	**33%**
Coastal	3.86%	7.74%	23.07%	50.32%	15.00%	0.00%	0.00%	0.00%	**65%**
Office buildings	**10.35%**	**13.16%**	**23.84%**	**28.69%**	**15.10%**	**6.65%**	**1.29%**	**0.92%**	
Continental	8.57%	10.43%	23.30%	28.37%	17.91%	8.60%	1.63%	1.18%	**29%**
Coastal	16.28%	22.26%	25.66%	29.74%	5.74%	0.14%	0.14%	0.04%	**36%**
Multi-apartment buildings	**4.89%**	**20.70%**	**29.30%**	**21.40%**	**15.28%**	**5.80%**	**2.03%**	**0.60%**	
Continental	1.07%	11.50%	31.54%	22.02%	20.53%	9.00%	3.37%	0.97%	**34%**
Coastal	10.29%	33.70%	26.14%	20.52%	7.87%	1.28%	0.13%	0.08%	**30%**

Wholesale and retail trade services buildings	**14.95%**	**15.90%**	**28.86%**	**23.79%**	**8.91%**	**5.68%**	**1.19%**	**0.71%**	
Continental	4.90%	11.73%	29.00%	30.58%	11.46%	9.22%	1.97%	1.14%	**24%**
Coastal	29.80%	22.06%	28.67%	13.75%	5.14%	0.45%	0.04%	0.09%	**19%**
Educational buildings	**6.93%**	**10.71%**	**29.53%**	**29.48%**	**14.62%**	**6.51%**	**1.85%**	**0.36%**	
Continental	2.41%	6.98%	32.92%	29.09%	17.31%	8.36%	2.44%	0.47%	**29%**
Coastal	21.10%	22.39%	18.90%	30.69%	6.20%	0.72%	0.00%	0.00%	**38%**
Grand total	**5.94%**	**16.18%**	**26.30%**	**22.83%**	**15.07%**	**7.56%**	**3.47%**	**2.65%**	

In addition to poor energy performance, the threat of energy poverty is another problem. The draft Programme to combat energy poverty in residential buildings in assisted areas and in areas of special state concern for 2021–2025 addresses a segment of the worst-performing building stock covering 407 buildings, elaborating a detailed set of criteria for the assessment of the energy renovation potential of these buildings which may also be applied to other worst-performing buildings, as well as their ranking according to energy renovation priorities. As a result, the Programme may be expanded to cover not only state-owned multi-apartment buildings but other multi-apartment buildings and family houses as well.

According to the construction period and the regulations related to the seismic resilience of buildings, seismically vulnerable buildings also fall in the category of worst-performing buildings. When it comes to residential buildings, only those built after 2012 meet the applicable requirements for earthquake protection, while most buildings built prior to 2012 face a considerable risk.

Table 5-2: Share of buildings according to seismic load bearing by construction period

Period	Up to 1945	1946–1964	1965–1981	1982–1997	1998–2011	2012–present
Defined horizontal activity	0–5%	0–10%	30–50%	30–50%	75–100%	100% relevant
Residential units built according to the 2011 list	≈ 13%	≈ 17%	≈ 35%	≈ 21%	≈ 14%	
Total	13%	30%	65%	86%	100%	

5.2 POLICIES AND MEASURES FOR THE WORST-PERFORMING NATIONAL BUILDING STOCK

In light of the experiences acquired in the implementation of the programmes for the energy renovation of buildings in Croatia to date, public policy measures and co-funding programmes will primarily focus on public and residential buildings (multi-apartment buildings and family houses) with the worst performance (buildings with a D energy rating or worse according to $Q_{H,nd}$ in continental Croatia, or with a C rating or worse in coastal Croatia). The measures or policies envisaged for the energy renovation of these buildings are shown below and form an integral part of the Integrated national energy and climate plan for 2021–2030. The measures are expected to be implemented even in the period after 2030, that is, until 2050, with adjustments to be made based on the experiences acquired in their very implementation.

When it comes to commercial buildings, the energy efficiency obligation scheme for energy suppliers is expected to have a major contribution to the renovation of this building segment at least until 2030 and possibly thereafter too, primarily thanks to a further development of the energy services market and the possibility of trading the energy savings achieved.

ENU-3: Energy renovation programme for multi-apartment buildings

Financing measure; 2021–2030 implementation (This measure will continue to be implemented until 2050, with possible changes to be made based on experiences acquired.)

Description of the measure and its goal: The Programme should be envisaged as a continuation of the Energy renovation programme for multi-apartment buildings, implemented between 2014 and 2020. For that purpose, funding provided under the Recovery Fund and ESI Funds should be planned for the next programming period 2021–2027 (with implementation until 2030), while facilitating the implementation procedures considerably, primarily when it comes to the implementation of public procurement. Deep as well as comprehensive building renovation should be encouraged. In relation to buildings undergoing major renovation, high-efficiency alternative systems will be encouraged, in so far as this is technically, functionally and economically feasible, and particular attention will be given to healthy indoor climate conditions, fire safety and risks related to intense seismic activity.

Renovation to the nZEB standard for renovation should be encouraged further. In addition, the establishment of a special fund from which the costs will be reimbursed to energy-poor households or households at risk of energy poverty should be considered to remove the barrier of having to obtain a sufficient number of co-owner consents for the energy renovation. The Programme implementation must be accompanied by intensive promotional activities and technical assistance provided to applicants, while ensuring that energy consumption is monitored before and after the energy renovation, with the prerequisites for such monitoring to be created as part of the EMIS. Savings were calculated assuming that the energy renovation of buildings will be achieved at the level necessary to meet the requirements of the Technical regulation on rational energy use and heat retention in buildings, by periods of building construction, at an annual renovation rate of 1% at the beginning of the period (in 2021) and rising gradually to 3% by 2030. The annual savings amount to 0.148 PJ. The estimated unit cost of energy renovation is HRK 1 500 per m^2, which corresponds to the 2020 cost. On inclusion of seismic rehabilitation costs, ranging between HRK 1 000 and HRK 2 500 per m^2, the unit cost of integral renovation rises to HRK 3 500 per m^2.

Note: The targets, conditions and activities, as well as the stated numerical values, are indicative but will be specified in detail in the Energy renovation programme for multi-apartment buildings for 2021–2030.

Activities: The following activities will be implemented under this measure:

- The MPCA will prepare the Energy renovation programme for multi-apartment buildings for 2021–2030, to be adopted by the Croatian Government, which serves as the basis for the use of EU funds in the programming period 2021–2027; under the Construction Act, the Programme is to be adopted by 30 June 2021.
- Implementation in the manner defined in the Programme

Funds required for implementation: The estimated investment cost to be incurred for the 2021–2030 renovation of buildings only at projected rates is HRK 6.36 billion. However, it is estimated that 50% of the buildings will also require seismic retrofitting at an estimated investment cost of HRK 14.84 billion. The exact amounts of investment costs and required grants will be defined in the Energy renovation programme for multi-apartment buildings for 2021–2030.
Sources of financing: Grants need to be secured from the Recovery Fund and ESI Funds to cover up to 60% of eligible costs, with maximum co-financing of energy audits, pre- and post-renovation energy certificates, project documents and technical assistance with project preparation and implementation. The possibility of using national funds and other sources of funding should be considered.
Executive body: MRDEUF – Managing authority in the management and control system for the use of ESI funds, MPCA – Intermediate body level 1 (IB1) in the management and control system for the use of ESI funds; MPCA – operational monitoring of programme implementation; EPEEF – Intermediate body level 2 (IB2) in the management and control system for the use of ESI funds
Monitoring bodies: MESD – NEEA

Impact: Reduction in heating requirements and energy consumption in multi-apartment buildings, with an increase in RES use and the consequent reduction in CO_2 emissions; estimated savings of 1.48 PJ (35.40 ktoe) in 2030; estimated CO_2 emissions reduction of 40.74 $ktCO_{2e}$ in 2030; cumulative energy savings of 8.15 PJ (194.70 ktoe) between 2021 and 2030; cumulative CO_2 emissions reduction of 232.17 $ktCO_{2e}$ between 2021 and 2030
Monitoring method: System for monitoring, measuring and verifying energy savings (EMVS), applying the bottom-up method for the integral renovation of buildings

ENU-4: Energy renovation programme for family houses

Financing measure; 2021–2030 implementation (This measure will continue to be implemented until 2050, with possible changes to be made based on experiences acquired.)

Description of the measure and its goal: The Programme should be envisaged as a continuation of the Energy renovation programme for family houses implemented between 2014 and 2020, with co-funding from the Environmental Protection and Energy Efficiency Fund. It is necessary to ensure the continuous implementation of the renovation of family houses by annually renewing public calls for the award of grants in the period between 2021 and 2030. The primary co-financing sources should be revenues generated by the auctioning of greenhouse gas emission allowances and revenues from fees paid by suppliers for failure to perform their obligations under the energy efficiency obligation scheme. The Programme should leave room for the implementation of individual measures, while respecting the order of measure implementation (e.g. replacing the heating system with a more efficient system using RES should be allowed only to the houses with good thermal characteristics which require no envelope interventions). Deep renovation and renovation to the nZEB standard for renovation should be encouraged further. In relation to buildings undergoing major renovation, high-efficiency alternative systems will be encouraged, in so far as this is technically, functionally and economically feasible, and particular attention will be given to healthy indoor climate conditions, fire safety and risks related to intense seismic activity.

The Programme will also address citizens who are at risk of energy poverty. Savings were calculated assuming that the energy renovation of buildings will be achieved at the level necessary to meet the requirements of the Technical regulation on rational energy use and heat retention in buildings, according to the periods of building construction, at an annual renovation rate of 1% at the beginning of the period (in 2021) and rising gradually to 3% by 2030. The annual savings amount to 0.191 PJ. The estimated unit cost of energy renovation is HRK 1 500 per m^2, which corresponds to the 2020 cost. On inclusion of seismic rehabilitation costs, ranging between HRK 1 000 and HRK 2 500 per m^2, the unit cost of integral renovation rises to HRK 3 500 per m^2.

Note: The targets, conditions and activities, as well as the stated numerical values, are indicative but will be specified in detail in the Energy renovation programme for family houses for 2021–2030.

Activities: The following activities are to be implemented under this measure:

- The MPCA will develop the Energy renovation programme for family houses for 2021–2030 to be adopted by the Croatian Government; under the Construction Act, the Programme should be adopted by 30 June 2021;
- During 2020, the Government adopted a new Plan for the use of funds obtained from the auctioning of emission allowances in Croatia from the year 2021 onwards, which provides for sufficient funds for the implementation of this measure, as well as the Plan for the use of funds obtained from fees paid by suppliers under the energy efficiency obligation scheme;
- The EPEEF is put in charge of the overall implementation of this measure by issuing annual public calls, the criteria of which are to be developed in cooperation with the MPCA.

Funds required for implementation: The estimated investment cost to be incurred for the 2021–2030 energy renovation only is HRK 10.16 billion. However, it is estimated that 50% of the buildings will also require seismic retrofitting at an estimated investment cost of HRK 23.71 billion. The exact amounts

of the investment costs and required grants will be defined in the Energy renovation programme for multi-apartment buildings for 2021–2030.

Sources of financing: Grants need to be secured from the EPEEF to cover up to 60% of eligible costs of energy renovation equipment and works. EPEEF funds are obtained from revenues generated from the auctioning of emission allowances and those generated under the energy efficiency obligation scheme, as well as from other revenue sources of the EPEEF. The possibility of using EU funds should be considered.
Executive body: MPCA – development of the Programme, laying down of criteria, operational monitoring of Programme implementation; EPEEF – overall implementation of the Programme by issuing annual public calls
Monitoring bodies: MESD – NEEA
Impact: Reduction in heating requirements and energy consumption in family houses, with an increase in RES use and the consequent reduction in CO_2 emissions; estimated savings of 1.91 PJ (45.60 ktoe) in 2030; estimated reduction of 52.57 $ktCO_{2e}$ in CO_2 emissions in 2030; cumulative energy savings of 10.50 PJ (250.80 ktoe) between 2021 and 2030; cumulative reduction of 299.12 $ktCO_{2e}$ in CO_2 emissions between 2021 and 2030.
Monitoring method: System for monitoring, measuring and verifying energy savings (EMVS), applying the bottom-up method for the integral renovation of buildings, or another appropriate method, in case individual measures are implemented

ENU-5: Energy renovation programme for public buildings

Financing measure; 2021–2030 implementation (This measure will continue to be implemented until 2050, with possible changes to be made based on experiences acquired.)

Description of the measure and its goal: The measure is a continuation of the Energy renovation programme for public buildings, implemented between 2016 and 2020. For this purpose, funding provided under the Recovery Fund and from ESI Funds should be planned for the next programming period 2021–2027 (with implementation until 2030). Funding needs to be planned so as to ensure the mobilisation of private capital and ESCO markets, especially for buildings which are suitable for such financing models (continuous operation buildings such as hospitals, penitentiaries, senior citizens' homes, etc.) and belong to the category of central government buildings, for which a binding renovation target has been defined in Directive 2012/27/EU on energy efficiency. Market models should be combined with grants in order to achieve deep renovation and attain the nZeb renovation standard. In addition to EU funds, the EPEEF is also required to plan funds for this Programme, specifically in the part related to the co-financing of the energy renovation of central government buildings according to the ESCO model. For buildings which are not suitable for market models, grants need to be secured under the same conditions as in the previous programme. The renovation of public buildings should be directed towards the nZEB renovation standard wherever technically feasible. In relation to buildings undergoing major renovation, high-efficiency alternative systems will be encouraged, in so far as this is technically, functionally and economically feasible, and particular attention will be given to healthy indoor climate conditions, fire safety and risks related to intense seismic activity.

Savings were calculated assuming that the energy renovation of buildings will be achieved at the level necessary to meet the requirements of the Technical regulation on rational energy use and heat retention in buildings, according to the periods of building construction, at an annual renovation rate of 1% at the beginning of the period (in 2021) and rising gradually to 3% by 2030. The annual savings amount to 0.169 PJ. The estimated unit cost of energy renovation is HRK 2 500 per m^2, which corresponds to the 2020 cost. On inclusion of seismic rehabilitation costs ranging from HRK 1 000 to HRK 2 500 per m^2, the unit cost of integral renovation rises to HRK 4 500 per m^2.

Note: The targets, conditions and activities, as well as the stated numerical values, are indicative and will be specified in detail in the Energy renovation programme for public buildings for 2021–2030.

Activities: The following activities are to be implemented under this measure:

- The MPCA will prepare the Energy renovation programme for public buildings for 2021–2030, to be adopted by the Croatian Government, which serves as the basis for the use of EPEEF funds in the programming period 2021–2027; under the Construction Act, the Programme is to be adopted by 30 June 2021.
- Implementation in the manner defined in the Programme
- Where possible, the energy services company model (ESCO) will be applied in the energy renovation of central government buildings and other public buildings, with the ATMIP responsible for its implementation and co-financing provided by the EPEFF and from other sources, including ESI funds; this segment of the Programme is necessary for mobilising private capital, developing the energy services market and achieving targets without additional public sector borrowing.

Funds required for implementation: The estimated investment cost to be incurred for the 2021–2030 energy renovation only is HRK 4 billion. However, it is estimated that 50% of the buildings will also require seismic retrofitting, at an estimated investment cost of HRK 7.2 billion. The exact amounts of investment costs and required grants will be defined in the Energy renovation programme for public buildings for 2021–2030.

Sources of financing: Grants need to be secured from the Recovery Fund and ESI Funds, depending on the climate zone (coastal or continental) and the development index, with maximum co-financing of energy audits, pre- and post-renovation energy certificates, project documents and technical assistance with project preparation and implementation. When it comes to the ESCO model, EPEEF funds are obtained from revenues generated from the auctioning of emission allowances and those generated under the energy efficiency obligation scheme, as well as from other revenue sources of the EPEEF.

Executive body: MRDEUF – Managing authority in the management and control system for the use of ESI funds, MPCA – Intermediate body level 1 (IB1) in the management and control system for the use of ESI funds; MPCA – operational monitoring of programme implementation; EPEEF – Intermediate body level 2 (IB2) in the management and control system for the use of ESI funds / co-financing of projects with own resources; ATMIP – implementation according to the energy contracting model

Monitoring bodies: MESD – NEEA

Impact: Reduction in heating requirements and energy consumption in public buildings, with an increase in RES use and the consequent reduction in CO_2 emissions; estimated savings of 1.69 PJ (40.40 ktoe) in 2030; estimated reduction of 46.52 $ktCO_{2e}$ in CO_2 emissions in 2030; cumulative energy savings of 9.30 PJ (222.20 ktoe) between 2021 and 2030; cumulative reduction of 264.93 $ktCO_{2e}$ in CO_2 emissions between 2021 and 2030

Monitoring method: System for monitoring, measuring and verifying energy savings (EMVS), applying the bottom-up method for the integral renovation of buildings

The worst-performing building stock includes buildings with the status of cultural property. Due to the specific character of those buildings, their renovation will be undertaken under a special programme detailed in Chapter 6.2, Measure ENU-6.

5.3 SPLIT-INCENTIVE DILEMMAS

The split-incentive dilemma has been identified as one of the barriers to the energy renovation of buildings. Directive 2012/27/EU on energy efficiency recognises this issue in its Article 19(1) and lays down the requirement for Member States to address it. The split-incentive dilemma refers to any situation in which the benefit to be gained from a transaction (in this case, an investment into energy efficiency improvements) is not obtained by the actor paying for the transaction[28]. In the context of energy efficiency in buildings, this would mean that the benefits of energy efficiency are obtained by tenants (energy costs)

[28] *Source: Overcoming the split-incentive barrier in the building sector – Unlocking the energy efficiency potential in the rental & multifamily sectors, JRC, 2017*

and the investment is covered by landlords (owners of the building or part of the building). That situation leads to no investment into the energy renovation of buildings.

This problem is not as pronounced in Croatia as it is in the countries of Western and Northern Europe. The ownership rate of housing units in Croatia is extremely high at 90.1%, ranking Croatia the second among EU countries, after Romania, in terms of the share of housing units occupied by their owners[29]. Therefore, no special measures are envisaged to address the split-incentive issue in the housing sector.

On the other hand, while the problem may be somewhat more pronounced in the business sector, it has not proven to be among high-impact obstacles to the activities implemented so far. However, introducing limitations and restrictions on the sale and lease of buildings with the energy rating of D or worse in the commercial sector needs to be considered in further development of the legislative framework (from 2021 onwards) because it might provide an additional impetus to the energy renovation. That measure would not require any funding, but rather amendments to construction and property legislation.

5.4 MARKET DEFICIENCIES

The Croatian real estate market is recovering gradually. In 2017, there was an increase in the number of newly built non-residential buildings, as well as in the number of newly built apartments. Meanwhile, the average price of newly built apartments rose, mostly thanks to the increase in prices in coastal areas and the City of Zagreb (19). This further confirms the assumptions about the building stock moving towards larger urban centres and coastal areas, along with an extensive flight from rural and less developed areas, resulting in an increase in costs, i.e. new construction instead of energy renovation, and the necessity to develop new infrastructure. A study providing an overview of the real estate market in Croatia (*Pregled tržišta nekretnina Republike Hrvatske* (18)) shows the highest volume of transactions in residential and non-residential properties in the City of Zagreb and the Split-Dalmatia County. The affordability index also confirms the lowest affordability of real estate in that very area. At the same time, greater affordability of real estate, especially of residential properties, in the areas facing the strongest depopulation pressures, is not sufficient to increase the renovation rate in those areas because of the high cost of energy renovation compared to the purchase prices in the market, so investing in energy renovation does not reflect on the market value of real estate.

5.5 ENERGY POVERTY

Energy poverty is recognised as a growing problem in the EU. Amended Directive (EU) 2018/844 on the energy performance of buildings requires Member States to define measures to help alleviate energy poverty in their long-term strategies. Under amended Directive (EU) 2018/2002 on energy efficiency, Member States, in designing policy measures to fulfil their obligations to achieve energy savings, are required to take into account the need to alleviate energy poverty in accordance with criteria established by them, taking into consideration their available practices in the field, by requiring, to the extent appropriate, a share of energy efficiency measures under their national energy efficiency obligation schemes, alternative policy measures, or programmes or measures financed under an Energy Efficiency National Fund, to be implemented as a priority among vulnerable households, including those affected by energy poverty and, where appropriate, in social housing. Finally, Directive (EU) 2018/1999 on the Governance of the Energy Union and Climate Action requires EU Member States to assess the number of households in energy poverty in their integrated national energy and climate plans, taking into account the necessary domestic energy services needed to guarantee basic standards of living in the relevant national context, existing social policy and other relevant policies, as well as Commission indicative guidance on relevant indicators, including geographical dispersion, that are based on a common approach for energy poverty, and to adopt policies and measures to protect consumers, especially vulnerable and energy-poor consumers.

Croatia lacks both a definition of energy poverty and general criteria or methodology for determining energy poverty. Therefore, the Integrated national energy and climate plan provides for the preparation, adoption

[29] *Source: https://www.statista.com/statistics/246355/home-ownership-rate-in-europe/ (accessed on 8 November 2019)*

and implementation of a comprehensive Programme to combat energy poverty. A description of the measure is provided below. Also, the plan provides for the integration of the energy poverty criteria into energy renovation programmes for multi-apartment buildings and family houses for 2021–2030. Certain steps in this regard have already been taken, specifically in two documents:

I. Amendments to the Energy renovation programme for family houses for the period between 2014 and 2020 with a detailed plan for 2014–2016 (NN No 57/2020) and
II. Draft Programme to combat energy poverty, including the use of renewable energy sources in residential buildings in assisted areas and in areas of special state concern for 2021–2025.

On 14 May 2020, the Government adopted a Decision amending the Energy renovation programme for family houses. On 25 June 2020, based on the amendments to the Programme, the Environmental Protection and Energy Efficiency Fund issued a first ever public call in Croatia which included subsidies for the energy renovation of houses for citizens in danger of energy poverty, with a full funding rate (100%) covering the cost of the integrated energy renovation.

Both documents address the issue of energy poverty and provide for the launch of pilot projects for the energy renovation of buildings inhabited by citizens at risk of energy poverty. The pilot projects are focused on the most socially vulnerable groups of citizens, i.e. primarily on the recipients of a guaranteed minimum allowance. The allowance is granted to the socially most vulnerable citizens under the Social Welfare Act (NN Nos 157/13, 152/14, 99/15, 52/16, 16/17, 130/17, 98/19 and 64/20). These citizens will be provided with subsidies to cover 100% of the energy renovation.

It is important to note that, in implementing the energy renovation programme focused on citizens at risk of energy poverty, the citizens are provided with full technical assistance and management of the procedures related to both the use of financial incentives and the implementation of the energy renovation itself. Social welfare centres coordinate EPC certifiers in order to assist the most vulnerable citizens with project application and implementation. The planned energy renovation measures and the cost of EPC certifiers for such citizens will be financed in full from the Environmental Protection and Energy Efficiency Fund. In this regard, EPC certifiers provide a complete, door-to-door service to the most vulnerable groups of citizens.

Based on the experiences acquired in the implementation of the two pilot projects, the definition of energy poverty in Croatia will be further elaborated, and criteria for establishing citizens who are at risk of energy poverty and require help with energy renovation will be expanded. A broad discussion among stakeholders on energy poverty criteria has already started through the 'Open partner dialogue' initiative, with its second working meeting focusing on energy poverty[30]. Apart from the guaranteed minimum allowance, some of the most important criteria discussed, which will be further elaborated as risk indicators for energy poverty, are the following:

- Household income,
- Building energy rating,
- Floor area per household member,
- Total energy costs vs. total household income,
- Other social welfare categories (disability benefits, child benefits, pensioners with the minimum pension, welfare and health insurance threshold, means testing, etc.).

Measure UET-5: Adoption and implementation of the Programme to combat energy poverty

Information and financing measure; 2021–2030 implementation

Description of the measure and its goal: alleviating energy poverty and the related degree of vulnerability; establishing a system for the monitoring of energy poverty

[30] *More information is available at https://MPGI.gov.hr/vijesti/drugi-otvoreni-dijalog-partnera-energetsko-siromastvo/8938*

Activities: Under the Programme to combat energy poverty, capacity building will continue through local information centres, so energy-poor citizens and citizens at risk of energy poverty will be provided with adequate information and advice on energy efficiency measures to help combat energy poverty, and on the possibilities of co-financing the activities in this field. Furthermore, the indicators necessary for monitoring energy poverty will be identified and a system to monitor them will be established, through the already existing system for the collection of data on household consumption and habits (Croatian Bureau of Statistics). The data will be used to analyse a possible extension of criteria for attaining the status of vulnerable energy customers. Co-financing will be provided for the implementation of energy efficiency measures in energy-poor households, such as the replacement of household appliances according to the 'old-for-new' system, the improvement or replacement of heating systems (improving the efficiency of heating systems and replacing energy products, especially electricity and fuel oil) with more favourable ones in environmental, economic and energy terms, primarily with systems using renewable energy sources; as well as the implementation of other technical energy efficiency measures. These measures and the possibility of their implementation under the energy efficiency obligation scheme for suppliers will be elaborated in the Programme in further detail and, if necessary, other measures will be formulated. A model for the coverage of energy costs will be further developed and implemented under the Programme. The model will determine the level of assistance required for households facing the problem of paying for their energy costs, based on the amount of energy required to meet the minimum standard of housing. Measures to combat energy poverty by undertaking the energy renovation of buildings will be elaborated further in the Energy renovation programme for multi-apartment buildings for 2021–2030 and in the Energy renovation programme for family houses for 2021–2030.

Sources of financing: Resources of the entities subject to the energy efficiency obligation schemes; EU funds

Executive body: the ministry responsible for energy and the ministry responsible for social welfare, Croatian Bureau of Statistics (CBS)

Monitoring bodies: the ministry responsible for energy and the ministry responsible for social welfare

Impact: Establishment of a system for monitoring energy poverty and vulnerability to it; capacity building for the alleviation of energy poverty; establishing a model for covering energy costs; reduction in the end-use energy consumption and the consequent reduction in CO_2 emissions in energy-poor households and those vulnerable to energy poverty

Monitoring method: CBS publications; savings achieved are to be monitored and proven using bottom-up methods according to the Rules for monitoring, measuring and verifying energy savings

Adoption and implementation of the Programme to combat energy poverty, including the use of renewable energy sources in residential buildings in assisted areas and areas of special state concern for 2021–2025

Information and financing measure; 2021–2025 implementation

Description of the measure and its goal: the alleviation of energy poverty and the related degree of vulnerability in the buildings owned and managed by the Central State Office for Renovation and Housing (CSORH), in which occupants are not able to participate in the financing of necessary repairs

Activities: Under the Programme to combat energy poverty, which includes the use of renewable energy sources in residential buildings in assisted areas and areas of special state concern for 2021–2025, 413 residential buildings have been identified for the purposes of the Programme, which covers 407 buildings on the working list and 12 additional buildings, with 22 buildings included in other units, or a total of 397 buildings. The renovation priorities were determined according to the deficiencies observed in the buildings, and possible savings of the energy required for heating and primary energy to be achieved through the renovation of the buildings were estimated. A total of 397 buildings with a total floor area of 297 575 m², requiring an investment of HRK 297–355 million into their renovation, were included. Total potential primary energy savings in all buildings amount to 27 GWh per year.

Sources of financing: Resources of the entities subject to the energy efficiency obligation scheme, EPEEF, EU funds

Executive body: CSORH, EPEEF

Monitoring bodies: MESD – NEEA

Impact: a comprehensive renovation of buildings in assisted areas and areas of special state concern; capacity building for the alleviation of energy poverty; establishing a model for covering energy costs; reduction in end-use energy consumption and the consequent reduction in CO_2 emissions in energy-poor households and those vulnerable to energy poverty

Monitoring method: CBS publications; savings achieved are to be monitored and proven using bottom-up methods according to the Rules for monitoring, measuring and verifying energy savings

5.6 PROMOTING SKILLS, NEW TECHNIQUES AND TECHNOLOGIES IN THE FIELD OF NEARLY ZERO-ENERGY BUILDINGS (NZEBS) AND ENERGY RENOVATION

This Long-term strategy lays down plans for the implementation of a comprehensive programme to promote nZEB construction and renovation standards, as described below.

ENU-2: Promoting nZEB construction and renovation standards

Information measure; 2019–2030 implementation

Description of the measure and its goal: After 31 December 2018, all public buildings in Croatia occupied or owned by public bodies must be constructed according to the nZEB standard, and the obligation for all other newly constructed buildings takes effect after 31 December 2020. These legal provisions ensure that all newly constructed buildings from 2021 onwards comply with the nZEB standard. However, in order to ensure the correct application of these provisions and encourage the energy renovation of buildings to the nZEB standard, a series of information and educational activities are planned in the coming period to promote construction and renovation according to the nZEB standard.

Activities: The following activities will be implemented under this measure:

- Open partner dialogue – workshops which will bring together stakeholders of the state administration, local government, construction sector, energy sector, as well as educational and other public institutions, to develop through mutual dialogue an adequate national definition of a nearly Zero-Energy Building and a roadmap for the transformation of the existing buildings into a highly energy-efficient and decarbonised building stock by 2050;
- Development of nZEBs guidelines for investors and designers – the guidelines will provide professional, clear and unambiguous information on nZEBs, with the general and the professional public as the two target groups;
- Media campaigns for energy certification and nZEB standards promotion – the campaigns will provide information to the public with an aim of raising awareness of the importance of energy certificates, their significance in energy renovation and use in proving compliance with nZEB standards, and of the availability of information in the Information system of energy certificates (IEC); additionally, a targeted campaign will be conducted for the purpose of information provision and raising awareness of the nZEB standard for new builds and the energy renovation of buildings.

Sources of financing: State Budget (MPCA)
Executive body: MPCA – implementation of all Programme activities
Monitoring bodies: MESD – NEEA
Impact: The measure does not have a direct effect on reducing energy consumption, but rather supports the regulatory measure for the construction of new buildings to the nZEB standard, and also serves as a promotional measure for energy renovation to the nZEB standard, which will result in a measurable reduction in energy consumption, higher RES use and CO_2 emissions avoidance.

Monitoring method: Reports on informative and educational activities undertaken

5.7 SUSTAINABILITY OF URBAN AREAS

In the context of the preservation and balanced use of spatial resources, Croatia's Spatial Development Strategy (NN No 106/17) states that development activities, as a priority, should focus on the already used space, whether through transformation of abandoned or underused facilities which no longer serve their primary purpose or through urban rehabilitation, especially of the areas of initial illegal construction, or rehabilitation of parts of the urban area which have specific problems and requirements. The importance of mobilising abandoned and underused publicly-owned real estate and spatial units, and the related task of recording, evaluating and planning new and sustainable forms of their use, while improving the quality of the settlement as a whole is especially highlighted. In that respect, it is necessary to improve the state of the urban environment in cities and settlements, revitalise abandoned and neglected urban facilities and their immediate environment, and undertake a decontamination of space where necessary.

MS-9: Improving the sustainability of urban areas

Research and analytical measure; financing measure; 2021–2030 implementation

Description of the measure and its goal: The MCPP is currently developing a new national Programme for the development of green infrastructure in urban areas and a new national Programme for the development of circular management of space and buildings, aimed at achieving the environmental, economic and social benefits of sustainable development. The Programme for the development of green infrastructure in urban areas maps out the goals and measures for the development of green infrastructure which, among other things, affect the increase in the energy efficiency of buildings and building areas, the development of green infrastructure in building construction, urban transformation and urban rehabilitation, and the reduction in temperature in urban heat islands. The Programme for the development of circular management of space and buildings details the objectives and measures for circular management of space and buildings which, among other things, promotes the circularity measures when planning new buildings, the reuse of abandoned and/or neglected buildings and extending the durability of existing space and buildings, as well as reducing the amount of construction waste and increasing the energy efficiency of buildings. This measure is aimed at encouraging cities and municipalities to found their projects for the revitalisation and development of new urban areas on the principles of sustainability. The first step is to prepare urban development plans which, based on the evaluation of sustainability indicators, will define development projects to improve these indicators. Furthermore, co-financing for these projects will be provided from ESI funds in 2021–2027 (2030). The Ministry of Physical Planning, Construction and State Assets, as the ministry responsible for sustainable urban development issues, will define key sustainability indicators, including those related to built space, the economy, energy, emissions into the atmosphere, use of natural resources, the environment and social aspects, which will need to be monitored at both the national and local level. The measure will provide for sustainable development through more direct linking of strategic and physical planning documents, as well as through the introduction of performance measurements for planned and implemented projects. Under this measure, financial support for such projects will also be provided from ESI funds, in line with the 2021–2027 target. PO2 – 'A greener, low carbon Europe by promoting clean and fair energy transition, green and blue investment, the circular economy, climate adaptation and risk prevention and management'

Activities: The following activities are to be implemented under this measure:

- development of the Programme for the development of green infrastructure in urban areas;
- development of the Programme for the circular management of space; and
- implementation of green infrastructure and circular spatial management projects through EU co-financed programmes.

Funding required for implementation: EUR 375 000 000.00 in project financing and HRK 762 000.00 (excluding VAT) for programme development

Sources of financing: MPCA, EU funds

Executive body: MPCA, Faculty of Architecture

Monitoring bodies: MPCA

Impact: Reduction in heating requirements and energy consumption in public and residential buildings, with an increase in RES use and the consequent reduction in CO_2 emissions

Monitoring method: The study will be conducted by using the Questionnaire sent to LSGUs, with monitoring through the PPIS planned at a later stage

Connection with other dimensions: The measure is innovative and enables the development of urban areas, which will not only contribute to decarbonisation and energy efficiency but will bring numerous other social, economic and environmental benefits as well.

Connection with climate change adaptation: The development of green infrastructure in urban areas makes buildings and building areas more resilient to some of the effects of climate change (e.g. extreme temperature conditions, urban heat islands, etc.).

Research and Development: This measure is directly related to research and development, as well as innovative measures to improve the sustainability of urban areas.

5.8 ELECTROMOBILITY

Requirements to include electromobility are integrated in Articles 21.a, 21.b and 21.c of the Construction Act to ensure that new non-residential buildings and non-residential buildings undergoing major renovation, with more than ten parking spaces, have at least one recharging point and ducting infrastructure installed for at least one in every five parking spaces, and where there are more than twenty parking spaces, at least one recharging point installed. With regard to new residential buildings and residential buildings undergoing major renovation with more than ten parking spaces, ducting infrastructure is to be installed for every parking space to enable the installation of recharging points for electric vehicles at a later stage.

The installation of recharging points in new and existing residential and non-residential buildings is left to market actors, according to market needs and the actual number of electric vehicles. Under the National policy framework for the deployment of infrastructure and development of the market as regards alternative fuels in the transport sector (NN No 34/17), the development of the electric vehicle market does not foresee the share of vehicles using alternative energy in excess of 10% by 2025. The deployment of minimum infrastructure for the supply of electricity to vehicles in the Croatian territory is aimed at creating a more sustainable urban and road transport and enabling the operation of electric vehicles in larger urban centres and along major Croatian transport routes, as well as enabling shore-side supply of electricity to inland waterway vessels and seagoing ships at the ports of the TEN-T core network.

An appropriate number of publicly accessible charging stations needs to be accessible in agglomerations and in the transport network. Currently, the 126 charging stations and 856 vehicles (1 charging station for 6 vehicles) exceed market needs on the one hand, while not enabling the use of electric vehicles in the entire Croatian territory on the other hand.

For the purpose of meeting the requirements for the functioning of electromobility, the proposal on the number of charging stations and plug-in spots is based on a scenario featuring a low share of energy transmission in the public network of charging stations, contained in the document on the modelling of parameters for the electric-vehicle charging infrastructure, which also provides an overview of measures to promote the acceptance of electric vehicles (*Modeliranje parametara infrastrukture za punjenje električnih vozila – Pregled mjera poticanja prihvaćanja električnih vozila*)[31]. An adequate monitoring of growth of the electric vehicle market necessitates the following conditions to be ensured:

[31] *Decision adopting the national policy framework for the deployment of infrastructure and development of the market as regards alternative fuels in the transport sector, NN No 34/17*

- 2020 – a minimum of 296 plug-in spots (222 AC with a minimum power of 22/(11) kW, 74 DC with a minimum power of 50 kW); at 164 charging stations;
- 2025 – a minimum of 602 plug-in spots (434 AC with a minimum power of 22/(11) kW, 168 DC with a minimum power of 50 kW); at 348 charging stations;
- 2030 – a minimum of 806 plug-in spots (554 AC with a minimum power of 22/(11) kW, 252 DC with a minimum power of 50 kW); at 479 charging stations;
- the optimal number of charging station locations in 2030 is slightly less than 300.

The procedure for obtaining permits for the installation of charging equipment for electric vehicles follows the Rules on simple and other buildings and works, in accordance with the main design, without the need to obtain a building permit in order to shorten and simplify the administrative procedure as much as possible, except that technical prerequisites for the connection must be provided in the form of a study of the optimal technical solution for the connection [*Elaborat optimalnog tehničkog rješenja priključka*] and preliminary electrical power approval must be obtained.

6 POLICIES AND ACTIONS FOCUSING ON ALL PUBLIC BUILDINGS

6.1 OVERVIEW OF POLICIES AND MEASURES FOR PUBLIC BUILDINGS

The key measure for public buildings is ENU-5: Energy renovation programme for public buildings, detailed in Chapter **5.2.** In addition to this measure, other public sector measures are also expected to be implemented, contributing to the energy renovation and the overall improvement of the energy performance of public buildings at both the national and local level. These measures are also specified in the Integrated national energy and climate plan, as described below.

ENU-7: Systematic energy management in the public sector

Information measure; 2014–2030 implementation

Description of the measure and its goal: Croatia's public sector is obligated to systematic energy management, laid down specifically in the Energy Efficiency Act and the Rule on systematic energy management (NN Nos 18/15, 06/16). This measure is founded on the energy management information system (EMIS). The strategic objective is to cover and regularly monitor through the EMIS all public buildings and public lighting systems by the end of 2030. Savings stemming from the activities of systematic energy management and introduction of remote metering over the previous period were found to have been around 335 TJ per year (according to the 4th NEEAP). In light of systematic work on this measure since 2014, the presumed potential for savings was reduced to 100 TJ per year to keep the estimate conservative.

Activities: The following activities are to be implemented under this measure:

- In the period up to 2021, the collection of data on fuel and water consumption will be automated (remote reading), the EMIS will be connected to the systems of fuel and water suppliers, energy associates and advisers responsible for energy management will be trained in their buildings, with the EMIS to be developed and upgraded further. The focus will be placed on the development of a module to monitor and verify savings made as a result of the energy renovation, as well as compliance with the building use pattern set for the purpose of achieving and maintaining comfort. The 2020 remote reading covered all public sector locations with the annual energy and water consumption higher than HRK 400 000.00. Supplier databases are planned to be merged with the EMIS in 2021 for the purpose of automated data collection, while integrating the EMIS with all relevant energy databases. In addition, measures including an optimisation of peak power contracting, a reduction of the excess idle power supplied, an optimisation of thermal input contracting, an analysis of the potential for boiler replacement and operational optimisation and an analysis of the potential for cooling energy accumulation in public buildings are also planned to be implemented by 2021.
- Between 2021 and 2030, an energy management system and the EMIS are to be deployed in all public buildings, while improving and expanding the entire system through the following activities:
    1. incorporate all distance reading systems deployed into the EMIS;
    2. integrate the EMIS and other databases: Geoportal of the State Geodetic Administration, the cadastre, the register of protected facilities, the IEC, the EMIS, etc.:
    3. specify the EMIS as the system to be used for verifying actual savings resulting from building renovation (define data to be sent by room sensors to the system; the EMIS is ready to receive such data already);
    4. expand EMIS use in all sectors (private, industrial, etc.) on a voluntary basis and/or as a requirement related to the award of financial assistance for renovation and the implementation of energy efficiency measures;
    5. improve the EMIS so that it may perform financial analysis of renovation cost-effectiveness based on real data;

6. develop the EMIS along the lines of artificial intelligence so that the system itself, based on the parameters entered, may propose measures to enhance energy efficiency;

7. install measurement instruments / sensors to measure indoor temperature and air quality in public buildings and connect them to the EMIS.

- In addition to improving the EMIS, this measure also provides for a resumption and increase in the scope of training courses for public and other institutions, creating a base of users who are well-acquainted with energy efficiency and have the capacity to act on it within their institutions, and further development of the proposal for an 'energy manager' position in public institutions.

Sources of financing: State Budget (ATMIP)
Executive body: ATMIP
Monitoring bodies: MESD – NEEA
Impact: Reduced energy consumption in public buildings; changes in the habits and behaviour of the occupants of public buildings; estimated savings of 0.20 PJ (4.78 ktoe) in 2030; estimated reduction in CO_2 emissions of 5.50 $ktCO_{2e}$ in 2030; cumulative energy savings of 1.90 PJ (45.41 ktoe) between 2021 and 2030; cumulative CO_2 emissions reduction of 54.13 $ktCO_{2e}$ between 2021 and 2030.
Monitoring method: The monitoring of actual energy savings to date has been possible through basic and advance database analyses in the EMIS system. The achieved savings are based on metered consumption data for all energy forms. Database synchronisation enables data to be checked, while their linking to the metering systems produces real-time data to provide for strategic planning and implementation of measures. Direct hourly monitoring of energy and water consumption through the EMIS system yields quality indicators of energy requirements, serving to improve planning and resource management.

ENU-9: Green public procurement

Information measure; 2014–2030 implementation

Description of the measure and its goal: In 2015, the Croatian Government adopted its 1st National action plan for Green public procurement for 2015–2017 with an outlook to 2020, so green public procurement has been accepted as a measure under the 4th NEEAP, which sets a target for 50% of public procurement procedures conducted by 2020 to apply green public procurement benchmarks. Green public procurement will encourage the procurement of innovative low-carbon products and services, thus additionally supporting their market penetration, with the public sector serving as the role model. The strategic objective is for 75% of completed public procurement procedures for priority product groups to have applied green public procurement benchmarks.

Activities: The following activities will be implemented under this measure:
- training of public procurement participants and promoting green public procurement benchmarks;
- enhanced monitoring of green public procurement implementation aimed at quantifying its effects – entities subject to public procurement are required to publish their public procurement plans on their website, with the statistical public procurement report generated from the EOJN containing the information on the use of green public procurement benchmarks, and making monitoring system improvements a must;
- continued development of new criteria and benchmarks for green public procurement, including energy efficiency.

Sources of financing: State Budget (MESD)
Executive body: MESD; Central Public Procurement Office; state administration authorities; LRSGU and other entities subject to public procurement
Monitoring bodies: MESD – NEEA
Impact: Reduced energy consumption in public buildings; changes in the habits and behaviour of public building occupants

Monitoring method: 'Development of the method for monitoring greenhouse gas emissions savings for procurement categories in which green public procurement benchmarks were used. The Central Public Procurement Office provides procurement category data within its competence to the NEEA, which enters them in the EMVS.'

6.2 POLICIES AND MEASURES FOR THE RENOVATION OF CULTURAL HERITAGE BUILDINGS AND BUILDINGS OWNED AND USED BY THE CROATIAN ARMED FORCES

This Long-term strategy lays down plans to implement a comprehensive energy renovation programme for buildings with cultural heritage status, the draft of which has already been prepared, as described below.

ENU-6: Energy renovation programme for buildings with cultural heritage status

Financing measure; 2021–2030 implementation

Description of the measure and its goal: For the purposes of this Programme, protected buildings fall into two categories: individually protected cultural property (individual buildings and building complexes) and buildings located within a protected cultural and historical unit. The Programme does not cover buildings under preventive protection as cultural property or buildings registered as architectural heritage in physical planning documents. As part of the Programme, two basic approaches to the energy renovation of buildings covered by it have been developed: a comprehensive approach and an approach including the application of individual energy renovation measures.

Under the draft programme, an assessment of the needs was made as follows:

- Total investment (HRK): 6.342 billion
- Maintenance costs (HRK): 1.796 billion
- Average annual renovation rate (%): 1.6
- Total renovated area (m^2): 4 162 756
- Energy savings (MWh): 1 440 058.72
- Financial savings (HRK): 0.512 billion
- Reduction in CO_2 emissions (kt): 201.26

The total needs for the implementation of the energy renovation programme for buildings with cultural heritage status, aimed at achieving national goals, amount to HRK 18.74 billion for 2021–2030. That amount includes the required investments of HRK 13.67 billion and maintenance costs of HRK 5.07 billion. Given that the return-on-investment periods are very long, it will be necessary to make the most of the programme co-financing through grants to reduce simple return-on-investment periods and encourage the energy renovation of such buildings. EU Funds and funds collected through monument annuities are recognised as the sources from which grants may be funded. Considering the overall investment needs, the annual required investments total around HRK 0.63 billion between 2021 and 2030, of which HRK 0.46 billion would be the required co-financing. Given that around HRK 100 million in monument annuities is collected on an annual basis, the remaining amount of about HRK 360 million per year needs to be secured from EU Funds. VAT is not included in these amounts.

The exact investment costs and grants required will be stated in the final version of the Energy renovation programme for buildings with cultural heritage status.

Activities: The following activities are to be implemented under this measure:

- The MPCA has prepared a draft Energy renovation programme for buildings with cultural heritage status for 2021–2030 to be adopted by the Croatian Government, which serves as the basis for the use of ESI funds in the programming period 2021–2027, as well for the planning of EPEEF resources.
- Implementation in the manner defined in the Programme
- Where possible, the energy services company model (ESCO) will be applied in the energy renovation of central government buildings and other public buildings, with the ATMIP responsible for its implementation and co-financing provided by the EPEFF and from other sources, including ESI funds; this segment of the Programme is necessary for mobilising private capital, developing the energy services market and achieving targets without additional public sector borrowing.

Sources of financing: Monument annuity funds and EU Funds
Executive body: MPCA – implementation of all Programme activities
Monitoring bodies: MPCA
Impact: Total energy savings of 5 073 234.38 GWh, reduction in CO_2 emissions by 201.26 kt
Monitoring method: Entry of the measures implemented and savings achieved in the EMVS

The use of high-efficiency alternative systems will be encouraged during the renovation, in so far as this is technically, functionally and economically feasible, and particular attention will be given to healthy indoor climate conditions, fire safety and risks related to intense seismic activity.

The **Croatian Armed Forces Long-Term Development Plan 2015–2024** provides for a two-phase relocation of the Armed Forces troops to envisaged locations and the accompanying abandonment of low-potential properties – the first phase by the end of 2019 and the second phase between 2020 and 2024.

High-potential properties (properties built for military purposes and used by the Ministry of Defence) are maintained and facilities are consolidated, standards are raised and buildings adapted to meet the requirements of regulations in the fields of physical planning, construction, fire safety, occupational safety and health, environmental protection and technical protection. A concept for the construction of prefabricated and modular buildings for accommodation, logistics and other purposes and a rapid construction system, applying the processes aimed at achieving energy efficiency and waste management processes, are being explored.

Temporarily high-potential properties (properties built for military purposes and used by the Ministry of Defence which are undergoing abandonment) and low-potential properties (properties built for military purposes but which are not used by the Ministry of Defence) are being abandoned and will be handed over for management to the Ministry of Physical Planning, Construction and State Assets.

Top priority is given to 12 locations, with plans to renovate existing facilities and increase their energy efficiency, while building teaching, administrative, accommodation and technical facilities. Another 15 locations have second priority, with plans to reconstruct, expand existing and build new facilities to include the application of renewable energy sources.

Building on the macroeconomic reality, which currently does not allow reliable medium-term and long-term projections on GDP dynamics, the Croatian Armed Forces Long-Term Development Plan 2015–2024 is based on the assumption that the defence budget in the next three years will remain at its 2014 level of around HRK 4.3 billion in absolute terms. Of that amount, 12% are fitting-out and construction costs – the costs of the main fitting-out and modernisation projects, ancillary projects supporting the management of the main projects, and the costs of the construction and modernisation of buildings and infrastructure.

7 NATIONAL INITIATIVES TO PROMOTE SMART TECHNOLOGIES AND WELL-CONNECTED BUILDINGS AND COMMUNITIES, AS WELL AS SKILLS AND EDUCATION IN THE CONSTRUCTION AND ENERGY EFFICIENCY SECTORS

7.1 POLICIES AND ACTIONS TO PROMOTE SMART TECHNOLOGIES AND WELL-CONNECTED BUILDINGS AND COMMUNITIES

Policies and actions to promote smart technologies and well-connected buildings and communities are set out mostly on a local level by adopting strategies for the development of smart cities. Several Croatian cities have already prepared such strategies in accordance with the European Union initiative European Innovation Partnership on Smart Cities and Communities (EIP-SCC). Smart cities are based on digital infrastructure and encompass the following areas:

- efficient, transparent and smart city administration,
- smart energy and utilities management,
- smart environmental management, including physical planning,
- strengthening the role of citizens,
- smart (circular) economy,
- sustainable urban mobility.

Examples of such strategic commitments and projects implemented by Croatian cities are listed below:

- Zagreb Smart City – the City of Zagreb prepared its own smart city development strategy and provided the institutional capacities necessary for its implementation;
- Rijeka Smart City [*Rijeka Pametan grad*] – the development strategy of the City of Rijeka for 2014–2020 defines all areas for the development of Rijeka as a smart city;
- Zadar Urban Mobility 4.0 – the City of Zadar plans a number of measures to develop an intelligent transport system within the City (web portal and mobile application providing access to integrated services, electronic ticketing system for public transportation, smart parking system, traffic and public transport information system and the Central Information System (CIS), as the central system for monitoring and managing other elements of the project);
- Dubrovnik Smart City [*Pametni grad Dubrovnik*] – smart parking system; Dubrovnik Visitors [application] used by the City of Dubrovnik to monitor data on the movement of people in the historical city centre; 3D urban planning solution for a smart and sustainable city;
- The City of Bjelovar – Smart City [*Grad Bjelovar – Smart City*] – digitalisation of the city administration to make Bjelovar a city open to new technologies, facilitating the everyday life of citizens; e-Invoice via the electronic postal service which reduces costs and increases the efficiency of city officials and their communication with citizens; smart benches in the city centre; charging station for electric bicycles.

All these projects for the development of smart cities envisage the intensive use of digital technologies in buildings, as well as in services provided in these buildings, all with the purpose of environmentally, economically and socially sustainable city development.

7.2 POLICIES AND ACTIONS TO PROMOTE SKILLS AND EDUCATION IN THE CONSTRUCTION AND ENERGY EFFICIENCY SECTORS

• Croskills

The CROSKILLS project, as part of the Build Up Skills initiative, focuses on the lifelong learning and training of Croatian workers for energy efficiency in the building segment by strengthening the qualifications of craftspeople, employed and unemployed workers in the construction sector after their initial, basic education or after they have entered employment. The project also addresses the training and qualifications of workers who are currently unemployed.

The first part of the project (2012–2013) brought together relevant Croatian institutions and professional organisations in the construction, energy and education sectors through the National Qualifications Platform, and resulted in the formulation of needs, measures and priorities as part of the National Guidelines and Action Plan, which was formally accepted by as many as 23 sectoral organisations.

In the second phase, Croskills II, 24 training modules for EQF level 4 are being developed for shortage occupations related to works on the external building envelope, namely those of bricklayer, plasterer, painter-decorator, carpenter, roofer and dry construction fitter.

In order to strengthen the skills of construction workers in the field of energy efficiency and provide them with the highest-quality training, training materials were prepared for the occupations of bricklayer, plasterer, carpenter, painter-decorator, roofer and dry construction fitter. Training manuals were also prepared for training instructors for all these occupations. They are intended for anybody who possesses certain expertise in the occupations concerned and seeks to further their knowledge in the field of energy efficiency. Providing training to training instructors so that they can transfer the necessary skills and knowledge to others serves as the basis for the successful implementation of the CROSKILLS project.

The next step was establishing databases for certified construction workers installing parts of buildings which affect energy efficiency, as well as for leaders of the Training scheme for the certification of these construction workers:

– certified workers (bricklayer, plasterer, carpenter, painter-decorator, roofer, dry construction fitter),

– certified training instructors (bricklayer, plasterer, carpenter, painter-decorator, roofer, dry construction fitter),

– authorised training centres and training courses for workers.

The Rules on the training and certification scheme for construction workers installing parts of buildings which affect energy efficiency in the building segment (NN No 67/17) lay down a system of training and certification for construction workers installing parts of buildings which affect energy efficiency in the building segment. Among other things, these Rules lay down the conditions and criteria for the certification of construction workers installing parts of buildings which affect energy efficiency, educational qualifications and work experience required to enrol in the Training scheme, content and manner of implementation of the Training and testing scheme, and professional development, the Register of certified construction workers installing parts of buildings which affect energy efficiency, the Register of leaders of the Training scheme for the certification of construction workers installing parts of buildings which affect EE, conditions for issuing approvals for the implementation of the Training scheme, obligations of the Training scheme leader, etc.

• Green Building Pro

The Green Building professional training programme aims to educate a generation of multidisciplinary experts in the field of green and sustainable building, energy efficiency, renewable energy sources, and sustainable transport and e-mobility.

The topics covered are designing and funding green buildings; using ecological and sustainable materials for the construction, fitting-out and renovation of buildings (with the lowest carbon footprint and the least adverse effect on the environment and the building occupants); assessing the value and service life of

buildings with regard to green elements and the built environment; landscape design, energy efficient design and lighting technologies, use of daylight, achieving savings through recycling and energy saving, efficient use of water resources; choosing and managing sustainable locations, and creating green offices. The solutions offered are modern construction, service life impact assessment, whole-life cost assessment, energy and smart building management, legal framework and regulations, energy renovation, energy efficiency, sustainable transport, e-mobility, nZEB, thermotechnical systems in building construction, the method of combining and designing energy efficient buildings, and using the LEED, BREEAM or DGNB international green building certifications to create a healthier, more comfortable, more energy efficient and more economically viable environment, all based on the principle of sustainability.

- **BuildUp**

Several projects with a common denominator which are focused on the digitalisation of construction and the use of modern information technologies are currently under way:

NetUBIep

Enhancing the energy efficiency of buildings by promoting and increasing the use of Building Information Modelling (BIM) over the service life of the building. The application of BIM will help increase the energy efficiency of buildings by using different materials in both the implementation of the main project and in the process of the (energy) renovation of buildings.

BIMcert

BIMcert will develop a blended, fully supported set of BIM learning tools allowing dislocated teams on construction projects to use technology to improve information exchange and collaboration. Special focus is placed on green and passive construction in order to help boost energy efficiency. The curriculum and demonstration-based training modules for BIM in energy efficiency up to EQF level 4 were set up under the project, along with a digital platform for the blended knowledge transfer model.

BIMZEED

The BIMzeEd project focuses on defining the training currently needed by the construction industry, as well as training which will be necessary in the future to promote:

1) better employment opportunities,

2) low-carbon development,

3) green skills and skills needed for the construction of nearly Zero-Energy Buildings (nZEBs),

4) higher youth employment.

The challenge faced by the BIMzeED project is the need to overcome skills mismatches and improve employment opportunities in the current European construction market by enhancing the existing skills of trainers, small and medium-sized enterprises, construction site managers, craftspeople and other construction sector workers.

- **Fit-to-NZEB Innovative training schemes for retrofitting to nZEB-levels implemented under Horizon 2020**

The Fit-to-NZEB project is aimed at increasing the number of experts engaging in the deep energy renovation of buildings, as well as in the construction of new nearly-zero energy buildings. In Croatia, the project is implemented by the Faculty of Civil Engineering of the University of Zagreb. All the necessary materials for the introduction of curricular content on deep energy renovation at all levels of vocational training and the formal educational system, namely at universities, vocational secondary schools, universities of applied science and vocational training centres, were developed under the project. A catalogue of learning outcomes has been defined in accordance with the European Qualifications Framework (EQF) for levels 3–7 (three-year secondary education – higher education) and competences

(knowledge, skills, autonomy and responsibility) have been laid down for each level. More information on the project is available at www.fit-to-nzeb.com.

- ## The nZEB Roadshow

In the coming period (between 1 June 2020 and 30 November 2022), the Faculty of Civil Engineering of the University of Zagreb, together with its partners, will implement the nZEB Roadshow project activities under Horizon 2020. The nZEB Roadshow project is aimed at bringing together the general and the professional public, public administration employees, and manufacturers of materials and systems to spread knowledge and experience related to almost zero-energy buildings (nZEB). Thus, the nZEB concept will be brought closer to all interested investors, designers, workers, students of secondary vocational schools, other students, etc. Under the nZEB Roadshow project, marketing and communication campaigns will be organised in five European countries at the national level. These communication campaigns will focus around nZEB days, which will be organised in three to five selected cities in all the countries involved.

The nZEB days will feature various events:

- promotion of construction products;
- practical demonstrations and courses for designers and construction workers (including VR and AR solutions);
- information sessions and free consultations for citizens who are active in the real estate market;
- on-site trainings related to public building renovation.

As the focal point of the event, a mobile nZEB house will be built to serve as an information and demonstration centre to raise awareness of the nZEB benefits and specificities, thus creating the necessary prerequisites for effective communication among stakeholders. A mobile house of this kind is intended to offer the real experience of an nZEB, so it will be equipped with all the necessary technologies to provide complete information on the processes relevant to the building's performance in terms of comfort, indoor air quality parameters and energy consumption. In conclusion, the nZEB Roadshow will boost current efforts to promote nZEB by approaching stakeholders, especially the general public, as well as the professional public (designers, supervising engineers, companies and crafts, workers) and through strong media partnerships.

In terms of future plans, a Centre of Excellence is to be established for the fields of building physics and energy efficiency (Construction Innovation Centre at the Borongaj University Campus) and will certainly contribute to the long-term provision of highly qualified experts in sustainable construction in Croatia.

8 ROADMAP WITH MEASURES, MEASURABLE PROGRESS INDICATORS AND INDICATIVE MILESTONES FOR 2030, 2040 AND 2050

8.1 LONG-TERM ROADMAP WITH MEASURES FOR THE DECARBONISATION OF THE NATIONAL BUILDING STOCK BY 2050

The identification of efficient measures to stimulate cost-effective integral energy renovation of the Croatian national building stock will be based on the plan of possible strategic objectives and progress indicators for the period up to 2050, according to the Energy Roadmap 2050, adopted by the European Parliament in January 2013 (Table 8-1).

Table 8-1: Long-term roadmap for the integral energy renovation of the national building stock by 2050

Target year	Strategic objective
2050	All nearly zero-energy or high energy efficiency buildings 4% of buildings renovated annually 100% of occupants aware of the positive effects of the integral energy renovation of buildings
2040	60% of nearly zero-energy or high energy efficiency buildings 3.5% of buildings renovated annually 4% of buildings with cultural heritage status renovated annually 95% of occupants aware of the positive effects of the integral energy renovation of buildings
2030	25% of buildings has undergone energy renovation 3% of buildings renovated annually Prepared regulations in respect of the requirements for high energy-performance level of all buildings as a condition of sale or lease Completely developed integral renovation with optimised costs Contracting companies certified for renovation and employing workers trained to perform energy renovation works 50% of occupants aware of the benefits of renovation Techniques for the renovation of buildings with cultural heritage status developed
2025	12% of buildings has undergone energy renovation 2% of buildings renovated annually Renovation techniques for all types of buildings developed 20% of occupants aware of the benefits of renovation Techniques for the renovation of buildings with cultural heritage status being developed, and to overcome existing obstacles, Guidelines for the design and implementation of energy efficiency interventions on buildings with cultural heritage status also prepared 50% of contracting companies certified for the energy renovation of zero-energy buildings and employing 50% of workers trained to perform such works The Government supports banks in lending for the comprehensive renovation by socially vulnerable groups Occupants undergoing education on the benefits of renovation
2020	5% of buildings has undergone energy renovation

	1% of buildings renovated annually Renovation techniques for most types of buildings developed Defined comprehensive/integral/deep retrofit renovation categories The Government provides budget funding for public building renovation and incentives to renovate the buildings of citizens at risk of energy poverty Education of occupants conducted by energy agencies, etc. Training materials prepared for the education in schools and universities To overcome existing obstacles, Recommendations for applying energy efficiency measures on architectural heritage also prepared

Measures for the decarbonisation of buildings should result in an 80% reduction in the overall greenhouse gas emissions by 2050. The service life of buildings associated with high costs incurred in the implementation of measures is hampering the achievement of this target, shifting the focus of the implementation decision towards measures with shorter return-on-investment periods. The periods of the return on investment into increasing the energy efficiency of the building fund at a deep retrofit level average 15 years or more, which is comparable to the service life of some of the key building components.

In order for decarbonisation of buildings to be successful, resistance in the market itself needs to be overcome.

Market maturity

Despite strong institutional pressure through regulatory frameworks and financial support for energy efficiency measures, the market is not achieving expected results. An example of this is the slow implementation of nZEB requirements for public buildings despite the legal obligation to do so. Technologies available in the market are generally more expensive than comparable technologies of poorer energy performance, which shows that the market is not sufficiently prepared to achieve the decarbonisation targets. The message sent to suppliers through regulations, coordinated information and signals must be continuous, focusing clearly on a decarbonisation of the building stock by 2050.

Market development

The technologies developed and policies designed, which receive support in the form of aid, need to be transferred to the market with clear time limits and targets, as well as expected results.

Market expansion

The implementation of measures proving successful in the previous step needs to continue to enhance their effects on the market. The key factor is the continuity of policies and measures, irrespective of the intensity with which they are implemented, because this sends the vital message to the market about unchanged or even more ambitious decarbonisation targets.

8.2 MEASURABLE PROGRESS INDICATORS

Progress in achieving the targets can be monitored directly through indicators illustrating the situation in the building fund, as well as indirectly, through reduced energy consumption in the building segment. The basic indicator defined in the Long-term strategy is the number of renovated buildings or their floor area.

The starting point for monitoring progress is the floor area of residential buildings permanently occupied in 2020 deducted from the floor area of newly built and renovated buildings since 2011, which amounts to 110 143 965 m², and the total useful floor area of non-residential buildings of 58 722 937 m² in 2020.

Of the 110 143 965 m² in residential buildings, 38.5% (42 395 923 m²) is accounted for by multi-apartment buildings and 61.5% (67 748 042 m²) by family houses.

The total useful floor area of non-residential buildings is 58 722 937 m², of which 42 623 410 m² is accounted for by commercial buildings and 16 099 527 m² by public buildings.

- ## Number and floor area of renovated buildings

The strategic objective of the Long-term strategy is to raise the renovation rate of buildings from the current 0.7% per year (1 350 000 m²) to 3% by 2030, 3.5% between 2031 and 2040 and 4% between 2041 and 2050.

Table 8-2: Target floor area and renovation rate in m², 2021–2030

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total renovated buildings	1 687 918	1 670 294	2 479 284	2 441 006	3 204 426	3 138 936	3 843 482	3 745 722	4 380 538	4 247 224
Renovated residential buildings	1 101 440	1 090 425	1 619 282	1 594 992	2 094 757	2 052 861	2 514 755	2 451 886	2 868 707	2 782 646
Target energy renovation rate	1.0%	1.0%	1.5%	1.5%	2.0%	2.0%	2.5%	2.5%	3.0%	3.0%
Renovated non-residential buildings	587 229	579 869	860 002	846 014	1 109 669	1 086 075	1 328 727	1 293 836	1 511 831	1 464 578
Target energy renovation rate	1.0%	1.0%	1.5%	1.5%	2.0%	2.0%	2.5%	2.5%	3.0%	3.0%

Table 8-3: Target floor area and renovation rate in m², by end-2030

	2030
Total renovated buildings	30 838 830
Renovated residential buildings	20 171 751
Average energy renovation rate	2% per year
Renovated non-residential buildings	10 667 079
Average energy renovation rate	2% per year

Table 8-4: Target floor area and renovation rate in m², between 2031 and end-2040 and between 2041 and end-2050

	2040	2050
Total renovated buildings	41 063 535	32 099 102
Renovated residential buildings	26 966 267	21 117 537
Target energy renovation rate	3.5% per year	4% per year
Renovated non-residential buildings	14 097 268	10 981 565
Target energy renovation rate	3.5% per year	4% per year

Building renovation, that is, the registered renovation floor area, provides for the assessment of environmental, social and economic progress indicators – greenhouse gas emissions, reduced annual energy consumption, smaller share of citizens hit by energy poverty, reduced health problems and increased investment into renovation.

- ## Improving external envelope quality

The external envelope quality is measurable directly through the thermal transmittance coefficient of the external envelope. The database of energy performance certificates enables the monitoring of crucial properties of the external envelope and their comparison by building type and age, as well as by climate data.

Requirements for the external envelope are determined by the cost-optimal method and are not linearly correlated to the energy needs of buildings.

- **Number and floor area of nZEBs**

The number and the floor area of nZEBs is a direct indicator of progress in the implementation of measures to increase energy efficiency of the building stock. The data on compliance with the nZEB requirements will be available through the Information system of energy certificates (IEC) for all new and reconstructed buildings.

In view of the defined requirements for nZEBs, with the obligation for new public buildings in effect as of 31 December 2018, the introduction of additional requirements for building renovation to near zero energy level may also be expected. Therefore, a new indicator showing the number of new and reconstructed buildings meeting that additional requirement needs to be introduced:

- Compliance with the nZEB requirements – number of buildings reconstructed to the level of nZEB requirements for renovated buildings by purpose; total area of buildings reconstructed to the level of nZEB requirements for renovated buildings by purpose.

- **Other specific indicators**

Other specific indicators to be monitored under individual energy renovation projects are the following:

- average annual thermal energy required for heating/cooling in a renovated building before and after the renovation (kWh/m^2);
- contribution to a decrease in energy consumption – difference between delivered energy before and after the energy renovation (kWh/h);
- contribution to an increase in the use of renewable energy sources – RES energy production before and after the energy renovation (kWh/h);
- contribution to the economic development – number of immediate employees during preparations for the building's energy renovation and its implementation.

8.3 INDICATIVE MILESTONES FOR 2030, 2040 AND 2050

The strategic objective set in this Long-term strategy is to transform the overall existing building stock into an energy efficient building stock by 2050, for which ensuring a continuous renovation of the existing building stock is crucial. The starting point is the 2020 building stock minus the already renovated and newly built buildings between 2011 and 2020, including 110 143 965 m² in residential buildings and 58 722 937 m² in non-residential buildings.

The renovation floor area shows how many buildings must be directly covered by the energy renovation over a 10-year period by 2030, 2040 and 2050. The replacement of the demolished represents the portion of the building fund to be built in order to replace the buildings being abandoned due to depopulation, thus gradually leaving the building fund according to population and household censuses.

The strategic objective will be achieved through energy renovation, at a renovation rate which is to increase gradually from 1.0% to 3.0% in 2021–2030, to stand at 3.5% between 2031 and 2040 and 4% between 2041 and 2050, according to the table:

Table 8-5: Strategic objective of renovation by decades, by 2050

Period	2021–2030	2031–2040	2041–2050
Total renovation scope (million m^2)	30.84	41.06	32.10
Renovated residential buildings (million m^2)	20.17	26.97	21.12
Renovated non-residential buildings	10.67	14.09	10.98

(million m²)			
Replacement of the demolished buildings – residential buildings (million m²)	2.40	2.16	2.54

It must be noted that the renovation targets set at these levels are in line with the EU Green Plan but are more ambitious than the presumptions used in the National energy and climate plan (NECP). Such renovation dynamics will guarantee that the entire existing building stock is transformed into near zero-energy buildings or buildings with a high energy efficiency level by 2050.

8.4 CONTRIBUTION TO THE INDICATIVE NATIONAL TARGET TO IMPROVE ENERGY EFFICIENCY

The national indicative energy efficiency target, expressed as an absolute amount of primary energy consumption and end-use energy consumption, by 2030 is set in the Integrated national energy and climate plan, while consumption projections for 2040 and 2050 are defined in Croatia's Energy development strategy.

Table 8-6: Indicative national energy efficiency targets – targeted energy consumption, 2030, 2040 and 2050

ENSTRAT – NECP [PJ]	2017	2020	2030	2040	2050
Primary energy consumption	349.4	333.0	344.4	325.7	287.4
End-use energy consumption	289.9	281.7	286.9	265.2	225.6

Source: Integrated national energy and climate plan

The energy renovation of buildings contributes greatly to the achievement of these targets, and is undertaken in the household and services sectors. The table below shows projected energy consumption for the two sectors.

Table 8-7: Energy consumption in the services and household sectors for 2030, 2040 and 2050

Energy Consumption [PJ]	2017	2020	2030	2040	2050
Services	33.5	34.6	39.2	39.5	36.8
Households	99.5	98.5	96.9	83.6	68.4

Source: Analyses and expert material for the development of Croatia's Energy development strategy – Green Book and the Integrated national energy and climate plan.

The consumption of fuels in households will decline by about 31% in 2050 compared to 2017. Such a strong energy consumption decline is a result of two trends: increase in the energy efficiency level in the building segment, reducing the energy required for heating, and greater penetration of energy efficient technologies for heating, such as heat pumps. The consumption of firewood is expected to fall by 81%, with the use of fuel oil ceasing by the end of the period under observation. The natural gas consumption will decrease 27% and account for 21% in the structure of total fuel consumption, while electricity will account for 38%, compared to the current 22%[32].

The main driver of energy consumption growth in the services sector is the increased service sector activity and an increase in the total floor area in that sector, while the trend of consumption decrease is determined largely by the increased energy efficiency level in the building segment, similarly to the household sector. Energy consumption growth in the services sector will come to an end around 2035. Electricity is the dominant energy source with a 70% share in 2050, while natural gas will account for 17% in the fuel consumption structure[33].

[32] *Source: Analyses and expert material for the development of Croatia's Energy development strategy – Green Book (Analize i podloge za izradu Strategije energetskog razvoja Republike Hrvatske – Zelena knjiga).*

[33] *Ibid.*

It is evident from the table above that the services sector will participate with around 14%, and households with around 34% in the end-use energy consumption in 2030. In 2050, those shares will be 16% and 30%, respectively, for the services sector and households. Given that these two sectors together constitute the building segment, it is evident that the building segment's contribution to end-use energy consumption accounts for a high 48% in 2030 and 46% in 2050. It should be noted that these projections are based on the targets and measures foreseen in the Integrated national energy and climate plan and this Long-term strategy, that is, on the assumption and the continued increase in the building energy renovation rate from 1% in 2021 to 3% in 2030, and then on the resumed building stock renovation at a rate of 3.5% between 2031 and 2040 and 4% between 2041 and 2050. The absence of these measures would result in a substantially higher energy consumption in buildings looking ahead and failure to meet the indicative national targets shown in Table 8-.

9 ESTIMATE OF EXPECTED ENERGY SAVINGS AND WIDER BENEFITS

9.1 ESTIMATE OF EXPECTED ENERGY SAVINGS AND REDUCTIONS IN CO_2 EMISSIONS

Energy savings were estimated using the bottom-up method for each proposed measure for the energy renovation of buildings (see measures in Chapters 5 and 6). In addition, to capture other factors affecting energy consumption in a sector, projections of fuel consumption were made under two scenarios. The S0 scenario presents baseline (so-called business as usual) end-use energy consumption, i.e. end-use energy consumption which would materialise using only the existing measures. That scenario foresees no implementation of new measures provided for in this Long-term strategy, with energy consumption projections based on existing developments, technologies and structure of energy consumption by fuel. Scenario S2 presents a projection of energy consumption which is to materialise with the implementation of the measures provided for in this Long-term strategy, which means that this scenario foresees a strong energy renovation of buildings, as well as change in the structure of energy consumption in favour of an increasing use of renewable energy sources. The difference between these two scenarios (Table 9-1) are the energy savings in end-use consumption which would be achieved predominantly as a result of the activities of building energy renovation, as well as a further technology advance. It needs to be emphasised that these scenarios were developed for the purposes of the Integrated national energy and climate plan, so all data were taken from that Plan.

Table 9-1: Decrease in energy consumption in the household and services sectors

Scenario S0 – end-use energy consumption (PJ)	**2020**	**2030**	**2040**	**2050**
Services	34.6	39.8	41.9	41.7
Households	98.5	102.5	94.9	82.8
Total	**133.1**	**142.3**	**136.8**	**124.5**
Scenario S2 – end-use energy consumption (PJ)				
Services	34.6	39.2	39.5	36.8
Households	98.5	96.9	83.6	68.4
Total	**133.1**	**136.1**	**123.1**	**105.2**
Difference between S0 and S2 scenarios – energy savings (PJ)				
Services	0.0	0.6	2.4	4.9
Households	0.0	5.6	11.3	14.4
Total	**0.0**	**6.2**	**13.7**	**19.3**

Table 9-1 shows that expected energy savings stemming directly and indirectly from the implementation of planned new policies and measures for the energy renovation of residential and non-residential buildings will amount to 6.2 PJ (around 1 722 GWh) in 2030 and 19.3 PJ (around 5 361 GWh) in 2050. It needs to be emphasised that, at the level of total end-use energy consumption (in all sectors)[34], savings of 10.8 PJ (difference between end-use energy consumption under scenarios S0 and S2) are expected in 2030, which means that the **building segment contributes more than 57% to this target in 2030**. In 2050, the expected total energy savings will amount to 29.7 PJ, which means that the **expected contribution of the building segment to the total energy savings in 2050 will equal around 65%**.

The reduction in CO_2 emissions has also been estimated for the purposes of the Integrated national energy and climate plan, as a difference between the scenario featuring existing measures only (S0) and the energy consumption scenario including additional measures provided for in that Plan and in this Long-term strategy. The resulting reduction in CO_2 emissions from the household and services sectors, stemming predominantly from the implementation of building energy renovation measures, is shown in Table 9-2.

Table 9-2: Reduction in CO_2 emissions in the household and services sectors

Scenario S0 – emissions (kt CO2-eq)	**2020**	**2030**	**2040**	**2050**
Services	639.4	708.8	687.7	612.7
Households	1 527.8	1 621.9	1 608.8	1 563.4
Total	**2 167. 2**	**2 330. 7**	**2 296. 4**	**2 176. 2**
Scenario S2 – emissions (kt CO2-eq)				
Services	639.4	641.0	530.8	350.3
Households	1 527.8	1 372.3	1 206.3	913.8
Total	**2 167. 2**	**2 013. 3**	**1 737. 0**	**1 264. 0**
Difference between S0 and S2 scenarios – emissions (kt CO2-eq)				
Services	0.0	67.8	156.9	262.5
Households	0.0	249.6	402.5	649.7
Total	**0.0**	**317.4**	**559.4**	**912.1**

Table 9-2 shows that the expected reduction in CO_2 emissions stemming directly and indirectly from the implementation of planned new policies and measures for the energy renovation of residential and non-residential buildings will amount to 317.4 kt in 2030 and 912.1 kt in 2050. It needs to be outlined that, at the level of total end-use energy consumption (in all sectors)[35], a reduction in CO_2 of 880.8 kt (difference between end-use energy consumption under scenarios S0 and S2) is expected in 2030, which means that the **building segment will contribute more than 36% to this target in 2030**. In 2050, the expected CO_2 emissions will amount to 2 260.9 kt, which means that the **expected contribution of the building segment to the reduction in total CO_2 emissions in 2050 will equal around 40%**.

9.2 CONTRIBUTION TO THE ACHIEVEMENT OF EU ENERGY EFFICIENCY TARGETS

Directive (EU) 2018/2002 amending Directive 2012/27/EU on energy efficiency sets the targets of primary energy consumption and end-use energy consumption at EU level, which must not exceed 1 273 Mten (53 298 PJ) in primary and 956 Mten (40 026 PJ) in end-use energy consumption in 2030.

[34] *All data were taken from the Integrated national energy and climate plan.*

[35] *All data were taken from the Integrated national energy and climate plan.*

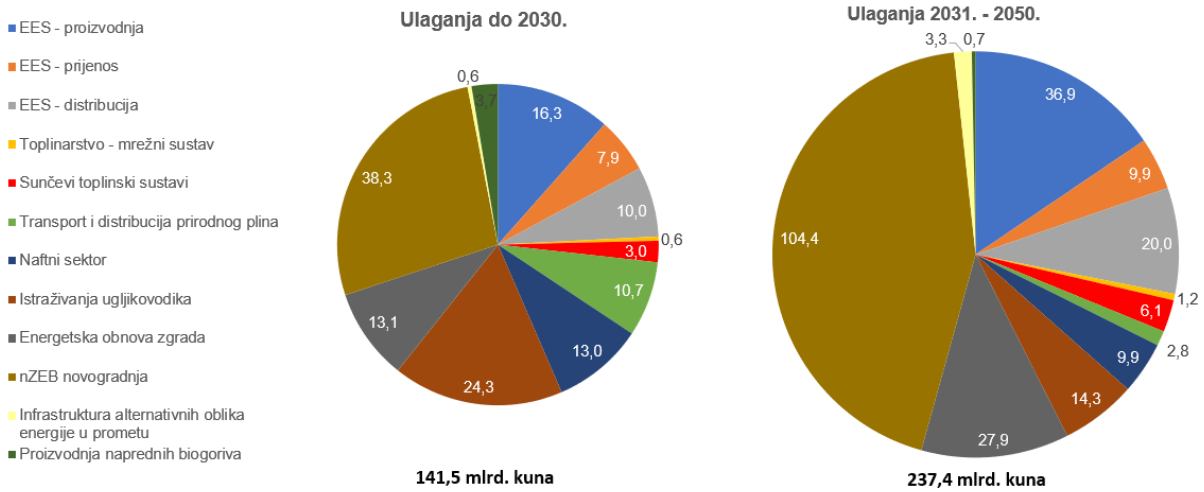
A revised Long-term strategy for mobilising investment in the energy renovation of Croatia's national building stock confirmed and supplemented the figures on the floor value of the building stock, while also setting out a roadmap with measures and domestically established measurable progress indicators in respect of the long-term goal of reducing greenhouse gas emissions in the Union by 80–95% in 2050 compared with 1990, in order to ensure a highly energy efficient and decarbonised national building stock and facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings. Targets aligned with Union targets with regard to energy efficiency under Directive 2012/27/EU were added to specific critical control points for 2030, 2040 and 2050. Estimated amounts of investment into increasing the energy efficiency of the building stock indicate the necessity to reduce the risks of energy renovation projects through project aggregation, reduce the perceived risk of energy efficiency interventions, use public resources to increase the potential of additional private sector investment, channel investment into an energy efficient public sector building stock. Further development of the energy efficiency regulations includes considering fire safety and risks related to intense seismic activity affecting energy renovations and the lifetime of buildings to focus quality renovation on buildings with a higher potential for the extension of their lifetime.

Croatia has set its indicative national targets for 2030 which must not exceed 344.38 PJ of primary energy consumption and 286.91 PJ of end-use energy consumption. Based on these targets, Croatia will participate with 0.65% in the total primary energy consumption and 0.72% in the total end-use energy consumption of the EU. Thus, it is evident that its contribution in achieving the targets is minor but proportional to the country size, as well as its demographic and economic limitations.

9.3 MACROECONOMIC EFFECTS ON GDP, EMPLOYMENT AND THE STATE BUDGET

The macroeconomic framework for the energy renovation of buildings in Croatia is much less favourable than assumed earlier; in harmonisation with Croatia's Energy strategy for the period until 2050 and its Integrated national energy and climate plan for 2021–30, the demographic potential has been reduced considerably, so despite improved economic parameters as an expected consequence of population developments, the abandonment of the outdated housing stock has recorded a considerably higher rate and such stock has been left lying inactive. Pressure on urban settings is expected to continue, additionally burdening economically inactive areas through reduced intensity of infrastructure use.

If the structure of investment into efforts to reduce energy consumption is observed, it is evident that in such circumstances the investment in increasing energy efficiency of the building stock – through energy renovation, deep retrofitting and replacement of the abandoned building stock – accounts for 48.5% of the total energy sector investment. The portion relating to the electricity system equals 26.7% of total investment. Other investment concern transport infrastructure, advanced biofuel, heating sector, solar thermal systems and investment into the infrastructure of fossil fuels: gas, crude oil and petroleum products.



CROATIAN	ENGLISH
	Investment by 2030
	Investment 2031–2050
	Electrical power system (EPS) – production
	EPS – transmission
	EPS – distribution
	Heating sector – network
	Solar thermal systems
	Natural gas transport and distribution
	Oil sector
	Research in hydrocarbons
	Energy renovation of buildings
	nZEB new-builds
	Infrastructure of alternative energy forms in transport
	Production of advanced biofuels
	HRK 141.5 billion
	HRK 237.4 billion

Figure 9.1: Total investment in the energy sector 2021–2050 under Croatia's Energy strategy, S2 scenario

Macroeconomic impacts of the overall Integrated national energy and climate plan, including the measures defined in this Long-term strategy, have been calculated by the input-output analysis based on the 2015 input-output table for Croatia, published by Eurostat in 2019[36]. The analysis takes into account direct and indirect, multiplicative effects of investment, disaggregated under various estimates by individual activities (of 65 activities in total) stated in the symmetrical input-output table in respect of the specifics of each investment. Direct effects include additional employment, and income, in the sectors which produce goods and services aimed at meeting additional final demand. Indirect effects include indirect employment, and income, in other sectors increasing their production level to deliver intermediary inputs necessary for production in the sector which supplies the output directly for the purposes of final demand. The input-output model covers existing technology relationships among 65 different activities, that is, sectors of the Croatian economy. The ratio of the imported to the domestic component is based on the 2015 input-output table.

Results of the analysis are divided into two periods: the 2021–2030 period and the 2031–2050 period. The results of the analysis of the first period indicate that the total investment foreseen in the Integrated national energy and climate plan will contribute to an increase in gross domestic product (GDP), and gross value added (GVA), with 2–2.5% compared to the 2018 GDP level. In the structure of growth, Sector F construction accounts for as much as 32%, as a direct result of investment into the energy renovation of buildings as well as new nZEB building construction.

Estimated macroeconomic effects on gross value added, employment and tax revenue are shown in the figures below.

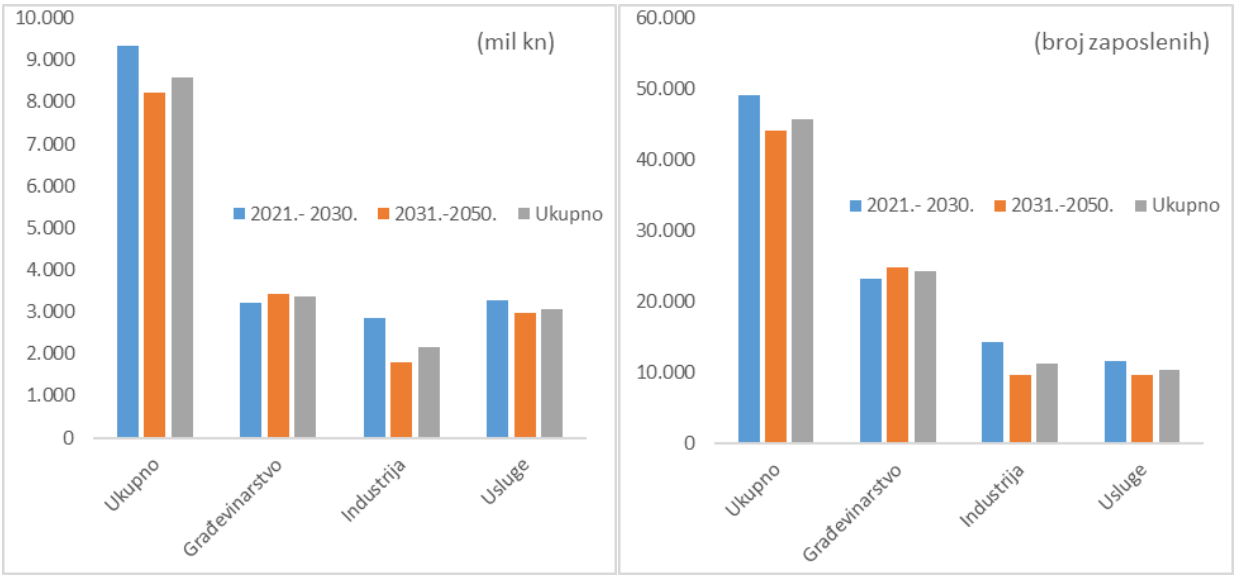
Total investment foreseen by the Integrated national energy and climate plan will increase average annual gross value added by HRK 9.346 billion between 2021 and 2030 and by HRK 8.126 billion between 2031 and 2050. Meanwhile, projected growth in the construction sector gross value added accounts for as much as 34% and 42% of the total gross value added growth, respectively, in the first and the second period being analysed.

The total number of employees will increase by 49 066 between 2021 and 2030 and by 44 083 between 2031 and 2050. Meanwhile, projected employment growth in the construction sector accounts for as much

[36] *Source: Study assessing the macroeconomic effects of policies and actions under the Integrated national energy and climate plan in Croatia (Procjena makroekonomskih učinaka politika i mjera Integriranog nacionalnog energetskog i klimatskog plana Republike Hrvatske), Faculty of Economy, University of Zagreb, 2019.*

as 47% and 56% of the total employment growth, respectively, in the first and the second period being analysed.

The most significant impact on employment growth as well as gross value added growth is that of investment into the building segment (energy renovation of buildings and new nZEB construction). In its research[37], the Buildings Performance Institute Europe (BPIE) confirmed the labour intensive nature of energy renovation. Specifically, 18 new jobs are created in the EU on average for each EUR million invested into energy renovation. In Croatia, that figure stands at 29, which is a clear indication of the strength of impact on the Croatian economy. An identification of specific segments of buildings (such as kindergartens, schools, hospitals, social housing, multi-apartment building) to achieve the highest level of energy efficiency provides for a very clear investment cycle, with precise indicators [necessary to reap] the maximum social benefit.



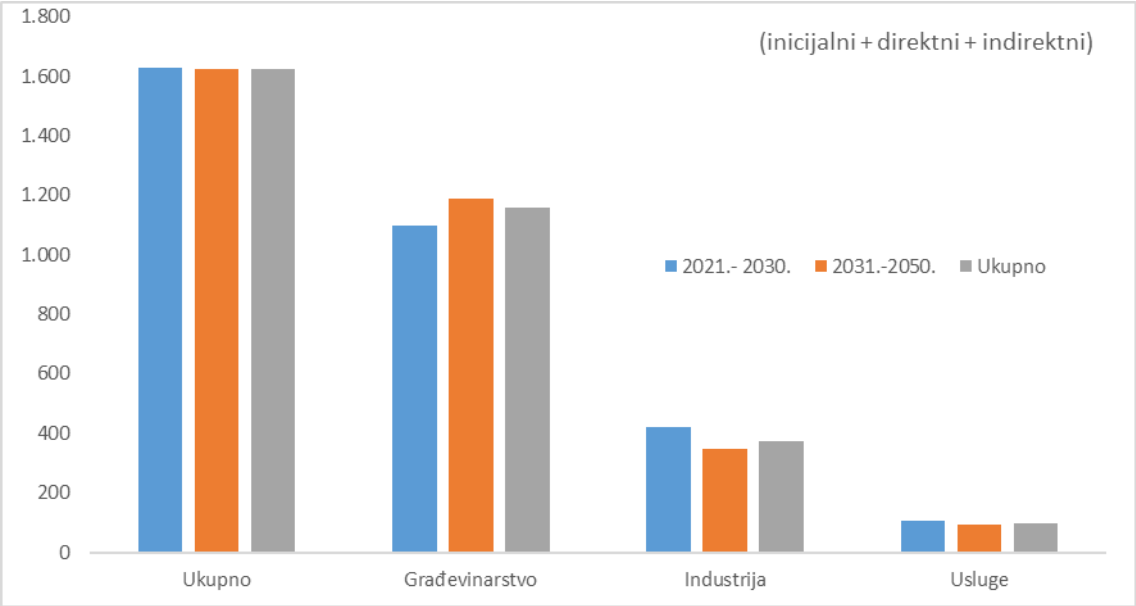
CROATIAN	ENGLISH
	Total
	Construction
	Industry
	Services
	10 000
	9 000
	8 000
	7 000
	6 000
	5 000
	4 000
	3 000
	2 000
	1 000
	(million HRK)
	2021–2030
	2031–2050
	60 000
	50 000
	40 000

[37] *Building Renovation: A kick-starter for the EU recovery, BPIE for Renovate Europe, 2020*

	30 000
	20 000
	10 000
	(number of employees)

Figure 9.2: Estimated macroeconomic and sectoral effects of investing in GVA (lhs) and employment (rhs)[38]

Total increase in tax revenue (including initial, direct and indirect effects) will be HRK 1.628 billion between 2021 and 2030 and HRK 1.626 billion between 2031 and 2050. The projected increase in tax revenue in the construction sector accounts for as much as 45% and 35% of the total tax revenue growth, respectively, in the first and the second period being analysed, as shown in Figure Figure 9.3:.



CROATIAN	ENGLISH
	Total
	Construction
	Industry
	Services
	1 800
	1 600
	1 400
	1 200
	1 000
	(initial + direct + indirect)
	2021–2030
	2031–2050
	60 000
	50 000
	40 000
	30 000
	20 000
	10 000
	(number of employees)

[38] *Source: Study assessing the macroeconomic effects of policies and actions under the Integrated national energy and climate plan in Croatia (Procjena makroekonomskih učinaka politika i mjera Integriranog nacionalnog energetskog i klimatskog plana Republike Hrvatske), Faculty of Economy, University of Zagreb, 2019.*

Figure 9.3: Estimated total and sector-specific effects of investment on tax revenues (million HRK)[39]

9.4 ESTIMATE OF THE WIDER BENEFITS OF ENERGY RENOVATION OF THE NATIONAL BUILDING STOCK

Additional beneficial effects of the energy savings and reduced harmful gas emissions, new investment and their multiplicative effects on GDP, employment and tax revenue of the general government provide an additional justification for the use of coordinated incentives to boost supply and demand. Other benefits are impossible to estimate exactly but they may be described in correlation to increased disposable income, preservation and growth of real estate value, incidental aesthetic benefits for other economic activities (e.g. tourism), positive effects on people's health, reduction of energy poverty, and energy security.

Increased disposable income

Savings on energy costs free up funds for other categories of consumption. Thus, general government sector units using buildings which have undergone energy renovation change the structure of their expenditure and, instead of using budgetary resources to purchase energy, may use them for their primary activity – i.e. education, schooling and other functions. The funds freed up in this manner increase public sector flexibility in terms of additional employment, in so far as it is necessary in certain segments of the system, or in terms of stimulating existing employees with higher income. Additional funds may also be used to reduce the general government deficit and public debt.

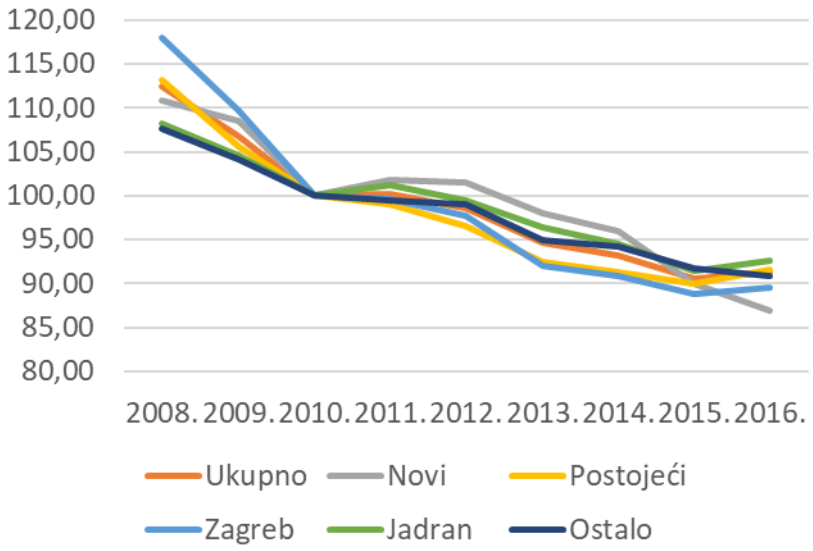
When it comes to residential buildings, borrowing or an increase in [housing maintenance] reserves, which is typically necessary for the repayment of energy renovation costs, reduces disposable household income over the repayment period. However, a comprehensive analysis taking into account the effects of increased economic activity, employment and thus, generally, also household income growth, yields positive net values[40].

Value of real estate and aesthetic external effects

Real estate prices in Croatia are recovering from the crisis (Figure Figure 9.4:). The recovery, which began in 2016, is slowly expanding to include new construction, where prices have continued their downward correction. This was to be expected, given the demographic trends. Signs of a dispersed recovery, as indicated by the 2016 data, point to the erroneous allocation of construction activity, which should turn away from new-builds in its structure towards remodelling, reconstruction and major repairs. The programme for the renovation of the national building stock may take the role of a catalyst in this respect.

[39] *Ibid.*

[40] *Source: Study on the valuation of economic effects of programmes focused on reducing energy consumption in public and residential buildings (Valorizacija ekonomskih učinaka programa usmjerenih na smanjenje potrošnje energije u zgradama javnog sektora i stambenim zgradama), Institute of Economics, Zagreb, for the Ministry of Construction and Physical Planning, October 2019.*



CROATIAN	ENGLISH
	Total
	New
	Existing
	Zagreb
	Adriatic
	Other
	120.00
	115.00
	110.00
	105.00
	100.00
	95.00
	90.00
	85.00
	2008
	2009
	2010
	2011
	2012
	2013
	2014
	2015
	2016

Figure 9.4: Base index of real estate prices, 2010 = 100

Source: Croatian National Bank, Statistics, Table J3

The energy renovation of buildings paves the way for cost savings, an increase in the aesthetic value as well as in the overall satisfaction with housing and quality of life, which is reflected in the value of real estate. Therefore, the protracted and steep decline in real estate value should be attributed, apart from fundamental (demographic and economic) factors, to the absence of a more ambitious building renovation programme.

The renovation programme leading to an increase in the value of real estate also has economic side effects, which are manifested in two ways. First, through the so-called wealth effect, real estate value growth leads to an increase in consumption, which in turn affects growth in both GDP and state budget revenue. The

wealth effect has a parameter of around 0.1,[41] which means that a 10% increase in real estate value boosts total personal consumption by 1%. The overall impact on GDP should also take into account the positive GDP growth-related impact on investment. Second, positive aesthetic external effects can spill over to the wider community, especially in the areas making their living from tourism, where the overall impression of buildings may be a factor of attraction. While it is clear that valuation and aesthetic effects related to real estate cannot be reliably estimated, they are certainly to not as great as the effects which are directly related to investment activities. Nevertheless, they are worth mentioning too.

Reduced health, poverty and energy supply risks

The group of effects which are difficult to estimate, but which should be mentioned, also includes reduced health, energy poverty and energy supply risks. This last effect is particularly important for Croatia, which imports up to a half of its required energy, so reduced consumption which is related to increased energy efficiency improves the current account balance of the balance of payments and the parameters of the country's international financial stability. Apart from its direct effect on a reduction in energy imports, energy renovation may also result in decreased vulnerability of the overall economy to potential turbulence in the global market. Specifically, energy prices have exhibited considerable volatility over the past period, depending on the stage of the global economic cycle and on changes in geopolitical relations.

The valuation effects of the improvement of people's health are currently not being monitored in Croatia, but are certainly worth mentioning. The most significant health risks are related to uninsulated buildings, which are too cold in the winter, so it is twice as likely that their occupants will report a poor health condition, caused by the cold, damp, draught, mould, etc.[42] The energy renovation of buildings eliminates these risk factors and improves the population health, which in turn plays a role in reducing the number of sick leave episodes and costs of the public health care system.

On the other hand, account should be taken of ensuring that the energy renovation does not lead to the so-called sick building syndrome, that is, it is necessary to ensure the indoor air quality after the energy renovation. This may be achieved through the application of technical regulations and the high-quality execution of works.

In addition, reduced energy consumption in buildings not only contributes to the fight against climate change but also reduces the emissions of other gaseous pollutants, such as SO_2, NO_x and small particles produced by power plants and heating systems. These emissions have a negative impact on the environment and health. According to the European Environment Agency data, 5 750 premature deaths in Croatia in 2016 were caused by emissions of those gaseous pollutants[43]. Furthermore, energy renovation can also help address the asbestos issue in existing buildings; removing asbestos means eliminating a major health risk in the buildings which still contain asbestos.

When it comes to energy poverty, the renovation of buildings has major potential for savings, which are relatively higher for poorer households. According to the 2015 poverty indicators, 9.9% of people in Croatia live in households facing problems with adequate heating, and 28.7% of them live in households which are in arrears with their utility bills. Energy products play an important role in that because, according to the 2014 Household Budget Survey, the average annual household expenditure for electricity, gas and other fuels amounted to HRK 8 569, accounting for about 10.5% of annual monetary expenditure. One should keep in mind that this share is 2–3 times higher in households in the bottom part of the income distribution than in those in the upper parts of the income distribution; therefore, the programme for the renovation of the national residential building stock has vast potential for reducing energy poverty.

The following figure illustrates schematically the classification of the estimated and mentioned effects of the national building stock renovation (Figure Figure 9.5:).

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[41] *According to: Ahec Šonje, Čeh Časni and Vizek (2014)*

[42] *Source: https://www.velux.com/health/healthy-homes-barometer-frontpage*

[43] *https://www.eea.europa.eu/themes/air/health-impacts-of-air-pollution*

CROATIAN	ENGLISH
	DIRECT EFFECTS
	Stabilisation and increase in economic activity
	Employment
	Increase in budget revenues
	Improved human health
	Reduced energy poverty
	Increase in real estate value
	COMPLEX CORRELATIONS
	Reduced poverty thanks to employment
	Reduced healthcare expenditure thanks to improved human health
	Increased fiscal stability
	Wealth effect: greater consumption due to an increase in real estate value
	Reduced grey economy
	INDIRECT EFFECTS
	Tourism development
	Improved quality of life
	Energy security

Figure 9.5: Schematic representation of all potential effects of the energy renovation of buildings

10 FIRE SAFETY AND RISKS RELATED TO INTENSE SEISMIC ACTIVITY

Articles 2(a) and 7 of Directive (EU) 2018/844 lay the groundwork for connecting the Long-term strategy for the renovation of the national building stock with the fire safety requirements and risks related to intense seismic activity affecting energy efficiency renovations and the lifetime of buildings.

The Construction Act sets out essential requirements for buildings in the event of a fire:

-to secure the load-bearing capacity of the structure for a period of time as specified by a special regulation;

-to prevent fire and smoke from spreading inside the building;

-to prevent fire from spreading to adjacent buildings;

-to enable persons to leave the building unharmed or be rescued;

-to ensure the safety of rescuers.

Fire resistance rules and other requirements that buildings must meet in the event of a fire (NN Nos 29/13 and 87/15) provide in greater detail for fire resistance and other requirements that buildings must meet in the event of a fire in order to prevent fire and smoke from spreading inside the building, prevent fire from spreading to adjacent buildings, enable persons to leave the building unharmed, ensure their rescue and the safety of rescuers when designing and building new-builds and in the case of reconstruction (design and construction) but do not apply to buildings entered in the Croatian Register of Cultural Property or buildings located in a cultural and historic unit entered in the Register. Requirements for existing buildings are not given, in particular for the energy renovation of buildings. Requirements should be laid down for existing buildings, which cannot be the same as those for new-builds (because most buildings do not have separate fire sections), in respect of the installation of different types of thermal insulation on the façade (separation distances) and fire safety requirements for the installation of lifts in existing buildings which increase the fire load of the buildings. Energy renovation projects should require the presentation of all fire safety measures applied in all parts of the main project, including organisational measures and actions to eliminate the risk of fire in the building concerned, early fire detection in the building, alerting users of the building about a fire, preventing fire and smoke from spreading inside the building, as well as effective extinguishing of a fire in the building, safe rescue of people and animals endangered by fire in a building.

Energy renovation of buildings constitutes a substantial intervention on buildings. The current law, under which a considerable number of energy renovations are carried out according to the Rules on simple and other buildings and works (NN 112/17, 34/18, 36/19, 98/19, 31/20) (20) because of simplified and accelerated procedures, results in work being carried out without a building permit and the main design or work being carried out according to the main design without a building permit, and entails the responsibility of participants in the construction process.

Encouraging the comprehensive renovation of buildings increases the scope and quality of fire safety solutions. Given the possible ways of using buildings and the vulnerability of individual groups of users, with the application of minimum requirements to the contents of project documentation, the extension of the scope of previous analyses in respect of fire safety and seismic activity is covered by eligible costs of energy renovation.

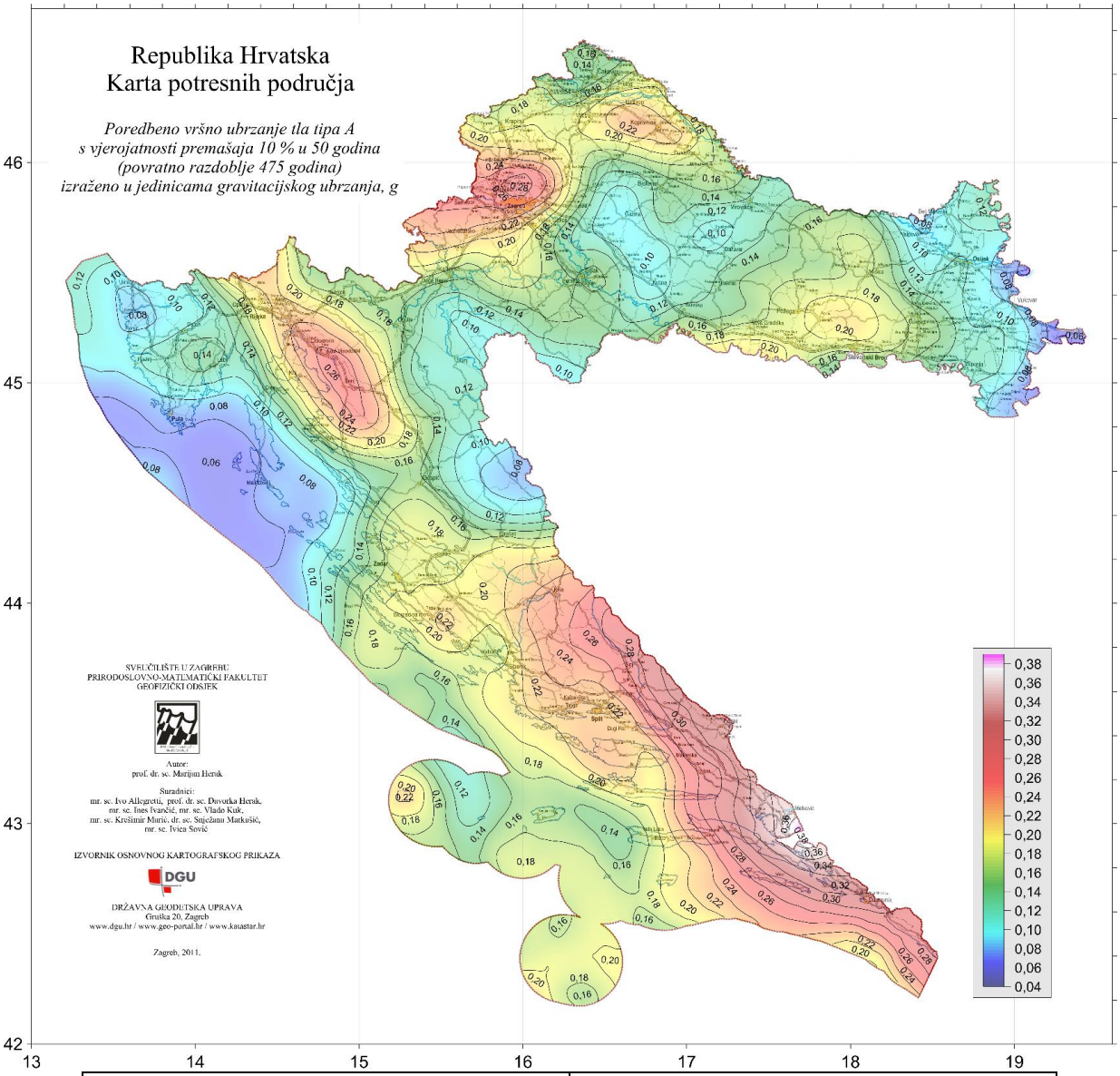
Minimum requirements for new-builds in respect of fire safety and risks related to intense seismic activity are in some cases inapplicable to existing buildings. Although the model for building stock development until 2050 shows that buildings are being increasingly replaced, the model of the preliminary assessment of building sustainability is not applicable (deviations from the basic requirements for buildings are already allowed by the Construction Act in a number of situations), and energy renovation projects assess risks to the building and possible methods of risk mitigation.

Only buildings built after 2012 fully meet the seismic resistance requirement under present regulations, while buildings dating from before 1963 have little or no resistance to increased seismic activity. Reinforced concrete structures built in the 1980s and later have proved to be more earthquake resistant. Since almost the entire territory of Croatia lies in a seismically active area, with very limited areas in which horizontal ground acceleration is less than 0.98 m/s², the existing assessments indicate earthquakes among the biggest risks to Croatia with possible catastrophic consequences. The possible consequences of catastrophic earthquakes by far surpass the country's financial capacity, and earthquake risk assessments are needed as a basis for the implementation of policies (capability and capacity assessments, implementation of strategies and the like). Buildings built after the 1963 earthquake in Skopje are substantially more resistant to earthquake activity than earlier buildings.

Table 10-1 Proportion of buildings according to defined horizontal activity by period

Period	Up to 1945	1946–1964	1965–1981	1982–1997	1998–2011	2012–present

Defined horizontal activity*	0-5%	0-10%	30-50%	30-50%	75-100%	100% relevant
Residential units built	≈ 13%	≈ 17%	≈ 35%	≈ 21%	≈ 14%	
Total	13%	30%	65%	86%	100%	



CROATIAN	ENGLISH
	Republic of Croatia Map of earthquake areas
	Comparative peak acceleration of type A ground with a probability overshoot of 10% in 50 years (return period of 475 years) expressed in gravitational acceleration units (g)
	UNIVERSITY OF ZAGREB FACULTY OF SCIENCE DEPARTMENT OF GEOPHYSICS
	Author: Prof. Marijan Herak, DSc Associates: Ivo Allegretti, MSc; Prof. Davorka Herak, DSc;

	Ivo Allegretti, MSc; Ines Ivančić, MSc; Vlado Kuk, MSc; Ivo Allegretti, MSc; Krešimir Marić, MSc; Snježana Markušić, DSc; Ivo Allegretti, MSc; Ivica Sović, MSc.
	SOURCE OF BASIC CARTOGRAPHIC REPRESENTATION
	0.38 0.36 0.34 0.32 0.30 0.28 0.26 0.24 0.22 0.20 0.18 0.16 0.14 0.12 0.10 0.08 0.06 0.04

Figure 10.1: Map of earthquake-prone areas in Croatia

On 22 March 2020, at 6.24 a.m., seismographs of the Croatian Seismology Service recorded a very strong earthquake with a magnitude of 5.5 on the Richter scale and an epicentre 7 km north of the centre of Zagreb at a depth of 10 km, which resulted in the partial or total destruction of many buildings and structures in the City of Zagreb, Zagreb County and Krapina-Zagorje County. The earthquake damaged and partly destroyed the cultural and historic unit of Zagreb's Lower Town, with many old apartment buildings and public cultural objects, and the Markuševec area with predominantly family houses, as well as the area between these two parts of the city and the area behind Mount Medvednica in Krapina-Zagorje County and Zagreb County. The exceptionally valuable highly urban structure of the Croatian capital was damaged the most, with the districts of Donji Grad, Gornji Grad, Medveščak, Gornja Dubrava, Maksimir, Podsljeme and Sesvete estimated to have suffered the most severe damage.

From 22 March to 14 April 2020, within a period of 24 days, seismographs recorded about 1 000 earthquakes, including 145 with magnitudes of above 1.3 on the Richter scale, and another 850 earthquakes with magnitudes of below 1.3.

More than 24 000 buildings were damaged, 1 311 buildings were marked as unusable and 4 896 as temporarily unusable. A total of 27 people were injured, while one person died from injuries sustained.

Under Directive (EU) 2018/844, in addition to energy renovation, a Member State may encourage renovation to address the issue of fire safety and mechanical resistance and stability due to seismic activity. Accordingly, in the case of buildings undergoing a major renovation, all national programmes of energy renovation of buildings in Croatia for the period 2021-2030 will encourage ensuring healthy indoor climate conditions, fire safety and risks related to intense seismic activity.

Furthermore, the amended Technical regulation on energy economy and heat retention of 2020 provides that during a major renovation designers must analyse the existing state of the building concerned and present measures to improve the existing state of the whole building with an estimate of investment in respect of healthy indoor climate conditions, fire safety and risks related to earthquake activity.

In addition to these measures, building owners should be further encouraged through a model of aid for design documentation to prepare additional analyses (verification of seismic stability, fire safety studies).

Additional analyses may cover a series of measures to increase the stability of the earthquake load capacity, which may be divided as follows:

- Technical measures
    - ensuring structural integrity;
        - adequate connection of the wall and ceiling structures; ensuring the stiffness of the structures;
        - structural walls should be evenly distributed in two orthogonal directions of the buildings to successfully resist the expected seismic loads;
        - adding load-bearing walls;
    - reinforcing masonry;
        - injecting;
        - external cladding (ferrocement, reinforcement, carbon fibres);
        - regrouting;
        - horizontal or vertical prestressing of walls;
    - reinforcing skeleton and frame structures;
    - alleviating the structures of buildings and reducing the constant load;
- Verification of seismic resistance
    - calculation.

In the case of buildings designated as protected cultural property, the earthquake risk assessment should estimate the possibility of intervention in accordance with the ranking of the cultural property concerned:

- no intervention – preserve the existing state and document how it could be reconstructed, limit the use if the risk to people is too high;
- minimum intervention – minimum interventions to allow unlimited use, document how it could be reconstructed in rare earthquake scenarios;
- moderate intervention – ensure the same level of resistance as for buildings not designated as protected cultural property;
- maximum intervention – ensuring seismic resistance according to the building's purpose – maximum building use.

The buildings in Zagreb damaged in the 22 March 2020 earthquake are generally used to the maximum, so both the moderate and the maximum level of intervention is relevant to them.

The technical regulation for engineering structures (NN Nos 17/17, 75/20) and the Manual for the earthquake-proof renovation of existing masonry buildings (21), designed after the earthquake in Zagreb on 22 March 2020, elaborate in great detail the four levels of earthquake-proof renovation of buildings with an example and an indicative renovation cost range.

Table 10-2: Measures for earthquake-proof renovation of masonry buildings

Renovation level	Basic measures	Earthquake resistance level	Cost assessment
Level 1	Demolition of gables and chimneys, rebuilding and reinforcement with the FRCM system Roof repair and stabilisation Connecting ceilings and gable walls	Minimum reinforcement - restoration to the pre-earthquake state	HRK 581/m²

	Local reinforcement of walls, lintels, etc. Local connection of walls		
Level 2	Execution of a horizontal grid in the ceiling and connecting all the walls to the ceiling Execution of a wooden pressure plate in the attic floor Partial reinforcement of the walls Reinforcement of the stairwell vaults with FRCM	Reinforcement of critical points, achieving resistance at 50% EC	HRK 1,036/m² (Level 1+2)
Level 3	Stiffening of all ceiling structures Installation of sectional steel in lintels Wall reinforcement	Raising resistance to 75-100% EC	HRK 2,150/m² (Level 1+2+3)
Level 4	Execution of new reinforced concrete walls alongside existing ones Execution of reinforced concrete lintels Execution of composite pressure plates of all floors	Raising resistance to 90-100% EC	1.418 HRK/m²

The amount of investment in the implementation of earthquake safety measures and fire safety measures supports the requirement of Directive (EU) 2018/844 for simultaneous consideration of earthquake and fire safety measures when implementing integrated energy renovation of buildings. Since equivalent costs are avoided in the case of comprehensive renovation of buildings, the estimate of the value of investment is reduced and the estimate of required investment in Chapter 11.1 starts with an average investment value of HRK 2 500/m² for residential buildings and HRK 3 500/m² for non-residential buildings. However, the values of investment in the comprehensive renovation of buildings already damaged in the earthquake reach considerably higher amounts – up to as much as HRK 6 900/m².

Guidelines should be drawn up for reinforcing the structure of buildings against seismic activity with a catalogue of materials and examples of good practice in Croatia and the EU to assist designers. The guidelines should be available online at all times and updated with new materials and technologies. A book by a group of authors published by the University of Zagreb's Faculty of Civil Engineering, 'Earthquake engineering – Renovation of masonry buildings', will be of great assistance to designers.

Considering the recommendations from the Directive and the increased risk of seismic activity in a large area of Croatia, the model of comprehensive renovation and renovation until the level established for nearly zero-energy buildings (which could be given a priority in calls for applications through a scoring system) should be added to all programmes for the energy renovation of buildings to motivate investors to invest more in the renovation of buildings.

Comprehensive renovation should include encouraging high-efficiency alternative systems, if technically, functionally and economically feasible, while also addressing the issues of healthy indoor climate conditions (damp remediation, CO_2 reduction, etc.), fire safety and risks related to intense seismic activity. Before the energy renovation of a building, the designers should analyse the existing building and propose measures to improve its condition, and if the building in question has cultural heritage status, the proposed measures should be aligned with the conservation criteria.

11 ESTIMATE OF THE REQUIRED INVESTMENT AND AID TO MOBILISE INVESTMENT INTO RENOVATION

11.1 ESTIMATE OF THE REQUIRED INVESTMENT

The required investment into the energy renovation of buildings has been estimated in Croatia's Energy Development Strategy and its Integrated national energy and climate plan. In the household sector, the renovation of about 10 000 housing units annually is projected. In the services sector, the average energy consumption is forecast at 55 kWh/m^2 annually in 2050. That corresponds to the renovation of the existing building stock, fit for renovation, at an annual rate of 1.6%, which is an increase from the current rate of 0.7% to 1% annually for 2021 and 2022, 1.5% by 2024, 2% by 2026, 2.5% by 2028 and 3% for 2029 and 2030.

The total investment cost of the energy renovation of buildings is calculated on the basis of the present value of presumed prices of renovation to the nZEB standard. The price for residential buildings is HRK 1 500/m^2, while the price for non-residential buildings is HRK 2 500/m^2 due to the presence of more complex technical systems in such buildings[44].

In addition to the costs of energy renovation, a considerable number of buildings require additional investment in structural repairs. Looking at a limited sample of buildings with the poorest energy performance covered by the draft Programme to reduce energy poverty, including the use of renewable energy sources in residential buildings in assisted areas and in the areas of special state concern for 2021–2025, the value of additional investment is HRK 1 500/m². Buildings that meet the requirements of applicable legislation account for 4% of the building stock, but 75% of buildings are stable and energy renovation does not present a substantial risk to them in terms of mechanical resistance and stability.

Costs of additional fire safety measures are estimated on the basis of application of materials that meet the fire safety requirements of the Fire resistance rules, which increase the value of the investment in improving the quality of the external envelope by about 10%. Additional fire safety measures that can reduce the risk to the building concerned relate to design features of energy renovation and the existing risk assessment of the building. In the case of non-residential buildings, minimum measures to reduce the risk of fire are included in the buildings themselves, while in the case of residential buildings the scope of measures to improve the external envelope is generally limited because of the minimum evacuation requirements for buildings.

Finally, the cost of comprehensive renovation is estimated as the average value of an investment of HRK 3 500/m² for residential buildings and HRK 4 500/m² for non-residential buildings. Hence, the average value of an investment of HRK 2 500/m² for residential buildings and HRK 3 500/m² for non-residential buildings is taken in the total estimate of investment in the renovation of buildings (including energy renovation and comprehensive renovation).

Due to a high demolition rate projected for the building stock by 2050, in addition to direct costs of energy renovation there is an unexpressed value of new-builds which actually represents energy renovation with the relocation of the building stock in space. This cost is considerably higher than the cost of energy renovation because of permanent abandonment of space, which affects its economic potential and the

[44] According to the Call for submission of project proposals 'Energy renovation of multi-apartment buildings' (reference number: KK.04.2.2.01), the maximum eligible investment cost of energy renovation is HRK 1 000.00/m^2. Because energy renovation is being targeted towards the nZEB standard, this value has increased by 50%. As for non-residential buildings, the value of a specific investment is taken from the Call for submission of project proposals 'Energy renovation of public sector buildings' (reference number: KK.04.2.1.04).

sustainability of activities in that space, but this process has been present for years and in the present macroeconomic and demographic circumstances it is irreversible.

Table 11-1 Estimate of investment in the renovation of buildings by 2050

Period	2021-2030	2031-2040	2041-2050
Scope of renovation – residential (million m²)	17.77	24.57	18.58
Scope of renovation – non-residential (million m²)	10.67	14.10	10.98
Investment cost of renovation – residential and non-residential (HRK billion)	71.24	97.26	74.73
Total investment cost of renovation (HRK billion)	**243.23**		
Replacement of demolished – residential (million m²)	2.40	2.16	2.54
New-builds – residential (million m²)	9.60	9.60	10.16
New-builds – non-residential (million m²)	3.27	2.49	1.69
Investment cost of replacement of demolished buildings and new-builds (HRK billion)	118.39	108.76	107.63
Total investment cost of replacement and new-builds (HRK billion)	**334.77**		

11.2 IDENTIFICATION OF FINANCING SOURCES

The Long-term strategy requires an integral and systematic approach to provide the most suitable financing mechanisms for private and public sector investors over the long term. The primary role of the government is not in providing financial resources for energy renovation, but in creating and improving conditions to create a favourable investment climate among investors for the implementation of required investments defined within the scope of the Long-term strategy for mobilising investment in the renovation of Croatia's national building stock. Favourable conditions include macroeconomic stability, efficient state administration, a competitive level of the tax burden, legal certainty, protection of competition, and existence of appropriate financial incentives to invest. An overview of existing sources of financing, limits and barriers to their implementation and a long-term financing strategy for renovation projects in the building segment is provided below.

11.2.1 Existing sources of financing

Energy renovation projects in the building segment are a demanding capital investment whose successful implementation largely depends on the sources of financing. To date, a number of different financial instruments and models have emerged, with the most significant ones including grants, preferential loans, guarantees, tax instruments, the ESCO and PPP [public-private partnership] models, which can all use different sources of financing.

Investors in Croatia have so far mostly relied on public sources of financing which provided grants or various forms of subsidies. Lengthy periods of return and very high amounts of investment in increasing energy efficiency are the reason why this form of financial aid has been introduced in most EU Member States, increasing the profitability level of such investments for investors. Although financial institutions have developed market models involving more favourable lending conditions for energy efficiency projects, the government role in this sector remains crucial for the success of their implementation. That is why the

Ministry of Construction and Physical Planning has developed energy renovation programmes for four identified building purposes (public, commercial, multi-apartment buildings and family houses) for the period until 2020. The existing sources of financing of these programmes are shown in Table 11-2.

Table 11-2 An overview of the existing sources of financing of programmes for energy renovation of buildings in Croatia until 2020

National programme	Sources of financing
Programme for energy renovation of public buildings for the period between 2014 and 2015	• Private sources – energy service companies (ESCO) • Environmental Protection and Energy Efficiency Fund – grants
Programme for energy renovation of public buildings for the period between 2016 and 2020	• ESI funds (ERDF) under the OPCC – co-financing of investment through grants • ESI funds (ERDF) under the OPCC – specialised HBOR credit facility with a favourable interest rate • Funds from the Fund for co-financing the implementation of EU projects, provided by the Ministry of Regional Development and EU Funds to co-finance the implementation of EU projects at regional and local level.
Programme for energy renovation of family houses for the period between 2014 and 2020	• Environmental Protection and Energy Efficiency Fund – funds obtained from the auctioning of emission allowances – grants
Programme for energy renovation of multi-apartment buildings for the period between 2014 and 2020	• ESI funds (ERDF) under the OPCC – co-financing of investment through grants • Environmental Protection and Energy Efficiency Fund
Programme for energy renovation of commercial non-residential buildings for the period between of 2014 and 2020 with a detailed plan of energy renovation of commercial non-residential buildings for the period between of 2014 and 2016	• Environmental Protection and Energy Efficiency Fund – grants • ESI funds (ERDF) under the OPCC – co-financing of investment through grants for buildings in the tourism and trade sectors

Other existing sources of financing are shown in Table 11-3.

Table 11-3 An overview of other existing sources of financing of energy efficiency in Croatia

Development banks, funds and credit facilities	
Croatian Bank for Reconstruction and Development (HBOR)	Preferential loans and guarantees are offered under several programmes to increase energy efficiency aimed at public and private sector investors.
Croatian Agency for SMEs, Innovations and Investments (HAMAG-BICRO)	Financial instruments also provide support to investment in the energy renovation of commercial buildings through loans and guarantees with a possibility of combining them with interest rate subsidies
European development banks and funds (EIB Group, EBRD, European Energy Efficiency Fund, European Fund for Strategic Investments)	Direct preferential loans and guarantees are offered to public and private sector investors for large energy renovation projects
EBRD support programme for the Croatian private sector (REENOVA+)	EBRD loan programme intended for citizens and enterprises
EIB programme to finance energy efficiency in the private sector (PF4EE)	EIB loan programme intended for enterprises
Technical assistance programmes	
European technical assistance programmes (ELENA, JASPERS, Horizon2020)	Programmes of co-financing and technical assistance for the preparation of large public sector projects

Energy efficiency obligation schemes	
Energy suppliers	Since 2019, energy suppliers in Croatia have been required by the Energy Efficiency Act to effect energy savings for end-customers by making own investments, purchasing savings or paying a fee to the Environmental Protection and Energy Efficiency Fund

Source: REGEA, 2017, EIHP 2019

11.2.2 Financial barriers and limits

Directive 2012/27/EU dictates support for development of the energy services market, development of new financial mechanisms and incentives, as well as institutional, financial and legal frameworks to remove existing market barriers and shortcomings preventing efficient end-use energy consumption. Barriers of a financial nature which currently hinder the development of energy renovation projects and are to be removed with the help of the Long-term strategy include:

- very limited public aid funding available;
- lack of continuity in public aid programmes;
- lack of financial capacity and a high degree of public sector indebtedness;
- tax (VAT) and statistical (EUROSTAT) treatment of energy performance contracts;
- lack of adequate, renewable financial instruments;
- high cost of capital due to a perceived risk of energy renovation projects and lack of financial products intended for project financing;
- lack of special aid schemes for energy renovation of cultural heritage buildings;
- lack of support instruments for large enterprises;
- absence of tax breaks for energy renovation projects;
- underdeveloped ESCO market;
- energy prices not determined by the market;
- high minimum project size to qualify for the use of the EU technical assistance programmes for Croatian investors.

Existing institutions and associated sources of financing in Croatia currently lack sufficient financial strength to carry through the total investment envisaged under this Long-term strategy. This is particularly true for limited budget funds of the central government and regional and local self-government units , which must be relieved by new and innovative financing mechanisms.

The commercial sector is driven by the principle of profit maximisation and constant operating cost reduction, hence it finds its interest in energy efficiency in the cases where investments result in a significant reduction in expenditures, enabling a return on investment over a short horizon. In the context of public financial incentive, enterprises are subject to restrictions on the use of state aid imposed on EU Member States by the European Commission to prevent distortions of competition in the market by placing certain economic operators into a more favourable position.[45] In order to enable this sector to use public aid above the de-minimis threshold, the Ministry of Environment and Energy has developed a state aid model for the energy renovation of commercial buildings in accordance with the state aid rules assuming that general block exemption (GBER) rules apply.

Citizens are a particularly vulnerable group of end-consumers, so not only special financial models but also promotional campaigns are necessary to raise their awareness and level of information on the need for and benefits of investing in the energy renovation of their homes. Energy renovation in the sector of family houses and multi-apartment buildings can be used to efficiently combat a growing danger of energy poverty among citizens, which is why a draft energy poverty reduction programme has been drawn up, including

[45] *Official Journal of the European Union* (OJ C 83, 30.03.2010). Consolidated version of the Treaty on the Functioning of the European Union, available at: http://eur-lex.europa.eu/resource.html?uri=cellar:c382f65d-618a-4c72-9135-1e68087499fa.0006.02/DOC_3&format=PDF [26.10.2012.]

the use of renewable energy source in residential buildings in assisted areas and areas of special state concern for the period 2021-2025, and energy poverty criteria are integrated into the drafts of the following energy renovation programmes for family houses and multi-apartment buildings.

11.2.3 Long-term energy renovation financing model and sources of financing

Lack of favourable and constantly available sources of financing leads to the implementation of only commercially viable projects to increase energy efficiency in the building segment. By establishing special programmes, funds and credit facilities in cooperation with European development banks, Croatia has recognised the importance of financial support to investors. Lack of financial resources in the public sector due to unfavourable macroeconomic developments has been a key impediment to a wider implementation of energy efficiency projects. In the implementation of programmes to stimulate energy renovation to date, Croatia has had no access to Cohesion Policy Funds or European Structural and Investment Funds[46], which greatly limited its possibilities of support to investors in this sector. At the same time, the European Union requires and allows Member States to use these instruments to finance the implementation of their energy renovation programmes in the building segment. This is particularly emphasised in Article 20 of Directive 2012/27/EU which calls upon Member States to set up national funds to encourage energy efficiency if there are no market instruments strong enough to achieve the planned targets.

The ESI Funds are a primary source of financing for a majority of national energy renovation programmes. The European Commission has set a minimum allocation of funds from the European Regional Development Fund to achieve Thematic Objective 4 – Support to a shift towards an economy based on low-level CO2 emissions in all sectors, for less developed members such as Croatia, of 12%[47]. Through operational programmes, funding must be used to mobilise investment in the energy renovation of the public and private sector building stock and stimulate the use of renewable energy sources, advanced energy networks and urban mobility. This funding represents a major step forward and an opportunity to support the integral energy renovation of the national building stock, hence the financial mechanisms of the long-term strategy are mostly based on European funds. The ESI funds that were available to Croatia in the period between 2014 and 2020 for the energy renovation of buildings are as follows:

- EUR 211 million for the energy renovation of public buildings;
- EUR 100 million for the energy renovation of residential buildings;
- EUR 40 million for the energy renovation of buildings in the commercial services sector (tourism and trade).

In order to achieve the objectives of this Long-term strategy, substantial ESI funds should also be budgeted in the next financial framework for the use of ESI funds between 2021 and 2027. The following three principles of the use of ESI funds should be taken into account:

- financial sustainability
- rationality in the allocation of grants aimed at encouraging integral energy renovation projects, which result in ambitious energy savings;
- inclusion of the private sector and market mechanisms in project financing.

In addition to compliance with the requirements for the introduction of innovative and sustainable financial instruments, and taking into account the barriers identified in Chapter 11.2.2, an overview of financial measures to facilitate the implementation of the national building stock renovation in the period up to 2050 has also been prepared (Table 11-4).

[46]Cohesion Policy Funds consist of the European Regional Development Fund (ERDF), the European Social Fund (ESF) and the Cohesion Fund (CF). European Structural and Investment Funds (ESI Funds) include the three above-mentioned funds, the European Agricultural Fund for Rural Development (EAFRD) and the European Maritime and Fisheries Fund.

Table 11-4 Long-term financial and fiscal measures to stimulate energy renovation of buildings

Financial measures	Effects on identified barriers
Establishment of financial instruments – an urban renovation fund for energy renovation projects through European Structural and Investment Funds and development banks to offer long-term and sustainable financing mechanisms (loans, guarantees, equity) for public and private sector beneficiaries	• Securing permanent availability of funding, irrespective of budgetary resources of the central government and local and regional government units • Including commercial financial institutions and mobilising a greater volume of private capital • Reducing the risk of lending for energy renovation projects for financial institutions. • Possibility of obtaining grants to increase the cost-effectiveness of ambitious and innovative projects • Easier access to capital and lower financing costs for energy service providers and public-private partnership projects
Further implementation of the Programme for energy renovation of public buildings	• Stimulating the development of the energy services market • Reducing the burden on the budget of public sector beneficiaries by avoiding additional borrowing • Engaging financial resources and capacities of the private sector
Establishing a special support scheme to co-finance the energy renovation of protected cultural heritage buildings	• Stimulating the energy renovation of buildings with cultural heritage status that generate a high economic rate of return (ERR) and a low internal rate of return (IRR)
Setting up a special instrument to co-finance the technical preparation of projects	• Avoiding high costs of project development • Creating a database of projects ready for financing and implementation
Energy efficiency obligation scheme for energy suppliers	• Securing additional sources of grants outside the state budget and public funds, including ESI funds • Stimulating the development of the energy services market • Relief for financial and human resources of public institutions
Establishing a system of tax relief for investment in energy renovation	• Promoting investment in the renovation of inefficient buildings

An optimal financial model to support the implementation of the Long-term strategy for mobilising investment in the renovation of the national building stock of Croatia is a complex package of financial and fiscal mechanisms combining market and public instruments. Meanwhile, the Government must ensure maximum efficiency of public funds by taking due care that the use of grants does not crowd out private investments in the projects of commercial nature. Detailed models of financing, including sources of financing, financing mechanisms and procurement models, also depend on the type of building and will be elaborated in detail in separate energy renovation programmes.

11.3 INVESTMENT MOBILISATION ACTIVITIES

The Long-term strategy is aimed at ensuring a long-term removal of barriers to private investment in the energy sector by providing instructions to create a clear, unambiguous and stable legal and administrative framework that will stimulate investment in the energy renovation of buildings in order to reduce the degree of uncertainty faced by private investors. Because of high investment amounts, their long-term nature and sensitivity when it comes to the outcome amid considerable movements in the market prices of energy, investments in the energy sector need to be stimulated further to make them more attractive to investors.

This may include provision of timely information to all relevant stakeholders about the financial and legal frameworks and an extensive exchange of best practices at all levels. One of the effective tools for exchange of experience is certainly the 'Open partner dialogue' (see Chapter 12.1). In addition, it is important that energy renovation financing programmes always ensure advisory support to beneficiaries so that available funds are used in the best possible way.

Stimulating private investment in energy renovation is key to achieving the goals of this Long-term strategy. Financial institutions are a key stakeholder in the strategic renovation of the national building stock because the public sector lacks financial strength to support the implementation of all planned measures on its own.

The involvement of private investors and banks in energy efficiency projects was minimal in the past and limited to commercial projects. Energy renovation projects do not generate direct cash receipts, but contribute to a reduction of existing costs. Such financial benefits are more susceptible to technical risk and customer behaviour, therefore banks were less willing to finance this type of projects or demanded higher interest rates and high guarantees. Removing and overcoming these risks and the lack of trust in alternative project procurement models (such as design-build-finance (DBF), ESCO, PPP, right to build, concession, sale-leaseback (SLB)) are a key prerequisite for more intense involvement of financial institutions, while the central government has mechanisms to enable this. Some progress has nevertheless been achieved to date thanks to the intervention of European development banks (EBRD and EIB) which, in cooperation with local development and commercial banks, have established financing facilities for sustainable energy projects and strengthening the capacity of financial institutions for project evaluation and structuring.

The greatest barrier for private investors and energy services providers is a limited access to affordable sources of financing. Lack of support by financial institutions in the form of long-term preferential loans, guarantees and project financing has led to a very high price of ESCO projects and consequent investor reluctance to opt for this model. The European Union's cohesion policy requires that sustainable energy projects be implemented with the greater participation of private investors. Public aid must meanwhile assume the role of complementary financial resources to mobilise private investor funding by raising the attraction of their involvement in renovation financing. This goal may be achieved by introducing the following financial and regulatory mechanisms:

- establishment of a national revolving fund with ESI funds to enable access for energy services providers to a long-term source of financing under more favourable market terms, while providing an opportunity for banks lend through the fund;
- introduction of special guarantee instruments to reduce the risk of investment by private investors;
- subsidising interest rates on commercial loans to enable the placement of commercial banks' financial resources into the energy renovation of buildings;
- promotion of the energy services market by implementing the Programme for the renovation of public buildings – in this segment the aggregation of public sector projects should be considered to make them more financially attractive to private investors;
- development of standardised energy performance contracts to measure and verify energy savings, thereby increasing the confidence of beneficiaries and financial institutions in the ESCO model.

Apart from intervening on the supply side, it is important to make efforts to increase demand for financing services in energy efficiency projects through promotional and information campaigns to increase beneficiaries' awareness of the existence of favourable sources of financing. Many banks in Croatia have recognised the importance of this element, which not only enables them to engage their resources, but also to build an image of socially and environmentally responsible institutions.

12 SUMMARY OF THE RESULTS OF THE PUBLIC CONSULTATION ON THE LONG-TERM STRATEGY

12.1 MODALITIES OF PUBLIC CONSULTATION

12.1.1 Open partner dialogue

The ministry responsible for construction has launched the initiative 'Open partner dialogue' to strengthen interdepartmental communication and cooperation between state administration authorities and the real sector. The aim of the Open partner dialogue is to create a wide network of professionals prepared to engage in dialogue and contribute to a decarbonisation of the building stock by 2050. Open partner dialogues bring together representatives of central and local government, the academic community and professional public, the construction and energy sectors and related industries at thematic workshops organised by the ministry responsible for construction.

FIRST OPEN PARTNER DIALOGUE

Held on: 27 September 2018, organised by the MCPP, at the Westin Hotel in Zagreb

Topic: 'Implementation of the nearly zero-energy building standard and the national long-term strategy for the energy renovation of buildings by 2050'

It was organised by the Ministry of Construction and Physical Planning as a side event to the international conference 'Energy efficiency in buildings – for a better tomorrow', with the participation of up to 100 participants. Active participants were representatives of central and local government, the academic community and professional public, and the construction and energy sectors.

Workshops were held with topics of importance for the development of the long-term strategy for the energy renovation of buildings by 2050, such as decarbonisation of the building stock by 2050, smart financing and reducing investment risk, electromobility, establishing one-stop shops, regulation and automation in buildings, seismic survey and fire safety in building renovation

Awareness was raised about some of the problems we should continue to address, such as: design problems (everyone works together on nZEB already in an early stage of design, project oversight); international nZEB criteria do not exist; implementation of a high proportion of renewable energy sources in situ in existing buildings; problems with execution (necessary oversight of execution and performance); there are no disincentives for the use of fossil fuels; a consensus of all political groups is needed for a stable and long-term strategy; severe deterioration of the existing building stock; locations for the installation of photovoltaic systems (car parks, unused flat roofs); electric grid balancing and energy storage; training for new disciplines; training of users of new/newly-renovated houses; low-technology challenges; networking challenges; energy independence of Croatia; launch of smart-grid neighbourhoods; elimination of fossil fuels; reallocation of funds from the OPCC 2014-2020 needed; timely provision of information on future calls and the amount of funds; development of new financial sector services for energy efficiency. Special emphasis was put on energy poverty.

As regards electromobility, no major problems are expected in the construction of new-builds relating to the design of e-parking spaces, but in existing buildings problems may arise concerning the ownership of e-parking spaces, use, management, maintenance of the capacity of the distribution network for connections to it. In building e-mobility cooperation will be needed from the construction, energy, economics, justice and enterprise sectors.

Furthermore, it was concluded that it would be very useful to set up one-stop shops as contact points where all relevant information about energy efficiency in buildings would be available, such as establishing special offices or special 'bookmobiles'.

Regulation and automation in buildings was supported, but its financing may be a problem, as is the motivation to install regulation and automation systems in buildings, their maintenance, the handover of buildings and training of occupants.

The new EPBD [Energy Performance of Buildings Directive] pays special attention to solutions to risks from intense seismic activity and fire safety in the energy renovation of buildings. Questions were raised about financing structural renovation during the energy renovation of buildings, in which the designer is responsible for ensuring that the risk of fire or the structural load does not increase in the process of building renovation compared with the current state of the building, while at the same time ensuring that the energy renovation remains financially interesting to the owners.

As for fire safety, materials cannot be banned (individually), while regulations on the use of materials have not yet been aligned; also, co-financing rules for energy renovation do not address the attitude towards fire safety.

Many issues were raised in this area, so it was concluded that further cooperation and dialogue involving all stakeholders in construction, lawmakers and the professional public at large was necessary, which is indeed the objective of Open partner dialogue.

SECOND OPEN PARTNER DIALOGUE

Held on: 1 February 2019 at the Panorama Hotel in Zagreb

Topic: 'Energy poverty'

The aim was to define energy poverty criteria that would later be incorporated into public calls for the energy renovation of residential buildings, primarily family houses, i.e. those for private occupants, and worst-performing buildings in assisted areas and areas of special state concern.
In the introductory part, the Society for Sustainable Development Design (Cr. abbr. DOOR) held a presentation. Energy poverty is a situation in which individuals or households are unable to adequately heat their homes or use other energy services at an affordable price. Research shows that as many as 54 million EU citizens (10.8% of the European population) were unable to keep their homes adequately heated in 2012. Central-eastern and southern Europe are particularly affected by energy poverty, including Croatia.

All professionals attending the Second open dialogue took an active part in the workshop (round-table discussions), defining the energy poverty criteria through constructive and meaningful debate.

Conclusions of the Second open partner dialogue

The following criteria were chosen to determine vulnerable groups of citizens/households affected by energy poverty (scoring and proposal of new criteria), according to the energy poverty criteria:

CRITERION:	NUMBER SCORE
Low household income / income per household	37
Building energy rating ($Q_{H,nd}$ i.e. heating demand)	25
Guaranteed minimum allowance	24
Floor area per household member	13
Total household energy costs vs. total household income	12
Share of the energy basket (heating, hot water consumption, lighting, electricity consumption) in household income	11
Personal disability allowance	8
Child benefit beneficiaries	7
Pensioners with a pension allowance of less than ...	5
Area development index	4
Welfare and health insurance threshold	3

Single parents	2
Total heating costs vs. to total household income	2
Means test	2
Certificate proving that the person concerned owns no other real estate	2
Health risk assessment	1
Ownership	1
Real energy consumption proven by bills (per m^2)	0

Participants added the following criteria:

- Number of household members * minimum floor area per person * $Q_{H,nd}$ * HRK/kWh;
- 15 m^2 per household member;
- 70 m^2 + 20 m^2 per each household member.

The selected energy poverty criteria will also be used to develop a Programme to combat energy poverty, including the use of renewable energy sources in residential buildings in assisted areas and areas of special state concern for which the Croatian Government, at its session of 23 January 2019, adopted a conclusion supporting Programme development because:

- A particularly vulnerable category of residential buildings are located in areas of special state concern or assisted areas of Croatia, and their occupants have very modest or no income at all.
- An assisted area is an area of Croatia that has been assessed on the basis of the development index as an area which, according to its level of development, lags behind the national average and whose development requires additional incentives.

THIRD OPEN PARTNER DIALOGUE

Held on: 29 April 2019 at the Sheraton Hotel

Topic: 'Application of state-of-the-art solutions and rules on fire safety and protection from the risk of intense seismic activity in the energy renovation of buildings'

Objective: to apply state-of-the-art solutions and rules in respect of fire safety and the risk of intense seismic activity in the energy renovation of buildings

Presentations were followed by a panel discussion in which the panellists were representatives of the Faculty of Civil Engineering in Zagreb, the Faculty of Science in Zagreb, a Croatian representative in the European Parliament involved in fire safety issues, and other professionals in this field. The issues discussed concerned ways of improving the earthquake resistance of existing buildings, who and when needs to decide when a structural inspection of buildings is required in energy renovation, etc.

About a hundred participants – representatives of the central and local governments, the academic community and professional public, construction and energy sectors and related industries – were involved in the panel discussion, with the panellists answering questions from the audience.

Some of the conclusions and problems which need to be addressed are as follows:

- There is no (EU) harmonised fire safety standard for façade systems.
- Regulations have been harmonised with EU legislation (Rules from 2013, ID 2015).
- Rules on the fire resistance of buildings were to be adopted early in 2019.
- In some renovations, inadequate thermal insulation or façade systems were installed, posing a considerable fire risk. There is a particularly high risk of fire spreading in high-rise buildings.

- In the energy renovation of buildings, particular account should be taken of the level of fire safety of the entire building and to what extent the building meets the basic fire safety requirement, after which the type of façade system should be chosen accordingly. The recommendation is to use non-flammable materials and to include in projects of energy renovation of buildings a professional authorised under a special regulation who prepares an overview of all fire safety measures applied and who, by signing the cover page of the first portfolio of the main design, assumes responsibility in accordance with the provisions of the Act and special regulations for the overview of all fire safety measures applied in all parts of the main design.
- The construction supervision system needs to be improved.

FOURTH OPEN PARTNER DIALOGUE

Held on: 24 October 2019 at the Panorama Hotel in Zagreb

Topic: 'Amendments to the Construction Act'

The focus of this Dialogue of partners was the amendments to the Construction Act relating to the adoption and implementation of the Long-term strategy for the renovation of the national building stock by 2050, promotion of electromobility by deploying charging infrastructure for electric vehicles in buildings and in car parks adjacent to buildings, simplification of regular inspections of heating and cooling or air-conditioning systems in buildings, adjustment and control of the technical building systems, defining the requirements related to the installation of self-regulating devices and building automation and control systems as well as amendments to the authorisation system for energy performance certification of buildings.

Amendments to the Construction Act are necessary to align national energy efficiency legislation in the building segment with European Union legislation.

After the amendments were presented by the head of the Directorate for energy efficiency in the building segment and nearly zero-energy buildings, a workshop/discussion was held on the following topics:

- Long-term strategy for the renovation of the national building stock by 2050 – the scope of the strategy, policies and measures, the choice of measurable progress indicators for 2030, 2040 and 2050.
- Promotion of electromobility by deploying charging infrastructure for electric vehicles in buildings and in car parks adjacent to buildings
- Simplification of regular inspections of heating and cooling or air-conditioning systems in buildings
- Introduction of building automation and control systems, self-regulating systems
- Changes to the conditions for issuing authorisation for energy certification of buildings.

In short, the conclusions of the Fourth open partner dialogue are as follows:

- There is no overview of the national building stock, availability and relevance of information (no register of buildings)
- Apartments that are always or temporarily empty are a problem (there is no information about them) as they are included in the floor area of the building stock, so the question arises whether it is necessary to renovate those apartments.
- Article 5(1) of the Energy Efficiency Directive requires that 3% of the total floor area of heated and/or cooled buildings owned and used by central government be renovated every year, while the accepted goal of the Croatia's Energy Development Strategy until 2030 with an outlook to 2050 (moderate scenario S2) is 1.6% annually (energy renovation of the building stock)
- Another problem is private renovations that are not co-financed i.e. the results are not entered in a single database of savings and total savings are not visible (especially in the case of family houses)
- Relevant trigger points in the life cycle of a building need to be determined, e.g. real estate transactions (sale, lease, refinancing, repurposing), planned renovation unrelated to energy, disasters (fire, earthquake, flood)

- Split-incentive dilemmas and market failures (building co-owners not motivated for energy renovation, do not have the financial capacity, are not interested ... Landlords must be aware of their obligations to maintain the building and make it safe)
- How to include the issues of fire and earthquake safety, except in an emergency when a disaster (a trigger point) has already happened, meaning planned energy renovation including fire, earthquake and flood safety?
- What are the modalities of inclusive consultation during the implementation of the renovation strategy relating to the submission of triennial progress reports to the European Commission other than e-consultation and Open partner dialogue ? What are the indicators and how to monitor them? A statistical survey of the structure of the building stock on a statistically relevant sample? MCPP's long-term energy renovation strategy web pages?
- Monitoring the implementation of the long-term strategy for building renovation, in what way? Indicators, which ones?
- Promoting smart technologies, what are the national initiatives for their promotion, how to bring them closer to users and make them desirable and affordable? Promoting skills and education in the construction sector.
- Promoting electromobility by deploying charging infrastructure for electric vehicles in buildings and in car parks adjacent to buildings.

The Long-term strategy includes an analysis of measures to simplify the deployment of charging points in new and existing residential and non-residential buildings addressing possible regulatory barriers, including permitting and approval procedures, without prejudice to property and tenancy law.
Participants in this Open dialogue believe that the introduction of e-mobility for new-builds is a justified and good investment, and cable infrastructure should be deployed for ALL parking spaces (instead of 1 parking space, more than 10 parking spaces according to the proposed amendments to the Construction Act).

Also, in designing and constructing new-builds, provisions should be made for installations and rooms to put new elements in, such as rooms for power generating units, meters, installation shafts, cable routes and the like.

In respect of non-residential buildings, it is proposed that provisions also be made for ducting infrastructure for each parking space, whenever possible. This could be a good opportunity for co-financing with EU funds (the requirement is higher than prescribed) in future calls for energy renovation. (This could also be applied to residential buildings.)

Problems which might arise from the e-mobility requirement:

– considerable change that will affect public infrastructure (which is old and probably lacking the capacity);

– possible problems with connections and the required peak power (does [the state-owned power company] HEP have the strength to meet all the needs in the near future?);

– the construction cost will obviously go up;

– in the case of existing buildings with more parking spaces or spaces which are not individually owned – the issue of ownership, the time of use and payment;

– in the case of exceptions: small and medium enterprises – a problem will arise in designing new-builds where the future occupant is unknown – such cases should be further specified or dealt with by law.

FIFTH OPEN PARTNER DIALOGUE

Held on: 5 February 2020 in the Illyrian Hall of the National Home palace in Zagreb

Topic: 'Renovation of the national building stock of the Republic of Croatia'

The Fifth open partner dialogue focused on the renovation of Croatia's national building stock. The Long-term strategy is aimed at achieving a highly energy-efficient and decarbonised national building stock by 2050 and delivering the necessary progress towards the transformation of existing buildings into nearly zero-energy buildings, in particular by increasing deep retrofits. The Long-term strategy provides for clear

guidelines, defines measurable, targeted actions and equal access to financing, including for the worst-performing segments of the national building stock, for energy-poor consumers and for those subject to split-incentive dilemmas. The Long-term strategy needs to determine a clear level of ambition in respect of the energy renovation of existing buildings in order to achieve the European Union's goals of developing a sustainable, competitive, secure and decarbonised energy system by 2050.

The targets of the energy renovation of buildings by 2050 were presented, along with the amendments to the Energy renovation programme for family houses for 2014–2020, the Programme for development of green infrastructure in urban areas, the Programme for development of circular management of space and buildings for 2021–2030, a new call for the energy renovation of multi-apartment buildings, and an Analysis of savings on the completed energy renovations of buildings.

Also presented at this gathering were the new Guidelines for nearly zero-energy buildings and a review of the Long-term strategy.

After the presentations, the partners discussed this topic.

The conclusion is that Croatia has done a considerable part of the work through energy renovation of buildings and co-financing with national and EU funds, and that it is everyone's task to find a pathway and ensure continued financial support for further renovations.

After five open dialogues, a total of 68 partners signed a Charter for cooperation aimed at decarbonisation of buildings by 2050.

12.1.2 Charter for cooperation aimed at decarbonisation of buildings by 2050

The ministry responsible for construction has initiated the signing by a wide circle of stakeholders of the Charter for cooperation aimed at decarbonisation of buildings by 2050.

Accession to the community of partners who support the path towards decarbonisation of buildings symbolically begins with the signing of the Charter for decarbonisation of buildings by 2050 under the auspices of the ministry responsible for construction.

The signing of the Charter encourages continued cooperation in the development of the long-term strategy for the renovation of the national building stock and the transition to the nearly zero-energy building (nZEB) standard.

The signatories of the Charter support and promote the decarbonisation of buildings in their further activities, wherever possible. The signatories of the Charter or their representatives actively participate in workshops and panel discussions where, through constructive and meaningful debate, they define criteria or propose further courses of action on individual topics. With their opinions and proposals they influence the development of legislation which will facilitate progress towards decarbonisation of all sectors of the economy.

The Charter aims at bringing together as many partners as possible to raise awareness of the need for energy renovation and independence, implement an information campaign for the general public and professionals about the European Union's goals and the vision of Europe as the first clean and energy efficient continent.

The content of the Charter relates to the achievement of energy and climate objectives at national and EU level through decarbonisation of the building stock, renovation of buildings and construction of nearly zero-energy buildings, emphasising the importance of further reducing greenhouse gas emissions, increasing the share of renewable energy sources, improving energy security and introducing innovations and smart technologies that allow buildings to support the overall decarbonisation of the economy. The signing of the Charter encourages continued cooperation in the development on the Long-term strategy for the renovation of the national building stock and the transition to the nearly zero-energy building (nZEB) standard.

The signing of the Charter began at the First open partner dialogue held on 27 September 2018, when it was signed by the Ministry of Construction and Physical Planning, the Croatian Green Building Council, the

Croatian Association of Thermal Façade System Producers, the nZEB Cluster and the Environmental Protection and Energy Efficiency Fund.

By the end of March 2020, the Charter had been signed by 68 business and public sector stakeholders.

MINISTARSTVO GRADITELJSTVA I PROSTORNOGA UREĐENJA

OTVORENI DIJALOG PARTNERA 2050

POVELJA

O SURADNJI U CILJU DEKARBONIZACIJE ZGRADA DO 2050. GODINE

Mi, potpisnici ove povelje, svjesni smo važnosti energetske učinkovitosti u sektoru zgradarstva, osobito uzimajući u obzir da se gotovo 50% konačne potrošnje energije u Hrvatskoj i cijeloj Europskoj uniji upotrebljava za grijanje i hlađenje, od čega 80% u zgradama. Radi zajedničkoga djelovanja, a u svrhu postizanja ciljeva utvrđenih ovom poveljom, svjesni smo važnosti uspostave otvorenog dijaloga partnera koji čine svi zainteresirani dionici koji mogu doprinijeti ostvarenju postavljenih ciljeva. Predani smo postizanju energetskih i klimatskih ciljeva na nacionalnoj i EU razini kroz dekarbonizaciju fonda zgrada, obnovom zgrada i građenjem zgrada gotovo nulte energije, svjesni važnosti dodatnog smanjenja emisija stakleničkih plinova, povećanja udjela obnovljivih izvora energije, poboljšanja energetske sigurnosti, te uvođenja inovacija i pametnih tehnologija koje omogućuju zgradama da potpomognu sveukupnu dekarbonizaciju gospodarstva.

Postojeće stanje zahtjeva brze i učinkovite odgovore, ali i intenzivnu suradnju i sinergiju kako bi se postigli navedeni ciljevi. Stoga potpisivanjem ove povelje želimo svoja nastojanja usmjeriti na kontinuiranu suradnju na izradi Dugoročne strategije obnove nacionalnog fonda zgrada i prelazak na standard gradnje zgrada gotovo nulte energije (nZEB), kako bi poduprli transformaciju postojećeg fonda zgrada u energetski visokoučinkovit i dekarboniziran fond zgrada do 2050. godine.

U postizanju energetskih i klimatskih ciljeva vodit ćemo se primjenom načela „energetska učinkovitost na prvom mjestu" podupirući unapređenje energetskih svojstava zgrada kojima se doprinosi postizanju zdravijih i ugodnijih životnih i radnih uvjeta, smanjenju klimatskih promjena, svjesni da zgrade boljih energetskih svojstava pružaju veću udobnost i doprinose zdravlju korisnika.

Poseban naglasak stavljamo na korištenje obnovljivih izvora energije, kako kod projektiranja i izvedbe novih, tako i kod obnove i re-konstrukcije postojećih zgrada, vodeći računa o optimalnoj kombinaciji mjera energetske učinkovitosti i obnovljivih izvora energije.

Imajući u vidu važnost energetske učinkovitosti i upotrebe obnovljivih izvora energije aktivno ćemo se zalagati za podizanje svijesti javnosti o navedenim pitanjima.

Kako bi se postigao energetski visokoučinkovit i dekarboniziran fond zgrada i osiguralo da se Dugoročnom strategijom obnove ostvari potreban napredak prema troškovno učinkovitoj pretvorbi postojećih zgrada u zgrade gotovo nulte energije, osobito pove-ćanjem integralnih obnova, nastojat ćemo donijeti jasne smjernice te plan sa ciljanim mjerama i mjerljivim pokazateljima napretka s obzirom na dugoročni cilj smanjenja emisija stakleničkih plinova u EU za 80-95% do 2050. godine u usporedbi s 1990. godinom.

Svjesni smo činjenice da ulaganja u integralnu obnovu zgrada stvaraju daleko šire ekonomske koristi od samih energetskih ušteda što će se posebno odraziti na povećanje gospodarskih aktivnosti, prihod proračuna i jačanje opće financijske stabilnosti države, povećanje BDP-a i porast zapošljavanja, na kontinuirani rast vrijednosti nekretnina, i razvoj turizma, odnosno unaprjeđenje gospodarstva u gotovo svim njegovim segmentima.

Promicati ćemo jednaki pristup financiranju, dajući prednost fondu zgrada s najlošijim energetskim svojstvima, kao i građanima pogođenim energetskim siromaštvom.

Svjesni smo potrebe za uspostavom jasne veze između dugoročne strategije obnove i promicanja razvoja vještina i unapređenja obrazovanja u građevinskom sektoru i sektoru energetske učinkovitosti.

Dugoročnom strategijom obnove nastojat ćemo dati odgovore na pitanja zaštite od požara i rizika povezanih s pojačanom seizmičkom aktivnošću svjesni njihovog utjecaja na energetsku obnovu i održivost zgrada.

Svjesni da inovacije i nove tehnologije također omogućuju zgradama da potpomognu sveukupnu dekarbonizaciju gospodarstva, podupirati ćemo razvoj potrebne infrastrukture i opreme, osobito vezano na modernizaciju, automatizaciju i kontrolu tehničkih sustava u zgradama te e-mobilnost.

Stoga, odlučni da ostvarimo navedene ciljeve pridružujemo se otvorenom dijalogu partnera i potpisujemo ovu povelju.

CROATIAN	ENGLISH
	MINISTRY OF CONSTRUCTION AND PHYSICAL PLANNING
	OPEN PARTNER DIALOGUES
	CHARTER
	FOR COOPERATION AIMED AT DECARBONISATION OF BUILDINGS BY 2050
	We, the signatories of this Charter, are aware

	of the importance of energy efficiency in the building segment, particularly taking into account that nearly 50% of final energy consumption in Croatia and across the European Union is used for heating and cooling, of which 80% in buildings. For the purpose of concerted action to achieve the goals set out in this Charter, we are aware of the importance of establishing open partner dialogue involving all interested stakeholders who can contribute to achieving the set goals. We are committed to achieving the energy and climate goals at national and EU level through decarbonisation of the building stock, renovation of buildings and construction of nearly zero-energy buildings. We are also aware of the importance of further reducing greenhouse gas emissions, increasing the share of renewable energy source, improving energy security and introducing innovations and smart technologies that allow buildings to support the overall decarbonisation of the economy. The existing situation requires rapid and effective responses as well as intense cooperation and synergy to achieve these goals. That is why by signing this Charter we seek to direct our efforts at continued cooperation in developing the Long-term strategy for the renovation of the national building stock and the transition to the nearly zero-energy building (nZEB) standard in order to support the transformation of the existing building stock into a highly energy efficient and decarbonised building stock by 2050. In achieving the energy and climate goals, we will follow the 'energy efficiency first' principle supporting the advancement of the energy performance of buildings to help achieve healthier and more pleasant living and working conditions and reduce climate change, aware that better performing buildings provide higher comfort for their occupants and improve their health. We place special emphasis on the use of renewable energy sources, both in designing and constructing new-builds and in renovating and reconstructing existing buildings, taking account of the optimal combination of energy efficiency measures and renewable energy sources. Bearing in mind the importance of energy efficiency and the use of renewable energy sources, we will actively work on raising public awareness of these issues. In order to achieve a highly energy efficient and decarbonised building stock and enable the

	Long-term strategy to achieve the necessary progress towards a cost-effective transformation of existing buildings into nearly zero-energy buildings, in particular by increasing integral renovations, we will seek to adopt clear guidelines and a plan with well-targeted actions and measurable progress indicators in respect of the long-term goal of reducing greenhouse gas emissions in the EU by 80-95% by 2050 compared with 1990. We are aware of the fact that investment in integral building renovation brings far wider economic benefits than energy savings alone, which will particularly translate into increased economic activity, budget revenue and general financial stability of central government, increased GDP and employment, continued growth in the value of real estate, tourism development and improvement of the economy in nearly all its sectors. We will promote equal access to financing by giving priority to the worst-performing buildings, as well as to energy-poor citizens. We are aware of the need to establish a clear link between the long-term renovation strategy and the promotion of skills development and education in the construction and energy efficiency sectors. The Long-term strategy will seek to address fire safety and risks related to intense seismic activity as we are aware of their impact on the energy renovation and sustainability of buildings. Aware that innovations and new technologies also allow buildings to support the overall decarbonisation of the economy, we will support the development of the necessary infrastructure and equipment, particularly with regard to the modernisation, automation and control of the technical building systems, as well as e-mobility. Determined to achieve these goals, we join the open partner dialogue and sign this Charter.

Figure 12.1: Charter for cooperation aimed at decarbonisation of buildings by 2050

12.1.3 Consultation with the interested public

The development of this Long-term strategy was preceded by the preparation of Croatia's Energy Development Strategy until 2030 with an outlook to 2050, the Low-Carbon Development Strategy until 2030 with an outlook to 2050 and the Integrated national energy and climate plan. All these documents deal in detail with the building segment, with the Integrated national energy and climate plan also specifying measures for the energy renovation of buildings. This Long-term strategy is fully aligned with those documents.

Consultations with the interested public regarding the Long-term strategy are ongoing at several levels and in several ways. As early as the preparatory phase of the development of the Long-term strategy, all relevant stakeholders were included through Open partner dialogues, established by the MCPP with the aim of strengthening interdepartmental communication and cooperation between state administration authorities and the real sector, during which the topics related to the Long-term strategy were presented, addressed and discussed. In September 2018, the topic was 'Implementation of the nearly zero-energy building standard and the national Long-term strategy for the renovation of the national building stock by 2050'. It was followed by 'Energy poverty', as one of the considerable barriers to the integral renovation of buildings, and 'Application of state-of-the-art solutions and rules in respect of fire safety and the risk of intense seismic activity in the energy renovation of buildings', which turned out to be an important trigger point after the earthquake in Zagreb and its environs, so a considerable number of buildings will undergo integral renovation. These topics were followed by 'Amendments to the Construction Act', which were necessary to harmonise national energy efficiency legislation in the building segment with European Union legislation. That Partner dialogue focused on the adoption and implementation of the new Long-term strategy for the renovation of the national building stock by 2050, promotion of electromobility by deploying charging infrastructure for electric vehicles in buildings and in car parks adjacent to buildings, simplification of regular inspections of heating and cooling or air-conditioning systems in buildings, adjustment and control of the technical building systems, defining the requirements related to the installation of self-regulating devices and building automation and control systems, as well as amendments to the authorisation system for energy performance certification of buildings. The most recent Open partner dialogue took place in February 2020. The focus of the Fifth Open partner dialogue was the renovation of Croatia's national building stock to achieve a highly energy efficient and decarbonised national building stock by 2050, in accordance with the goal of the Long-term strategy for the renovation of the national building stock.

Consultations with the interested public opened on the MCPP website and lasted for a month (between 10 August and 9 September 2020), and all citizens of Croatia had an opportunity to participate by e-mailing their comments. Comments were received from the Faculty of Civil Engineering of the University of Zagreb, the Support Centre for Smart and Sustainable Cities of the University of Rijeka, PPP Centar, the Ministry of the Interior, the Croatian Association of Counties, the Danfoss company, the MCPP Directorate for EU Affairs, the Croatian Chamber of Architects, and the Environmental Protection and Energy Efficiency Fund. All the comments were examined and processed and the relevant ones were accepted and incorporated into the text of the Long-term strategy.

An overview of the comments received and replies provided is available on the MCPP's official website.

12.2 RESULTS OF PUBLIC CONSULTATIONS

About 200 stakeholders, representatives of the central and local governments, the academic community and professional public, construction and energy sectors and related industries participated directly through open partner dialogues. That ensured a participatory approach to the development of this Long-term strategy, and the opinions and inputs of all stakeholders were taken into account during its development.

The general public, i.e. all citizens of Croatia, had an opportunity to see the draft Long-term strategy for the renovation of the national building stock and could comment on it during month-long consultations with the interested public. The observations and comments received did not indicate the need for key substantial changes to the Long-term strategy, which confirmed the general acceptance of its goals and measures to achieve them, as well as the support of the professional and general public in Croatia for the policy of energy renovation and decarbonisation of the building stock by 2050.

13 LIST OF FIGURES AND TABLES

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